Rock Valley Bridge
Marshalltown vicinity
Marshall County
Iowa

HAER No. IA-29

HAER
IOWA,
64-MARS.V,
1-

PHOTOGRAPHS
HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
Department of the Interior
National Park Service
Rocky Mountain Regional Office
P.O. Box 25287
Denver Colorado 80225

HAER IOWA, 64-MARS.V, 1-

Historic American Engineering Record

Rock Valley Bridge

Location:	Spanning North Timber Creek on old U.S. Highway 30; 2.9 miles east of Marshalltown; Marshall County, Iowa; NW1/4, SW1/4, SE1/4 of Section 8, Township 83N, Range 17W; UTM: 15.511260.460560.
USGS Quadrangle:	Le Grand, Iowa (7.5 minute series, 1960)
Date of Construction:	1918
Engineer:	Marsh Engineering Company, Des Moines, Iowa
Builder:	Alexander and Higbee, Des Moines, Iowa
Present Owner:	Marshall County, Iowa
Present Use:	Two-lane highway bridge [currently closed for demolition]
Significance:	The Rock Valley Bridge represents the culmination of an extensive concrete bridge construction program undertaken by Marshall County in the 1910s. It is the only span built by the county on the Lincoln Highway, America's first transcontinental route. This medium-span, reinforced concrete rainbow arch is a representative example of the hundreds of such structures designed and marketed by their inventor, Des Moines engineer James B. Marsh. Dozens of rainbow arches were built in Iowa in the 1910s, 20s and 30s. Now only eleven remain, most in deteriorating condition.

Report Assembled by: Clayton B. Fraser
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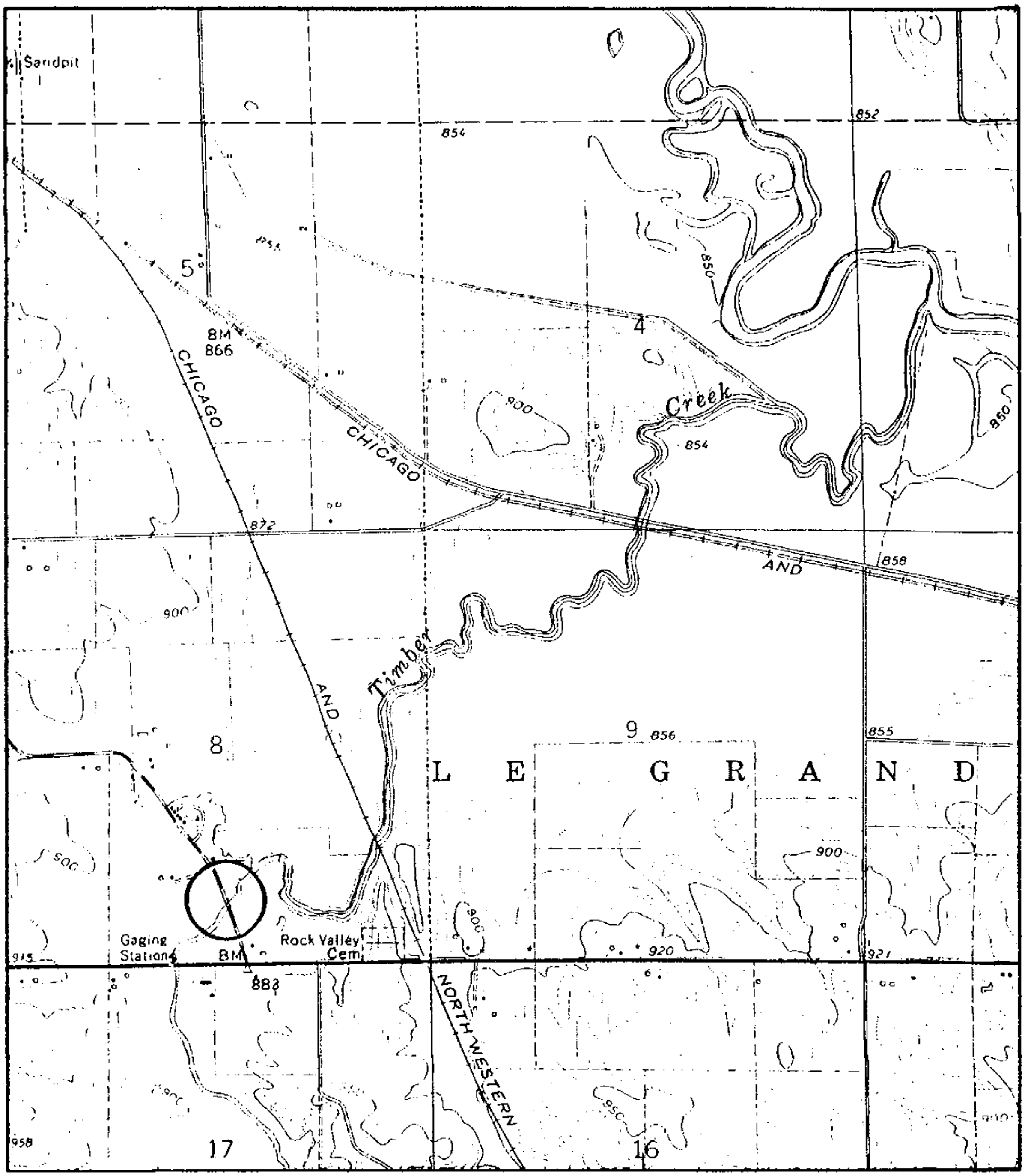
October 1988



Taken from 1960 USGS Le Grand, Iowa, 7.5' Quadrangle map.

On August 6th, 1912, Des Moines engineer James Marsh patented an innovative new concrete bridge, which incorporated "certain new and useful improvements in reinforced arch bridges."[1] A month later, Indianapolis businessman Carl Fisher sponsored a banquet at the Old Deutsches House in Indianapolis to announce his idea for a new transcontinental highway. "A road across the United States," Fisher enthused to the gathering. "Let's build it before we're too old to enjoy it."[2] At about that time Marshalltown newspaper editor D.W. Norris bought his first automobile and, after miring it repeatedly in the bottomless Iowa gumbo, became a staunch supporter of the good roads movement. These three events, related only tangentially, would combine six years later in the construction of the Rock Valley Bridge in Marshall County, Iowa.

James Barney Marsh is an Iowa success story. Born in 1856 in North Lake, Wisconsin, he moved to Iowa at the age of eighteen to attend a preparatory school at Fredricksburg. Once in the state, he never left. In 1882 Marsh received a Bachelor of Mechanical Engineering degree from Iowa State College of Agriculture and Mechanic Arts (now Iowa State University) in Ames. A year later he married Ione Wetherby.[3] Marsh began his professional career in the Des Moines office of the King Iron Bridge Company, the giant bridge fabrication and contracting firm based in Cleveland, Ohio. There he designed, marketed and supervised erection of iron structures across Iowa. This included three pin-connected trusses for Marshall County.[4] One of these was an 80' Pratt through truss over North Timber Creek, built in 1884 near the Rock Valley grist mill east of Marshalltown.[5] Marsh left King in March 1887 to head the northern Iowa office in Des Moines for the Kansas City Bridge and Iron Company. Two years later he returned to the King Iron Bridge Company to serve as general western agent and contracting engineer. Marsh functioned in this capacity for seven years before establishing a consulting engineering practice in Des Moines in the spring of 1896. He incorporated the Marsh Bridge Company in 1904 to build bridges as well. Five years later he reorganized the firm into the Marsh Engineering Company to encompass both design and construction.[6]

Among Marsh's earliest bridges were structures over the Chippewa River at Eau Clair, Wisconsin, and the Red River at Alexandria, Louisiana. He also designed and built the Huerfano Street Bridge in Colorado Springs, Colorado.

Around the turn of the century Marsh began specializing in reinforced concrete. In 1902-03 he engineered concrete bridges for Kankakee, Illinois, and Kenosha, Wisconsin. He typically built from his own designs, but also bid on construction projects engineered by others. On at least one occasion he built a concrete arch designed by his archrival, Indianapolis engineer Daniel Luten.[7] Although Marsh's practice extended across the West and Midwest, his stronghold remained Iowa throughout the 1910s. At this time he designed major vehicular structures for three of Iowa's major cities: the Walnut Street Bridge in Des Moines, the Fourth Street Bridge in Waterloo, and the Second Avenue Bridge in Cedar Rapids. Marsh also undertook several smaller bridges for the Iowa State Highway Commission and for individual counties throughout the state.

In 1912 Marsh received a patent for an innovative medium-span concrete bridge. Comprised of two tapered concrete arches that carried the roadway deck between them from hangers, his invention soon became known as the rainbow arch for its distinctive profile. In the patent application, Marsh described the components of the structure as "two abutments (which could be piers), a pair of arches disposed between and springing from the abutments, the floor carried by and between the arches and reaching from one abutment to the other where it alines [sic] with the parapets or rails along opposite sides of the floor line." [See Marsh's patent application in Appendix A.] He further described the patentable features of the bridge:

> **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, 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.[8]**

Marsh's design represented the hybridization of continuous concrete and segmental steel arch designs. This marked a radical departure from standard engineering practice. Concrete can withstand a nominal amount of tension, but is much stronger against compressive loading. Steel, on the other hand, can resist compressive forces, but is much more efficient in tension. For this reason, most previous concrete arches - both reinforced and mass arches in filled and open spandrel configurations - had been built with the arch below the deck, where the downward force of the deck could be carried in compression by the arch ribs and spandrel walls or columns. Marsh's suspended deck reversed this.

His arches, of course, acted in compression. But the hangers and floor beams carried the deck in tension. Further, the novel treatment of the deck over sliding steel plates on the floor beams and the use of pin-connected, articulated steel hangers for the end panel points were devices more suited to steel construction than concrete. To make the concrete thus act against its nature, Marsh inserted large amounts of structural steel. His bridges may have looked like concrete spans, but the arch ribs and hangers carried such heavy and complicated reinforcing that they were in reality steel structures encased in concrete.

Marsh designed his bridges with either tied (with the arches attached to the abutments at the floor beam level) or fixed (arches extending below the floor beams to the abutments) configurations. Aside from this, all of his rainbow arches were similar, varying only in their span length, arch rise and number of hangers. Marsh's bridges used a standardized construction sequence. The abutments and piers of a typical rainbow arch were poured first, followed by the arch ribs, hangers and floor beams. Then the intermediate ties, floor slab, wall copings and rails were concreted. Once the formwork for the floor was removed, the intermediate hangers were coated. Because the hangers had to be under full dead load when they were concreted, the forms were struck no less than 10 days or more than 21 days after the slab was poured. Pouring the guardrails completed the bridge.

One structural advantage of the rainbow arch was that the roadway deck could expand and contract longitudinally without affecting the arch ribs. "Broadly speaking," Marsh stated in the patent application, "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."[9] He accomplished this by making the slab independent of the arches at the points where its plane intersects them on the two ends. He supported the slab at each of these points with a cross girder or floor beam formed integrally with the arches. The floor was essentially monolithic, but could deflect between the floor beams by means of a construction joint over the center of each beam. The reinforcing steel in the top of the slab did not extend continuously over the beams, although the rods in the bottom were continuous.[10]

Marsh envisioned another advantage to his bridge in its manner of construction. After completion of the concrete abutments and piers, the reinforcing steel of the arch ribs would be erected and connected rigidly with the struts, floor beams and hangers. The arch centering formwork would then be placed around this reinforcing armature. The arch reinforcing consisted of four angles, laced on all sides. The angles could be made heavy enough to carry the formwork for the concrete in addition to the dead weight of the concrete itself, without benefit of timber pile falsework. This eliminated the danger of falsework washouts during construction of the bridge.

Marsh marketed his invention aggressively across the Midwest through his own company and through associate firms such as the Westcott Engineering Company of Chicago. He claimed that his bridges were economical for relatively short-span applications. With the main structural members of the rainbow arch held above the roadway, he could point to greater waterway clearance than that provided by concrete deck arches. Marsh often submitted arch designs to state and county engineers as alternatives for steel trusses. The comparison was apt, given the large quantities of steel that made up his structures. Finally, with the arch regarded by many as the most aesthetic of bridge forms, Marsh could promote his spans as more attractive than their truss counterparts.

Marsh's invention coincided with the development of the good roads movement and the formative efforts to build a transcontinental highway. As Marsh was waiting for approval of the rainbow arch patent, Carl G. Fisher, founder of the Prest-O-Lite headlight company and non-stop promoter, was formulating a daring idea for a new road across America. In 1912 Fisher began boosting what he called the Coast-to-Coast Rock Highway, a continuous line that extended from New York to San Francisco. In September he sponsored a banquet for members of the Indianapolis auto industry to solicit help and money. Fisher wanted $10 million for road-building materials; the labor and machinery, he reasoned, would be provided by cities and counties along the route. The response was immediate. Goodyear president Frank A. Seiberling offered $300,000 that night. Within a month Fisher had $1 million in pledges. The road was soon renamed the Lincoln Highway, and in July 1913 the Lincoln Highway Association was formed to further it.

Although not the first to propose such a venture, Fisher had timed his promotion well.[11] Some 2.5 million miles of roadway had been laid in the country, but less than 7% of these had been improved by grading or graveling. Only a few hundred miles had been paved with brick. Concrete was as yet untried as a rural paving material.[12] Moreover, the roads that did exist lacked any coordination. Road construction was then largely a county-level function. Seldom following premeditated plans, county officials authorized surveying and clearing of roads and construction of bridges in response to immediate needs. This created an uneven patchwork of dissimilar routes, making travel difficult for all but a few areas and virtually impossible on a cross-country basis. "The highways of America," Fisher stated, "are built chiefly of politics, whereas the proper material is crushed rock or concrete." With the numbers of automobiles growing geometrically and their drivers becoming increasingly more adventurous, the transcontinental route was an idea whose time had come.[13]

In its formative years, the Lincoln Highway was more imaginary than real. Using existing section-line roads and county-built river crossings, it zigzagged across central Iowa on its way between Clinton, on the Mississippi River, and Council Bluffs, on the Missouri. Counties and towns along the route profited from the trade and publicity it brought but generally did little to improve the road itself. Marshall County, which was bisected by the highway, was as guilty in this as the rest. The result was that the road was often impassable for days after rainstorms. Although travelers worried about the long, unimproved stretches through Wyoming and Utah, in reality the mud-choked roads of Iowa proved far more problematical. Lincoln Highway Association president Henry Joy in 1916 stated, "Today, in the rich state of Iowa, not a wheel turns outside the paved streets of her cities during or for some time after the frequent heavy rains. Every farm is isolated. Social intercourse ceases. School attendance is impossible. Transportation is at a standstill. Millions of dollars worth of wheeled vehicles become, for the time being, worthless."[14]

When donations fell far short of the $10 million goal in 1914, the association dropped Fisher's overly ambitious scheme to lay a gravel road entirely across the country. It instead focused on lobbying and public education in behalf of paved roads. Out of this was born the seedling mile program. Under this novel plan, the association would promote the use of concrete as a paving material by funding demonstration miles of concrete-paved roads along the highway's route. These so-called "seedling miles" would be placed in rural areas to engender widespread support for paved roads. Mindful of the potentially huge gains, the cement industry donated a million and a half barrels of cement to the association for distribution.

The first seedling mile was built near DeKalb, Illinois, using 2,000 barrels of cement to pour a 10' wide roadway. In 1915 four more seedling miles were poured: two in Nebraska and one each in Illinois and Indiana. It was a modest beginning by any measure. But in this, the Lincoln Highway made the first step from paper to concrete. Soon several other transcontinental and regional routes began to appear: the Midland Trail, the Ocean-to-Ocean Highway, the Sunset Trail, the Black and Yellow Highway. Like the Lincoln, most remained largely unimproved. With the announcement of each new route, though, the good roads movement picked up valuable new support.

Marshall County, Iowa, had its own booster for good roads in the person of Marshalltown *Times-Republican* editor D.W. Norris. Since buying his automobile, he had spoken frequently at meetings across the state of the need for paving primary roads and graveling for secondary. When Iowa Governor George Clarke formed a statewide good roads committee, he appointed Norris as chairman. Norris pushed so often and so insistently for paved roads that a rival newspaper cartooned him as an agent of the cement trust.[15] It was that cartoon which prompted Norris to approach his friend C.H. McNider, Mason City banker and cement company director, to pave a demonstration road between Mason City and Clear Lake. Built in cooperation with Cerro Gordo county officials, this was reportedly Iowa's first rural pavement.[16]

Norris campaigned in his own county as well, lobbying for improved rural roads, bringing in guest lecturers to extol the benefits of good roads, and reporting each street paving project in Marshalltown in great detail. He faced tremendous opposition from the "mud roaders", a faction made up primarily of farmers who feared that such road improvement projects would be funded by levying burdensome property tax assessments. Norris was also opposed actively by the brick manufacturers, who fought to protect their monopoly on paving materials.

Through his newspaper, Norris tried to influence the Marshalltown city council to pave city streets with concrete. He was finally successful when the council ordered concrete for Jerome Street and North Fifth Street adjacent to Norris's property. His lobbying for paved county roads appeared to bear fruit in January 1915, when the Marshall county supervisors voted to participate in the Lincoln Highway's seedling mile program. The county would pave and maintain two sample miles of the route using 2,000 barrels of cement donated by the Lincoln Highway Association.[17] This would have been Marshall County's first rural paved road. It was never undertaken, however.

Although local sentiment for road paving ranged from indifference to vocal opposition, concrete was generally accepted for bridge use. The county's numerous small crossings over creeks and ditches made erection of hundreds of steel trusses impractical. And timber structures were predictably short-lived. Small concrete culverts and bridges, on the other hand, could be built economically using standardized designs, were stronger under load and more resistant to washouts than other bridge types, and generally required only minimal maintenance. Marshall County began using concrete on a regular basis for bridge construction in 1910. The supervisors began modestly, letting a contract for six arch bridges in April 1910 to Des Moines contractor N.M. Stark.[18] In 1912 gazetteers William Battin and F.A. Moscrip counted nine spans over the Iowa River and about 160 creek bridges in Marshall County.[19]

"Some of these are now being replaced as needed by concrete structures," they stated, "and many of the culverts are being made of concrete. Our people are learning the uses of concrete and how to make it."[20]

The county continued in this manner over the next eight years, letting contracts for increasingly larger groups of concrete bridges and culverts on its unimproved dirt roads. By 1916 the supervisors were letting contracts for 30 or 40 structures at a time. One typical contract in August 1916 included three bridges and 29 culverts, distributed across nine of the county's sixteen townships. The supervisors awarded the construction contract to the Ingersoll Stoufer Engineering Company of Marshalltown from a field of four Iowa construction firms.[21] When Marshall County first associated with the Marsh Engineering Company in November 1915, it was for construction rather than design. The supervisors contracted with Marsh at that time to complete the East Main Street Bridge after the Capital City Construction Company had defaulted on its contract.[22]

County engineer W.W. Morehouse and his successor, H.O. Hickock, designed the many small-scale structures using standard plans promulgated by the State Highway Commission. Consisting of concrete slabs, girders and boxes and steel I-beam stringers, the bridges and culverts featured modest spans with concrete decks and guardrails, supported by reinforced concrete abutments and piers. For longer and more complex bridges, the county depended directly on the highway commission for engineering. Marshall County may have been plagued by dismal roads, but its drainage structures were solidly constructed.

To help defray the costs for this ambitious bridge program, the county issued bonds totaling $78,000 in 1917 and $79,000 in 1918.[23] The bridge building culminated in 1918, when the supervisors awarded contracts for over 75 concrete structures. In March the county contracted for 10 bridges and 64 box culverts, divided for bidding purposes into four groups. A.P. Munsen of Marion, Iowa, received the contracts for Groups 1 and 4, the Cole Brothers Construction Company of Ames for Group 2, and the Ingersoll Stoufer Engineering Company for Group 3. The cost for these structures was over $70,000 - more than twice the amount the county had spent for bridges in all of 1910.[24]

As the supervisors awarded the contracts in March, county engineer Hickock was planning two of the largest spans undertaken by the county since the turn of the century. One of these would carry a township road across Minerva Creek north of Moninger. The other, east of Marshalltown in Le Grand Township, would replace the existing Rock Valley Bridge over North Timber Creek - the bridge for which James Marsh had supervised construction three decades earlier. Located on the Lincoln Highway, this would mark the first and, as it turned out, the only major bridge that Marshall County would build specifically for the transcontinental route.

Hickock sought design assistance for both structures from the State Highway Commission. In March commission engineers delineated standard riveted Pratt through trusses for both crossings: a 100' span for Minerva Creek and a 110' span for Rock Valley. Additionally, Hickock contacted James Marsh to design rainbow arches of similar spans for the two bridges, to be bid as alternate designs. Marsh apparently engineered both structures on a speculative basis. He would not be paid unless the county actually contracted for construction of one or both arch bridges.

The rainbow arch that Marsh designed for Rock Valley displayed typical form and detailing. [See figures 1-3, original construction drawings.] The bridge consists of a single 110' span carried some 26' above the streambed. The overall length is 158'; the roadway width, 20' between the curbs. The segmental arches extend beneath the deck and thrust against the concrete abutments in the fixed configuration. They rise 22' at the crown and taper from a 25"x 50" cross section at the floor to 25"x 30" at the crown. Each arch is reinforced with four steel angles, spliced using riveted plates and laced together with riveted steel bars to form a box-lattice girder. The bridge is subdivided into eleven panels, with hangers and floor beams spaced at 8' 9" intervals.

Typically, the outermost hangers are articulated, using 3/4" steel bars looped around 2.5" pins at top and bottom. The other hangers consist of four angles connected rigidly (and poured integrally) with the arch ribs. The 14"x 33" end floor beams are also built integrally into the arch ribs, with sliding steel plates separating them from the underside of the slab to allow for longitudinal deck movement. The remaining 12"x 20" floor beams are formed integrally with the hangers and deck. The deck consists of a longitudinally and transversely reinforced concrete slab, with an edge thickness of 8" and a slight crown. The abutments consist of reinforced concrete side and end walls, filled with earth and supported by 120 treated timber piles. The guardrails on the span are standard slotted concrete walls. Those on the approaches are paneled parapet walls.

The massive structure consumed 522 cubic yards of concrete and 32,040 pounds of reinforcing steel, for a total weight in excess of 720,000 pounds. The truss required a lighter substructure (369.7 cubic yards of concrete and 25,240 pounds of reinforcing steel, including deck) with far fewer timber piles (72). But the arch used substantially less structural steel (19,400 pounds, versus 83,000 pounds for the truss).[25]

When the supervisors opened the proposals for the two structures on the afternoon of Monday, May 6th, they were dismayed to find the bids substantially higher than the original estimates. The lowest proposal for the Minerva Creek bridge had been submitted by Ingersoll Stoufer. Ingersoll's bid of $8,900 was almost $2,000 less than the lowest rainbow arch proposal, but still $400 greater than the estimate. Proposals for the Rock Valley bridge were similar:

	steel truss	rainbow arch
Des Moines Bridge and Iron Company	$15,383	-
Alexander and Higbee, Des Moines	-	$16,200
Hey-Keeler Construction Company, Waterloo	$15,897	$16,936
Iowa Bridge Company, Des Moines	$15,885	$16,956
F.E. Marsh and Company, Des Moines	-	$17,250
Fifield Construction Company, Waterloo	$16,999	$17,477 [26]

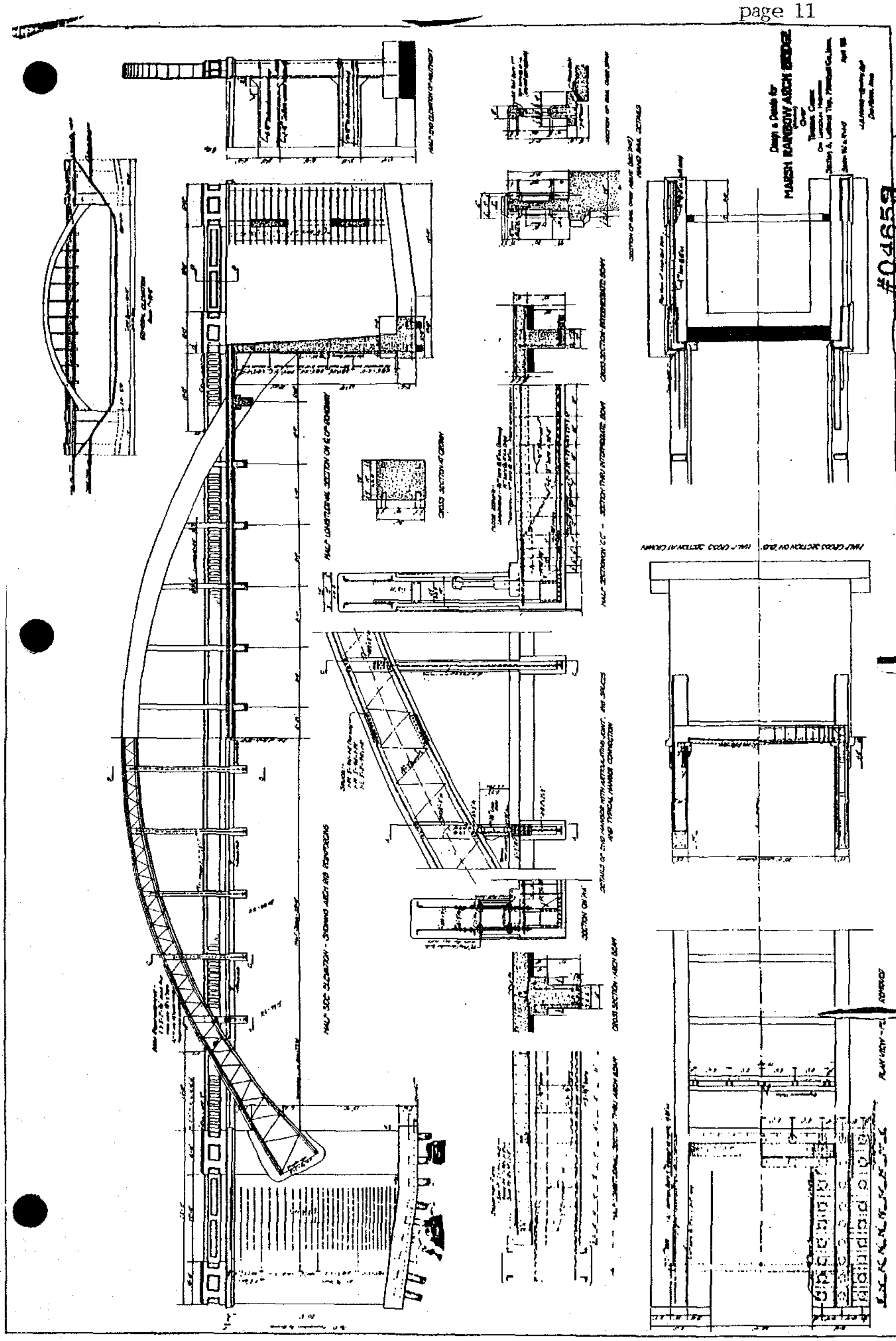


Figure 1. Original construction drawings, prepared by Marsh Engineering Company, April 1918. Located at Iowa Department of Transportation, Ames Iowa.

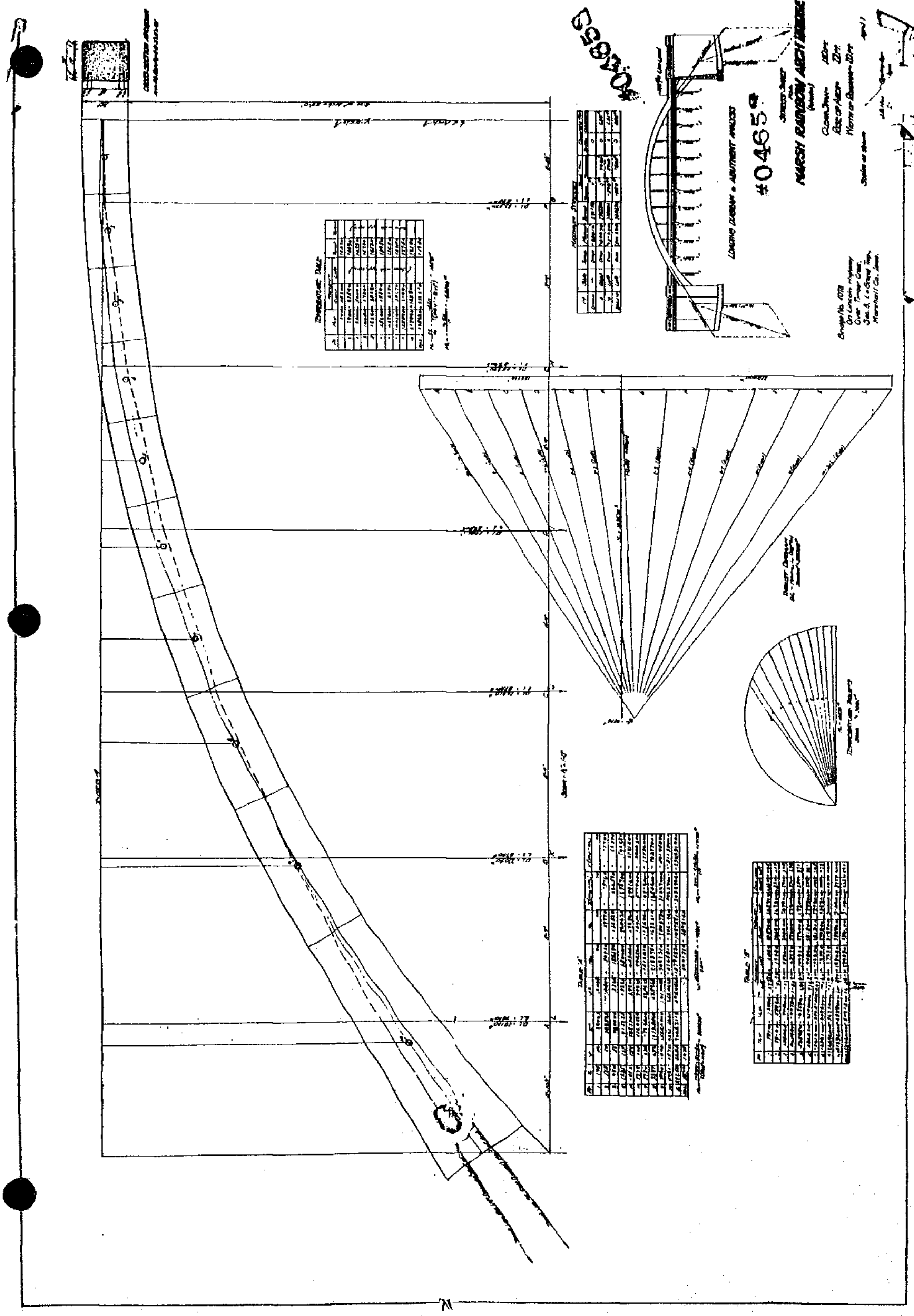


Figure 2. Original construction drawing, prepared by Marsh Engineering Company, April, 1918. Located at Iowa Department of Transportation, Ames, Iowa.

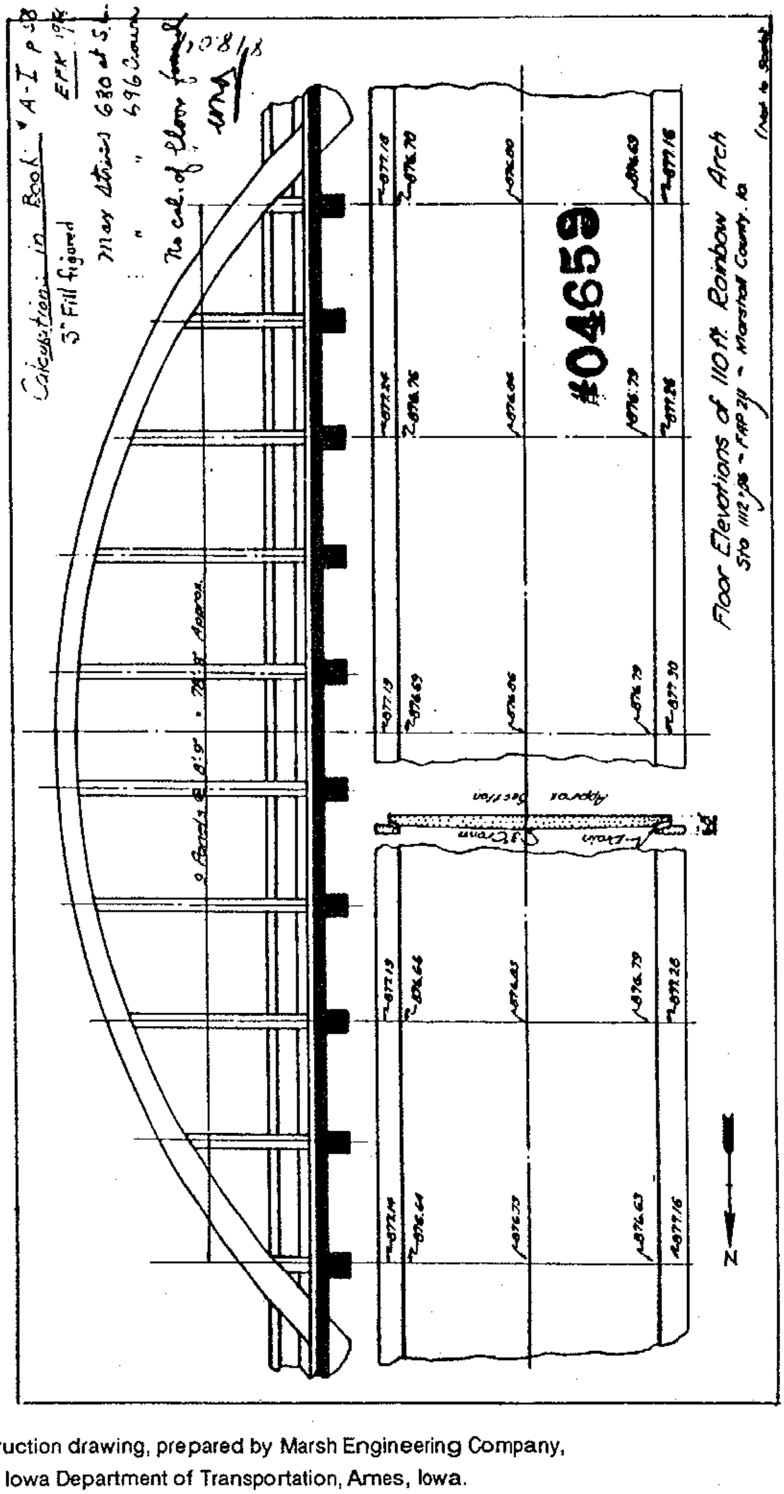


Fig. 3. Original construction drawing, prepared by Marsh Engineering Company, April 1918. Located at Iowa Department of Transportation, Ames, Iowa.

When the cost of engineering, royalties and construction inspection to the Marsh Engineering Company was added to the cost of the rainbow arch and the cost of substructural piles was added to the cost of the steel truss, the difference between the low bids of the two types of bridges was less than $300. But Alexander and Higbee's arch proposal exceeded the county's estimate by almost $3,000. Nonplused, the supervisors postponed making a decision for two days until highway commission district engineer W.F. Beard could be consulted.[27]

Beard advised them to build the rainbow arch. The supervisors were apparently unconcerned by the war-caused steel shortages, because they elected to erect a truss for the Minerva Creek bridge site. Their decision to build a concrete arch for the Rock Valley site was predicated more by its position on the transcontinental highway than by the availability of materials. Ultimately, the choice came down to aesthetics. On Wednesday, the supervisors awarded the contract to Alexander and Higbee of Des Moines for $16,200 and voted to pay $810 to the Marsh Engineering Company for the drawings.[28] "The supervisors chose this type of bridge, which is of handsome design, because the price was only $245 more than the lowest bid for the high steel truss bridge," the *Times-Republican* reported. "The absence of cost of maintenance on the arch, as compared with painting the steel truss and depreciation of the latter bridge together with the prettier design influenced the board to select the arch. It is much handsomer in design for so important a road as the [Lincoln] highway."[29]

The new structure was to be located about 100' south of the existing truss, over a newly dredged channel of North Timber Creek. [See figure 4.] The county immediately purchased land for the new site from property owners Bramer and Matilda Moore.[30] Once this had been done, Alexander and Higbee began excavation for the abutments. Construction of the bridge progressed through the summer without report of incident. By November the contractors had poured the arch ribs and floor beams. They completed the structure by year's end.

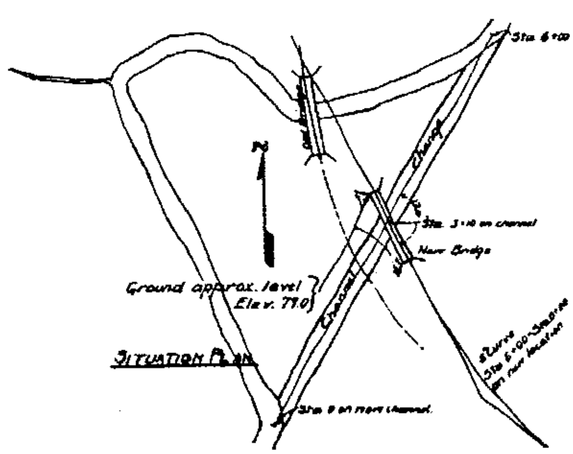


Fig. 4. From construction drawing by Iowa State Highway Commission, March 1918.

The opening of the new Rock Valley Bridge sparked renewed interest for highway paving in the county. In March 1919 the supervisors voted once again to accept donated concrete from the Lincoln Highway Association to pave a seedling mile.[31] They had waited too long, however. The association ended its seedling mile program that year, after paving segments in Iowa, Nebraska, Ohio, Illinois and Indiana, but not in Marshall County.

The county remained reluctant to embrace the concept of paved roads. As late as January 1921, the *Times-Republican* counted 111 miles of ungraded dirt roads, 23 miles of graded dirt roads and only eight miles of graveled road.[32] Marshall County still had no paved roads outside of the urban areas. In 1920 the board ordered the main roads into Marshalltown from four directions paved for a distance of 1.5 miles to serve as local equivalents to seedling miles. The first concrete was poured on May 13, 1921, "amid the shrieking of whistles," according to the *Times-Republican.* Two years later the supervisors called a referendum to approve $800,000 of bonds to pave the Lincoln Highway across the county, precipitating what was known locally as the Big Road Fight. The measure passed by a small margin in August 1923. Soon after the mud roaders filed for an injunction to restrain the board of supervisors from selling the bonds or letting the paving contracts. Saying that "ruin confronts the county if bonds are sold," the mud roaders petitioned for a new election and held rallies to garner support for their cause. The *Times-Republican* - no friend of the mud roaders - reported the irony of the September 19th meeting:

> **Rain and mud late Wednesday made such ideal weather for the big mud roads meeting that only a few ardent mud roaders from inside of the city could attend. Cars stuck in the mud or in the ditch on all sides of the city last night and this morning were reported by the few motorists who have been able to get thru.[33]**

The injunction suit was denied by the court, and in December 1924 the state supreme court upheld the lower court's findings. Paving of the Lincoln Highway through Marshall County began in March 1925. By late summer motorists were able to drive on pavement from Marshalltown west to the Story County line. On June 12, 1926, the pavement was completed.[34]

The Marsh Engineering Company continued designing and building rainbow arches well into the 1930s. In 1919 the company designed a 106' arch for the City of Marshalltown to carry South Third Avenue over Linn Creek.[35] Three years later Marsh designed his longest rainbow arch bridge ever, spanning the South Platte River at Fort Morgan, Colorado. Built by the Colorado Bridge and Construction Company, this structure consisted of eleven fixed-arch spans, with a total length of 1110'.[36] In 1930 Marsh surpassed this by 100' on the seven-span Cotter Bridge, over the White River in Arkansas.[37] By the time James Marsh died of cancer in 1936, his company had engineered and erected concrete arches throughout the country.

The Lincoln Highway continued to develop throughout the 1920s. The traffic tie-ups that had snarled the railroads during World War I clearly demonstrated the need for a comprehensive vehicular highway system across the country. As a result, increasingly greater amounts of federal money were committed to road construction in each succeeding year. As more counties and states improved their pieces of the Lincoln, the route eventually became recognizable as a highway. Iowa was one of the last states to pave the road, due in large part to a legal structure that placed most of the burden of construction costs on adjacent landowners. In 1925 the American Association of State Highway Officials developed a numbering system for the nation's routes. The Lincoln Highway was assimilated into U.S. Highways 1, 30, 40 and 50. Its goals accomplished, the Lincoln Highway Association ceased its "active and aggressive operations" on December 31, 1927.[38]

The highway, as it turns out, has fared much better than Marsh's rainbow arches. With such large quantities of steel encased in a relatively thin envelope of porous concrete, these bridges have routinely failed due to excessive rusting, spalling and cracking. Of the many rainbow arches built in Iowa, only eleven are known to remain, and most of these are deteriorating. The irony is that Marsh's concrete structures, touted as superior to metal trusses, have often fallen short in this comparison. Currently scheduled for demolition, the Rock Valley rainbow arch will be outlasted by the Minerva Creek Bridge, the 100' steel truss also built 1918 by the county, and even by the 1884 wrought iron truss erected originally at this location.[39]

Marsh's invention did not foretell a new direction in reinforced concrete design. The industry would later turn to other, simpler slab and beam configurations as it developed more sophisticated reinforcing techniques in the 1930s and 1940s. The rainbow arch did, however, mark one of the more interesting early experiments in concrete engineering and represented the proliferation of concrete for road and bridge construction.

ENDNOTES

1 Patent file 1,035,026; 6 August 1912.

2 Drake Hokanson, *The Lincoln Highway: Main Street Across America* (Iowa City, Iowa: University of Iowa Press, 1988), page 6.

3 "J.B. Marsh Is Dead at 60," *Des Moines Tribune*, 26 June 1936; "Deaths," *Des Moines Register*, 27 June 1936; C.S. Nichols, ed., *Directory of the Division of Engineering* (Ames, Iowa: Iowa State College of Agriculture and Mechanic Arts), page 112.

4 The three bridges built by the King Iron Bridge Company for Marshall County during James Marsh's first tenure with the company were the Stanley Bridge, a 150' Whipple truss built in 1884 for $4,550; the Rock Valley Bridge, an 80' Pratt truss built in 1884 for $2,150; and the Quarry Bridge, a 150' Whipple truss built in 1885 for $3,295. The latter two trusses still carry county traffic, although the Rock Valley Bridge has since been moved.

5 Minutes of the Marshall County Board of Supervisors, 25 June 1884 (Book 5, page 155), Marshall County Courthouse, Marshalltown, Iowa.

6 C.S. Nichols, ed., *Directory of the Division of Engineering*, page 112.

7 This was the Commercial Street Bridge in Trinidad, Colorado, built jointly by the City of Trinidad and Las Animas County. After competitive bidding, Marsh was awarded the construction contract in January 1905 for $25,000 to build the bridge. The two-span concrete arch was built from a patented design of Luten's Concrete-Steel Engineering Company. Minutes of the Las Animas County (Colorado) Commissioners, 4 October 1904, 6 December 1904, 5 January 1905.

8 Patent file 1,035,026; 6 August 1912.

9 *Ibid.*

10 "Concrete Bridges with Through Arches," *Engineering News*, 15 February 1917, pages 272-73; "A 270 Ft. Rainbow Arch Bridge," *Engineering and Contracting*, Vol. 49, No. 26 (1918), page 648.

11 The American Automobile Association proposed a transcontinental highway as early as 1902.

12 A one-mile stretch of rural concrete paving was undertaken in 1908 on an experimental basis on Woodward Avenue outside of Detroit in Wayne County, Michigan. It stood up well under the traffic of thousands of skeptical motorists.

13 Warren James Belasco, *Americans on the Road: From Autocamp to Motel, 1910-1945* (Cambridge, Massachusetts: MIT Press, 1981). Drake Hokanson, *The Lincoln Highway: Main Street Across America.*

14 *Ibid*, page 97.

15 Gerard Schultz, *History of Marshall County, Iowa* (Marshalltown: Marshall Printing Company, 1955), page 87.

16 "Fight Required To Get County Out of Mud," Marshalltown *Times-Republican*, 6 June 1949.

17 Minutes of the Marshall County Board of Supervisors, 7 January 1915 (Book 9, page 3), Marshall County Courthouse, Marshalltown, Iowa.

18 Minutes of the Marshall County Board of Supervisors, 16 April 1910 (Book 8, page 138), Marshall County Courthouse, Marshalltown, Iowa.

19 The nine bridges over the Iowa River were located at Liscomb; Stanley's Mill, near Albion; Marietta; Nicholson's Ford, northeast of Marshalltown; Quarry; Le Grand; Young's Ford, east of Marshalltown; and North Third Avenue and North Center Street in Marshalltown.

20 William Battin and F.A. Moscrip, *Past and Present of Marshall County, Iowa* (Indianapolis: B.F. Bowen and Company, 1912), page 455.

21 Minutes of the Marshall County Board of Supervisors, 14 August 1916, (Book 9, page 75), Marshall County Courthouse, Marshalltown, Iowa.

22 Minutes of the Marshall County Board of Supervisors, 10 November 1915, (Book 9, page 49), Marshall County Courthouse, Marshalltown, Iowa.

23 Minutes of the Marshall County Board of Supervisors, 5 December 1917 (Book 9, page 121), 10 September 1918 (Book 9, page 142), Marshall County Courthouse, Marshalltown, Iowa.

24 "Contracts for Bridges Are Let," *Times-Republican*, 5 March 1918.

25 Marshall County Engineer, "Instructions to Bidders: Bridge Numbers 7138, 4078," April 1918.

26 "Bridge Bids Are High, Board Finds," *Times-Republican*, 7 May 1918; Minutes of the Marshall County Board of Supervisors, 6 May 1918 (Book 9, page 135), Marshall County Courthouse, Marshalltown, Iowa.

27 *Ibid.*

28 Minutes of the Marshall County Board of Supervisors, 8 May 1918 (Book 9, page 137), Marshall County Courthouse, Marshalltown, Iowa.

29 "Large County Contracts Let," *Times-Republican*, 9 May 1918.

30 Minutes of the Marshall County Board of Supervisors, 8 May 1918 (Book 9, page 137), Marshall County Courthouse, Marshalltown, Iowa.

31 Minutes of the Marshall County Board of Supervisors, 3 March 1919 (Book 9, page 165), Marshall County Courthouse, Marshalltown, Iowa.

32 The eight-mile gravel road was known as the Marietta Road between Marshalltown and Albion, promoted widely by automobile dealer (and later Marshalltown mayor) G.W. Darling. *Times-Republican*, 6 January 1921.

33 *Times-Republican*, 20 September 1923.

34 Gerard Schultz, *History of Marshall County, Iowa*, page 87.

35 J.B. Marsh, Consulting Engineer, "Design for a Rainbow Arch Bridge over Linn Creek at South Third Avenue, Marshalltown, Iowa," January 1919, original construction drawing located at Iowa Department of Transportation in Ames, Iowa; see also HAER No. IA-8, South Third Avenue Bridge [1981].

36 Clayton B. Fraser, *Historic Bridges of Colorado* (Denver: Colorado Department of Highways, 1986), page 93.

37 Donald C. Jackson, *Great American Bridges and Dams* (Washington, D.C.: Preservation Press, 1988), page 165.

38 Drake Hokanson, *The Lincoln Highway: Main Street Across America*, pages 108-09.

39 The original Rock Valley Bridge was dismantled after completion of the new bridge and reassembled at a new location by Marshall County in 1921.

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 alines 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.

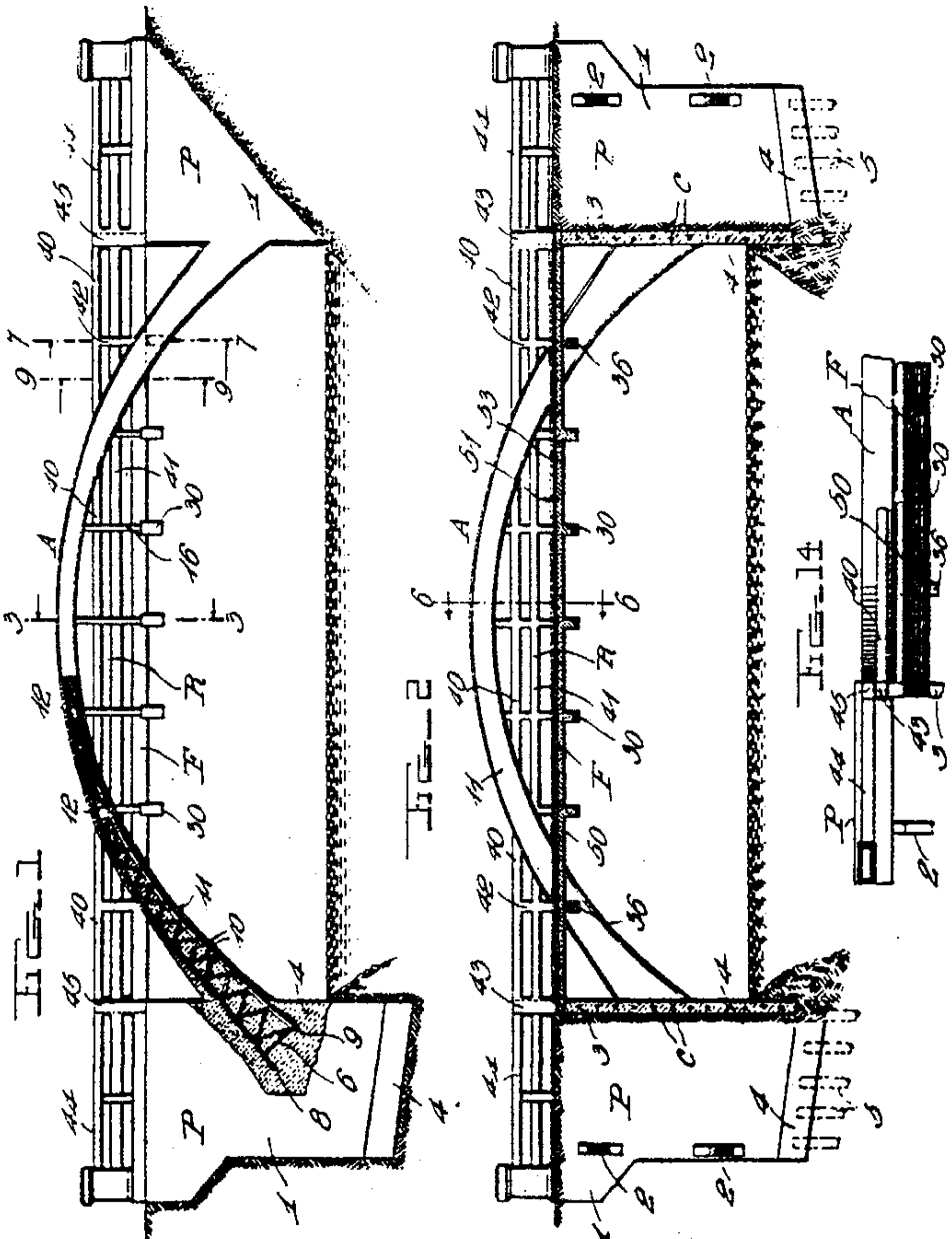
REINFORCED ARCH BRIDGE.

APPLICATION FILED NOV. 1, 1911.

1,035,026.

Patented Aug. 6, 1912.

4 SHEETS—SHEET 1.



Witnesses

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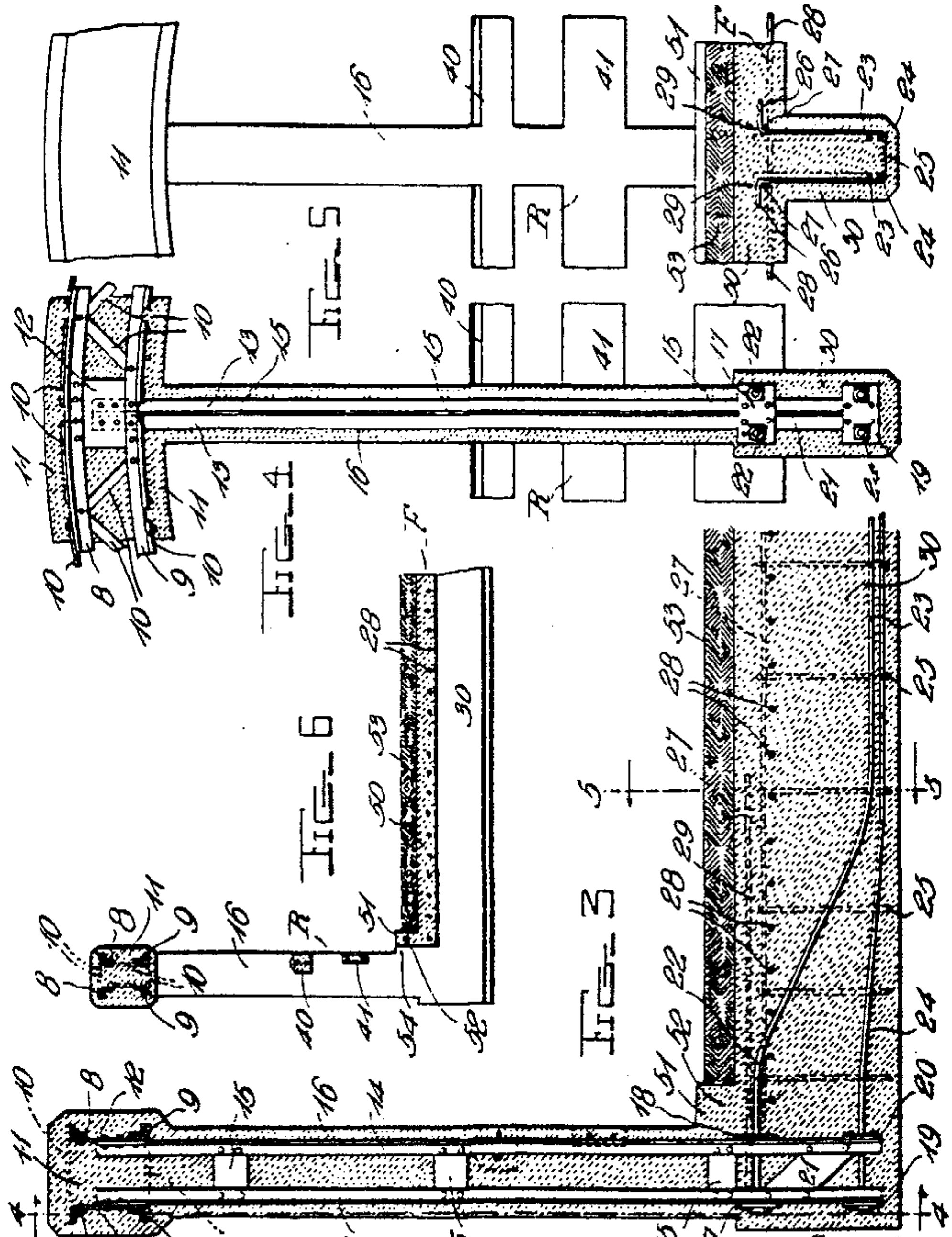
4 SHEETS—SHEET 2.



Witnesses

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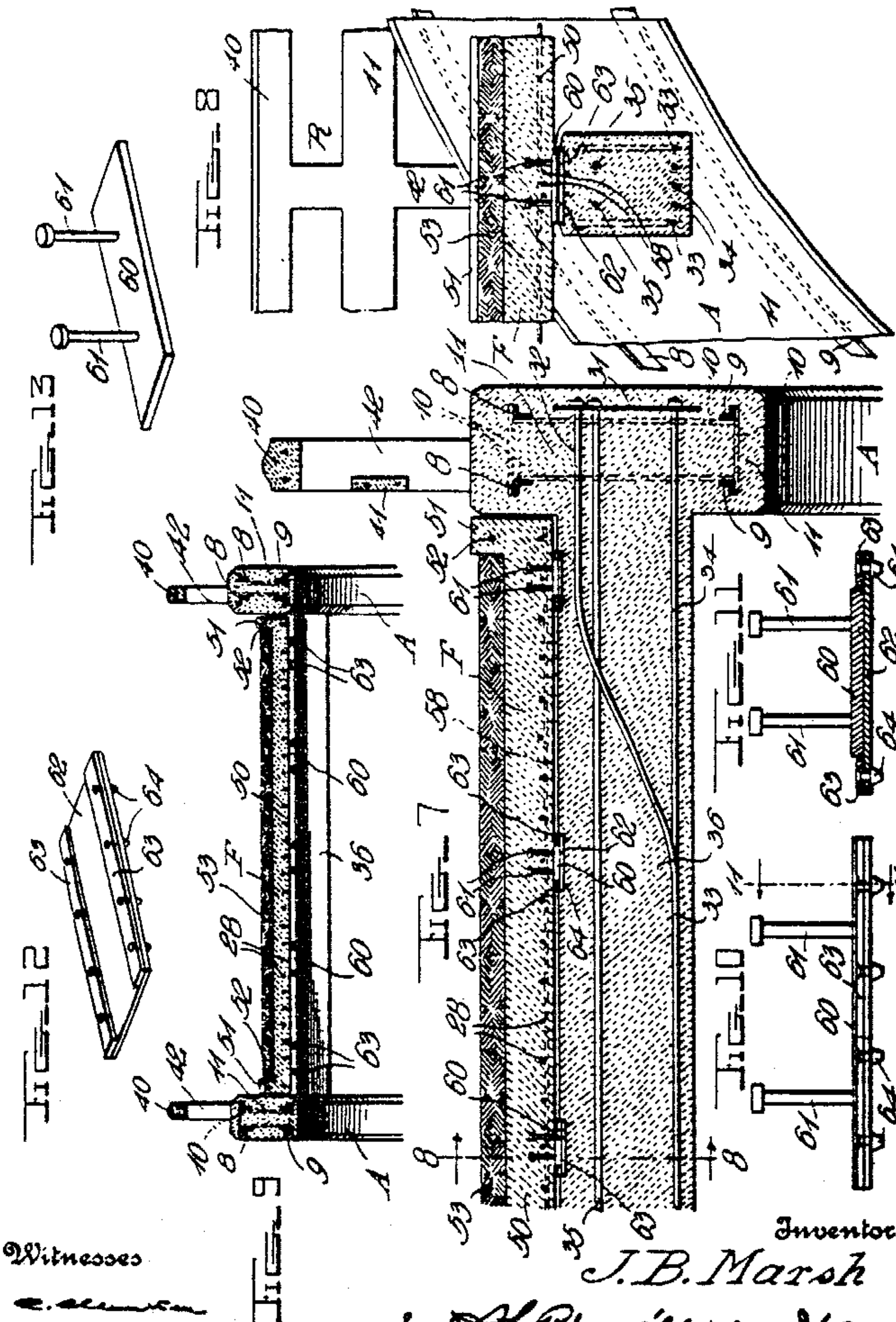
4 SHEETS—SHEET 3.



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4 SHEETS—SHEET 4.

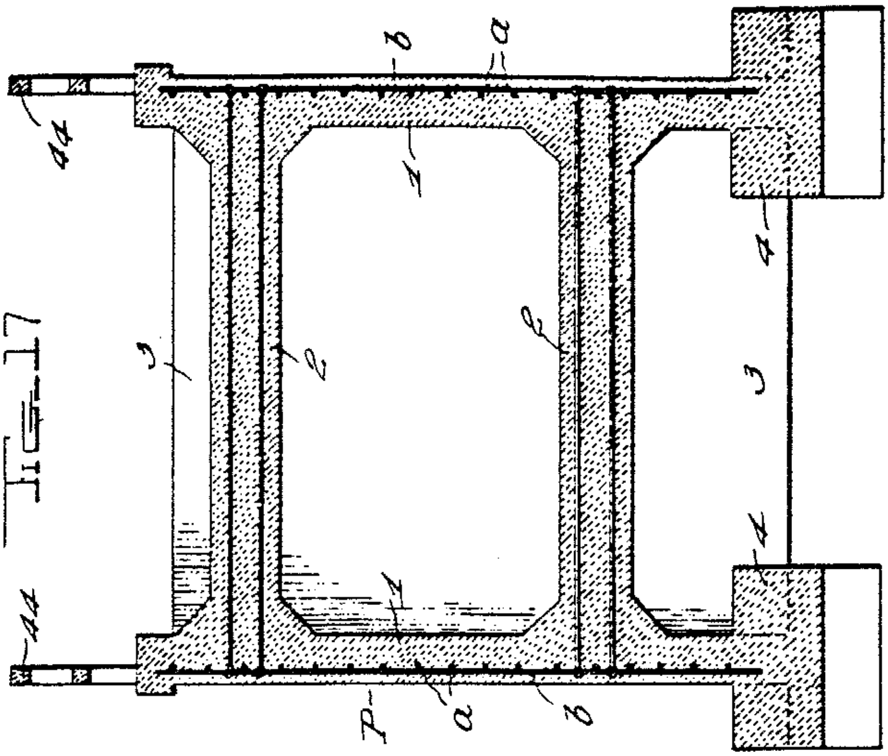

Fig. 17

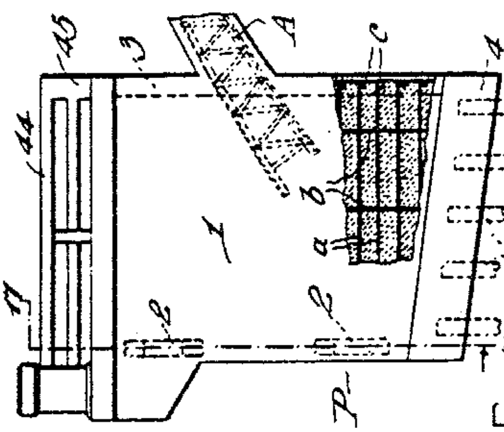

Fig. 15

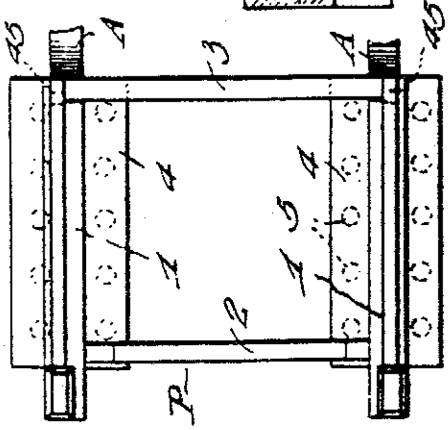

Fig. 16

Witnesses:

[illegible]

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ADDENDUM TO
ROCK VALLEY BRIDGE
Spanning North Timber Creek at Old U.S. Highway 30
Marshalltown vicinity
Marshall County
Iowa

HAER No. IA-29

HAER
IOWA
64-MARS.V,
1-

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
1849 C Street, NW
Washington, DC 20240

HISTORIC AMERICAN ENGINEERING RECORD

ROCK VALLEY BRIDGE

This appendix is an addendum to a 26-page report previously transmitted to the Library of Congress.

APPENDIX: ADDITIONAL REFERENCES

Interested readers may consult the Historical Overview of Iowa Bridges, HAER No. IA-88: "This historical overview of bridges in Iowa was prepared as part of Iowa Historic Bridges Recording Project - I and II, conducted during the summers of 1995 and 1996 by the Historic American Engineering Record (HAER). The purpose of the overview was to provide a unified historical context for the bridges involved in the recording projects."