MEMPHIS BRIDGE

Morison's last major bridge over the Mississippi River was also his largest and most technologically ambitious structure. Begun twenty years after he started his engineering career at the Kansas City Bridge, the railroad bridge at Memphis, Tennessee, was an immense undertaking, which would ultimately become known as his most important bridge project.

Memphis had long been considered by engineers and railroad capitalists as a particularly attractive location for a bridge across the Mississippi. Situated on the line of expanding industrial traffic between Kansas City and the Southwest and the Atlantic and Gulf coasts, Memphis presented an ideal crossing site. By the mid-1880s, no less than ten rail lines entered the southern city: three from the west and the remainder from the east. These included the Kansas City, Fort Scott & Memphis; the Kansas City, Memphis & Birmingham; the St. Louis, Iron Mountain & Southern and the Little Rock & Memphis Railways, all important regional carriers. As had been the case at numerous other Mississippi and Missouri River crossings, rail traffic over these lines was often tangled at Memphis by a transfer steamer operation.[109]

In February 1885, Congress granted a charter to two corporations to build and maintain a bridge over the Mississippi River at Memphis. Granted to the Tennessee and Arkansas Bridge Company, incorporated in Arkansas, and the Tennessee Construction Company, incorporated in Tennessee, the charter specified a bridge with two 550-foot spans and the remainder of the spans to be no less than 300 feet in length. The stone bluff on the Tennessee side of the river dictated that the bridge be a high structure. The charter, therefore, called for the fixed spans to be at bluff level, 65 feet above the high water mark.[110]

A few months after the charter was granted, consulting engineer Simon Stevens visited George Morison in his New York office in behalf of the two bridge companies. At Stevens' request, Morison prepared preliminary plans and estimates for the proposed structure. Morison's design featured two long spans, supported by abutments at either side of the river and a center double pier. No surveys had been made of the river at the proposed crossing, and Morison prepared the plans from some old maps of the river. When actual surveys were made, however, the width of the river proved to be substantially greater than the maps had indicated, and he scrapped his first design.

Although his initial engineering proved worthless, Morison was intrigued by the possibility bridging the Mississippi at Memphis. No engineer had ever bridged what he termed the "real Mississippi." During the 1880s, the general wisdom in the industry held that bridging the Mississippi as far south as Memphis was a practical impossibility.[111] Morison described this sentiment, saying:

> The construction of a bridge at Memphis has been a matter of professional interest among American engineers for many years. In 1867 the bridge across the Missouri River at Kansas City, the first bridge across that river and the bridge whose construction led to the building of the railroad of whose system the Memphis Bridge now forms a part, was begun. At this time a bridge at Memphis was talked of as one of the works in the future. Like other works which were considered far in the future, the difficulties of the problem were overestimated: the depth of the river was overstated and other conditions were considered much more difficult than they really were. At that time, however, the construction of a bridge at Memphis would have been a matter of great expense, and the changes which finally rendered the building of this bridge a comparatively simple affair represent the advances which bridge engineering has made in twenty years.[112]

In addition to the far greater amount of water which flowed through it, the river here was vastly different in character than in its more northerly reaches. The Mississippi and the Missouri rivers join near Alton, Illinois, and although roughly equal in flow, they differ significantly in character. There the Mississippi changes from a relatively clear, calm watercourse and takes on the characteristics of the muddy Missouri. "Like the Missouri, it is a great silt-bearer. Like the Ohio, it is subject to extreme floods," Morison stated. "As is always the case when magnitude is increased, the changes in channel and the local disturbances are much less rapid than on the Missouri, but they are of the same character, and on a much larger scale. The floods which are most active and dangerous come from the Ohio. The flood season in the Ohio is in winter and early spring; the flood season of the Mississippi and Missouri is in the spring and early summer; the flood season of the two rivers covers about one half of the year, extending from about the first of January into July. The whole working season which can be safely depended upon in the Lower Mississippi covers only about five months of the year."[113]

Morison was anxious to be the first engineer to bridge the lower Mississippi. Having analyzed railroad finances on many occasions as a consultant, however, he was concerned about the bridge companies' ability to undertake the project. The two companies which held the bridge charter were independent of any railroad. Their intention was to build the bridge and charge tolls to any train which crossed. Morison worried about their ability to undertake the extraordinarily expensive project independently, and shortly after he became involved with the project, he contacted George H. Nettleton, president of the Kansas City, Ft. Scott & Memphis System of railroads.

Morison knew Nettleton from earlier work with the railroad, beginning with his own apprenticeship on the Kansas City Bridge. On January 15, 1886, he met with Nettleton at the railroad's headquarters in Kansas City with the proposal that the railroad take an active interest in the construction of the bridge. "It is from this date that the connection of your system with the scheme really began," Morison later reported to the railroad. He left Kansas City that night and arrived at Memphis the following afternoon. "The river was full of ice and it was difficult to go about," he wrote, "but I made a short trip on the transfer-boat Charles Merriam and climbed up the bluff on the Memphis side of the river. On this day I selected the location for the bridge, this location being fixed by the top of a rude staircase on the Memphis side and by a log cabin in the bottom-land on the Arkansas side. I never had occasion to alter this location and the bridge was built upon it."[114]

After choosing the bridge site, Morison waited throughout most of 1886 for either the bridge company or the railroad to act. Late in the year, Nettleton asked him to investigate the site once more and prepare another set of cost estimates for the bridge's construction. On November 23, Morison and his long-time assistant, Edwin Duryea, traveled to Memphis. Morison looked the site over briefly and returned to New York. Duryea remained throughout the winter, making borings of the river bottom. The borings showed a favorable subsoil condition under the river at Morison's chosen location. Here the river was floored across its entire width by a thick layer of hard clay at a depth within the limits to which caissons could be sunk.

With a more definite picture of the river conditions at Memphis, Morison prepared two revised designs. The conservative version featured three equal, simply supported spans of about 660 feet each. The more daring design incorporated a 1,300-foot cantilevered span. The railroad used these designs in its application for another Congressional charter, and soon after Morison submitted his report, a bill was introduced in Congress to grant another charter for a bridge at Memphis. It did not pass. The railroad tried again the following year, and on April 24, 1888, Congress granted permission to erect the bridge, with the stipulation that it also carry highway traffic. The new charter (given in Appendix R) was more stringent than its predecessor, however, with regard to the dimensions of the bridge.[115] The Act fixed the minimum length of the channel span at 700 feet - 150 feet longer than the clear spans specified in the 1885 Act. A more serious difference to Morison lay in the fact that the new charter fixed the height of the bridge at 75 feet above high water, instead of the original 65 feet. Morison was quarantined aboard ship in San Francisco at the time, and his partner Elmer Corthell prepared the documents for the War Department.[116]

The 1888 charter required that three government engineers from the War Department visit the site to determine the bridge location and specify the lengths of the channel spans. The board, consisting of Colonel W.E. Merrill, Major O.H. Ernst and Captain D.C. Kingman convened in Memphis in May 1888. Only recently freed from California, Morison presented the case for the railroad company, while a number of representatives of the steamboat companies voiced objections. Morison was prepared to accept the span lengths given in the charter but argued that the 75-foot height provision would add unnecessary expense to the construction of the bridge, would force the railroad to grade extensive approaches on both sides and would interfere with existing street levels in the city of Memphis. He recounted the original charter and referred to Senate Bill 275, the so-called General Bridge Law introduced in 1887 but never enacted.[117] With no bridges under which to pass, the boats which ran the lower Mississippi did not use hinged smokestacks. In quoting a report of the Board of Engineers commissioned for the bill, Morison argued in favor of the Telegraph-plan smokestacks used on the Ohio River, saying, "the Board recognized the fact that smoke stacks can be so easily lowered that it is unwise to insist on bridges being built so as to give the height necessary for boats to pass without lowering their smoke stacks."[118]

Morison even went so far as to send an agent down the Mississippi from St. Louis to New Orleans to examine and measure every boat then operating on the river. (His inventory of boats is given in Appendix U.) "The pilot houses of the western river boats as now built are surmounted by a wooden ornament of absolutely no use, several feet higher than the flat roof of the pilot house," he stated. "The smoke stacks are also ornamented on top, the ornamentation being often in the form of an open work resembling the feathered head dress of an Indian." Morison concluded his argument, saying, "There are only about six steamboats on the Mississippi River whose pilot houses including ornamentation are more than 60 feet high, and there is not a single boat on which the pilot house without ornamentation is 60 feet high, while there are only six boats in which the height of pilot houses without ornamentation is more than 55 feet."[119]

The board maintained the 75-foot height requirement, despite Morison's well-documented objections. Although the three engineers were unanimous in their recommendations to locate the channel span next to the Tennessee shore, they could not agree on the minimum length for the channel. The two younger officers recommended a 1,000-foot span length, while the senior board member considered 700 feet enough clearance. Secretary of War William Endicott resolved the matter by overruling the board entirely and specifying a 730-foot minimum length. Morison calculated that if the channel span could be increased to a 770-foot length, fenders would not have to be installed to protect the piers from collision by barges, because of the decreased likelihood of collision. With this new requirement, Morison designed the bridge and submitted a revised report to Nettleton in August 1888.[120]

In this final design, Morison followed Endicott's dictates. On August 2, he hand-carried the plans for the bridge to Endicott in Washington. The Secretary approved the plans in a contract with the bridge company, dated August 23,

1888. The charter had required that provisions would be made "for the passage of railway trains, and wagons and vehicles of all kinds, (and) for the transit of animals." At Endicott's insistence, Morison showed a deck for vehicular and pedestrian traffic on the same floor as the railway traffic. If this arrangement proved inadequate, the railway company agreed to operate ferry trains across the river for the benefit of the other bridge users.[121]

Morison's final design for the bridge at Memphis contained both familiar and novel elements. For the substructure, he engineered typically long masonry piers founded on heavy timber caissons. This bridge, unlike his others across the Missouri and Ohio Rivers, would not be founded upon bedrock, however, but on the hard clay that floored the river bottom. Morison realized that the foundations would have to be sunk through the riverbed sand and well into the alluvial clay to develop sufficient bearing capability. Duryea's tests had revealed that this clay was so compact that it would be impractical to dredge using traditional means. He therefore designed the foundations to meet four requirements: The weights of the piers were to be limited as much as possible to reduce their immense dead loads. The pier bases were to be large enough to distribute the bearing pressures over as great as areas as possible. The pier bases would be heavily protected against scouring at the river bottom. Finally, the foundations would be sunk using the plenum caisson process.

To reduce the pier weights, Morison specified an unusually high quality of masonry, reduced their overall dimensions and designed their bottom portions using hollow construction. Although usually considered imprudent in colder climates, this last feature would be acceptable under the relatively warm conditions at Memphis. The general rule he followed in determining the size of the foundations was to build the caissons so that their weight below the river bottom would not exceed that of the sand that they displaced and that, after deducting 400 pounds per square foot for friction along the caisson sides, the weight placed on top of the caissons would not exert more than two tons per square foot of downward pressure. Using this guideline, Morison determined that the caissons would measure 92 feet long and 47 feet wide. He configured them with vertical sides below the bottom of the river. To limit scour, he designed a unique system whereby woven willow mats would be built on the surface of the river and sunk with riprap ballast to carpet the river bottom around the pier bases.[122]

Morison designed a superstructure for the Memphis Bridge unlike any of his others. To achieve the requisite 770-foot clear channel width, he delineated a bridge with a 790-foot cantilevered main span next to the Tennessee shore and two 620-foot spans over the remainder of the channel. Two other bridges in the world - the Forth Bridge at Queensferry, Scotland, then under construction, and the Lansdowne Bridge over the Indus River at Sukkur, India - exceeded the span length of the Memphis Bridge, but they were completely unlike Morison's bridge in design and detailing and did not employ American-type pinned connections.

The bridge that Morison had designed for Memphis would feature the longest span length built to date in America. Still, Morison would have preferred to engineer the bridge with three equal, simply supported spans or with the long span placed in the center.[123] The Secretary of War's stipulations procluded such a solution, however, as the engineer stated in a report to Nettleton:

> The arrangement which would have been most satisfactory to the engineer would have been three equal spans of about 675 feet each. If, however, one span of extra length was required, it would have been preferable to place it at the centre, making this central span a cantilever structure, the cantilevers projecting from the ends of two heavy side spans. The arrangement required by the War Department, however, placed the long span next to the east shore, so that if this span was built as a cantilever span it was necessary to provide an independent anchorage on the Memphis bluff. This course was adopted.[124]

The result was an oddly asymmetrical structure, which would later be criticized for its starkly pragmatic configuration.[125] But even given the severe design constraints and the overwhelming need for economy, Morison managed to rationalize the shape of the bridge in technological terms. By projecting a 170-foot cantilever from Pier I on the Tennessee shore, the distance between the end of this cantilever and Pier IV on the Arkansas shore was divided by the two other piers into three equal 620-foot spans. Morison engineered the central span with continuous chords and 170-foot cantilevers at either end. This left two equal 450-foot spans to complete the bridge, one between two cantilevers and the other between a cantilever and Pier IV. The result was a bridge with a central span 620 feet long, three identical 170-foot cantilevers and two identical 450-foot spans, with an anchorage span between Pier I and the Tennessee abutment.[126]

To simplify fabrication and construction, Morison sought to configure the through trusses with equal panel lengths throughout. This required that the panel lengths be common divisors of the cantilevers, the suspended spans and the central span. No practical increment existed for 170 feet and 450 feet, but by shortening the length of the cantilevers to 169'-4 1/2" and increasing the length of the suspended span to 451'-8", he could use a common panel dimension of 56'-5 1/2". Thus Morison adjusted the shape of the bridge slightly to provide for uniformity, with each cantilever arm divided into three panels, each suspended span into eight and the central span divided into eleven panels, all of equal length. The anchorage span on the east end consisted of four panels and the channel span, fourteen, making a total of 40 equal panels over the river channel. As each truss panel was subdivided into two equal-length floor panels, there were therefore 80 panels in the floor system. The total length of the through superstructure is given in the table on the following page:

Anchorage span	225 ft. 10.0 in.
Channel span	790 ft. 5.0 in.
Central span	621 ft. 0.5 in.
West span	621 ft. 0.5 in.
Deck span	338 ft. 9.0 in.
Total length	2597 ft. 1.0 in. [127]

Morison proportioned the width of the single-track bridge based upon the length of the channel span and the need for economy in the breadth of the masonry piers. "In the matter of transverse stiffness," he stated, "the position of this span corresponds with the separate spans of a common bridge, whereas the longer span by its cantilever construction was held rigidly at the ends." To determine the width for the 620-foot central span at Memphis, Morison looked to the 518.5-foot channel spans of the Cairo Bridge, which were 25 feet wide. He established the width for this bridge empirically at 30 feet.[128]

Morison established the trusses' depth similarly, with economy of fabrication and erection as overriding considerations. The difficulties of erection made it important to keep the truss dimensions within limits of ordinary falsework. And to keep live load vibrations to a minimum, he restricted the depth to no more than 2-1/2 times the width of the bridge. "By fixing the depth of both the central and the suspended spans at one eighth of the span and making all three of the cantilevers alike," Morison reasoned, "the depth of the structure over each of the piers and for the whole length of the central span became 77 ft. 7-13/16 in., and the depth of the suspended spans, 56 ft. 5-1/4 in. These dimensions were adopted."[129] Because the depth of the cantilevers over the piers corresponded to the depth of the central span, the upper chords were not parallel with the lower. To maintain uniform floor panel lengths, Morison found it necessary to keep the points of intersection of the web members over the panel centers, which created irregular upper panel chord lengths. But with eyebar upper chords, this would not present serious fabrication difficulties.

For the truss design, Morison chose what he termed a double triangular or double Warren girder. He intended to erect the channel span without falsework, cantilevering from each end. In addition to the elimination of dangerous and expensive falsework, the cantilever construction made it possible to bear the weight of the spans on each side of each pier to a single large bearing shoe and transfer this weight directly to a single point at the center of the pier. This allowed the engineer to use somewhat lighter and thinner piers than would have been possible with simply supported trusses, which require individual bearing points. The increased cost of the superstructure design over three equal separate spans was thus balanced to a degree by the decreased substructural costs.[130]

The only truly continuous span on the Memphis Bridge was to be the central one, and Morison allowed for expansion and contraction at one end of this. All other expansion was taken up by pinned sliding joints at the ends of the cantilevers. With two such joints in the channel span and only one in the west span, he had a double chance to take up expansion in the chords and floor system of the channel span. For this reason, Morison fixed the west end of the central span and placed the east end on expansion rollers.

At the west end of the through channel truss, Morison engineered a long-span deck truss to reach over the flood plain on the Arkansas shore. Spanning 338'9", this truss used a Warren, or as Morison termed it a single triangular, configuration, which was subdivided into six panel points with the floor supported at the half panel points by columns. The length of the floor panels of the deck truss equaled that used for the through spans, and the actual weight of the truss, including the floor system, was 3600 pounds per lineal foot. On its west end the truss was supported conventionally with the lower chord bearing shoe resting atop a double-cylinder pier. On its east end, the truss corner points rested in two niches in the stone pier which also held the easternmost through span. This asymmetrical bearing condition prompted Morison to design the truss using a peculiarly asymmetrical web profile, with the end posts on the east end shortened and the lower chord at the end panel point angled upward somewhat.

West beyond the deck truss, Morison delineated an extensive iron viaduct with a total length of 2290 feet. His design for the viaduct featured a standard series of plate girders, supported by iron towers. The spans over the towers measured 29 ft. 6 in. and the spans between the towers were twice this length at 59 feet. Each pier rested on concrete foundations, with driven piles beneath.[131]

The total superstructural weight of the bridge proper, excluding the approach viaduct, exceeded 16 million tons - more than any previous Morison bridge, except the two-mile-long Cairo Bridge. Truss weights are given by span in the following table:

East approach	66,812	pounds
Anchorage span	1,606,727	
Cantilever Pier I	1,252,365	
East intermediate span	2,329,759	
Cantilever Pier II	1,284,674	
Central span	5,122,252	
Cantilever Pier III	1,260,452	
West intermediate span	2,327,845	
Deck span	1,072,951	
Total weight	16,323,837	pounds [132]

With such numbers, dead weight was a critical factor in the bridge design, particularly for the long continuous spans. To decrease the weight while maintaining sufficient structural strength, Morison specified that all the trusses were to be composed entirely of steel, produced either by the Bessemer of open-hearth process. "As the sections of the superstructure were necessarily unusually heavy, and the strains from the dead load were greatly in excess of those from moving load," he stated, "it was thought best to use a slightly higher steel than is now generally used for lighter structures, and to work this steel without punching, all holes being drilled."[133] The specified strengths for the steel are given in the following table:

	high-grade steel	medium steel	soft steel
Maximum ultimate strength	78,500 psi	72,500 psi	63,000 psi
Minimum ultimate strength	69,000 psi	64,000 psi	55,000 psi
Minimum elastic limit	40,000 psi	37,000 psi	30,000 psi
Minimum % of enlongation in 8"	18%	22%	28%
Minimum % of reduction at fracture	38%	44%	50% [134]

Additionally, a sample bar from each melt was to be bent 18 degrees without showing any cracks or flaws on the outside of the bend portion.

The problem of securing a sufficient quantity of steel to meet his stringent specifications - which by then had been adopted more-or-less as the industry standard - again plagued Morison as it had on virtually all of his previous major bridges.[135] The problem was only exacerbated on the Memphis Bridge, because of the extremely long spans and the cantilevered construction required an extraordinarily heavy superstructure. Morison called for strength testing on 3/4" round sample bars produced from the melts. But even after reducing the strength requirements, the engineer still could not coax an adequate performance from the Bessemer material. "So much difficulty was experienced in getting a satisfactory Bessemer steel," he said, "and the requirements for the preliminary test on the round bar were so much reduced as to amount to little, that all steel was required to be made by the open-hearth process."[136] This revision was incorporated in a new set of steel specifications, issued in May 1890.

Under these new specifications, the strength of the steel for the eyebars was reduced for the sake of expediency. The new requirements are given in the following table:

	eyebar steel
Maximum ultimate strength	75,000 psi
Minimum ultimate strength	66,000 psi
Minimum elastic limit	38,000 psi
Minimum % of enlongation	20%
Minimum % of reduction at fracture	40% [137]

While the railroad company was making the financial arrangements for the bridge construction, Morison convinced Nettleton to construct the foundation for Pier IV during the low-water season of 1888, "believing that the information to be obtained by sinking this pier might be of great assistance in preparing the plans for the other piers."[138] Nettleton agreed, and on October 7, actual construction of the bridge commenced as carpenters began framing the caisson for the pier. To supervise the construction of the great bridge, Morison appointed Alfred Noble as resident engineer. Noble arrived on the site on October 1. Meanwhile, the steamers John Bertram - veteran from the Rulo and Nebraska City Bridge projects - and the John F. Lincoln from the Sioux City Bridge were bought and piloted to Memphis. The two boats were used to hold compressors and equipment and to maneuver the nine coal barges used on the project.[139]

For the construction of this bridge, Morison again assembled an experienced group of assistants and contractors. Noble, who had been with Morison since the Omaha Bridge, would act as resident engineer, dividing his time for the first year equally between the Memphis and Cairo bridges. M.A. Waldo, Assistant Engineer; E.H. Connor and W.S. McDonald, the Inspectors of the Superstructure; Emil Gerber, Office Engineer; and Irving Dickinson, Draftsman, had all served with Morison on previous bridge projects. Ralph Modjeski, who like Alfred Nobel had first signed on in 1885 during construction of the Omaha Bridge, functioned first as Chief Draftsman and later as the Chief Inspector of the Superstructure. Memphis would mark his last bridge project with his mentor. Morison hired his contractors and fabricators one-by-one, but the assembled group was a familiar one. Lewis Loss, veteran of the Cairo and Alton bridges, would build the masonry piers. The Union Bridge Company - with the help of several subcontractors - would fabricate the superstructure, and the Baird Brothers, erectors on almost all of Morison's major bridges, would erect the trusses. One newcomer to the project was the Pennsylvania Steel Company, contracted in March 1891 to manufacture the west approach viaduct. (A complete list of engineers, employees and contractors is given in Appendix V.)[140]

The work on Pier IV continued throughout the fall and winter of 1888. The foundation was completed in February 1889. By this time, Morison had completed the design of the large caissons for Piers II and III. He pushed the work on these two channel piers during the low-water season of 1889-90, employing up to 160 men to work in three eight-hour shifts, with the thought of completing the bridge by 1891.[141] "But the season was too short, and the foundation of Pier II had to be abandoned before it was completed," he stated. "No harm was done, but two seasons instead of one were required for the foundation work."[142] To develop sufficient bearing capacity, Morison called for unusually great caisson depths on the channel piers. The deepest foundations - under Piers II and III - extended almost 131 feet below the high water level. With a maximum immersion depth of 108 feet during construction, these piers ranked second only to the Eads Bridge (109.7 feet) as the greatest depth to which the pneumatic process had ever been taken.[143]

At these extreme depths, caisson fever once more plagued the men working so far under the river. The air pressure in the poorly lit, poorly ventilated chambers reached up to 47 pounds per square inch, and to lessen the risk, the men worked three 45-minute shifts during each 24-hour period. Still, four of them died and many others were crippled from the bends.[144] The pier construction was further marred by tragedy, when early on the morning of February 10 a towboat pulling a load of grain barges rammed one of the partially completed, submerged piers. The boat was ripped to pieces, the barges scattered over the river and six crewmen died.[145] Because the accident did not damage the bridge or delay construction significantly, Morison noted it only briefly in a later report to the railroad.

On April 3, 1889, a contract was executed with Lewis M. Loss of Rochester, New York, to build the slender masonry piers. Loss completed the last of the stonework for Pier II on April 25, 1891, almost 2-1/2 years after beginning construction of the first caisson. "During the entire work very little trouble was experienced from bad weather or high water," Morison stated flatly, "and with the exception of a few unimportant delays work was carried on continuously from the beginning."[146] On January 24, 1890, Morison awarded the contract for the fabrication of the superstructure to the Union Bridge Company, and that May he contracted with the Baird brothers to erect the cantilevered truss.

The masonry piers for the bridge were typically massive and tall. The 75-foot requirement of the War Department meant that the Memphis Bridge was some 25 feet taller than Morison's Missouri River structures. Although the superstructural design allowed Morison to reduced their mass somewhat, the four huge channel piers for Memphis nevertheless consumed a prodigious amount of material. Pier II, which stretched 193 feet from caisson floor to starling course and was the heaviest support, weighed over 37 million pounds.[147] Materials used in the piers are given in the following table:

Pier	Timber (m.b.f.)	Iron (lbs.)	Concrete (cu.yds.)	Limestone (cu.yds.)	Granite (cu.yds.)
I	336,768	187,206	3,079	1,292	1,403
II	1,560,492	450,187	3,379	2,459	1,738
III	1,085,496	366,967	2,379	2,868	2,002
IV	266,472	145,147	2,065	1,157	1,604
Total	3,249,228	1,149,507	10,902	7,776	6,747 [148]

Throughout 1889 and 1890, work was pushed in the great northeastern bridge fabricating plants to produce the components for the superstructure. All the steel for the bridge was poured by Carnegie, Phipps and Company (later the Carnegie Steel Company). From there the uncut structural sections were shipped by rail to the fabricating plant for cutting, punching, riveting and assembly.

Morison had contracted exclusively with the Union Bridge Company for the steel fabrication of the Memphis Bridge. That the project was more than a single mill could handle soon became apparent, as Union fell behind on the fabrication schedule. This was exacerbated by Morison's repeated rejections of the Bessemer steel during the early months of production. Although Union actually produced the majority of the material at its Athens, Pennsylvania, shops, almost 36% of the steel was produced elsewhere. This was procurred either by subcontractors with Union or by orders which Morison made directly. The largest supplementary steel contract was placed with A.P. Roberts and Company. To speed production, Morison convinced Union to relinquish parts of its original contract to Roberts for the deck span and one of the intermediate spans, excluding eyebars. Additionally, several other shops ultimately became involved with the fabrication of the immense bridge. The weights and percentages of steel produced by the different mills are given in the following table (components produced are given in parentheses):

	pounds	percentage
Union Bridge Company (majority of bridge parts)	10,432,020	63.90%
A.P. Roberts & Company (deck span; intermediate through span)	3,113,250	19.07%
Elmira Bridge Works (web members of central and intermediate spans)	1,127,574	6.94%
Lassig Bridge & Iron Works (web members; four vertical posts and central span portals)	806,617	4.94%
Scaife Foundry & Machine Co. (large castings on the piers)	423,963	2.59%
Keystone Bridge Company (anchor rods for anchorage pier; eyebars; bearing plates for Pier II)	310,585	1.90%
Pittsburg Steel Casting Co. (steel castings for Piers II, III and IV)	61,935	0.37%
New Jersey Steel & Iron Co. (expansion rollers)	40,712	0.25%
Pittsburg Bridge Company (miscellaneous)	7,171	0.04%
Total	16,323,837 pounds	

[149]

All of the bridge except the suspended span between the cantilevers of the channel span was erected on falsework. The suspended span was projected from the ends of the cantilevers, connected at the center and then swung free. Because of the extreme height of the bridge above the river bottom, it was impossible to drive single-pile falseworks under the trusses. Instead, the Baird Brothers erected three-story timber bents under the panel points of the trusses. Each bent rested on each side, to carry the four lines of travelor tracks. The traveler itself was a timber structure almost 100 feet tall and long enough to span three floor panels of the bridge.[150]

Erection began on the east shore anchorage span at the end of March 1891. The Baird's crew laid the first lower chord sections for this truss on April 3, completing it three days later. At the same time, the pile driving crew was placing the falsework under the east cantilever arm, which was then completed on June 20. The driving of the falsework for the central span was begun in July, with the steelwork completed two months later. The west cantilever was completed in late November, the suspended span to Pier IV a month later.[151]

The Baird Brothers commenced the erection of the last suspended span - the only part of the Memphis Bridge built without falsework - on February 9, 1892. To aid with the construction, the men built another traveler. Simpler than the device used for the other spans, the traveler consisted of a platform which rested on the top chords of the truss. It carried two derricks guyed to a stiff timber frame, which had been placed at the end of the west cantilever. The material for this last span was floated by barge beneath the span opening and hoisted into place by the traveler's boom. The opening between the cantilever arms on both sides was carefully triangulated and measured with a steel wire. Computations were then made showing the change in length of the members of the central span, the anchorage span and the cantilever arms resulting from the building out of the half spans of the intermediate span.[152]

The weight of the suspended span was so great that Morison hesitated to use standard adjustable wedges at the connections between the cantilever arms and he suspended span. With the wedges, oblong holes each carrying two pins could be placcs at the sliding joints and by placing wedges between these pins the position oft he projecting span could be raised or lowered or the span could have been moved forward or backward to fit the suspended span properly. Instead, he decided to erect the west end without adjustment and the east end with a hydraulic adjustment, making the bottom chord connection between the two ends with eyebars, which, acting as a toggle joint, could take up variations in length.[153]

In calculating the final position of the half span, Morison assumed that the erecting outfit of travelor, engines, lines and scaffolds would remain on it until the span was swung. "This was an error," he later admitted, "the unusual weight of the span insured much difficulty in swinging, and it should have been assumed in the first place that all appliances not absolutely necessary in swinging the span would be removed as soon as the half spans were built out."[154] Morison's miscalculation meant that the half spans were some five inches above their intended height, which added to the already difficult task of swinging and connecting the suspended truss. To further complicate the erection, the removal of all the equipment reduced the strains in the trusses, causing the free end of the upper chord to move about an inch out of line. This was balanced, however, because the time to erect the span was greater than the engineer had accounted for, pushing the connection at the center later in the season when the temperatures were higher.

The crew completed the erection of the east half of the suspended span on April 8. The west half had already been completed, and it remained to join and adjust the two halves to complete the bridge. To supply the place of the end adjustments ordinarily provided for swinging the span, Morison decided to depend mainly on expansion by temperature to extend the upper chord and on toggle joints to shorten the lower chord, so that the adjustment pins could be withdrawn. For one full truss panel of the lower chord, he substituted two lengths of eyebars for the normal chord members. These he had connected to the adjacent chords with temporary pins and to each other by short coupling bars. A short vertical rod with a nut at the lower end and an eye at the upper end passed between each pair of coupling bars and through a washer, which bore on the lower edge of the coupling bars. This formed the toggle joint. After completion of the east end, the men removed the travelor and all other unneeded equipment from the span and erected a derrick on the end of each arm to handle the closing sections. With the arm ends higher than anticipated by the removal of the weight, the crew was forced to wait for cooler weather to couple the two suspended halves. On the morning of April 10, the temperature had cooled sufficiently to allow the connection, and the crew inserted the last pins with an opening of only 1/16" more than required.[155]

The cool weather aided the connection, but hindered the final swinging of the span. Workers removed the derricks and installed two pairs of heavy triple blocks rove with 2-inch manilla rope to hold the spans, "but the weather became cold when heat was wanted," Morison lamented. The men loaded the cantilever arms between Piers I and II with timber rails, locomotives and machinery to shorten the upper chords. A 97 temperature was necessary, however, to release the adjustment pins in the upper chord. Finally, after waiting several days in vain for the weather to improve, Noble began heating the upper chord with steam from the locomotives while adjusting the ropes and the toggle rods to apply a sufficiently heavy strain to the upper chord eyebars. As the temperature reached its high that afternoon, the immense truss remained in place but the masonry piers on either end began to push outward. "The motion of the piers worked against the shortening of the top chord by compression," Morison stated, "and this attempt to swing the span failed."[156]

During the next two days, the workers installed additional rods to the toggle joints, attached steam pipes to the adjustment points and installed more clamps and blocks to budge the truss into position. On the morning of April 22, they again began lifting the toggle joints to adjust the upper chords. With 24 toggle rods, it took several hours to turn their nuts, but the joint was finally raised almost four feet above the line of the lower chord. Late that afternoon, they connected the steam pipes to the locomotives, tightened the clamps, and within an hour the adjustment pins at the west end of the upper chords became loose enough to remove. The Baird crew loosened the adjustment wedges, releasing the upper chord at both ends, and the job of swinging the span was almost complete when approaching darkness halted the work. The following day they completed the continuous superstructure for the Memphis Bridge. The railroad crew installed the floor system while the steelworkers completed the last of the field riveting.[157]

By May 12, 1892, the structure was ready for its formal testing and opening. Given the importance attached to the bridge by the city of Memphis, the opening ceremonies were fittingly grand. Called by the local newspaper "the event most auspicious to the people of Memphis in the history of this city since the first lone wanderer found resting place on the banks of the Mississippi in the long ago", the celebration had been planned well in advance and drew tens of thousands of spectators.[158]

The celebration opened at noon with the crossing of the first train, a string of 18 locomotives, each newly painted and polished and heavily decorated with flags, flowers and bunting. (The engine covered with birds and cranes won the prize for best ornamentation.) Engineer William Haggerty piloted the lead engine as the train crossed slowly from the Arkansas side into Memphis to test the flag-draped bridge under load. As the train labored over each span of the bridge under the inspection of observors placed on each pier, steam whistles throughout town and on the riverboats crowded around the bridge screamed, cannons boomed and the throng of 50,000 people lining the riverbank cheered wildly. Haggerty then turned the train around in Arkansas and roared back across the bridge into Arkansas at full steam. Then Tennessee Governor John P. Buchannon and his entourage met Arkansas Governor J.P. Eagle and his midway on the bridge, the two men shook hands and exchanged congratulations to themselves and to the railroad. The two governors were followed by a similar meeting on the bridge between George Nettleton and George Morison, who also exchanged pleasantries and adressed the crowd "to the great edification and delight of those who heard." according to the Memphis Appeal-Avalanche.[159] Morison briefly and rather dryly recounted the history of the railroad and the bridge project, concluding by turning the bridge over ceremoniously to Nettleton. Nettleton replied, saying:

> Mr. Morison, for a little more than four years your time and talents have been engaged in planning and building this noble structure which I now, as the president of the Kansas City & Memphis Railway and Bridge Company, receive from your hands. The work is a triumph of engineering skill and will rank high in the list of the great bridges of modern times. It is my duty - a pleasant and grateful duty - to congratulate you upon its successful completion. It will stand long after the generation which witnessed its erection has passed away, a monument to your genius in designing and skill and ability of your assistants, Mr. Alfred Noble, Mr. M.A. Waldo and Mr. Ralph Modjeski, who thoroughly understood your plans and, overcoming all difficulties, successfully executed them.[160]

Morison's meeting with Nettleton was followed by more speechmaking from assorted dignitaries at a nearby grandstand built for the occasion, and the festivities lasted throughout the night and into the next day. After the crowds had dispersed two days later, the Memphis Bridge attracted additional attention from the city as a man attempted suicide by jumping from it.[161]

Construction on the highway deck and the viaduct continued throughout 1892, and Morison finally turned the bridge officially over to the railroad almost a year later, on May 1, 1893. As predicted, the cost of the bridge was staggering: slightly less that $3 million. This is itemized in the following table:

Substructure		$968,987.55	
Superstructure		979,991.04	
(steel work:	739,532.77)		
(erection:	211,746.86)		
(painting:	8,692.60)		
(flooring:	20,018.81)		
Total bridge proper			$1,948,978.59
Approaches		289,751.38	
Permanent track		38,895.33	
Shore protection		93,683.44	
Tools, service tracks, etc.		43,533.59	
Engineering		128,523.12	
Real estate		218,369.94	
Sidings, switches, etc.		7,425.47	
Interest during construction		206,409.86	
General expense		23,573.33	
Total cost of project			$2,998,144.05 [162]

Completion of the Memphis Bridge marked the climax of George Morison's bridge engineering career. Considered by his peers as his greatest accomplishment, it marked the first time the Mississippi river had been crossed this far south. Although Morison would design other bridges, none could match this structure for technology and sheer size.

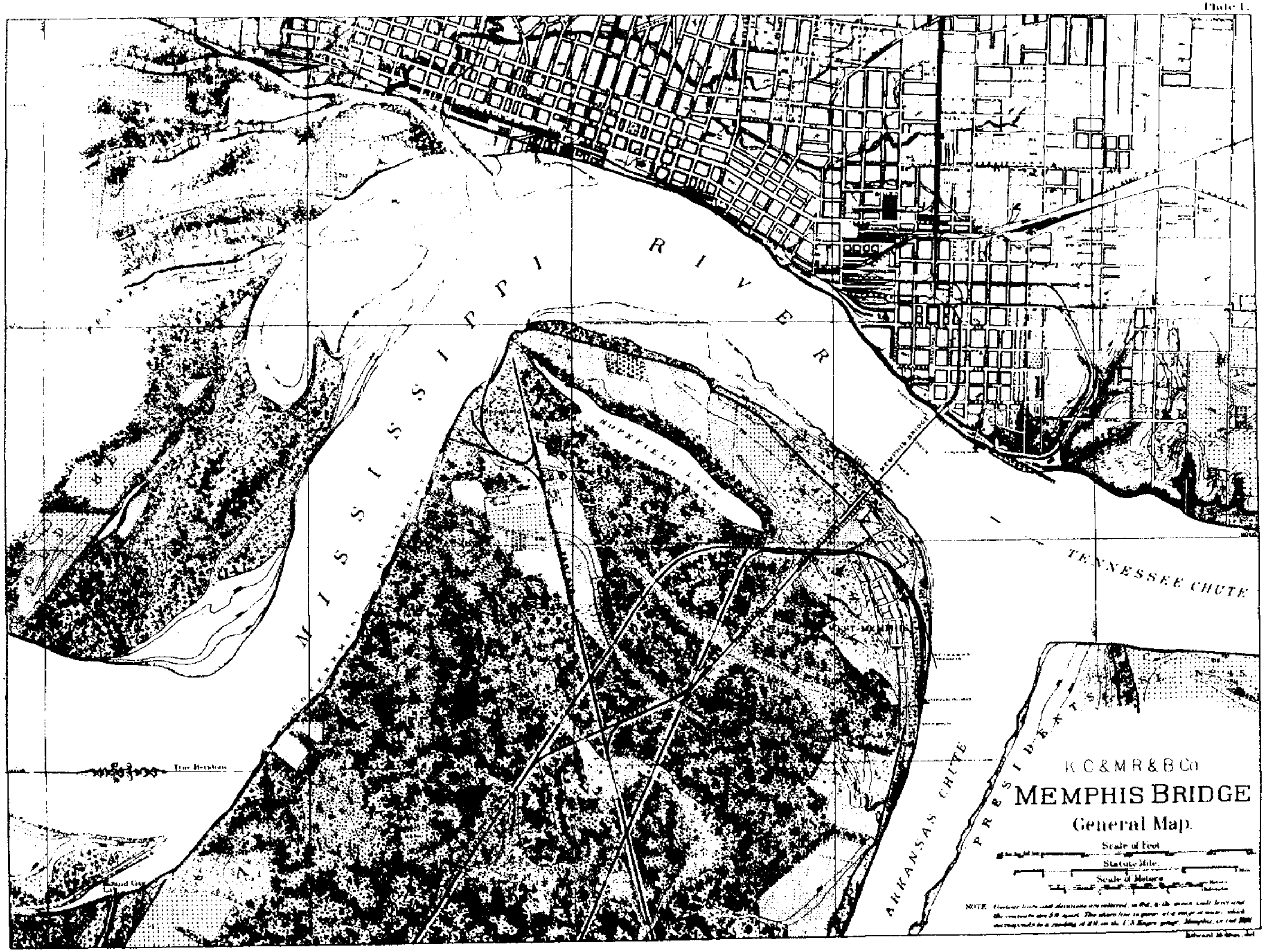


Plate I.
MISSISSIPPI RIVER
HOPEFIELD LAKE
MEMPHIS BRIDGE
TENNESSEE CHUTE
ARKANSAS CHUTE
True Meridian
K C & M R & B Co
MEMPHIS BRIDGE
General Map.
Scale of Feet
Statute Mile
Scale of Meters

Figure 137

Nebraska City Bridge
HAER No. NE-2
(Page 332)

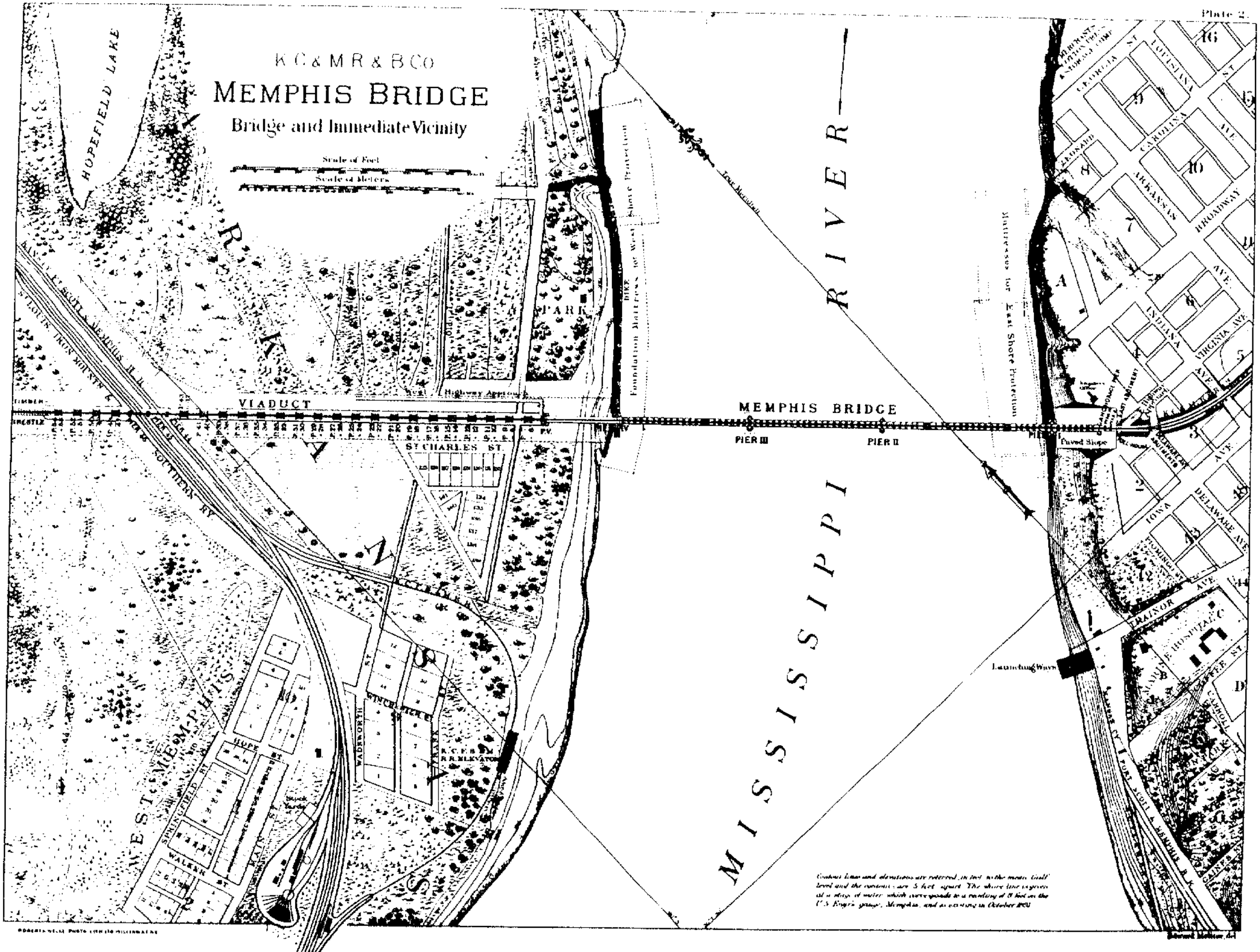
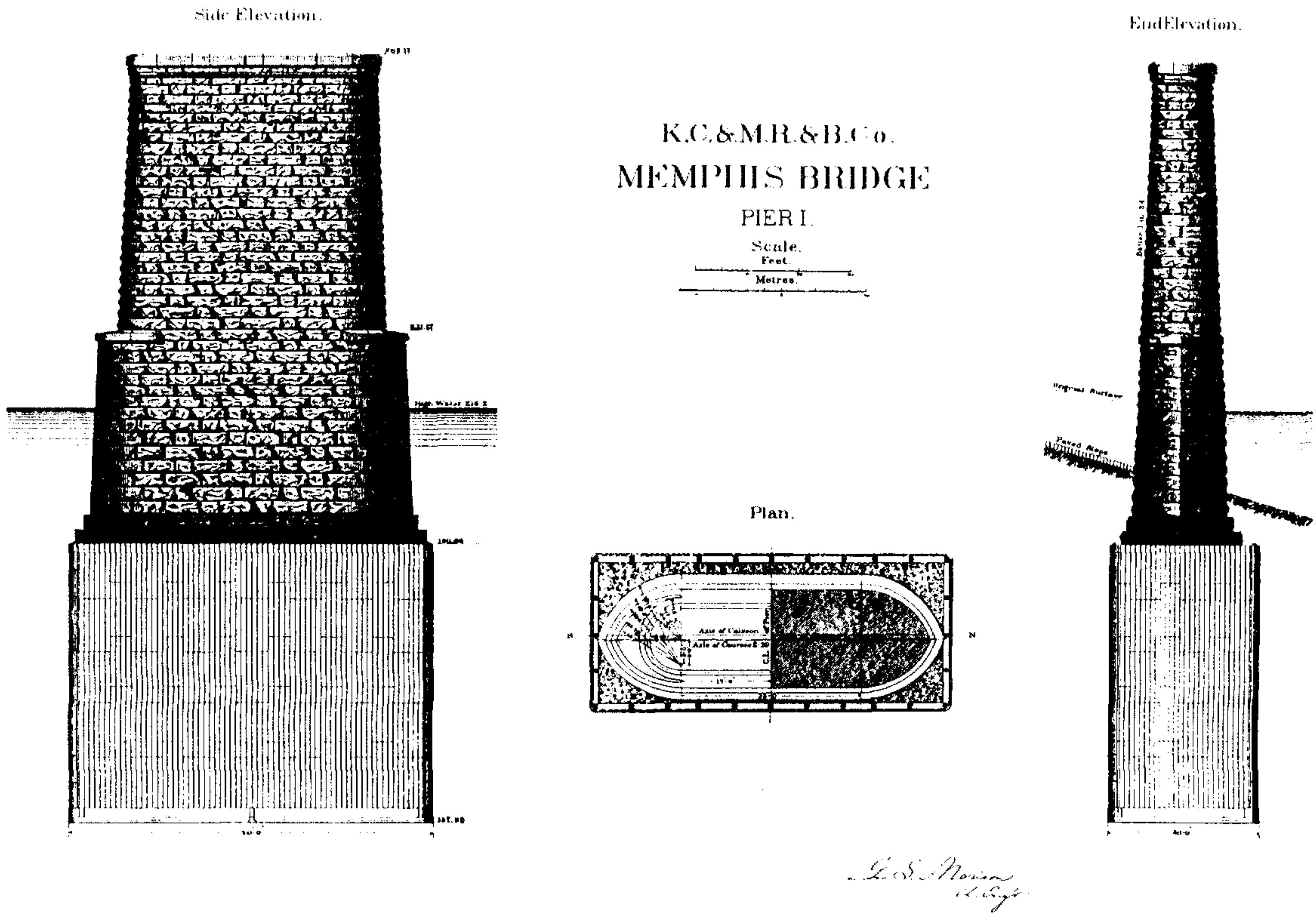


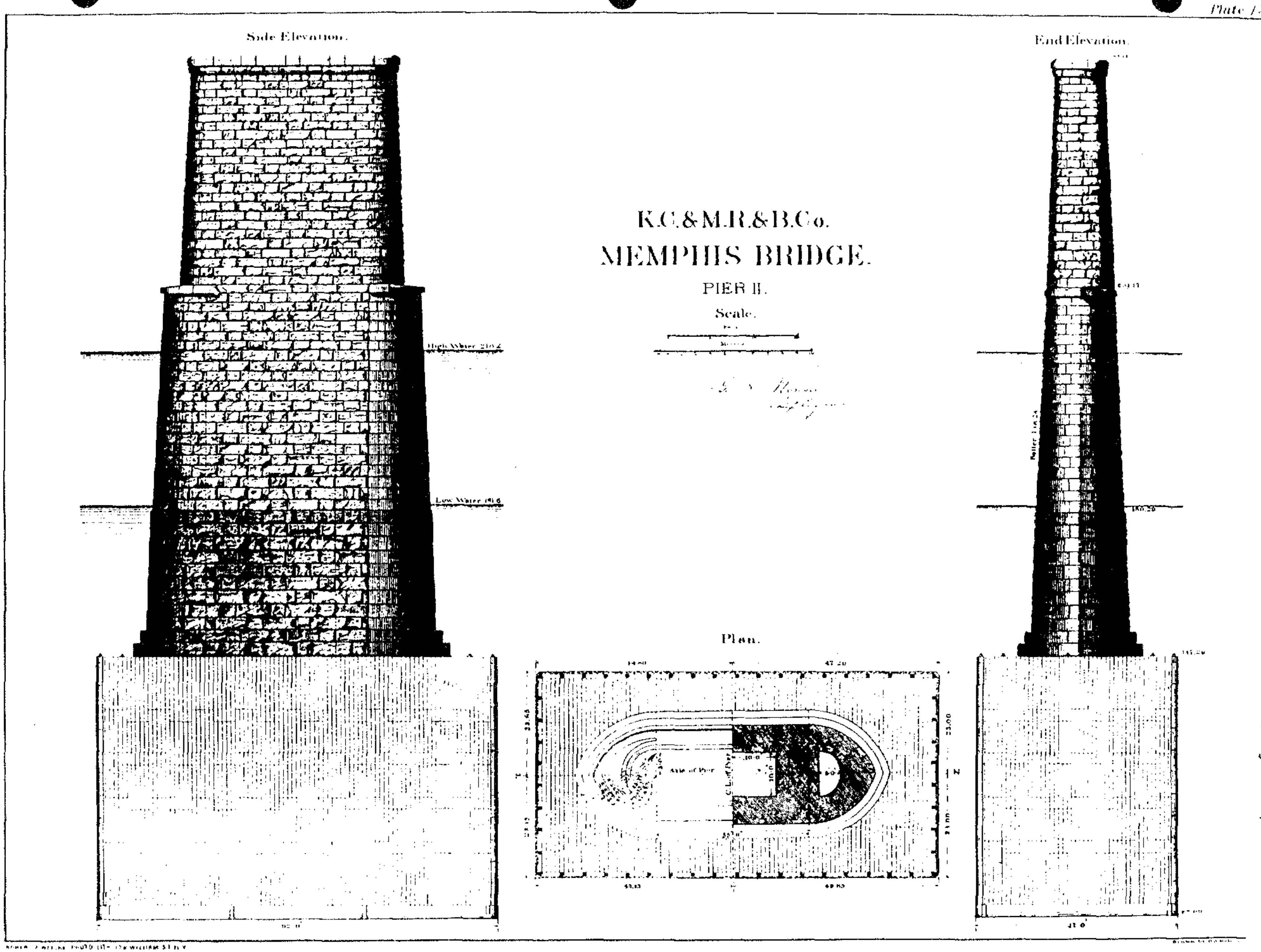
Figure 138

Figure 139



Nebraska City Bridge
HAER No. NE-2
(Page 333)

Figure 140



Nebraska City Bridge
HAER No. NE-2
(Page 334)

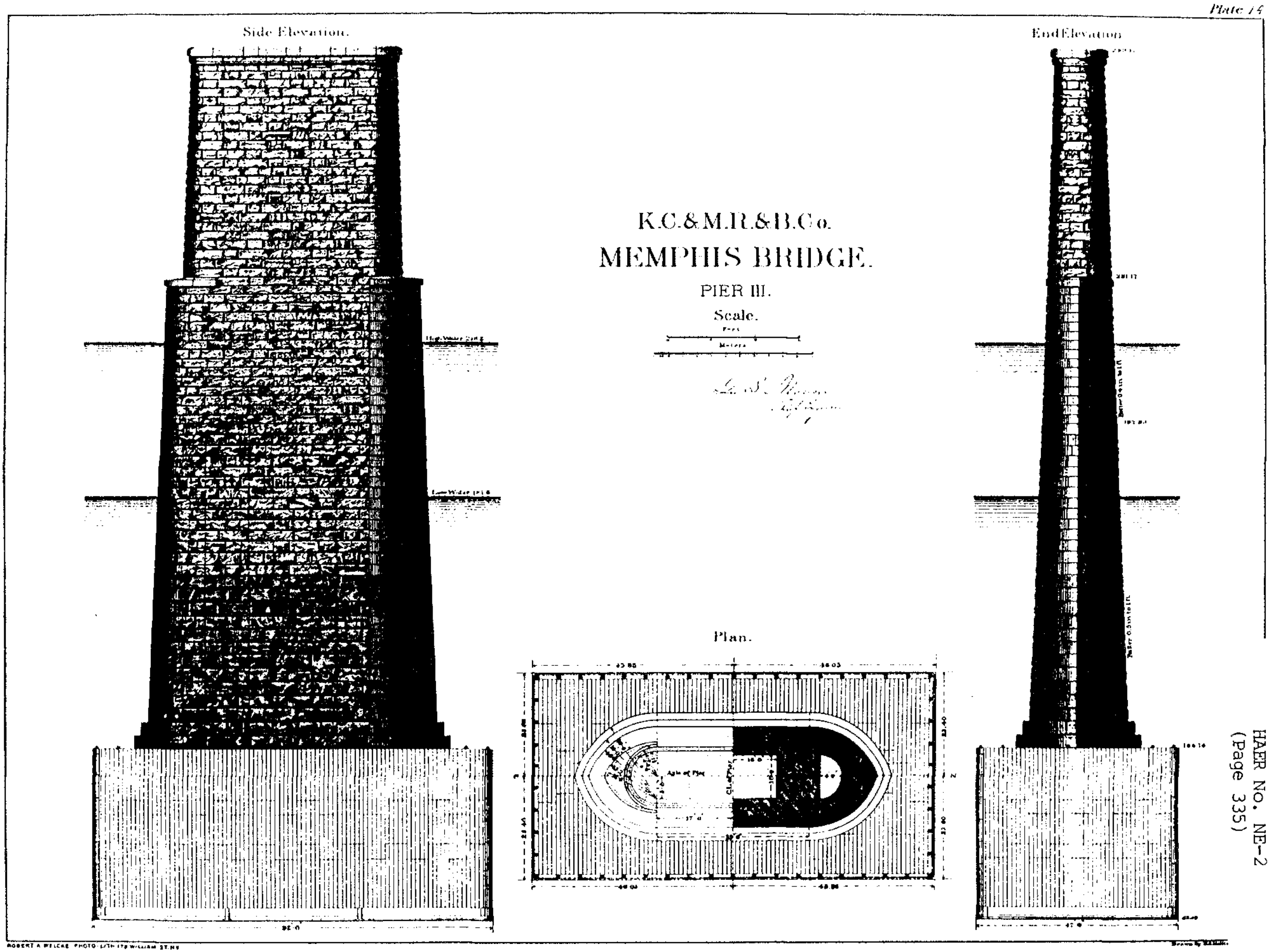


Figure 141

Nebraska City Bridge
HAER No. NE-2
(Page 335)

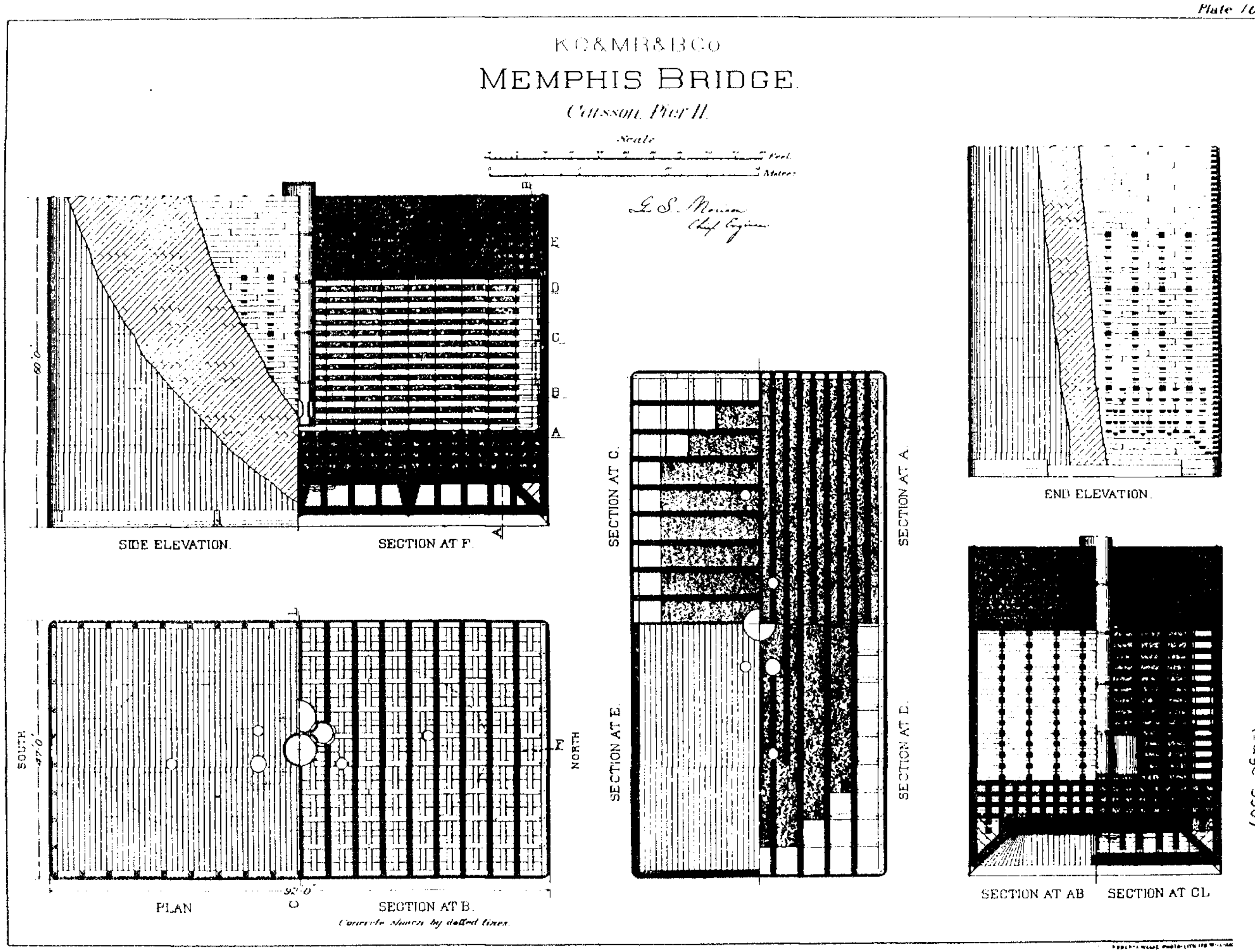
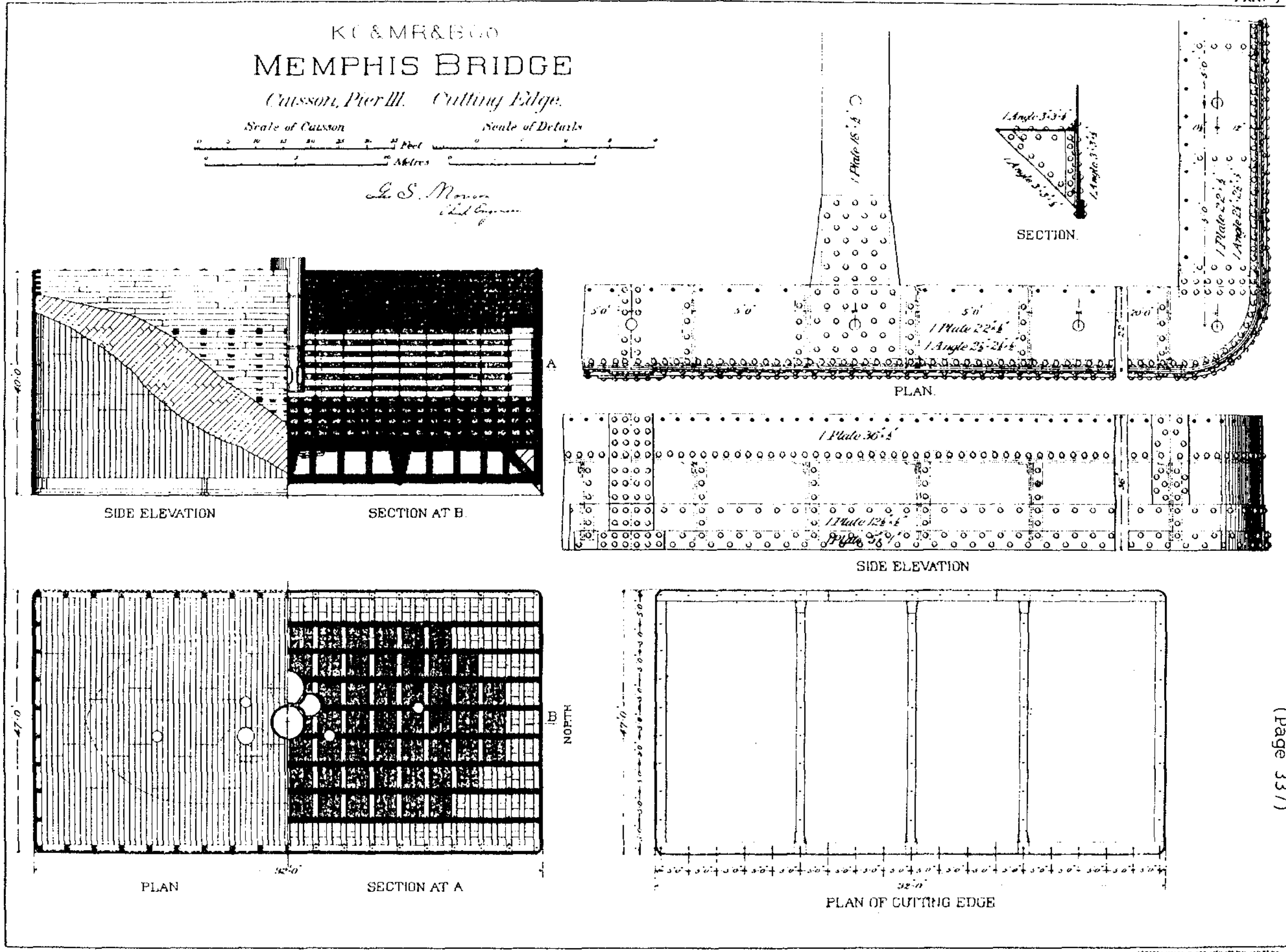


Figure 142

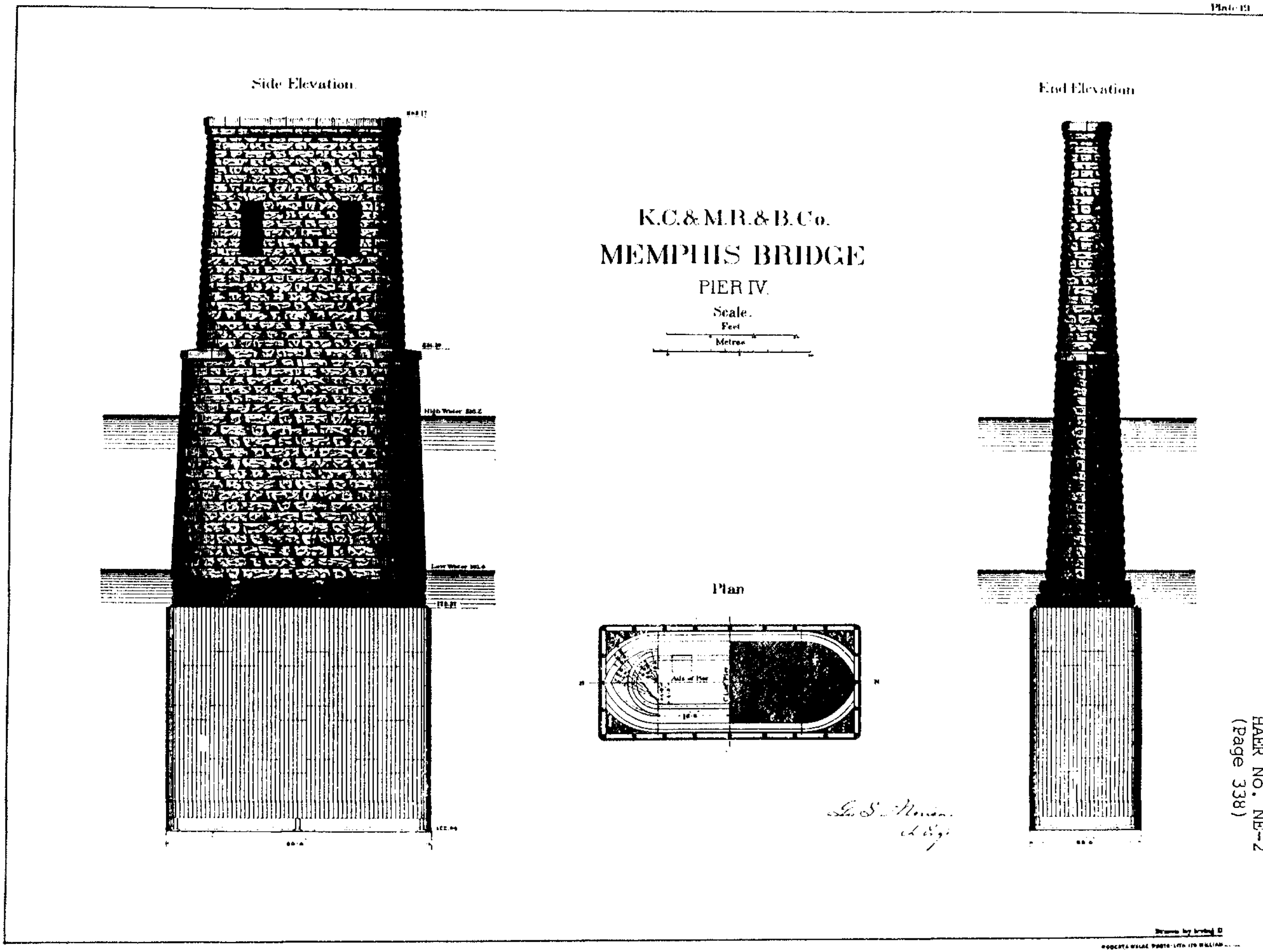
Nebraska City Bridge
HAER No. NE-2
(Page 336)

Figure 143



Nebraska City Bridge
HAER No. NE-2
(Page 337)

Figure 144



Nebraska City Bridge
HAER No. NE-2
(Page 338)

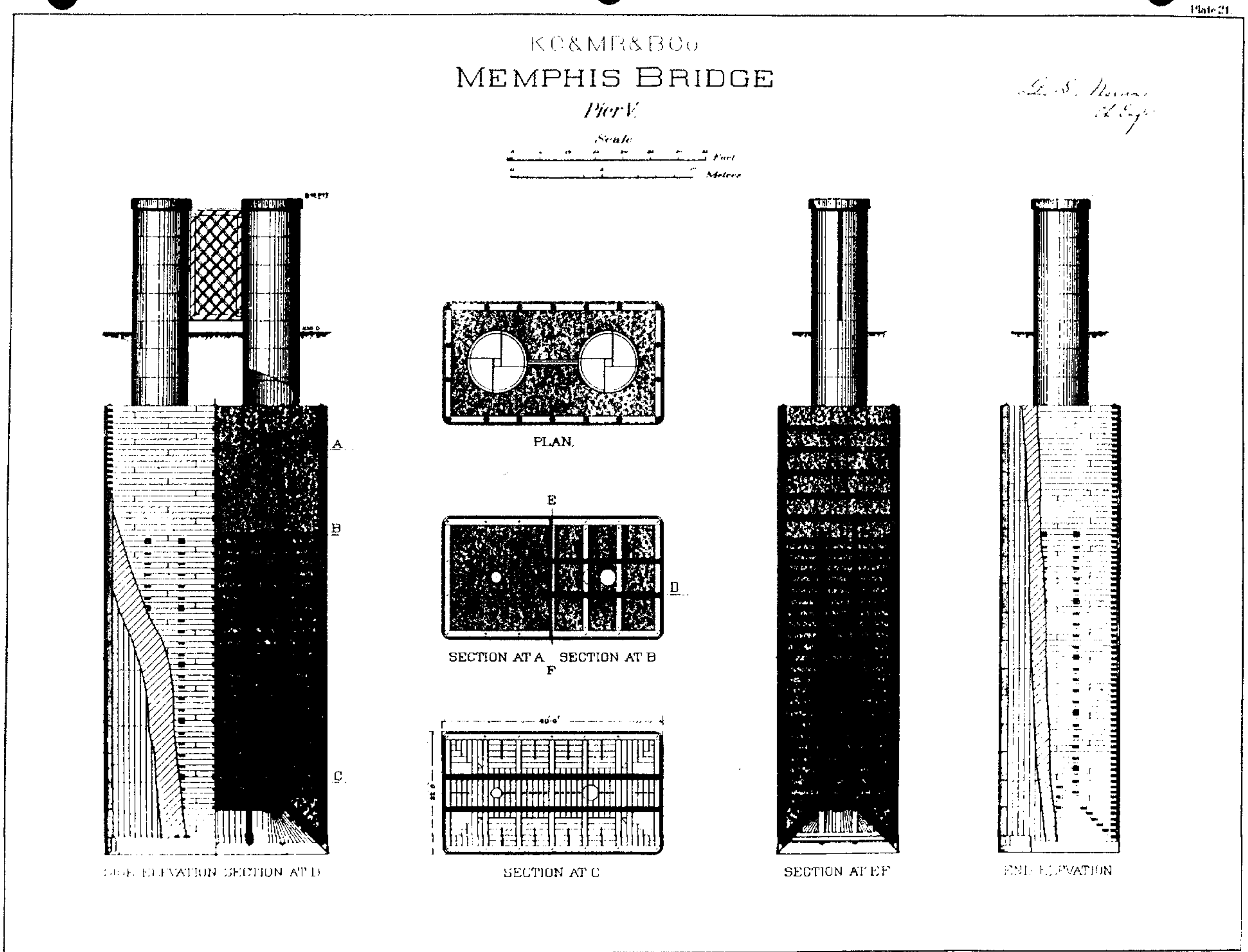


Figure 145

Nebraska City Bridge
HAER No. NE-2
(Page 339)

Plate 26

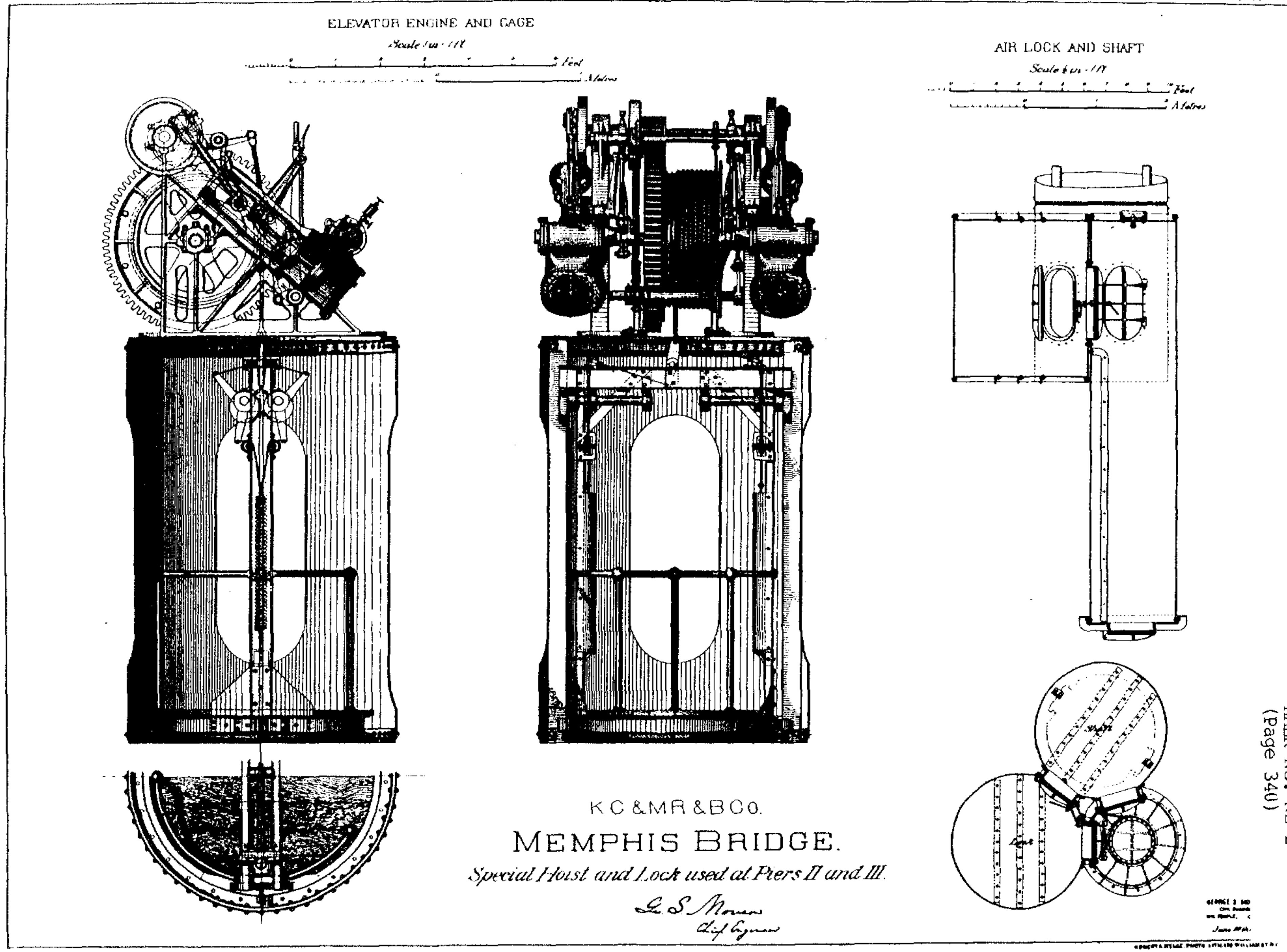


Figure 146

Nebraska City Bridge
HAER No. NE-2
(Page 340)

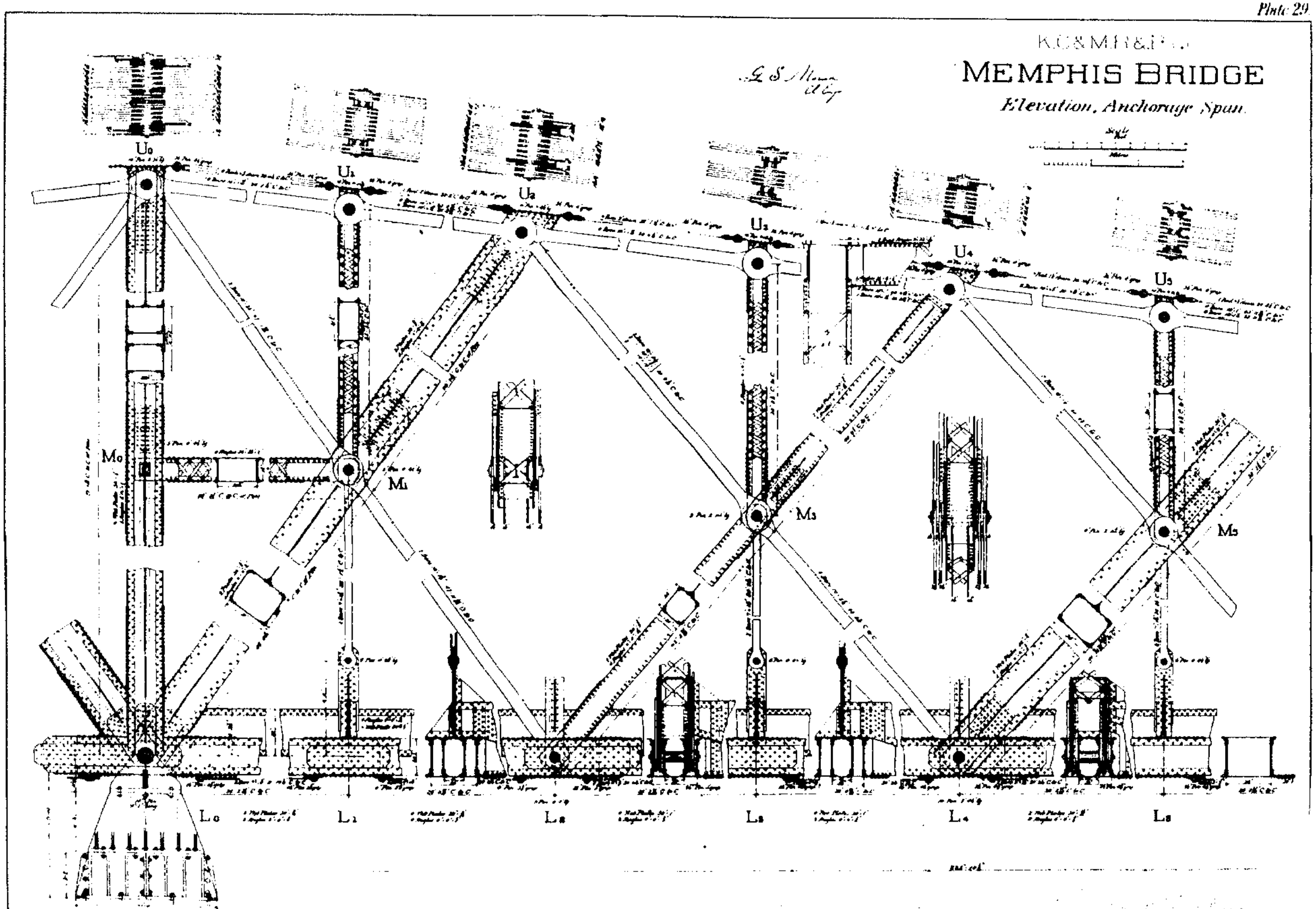
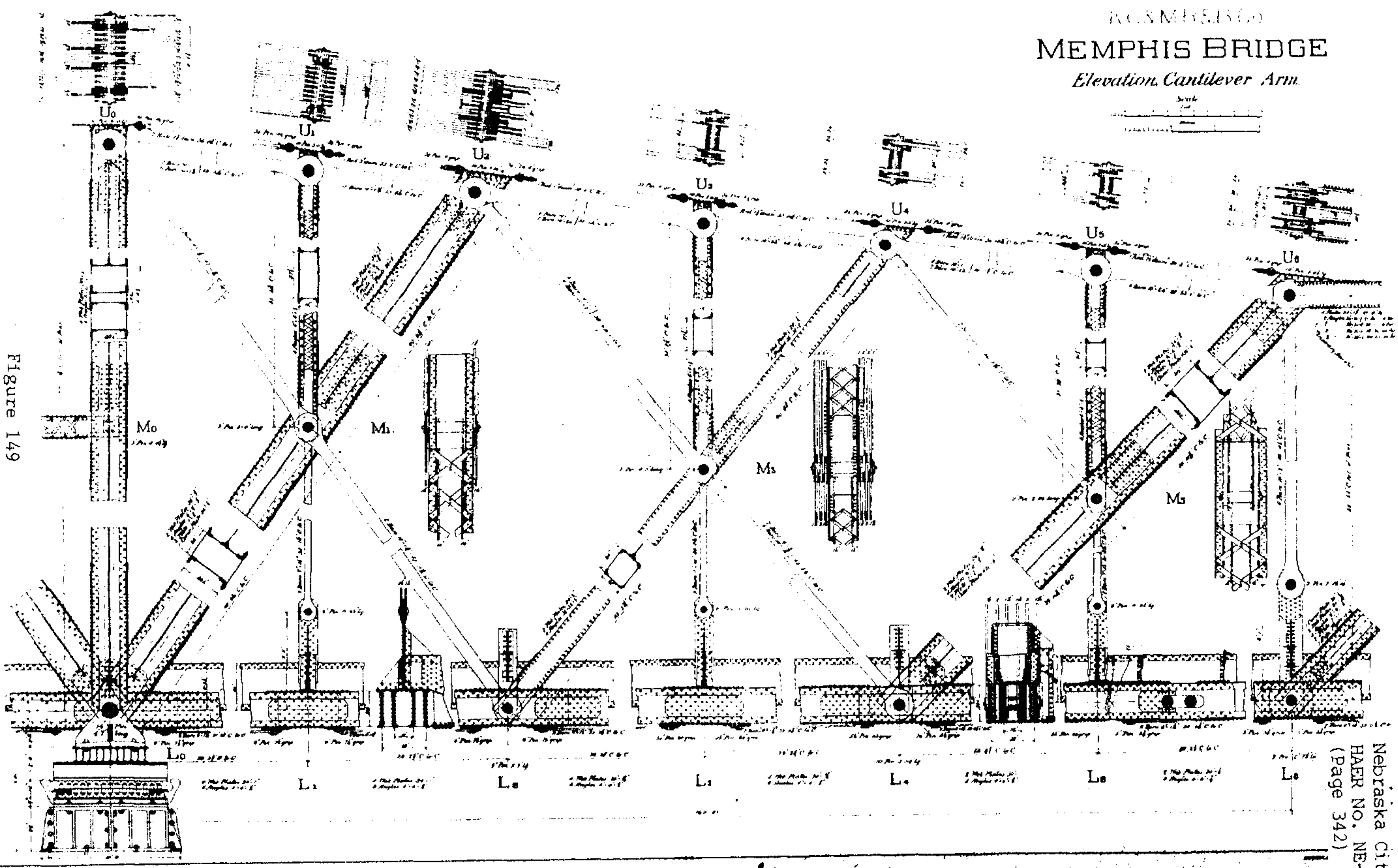


Plate 29
K.C.&M.R.R.&B.Co.
MEMPHIS BRIDGE
Elevation, Anchorage Span.
U₀
U₁
U₂
U₃
U₄
U₅
M₀
M₁
M₃
M₅
L₀
L₁
L₂
L₃
L₄
L₅

Figure 147

Figure 149



Nebraska City Bridge
HAER No. NE-2
(Page 342)

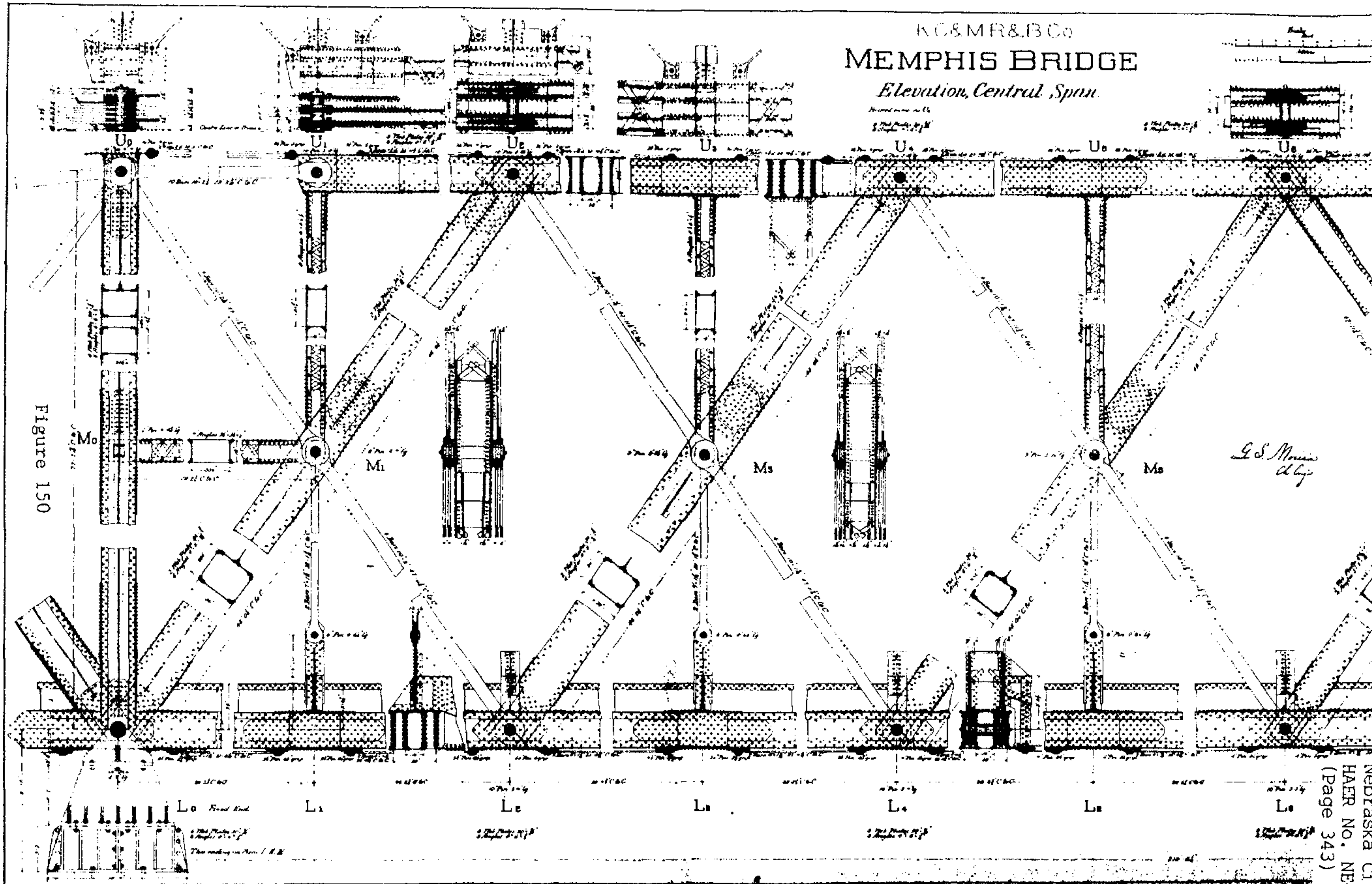


Figure 150

Nebraska City Bridge
HAER No. NE-2
(Page 343)

K.C.&M.R&B.Co.

MEMPHIS BRIDGE

Elevation and Section. Anchorage Span.

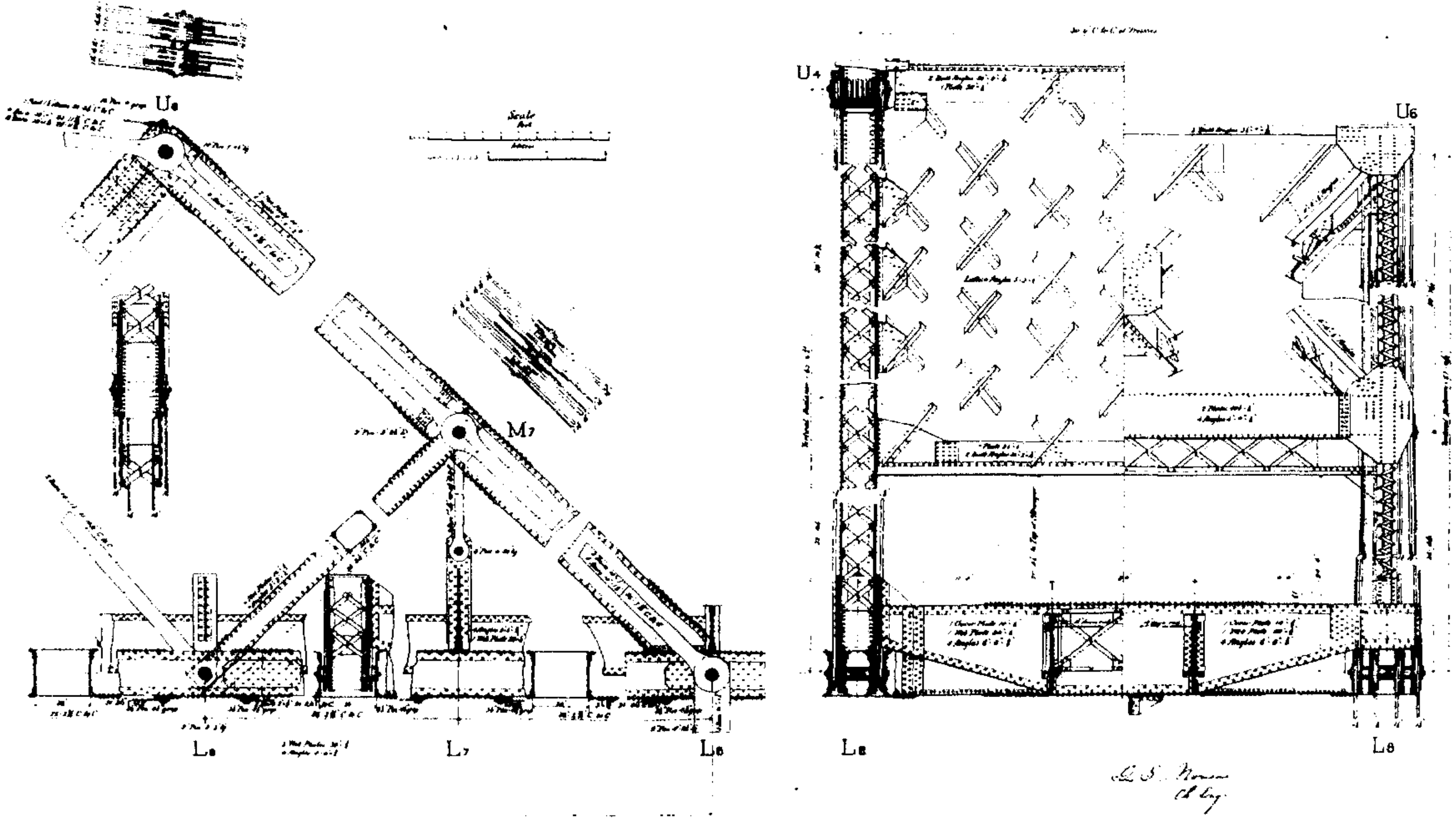


Figure 148

Plate 34

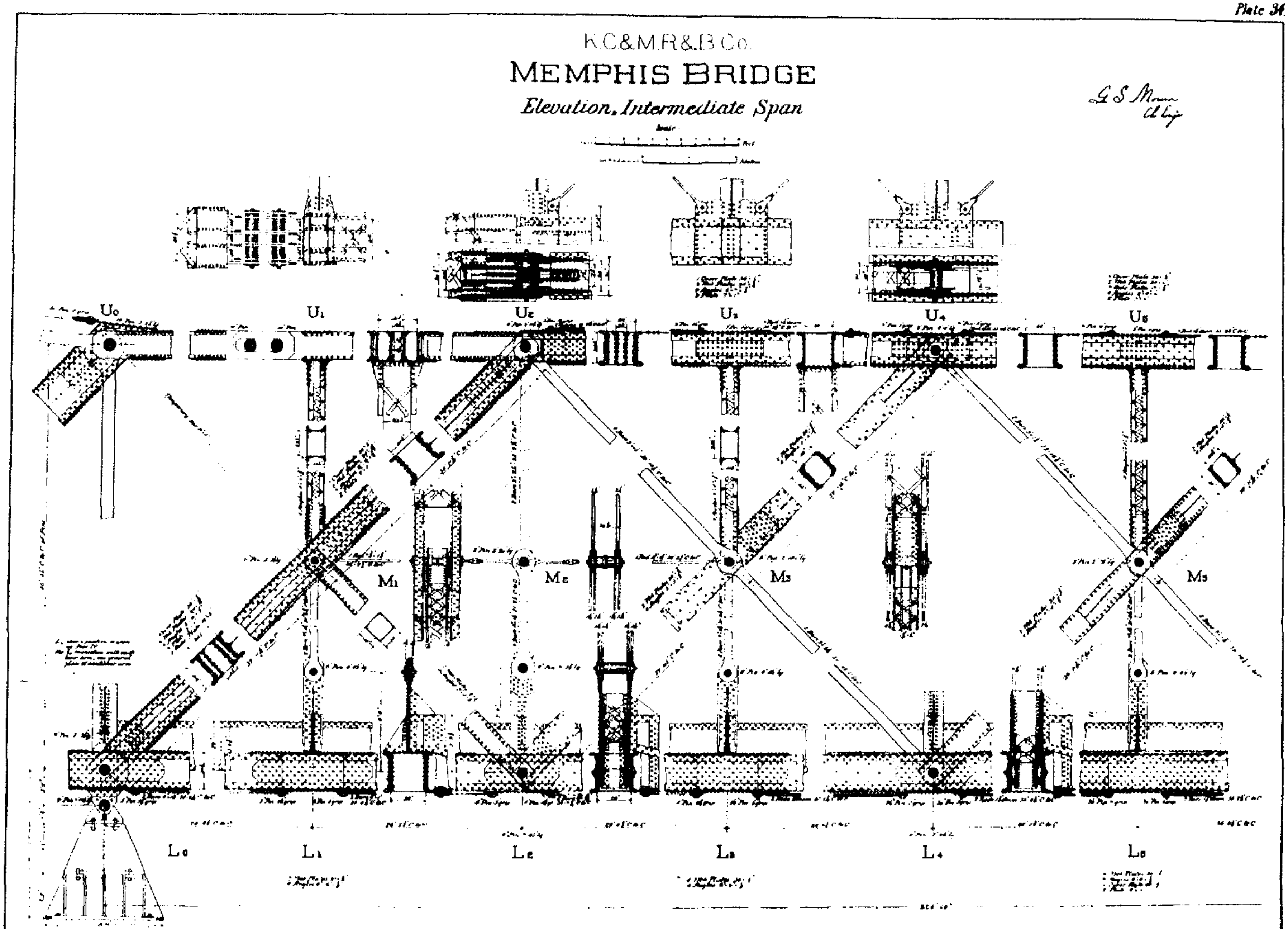


Figure 151

Nebraska City Bridge
HAER No. NE-2
(Page 345)

Plate 35

K.C.&M.R.R.&B.Co.

MEMPHIS BRIDGE

Elevation and Section. Intermediate Span

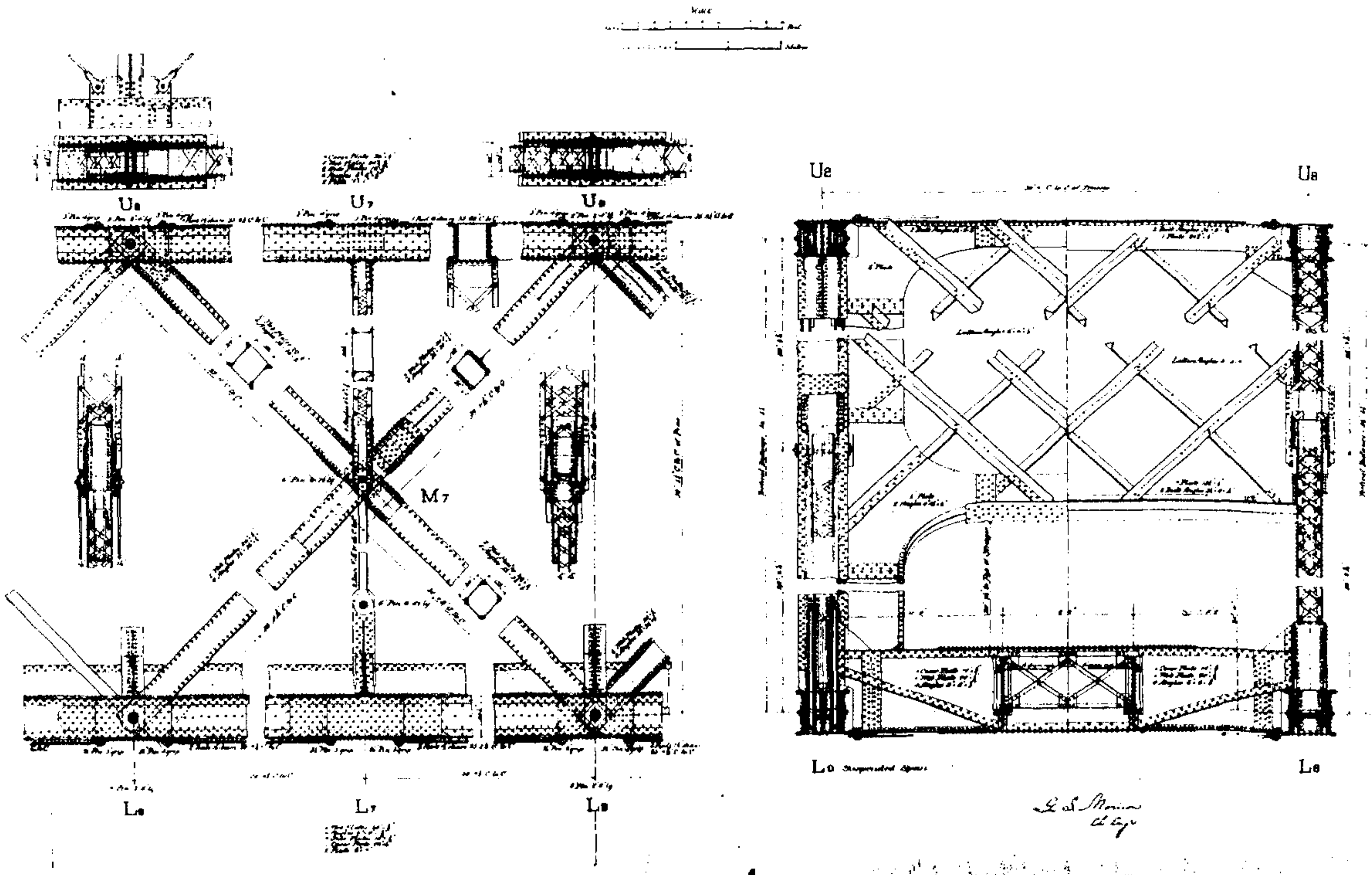


Figure 152

Nebraska City Bridge
HAER No. NE-2
(Page 346)

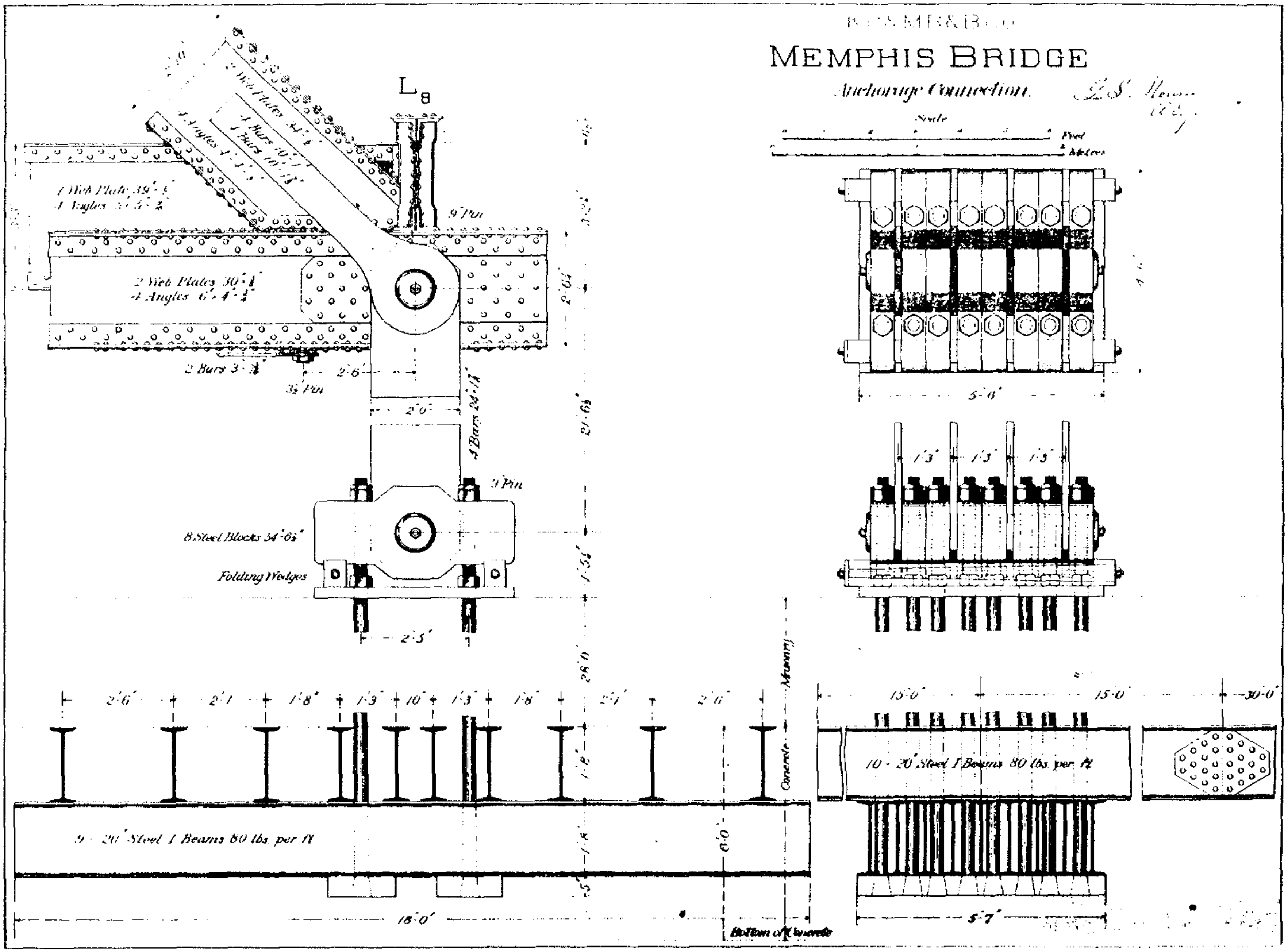


Figure 153

Nebraska City Bridge
HAER No. NE-2
(Page 347)

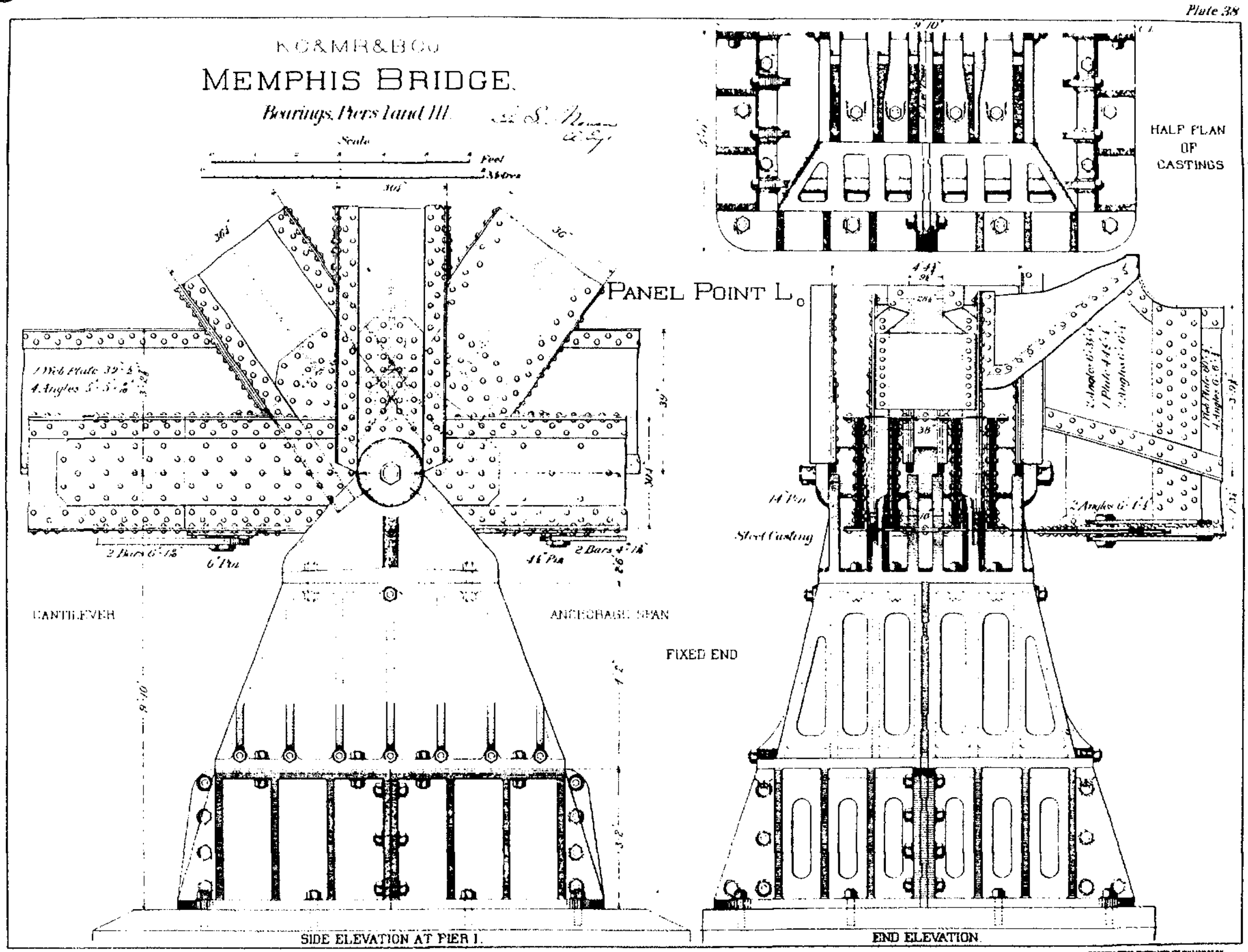


Figure 154

Nebraska City Bridge
HAER No. NE-2
(Page 348)

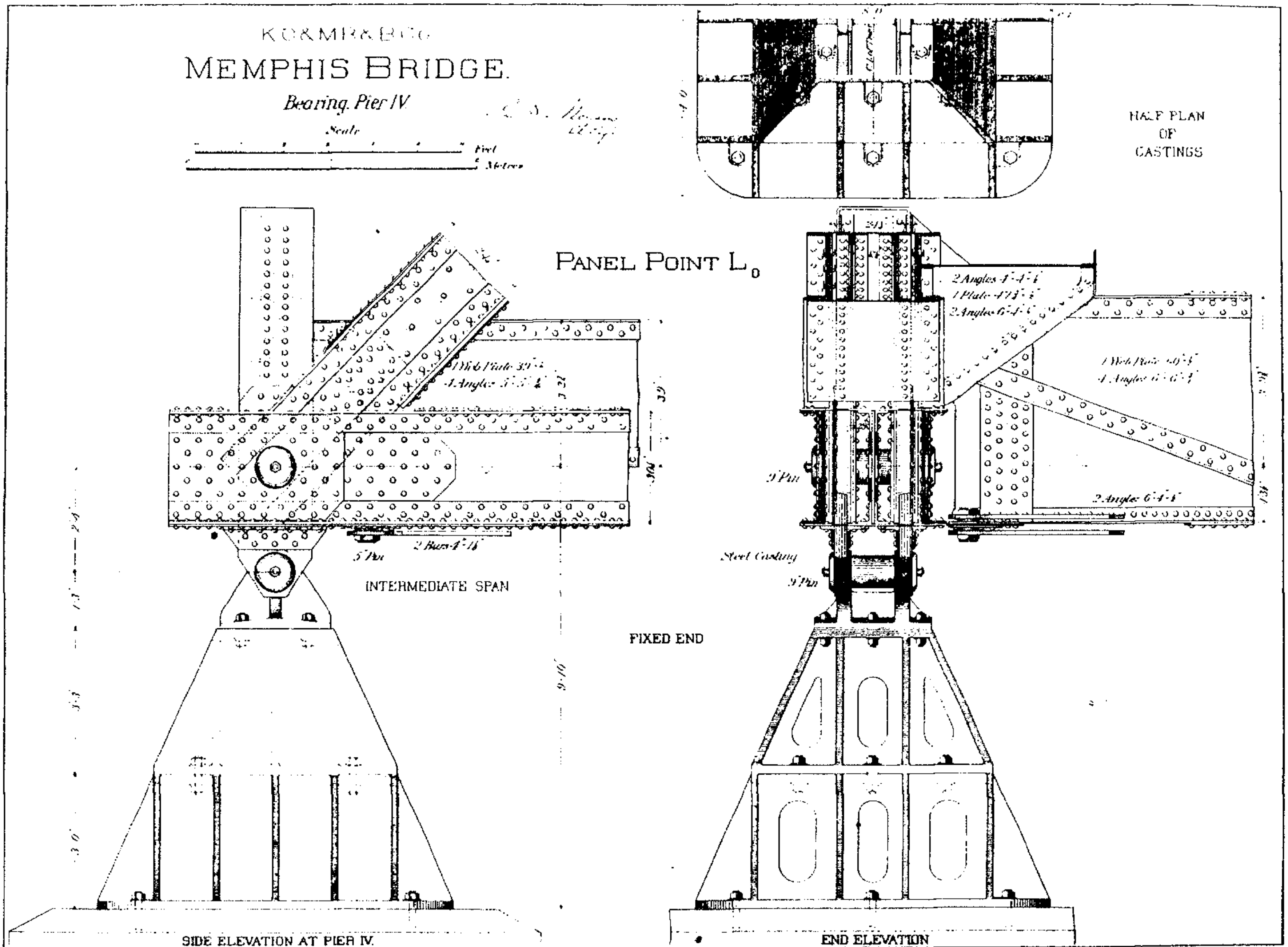


Figure 155

Nebraska City Bridge
HAER No. NE-2
(Page 349)

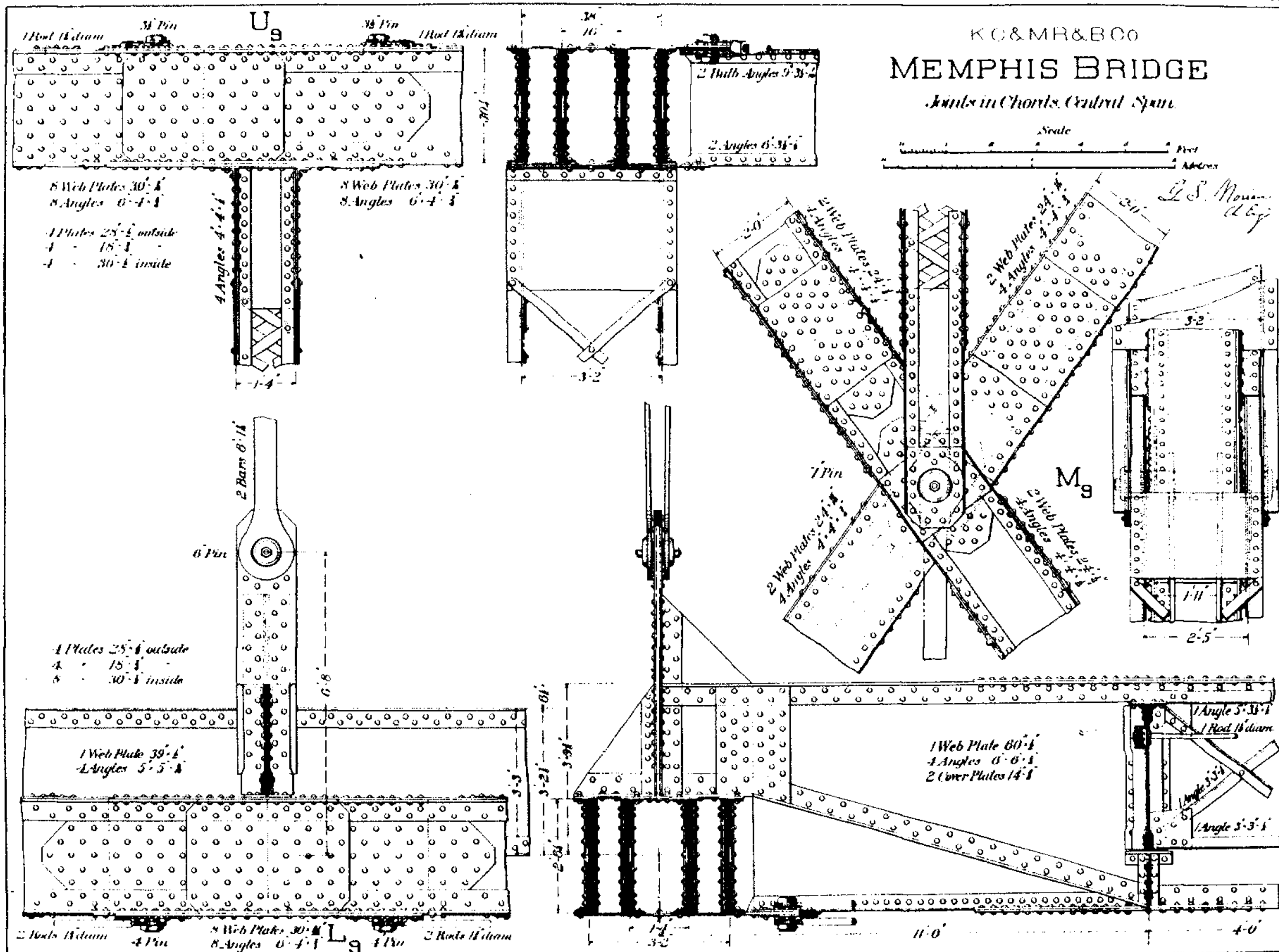


Figure 156

Nebraska City Bridge
HAER No. NE-2
(Page 350)

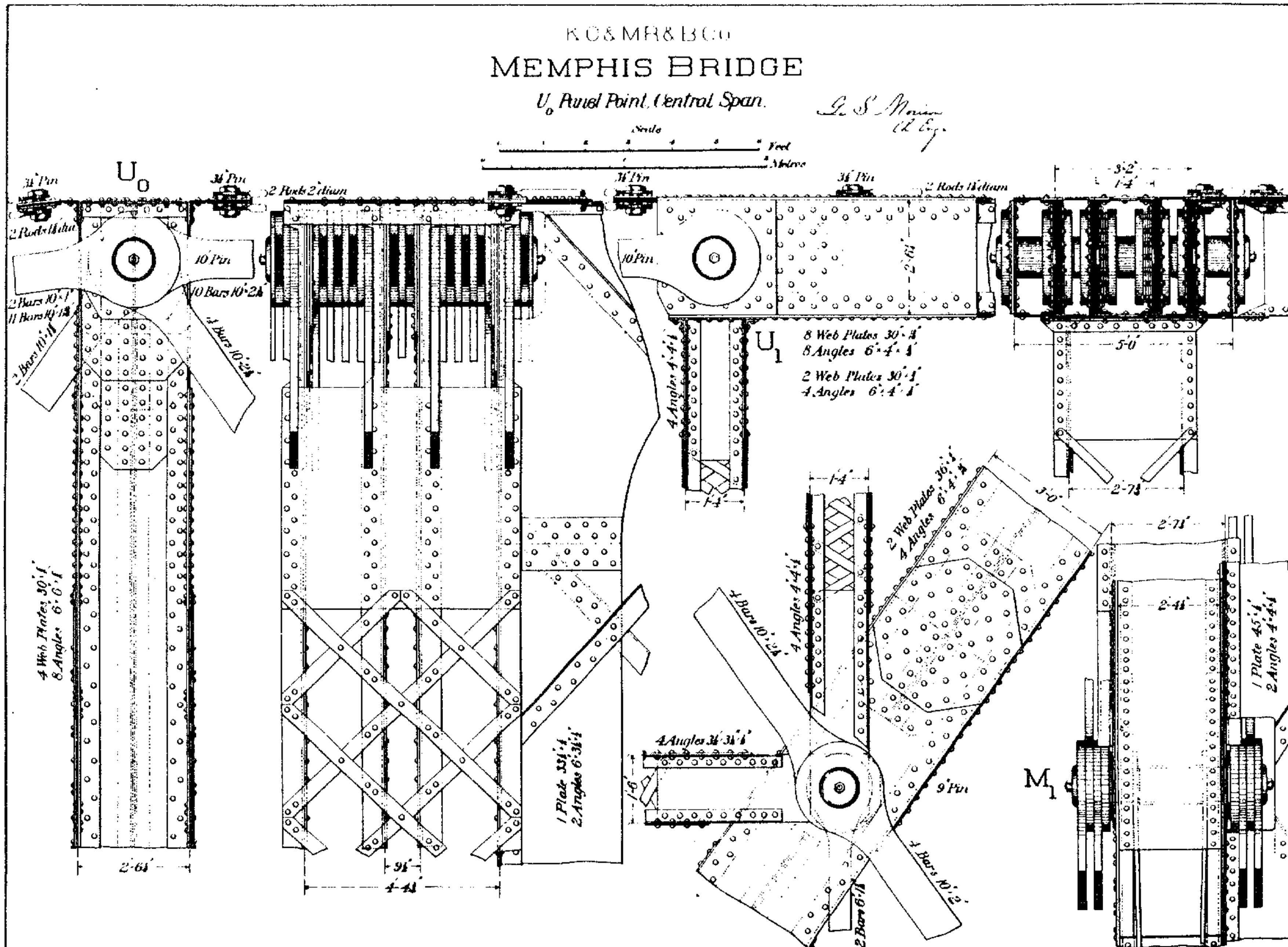


Figure 157

Nebraska City Bridge
HAER No. NE-2
(Page 351)

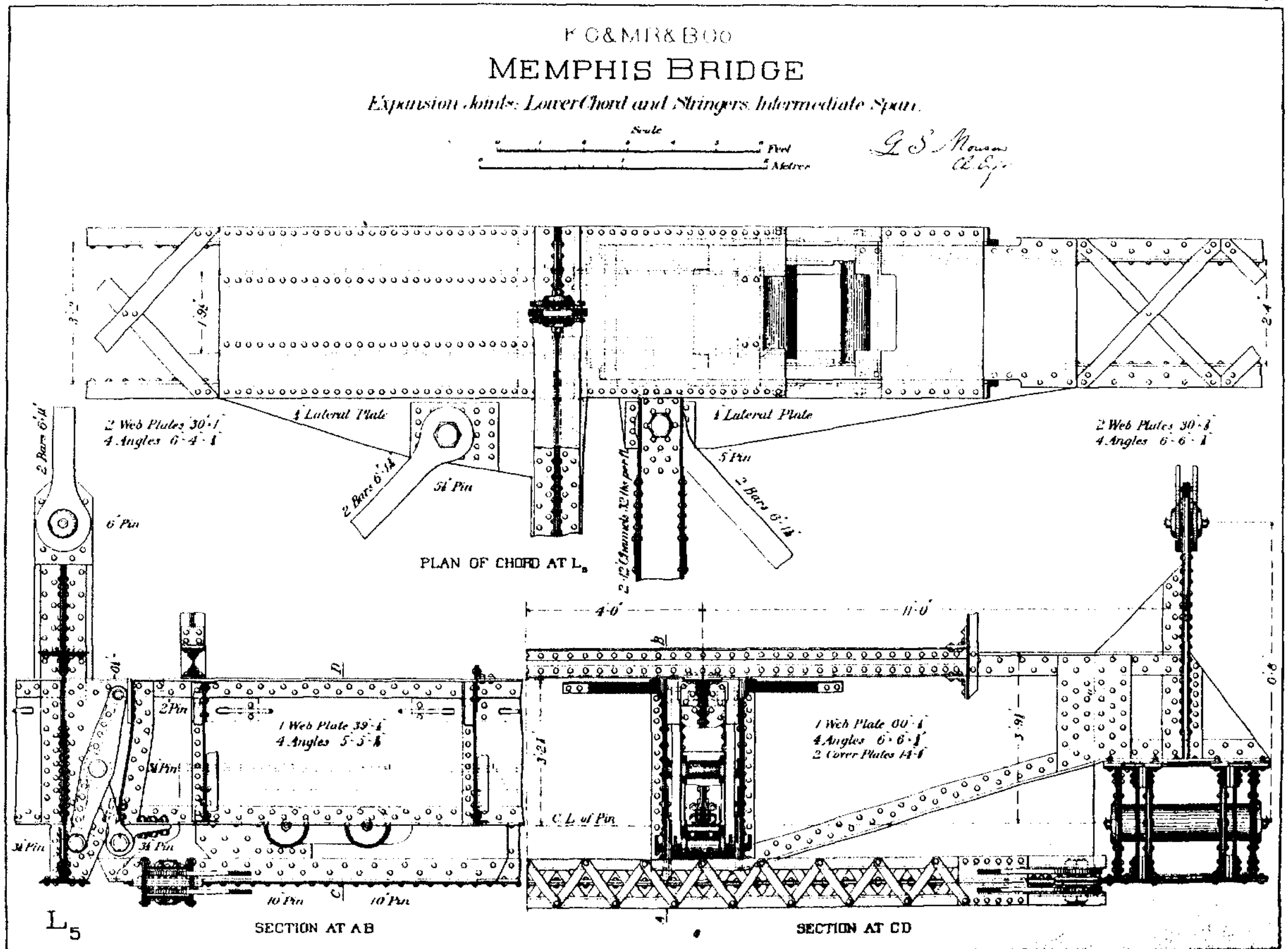


Figure 158

Nebraska City Bridge
HAER No. NE-2
(Page 352)

Plate 44

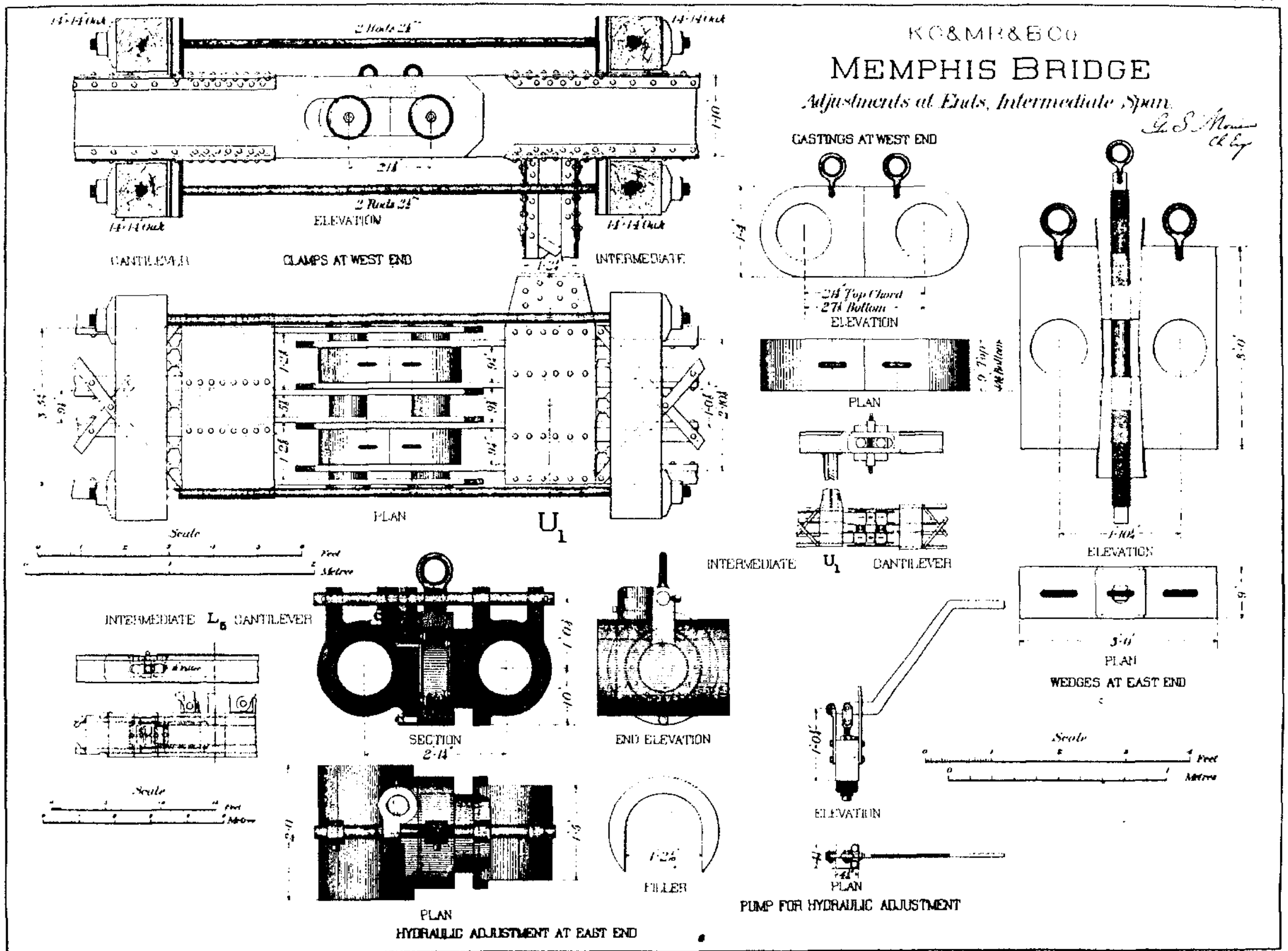
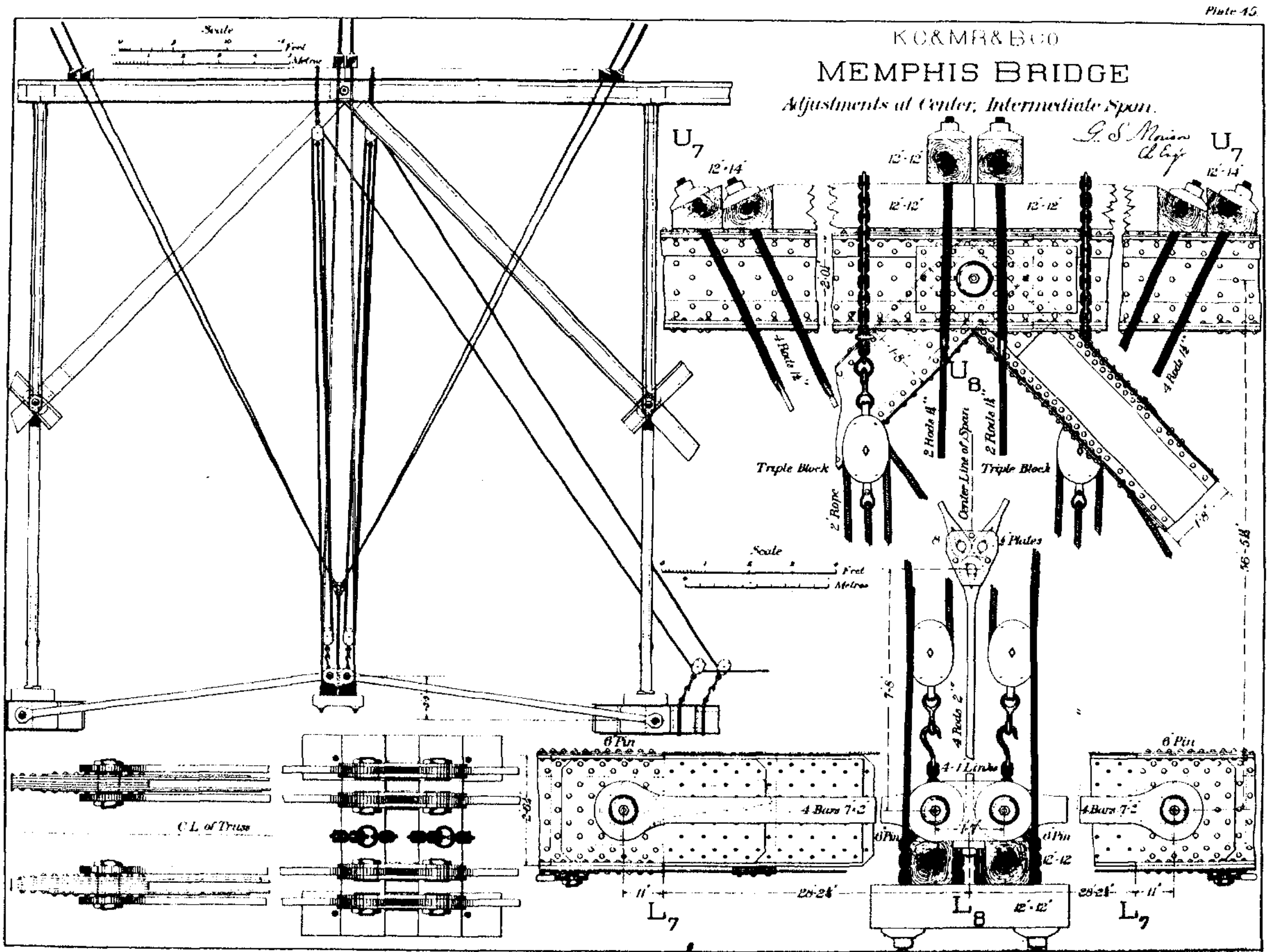


Figure 159

Nebraska City Bridge
HAER No. NE-2
(Page 353)

Figure 160



Nebraska City Bridge
HAER No. NE-2
(Page 354)

Plate 47

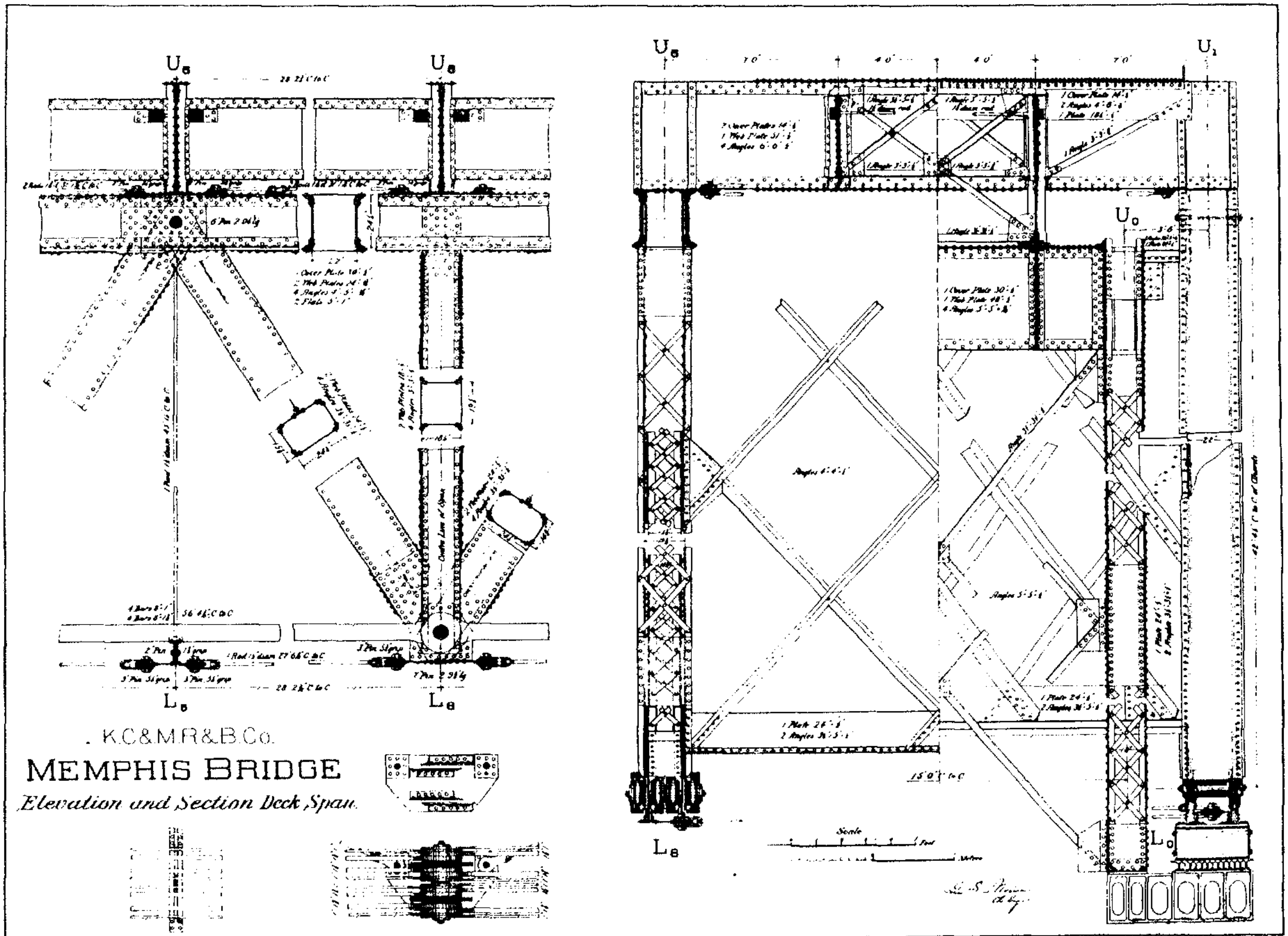
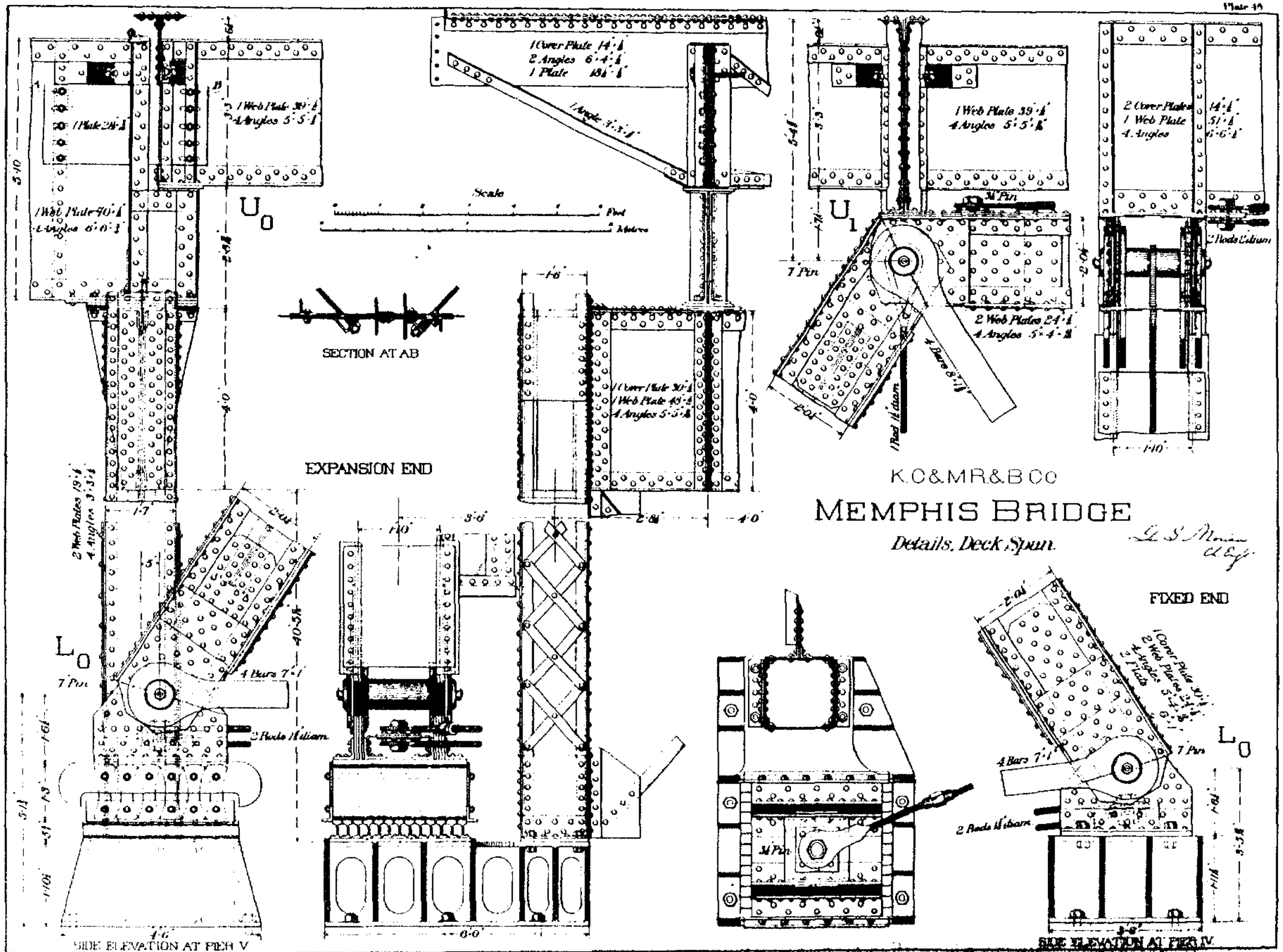


Figure 161

Figure 162



Nebraska City Bridge
HAER No. NE-2
(Page 356)

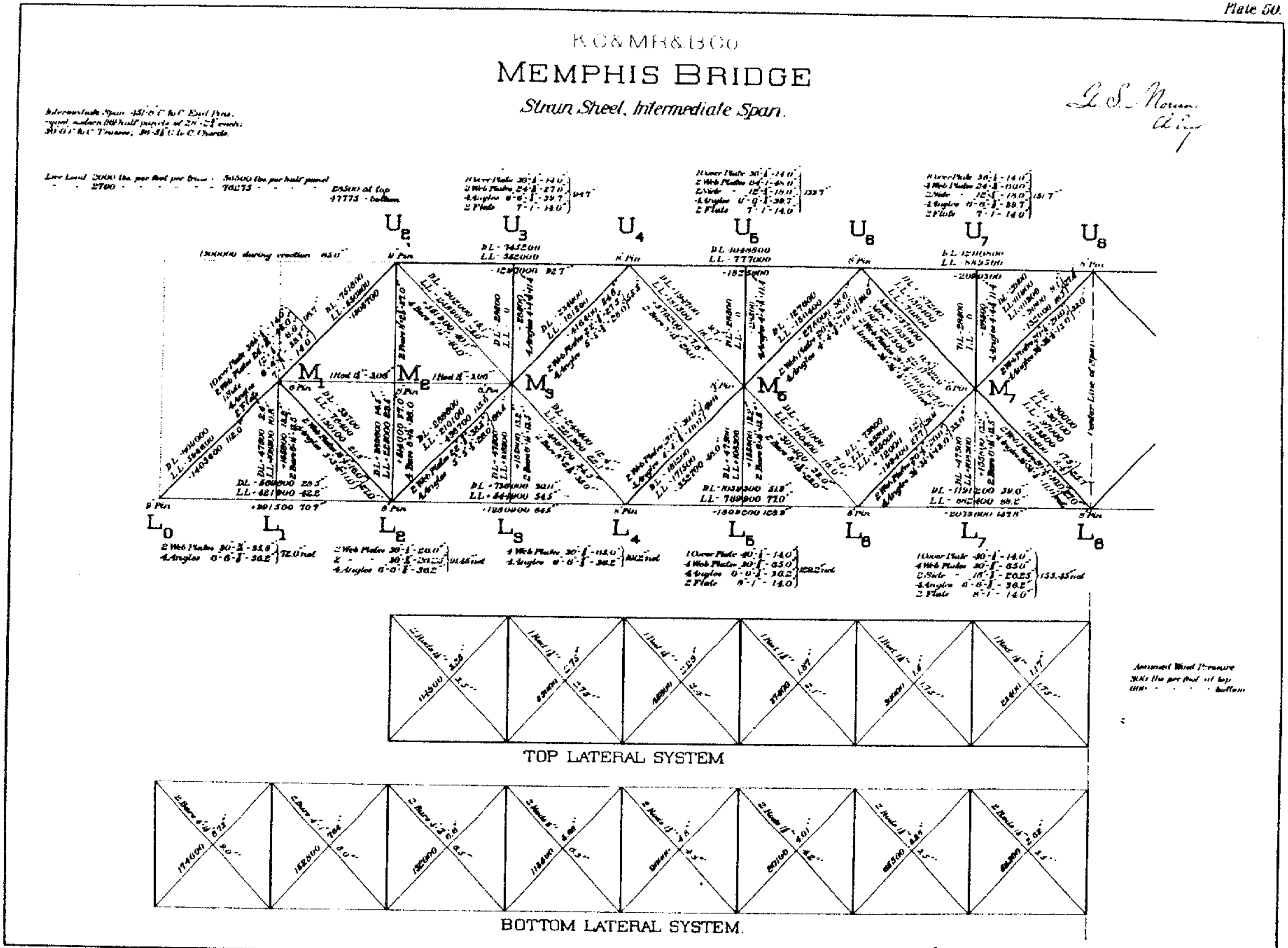


Plate 50.
K.C.& M.R.& B.Co.
MEMPHIS BRIDGE
Strain Sheet, Intermediate Span.
U2
U3
U4
U5
U6
U7
U8
M1
M2
M3
M5
M7
L0
L1
L2
L3
L4
L5
L6
L7
L8
TOP LATERAL SYSTEM
BOTTOM LATERAL SYSTEM.

Figure 163

K C & M R & B Co

MEMPHIS BRIDGE

Strain Sheet, Cantilever Arm.

G. S. Morison
Ch. Eng.

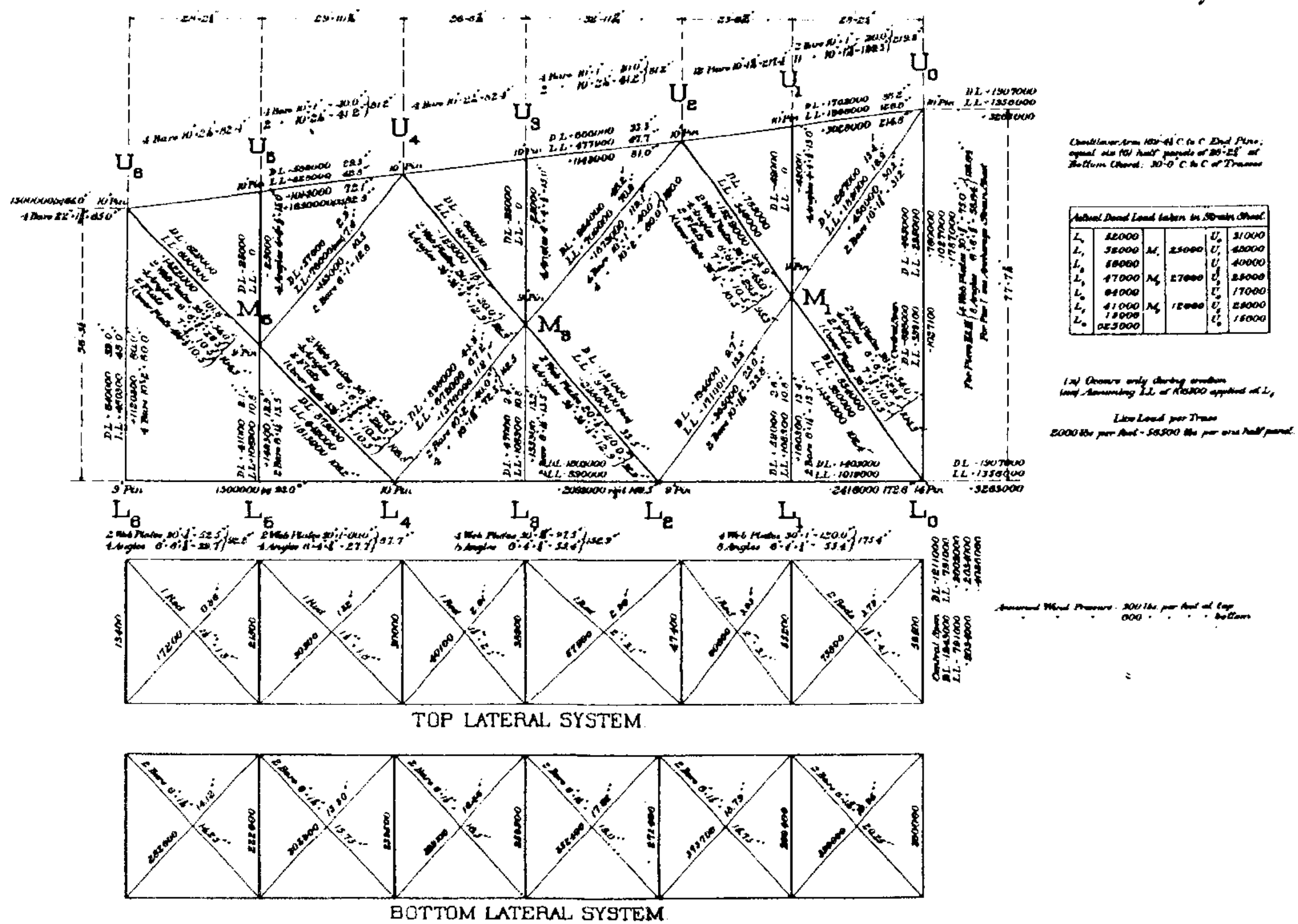


Figure 164

Plate 52

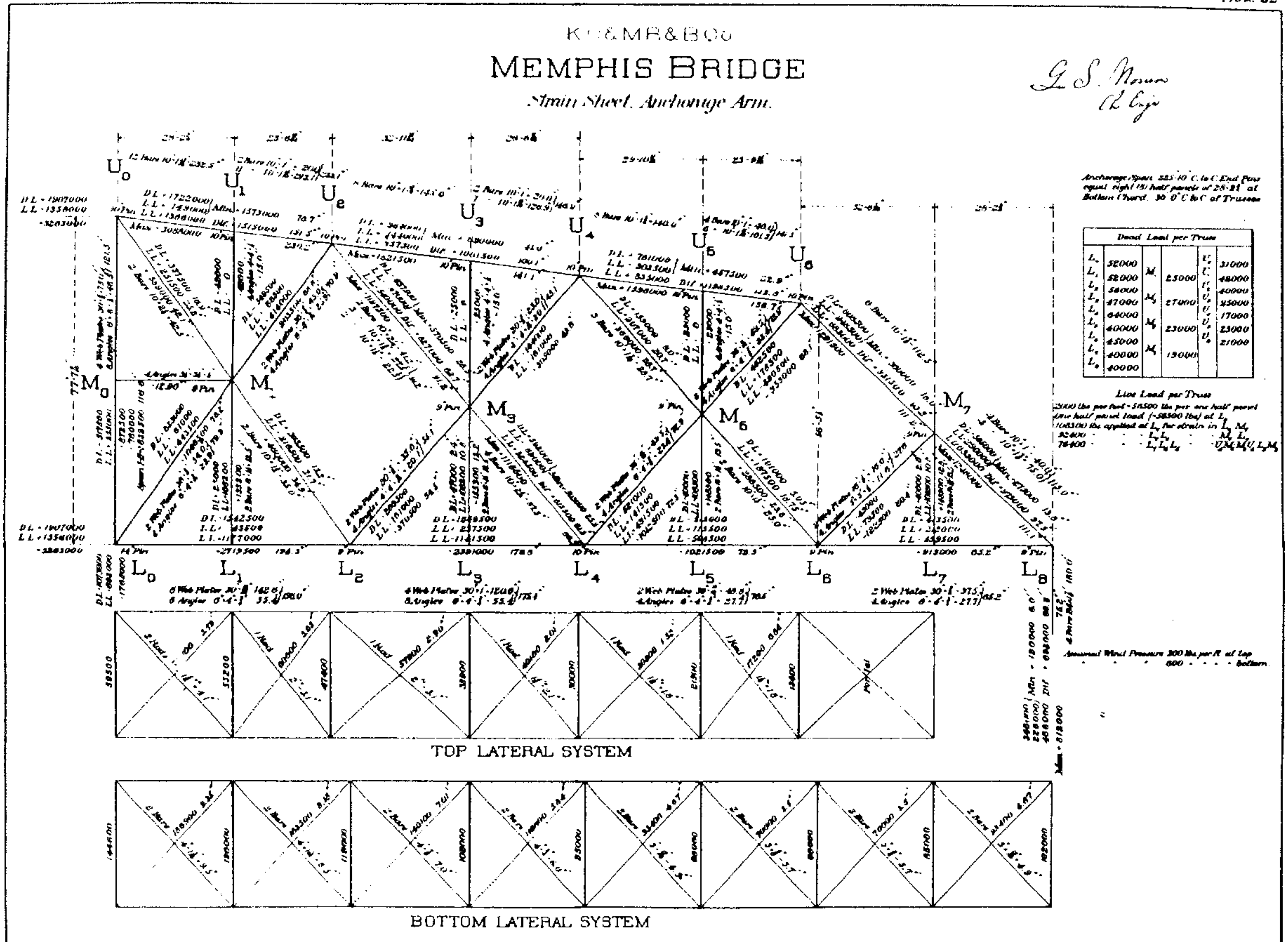


Figure 165

Nebraska City Bridge
HAER No. NE-2
(Page 359)

Plate 58

K C & M R & B Co

MEMPHIS BRIDGE

Strain Sheet, Central Span.

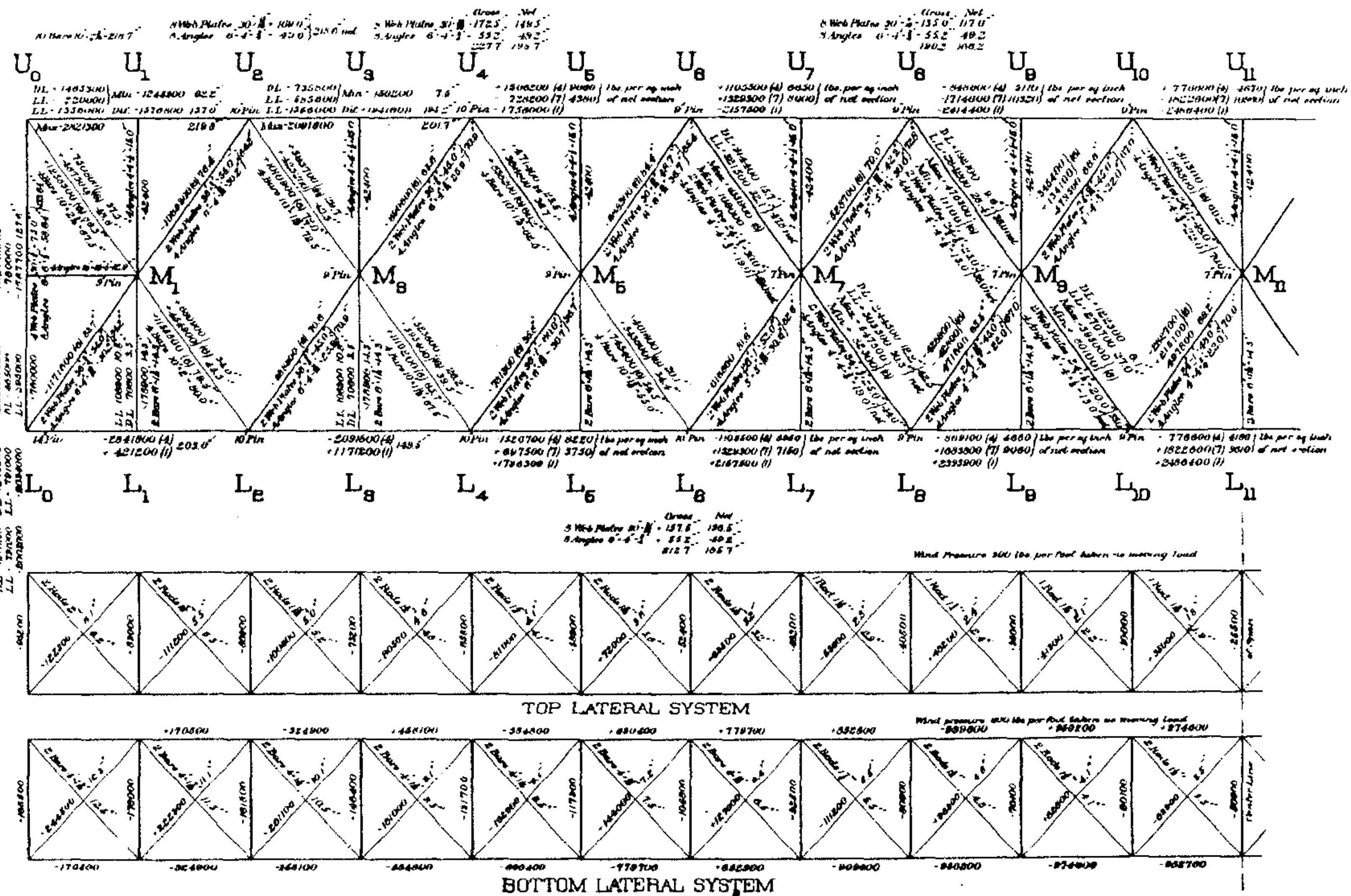


Figure 166

Nebraska City Bridge
HAER No. NE-2
(Page 360)

Plate 55.

K.C.&M.R.&B.Co.

MEMPHIS BRIDGE

Strain Sheet, Deck Span.

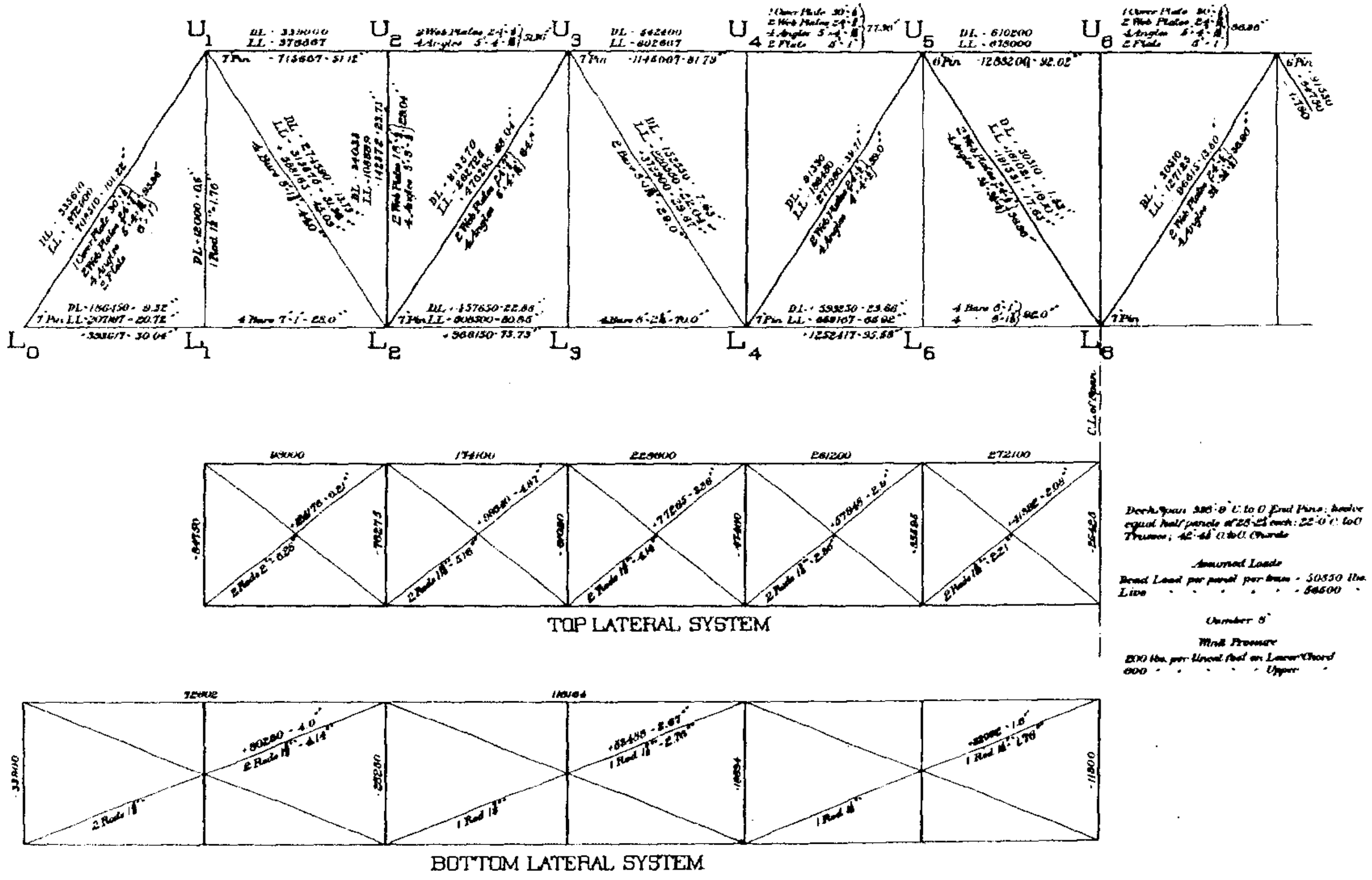


Figure 167

Nebraska City Bridge
HAER No. NE-2
(Page 361)

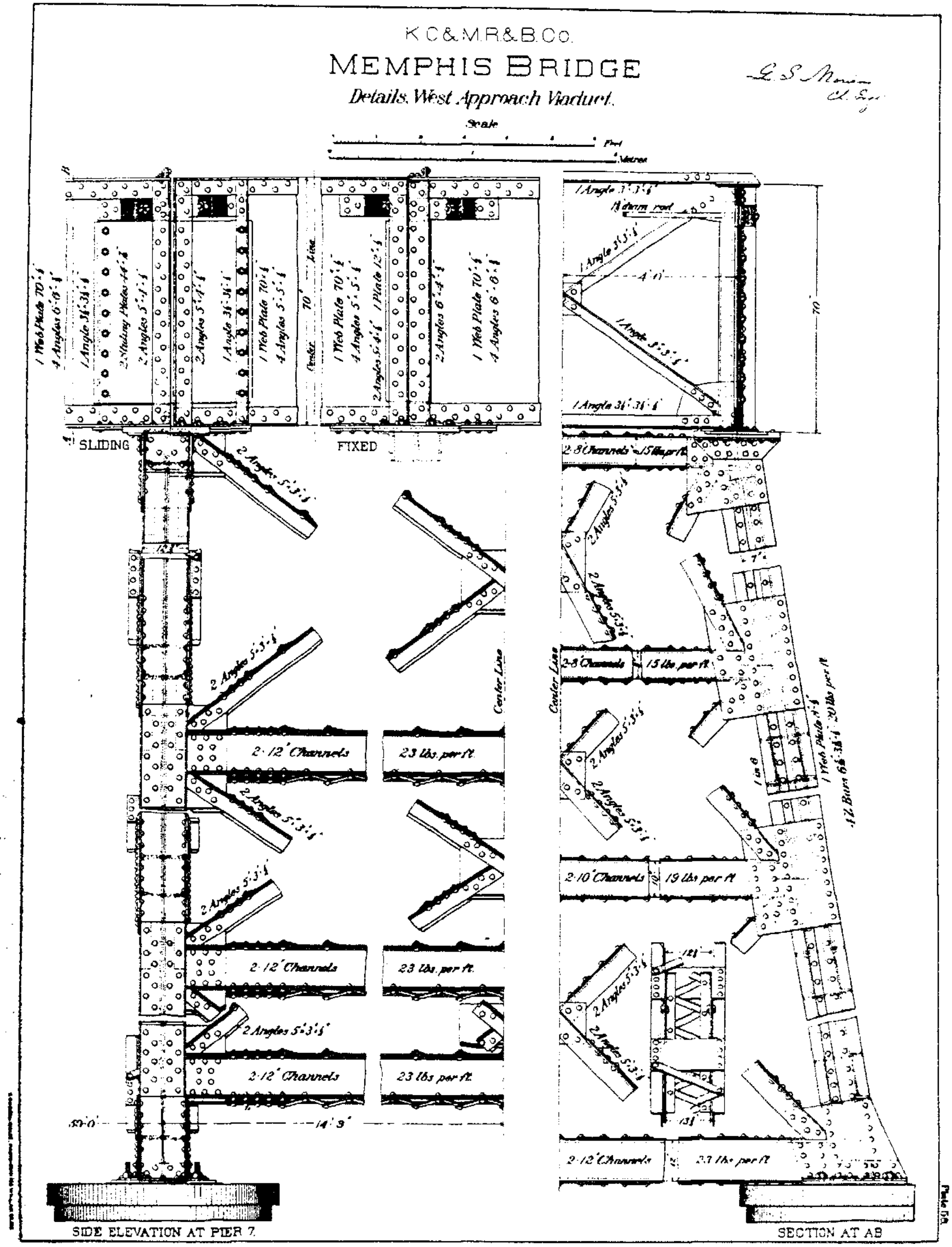

K.C.&M.R.&B.Co.
MEMPHIS BRIDGE
Details, West Approach Viaduct.
Scale
Feet
Metres
1 Web Plate 70 · ½
4 Angles 6 · 6 · ½
1 Angle 3½ · 3½ · ½
2 Sliding Plates 44 · ½
2 Angles 5 · 4 · ½
1 Angle 3½ · 3½ · ½
1 Web Plate 70 · ½
4 Angles 5 · 5 · ½
Center 70 Line
1 Web Plate 70 · ½
4 Angles 5 · 5 · ½
2 Angles 5 · 4 · ½
1 Plate 12 · ½
2 Angles 6 · 4 · ½
1 Web Plate 70 · ½
4 Angles 6 · 6 · ½
1 Angle 3 · 3 · ½
1 Angle 3½ · 3½ · ½
4 · 0
1 Angle 5 · 3 · ½
70
SLIDING
FIXED
2 Angles 5 · 3 · ½
2 · 12 Channels
23 lbs. per ft.
Center Line
2 · 8 Channels
15 lbs. per ft.
2 · 10 Channels
19 lbs. per ft.
1 in 6
1 Web Plate ½
4 Z Bars 6⅛ · 3½ · ½ 20 lbs per ft
2 · 12 Channels
23 lbs per ft
14 · 3
SIDE ELEVATION AT PIER 7.
SECTION AT AB

Figure 168

Plate 56.

K.C.&M.R.&B.Co.

MEMPHIS BRIDGE

West Approach Viaduct.

G. S. Morison
Ch. Engr.

Scale

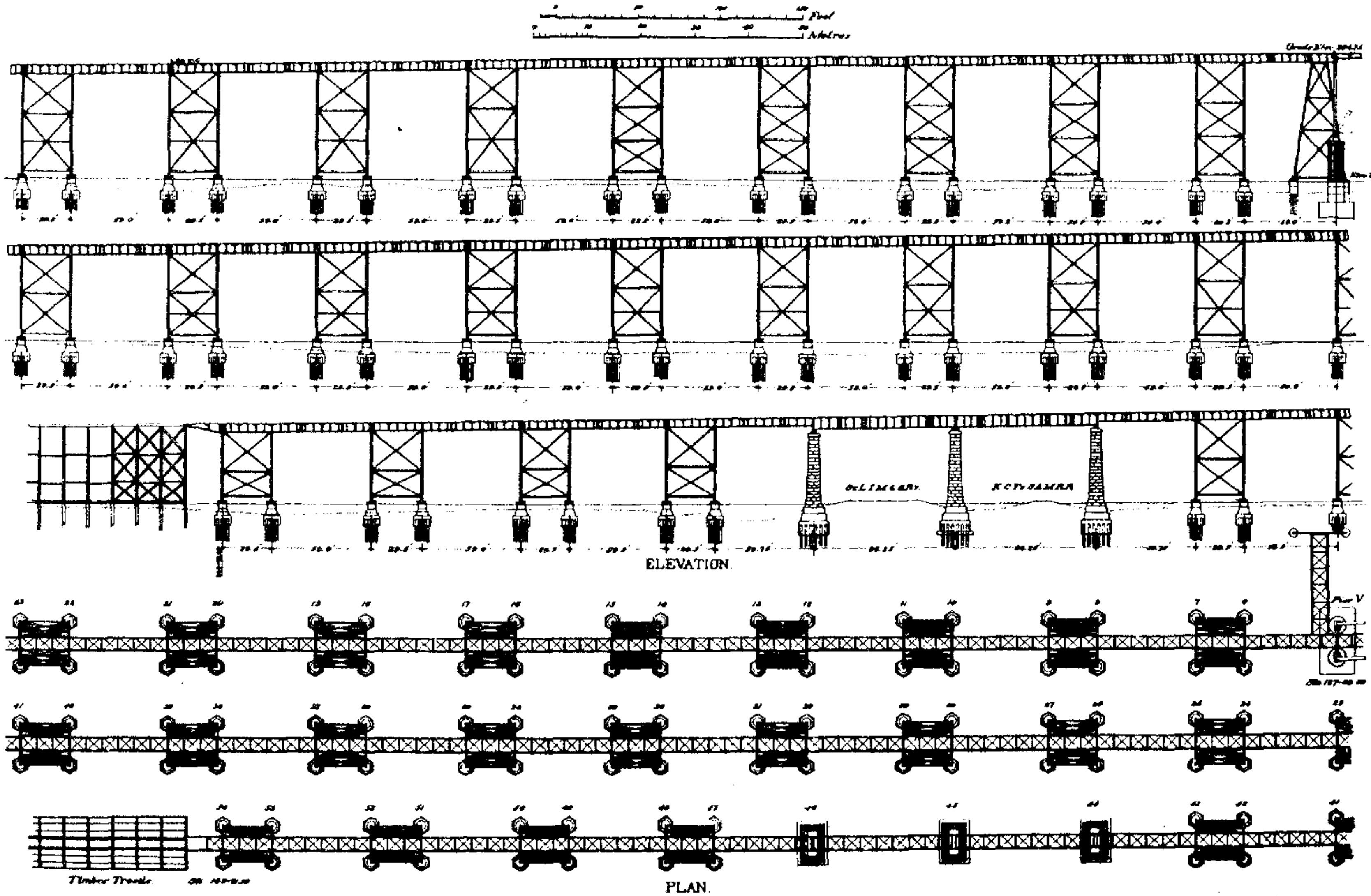


Figure 169

ENDNOTES

1 Of the three great Midwestern rivers - the Missouri, the Mississippi and the Ohio - the Mississippi was by far the largest, receiving much of its flow from the other two. The Ohio contributed 31% of volume to the lower Mississippi; the upper Mississippi, 19%; and the Missouri, 14%. Combined, these three watercourses contributed almost two-thirds of the flow through the lower Mississippi. The remainder poured in from a series of major and minor tributaries, including the St. Croix, Wisconsin, Iowa, Des Moines, Salt, White, Arkansas, Yazoo and the Red. In all, more than fifty navigable tributaries drain into the Mississippi along its twisting course through Mid-America, totaling more than 14,000 miles of navigable waterways which bordered or traversed twenty-seven states. (William J. Petersen, Steamboating on the Upper Mississippi (1937; reprint edition, Iowa City, Iowa: State Historical Society of Iowa, 1968), pages 22-27; Henry Lewis, The Valley of the Mississippi (St. Paul: Minnesota Historical Society, 1967), pages 59-63.)

From its source at diminutive Lake Itasca, the Mississippi first trickled through a series of deep-forest lakes in northern Minnesota and glided swiftly through a series of other lakes past Grand Rapids, Little Falls and St. Cloud. By the time it reached Minnesota's Twin Cities, 600 miles south, the Mississippi dropped only 900 feet. Below the Falls of St. Anthony, some 1100 miles below its source, the river was bounded by steep limestone bluffs and flowed through a relatively stable channel.

At the mouth of the Missouri River, just above St. Louis, the Mississippi changed character dramatically, resembling more the raucous tributary than its own calm upper reaches. The silt-clogged water which roiled down the Missouri entirely changed the character of the parent river. "They are rivers of very different character," George Morison stated in 1894, "the Mississippi being a quiet stream of comparatively stable character and the Missouri a silt-bearer of the first magnitude. The Missouri gives the character to the united river below the junction. It is a silt-bearer subject to floods, but not to as violent floods as those in the Ohio." (George S. Morison, The Memphis Bridge (New York: John Wiley and Sons, 1894), page 7.)

The Mississippi at this point changed from a placid, relatively clear stream with smooth shores and gentle sand bars to, as George Conclin observed in 1852, "a furious and boiling current, a turbid and dangerous mass of sweeping waters, jagged and dilapidated shores, and, wherever its waters have receded, deposits of mud. In its course, accidental circumstances shift the impetus of its current, and propel it upon the point of an island, bend, or sand bar. In these circumstances, it tears up the island, removes the sand bars, and sweeps away the tender alluvial soil of the bends, with all their trees, and deposits the spoils in another place. At the season of high water, nothing more is familiar to the ears of the people on the river than a deep crash of a landslip, in which larger or smaller masses of the soil on the banks, with all the trees, are plunged into the stream. Such is its character, from the Missouri, to the [Gulf of Mexico] - a wild, furious, whirling river, never navigated, except with great danger." (George Conclin, New River Guide, or a Gazeteer of all the Towns on the Western Waters (Cincinnati, 1852), pages 67-71.) Between the Missouri and the mouth of the Ohio at Cairo, the Mississippi became deeper and more constricted, with a mean width of some three-quarters of a mile. It also gained velocity and a considerable amount of force with the increased amount of water.

The dividing line between the upper and lower Mississippi was generally believed to be the mouth of the Ohio, for it was this major tributary that almost doubled the flow of the Mississippi. For over 1000 miles below Cairo, the river meandered with a barely perceptible current through a level flood plain from 50 to 100 miles wide. With millions of years of accumulated silt lining its banks, the Mississippi throughout much of this length was actually higher than the surrounding countryside. Only elaborate series of high-banked earthen dikes protected many riverside towns from destruction by the river. Floods along the Mississippi were legendary. During low water, the lower Mississippi discharged about 70,000 cubic feet of water into the Gulf of Mexico; during flood stage, this increased more than thirty times to about 2.3 million cubic feet. In especially heavy flood years, the flow increased far more as the water-gorged river inundated its entire flood plain and overran the dikes, causing hundreds of millions of dollars of property damage.

2 F.B. Maltby, "The Mississippi River Bridges: Historical and Descriptive Sketch of the Bridges over the Mississippi River," Journal of the Western Society of Engineers, August 1903, pages 419-20.

3 As they had done with the Wheeling Bridge over the Ohio River, the steamboat companies fought the Rock Island Bridge as an intrusion into what had for decades been their private domain. In fact, the Wheeling dispute was still in the courts when surveyors began planning for the bridge at Rock Island. Its construction, and the ensuing battle between the railroad and the steamboat companies, would set the stage for bridge regulation and litigation for decades to follow.

The Chicago & Rock Island (C&RI) was the first railroad to reach the Mississippi River from the East, steaming the first locomotive to the banks of the river amid great celebration on Washington's birthday, 1854. The surveyors had chosen the port city of Rock Island as its western terminus, because they reasoned that a bridge over the Mississippi at this point would be economical to build to an existing center island and would present a minimal hazard to river navigation. Steamboat owners in St. Louis immediately cried out that the proposed bridge at Rock Island was "unconstitutional, an obstruction to navigation, dangerous," and stated that it was "the duty of every western state, river city, and town to take immediate action to prevent the erection of such a structure." (Carl Sandburg, Abraham Lincoln, the Prairie Years (New York: Harcourt, Brace, 1926), page 37.)

As soon as the Railroad Bridge Company, a C&RI subsidiary, began laying the foundations for the piers, Southern sectionalists led by Jefferson Davis protested its construction in favor of a transcontinental road across the southern, slave-holding states. This latter opposition proved formidible, for as Secretary of War, Davis stood in a position to block the bridge and ordered the railroad company to halt construction. (Dee Brown, Hear That Lonesome Whistle Blow (New York: Holt, Rinehart and Winston, 1977), pages 6-8.)

Late in 1854, a St. Louis merchant secured a federal injunction against the bridge, charging the C&RI with trespassing, destruction of government property and obstruction of navigation along the river. But in court in July 1855, the Railroad Bridge Company prevailed. The judge ruled for the railroad, stating that, "railroads had become highways in something the same sense as rivers; neither could be suffered to become a permanent obstruction to the other, but each must yield something to the other according to the demands of the public convenience and necessities of commerce." Thus freed from legal entanglements, the railroad continued with its construction, completing the 1,535-foot wooden structure in April 1856. (Benedict K. Zobrist, "Steamboat Men versus Railroad Men," Missouri Historical Review, 1965, pages 159-72.)

Vindication in the courts and completion of construction, however, did not assure the bridge's continued existence, however, as the steamboat companies took it upon themselves to eliminate their obstacle. Only two weeks after the first train passed over the Rock Island Bridge, it was struck by a riverboat. The 431-ton Effie Afton, caught in the swirling waters around the base of the bridge, smashed against the central bridge pier. The impact overturned the galley stove and the boat's smokestacks, which ignited the wooden vessel. While the Effie Afton floundered in flames, it in turn ignited the wooden bridge. The fire destroyed the boat and one span of the bridge. The railroad men began to suspect a plot when steamboats up and down the river that day blew their horns triumphantly, and the skipper of the Hamburg unfurled a large banner which read: "MISSISSIPPI BRIDGE DESTROYED. LET ALL REJOICE." (Dee Brown, Hear That Lonesome Whistle Blow, pages 8-9; Walter Havighurst, Voices on the River: the Story of the Mississippi Waterways (New York: The Macmillan Company, 1964), page 121.)

In the ensuing lawsuit, a young lawyer from Springfield, Illinois, named Abraham Lincoln successfully represented the bridge company. Lincoln argued convincingly that travel between East and West over the railroads was as important as travel between North and South over the river. He stated that, "rivers were to be crossed and that it was the manifest destiny of the people to move westward and surround themselves with everything connected with modern civilization." (Rock Island Magazine, February 1926, page 6.) Despite this defeat, the river interests continued their desperate struggle against the encroachment by the railroads. In 1858, they lobbied Congress unsuccessfully for a law forbidding bridges over navigable rivers. Later that year, the steamboatmen won a rare victory as an Iowa judge declared the Rock Island Bridge a "common and public nuisance" and ordered its Iowa portion demolished. The Supreme Court later overturned this decision, finally settling the issue of the railroads' right to bridge the Mississippi. Nevertheless, the steamboat interests would still use a variety of legal and illegal means to harass the railroads on subsequent bridges. (Dee Brown, Hear That Lonesome Whistle Blow, page 9; "At least one more attempt was made to destroy the Rock Island Bridge. On the night of June 5, 1859, a watchman making his rounds of inspection found in the middle of the bridge a collection of gunpowder, tar, oakum, and brimstone, heaped up and ready to be set on fire.")

4 "The Merchants' Bridge across the Mississippi River at St. Louis, Mo.," Engineering News, 21 December 1889, pages 578-79; "The St. Louis Merchants' Bridge, Engineering, 5 June 1891, pages 686-87.

5 These were, from north to south:

location	railroad	date	bridge type
Minneapolis MN	Minneapolis Union	1883	fixed stone arch
Minneapolis MN	Northern Pacific	1885	fixed deck truss
Minneapolis MN	C.M. & St. Paul	1880	fixed deck truss
St. Paul MN	C.M. & St. Paul et al.	1869	fixed truss
St. Paul MN	Chicago Great Western	1885	fixed truss
Hastings MN	C.M. & St. Paul	1871	pivot truss
Reed's Landing MN	C.M. & St. Paul	1882	moveable pontoon
Winona MN	Chicago & North Western	1871	pivot truss
La Crosse WS	C.M. & St. Paul	1876	pivot truss
Prairie Du Chien	C.M. & St. Paul	1874	pivot truss
Dubuque IA	Illinois Central	1868	pivot truss
Sabula IA	C.M. & St. Paul	1881	pivot truss
Clinton IA	Chicago & North Western	1865	pivot truss
Rock Island IL	Chicago & Rock Island	1856;1872	pivot truss
Keithsburg IL	Iowa Central	1886	pivot truss
Burlington IA	Chicago Burl. & Quincy	1868	pivot truss
Ft. Madison IA	independent	1888	pivot truss
Keokuk IA	independent	1871	pivot truss
Quincy IL	Chicago Burl. & Quincy	1868	pivot truss
Hannibal MO	independent	1871	pivot truss
Louisiana MO	C. & A.	1873	pivot truss
St. Louis (Eads)	independent	1874	fixed arch

6 Thwarted in Congress and in the courts in their efforts to stop the railroads and bridge companies, the river pilots engaged in a more clandestine tactic to rid themselves of these impediments. They rammed their boats into the bridge piers, causing varying amounts of injury and damage. Although it was never proved, the Effie Afton appeared to be the first of many deliberate wrecks on Mississippi River bridges. Major G.K. Warren of the Army Corps of Engineers reported to Congress during an 1866 debate that in the ten years since the burning of the Effie Afton an astonishing 64 steamboats had been damaged or destroyed on the piers of the Rock Island Bridge.

Montgomery Miegs described the collision of another famous boat, the War Eagle, with the Keokuk (Iowa) Bridge in 1881: "The War Eagle, a side-wheel boat and one of the largest class employed on the upper Mississippi River, came down over the rapids at a very high stage of water, being loaded down to about a 6-foot draft. The current was so rapid that the pilot was afraid of the east draw opening and attempted to pass through the opening next to the Iowa shore by stopping the boat and floating her through. Unfortunately the bow of the boat was caught in the eddy above the bridge along the Iowa shore, while the stern projected in to the strong current outside the lock. The result of these two forces was to turn the boat broadside to the bridge with her stern pointing towards the Illinois shore. The boat backed the wheel on the lower side and attempted to straighten her up, but before he could do so the bow struck one of the piers and she passed through the raft span broadside-to, pushing the span off its bearings and allowing it to drop into the river. The falling bridge razed the guards and wheel from the lower side of the boat and she floated over the submerged span and passed on through in a sinking condition. The pilot had the nerve to stay in the pilot house, and, assisted by the engineers, managed with one wheel to work the boat to shore some distance below the bridge on the Iowa shore, where she sank across the submerged railroad tracks." (F.B. Maltby, "The Mississippi River Bridges...," page 477.) The boat company later raised and repaired the War Eagle, and the boat served for many years after. In the litigation that inevitably followed, the courts once again affirmed the right of the railroads to span the river.

Most of these collisions, like the wreck of the War Eagle, were undoubtedly accidents, but several were merely thinly disguised attempts to destroy the bridges or force their removal in ensuing litigation. Virtually all of the bridges that had stood for any time were involved in steamboat incidents, many of which occurred under suspicious circumstances. In stating an obiter dictu-- for a bridge accident case, Supreme Court Justice David Davis all but indicted the steamboat companies in purposeful destruction, stating: "The officers of steamboats plying the Western rivers must be held to the full measure of responsibility in navigating streams where bridges are built across them. These bridges, supported by piers, of necessity increase the dangers of navigation, and rivermen, instead of recognizing them as lawful structures built in the interests of commerce, seem to regard them as obstructions to it, and apparently act on the belief that frequent accidents will cause their removal. There is no foundation for this belief. Instead of the present bridges being abandoned, more will be constructed. The changed conditions of the country, produced by the building of railroads, has caused the great inland waters to be spanned by bridges. These bridges are, to a certain extent, impediments in the way of navigation, but railways are highways of commerce as well as rivers... It is the interest as well as the duty of all persons engaged in business on the water routes of transportation to conform to this necessity of commerce. If they do this and recognize railroad bridges as an accomplished fact in the country, there will be less loss of life and property, and fewer complaints of the difficulties of navigation at the places where these bridges are built." (Louis C. Hunter, Steamboats on the Western Rivers: An Economic and Technological History (New York: Octagon Books, 1969), pages 595-96.)

7 These were, from north to south (Morison's bridges indicated with an asterisk):

location	railroad	date	bridge type
Minneapolis MN	Great Northern	1891	fixed truss/girder
St. Paul MN	St. Paul Belt	1895	pivot truss
*Winona MN	Chicago Burl. & North.	1890	pivot truss
Rock Island IL	Davenport R.I. & N.E.	1899	pivot truss
*Burlington IA	Chicago Burl. & Quincy	1893	pivot truss (replace)
Quincy IL	Chicago Burl. & Quincy	1899	pivot truss (replace)
*Alton IL	Chicago Burl. & Quincy	1894	pivot truss
*St. Louis (Merch.)	St. Louis Terminal	1890	fixed truss
*Memphis	Kansas City & Memphis	1892	fixed truss

8 Citing the Wheeling Bridge precedent, Congress excercised its power to regulate bridge construction on the Mississippi by the granting of charters. In an "act to authorize the construction of certain bridges, and to establish them as post roads," Congress in 1866 first authorized the construction of bridges over the Mississippi by approving structures at Winona; Dubuque, Burlington and Keokuk, Iowa; Quincy , Illinois; Hannibal, Missouri; and St. Louis (the Eads Bridge). Ironically, as Congress considered the authorization of these bridges in 1866, the rail company which had built the original Mississippi River railroad bridge, the Chicago and Rock Island, went into foreclosure, the victim of continuous litigation with the steamboat companies since the bridge's opening in 1856. (Robert Edgar Riegel, The Story of the Western Railroads (New York: The Macmillan Company, 1926), pages 98-99.) The enabling legislation for these bridges

specified the minimum dimensions of any bridge erected over the Mississippi, stating: "If built as high bridges, they should be 50 feet above extreme high water, with spans not less than 250 feet in length, and one main or channel span not less than 300 feet in length; if built as draw bridges, they should have two draw openings of 160 feet in the clear, and the next adjoining spans should not be less than 250 feet and should be 10 feet above high water and 30 feet above low water." (F.B. Maltby, "The Mississippi River Bridges...," page 420.)

The purpose of this legislation, of course, was to preserve the freedom of navigation over the river by stipulating both location and manner of the bridge construction. "In the frequent acts declaring bridges post-routes the operation of the post office and post-roads clause is seen," stated congressional historian Lewis Haney in 1910, "and the importance of bridges in this connection contributed to their regulation. But, judging from the congressional debates and legislation, this regulation seems to have been based on a broad interpretation of neither of these constitutional provisions, but to have rested on the preservation of the commerce of waterways and the better promotion of the public trade and welfare in general." (Lewis H. Haney, A Congressional History of Railways in the United States: 1850 to 1887 (1908-10; reprint edition, New York: Augustus Kelley, Publisher, 1968), pages 238-39.)

Congress was keenly aware of the tremendous influence garnered by the steamship companies and in 1866 passed the River and Harbor Act. This legislation provided for "examining and reporting upon the subject of constructing railroad bridges across the Mississippi between St. Paul and St. Louis upon such plans of construction as will offer the least impediment to the navigation of the river." Major Warren prepared the survey and published his report, titled, "Bridging the Mississippi River between St. Paul and St. Louis," in the 1878 annual report of the Chief of Engineers, U.S.A. (F.B. Maltby, "The Mississippi River Bridges...," page 419.)

Unlike its 1872 general authorization of bridges over the Ohio River, Congress chose to review construction on the Mississippi on a bridge-by-bridge basis. With the River and Harbor Act for a general guideline, Congress ruled on subsequent structures using the cumbersome, expensive and time-consuming process of enacting individual legislation for each. Final approval of the bridge designs rested with the War Department.

9 Letter: Charles Perkins to John Forbes, 20 October 1883, Newberry Library, Burlington Northern Collection (8 C5.321).

10 Richard C. Overton, Burlington Route (New York: Alfred A. Knopf, 1965), page 192.

11 Letter: Charles Perkins to Albert Touzalin, 6 October 1885. Newberry Library, Burlington Northern Collection (8 C5.321).

12 Richard C. Overton, Burlington Route, pages 193-94.

13 R.E. Miles, A History of Early Railroading in Winona County (Winona, Minnesota: self-published, 1958), page 26.

14 R.E. Miles, A History of Early Railroading in Winona County, pages 26-27.

15 Winona Weekly Republican, 3 December 1890.

16 Winona Weekly Republican, 5 November 1890.

17 F.B. Maltby, "The Mississippi River Bridges...," pages 447-48.

18 Winona Daily Republican, 30 June 1890.

19 Record Book of the Winona Bridge Railway Company, Newberry Library, Burlington Northern Collection, (f8 W7.1).

20 Lewis H. Haney, A Congressional History of Railways in the United States, pages 234-35.

21 Congressional Record, 1873-74, page 346.

22 Congressional Record, 1883-84, page 4182.

23 It was the CB&N's parent company, the CB&Q, which provided the test case for the high court. The railroad intentionally broke an 1874 Iowa granger law to test its constitutionality; a lower court found against the railroad, as, eventually, did the Supreme Court. (Overton, Burlington Route, pages 113-14.)

24 Record Book of the Winona Bridge Railway Company, Newberry Library, Burlington Northern Collection, (f8 W7.1).

25 "The River Spanned," Winona Weekly Republican, 24 June 1891; "Swing Span of the Winona Bridge," Engineering News, 17 October 1891.

26 "Swing Span of the Winona Bridge," Engineering News, 17 October 1891.

27 "Long Span Bridges," Railroad Gazette, 2 May 1890, page 302; "The 520-Ft. Span, Interstate Bridge, Omaha, Neb.," Engineering News, 7 December 1893, page 448.

28 "The River Spanned," Winona Daily Republican, 20 June 1891; "Swing Span of the Winona Bridge," Engineering News, 17 October 1891.

29 "Swing Span of the Winona Bridge," Engineering News, 17 October 1891.

30 "The River Spanned," Winona Daily Republican, 20 June 1891; Winona Weekly Republican, 3 December 1890.

31 "Swing Span of the Winona Bridge," Engineering News, 17 October 1891.

32 "Swing Span of the Winona Bridge," Engineering News, 17 October 1891; Winona Weekly Republican, 3 December 1890.

33 Winona Daily Republican, 14 July 1890.

34 "Swing Span of the Winona Bridge," Engineering News, 17 October 1891.

35 "Swing Span of the Winona Bridge," Engineering News, 17 October 1891.

36 Winona Weekly Republican, 17 September 1890.

37 Winona Weekly Republican, 3 December 1890.

38 "Swing Span of the Winona Bridge," Engineering News, 17 October 1891.

39 Winona Weekly Republican, 15 October 1890; Winona Daily Republican, 12 September 1890.

40 Winona Weekly Republican, 15 October 1890.

41 Winona Daily Republican, 8 October 1890.

42 Winona Weekly Republican, 3 December 1890.

43 Winona Weekly Republican, 5 November 1890.

44 Winona Daily Republican, 19 January 1890.

45 Winona Daily Republican, 19 January 1890.

46 Winona Daily Republican, 19 January 1890.

47 Winona Daily Republican, 12 February 1891.

48 Winona Daily Republican, 2, 3, 13 April 1891.

49 Winona Weekly Republican, 1 April 1891.

50 Engineering News, 25 April 1891, page 389.

51 Engineering News, 27 June 1891, page 543.

52 Winona Daily Republican, 6 July 1891; Engineering News, 27 June 1891, page 543.

53 "The Winona Bridge," Engineering Record, 25 August 1894, pages 200-201.

54 Winona Weekly Republican, 24 June 1891; "The River Spanned," Winona Daily Republican, 20 June 1891.

55 F.B. Maltby, "The Mississippi River Bridges," page 473. Two other bridges - at Clinton, Iowa, and Rock Island, Illinois - predated the structure at Burlington, but both were composed partially of timber.

56 Burlington Daily Hawk-Eye, 19 November 1891.

57 C.H. Hudson, "The Original Construction of the Burlington Bridge in 1867-68," paper read before the Western Society of Engineers, 7 March 1894, page 257.

58 Letter: George Morison to T.J. Potter, 29 September 1885, Newberry Library, Burlington Northern Collection (33 1880 2.31).

59 George S. Morison, "Reconstruction of the Burlington Bridge," paper read before the Western Society of Engineers, 6 December 1893, page 600.

60 C.H. Hudson, "The Original Construction of the Burlington Bridge in 1867-68," page 258.

61 Letter: George Morison to T.J. Potter, 29 September 1885.

62 George S. Morison, "Reconstruction of the Burlington Bridge," page 604.

63 George S. Morison, "Reconstruction of the Burlington Bridge," page 605.

64 George S. Morison, "Reconstruction of the Burlington Bridge," page 605.

65 Theodore Cooper, "American Railroad Bridges," Transactions of the American Society of Civil Engineers, July 1889, page 42.

66 George S. Morison, "Reconstruction of the Burlington Bridge," page 605.

67 George S. Morison, "Reconstruction of the Burlington Bridge," page 601-02.

68 George S. Morison, "Reconstruction of the Burlington Bridge," page 603.

69 George S. Morison, "Reconstruction of the Burlington Bridge," page 602.

70 George S. Morison, "Reconstruction of the Burlington Bridge," page 603.

71 "Crushed by Rock," Burlington Daily Hawk-Eye, 12 January 1892.

72 George S. Morison, "Reconstruction of the Burlington Bridge," page 604.

73 Engineering News, 13 February 1892, page 162.

74 George S. Morison, "Reconstruction of the Burlington Bridge," page 605-06.

75 C.H. Hudson, "The Original Construction of the Burlington Bridge," page 257.

76 George S. Morison, "Reconstruction of the Burlington Bridge," page 606.

77 George S. Morison, "Comments on 'The Original Construction of the Burlington Bridge,'" page 271.

78 Henry Goldmark, "Comments on 'The Original Construction of the Burlington Bridge,'" page 271.

79 F.B. Maltby, "The Mississippi River Bridges," page 485.

80 "Bridges over River Fulfilled Dreams of Alton Pioneers," Alton Evening Telegraph, Centennial Edition, 15 January 1936.

81 Richard C. Overton, Burlington Route, pages 174, 231.

82 "On Certain New Work in and about St. Louis," Railroad Gazette, 15 December 1893.

83 Richard C. Overton, Burlington Route, pages 174-75; Benjamin Crosby, "St. Louis Extension of the St. Louis, Keokuk and North Western Railroad," Journal of the Association of Engineering Societies, 1 January 1895, pages 57-58.

84 "The Draw Span," Alton Daily Telegraph, 1 March 1894.

85 "Swing Span of the Alton Bridge," Engineering News, 14 June 1894.

86 George S. Morison, "Bridges Regarded as Commercial Tools," New York: Evening Post Job Print, 1 February 1890. Privately published pamphlet reproducing paper read by George Morison to St. Louis Commercial Club in March 1889, pages 2-3.

87 "The Bridge," Alton Daily Telegraph, 10 February 1892.

88 "The Bridge," Alton Daily Telegraph, 10 February 1892.

89 "Bridge Items," Alton Daily Telegraph, 13 February 1892.

90 "Work on the Bridge," Alton Daily Telegraph, 19 February 1892.

91 "The Bridge," Alton Daily Telegraph, 25 February 1892.

92 "Bridge Notes," Alton Daily Telegraph, 3 March 1892.

93 Alton Daily Telegraph, 20 & 29 February, 3 March, 23 April, 15 & 30 August, 20 September 1892.

94 "Bridge Notes," Alton Daily Telegraph, 29 September 1892.

95 "Pier No. 10," Alton Daily Telegraph, 20 September 1892.

96 "Bridge Work," Alton Daily Telegraph, 16 November 1892.

97 "A Matter of Importance to Alton," Alton Daily Telegraph, 15 February 1893.

98 "Bridge Work," Alton Daily Telegraph, 2 August 1893.

99 "Bridge Work Delayed," Alton Daily Telegraph, 30 December 1893.

100 "The Bridge," Alton Daily Telegraph, 15 February 1894.

101 "The Bridge," Alton Daily Telegraph, 15 February 1894.

102 "Drowned," Alton Daily Telegraph, 15 March 1894.

103 "A Success," Alton Daily Telegraph, 22 March 1894.

104 Engineering News, 12 April 1894; "The First Train," Alton Daily Telegraph, 5 April 1894.

105 "It Is Dedicated," Alton Daily Telegraph, 3 May 1894.

106 "It Is Dedicated," Alton Daily Telegraph, 3 May 1894.

107 "It Is Dedicated," Alton Daily Telegraph, 3 May 1894.

108 "Fatal Accident," Alton Daily Telegraph, 10 May 1894.

109 "Act of Congress Approved February 26, 1885," reprinted in The Memphis Bridge, George S. Morison, (New York: John Wiley & Sons, 1894), page 30.

110 "The Memphis Bridge," Engineering News, 12 May 1893, page 470.

111 Engineering News, 16 February 1889, page 144. As the Memphis Bridge was under construction, the magazine editorialized about this, stating: "A very few years ago a bridge across the lower Mississippi was deemed an engineering impossibility owing to the deep alluvial bottom and the requirements of river navigation that called for spans of dimensions then unheard of, if spans of any kind were to be permitted. But the advance in the art of founding bridge piers has been so rapid, and spans have been stretched to such a length, that old-time objections have been met, and engineers stand ready to bridge almost any space for which capital will provide the means. As to the Mississippi river at the present date - another bridge is under contract at St. Louis [Merchants' Bridge], one is started at Memphis another is chartered for Natchez, and now a company is organized for the construction of a bridge at New Orleans with every indication of being pushed to completion. For many years the broad Mississippi made a gap in all east and west railway communication, for a thousand miles and more of its course; but that day has passed, and in the next decade we may look for bridges wherever the traffic needs or the public may demand them."

112 George S. Morison, The Memphis Bridge, page 5.

113 George S. Morison, The Memphis Bridge, page 7.

114 George S. Morison, The Memphis Bridge, page 5.

115 "Act of Congress Approved April 24, 1888," reprinted in The Memphis Bridge, page 31.

116 George S. Morison, The Memphis Bridge, page 5; George S. Morison, The So-Called Quarantine at San Francisco, New York: Evening Post Job Print, 1889

117 George S. Morison, "Argument for Amendment of [Memphis Bridge] Charter," 4 January 1890. Unpublished report to War Department, reprinted in The Memphis Bridge, page 39.

118 George S. Morison, "Argument for Amendment of [Memphis Bridge] Charter."

119 George S. Morison, "Argument for Amendment of [Memphis Bridge] Charter."

120 George S. Morison, "Report of August 2, 1888." Unpublished report to George H. Nettleton, President, Kansas City & Memphis Railway and Bridge Company, reprinted in The Memphis Bridge, page 37.

121 Contract between Kansas City & Memphis Railway and Bridge Company and the War Department, 23 August 1888, reprinted in The Memphis Bridge, page 32.

122 George S. Morison, "Construction of the River Piers for the Memphis Bridge," Engineering News, 28 December 1893, page 509.

123 George S. Morison, The Memphis Bridge, page 7. Morison reported to Nettleton in his initial report: "Comparing the two structures when once completed, I think the Three Span Bridge would be the better one for the railroads. It would be a perfectly simple structure, the expense for maintaining which would be a minimum. It would involve no complicated details, and as it consists simply of straight trusses resting on masonry piers, would be subject to a minimum degree of disturbance should any slight settlement occur in the foundations. In brief, it would fulfill the universal requirement that the simplest structure is the best." (George S. Morison, "Report of February 15, 1887." Unpublished report to George H. Nettleton, President, Kansas City & Memphis Railway and Bridge Company.)

124 George S. Morison, The Memphis Bridge, page 17.

125 "The Principal Bridges of the World - A Comparison," The Engineer, 24 May 1918, page 441. "This structure is criticized as being both unsightly, uneconomical of material, its lay out of spans unfortunate, and its truss depth too small. The spans were however, laid out to meet the desires of the War Department. There is no symmetry about the design, and it is not happy to have one end of the structure formed into an anchor arm of the through type and the other end as a deck span below the level of all the other openings."

126 George S. Morison, The Memphis Bridge, page 17.

127 George S. Morison, "The Continuous Superstructure of the Memphis Bridge," Transactions of the American Society of Civil Engineers, September 1893, page 574; "Details of the Anchor Span and Cantilevers for the Memphis Bridge," Engineering News, 16 June 1892, page 611.

128 George S. Morison, The Memphis Bridge, page 17.

129 Engineering News, 19 May 1892, page 521.

130 George S. Morison, The Memphis Bridge, page 18.

131 George S. Morison, "The Continuous Superstructure of the Memphis Bridge," page 576.

132 George S. Morison, The Memphis Bridge, page 25.

133 George S. Morison, Specifications for Superstructure of the Memphis Bridge, 4 January 1890.

134 George S. Morison, The Memphis Bridge, page 21.

135 George S. Morison, The Memphis Bridge, page 21; "Recent Construction in Railway Bridges," The Engineering and Building Record, 23 August 1890, In a paper presented to the Engineers' Club of Cleveland, James O. Ritchie called the specifications for the Memphis Bridge "the most complete and systematic, and on account of the minuteness of their details they are not likely to be evaded."

136 George S. Morison, The Memphis Bridge, page 21.

137 George S. Morison, The Memphis Bridge, page 21.

138 George S. Morison, The Memphis Bridge, page 8.

139 George S. Morison, The Memphis Bridge, page 6.

140 George S. Morison, The Memphis Bridge, page 9.

141 George S. Morison, "Construction of the River Piers for the Memphis Bridge," page 510.

142 George S. Morison, The Memphis Bridge, page 10.

143 "The Memphis Bridge," Engineering News, 12 May 1892, page 470.

144 George S. Morison, "Construction of the River Piers for the Memphis Bridge," page 510.

145 "She Is Gone: A Towboat Wrecked on the Bridge," Memphis Appeal, 11 February 1890. The newspaper reported the wreck: "The disaster occurred just before the mill whistles blew for 7 o'clock. The Eads sighted Memphis about daylight. The morning was clear, and presently the sun rose and the placid bosom of the river glittered like a silver shield. Pilot Gus Hiner was at the wheel... The Eads was towing six freight barges, loaded with about 8,000 tons of grain, flour and packages, and a fuel barge. As she came into the current, opposite the elevator, the east wind wafted the smoke from the chimneys and stacks of the city over the river. The atmosphere under the bluffs was lighter than the smoke, and it settled down on the water like a fog. The pilot could see the banks when he passed the wharfboat, but could not distinguish objects on the water. The artificial fog became denser as the mills and factories in Fort Pickering added their quota of smoke, and the pilot on the Eads lost his bearings.

He thought he was opposite the Bohlen-House Icehouse, when only a few hundred yards above the bridge site...

The channel of the river at the bridge is between the Tennessee shore and Pier 2, and Hiner thought he had plenty of room. He had the boat headed toward this bank, and was perfectly easy in his mind when Capt. Davis entered. Just at that moment the smoke lifted and the break of the current over the submerged top of the pier was seen on the starboasrd side of the bow, perhaps 100 feet away. There was but one course to pursue. If the boat or her tow drifted against the hidden pier a wreck was inevitable. The pilot called to the engineer for the full stroke of the powerful engines, and swung the nose of the boat quartering across the stream. The remorseless and practically irresistible current swept the doomed boat and her tow nearer and nearer to the pier. The pilot and Captain held their breath and almost prayed to the engines which were making the vessel tremble in every timber, to drive her past the danger line. Even if she could get far enough for the blow to be a glancing one, or if the wheel alone suffered, they would be thankful...

The boat was drawing about six feet of water and struck the pier, which was submerged about two feet, amidships. The engines were smashed and the furnace knocked to pieces. The lower deck caught fire, and when Pilot Townsend got his wife out of the cabin a sheet of flame was poking out of the front of the boat. Those members of the crew who were nearest the tow clambered over into the barges; others who were cut off by fire siezed life floats and planks and sprang overboard; others rushed off for the life boat; others hurried to the hurricane deck and a few jumped into the fuel barge. The boat went to pieces immediately and the freight barges drifted down the river, leaving the water around the pier black with fragments of the wreck, floating baggage and human beings floating for life in the icy current.

Before the Eads had ceased grinding out her life against the rock pier, the tugs were steaming forth to the rescue, and skiffs, manned by strong and willing arms, were darting out from both banks. There were thirty-four people on board, and the fact that only six lives were lost speaks well for the rescuers. Only one body was found."

146 George S. Morison, "Construction of the River Piers for the Memphis Bridge," pages 509-10.

147 George S. Morison, "Construction of the River Piers for the Memphis Bridge," pages 510.

148 George S. Morison, The Memphis Bridge, page 16.

149 George S. Morison, The Memphis Bridge, page 16.

150 George S. Morison, The Memphis Bridge, page 22.

151 George S. Morison, The Memphis Bridge, pages 22-23.

152 George S. Morison, The Memphis Bridge, page 23.

153 George S. Morison, The Memphis Bridge, page 23.

154 George S. Morison, The Memphis Bridge, pages 22-24.

155 George S. Morison, The Memphis Bridge, page 24.

156 George S. Morison, The Memphis Bridge, page 24.

157 George S. Morison, The Memphis Bridge, page 24.

158 "Novel Pageantry: Yesterday's Great Parade," Memphis Appeal-Avalanche, 13 May 1892.

159 "A World's Wonder: The Great Bridge at Memphis," Memphis Appeal-Avalanche, 13 May 1892.

160 "They Built the Bridge," Memphis Appeal-Avalanche, 13 May 1892.

161 Memphis Appeal-Avalanche, 15 May 1892; Engineering News, 26 May 1892, page 545.

162 George S. Morison, The Memphis Bridge, pages 226-28.