

THE CAIRO BRIDGE.

REPORT

OF
STUYVESANT FISH, PRESIDENT.

TO THE

BOARD OF DIRECTORS OF THE CHICAGO, ST. LOUIS & NEW ORLEANS R. R. CO.

FEBRUARY 24, 1892.

REPORT

OF
GEORGE S. MORISON, CHIEF ENGINEER,

TO THE

PRESIDENT OF THE CHICAGO, ST. LOUIS & NEW ORLEANS R. R. CO.

OCTOBER 1, 1891.

1892.

THE CAIRO BRIDGE.

New York, February 24, 1892.

To the Board of Directors of the Chicago, St. Louis and New Orleans Railroad Company:

GENTLEMEN:—The opening on the 29th of October, 1880, of your bridge across the Ohio River, for traffic, marked the completion of the railroad from the upper Mississippi and the Great Lakes to the Gulf of Mexico, for which Congress, more than forty years ago, made a grant of lands, and for the construction of a part of which the States of Louisiana, Mississippi, Tennessee and Kentucky chartered your Company and those to whose franchises it has succeeded. It is unnecessary at this time to refer to the early records for evidence of the efforts of your predecessors to forge their respective links in this chain of communication; suffice it to say that in our time the work has been finished.

As you are aware, the Illinois Central Railroad Company was chartered by the State of Illinois, in 1851, for the purpose of building that part of the line, laid out by the Federal Congress, which lies north of the Ohio. The annual reports of the directors of that Company to their shareholders show that this purpose of their corporation was never lost sight of. The following extracts from the reports made to the then president of the Illinois Central Railroad Company, Mr. William H. Osborn, by Captain, afterward General, George B. McClellan, Vice-President, and by Mr. James C. Clarke, then Master of Transportation, will suffice: Under date of January 1, 1859, Vice-President McClellan said:

"In accordance with your instructions, I, last summer, passed over most of the route from Cairo to New Orleans and Mobile. The prompt completion of these lines, of which no doubt can be entertained, will add greatly to our business."

While Mr. Clarke said:

"The Company's natural connections are with those roads leading to Mobile and New Orleans, and the early completion, probably not later than August next, of a through connection with those cities cannot fail to confer upon us substantial bene-

fits. The value of a great through traffic north and south by rail is yet unknown but it is reasonable to suppose that passengers, and the more costly freights, will seek the most direct and least expensive route, to the exclusion of that by the river, which is circuitous and uncertain. As this is the last time I shall submit a report upon the Operating Department of this road, I desire to record my opinion that the north and south traffic of the Mississippi Valley by rail will, ere long, give such results as will surprise the shareholders, and cause them to regret the sacrifice they have anticipated to its disposing of their stock at a time of temporary distrust and depression."

Although the advent of war postponed the realization of Mr. Clarke's expectations, his subsequent success in building up the business of your railroad, and his more recent achievements in connection with his present duties as President of the Mobile & Ohio Railroad Company, fully vindicate the opinion set forth by him at that early day.

In 1872, Col. Henry S. McComb, then President of the Southern Railroad Association, which was operating the New Orleans, Jackson & Great Northern and the Mississippi Central Railroads, effected a negotiation with Mr. Wm. H. Osborn, then one of the directors of the Illinois Central Railroad Company, which resulted in the extension of the Mississippi Central Railroad from Jackson, Tennessee, to Fillmore, a point in Ballard county, Kentucky, nearly opposite to Cairo, and the establishment of a transfer ferry between those points. The circumstances attending the subsequent bankruptcy and the sale under foreclosure, in 1877, of the New Orleans, Jackson & Great Northern and of the Mississippi Central railroads, and of the consolidation of the corporations which purchased those railroads, under the title of the Chicago, St. Louis & New Orleans Railroad Company, are too familiar to need repetition.

The question of bridging the Ohio River took definite shape in the year 1879, when, at the instance of Mr. W. K. Ackerman, President of the Illinois Central Railroad Company, soundings, surveys and estimates were made. From that time on the region of the river was watched carefully and repeated negotiations had between committees of your Board and that of the Illinois Central Railroad Company.

An Act of the Legislature of the Commonwealth of Kentucky, entitled "An Act to authorize the Chicago, St. Louis & New Orleans R. R. Co., and the Illinois Central R. R. Co., or either of them separately, to build and maintain a railroad bridge across the Ohio River," having been approved March 29, 1886, was formally accepted by the Chicago,

St. Louis & New Orleans R. R. Co. on April 1, 1886, and a certificate to that effect lodged with the Secretary of State of the Commonwealth.

Work was commenced by the Chicago, St. Louis & New Orleans Railroad Company on the approach to the bridge shortly thereafter, and detailed plans for the whole work were prepared by Messrs. George S. Morison and E. L. Corthell, in conjunction with Mr. E. T. Jeffery.

At a meeting of your Board held March 25, 1887, the following preamble and resolutions were unanimously adopted:

"WHEREAS, under powers granted by the United States and the several States hereinafter named, a trunk line of railway from the Lakes to the Gulf, passing through Illinois, Kentucky, Tennessee, Mississippi and Louisiana, has been constructed and is now in operation, save the space across the Ohio River at or near Cairo;

AND WHEREAS, by Acts of Congress in 1848 and subsequently, the construction of a trunk line from the Lakes to the Gulf was encouraged as a great national thoroughfare by grants of lands to the several States, to be used for the purpose of aiding its construction;

AND WHEREAS, in a popular convention, held in the City of New Orleans on the 6th of April, 1851, resolutions were adopted requesting the States of Louisiana, Mississippi, Tennessee and Kentucky to aid in the establishment of a trunk railroad from the Gulf of Mexico to the Great Northern Lakes, and in pursuance thereof the State of Louisiana, in 1852, incorporated the New Orleans, Jackson & Great Northern R. R. Co., for the purpose of building 'a continuous line of communication between New Orleans and the northern and western portions of the Confederacy,' on such a scale as to be a 'main trunk line.' And the State of Mississippi declared on March 11, 1852, that the construction of such road 'from the City of New Orleans, passing through the State of Mississippi' * * * 'is deemed a work of great public importance' * * * 'and should be encouraged by legislative sanction.' And the State of Tennessee, on February 25, 1852, in the preamble of an Act granting it power to pass through said State, says:

"WHEREAS, by resolutions adopted by a railroad convention begun and held on the 6th of April, 1851, at the City of New Orleans, in the State of Louisiana, it appears to this General Assembly that the rights of way and charter for a railroad, to extend northward from said City of New Orleans through a part of the States of Louisiana, Mississippi, Tennessee and Kentucky, to the Ohio River, having in view to connect the same with the proposed great North and South Central Railroad of Illinois, are currently collected from the legislatures of the State through which it is to pass' * * * and 'it is deemed a matter of vital importance to this State that a direct communication by railroad to the Gulf of Mexico and the Great Northern Lakes be established;'

AND WHEREAS, that part of said trunk line from Chicago to the Ohio River at Cairo was built and is now owned by the Illinois Central Railroad Company, under

THE CAIRO BRIDGE.

Act of Congress approved Sept. 20, 1850, and Act of State of Illinois approved Feb. 10, 1851; and that part of said trunk line from New Orleans, La., to Canton, Miss., was constructed by said New Orleans, Jackson & Great Northern R. R. Co.; and that part from Canton, Miss., to the Ohio River, opposite Cairo, was constructed by a corporation known as the Mississippi Central R. R. Co., said Company being incorporated in Mississippi by Act approved March 10, 1852, and by the State of Tennessee, by Act approved Nov. 20, 1853; and by Act of Kentucky approved March 18, 1872:

AND WHEREAS, the Chicago, St. Louis & New Orleans Railroad Company now owns said roads from New Orleans, La., through Louisiana, Mississippi, Tennessee and Kentucky, and is a corporation of each and all of said States, with all the powers, rights and franchises of the other two corporations, being incorporated in Louisiana by Act approved March 13, 1878; in Mississippi by Acts approved Feb. 27, 1878, and March 1, 1882; in Tennessee by Act approved April 7, 1881, and in Kentucky by Act approved March 27, 1886, leaving nothing remaining to be done to carry out the original object of its creation, except the construction of a bridge across the Ohio River:

AND WHEREAS, the State of Kentucky (whose territory extends across the Ohio River) has, by an Act entitled "An Act authorizing the Chicago, St. Louis & New Orleans Railroad Company and the Illinois Central Railroad Company, or either of them separately, to build and maintain a railroad bridge across the Ohio River," approved March 29, 1886, again affirmed the right and purpose of this through trunk line, and has therein expressly authorized the construction and maintenance of such bridge:

AND WHEREAS, this Company has heretofore, to-wit, on the 1st day of April, 1886, accepted said Act, and has, within the time required by the sixth section of said Act, filed with the Secretary of State of Kentucky a copy of the resolution of the Board of Directors accepting said Act:

AND WHEREAS, this Company has also, as required by said Act, had the work on said bridge or its approaches begun in good faith within one year from the passage of said Act, and has continued and now continues in good faith its construction without unnecessary delay, in accordance with the provisions of said Act, and intends to have said bridge in condition for use within six years from date of said Act; now, therefore, it is

RESOLVED, That this Company, to-wit, the Chicago, St. Louis & New Orleans Railroad Company, doth hereby accept the General Act of Congress entitled, "An Act to authorize the construction of bridges across the Ohio River, and to prescribe the dimensions of the same," approved December 17, 1872; and an Act of Congress amending said last-named Act, being entitled "An Act supplementary to an Act approved December 17, 1872, entitled 'An Act to authorize the construction of bridges across the Ohio River and to prescribe the dimensions of the same,'" approved February 14, 1883; and that a copy of the acceptance by this Company of said Acts of Congress, duly certified by the secretary of this Company under its seal, be filed in the office of the Secretary of State of the United States of America, and duplicate

copies thereof, and of the Act of Kentucky aforesaid, be delivered to the Honorable, the Secretary of War of the United States.

RESOLVED, That the Vice-President of this Company be and he is hereby authorized and requested for, on behalf of, and in the name of this Company, to make application to the Honorable the Secretary of War of the United States for his approval of the plans, profile and other papers required by the Act of December 17, 1872, aforesaid, and the supplementary Act of February 14, 1883, aforesaid, in reference to the proposed bridge across the Ohio River aforesaid, and that he submit to said Secretary all papers required by either of said Acts of Congress, and also such facts and papers as are required by the rule established by the Secretary of War, dated July 31, 1886; and that the recommendations of the Board of Army Engineers, dated May 7, 1886, and approved by the Chief of Engineers June 7, 1886, have been complied with in the maps, plans and profile so submitted.

RESOLVED, That the Vice-President of this Company, together with the application to the Secretary of War aforesaid, be requested to submit also copies in duplicate of the charters of this Company in Kentucky, Tennessee, Louisiana and Mississippi, certified by the several Secretaries of State and under the seal of the respective States; copies of the organization of this Company under said charters and of its acceptance of each thereof, certified by the secretary of this Company under its common seal; copies of minutes of this Company showing its present officers, their names and residences; copies in duplicate of the design and drawings of the proposed bridge and piers; a map of the location, showing, as required by said Acts of Congress, the topography of banks and bottom of said river and shore lines at high and low water; maps as required by said Acts, showing contour of bed of said river, width of river, the course and direction of currents at high and low water, and at least one intermediate stage; and that the Vice-President of this Company, in its name and on its behalf, be and he is hereby fully authorized and empowered to do all such acts and deeds, sign all such papers as are or may be necessary to secure the approval of the Secretary of War of said proposed bridge; and that he be authorized to enter into all such undertakings as are or may be required under said Act of the State of Kentucky and said Acts of Congress aforesaid, to facilitate the construction of said bridge so authorized and approved.

RESOLVED, Further, that the Vice-President, in behalf and in the name of this Company, may select E. L. Corbitt, or any other person whom he may deem best, to present the papers and plans in person to the Secretary of War, and to do such other acts as may be necessary in and about the same.

The foregoing action of the Board of Directors was unanimously ratified by the stockholders at their Annual Meeting held in New Orleans April 6, 1887.

At a meeting of your Board, held April 14, 1887, the Vice-President reported that in accordance with the resolution adopted March 25, 1887, he had made application to the Secretary of War for his approval of the plans and other papers relating to the proposed bridge at Cairo, and

submitted a letter from the Secretary of War, dated April 1, 1887, enclosing his approval (of the same date) of the design, drawings and maps submitted by this Company, of which the following are copies:

— WAR DEPARTMENT,

WASHINGTON CITY, April 1, 1887.

SIR:—I have the honor to enclose for retention by the Chicago, St. Louis & New Orleans Railroad Company, a duly executed copy of an instrument issued in duplicate, indicating my approval, under certain specified conditions, of the plans and location, as shown on the accompanying maps of a bridge to be constructed across the Ohio River under the provisions of the Acts of Congress approved December 17, 1872, and February 14, 1883, authorizing the construction of bridges across the Ohio River.

Very respectfully, your obedient servant,

WM. C. EADSWORTH, Secretary of War.

E. L. CORBITT, Esq., Room 79, No. 34 Nassau Street, N. Y.

(Enclosure.)

WHEREAS, by an Act of Congress approved December 17, 1872, entitled, "An Act to authorize the construction of bridges across the Ohio River and to prescribe the dimensions of the same," it was enacted that any persons or corporations, having lawful authority therefor, may hereafter erect bridges across the Ohio River for railroad or other uses upon compliance with provisions contained in said Act.

AND WHEREAS, by Section Four of an Act supplementary to the Act aforesaid, approved February 14, 1883, it was further enacted that any person, company or corporation authorized to construct a bridge across the Ohio River shall submit to the Secretary of War, for his examination, a design and drawings of the bridge and piers, and a map of the location, giving, for the space of at least one mile above and one mile below the proposed location, the topography of the banks of the river, and the shore lines at high and low water. This map shall be accompanied by others, drawn on the scale of one inch to two hundred feet, giving, for a space of one half a mile above the line of the proposed bridge and a quarter of a mile below, an accurate representation of the bottom of the river by contour lines two feet apart, determined by accurate soundings, and also showing over the whole width of this part of the river the force and direction of the currents at low water, at high water, and at least one intermediate stage, by triangulated observations on suitable floats. The maps shall also show the locations of other bridges in the vicinity, and shall give such other information as the Secretary of War may require for a full and satisfactory understanding of the subject. Said maps and drawings shall be referred to a Board of Engineers for examination and report, which Board shall personally examine the site of the proposed bridge, and shall hold a public session, at some convenient point, to hear all objections thereto, of which public session due notice and invitation to be present shall be given to all interested parties; and if said

Board of Engineers reports that the site is unfavorable, the Secretary of War shall be authorized, on the recommendation of said Board, to order such changes in the bridge or its piers, or such guarding dykes, or other auxiliary works as may be necessary, at the expense of the proprietors or managers of such bridge or piers, and other works for the security of navigation; and the proposed bridge shall only be a legal structure when built as approved by the Secretary of War.

AND WHEREAS, The Chicago, St. Louis & New Orleans Railroad Company, a duly organized corporation having authority to build a railroad bridge across the Ohio River at Cairo, in the State of Illinois, pursuant to the Acts of Congress aforesaid regulating the construction of bridges across the Ohio River, and having accepted the provisions of said Acts, has submitted for the approval of the Secretary of War the design and drawings of its proposed bridge and piers, and map of location of the same, together with maps giving a representation of the bottom of the river and the force and direction of the currents;

AND WHEREAS, the Chief of Engineers, United States Army, reports that said design, drawings and maps, in his opinion, conform to the requirements of the Board of Engineers, and also with the provisions of the Act of December 17, 1872, and the supplementary Act of February 14, 1882, authorizing the construction of bridges across the Ohio River;

NOW, THEREFORE, I, William C. Endicott, Secretary of War, having examined and considered the design, drawings and maps submitted by the Chicago, St. Louis & New Orleans Railroad Company, as aforesaid and hereto annexed, do hereby approve the same. But it is understood and agreed that this approval is given upon the express conditions following:

1. That the said bridge shall be built at the point indicated in the map of location submitted, and constructed in accordance with the design and drawings hereto approved, and the laws regulating the construction of bridges across the Ohio River.
2. That should any change be deemed necessary to be made in the design and drawing of said bridge during the progress of construction, such change shall be subject to the approval of the Secretary of War.

Witness my hand this first day of April, 1887.

(Signed)

W. C. ENDICOTT,

Secretary of War.

This instrument is also executed by the Chicago, St. Louis & New Orleans Railroad Company, by Stayveant Fish, its Vice-President, thereto lawfully authorized, this thirty-first day of March, 1887, in testimony of the acceptance by said Railroad Company of the conditions herein imposed.

(Signed)

STAYVEANT FISH,
Vice-President of the Chicago, St.
Louis & New Orleans Railroad
Company.

In presence of:

(Sgd.) E. T. H. GUNSON,

" W. E. RUTMAN.

Your Board then

"Resolved, That the action of the Vice-President be approved, and that the papers and design, drawings and maps be placed on file, together with duplicates or copies of all papers submitted to the Secretary of War, as follows:

1. A certified copy of the Act of Kentucky, being "Chapter 623, an Act relating to the Chicago, St. Louis & New Orleans Railroad Company, and incorporating said Company," approved March 27, 1880.

2. A certified copy of the Act of Kentucky, approved March 29, 1886, entitled, "An Act authorizing the Chicago, St. Louis & New Orleans Railroad Company, and the Illinois Central Railroad Company, or either of them separately, to build and maintain a railroad bridge across the Ohio River," which paper bears an indorsement, showing that it had been submitted to the Board of Directors of the C., St. L. & N. O. Co., on April 1st, 1886.

3. A certificate by the Secretary of State of Kentucky of the filing of the resolutions of this Company and of the I. C. Co., accepting the Act of March 29, 1886.

4. Certified copy of the Act of Mississippi, being "An Act ratifying the organization of the Central Mississippi R. R. Co., and its consolidation with the New Orleans, Jackson & Northern R. R. Co. into the Chicago, St. Louis & New Orleans R. R. Co., and incorporating said last-named Company," approved February 27, 1878.

5. Certified copy of the Act of Mississippi, being "An Act supplemental to the Act entitled 'An Act ratifying the organization of the Central Mississippi R. R. Co., and its consolidation with the New Orleans, Jackson & Northern R. R. Co. into the Chicago, St. Louis & New Orleans R. R. Co., and incorporating said last-named Company,'" approved March 1, 1882.

6. Certified copy of an Act of Tennessee, being "An Act ratifying the organization of the Central Mississippi R. R. Co., and its consolidation with the New Orleans, Jackson & Northern R. R. Co. into the Chicago, St. Louis & New Orleans R. R. Co., and declaring the incorporation of the last-named Company and its powers," approved April 7, 1881.

7. Certified copy of the Act of Louisiana, "An Act ratifying the organization of the New Orleans, Jackson & Northern R. R. Co., and its consolidation with the Central Mississippi R. R. Co. into the Chicago, St. Louis & New Orleans R. R. Co., and incorporating the said last-named Company," approved March 23, 1878.

8. Certificate of the Secretary of State of Kentucky, dated March 23, 1887, that the Chicago, St. Louis & New Orleans Railroad Company had filed in his office its written acceptance of the Act of March 29, 1886, and that the Chicago, St. Louis & New Orleans Railroad Company had commenced the work upon the approaches of the bridge contemplated in said Act in good faith.

9. Printed copy of letter of W. K. Ackerman, President I. C. Co., January 15, 1885, to which is attached report of Judge Fentress, showing the legislation in different States which constitutes the charters of the Chicago, St. Louis & New Orleans Railroad Company.

10. Act of Congress, December 17, 1872, authorizing the construction of bridges across the Ohio River, and prescribing the dimensions of the same.

11. Act of Congress, February 14, 1882, being an Act supplemental to the foregoing.

12. Report of Board of Engineers, May 7, 1886, on the House Bill No. 6047.

13. Application of Stayveant Fish, Vice-President of this Company, to the Secretary of War, March 26, 1887, transmitting papers, maps, and plans, and asking his approval thereof.

14. Statement of legislation from printed volume of laws and documents, 1882, relating to the organization of the Company, and from the minute book of this Company, certified to by the Secretary.

15. Letter of E. L. Corthell to John Tweedale, Chief Clerk of the War Department, March 31, 1887, quoting from the Illinois Constitution, showing that Kentucky has jurisdiction over the entire width of the Ohio River at Cairo, Illinois.

At the same meeting, Mr. E. T. Jeffery was appointed General Manager of the Chicago, St. Louis & New Orleans Railroad, and authorized to proceed with the construction of the bridge, and to act as engineer thereof, or to appoint some other person in that capacity, and the form of contract with the Union Bridge Co., and letters of Messrs. George S. Morison and E. L. Corthell, of March 25, 1887, addressed to Mr. Jeffery, recommending that the contract for the construction of the bridge be let to the Union Bridge Company, and other papers, were submitted, and authority given for the execution of the contract, to be drawn by the General Solicitor of the Company, Hon. James Fentress, on the basis of the provisional agreement entered into by Mr. Jeffery, subject to the ratification of the Board.

At your meeting held June 18, 1890, the following action was had:

"WHEREAS, Section VI, of the Act of the State of Kentucky, entitled 'An Act authorizing the Chicago, St. Louis & New Orleans Railroad Company and the Illinois Central Railroad Company, or either of them separately, to build and maintain a railroad bridge across the Ohio River,' approved March 29, 1886, requires that 'it shall be the duty of such Companies or Company to have the work upon said bridge or its approaches begun in good faith, and to so continue its construction without unnecessary delay within one year from the passage of this Act, and to have said bridge in condition for use within six years, and any failure herein shall at once work a forfeiture of all rights herein, and this Act from said date of said failure stand and be of no effect.'

AND WHEREAS, this Company did, by resolution of its Board of Directors, adopted April 1, 1886, accept said Act, and has in good faith begun and completed said bridge across the Ohio River and its approaches thereto so that it is in condition for use within the period named:

THEREFORE, as it resolves, That the Secretary is hereby directed, on behalf of

THE CAIRO BRIDGE.

this Company, to file with the Secretary of State of the Commonwealth of Kentucky a certificate to be drawn by the General Solicitor, which shall express the above facts."

At your meeting held on the 17th September, 1890, the Secretary reported that he had complied with these instructions, and submitted a receipt from the Secretary of State of Kentucky, of which the following is a copy:

RECEIVED July 9, 1890, of A. G. Hackstaff, Secretary of the Chicago, St. Louis & New Orleans Railroad Company, a certificate showing that said Railroad Company had complied with the provisions of an Act passed by the General Assembly of Kentucky, entitled, "An Act authorizing the Chicago, St. Louis & New Orleans Railroad Company and the Illinois Central Railroad Company, or

either of them separately, to build and maintain a railroad bridge across the Ohio River," approved March 29, 1884; also a certified copy of an extract from the minutes of a meeting of the Board of Directors of said Chicago, St. Louis & New Orleans Railroad Company, held in the city of New York June 18th, 1890, setting forth the facts contained in the certificate above indicated.

GEO. M. ADAMS,
Secretary of State."
By WILLIAM L. BROWN,
Asst. Sec'y of State.

Your attention is invited to the able and exhaustive report of Mr. George S. Morison, Chief Engineer of the Cairo Bridge, upon the details of the work.

Since the figures as to cost given in Mr. Morison's report were made

up, the work of filling the approaches with earth has continued, and the cost to your Company of the bridge proper, and of the approach on the Kentucky side of the river, down to December 31, 1891, including interest during construction, has been \$2,649,485.95. The Illinois Central Railroad Company has expended upon the approach on the Illinois shore, \$374,091.16. The total outlay has, therefore, been \$3,023,577.11.

It is estimated that 46,400 cubic yards of earth will be required to fill the remainder of the trestle approach on the Kentucky shore, and 269,300 yards on the Illinois shore.

Respectfully submitted,

STUYVESANT FISH, President.

THE CAIRO BRIDGE.

A REPORT

TO STUYVESANT FISH, PRESIDENT CHICAGO, ST. LOUIS AND NEW ORLEANS RAILROAD COMPANY.

BY

GEORGE S. MORISON, CHIEF ENGINEER OF THE CAIRO BRIDGE.

SUBJECTS.

	Page.
I. Preliminary Narrative.....	9
II. General Description.....	9
III. Substructure.....	10
IV. Superstructure.....	13
V. Approaches.....	13
VI. Cost.....	14

APPENDICES.

A. List of Engineers, Employees and Contractors.....	17
B. Ohio River Bridge Law.....	18
C. Kentucky Charter.....	20
D. Contract with War Department.....	21
E. Report February 3rd, 1887.....	22
F. Report March 23rd, 1887.....	23
G. Contract May 4th, 1887.....	25
H. Contract March 9th, 1889.....	29
I. Record of Sinking Caissons.....	42
K. Tests of Full Size Eyebars.....	52

1. General Map; Scale 1 to 30,000.	
2. General Map; Scale 1 to 10,000.	
3. General Elevation.	
4. Profile and Alignment.	
5. Piers I, XII and XIII.	
6. Pier VIII.	
7. Pier IX.	
8. Caissons.	
9. Profile showing Stratification on Bridge Line.	
10. Diagram showing Rate and Progress in Sinking Caissons.	
11. Record of Water Stage.	
12. Strain Sheets of 518 ft. Through Span and 249 ft. Deck Span.	
13. 518 ft. Through Span. General Elevation.	
14. " " Panel Point 0.	
15. " " Panel Points 1 and 2.	
16. " " " 3, 4 and 5.	
17. " " " 6 and 7.	
18. " " " 8 and Section.	
19. " " End Elevation.	
20. 400 ft. " Strain Sheet.	

PLATES.

21. 400 ft. Through Span. General Elevation.	
22. " " Panel Point 0.	
23. " " Panel Points 1 and 2.	
24. " " " 3 and 4.	
25. " " " 5 and 6.	
26. " " " 7 and Section.	
27. 249 ft. Deck Span. General Elevation and Plan.	
28. " " Panel Point 0 and Stringer Supports, Piers II and IX.	
29. " " Panel Point 1.	
30. " " Panel Points 2, 3 and 4.	
31. " " Section and End Elevation.	
32. Strain Sheets of 150 ft. Deck Span and 100 ft. 3 in. Deck Span.	
33. 150 ft. Deck Span. General Elevation. Plan and Packing of Bottom Chord.	
34. " " Panel Points L 0 on tangent and L 6 on Pier XIII.	
35. " " " 0 on curve and L.	
36. " " " 5 and U 6 on Pier XIII.	
37. Details 100 ft. 3 in. Deck Span.	

CHICAGO, October 1st, 1891.

STUYVESANT FISH, Esq.,

President Chicago, St. Louis & New Orleans R. R. Company.

DEAR SIR:—

I submit the following Final Report in relation to the construction of the bridge across the Ohio River at Cairo.

Yours truly,

GEOORGE S. MORISON,

Chief Engineer Cairo Bridge.

THE CAIRO BRIDGE.

I.

PRELIMINARY NARRATIVE.

On the 24th of December, 1886, Mr. E. T. Jeffery, then Manager of the Chicago, St. Louis & New Orleans Railroad Company, addressed a letter to me, advising me that his Company had in contemplation the construction of a bridge at Cairo, Illinois, over the Ohio River, and stating that when the plans were prepared he would like to submit them to two engineers, consisting of myself and Mr. E. L. Corthell. Owing to absence, this letter did not reach me until January 4th, 1887, when I replied, stating that the work was one which I should be glad to take part in, Mr. Corthell a gentleman I should be very happy to be associated with, and that I should be happy to do the work. To this letter Mr. Jeffery replied on the 7th of January, stating that he expected to have the preliminary plans within a week or ten days, and on the 20th of January, the plans were forwarded to my New York office by express.

These plans were examined by Mr. Corthell and myself and after some unimportant further correspondence, a preliminary report was made by us, dated February 3, 1887, which expressed our general views of the manner in which it seemed expedient that the bridge be built. This preliminary report is printed in Appendix E.

On February 8, 1887, Mr. Jeffery, in acknowledging receipt of the preliminary report, noted the suggestions contained therein and proposed that we meet at Cairo at as early a date as possible. Various business appointments, however, already made by Mr. Jeffery, Mr. Corthell and myself, prevented this being done immediately, but on the 11th of March I visited Cairo, coming from the south, and there met by ap-

pointment Mr. Jeffery and Mr. Corthell, Mr. Field of the Union Bridge Company being also of the party. We remained at Cairo three days, during which time we looked over the situation, and as the result of the examination then made, we prepared a second report, dated March 23, 1887, which is printed in Appendix F.

Your Company decided to proceed with the construction of the bridge under the provisions of the general law providing for bridges on the Ohio River. This law is printed in Appendix B.

The Ohio River is entirely in the Commonwealth of Kentucky, the low-water shore line of the north bank being the northern boundary of that State, and the bridge was built under the provisions of a Kentucky charter, which is printed in Appendix C. This charter provided that the work on the bridge should be begun within one year of the date of its passage, or before March 29, 1887. At the time of our visit there, pile-driving was already in progress on the Kentucky approach to the bridge.

It was thought best to have the entire work let in a single contract and after a reasonable amount of negotiation, prices were agreed upon with the Union Bridge Company and a contract for the construction of the main bridge from pier I to pier XIII was executed on the 4th of May, 1887. This contract is printed in Appendix G.

It was at first intended to appoint Mr. Corthell and myself jointly Chief Engineers, under the firm name of Morrison & Corthell, but it having been considered advisable that one person should be Chief Engineer of the work, I was appointed Chief Engineer and Mr. Corthell became Associate Chief Engineer. A general engineering partnership existed between us from May 1, 1887, to April 30, 1889, and this arrangement continued during the existence of that partnership. On the close of the partnership, the work remained entirely in my hands, but Mr. Corthell's position was not nominally changed.

On June 12, 1887, Mr. Addison Connor was sent to Cairo as assistant engineer, where he established a base line and began surveys.

Mr. Alfred Noble was appointed Resident Engineer, and arrived at Cairo on July 9, 1887, and took charge of the work.

Actual work in construction was begun on July 1, 1887, the first thing actually done being the building of the caisson for pier XI.

Work was prosecuted without interruption from this time forward.

The original estimates were made on the basis of timber trestles at each end of the bridge, these trestles to be of a temporary character and ultimately replaced by earth embankments. The amount of earth,

however, required to fill these trestles would have been so great that on further consideration it was decided that the portion of each approach next to the bridge proper should be of a more permanent character. Plans were prepared for these approaches and on the 9th of March, 1889, contracts were made with the Union Bridge Company for the construction of these approaches. These contracts are printed in Appendix H. At the same time that these contracts were executed, it was agreed with the Union Bridge Company that the time of completion of the bridge should be changed from January 1, 1890, to November 1, 1889. This supplemental agreement is also printed in Appendix H.

The timber trestles at each end of the iron work were built by the Company's own force under the direction of Mr. A. J. French, according to the standard plans used on your railroad.

The bridge was completed ready for traffic in the latter part of October, 1889. On October 29 the first train, consisting of ten locomotives, crossed the bridge from Illinois to Kentucky, followed by another train containing a number of officials of your Company. The President and Vice-President of the railroad, as well as the engineers of the bridge, went on the first train consisting solely of locomotives. The two trains then returned, crossing the bridge at speed. A south-bound train then crossed the bridge and it was immediately opened for general traffic.

A considerable amount of detail work in the floor, painting and various other matters remained to be done and the bridge continued in the hands of the engineers until March 1, 1890, when it was finally turned over to the Operating Department.

II.

GENERAL DESCRIPTION.

The Cairo Bridge is within the proper limits of the alluvial delta of the Mississippi River. The city of Cairo was originally laid out at the junction of the Mississippi and Ohio Rivers. The course of the Ohio River remains unchanged; the Mississippi River, however, has cut into the Missouri bottom land opposite and below the old mouth of the Ohio, while a sand bar forming on the opposite side of the river has extended the peninsula down stream, so that the present junction of

THE CAIRO BRIDGE.

the two rivers is more than a mile below the junction at the time the city was laid out, and Cairo is now on the Ohio River, about a mile and a half away from the Mississippi.

The bridge crosses the Ohio River about two miles above the old point of junction and about three and a half miles above the present point of junction. This location is shown on the two maps, Plates 1 and 2. It will be noted that the distance between the two rivers at the bridge line is less than the width of the Ohio River; if the bridge proper had been made two and a half times as long as it is, it would have crossed both rivers and the intervening space.

The neck of land between the two rivers is in Illinois; the south shore of the Ohio is Kentucky, and west shore of the Mississippi, Missouri. The entire alluvial land, extending several miles back into each State, is from ten to twenty feet below high water. The town site of Cairo is protected by a levee completely surrounding it. All other parts of this alluvial country are liable to be overflowed in any high water season.

Although the two rivers are in the same alluvial delta, their physical characteristics differ very materially. The bed of the Ohio River is strengthened by the heavy sands which are characteristic of that river, and which overlie the lower deposits, leaving the regimen of the river about as stable here as it is within the limits of its own proper valley. On the other hand, the upper deposits of the Mississippi are the light alluvial silts and sands which are characteristic of that river and the Missouri, and the same instability which characterizes the Mississippi everywhere below the mouth of the Missouri is to be found here. The two rivers are of about equal size, but the problem of bridging the Ohio River was a much more simple one than the bridging of the Mississippi would have been. Foundations which are perfectly safe in the Ohio would have been of doubtful character in the Mississippi.

On the other hand, the Ohio River is liable to more violent floods than the Mississippi, and the floods which generally cause the most trouble in the Lower Mississippi come from the Ohio and its tributaries.

Borings taken at the bridge site had been sunk to 86 feet on the Illinois side of the river, and to 193 feet below low water on the Kentucky side; nothing was found but alluvial deposit, which varied from fine sand to gravel with occasional masses of clay, there being no regularity in the variations. It was evident that the foundations of the

bridge must be sustained in the sand, and this was recommended in the reports already mentioned.

The bridge and approaches may be divided into five classes:

1. The Bridge Proper, being the main structure embraced in the original contract.
2. The Iron Viaduct on the Kentucky Approach.
3. The Iron Viaduct on the Illinois Approach.
4. The Timber Trestle on the Kentucky Approach.
5. The Timber Trestle on the Illinois Approach.

The bridge proper consists of nine through spans and three deck spans. Two of the through spans are each 518.5 feet long and the other seven 499 feet long between centers of end pins. The deck spans are 249 feet between centers of end pins. The through spans rest on ten masonry piers, all of which have pneumatic foundations. The deck spans are supported on two of these piers and on three masonry piers with pile foundations.

The total length of the bridge proper from center to center of end piers is 4644 feet.

The Viaduct on the Kentucky Approach consists of 21 spans of 150 feet each and one span of 106.25 feet, which rest on iron cylinder piers filled with concrete and supported by piles driven within the limits of the cylinders.

The Illinois Viaduct consists of 17 spans of 150 feet each and one span of 106.25 feet, and is precisely like the Kentucky Approach in construction.

The total length of the metal work from end to end is 10560 feet. It is the longest metallic structure across a river in the world, being 33 feet longer than the Tay Bridge. The total length of the bridge, including the timber trestles, is 20461 feet, or 3.875 miles.

The bridge proper crosses as nearly as possible at right angles to the river and is straight.

On each approach there is a five-degree curve (1146 feet radius) there being 90 degrees of curvature on the Kentucky Approach and 96 degrees and 45½ minutes on the Illinois Approach.

The general law fixes the elevation of the bridge at 53 feet above high water. The high water selected by the Chief of Engineers as the governing high water was that of 1867, which is 51.20 feet above the standard low water.

The bridge is built 104.42 feet in the clear above low water.

The deepest foundations are 75 feet below low water and the total height of the structure, from bottom of deepest foundation to top of highest part of iron work (top of ornamental casting), is 248.94 feet.

The grade is level across the whole length of the main structure, but descends from each end of this structure to the ends of the approaches. The grades on the approaches are in both directions 0.75 per cent. (40 feet per mile) on the straight line and 0.56 per cent. (30 feet per mile) on the five-degree curves. The five-degree curves are eased by compounding them into two-degree thirty-minute curves, 117.4 feet long at each end. The general features of the bridge grades and alignment are given on Plate 3.

III.

SUBSTRUCTURE.

The substructure comprises a small masonry pier on pile foundation on the Kentucky shore, ten large masonry piers on pneumatic foundations in the river, the three western piers being somewhat larger than the others, and two small masonry piers on pile foundations, similar to the one on the Kentucky shore, on the Illinois shore. The three larger piers in the river next to the Illinois shore have been called the channel piers, and the other seven the river piers, as distinguished from the three shore piers.

The dimensions of the pneumatic caissons are given in the table below:

Caisson	II,	60 feet long, 26 feet wide and 16 feet high.
"	III,	60 " " 26 " " " 16 " "
"	IV,	60 " " 26 " " " 16 " "
"	V,	60 " " 26 " " " 16 " "
"	VI,	60 " " 26 " " " 16 " "
"	VII,	60 " " 26 " " " 16 " "
"	VIII,	60 " " 26 " " " 16 " "
"	IX,	70 " " 30 " " " 16 " "
"	X,	70 " " 30 " " " 16 " "
"	XI,	70 " " 30 " " " 16 " "

The caissons are built of pine timber with oak sills and iron cutting edges, planked with one thickness of pine plank laid diagonally, and one thickness of oak plank laid vertically. The caissons are all surmounted by timber cribs of the same section as the caisson itself, and 34 feet high. The cribs are built of pine timber planked with two thicknesses of pine plank. The corners of the caissons and cribs are rounded and plated with three-eighths inch iron. Both the caissons and cribs were filled with concrete, that in bottoms of chambers, on roof of caisson and at top of cribs being made of Portland cement, sand and crushed stone, Louisville cement taking the place of the Portland cement in the other portions. The proportions of cement, sand and stone varied with the place and kind of cement used.

The caissons were built on launching ways on the Illinois shore. The pneumatic machinery was set up on a barge. During the progress of the work, it was found convenient to have a second pneumatic plant, which was mounted on the old steamer "Kate Elliott." Material was conveyed to the pier sites on barges. The work on the individual piers, except that of building and sinking Piers IX and X, was carried on in an intermittent way as the condition of the river, necessity, or convenience dictated.

PIER I.

Pier I was the last pier commenced, excavation being begun on June 15th, 1888. Pile driving was commenced August 27; the piles were cut off at elevation 130, September 10; concreting was begun September 14, and finished on the 18th; the masonry was begun on November 30, and the pier completed December 13th, 1888.

PIER II.

The framing of timber for the caisson for Pier II was commenced November 3. This caisson was originally intended for Pier VIII. The cutting edge was set up on launching ways on the 29th of November and the caisson proper was launched on the 8th of February and building of crib carried on while the caisson was afloat. On the 29th of that month it was placed in position and the filling with concrete was commenced on the following day. Air was put on the 3rd of March and sinking began. The timber work was finished on the 15th of the month and the concreting on the 17th. The masonry was commenced on the 29th. In sinking this pier, some difficulty was experienced in leveling it up and blocking was put under the cutting edge

to right it up. This was at first unsuccessful, but after a number of settlements, the caisson was gotten fairly into position. It reached its final elevation, after some intermissions in sinking, on the 8th of May, and the working chamber was filled with concrete on the 13th. Masonry was resumed on May 31 and carried on at odd intervals until November 28, 1888, when it was completed.

PIER III.

The framing of timber for the caisson of this pier was commenced on the 26th of December, 1887, the cutting edge placed on the 30th and building begun at once. On January 18, 1888, owing to high water, the caisson had to be loaded down with iron to prevent its being floated off the launching ways. On the 26th the water had gone down sufficiently to remove the iron and resume construction. The caisson was launched on the 16th of February; on March 18, it was placed in position and concreting commenced the next day. Air was put on on the 24th and building of the crib completed on the 30th and the concrete filling finished on the 31st. Masonry was commenced on the 7th of August and sinking was carried on at intervals during the months of April, May, June and July. The caisson reached its final position on the 29th of July; sealing was finished on the 3rd of August; masonry was resumed on the 5th, but stopped again on the 13th; resumed November 19th and the pier completed December 7, 1888.

PIER IV.

The first timber for the caisson was framed March 19, 1888, and the cutting edge was placed March 20th. On April 22nd an effort was made to launch the caisson, but when the lower side of the cutting edge was nine feet under water, the caisson stuck on the launching way, and, notwithstanding continued efforts, was not floated until the 4th of May. On the 13th the caisson was placed in position and concreting was begun the next day. Air was put on temporarily on the 18th to connect pumps, and sinking was actually commenced on the 21st. Concreting was finished on the 24th and the planking of the crib the next day. The masonry was commenced on the 26th, and sinking was carried on intermittently during the months of June, August and September, the caisson reaching its final position on the 10th of September and sealing was commenced that day. The working chamber was filled on the 13th; the shaft holes were filled on the 17th and masonry was

resumed that day. It was again suspended from the 27th till December 7, and the pier was finally completed on the 4th of January, 1889.

PIER V.

The framing of timber for this caisson was commenced April 24, 1888, and the cutting edge set up on May 6. On the 21st the caisson was launched and towed to the contractor's wharf boat, where concreting was commenced. It was towed to position on June 5 and air pressure put on June 11. Concreting was finished on the 15th and the timber work of the crib on the 16th and on the same day masonry was commenced. Sinking was carried on as found convenient during the remainder of June, July, August and September, and the final elevation of the pier was reached September 26. Sealing of working chamber was commenced on the 27th and finished on the 29th. Masonry was resumed October 7, and after several intermissions, completed January 17, 1889.

PIER VI.

The first timber for this caisson was framed May 14, 1888, cutting edge placed June 16, and the caisson launched on the 27th. On July 2 it was placed in position and concreting resumed. Air was first put on on the 5th. On the 14th timber work for the crib was finished and on the 18th concreting was completed. Masonry was begun on the 19th. Sinking was completed on August 20, and the sealing of the working chamber on August 23. The shaft holes were not filled till September 15. Masonry was resumed on the 19th of that month and the pier completed December 27, 1888.

PIER VII.

Framing of timber for this caisson was commenced June 1, 1888; the cutting edge was placed June 28, the caisson launched July 17, and placed at its site on the 24th. Concreting was commenced the next day and sinking August 4. The crib with its concrete filling was completed August 15, and masonry commenced on the 22nd. Sinking was completed October 4, the working chamber sealed on the 7th, shafts finished on the 8th and the pier completed January 19, 1889.

PIER VIII.

The first timber for this caisson was framed on July 5, 1888. On July 26 the cutting edge was placed and the caisson launched Au-

THE CAIRO BRIDGE.

gust 17. It was towed to wharf boat, where concreting was commenced. On September 30 the caisson was placed in its proper position and sinking commenced on October 8. The crib with its concrete filling was finished October 15 and the masonry commenced October 16. Sinking was suspended during the month of November, but resumed on the 1st of December, and the caisson reached its final elevation on the 3rd. Sealing was finished on the 6th, the building of masonry resumed on the 18th and the pier completed February 19, 1889.

PIER IX.

Framing of timber for this caisson was commenced September 10, 1887; cutting edge was placed October 6, and the caisson launched December 1. On the 5th it was placed in position and concreting commenced on the 11th. Sinking was commenced December 17. On January 4 the river commenced to rise very rapidly and by the next day the concrete in the crib was submerged. At the same time the sand at the bottom of the river scoured away from the caisson so it became necessary to use sand bags. On the 7th the scour had reached two feet below the cutting edge at the north-east corner and this scouring continued during the 8th, but was finally stopped by the use of sand bags. On the 10th an attempt was made to pump out the water, and some concrete was placed in the crib the next day. On the 12th, however, the water came over the top of the crib. A temporary protection was built for the shafts and sinking was continued till the 15th, when the boilers of the pneumatic outfit gave trouble, and the work was stopped. Some rip-rap was placed about the pier at this time. Sinking was resumed on February 9, 1888; it was again abandoned on the 18th and no more work was done until August 4. The temporary protection was then removed, the mud dredged out of the pockets, and the building of the crib resumed. Timber work was finished on the 9th of August and concreting was resumed next day and finished on the 13th. On the 14th the masonry was begun, and on September 3 sinking was resumed. On the 22nd the pier reached its final elevation and sealing of the working chamber was completed on the 26th, on which day the masonry was at once resumed and continued without intermission until October 26, 1888, when the pier was completed.

PIER X.

The framing of timber for this caisson was commenced August 15, 1887, cutting edge was placed on the 27th and the caisson launched

October 3 and towed to place on the 16th. On the 21st concreting was begun. This caisson was the second one completed and, like the first one, was built with a false bottom. The removal of this caused a great deal of trouble and in subsequent caissons the false bottom was omitted. The pier was not gotten into exact position until the 20th of October. Sinking was commenced November 16. On December 6, the crib and concrete filling were finished and on the 8th masonry was commenced. Sinking was completed December 25 and the working chamber sealed January 2, 1888. The masonry was at once resumed and the pier nearly finished by February 29, when work was suspended until August 1. The last stone was placed August 14, 1888.

PIER XI.

This was the first pier to be commenced. The first framing of timber was done July 1, 1887. The cutting edge was placed on the launching ways July 11 and building of the caisson began July 21. The caisson was launched August 20 and placed in position on the 24th. On the 26th concreting was commenced and on September 3 air pressure was first put on. On October 6 the timber work of the crib was completed and concrete filling was finished on the 10th. Masonry was commenced on October 11. With the exception of an intermission of one day, which occurred in taking out the false bottom from Caisson X, sinking was carried on without intermission until November 10, when the caisson reached its final elevation. Sealing of the working chamber was completed November 16. The masonry was carried up a short distance, after which it was built intermittently and finished August 9, 1888.

PIER XII.

Excavation for this pier was commenced on the 18th of November, 1887. Driving of piles was begun January 23, 1888, concreting of foundation on the 16th of February, and completed on the 18th. The masonry was begun March 3, and the pier completed on the 19th, this being the first pier to be completed.

PIER XIII.

The excavation for the foundation of this pier was commenced May 25. On the 5th of June the first pile was driven. On the 18th concreting was commenced, and finished three days later. The masonry

was commenced on June 25 and finished July 9, this being the second pier completed.

The full details of the thirteen piers and their foundations are given on Plates 5 and 6. The rate of progress of sinking the caissons is illustrated graphically on Plate 7. Full records of the progress in detail of sinking the pneumatic foundations are given in Appendix I.

The concrete used was manufactured in a mixer, consisting of a long box of square section, revolving on an axis passing through the center of the section. The sand, cement and crushed stone were mixed on a platform and passed into one end of this box through a hopper. The water was introduced about midway of the length of the box by a pipe running in from the discharge end; after being placed in position, the whole was thoroughly rammed. The proportion of cement, sand and stone varied from one cement, two sand and two stone, to one cement, three sand and four and eight-thirteenths stone.

The stone in the piers is all from Bedford, Indiana, except the nose stones, from the starling coping to low water, which are of granite.

The amount of material in the substructure of the bridge proper is as follows:

Piers.	Piles, lineal feet.	Timber, feet, B. M.	Iron and steel, lbs.	Concrete, cub. yds.	Masonry, cub. yds.
I.....	2 422			11.6	327.7
II.....		254 646	129 725	2 052.7	2 326.7
III.....		264 646	129 992	2 058.3	2 662.2
IV.....		264 646	124 644	2 059.8	2 871.7
V.....		264 646	128 922	2 029.2	2 859.3
VI.....		264 646	121 518	2 053.6	2 864.4
VII.....		264 646	128 370	2 022.1	2 864.3
VIII.....		264 646	127 864	2 070.8	2 861.4
IX.....		320 990	140 611	2 864.6	2 798.8
X.....		320 990	128 601	2 875.9	2 659.9
XI.....		320 990	124 390	2 845.3	2 861.3
XII.....	2 965			65.6	447.1
XIII.....	2 268			65.6	403.5
Total.....	6 665	2 845 430	1 290 982	31 251.0	31 265.4

The specifications for the substructure are printed in Appendix G.

IV.

SUPERSTRUCTURE.

The superstructure of the bridge proper consists of nine through spans and three deck spans. The two through spans over the channel of the river are each 518 feet 6 inches long between centers of end pins, divided into 17 panels of 30 feet 6 inches each, the trusses being 61 feet deep and placed 25 feet between centers. The other seven through spans are each 400 feet long between centers of end pins, divided into 15 panels of 26 feet 8 inches each, the trusses being 50 feet deep and placed 22 feet between centers. The three deck spans are each 249 feet long between centers of end pins, divided into nine panels of 27 feet 8 inches each, the trusses being 30 feet deep and placed 18 feet between centers. Expansion is provided on piers I, III, V, VII, IX, XI and XII.

The entire superstructure, except the pedestals, is of steel.

The trusses are proportioned to carry a moving load of 3000 lbs. per lineal foot, but in calculating the effects of a moving load, the portion of any strain in excess of that which would have been produced by a uniform load of equal amount was taken on a basis of 5000 lbs. per foot. The top lateral system is proportioned to resist a wind pressure of 300 lbs. per lineal foot, and the bottom lateral system 500 lbs. per lineal foot. The strains are given on Plates 12 and 20.

The floor system was designed for a uniform load of 6000 lbs. per lineal foot.

The compressive strain in the top chord is limited to 14000 lbs. per square inch of balanced section.

The tensile strain in the bottom chord is limited to 13000 lbs. per square inch, and that in the web members is kept somewhat lower.

The weight of iron and steel in the various spans is as follows:

TWO 518 FT. & IX. THROUGH SPANS.

Material.	Weight of two Spans.	Average.
Steel.....	4 348 674 lbs.	2 914 337 lbs.
Wrought Iron.....	6 976 "	2 325 "
Cast Iron.....	31 546 "	21 278 "
Total.....	4 486 196 lbs.	3 061 740 lbs.

SEVEN 400 FT. THROUGH SPANS.

Material.	Weight of seven Spans.	Average.
Steel.....	7 720 573 lbs.	1 102 820 lbs.
Wrought Iron.....	28 278 "	4 039 "
Cast Iron.....	202 984 "	27 571 "
Total.....	7 951 835 lbs.	1 134 430 lbs.

THREE 249 FT. DECK SPANS.

Material.	Weight of three Spans.	Average.
Steel.....	1 377 310 lbs.	459 103 lbs.
Wrought Iron.....	7 624 "	2 541 "
Cast Iron.....	22 613 "	7 538 "
Total.....	1 407 547 lbs.	469 182 lbs.

The weight of the twelve main spans is 13 478 781 pounds.

The specifications under which the superstructure was manufactured are given in Appendix G.

The dates on which the several trusses were erected are shown in the following table:

Piers.	Begin.	Sever.
I-II.....	December 21, 1888.	December 24, 1888.
II-III.....	March 16, 1889.	March 21, 1889.
III-IV.....	May 6, 1889.	May 8, 1889.
IV-V.....	June 2, 1889.	June 4, 1889.
V-VI.....	June 17, 1889.	June 20, 1889.
VI-VII.....	July 26, 1889.	July 28, 1889.
VII-VIII.....	August 26, 1889.	August 28, 1889.
VIII-IX.....	August 31, 1889.	August 33, 1889.
IX-X.....	October 20, 1889.	November 3, 1889.
X-XI.....	September 28, 1889.	October 30, 1889.
XI-XII.....	July 26, 1889.	July 30, 1889.
XII-XIII.....	August 3, 1889.	August 12, 1889.

The timber floor was put on by the Company's own men, working under the direction of the Resident Engineer. The delay in getting timber for this work retarded the completion of the bridge for some time.

The painting was done in the same manner.

V.

APPROACHES.

The East or Kentucky Approach consists of 3256 lineal feet of steel viaduct and 4594 lineal feet of trestle, 1080 feet of which is composed of frame bents and the balance of pile trestle. The end of the trestle is practically at the foot of the grade.

The construction of the viaduct was begun on November 23, 1888, by the excavation for the foundations. Pile driving was commenced on the next day. The concreting about the piles was commenced on the 17th of January, 1889.

The placing of cylinders for the piers was commenced on February 19, and all were erected by April 6. The piers were all concreted by the 1st of May.

The concrete placed on the outside of the cylinders during freezing weather was found to be defective, and all of this defective material was removed and replaced by sound concrete in June, 1889.

The concrete used in the cylinder piers was composed of Louisville cement, sand and crushed stone, in the ratio of one, two, and three and one-half. In the upper two feet of the cylinder, Portland cement was substituted for Louisville, and a steel cap was subsequently put on top as a covering.

The amount of material in the substructure of the Kentucky approach is given in the following table:

Piers.	Piles, lineal feet.	Concrete, cubic yards.	Steel, pounds.	Timber, feet, ft. x.
21 Cylinder Piers.....	16 864	2 894.5	662 817	.....
Timber Pier.....	140	.....	220	13 250
Total.....	17 004	2 894.5	664 137	13 250

The erection of the superstructure was begun on the 25th of April, and completed on the 19th of September.

THE CAIRO BRIDGE.

The amount of material in these spans is given in the following table:

	Twenty-one 150 ft. Spans.	Total.	Average for one Span.
Steel.....	4 355 905	4 315 049	185 718
Wrought Iron.....	9 985		471
Cast Iron.....	85 257		4 054
	One 108 ft. 2 in. Span.		300 717
Steel.....	141 209	145 286	
Wrought Iron.....	553		
Cast Iron.....	3 423		
Total Superstructure.....		4 360 334	

The timber trestle was built by the Railroad Company.

During the winter of 1889 to 1890 an earth embankment was built under the viaduct, the top of which is at elevation 150. In this embankment there were 2495 cubic yards of earth.

The Illinois Approach consists of 2656 lineal feet of steel viaduct and 5307 lineal feet of trestle, 3255 feet of which is composed of frame bents and the balance of pile bents.

Excavation for the substructure of the viaduct was commenced on February 11, 1889, and pile driving the next day. Concreting of the foundations was commenced March 2, and erection of the cylinders on the 8th. All the piers were finished on the 1st of June.

These piers were built in the same manner as those on the Kentucky Approach.

The material used in these piers is given in the following table:

Pier.	Piles, lineal feet.	Concrete, cubic yards.	Steel, pounds.	Timber, feet, B. M.
17 Cylinder Pier.....	12 329	1 996.3	696 483	
Timber Pier.....	549		323	14 259
Total.....	12 878	1 996.3	696 785	14 259

The erection of the superstructure was commenced on the 6th of June, 1889, and completed on the 1st of October.

The amount of material in the superstructure of the Illinois Approach is given in the following table:

	Seventeen 150 ft. Spans.	Total.	Average for one Span.
Steel.....	1 243 469	1 355 939	180 733
Wrought Iron.....	16 139		849
Cast Iron.....	97 232		5 725
	One 108 ft. 2 in. Span.		197 497
Steel.....	140 174	144 678	
Wrought Iron.....	1 079		
Cast Iron.....	3 432		
Total Superstructure.....		3 800 664	

The trestle of this approach was also built by the Railroad Company.

On the completion of the bridge, the Railroad Company at once commenced the filling of the pile trestles, ground being purchased for a borrow pit at Villa Ridge.

VI.

COST.

The cost of the pneumatic foundations is shown in detail in the following table, this cost including all concrete and other materials below the masonry:

Pier.	Timber.	Iron and steel.	Concrete.	Total cost of caissons and crib.	Sinking.	Total cost of foundation.	Gross volume cu. ft.	Cost of caisson per cu. ft. Cents.	Vertical ft. sunk bet. low water.	Cu. ft. sunk. (Archives cu. ft. sink)	Cost of sinking per cu. ft. Cents.	Cost of sinking per cu. ft. Cents.
II.....	\$ 11 114.85	\$ 6 625.95	\$ 22 189.30	\$ 39 930.10	\$ 13 437.58	\$ 53 367.68	78 371	50.84	66.38	108 226	13.0	\$ 262.80
III.....	11 114.85	6 625.31	22 266.80	39 997.96	13 614.18	53 612.14	78 346	50.86	69.11	107 678	12.9	\$ 261.33
IV.....	11 114.85	6 553.42	22 245.80	39 914.07	13 581.53	53 495.60	78 331	51.41	73.04	114 967	13.0	\$ 262.31
V.....	11 114.85	7 149.15	21 953.25	40 127.25	13 594.57	53 721.82	78 299	51.31	75.09	114 980	13.9	\$ 261.38
VI.....	11 114.85	6 695.48	22 292.00	39 999.33	13 519.09	53 518.42	78 127	51.59	73.09	114 833	13.0	\$ 262.80
VII.....	11 114.85	6 961.55	22 149.40	39 995.80	13 594.17	53 590.97	78 246	51.43	73.07	114 984	13.0	\$ 262.80
VIII.....	11 114.85	7 023.63	22 264.40	39 972.88	13 517.51	53 490.39	78 137	51.85	75.53	117 691	13.0	\$ 262.80
IX.....	12 961.28	7 723.61	20 939.00	32 573.89	20 507.76	53 081.65	103 553	49.82	73.22	189 027	13.9	\$ 771.77
X.....	12 961.28	7 491.79	21 986.00	32 439.27	20 761.85	53 201.12	103 544	49.78	74.05	189 358	13.0	\$ 773.60
XI.....	12 961.28	7 384.36	20 728.00	32 013.64	20 578.74	52 592.38	103 669	49.80	73.36	189 116	13.0	\$ 773.97
Totals and average.....	\$ 119 508.80	\$ 79 314.58	\$ 217 269.75	\$ 426 013.13	\$ 163 237.87	\$ 589 250.99	862 649	50.72	73.82	1 373 698	13.09	

THE CAIRO BRIDGE.

15

The cost of the masonry of the thirteen piers in detail is shown in the following table:

Piers.	Cost.
I.....	\$ 2 898.00
II.....	48 424.00
III.....	48 278.00
IV.....	51 490.00
V.....	51 753.00
VI.....	51 895.00
VII.....	51 817.40
VIII.....	52 448.00
IX.....	68 238.00
X.....	68 758.00
XI.....	68 427.00
XII.....	8 047.00
XIII.....	7 283.00
Total.....	\$298 780.00

The total cost of the thirteen piers was as follows:

Piers.	Foundation.	Masonry.	Total.
I.....	\$ 2 817.50	\$ 2 898.00	\$ 5 715.50
II.....	50 302.00	48 424.00	98 726.00
III.....	50 197.00	48 278.00	98 475.00
IV.....	50 397.45	51 490.00	101 887.45
V.....	50 324.00	51 753.00	102 077.00
VI.....	50 210.07	51 895.00	102 105.07
VII.....	50 462.00	51 817.40	102 279.40
VIII.....	50 830.41	52 448.00	103 278.41
IX.....	70 080.05	68 238.00	138 318.05
X.....	70 204.00	68 758.00	138 962.00
XI.....	70 084.00	68 427.00	138 511.00
XII.....	1 828.00	8 047.00	9 875.00
XIII.....	1 685.75	7 283.00	8 968.75
Total.....	\$609 962.00	\$ 298 780.00	\$1 188 742.00

The cost of the superstructure is shown in the following table:

Two 108 ft. 6 in. Spans.			
Iron, Steel and Ornamental Work.....	\$171 567.17		
Erection.....	30 000.00	\$201 567.17	
Cement for castings and Miscellaneous Material.....		25.44	
Labor filling castings, etc.....		28.91	
			\$201 621.52
Series 400 ft. Spans.			
Iron, Steel and Ornamental Work.....	\$515 490.51		
Erection.....	96 000.00	\$611 490.51	
Cement for castings and Miscellaneous Material.....		45.80	
Labor filling castings, etc.....		145.89	
Switching charges.....		52.50	
			\$611 734.70
Truss 540 ft. Spans.			
Iron and Steel.....	\$80 223.00		
Erection.....	6 000.00	\$86 223.00	
Cement and Miscellaneous Material.....		20.50	
Labor changing castings Pier XIII, etc.....		145.55	
			\$86 389.05
Piers and Truss.			
Material.....	\$16 768.17		
Labor.....	2 473.97	\$19 242.14	
Painting.			
Material.....	\$2 702.80		
Labor.....	1 687.04	\$4 389.84	
Total Superstructure of Bridge Piers.			\$201 621.52

The cost of the Kentucky Approach is shown in the following table:

SERRAVALLO.			
21 Cylinder Piers—			
Excavation.....	\$ 373.20		
Piles in place.....	5 902.40		
Concrete.....	14 803.75		
Steel in cylinders.....	28 407.77	\$49 487.12	
Timber Pier.			
Pile.....	\$286.00		
Timber.....	121.58		
Iron.....	6.48		
Labor.....	197.00	\$504.06	
			\$49 991.18
SERRAVALLO.			
21 150 ft. Spans—			
Iron and Steel erected.....	\$182 049.17		
1 190 ft. 8 in. Span—			
Iron and Steel erected.....	\$4 202.58		
		\$186 251.75	
Gas pipe struts, etc.....		100.78	
Cement in castings.....		21.00	
Labor placing struts, etc.....		110.00	
Switching charges.....		309.17	
			\$186 792.60
Piers and Truss.			
Material.....		\$11 738.50	
Labor.....		1 587.88	
			\$13 326.38
Painting.			
Material.....		\$1 008.40	
Labor.....		1 485.00	
			\$ 2 493.40
TRUSS TABLES.....			31 120.00
GRADINGS.....			8 824.00
Total.....			\$229 287.40

THE CAIRO BRIDGE.

The cost of the Illinois Approach is shown in the following table:

STRUCTURES.			
27 Cylinder Piers—			
Excavation	\$ 346.75		
Piles in place	4 495.00		
Concrete	14 969.75		
Steel in cylinders	39 544.40	\$53 354.90	
Timber Pier			
Pile	\$189.00		
Timber	135.29		
Iron, etc.	5.49		
Labor	180.07	\$509.12	
SUPERSTRUCTURE.			
17 130 ft. 8 in. Span—			
Iron and Steel erected	\$147 679.49		
1 106 ft. 3 in. Span—			
Iron and Steel erected	5 363.74	\$153 043.23	
Gas pipe struts, etc.		105.00	
Cement in castings		31.70	
Labor placing struts, etc.		85.00	
			\$154 055.19
FLOOR AND TRACK.			
Material		\$5 590.00	
Labor		2 100.00	
			\$77 520.00
PAVEMENT.			
Material		\$ 795.19	
Labor		1 479.91	
			\$ 2 275.10
TIMBER TRUCKS			68 697.51
GRADING			1 629.90
Total			\$290 190.31

The cost of the bridge and approaches is shown in the following table:

Foundation Pier I	\$ 2 657.90		
" " II	53 561.31		
" " III	53 897.05		
" " IV	53 297.43		
" " V	53 974.96		
" " VI	53 559.37		
" " VII	53 482.80		
" " VIII	53 650.41		
Amount carried forward	\$296 392.31		

Amount brought forward	\$296 392.31		
Foundation Pier IX	72 080.00		
" " X	72 594.35		
" " XI	72 594.35		
" " XII	1 300.00		
" " XIII	1 489.73		
Total Foundation		\$596 961.80	
Masonry Pier I	\$ 1 965.00		
" " II	46 434.00		
" " III	46 579.80		
" " IV	51 680.00		
" " V	51 754.00		
" " VI	51 919.80		
" " VII	51 915.40		
" " VIII	52 845.80		
" " IX	46 559.80		
" " X	46 758.50		
" " XI	46 625.00		
" " XII	9 647.60		
" " XIII	1 263.00		
Total Masonry		\$590 780.80	
Total Substructure Bridge Proper			\$1 187 742.60
Two 310 ft. 8 in. Channel Span	\$227 821.02		
Seven 400 ft. River Span	439 854.50		
Three 240 ft. Shore Span	68 797.00		
Floor and Track	32 843.04		
Painting	9 126.73		
Total Superstructure Bridge Proper			\$768 812.14
Substructure	\$ 69 450.82		
Superstructure	192 733.40		
Floor and Track	13 584.33		
Painting	2 513.71		
Timber Truss	51 130.29		
Grading	6 854.98		
Total Kentucky Approach			\$296 267.20
Substructure	\$ 32 563.39		
Superstructure	154 853.98		
Floor and Track	12 759.08		
Painting	2 253.00		
Timber Truss	68 697.51		
Grading	1 629.90		
Total Illinois Approach			\$290 190.31
Amount carried forward			\$1 560 812.79

Amount brought forward			\$1 560 812.79
Protection Work			8 623.87
Service Tracks			565.00
Right of Way and Franchises			12 375.00
Engineering			67 400.00
Legal and Supervisory			947.34
Miscellaneous			1 005.80
Total Cost of Bridge to March 1, 1890			\$1 673 457.91

This cost does not include the cost of paints and oil (\$243.26), left over after completion, nor labor of carpenters furnished by Road Department in October, 1889, to assist in placing floor, bill for this not being rendered before March 1, 1890.

The above table may be condensed as follows:

Substructure	\$1 189 742.72		
Superstructure	763 614.14		
Total Bridge Proper			\$1 953 356.87
Kentucky Approach	\$296 267.20		
Illinois Approach	290 190.31		
Total Approaches			\$586 457.51
Protection Works			\$ 8 623.87
Service Tracks			565.00
Right of Way and Franchises			12 375.00
Engineering			67 400.00
Legal and Supervisory			947.34
Miscellaneous			1 005.80
Total			\$1 673 457.91

APPENDIX A.

LIST OF ENGINEERS, COMPANY'S EMPLOYEES AND CONTRACTORS.

ENGINEERS AND COMPANY'S EMPLOYEES.

Geo. S. MORRISON, Chief Engineer.	
E. L. CORRELL, Associate Chief Engineer.	
ALFRED NOBLE, Resident Engineer.....	July 5, 1887—Nov. 30, 1889
Geo. A. LEWELL, " "	Dec. 1, 1889—Feb. 28, 1890
ANDREW CONNOR, Assistant Engineer.....	June 12, 1887—Oct. 22, 1889
E. DUVVLA, " "	Nov. 18, 1887—April 8, 1889
E. P. BETTS, " "	Apr. 16, 1889—Nov. 20, 1889
E. H. CONNOR, { " "	June 13, 1887—Dec. 31, 1888
Inspector of Superstructure.....	Jan. 1, 1889—July 26, 1889
E. H. MAYNE, Assistant Engineer.....	Sept. 22, 1888—Nov. 7, 1889
J. M. HENCKELL, Assistant Engineer.....	May 27, 1888—Oct. 21, 1888
CHANDLER DAVIS, Rodman.....	July 12, 1888—Dec. 22, 1889
STANFORD MORRISON, "	July 31, 1888—Apr. 20, 1889
R. W. HILBERT, Inspector of Superstructure.....	Apr. 22, 1888—July 23, 1889
R. MOONSHILL, " "	Feb. 20, 1888—Dec. 21, 1888
PAUL WILLIS, " "	Apr. 20, 1888—July 15, 1888
O. BENSON, " "	July 1, 1888—Feb. 28, 1889
J. V. W. REYNOLDS, " "	Mar. 1, 1889—July 30, 1889
I. DICKINSON, Draftsman.	

JOSUEA DIXON, Inspector of Masonry.....	Aug. 14, 1887—June 22, 1889
GEORGE REYNOLDS, " "	Sept. 30, 1887—May 20, 1889
F. H. JOYNER, Inspector of Stone at quarry.....	Aug. 10, 1887—Feb. 20, 1889
D. C. MORGAN, " Cement.....	Sept. 2, 1887—May 31, 1889
AUGUST HOLMQUIST, " "	Sept. 5, 1897—June 15, 1889
JAMES THOMPSON, " "	Mar. 1, 1888—Nov. 9, 1888
NELSON JOYNER, Asst. Inspector of Stone at quarry.....	Apr. 1, 1888—Apr. 28, 1889
JOHN E. GRIFFEY, Foreman Carpenters building floor.....	Dec. 28, 1888—Jan. 29, 1890
W. McMURRAY, Foreman of Painters.....	Apr. 20, 1889—Jan. 29, 1890

CONTRACTORS.

UNION BRIDGE COMPANY, Contractors for Entire Structure.

ANDERSON & BARR, Sub-Contractors for Foundations.

L. M. LOMB, Sub-Contractor for Masonry.

BAIRD BROTHERS, Sub-Contractors for Erection of Main Bridge.

JOHN GRANT, Foreman of Erection of Approach Spans.

APPENDIX B.

OHIO RIVER BRIDGE LAW.

ACTS OF CONGRESS, 17 DECEMBER, 1872, AND 14 FEBRUARY, 1882, AUTHORIZING CONSTRUCTION OF BRIDGES OVER THE OHIO RIVER.

ACT APPROVED DECEMBER 17, 1872.

AN ACT TO AUTHORIZE THE CONSTRUCTION OF BRIDGES ACROSS THE OHIO RIVER, AND TO PRESCRIBE THE DIMENSIONS OF THE SAME.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That any persons or corporations having lawful authority therefor, may hereafter erect bridges across the Ohio River, for railroad or other uses, upon compliance with the provisions and requirements of this Act.

SECTION 2. That every bridge hereafter erected across the Ohio River, above the mouth of the Big Sandy, shall have at least one span of a height of not less than ninety feet above low water, and of not less than forty feet above local highest water, measured to the bottom chord of the bridge; that every bridge hereafter erected across the Ohio River below the mouth of the Big Sandy, shall have at least one span of a height of not less than one hundred feet above low water, and of not less than forty feet above highest water, measured to the bottom chord of the bridge; that this high span shall give a clear opening of at least four hundred feet between the piers, measured at right angles to the current at every stage, and that it shall be placed over the main channel of the river used by the boats during ordinary stages of water: *Provided, however,* That any one company, lawfully authorized by the States of West Virginia and Ohio, is hereby authorized to construct a bridge across the Ohio River, from the City of Wheeling, in the State of West Virginia, to the opposite side of the said river within the State of Ohio, with a span over the main channel of not less than three hundred and fifty feet in length, and in all other respects conformable and subject to the provisions of this act, so far as the same are applicable to bridges above the mouth of the Big Sandy: *and provided,* That in case this high span is not over the low water channel, suitable arrangements be made elsewhere to permit the passage of single boats under the bridge at low water; that all bridges over the Ohio River, below Corington and Cincinnati suspension bridge, shall have, in addition to the high span prescribed above, a pivot-draw, giving two clear openings of one hundred and sixty feet each, measured at right angles to the current at the average stage of water in the river, and located in a part of the bridge that can be safely and conveniently reached at that stage; and that said draw shall be opened promptly, upon reasonable signal for the passage of boats, whose construction shall not be such as to admit their passage under the stationary spans of

said bridge, except when trains are passing over the same; but in no case shall unnecessary delay occur in opening the said draw before or after the passage of trains.

SECTION 3. That the piers of the high span and the piers of the draw shall be built parallel with the current at that stage of the river which is most important for navigation; and that no rip-raps or other outside protection for imperfect foundation will be permitted in the channel-way of the high span, or of the draw openings.

SECTION 4. That any person, company, or corporation, authorized to construct a bridge across the Ohio River shall give notice, by publication for one week in newspapers having a wide circulation, in not less than two newspapers in the cities of Pittsburgh, Cincinnati, and Louisville, for bridges above the mouth of the Big Sandy, and in the cities of Pittsburgh, Cincinnati, Louisville, Saint Louis, Memphis, and New Orleans, for bridges below the mouth of the Big Sandy; and shall submit to the Secretary of War, for his examination, a design and drawings of the bridge and piers, and a map of the location, giving, for the space of at least one mile above and one mile below the proposed location, the topography of the banks of the river, the shore lines at high and low water, the direction of the current at all stages, and the soundings accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject by the Secretary of War; and if the Secretary of War is satisfied that the provisions of the law have been complied with in regard to location, the building of the piers may be at once commenced; but if it shall appear that the conditions prescribed by this act cannot be complied with at the location where it is desired to construct the bridge, the Secretary of War shall, after considering any remonstrances filed against the building of said bridge, and furnishing copies of such remonstrances to the board of engineers provided for in this act, detail a board composed of three experienced officers of the corps of engineers, to examine the case, and may, on their recommendation, authorize such modifications in the requirements of this act, as to location and piers, as will permit the construction of the bridge; not, however, diminishing the width of the spans contemplated by this act: *Provided,* that the free navigation of the river be not materially injured thereby.

SECTION 5. That all parties owning, occupying, or operating bridges over the Ohio River shall maintain, at their own expense, from sunset to sunrise throughout the year, such lights on their bridges as may be required by the light-house board for the security of navigation; and all persons owning, occupying, or operating any bridge over the Ohio River shall, in any event, maintain all lights on their bridges that may be necessary for the security of navigation.

SECTION 6. That any bridge constructed under this act, and according to its limitations, shall be a lawful structure, and shall be recognized and known as a post-route, upon which, also, no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for the transportation over the railroads or public highways leading to said bridge; and the United States shall have the right of way for postal-telegraph purposes across any such bridge; and in case of any litigation arising from any obstruction or alleged obstruction to the navigation of said river, created by the construction of any bridge under this act, the cause or question arising may be tried before the District Court of the United States of any State in which any portion of said obstruction or bridge touches.

SECTION 7. That the right to alter or amend this act, so as to prevent or remove all material obstructions to the navigation of said river by the future construction of bridges, is hereby expressly reserved, without any liability of the government for damages on account of the alteration or amendment of this act, or on account of the prevention or requiring the removal of any such obstructions; and if any change be made in the plan of construction of any bridge constructed under this act, during the progress of the work thereon or before the completion of such bridge, such change shall be subject to the approval of the Secretary of War, and any change in the construction, or any alteration on any such bridge that may be directed at any time by Congress, shall be made at the cost and expense of the owners thereof.

SECTION 8. That joint resolution number ten, approved April seventh, eighteen hundred and sixty-nine, authorizing the construction of a bridge over the Ohio river at Paducah, be, and the same hereby is, repealed.

SECTION 9. That the provisions of an act entitled "An Act to provide for the better security of life on vessels propelled in whole or in part by steam," etc., approved February twenty-eighth, eighteen hundred and seventy-one, so far as they relate to the limitation of steam pressure of steamboats used exclusively for towing and carrying freight on the Mississippi River and its tributaries, are hereby so far modified as to substitute for such boats one hundred and fifty pounds of steam pressure in place of one hundred and ten pounds, as provided in said act for the standard pressure of standard boilers of forty-two inches diameter and of plates of one-quarter of an inch in thickness; and such boats may, on the written permit of the supervising inspector of the district in which such boats shall carry on their business for a period of twelve months from and after the passage of this act, be permitted to carry steam above the standard pressure of one hundred and ten pounds, but not exceeding the standard pressure of one hundred and fifty pounds to the square inch.

ACT APPROVED FEBRUARY 14, 1883.

AN ACT SUPPLEMENTARY TO AN ACT APPROVED DECEMBER 17, 1872, ENTITLED "AN ACT TO AUTHORIZE THE CONSTRUCTION OF BRIDGES ACROSS THE OHIO RIVER, AND TO PRESCRIBE THE DIMENSIONS OF THE SAME."

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the act of Congress approved December seventeenth, eighteen hundred and seventy-two, entitled "An Act to authorize the construction of bridges across the Ohio River, and to prescribe the dimensions of the same," shall be, and the same is hereby, amended by striking out sections two and four of said act and substituting therefor the following:

SECTION 2. "That every bridge hereafter erected across the Ohio river shall have its axis at right angles to the current at all stages, and all of its spans shall be through spans. Every such bridge shall have at least one channel span placed over that part of the river usually run by descending coal fleets, said channel span to give a clear waterway between the piers of five hundred feet, measured on the low water line. Said channel span shall be at least forty feet above local highest water measured to the lowest part of the span, and shall be at least ninety feet above low water in bridges built above the mouth of the Big Sandy River, and at least one hundred feet above low water in bridges built below the mouth of the Big Sandy River, measured to the lowest part of the span: *Provided, however,* that all bridges over the Ohio River below the Covington and Cincinnati Suspension Bridge shall have, in addition to the channel span prescribed above, a pivot draw giving two clear openings of one hundred and sixty feet each, measured at right

angles to the current at high stages, and located in a part of the bridge that can be safely and conveniently reached at such stages; that said draw shall be provided with suitable rest piers above and below the pivot pier, and suitable floats or crib work connecting said rest piers with the pivot pier, to enable boats to pass through said draw with safety; that in case said draw span is near either shore, the bridge company, by purchase or otherwise, shall extinguish the right of mooring boats or other water craft to the adjacent shore for a distance of at least seven hundred feet above and seven hundred feet below the bridge; and that said draw shall be opened promptly, upon reasonable signal, for the passage of boats whose construction shall not be such as to admit of their passage under the stationary spans of said bridge, except when trains are passing over the same, but in no case shall unnecessary delay occur in opening said draw before or after the passage of a train. *Provided, further,* That in lieu of the high draw prescribed above, bridges over the Ohio River below the Covington and Cincinnati Suspension Bridge may be built as continuous bridges, with a clear height of fifty-three feet above local highest water, measured to the lowest part of the channel span."

SECTION 4. "That any person, company, or corporation, authorized to construct a bridge across the Ohio river, shall give notice, by publication for one week in newspapers having a wide circulation, in not less than two newspapers in the cities of Pittsburgh, Cincinnati, and Louisville, for bridges above the mouth of the Big Sandy, and in the cities of Pittsburgh, Cincinnati, Louisville, St. Louis, Memphis, and New Orleans, for bridges below the mouth of the Big Sandy, and shall submit to the Secretary of War, for his examination, a design and drawings of the bridge and piers, and a map of the location, giving, for the space of at least one mile

above and one mile below the proposed location, the topography of the banks of the river and the shore lines at high and low water. This map shall be accompanied by others, drawn on the scale of one inch to two hundred feet, giving, for a space of one-half a mile above the line of the proposed bridge and a quarter of a mile below, an accurate representation of the bottom of the river, by contour lines two feet apart, determined by accurate soundings, and also showing over the whole width of this part of the river the force and direction of the currents at low water, at high water, and at least one intermediate stage, by triangulated observations on suitable floats. The maps shall also show the locations of other bridges in the vicinity, and shall give such other information as the Secretary of War may require for a full and satisfactory understanding of the subject. Said maps and drawings shall be referred to a board of engineers for examination and report, which board shall personally examine the site of the proposed bridge, and shall hold a public session at some convenient point to hear all objections thereto, of which public session due notice and invitation to be present shall be given to all interested parties; and, if said board of engineers reports that the site is unfavorable, the Secretary of War shall be authorized, on the recommendation of said board, to order such changes in the bridge or its piers, or such guiding dikes or other auxiliary works as may be necessary, at the expense of the proprietors or managers of such bridge or piers and other works for the security of navigation; and the proposed bridge shall only be a legal structure when built as approved by the Secretary of War."

SECTION 5. "That the right to alter, amend or repeal this act as set forth in section seven of the act hereby amended is hereby reserved."

APPENDIX C.

KENTUCKY CHARTER.

AN ACT AUTHORIZING THE CHICAGO, ST. LOUIS AND NEW ORLEANS RAILROAD COMPANY AND THE ILLINOIS CENTRAL RAILROAD COMPANY, OR EITHER OF THEM SEPARATELY, TO BUILD AND MAINTAIN A RAILROAD BRIDGE ACROSS THE OHIO RIVER.

Be it enacted by the General Assembly of the Commonwealth of Kentucky:

SECTION 1. That the Chicago, St. Louis and New Orleans Railroad Company, and the Illinois Central Railroad Company be and are hereby authorized and empowered jointly, or either of them separately, to build, erect, construct and forever maintain, use and operate a railroad bridge over and across the Ohio River from the Kentucky shore in Ballard County, opposite the City of Cairo, to any point in the City of Cairo, Illinois, or from the Kentucky shore in Ballard County at any point opposite to a point in Illinois below the mouth of Cash, or Casho River, or from the Kentucky shore within the city limits of Paducah, or within three miles of the City of Paducah, to a point opposite thereto in Illinois; provided, that if said bridge is built from a point within the city limits of Paducah, it shall be under such reasonable regulations as the City Council of Paducah may establish; and said bridge may be constructed with continuous unbroken spans, or with one or more draw spans, or as cantilever or suspension bridge or otherwise, as they or the one of them undertaking the construction may deem best; but the party building said bridge shall conform its height and dimensions to the conditions and limitations of an act of Congress entitled, "An Act to authorize the construction of bridges across the Ohio River, and to prescribe the dimensions of the same," approved December 17, 1872, and an act supplementary to an act approved December 17, 1872, entitled, "An Act to authorize the construction of bridges across the Ohio River, and to prescribe the dimensions of the same," approved February 14, 1883, or shall conform said bridge, as to the height and dimensions, to the conditions and limitations of any act of Congress which they or either of them may have secured as to this particular bridge before its completion.

SECTION 2. That the said railroad companies, or either of them, are hereby authorized and empowered to purchase or otherwise acquire, and to own and hold, and erect, construct, build and repair any and all approaches, landings, piers, abutments, bridges, embankments, inclines, side-tracks, switches, turnouts and other things, which are, or may at any time hereafter be necessary or convenient for the building, maintenance, repairs or use of said bridge and its connection with the

main tracks of each of said railroads, or for its proper or convenient use whatsoever; and they, or either of them, are authorized to condemn and acquire by condemnation under and in pursuance of the laws of this State, all lands and materials in this State which may be necessary or convenient for the purpose of said railroad bridge and its connections and approaches, and so forth.

SECTION 3. That in order to settle in advance of any money being invested therein, what tariff charges shall be reasonable and may, as long as said bridge is used, be demanded, collected and received for transportation over said bridge, it is hereby declared that fifty cents for each passenger, three cents for each hundred pounds of freight, four dollars additional for each passenger car and three dollars additional for each freight or other car, shall be held and considered as a reasonable charge for said transportation, and that the party owning or using and operating railroad trains over said bridge may, from time to time, fix, demand, use for and recover the tariff charges for transportation over said bridge, provided they do not exceed the sums heretofore set out respectively.

SECTION 4. That said railroad companies, or either of them, so building and using said bridge, and their or its successors or assigns, shall forever have the exclusive right to operate the same, and to transport persons and property thereon; but in transporting the trains, cars or property of other railroads over said bridge, no unjust discrimination as between such other railroad companies shall be made.

SECTION 5. That the said railroad companies, or company, their or its successors and assigns, which undertake the construction of said bridge under the powers herein granted, are hereby authorized and empowered to mortgage the same, and all its appurtenances, and the rights, powers, franchises, privileges and immunities hereby granted, and such as may hereafter at any time be acquired or granted, and also the rents and income thereof, or any part thereof, or interest therein, for the purpose of raising money to build, repair, maintain or increase the usefulness of said bridge and appurtenances, and so forth, from time to time, for such sums, not exceeding in all at any one time ten million dollars outstanding under said mortgage or mortgages, and may issue coupon bridge bonds thereunder and secured thereby, payable at such time or times and at such place or places and bearing such interest as the mortgagor chooses; but no mortgage or mortgage bonds of either of said railroad companies heretofore executed or authorized shall be held to cover or be a lien or claim upon said bridge, or its appurtenances or income or anything acquired or done, or to be acquired or owned or done, under this act or the powers herein granted.

SECTION 6. That this act shall be accepted, if at all, within sixty days from its passage, which acceptance shall be shown by filing a copy of a resolution of the Board of Directors of both or either of said railroad companies with the Secretary of State. It shall be the duty of such companies or company to have the work upon said bridge or its approaches begun in good faith, and to so continue its construction without unnecessary delay within one year from the passage of this act, and to have said bridge in condition for use within six years, and any failure herein shall at once work a forfeiture of all rights herein, and this act from said date of said failure stand and be of no effect.

SECTION 7. That this act shall take effect and be in force from and after its passage.

CHAS. OFFUTT,
Speaker of the House of Representatives.
JAMES R. HENDMAN,
Speaker of the Senate.

J. PROCTOR KNOTT.

Approved March 22, 1886,
by the Governor,

J. A. McKENZIE,
Secretary of State.
By H. M. McCARTY,
Assistant Secretary.

COMMONWEALTH OF KENTUCKY, }
Office of the Secretary of State. }

I, J. A. McKENZIE, Secretary of State for the Commonwealth aforesaid, do hereby certify that the foregoing writing has been carefully compared by me with the original on file in this office, whereof it purports to be a copy, and that it is a true and exact copy of the same.

In testimony whereof, I hereto sign my name, and cause my official seal to be affixed. Done at Frankfort, this 20th day of March, A. D. 1886.

J. A. McKENZIE,
Secretary of State.
By H. M. McCARTY,
Assistant Secretary of State.

APPENDIX D.

CONTRACT WITH WAR DEPARTMENT.

WHEREAS, by an Act of Congress, approved December 17, 1872, entitled, "An Act to authorize the construction of bridges across the Ohio River, and to prescribe the dimensions of the same," it was enacted, that any persons or corporations, having lawful authority therefor, may hereafter erect bridges across the Ohio River for railroad or other uses, upon compliance with provisions contained in said act;

AND WHEREAS, by section four of an Act supplementary to the act aforesaid, approved February 14th, 1883, it was further enacted that any person, company, or corporation, authorized to construct a bridge across the Ohio river, shall submit to the Secretary of War, for his examination, a design and drawings of the bridge and piers, and a map of the location, giving, for the space of at least one mile above and one mile below the proposed location, the topography of the banks of the river and the shore lines at high and low water. This map shall be accompanied by others, drawn on the scale of one inch to two hundred feet, giving, for a space of one-half mile above the line of the proposed bridge and a quarter of a mile below, an accurate representation of the bottom of the river by contour lines two feet apart, determined by accurate soundings, and also showing over the whole width of this part of the river the force and direction of the currents at low water, at high water, and at least one intermediate stage, by triangulated observations on suitable floats. The maps shall also show the locations of other bridges in the vicinity, and shall give such other information as the Secretary of War may require for a full and satisfactory understanding of the subject. Said maps and drawings shall be referred to a board of engineers for examination and report, which board shall personally examine the site of the proposed bridge, and shall

hold a public session at some convenient point to hear all objections thereto, of which public session due notice and invitation to be present shall be given to all interested parties; and if said board of engineers reports that the site is unfavorable, the Secretary of War shall be authorized, on the recommendation of said board, to order such changes in the bridge or its piers, or such guiding dikes or other auxiliary works as may be necessary, at the expense of the proprietors or managers of such bridge or piers and other works, for the security of navigation; and the proposed bridge shall only be a legal structure when built as approved by the Secretary of War;

AND WHEREAS, the Chicago, Saint Louis and New Orleans Railroad Company, a duly organized corporation, having authority to build a railroad bridge across the Ohio River at Cairo, in the State of Illinois, pursuant to the Acts of Congress aforesaid regulating the construction of bridges across the Ohio River, and having accepted the provisions of said Acts, has submitted, for the approval of the Secretary of War, the design and drawings of its proposed bridge and piers and map of location of the same, together with maps giving a representation of the bottom of the river and the force and direction of the currents;

AND WHEREAS, the Chief of Engineers, United States Army, reports that said design, drawings and maps, in his opinion, conform to the requirements of the board of engineers, and also with the provisions of the Act of December 17, 1872, and the supplementary Act of February 14, 1883, authorizing the construction of bridges across the Ohio River.

NOW, THEREFORE, I, William C. Eastcott, Secretary of War, having examined and considered the design, drawings and maps submitted by the Chicago, Saint

Louis and New Orleans Railroad Company as aforesaid, and hereto annexed, do hereby approve the same.

But it is understood and agreed that this approval is given upon the express conditions following:—

1. That the said bridge shall be built at the point indicated in the map of location submitted, and constructed in accordance with the design and drawings hereby approved and the laws regulating the construction of bridges across the Ohio River.

2. That should any change be deemed necessary to be made in the design and drawing of said bridge during the progress of construction, such change shall be subject to the approval of the Secretary of War.

Witness my hand this first day of April, 1887.

(Signed)

Wm. C. Eastcott,

Secretary of War.

[SEAL]

This instrument is also executed by the Chicago, Saint Louis and New Orleans Railroad Company, by Stayveant Fish, its Vice-President, thereto lawfully authorized, this thirty-first day of March, 1887, in testimony of the acceptance by said Company of the conditions herein imposed.

STAYVEANT FISH,

Vice-President of the Chicago, Saint Louis and New Orleans

Railroad Company.

In presence of

E. T. H. GIBSON,

W. E. HURMAN.

APPENDIX E.

REPORT OF FEBRUARY 3RD, 1887.

New York, Feb. 3rd, 1887.

E. T. JEFFERY, ESQ., Gen. Manager, Chicago, Ill.

DEAR SIR:—We have examined carefully the several plans which you have sent us relating to the proposed bridge across the Ohio River at Cairo. These plans comprise a map showing the location of the bridge and the river adjacent thereto, a profile showing the proposed grade and the bottom of the river, a cross-section of the river showing borings made in the fall of 1881, and a number of blue prints showing the designs of a structure which it has been proposed to erect here.

After examining these plans, we feel convinced that we cannot make a report which will be of any real value until we have actually visited the site and gone into the local details more carefully than we can do without a personal examination.

Inasmuch, however, as we understand you want some expression of our general views on this subject as early as possible, we have thought best to outline briefly the principles which, we think, should govern the construction of a bridge at this location.

The peculiarity of the situation at Cairo is, that, though the bridge will be across the Ohio River, it will really be built in the alluvial delta of the Mississippi River, and the bottom of the river is entirely of an alluvial character, in which nothing but sand is found, except at a depth of more than 150 feet below low water, while the material below this sand is of a character but little more permanent than the sand itself. On the other hand, from such information as we have obtained, the regimen of the Ohio River, even here, is that of a comparatively fixed stream which scours but little, even during extreme floods, and the bottom of the river is disturbed to no very great extent, though, of course, the construction of piers must be expected to make some little local disturbance.

It is pre-eminently a case in which some form of foundation in sand must be selected, and the form which seems to us best is that of a single foundation, sunk into this sand to such a depth that its stability resembles the stability of a pile, rather than the stability of a foundation on solid material.

As with any such foundation it is important that the river bed should be disturbed as little as possible after the foundations are in, we believe that special attention should be given to the form of the piers, so that they may pass the water with the least possible obstruction and the least possible accumulation of drift; and further, that an inexpensive protection in the way of mattress work should be placed around each pier on the present bottom of the river, instead of the customary mass of loose rip-rap. The model shape of the masonry pier should start below the bed of the river.

Below the masonry, we should propose to make the foundation of timber crib-work filled with concrete, the amount of timber-work and concrete to be in such proportions that the specific gravity of the whole should average the same as that of the sand which it displaces; so that the additional weight put on the foundation, this additional weight really measuring the fatigue of the foundation, should be simply the weight of the masonry and the superstructure above the bed of the river. The pier would then be sustained, first by the friction of the sand against the sides of the timber-work, and second, by the bearing on the sand at the base of this timber-work, and the design should be so made as to make this friction and bearing as great as possible. Both friction and bearing power increase with the depths of the foundation, and we think that the penetration of the foundation should be 50 feet below the bottom of the masonry and at least 60 feet below the present bed of the river, this providing for a possible scour of 10 feet. We also think that the timber foundation work should be of such dimensions that after providing for a friction of 400 pounds per square foot of surface in contact with sand, the pressure on the base should not exceed three tons per square foot, these amounts being applied to the fatigue weight of the foundation, that is, the weight in addition to the weight of the sand displaced. In order to utilize the whole frictional resistance, the foundation should be made with vertical sides without batter. The foundation would consist of a caisson at the bottom, surmounted by a timber crib planked and filled with concrete. The caisson may be adapted to the plenum pneumatic process or be sunk by dredging inside. As the depth to which these caissons would have to be sunk would not be excessive, it would, perhaps, be wiser to use the pneumatic process.

The general dimensions of the piers shown on the plans which you sent us seem to us about as they should be, but we think it desirable to change the form of the

piers somewhat, so as to create less resistance to the passage of water, and we have prepared plans of piers of the dimensions adapted to the 325 and 400 feet spans, which plans we send you with this report.

As regards the general arrangement of the bridge as shown on the plans which you have sent us, there are some important possible changes, such as putting a portion of the bridge on a grade, and perhaps using deck spans on a part of it, which we do not feel we can speak of until we have visited the location and until we have had a consultation with you, as there may be special reasons which led to the adoption of the high bridge of uniform level throughout, with which we are not familiar.

For the present we should not suggest any material alterations in the general design of the bridge, though in the interests of simplicity and uniformity we think it might be wise to substitute for the three 500-foot spans at the Kentucky end of the bridge two spans of 400 feet each, so that the main structure would consist of two spans of 325 feet each and seven spans of 400 feet each. There is at present at the Illinois end of the bridge one span of 200 feet. We think it would be wise to substitute for this span a 250-foot span, the shore end of which should rest on a pier founded on the original ground back of the levee, and not on the made ground of the levee. We should also recommend placing a span of equal length at the Kentucky end of the bridge, thus avoiding the high viaduct piers which now stand on the slope of the bank below the level of high water. Both of these spans we think could be deck spans to good advantage.

So far as the viaduct approaches are concerned, these are matters of simple construction, and it does not seem expedient to say anything about these or about the approaches until we visit Cairo.

We do not know how soon you wish to have us make a final report on this matter, but if the time suits your convenience, it would be most convenient to us to visit Cairo about the 20th of February or a week later.

Very respectfully yours,

(Signed) Geo. S. Monson,
E. T. CORRELL.

APPENDIX F.

REPORT OF MARCH 3RD, 1887.

CHICAGO, March 23rd, 1887.

E. T. JEFFERY, ESQ., General Manager, Chicago, Illinois.

DEAR SIR:—On the 3rd of February, we addressed to you a preliminary report in relation to the proposed bridge across the Ohio River at Cairo, this report being based upon the plans which you had sent to us in New York. Since then we have visited Cairo and spent three days there with you. The time of our visit was at the extreme high water of the spring flood of this year, this time being, perhaps, as favorable as any one time to observe the action of the river, though not giving us the information which we should like to have had, as to the character of the bottom of the river, which we could only see at low water. We believe, however, that our general knowledge of this river and the information we have obtained from various sources is enough to cover the present case.

In our preliminary report, we stated that the peculiarity of the situation at Cairo is that, though the bridge will be across the Ohio River, it will be really built in the alluvial deposit of the Mississippi River. In point of fact, both banks of the river are entirely alluvial for about ten miles above Cairo. During the lower half of this distance, the river has a curve to the east, the general course being one favorable to stability; but the want of any fixed material in either bank or bottom makes this a relative, rather than an absolute, stability. The changes that may occur here will be very small, compared with those which are constantly taking place in the Mississippi, but there is apparently a regular course of change which, though slow, is actual. At the site of the proposed bridge, the width between the banks is nearly 4,000 feet; two miles below it is about 3,000 feet; at the broader place the channel is much deeper near the Illinois, or concave, shore than anywhere else; at the narrower place, it is of comparatively uniform depth throughout. These different widths and depths probably mark a progressive change in the river, and as the junction between the Ohio and the Mississippi works down the valley, which it is doing regularly, it is probable that the changes in the width and depth of the river above will follow. The first conclusion which we draw from this is that we must treat the whole width of the river in substantially the same manner, as there is a possibility of having the same depth of water at one point as at another, and that it is expedient to sink all of the foundations to the depth recommended in our preliminary report for the deepest, that is fifty feet below the present bed of the river at the very deepest point and seventy-five feet below low water.

For the present, this seems to us the wisest course, but we do not wish to bind ourselves absolutely to an arbitrary decision, as the character of material excavated,

or some subsequent observations, may make it seem expedient to increase or diminish the depth of one or more foundations.

Another effect of the slightly curved form of the river is to make the high water current next to the Illinois bank about one quarter stronger than that along the Kentucky bank, the result being that steamers going up stream lag the Kentucky bank during high water. Neither of these currents is excessively rapid, and there will be no real difficulty in going up the Illinois shore; still any plan of bridge which would diminish the head-room along the Kentucky shore during high water, and compel the boats, especially those with tow, to depart from their present course, would undoubtedly meet with opposition, and this opposition would be made the most of by all disaffected parties. For these reasons, the suggestion made in our previous report as to the possibility of putting a portion of the bridge on a grade, and using dock spans on a part of it, must be set aside.

The fact that the river two miles below the proposed bridge is nearly 1,000 feet narrower than at the bridge site, raises the question as to whether the river might not be artificially narrowed to 3,000 feet, and the length of the bridge correspondingly reduced. This could undoubtedly be done, and we believe it could be done successfully, but any such action would throw upon your Company the burden of proving that any injuries to local interests caused subsequently by the river were not due to the reduction in its width at this point; and while this might be proved to the complete satisfaction of a board of river engineers, it could not be proved to the satisfaction of a jury. We think that any such scheme, though good engineering, would be, commercially speaking, very imprudent. This is more so because of the alluvial character of the banks, both of which are subject to erosion, and the terrible disaster which would befall Cairo if any one of its levees were to break in high water.

After examining the ground as carefully as we were able, we see no reason to suggest any changes in the location of your bridge, but believe that the site is as well chosen as possible, and that while the piers will not be strictly parallel with the current at all times and stages, this is due to the fact that the currents are not exactly parallel with themselves, and the actual position is as nearly perfect as can be obtained.

The slight change which we now recommend in the arrangement of spans, as shown in the plans which you previously submitted, are hardly more than matters of detail. The arrangement which seems best to us consists of two spans of 518.5 feet between centers of end piers placed next to the Illinois shore, and seven spans of 400 feet each reaching to the Kentucky shore. These nine spans are to be through spans, with the bottom chord fifty-three feet above high water, as required by law. The ten piers on which these nine spans would rest would all be treated as river piers, and the foundations sunk to the same depth. At the Kentucky end, we should place a single dock span of 250 feet, reaching to the higher level of the

bottom land, and at the Illinois end two dock spans of the same length, reaching across the various tracks which now occupy this ground. The piers on which these shore spans would rest would have inexpensive foundations, and the twelve spans and thirteen piers, having a total length of 4,650 feet, will constitute the bridge proper.

In the matter of piers and foundations, we have no changes to suggest in the recommendations of our report of Feb. 2nd, excepting that all of the foundations should be sunk to a uniform depth of seventy-five feet below low water, and the masonry started twenty-five feet below low water. The form of the lower works and piers then recommended, we believe, cannot be improved upon. We think the piers should be built of the best limestone which can be obtained for this purpose, and the sharp edge of the up-stream cut-water should be of granite.

Below the masonry, we should propose to make the foundation of timber crib-work filled with concrete, the amount of timber-work and concrete to be in such proportions that the specific gravity of the whole should average the same as that of the sand which it displaces; so that the additional weight put on the foundation, this additional weight really measuring the fatigue of the foundation, should be simply the weight of the masonry and the superstructure above the bed of the river. The pier would then be sustained, first by the friction of the sand against the sides of the timber-work, and second, by the bearing on the sand at the base of this timber-work, and the design should be so made as to make this friction and bearing as great as possible. Both friction and bearing power increase with the depths of the foundation, and we think that the penetration of the foundation should be fifty feet below the bottom of the masonry, and at least sixty feet below the present bed of the river, thus providing for a possible scour of ten feet. We also think that the timber foundation work should be of such dimensions that after providing for a friction of 400 pounds per square foot of surface in contact with sand, the pressure on the base should not exceed three tons per square foot, these amounts being applied to the fatigue weight of the foundation, that is, the weight in addition to the weight of the sand displaced. In order to utilize the whole frictional resistance, the foundation should be made with vertical sides without batter.

We have prepared plans of caissons and foundations, and full specifications covering this portion of the work.

We consider that the best method of sinking these foundations would be by the plenum pneumatic process. This will give complete control of the work in case any obstructions, such as steamboat wrecks, should be met with, and is a method by which caissons of limited weight, and horizontal dimensions can be sunk rapidly, where there might not be enough weight to sink by dredging.

The three shore piers would have cheap pile foundations, which are also provided for in the specifications.

In the matter of superstructure, we should recommend that it be built entirely

of steel, excepting only such small pieces as nuts, bolts and clevises, which may be of wrought iron, and the large bearing plates on the masonry, which should be of cast iron. We should also advise that a uniform grade of steel be used through out for this work, and this steel may be either an American or imported steel, and that the bridge be proportioned for a moving load of 3,000 pounds per lineal foot, with a provision for double this load on the floor system and all members which are liable to sudden shocks, and that the strain shall be kept about 1,000 pounds per square inch less than has lately been customary in steel structures. Under these provisions the structure will have a large factor of safety under a moving load of two tons per foot.

We have prepared specifications for material and workmanship, and as soon as possible will have detailed plans made of the superstructure.

We should recommend that this bridge have a special floor substantially similar to that which one of us has put on a number of the Missouri River bridges, which is bolstered to have all possible provisions for safety in case of derailment, and under which the shocks communicated by bad wheels to the trusses are reduced to a minimum.

After the completion of the piers, we recommend that a protection mattress be woven around the piers that come in the water at ordinary low water stages, and weighted with rip-rap, while it is possible that a small amount of rip-rap will be required on the shores. The expense for this purpose, however, will not be large.

In the matter of approaches, we should recommend that these be built at first in the form of temporary pile bridges, or timber trestles, as has already been begun on the Kentucky side. The situation is one in which it is desirable to avoid iron viaducts, both on account of the curvature on the approaches, and because the ground on both sides is subject to overflow to a depth of from 10 to 20 feet, which would make the masonry foundations for an iron viaduct very expensive. The timber trestles built in this way will last from six to eight years; all but the highest portions of them could be subsequently filled economically, and the high portions at each end of the bridge might ultimately be replaced with iron viaducts, the level of the ground having been first raised above high water so as to reduce the cost of the under works.

The estimated cost of the entire bridge and approaches is given in the following table:

ESTIMATE.	
350 M. B. M. Timber at \$42.....	\$14 700
77 000 cub. ft. Concrete at 40c.....	30 800
130 000 lbs. Iron at 5.5c.....	7 150
158 000 cub. ft. Excavation at 13c.....	20 540
5 800 cub. yds. Masonry at \$15.....	85 400
Three Channel Piers at.....	\$141 590
265 M. B. M. Timber at \$42.....	\$11 130
35 000 cub. ft. Concrete at 40c.....	14 000
114 000 lbs. Iron at 5.5c.....	6 270
Three Shore Piers at.....	\$10 000
Total Substructure.....	\$1 204 100
1 950 000 lbs. Steel at 4.3c.....	\$83 850
Erection.....	25 000
Two Channel Spans at.....	\$108 850
1 100 000 lbs. Steel at 4.3c.....	\$47 300
Erection.....	14 000
Seven River Spans at.....	\$61 500
450 000 lbs. Steel at 4.3c.....	\$19 350
Erection.....	2 000
Three Shore Spans at.....	\$21 350
Total Superstructure.....	\$ 710 850
Total Contract Work.....	\$ 1 914 950
4 650 ft. Bridge Floor at \$4.50.....	\$20 925
- - - Rails and Fastenings at \$1.....	4 650
Painting.....	20 000
Protection Work.....	25 000
Total Bridge Proper.....	\$1 985 525
Illinois Pile Bridge Trestle.....	\$62 500
Kentucky Pile Bridge Trestle.....	\$2 310
14 265 ft. Rails and Fastenings.....	14 265
Approaches.....	\$159 185
Engineering and Inspection.....	70 000
Add 10 per cent. for contingencies.....	221 471
Grand Total.....	\$2 436 181

This makes the entire cost of the structure, including a 10 per cent. allowance for contingencies, about two and a half million dollars. While this seems a very large sum for a single-track bridge, it must be remembered that the

bridge is one of very unusual dimensions. It is twice as long as the bridges on the Upper Mississippi. The foundations are of unusual depth, and the distance from the bottom chord of the bridge to the bottom of the foundation is more than 180 feet. If the size of the structure be compared with other Western bridges, it will be found to be a very economical bridge.

The estimate of the bridge proper has been made on the basis of prices established by us and on which the Union Bridge Company has agreed to do the work, these being detailed prices for foundations, masonry and superstructure, and covering everything required to complete the 4,650 feet of bridge proper ready to receive the timber floor and to be painted.

It has seemed best to us that the timber floor should be laid by your Bridge Department and that the painting should not be done by contract. We also think that the protection work should be done by your own men, and it is perhaps best that the timber approaches should be built in the same way, though the work on these approaches can be deferred for some time.

We believe that the Union Bridge Company is better able to carry out the entire work of the bridge proper, both substructure and superstructure, than any other concern in America, and that the interests of your company will be furthered by closing a contract with them on the basis of the prices in this estimate.

In the matter of time, the preparation for the foundations should be begun at once and the work conducted on the basis of having the three foundations of the piers supporting the long channel spans finished in 1887, the masonry to be built up during the first half of 1888, and these spans erected during the low water season of 1888; the foundations for the other seven river piers to be put in before the end of 1888, the masonry completed by July 1st, 1889, and the entire structure made ready for the track before the close of 1889. This scheme provides for three working seasons, and builds the bridge in about two and a half years, which is as short a time as would appear to be economical.

As to the best manner of conducting the work, there must, of course, be some engineer or engineers who will have the direction of the whole work, and to whom the contractors will look for their instructions. A first-class man should be located at Cairo as resident engineer, having entire charge of all work there and acting upon such instructions as he might receive from the engineer of the work. This resident engineer would require a staff of assistants and inspectors. There should be also an inspector at the shops while the work is being manufactured there, with one or more assistants, so that all work may be inspected during progress.

We have prepared a full specification for the entire work of the bridge proper, a copy of which accompanies this report, as also a draft of a contract with the Union Bridge Company.

The plans required by the Secretary of War have also been prepared under our direction and are ready for submission to him, with the proper official documents.

Very respectfully,
(Signed)

Geo. S. MONROE,
E. L. CORRELL.

APPENDIX G.

CONTRACT MAY 4, 1887.

CONTRACT FOR BRIDGE ACROSS THE OHIO RIVER, AT
CAIRO, ILLS.

THIS AGREEMENT, made and entered into on this the fourth day of May, 1887, by and between GEORGE S. FIELD, EDMUND HAYES, C. S. MATHEW AND CHARLES MACDONALD, who as individuals, and also as a partnership firm, doing business under the firm name of "UNION BRIDGE COMPANY," of New York, contract, as hereinafter set forth, as parties of the first part, and the CHIEF ENGINEER, ST. LOUIS AND NEW ORLEANS RAILROAD COMPANY, a corporation existing under the laws of Kentucky, Tennessee, Mississippi and Louisiana, and acting herein under authority granted by the State of Kentucky, contracts as hereinafter set forth as party of the second part, witnesseth as follows:

FIRST.—The parties of the first part aforesaid contract and agree with the party of the second part aforesaid that they will, according to the annexed plans and specifications, and under the directions of the Chief Engineer, construct a railroad bridge across the Ohio River, between Ballard County, in the State of Kentucky, and Alexander County, in the State of Illinois, at a place where the Chief Engineer of said bridge has located the same, upon the terms and conditions following, to-wit:

The parties of the first part agree to furnish the necessary materials, means and appliances, and to perform and do in accordance with the plans and specifications aforesaid, and under the direction of the Chief Engineer aforesaid, the work of sinking foundations for the river piers of said bridge, and constructing them in the manner described in the accompanying specifications, for five and five tenths ($5\frac{1}{2}$) cents per pound for the iron and steel; forty-two dollars (\$42) per thousand feet, board measure, for the timber; forty (40) cents per cubic foot for the concrete used therein, and thirteen (13) cents per cubic foot for materials removed in sinking each foundation. The amount of such material to be estimated as equal to the area of the base of the foundation multiplied by the depth from low water to the bottom of the cutting edge.

SECOND.—To construct the pile foundations of the shore piers as described in the accompanying specifications, and furnish all the materials, means and appliances therefor, at twenty-five (25) cents per cubic yard for necessary earth excavation; thirty-five (35) cents per linear foot for the necessary piles left in the completed work, and forty (40) cents per cubic foot for the concrete used therein.

THIRD.—To furnish stone and all other materials to be used in the masonry and all the necessary means and appliances, and construct the masonry, as required in the accompanying specifications, in the river piers of said bridge for eighteen dollars (\$18) per cubic yard of such masonry when complete.

FOURTH.—To furnish the materials and manufacture the superstructure of said bridge—

Two (2) five hundred and eighteen and five tenths ($518\frac{1}{2}$) feet spans;

Seven (7) four hundred (400) feet spans;

Three (3) two hundred and fifty (250) feet spans;

according to the annexed specifications, at four and three tenths ($4\frac{3}{10}$) cents per pound for finished material delivered at Chicago.

FIFTH.—To erect the superstructure complete, ready for the cross-ties, for the following prices:

Each $518\frac{1}{2}$ foot span at twenty-five thousand dollars (\$25,000).

Each 400 foot span at fourteen thousand dollars (\$14,000).

Each 250 foot span at two thousand dollars (\$2,000).

SIXTH.—The work herein specified shall be executed under the direction of the Chief Engineer of the bridge and his assistants, by whose measurements and calculations of the quantities and amount of the several kinds of work done and materials furnished, the monthly estimates shall be made and the final estimate determined, and the said Chief Engineer shall have power to reject all work and materials which, in his opinion, shall not be in accordance with the plans and specifications hereto attached, and with the spirit of this agreement. During the progress of the work, he shall determine any questions as to what is required by the plans and specifications, and he shall decide whether the work is from time to time proceeding with such diligence as to insure the completion of the several parts, and of the whole work, as herein contracted and by the times mentioned in this contract; and if, in the opinion of said Chief Engineer, said work, or any part thereof, shall not be so proceeding, he shall require each additional force to be put upon the same within such time as he may, in writing, designate, and upon the failure of the parties of the first part to comply with such requirements, the said Chief Engineer may put upon said work the additional force so required at the expense of the parties of the first part.

Or the said Chief Engineer, upon the failure of the parties of the first part to comply with such requirements or any of them within the time so designated, or of their failure to perform any of their covenants or agreements as herein covenanted or agreed, for thirty days after notice of the breach thereof, may, and on the demand of the party of the second part shall, declare that the parties of the first part have broken this contract and have failed to comply with its terms, and thereupon said parties of the first part shall forfeit all claim to the reserved fund or any part thereof which is hereinafter mentioned, and this contract shall be, by their said default so declared, terminated.

SEVENTH.—The work shall be at all times under the supervision of the said Chief Engineer of said bridge and his assistant engineers, all of whom are to be ap-

pointed by the second party, and said Chief Engineer shall have authority to discharge disorderly or inefficient foremen or other employees of the parties of the first part engaged in said work, if in his judgment their presence or employment upon the work is detrimental to its character, progress or interests; provided, the parties of the first part fail to discharge them upon his request to do so.

EIGHTH.—The rate of progress and time of completion shall be as follows: The foundations of the three large river piers shall be completed in the year 1887, and the masonry of these piers before July, 1888. The two longest spans shall be raised in the fall of 1888. The seven remaining foundations shall be put in during the year 1888, and the masonry of these piers completed before July, 1889. The seven remaining river spans shall be erected in the fall of 1889, and the entire bridge, including all piers and spans and other work mentioned in this contract, shall be completed on or before December 31, A. D. 1889.

The work on said bridge and piers and foundations shall be continued without unnecessary delay to completion, and there shall be no unnecessary delay in furnishing the materials nor in any part of the work of construction, nor any halt in the work or any part thereof which may affect injuriously the stability of foundations, piers or superstructure or any part thereof, nor shall any material mentioned in or allowed by the specifications be used which is not the best for the purpose, used according to the opinion of the Chief Engineer of said bridge.

In case any change in the location, specifications or plans of said bridge, prior to its final completion, is required by the Secretary of War, or the party of the second part, the prices of the material furnished therefor or work done thereon shall not exceed those herein mentioned for similar material or work.

NINTH.—In case the entire work is not completed on the said 31st of December, 1889, then and in that case the parties of the first part shall pay to the party of the second part three hundred and fifty dollars (\$350) per day as liquidated damages for each day beyond said date that the entire work remains incomplete.

TENTH.—It is further agreed between the parties hereto, that the parties of the first part shall have no right or power to assign this contract in whole or part, nor to assign any right arising thereunder; and in case of the insolvency or bankruptcy of said parties of the first part, or any of them, prior to the final completion of said bridge, there shall be nothing due them under this contract save for such parts of material furnished and accepted, and for work therefor done that had not been at that time estimated, or, if estimated, had not been paid; but the failure from insolvency to progress with or finally complete said work and its several parts, or either of them, as and at the dates heretofore mentioned, or the failure from any cause to finally complete said bridge as herein contracted, shall, *ipso facto*, be a forfeiture of the reserved fund, and neither of said parties of the first part, nor

any assignee in bankruptcy or otherwise, shall have any right or claim thereto or to any part thereof. And it is further agreed that no part of the work mentioned herein shall be sublet or in any way removed from the control of the parties of the first part, under the direction and supervision of the Chief Engineer as aforesaid, except as herein provided.

Eleventh.—The character of the work, the kind of materials furnished and all other requirements of the annexed specifications and plans, and the times limited for the completion of each part, and of the whole, are agreed to be essential parts of this contract.

Twelfth.—The terms of payment for the work shall be as follows: During the progress of the work the Chief Engineer shall cause estimates to be made of the work done and materials delivered during each calendar month, and about the 15th day of the succeeding month, the amount of the same shall be paid to the parties of the first part, less, however, a reserved fund of ten (10) per cent., which reserved fund shall be held by the second party as security for the completion of the whole work and its several parts; and if at the times herein contracted, each and every part of said bridge has been built in accordance with the specifications and plans, and is delivered up to the second party free from all claims, and if the parties of the first part have done and performed all their covenants and undertakings herein, then the party of the second part is to pay over to the parties of the first part all of said reserved fund.

And provided further, that when the last foundation shall have been completed in accordance with the terms of this contract, then the party of the second part shall pay over to the parties of the first part so much of such reserved fund as shall be necessary to reduce the amount held by the party of the second part to the sum of one hundred thousand dollars (\$100,000), and said sum of one hundred thousand dollars, and no more, shall be retained by the party of the second part as security for the completion of the whole work.

It is agreed that, after the completion of the entire work in accordance with the specifications and directions of the Chief Engineer, and before the final settlement is made, any differences or controversies arising under this contract between the parties hereto may be finally settled by a body of arbitrators consisting of three persons: one to be the Chief Engineer of said bridge, one to be named by the contractors, to wit, the parties of the first part, and the third to be selected by the other two. The arbitrators shall judge by a majority vote, and their decision shall be final and binding on both parties, and their award shall be performed within fifty (50) days after the work is finally completed and accepted and the award announced; but the party asking said arbitration shall, in writing, specify the particular thing to be arbitrated, and the arbitrators shall be confined to the things so specified by the one or both parties.

Thirteenth.—It is further agreed that no material shall be estimated until delivered at the bridge site, except steel for the superstructure, which shall be estimated when delivered at the shops of the party of the first part; and such steel

shall be marked and set apart for use in said bridge, and the parties of the second part shall have special lien thereon to the extent of the advances thus made; nor shall any material be paid for on final estimate or otherwise which does not form an actual part of the finished structure or is not of the class and quality required by the specifications.

In making monthly estimates the following prices shall be used:

Dimension stone, cut and delivered, ten dollars (\$10.00) per cubic yard.

Backing, cut and delivered, seven dollars (\$7.00) per cubic yard.

Timber for foundation, delivered, sixteen dollars (\$16.00) per thousand feet, board measure.

Iron for foundation, delivered, four cents (\$0.04) per pound.

Steel for superstructure, delivered at shops but not completed, sixty (60) per cent of finished price.

Steel for superstructure, manufactured at shop, eighty (80) per cent. of finished price at Chicago.

No claim for extra work shall be paid unless it be presented within fifteen (15) days after the end of the month in which said work is performed, and then only when approved by the Chief Engineer as having been ordered by him to be done.

FOURTEENTH.—It is further agreed that the materials of the superstructure of said bridge which said parties of the first part may ship from Chicago to Cairo over the Illinois Central Railroad, and also any necessary switching of the same at Cairo or East Cairo, or transferring across the Ohio River between the inclines at Cairo and East Cairo, shall be carried and done without unreasonable delay and without cost to said parties of the first part, but all losses or damage during such transportation, switching or transfer shall be borne alone by said party of the first part.

FIFTEENTH.—The parties hereto respectively covenant and agree in behalf of themselves, their representatives and successors.

IN WITNESS WHEREOF, the parties of the first part, as individuals and also as a partnership firm, have hereunto set their several and their partnership names and private seals, and the party of the second part has caused its corporate name to be hereto signed and its corporate seal to be hereto affixed this the day and year first above written.

(L. S.)

(L. S.)

(L. S.)

(L. S.)

GEORGE S. FIELD,

EDMUND HAYES,

C. S. MACDONALD,

CHARLES MACDONALD,

UNION BRIDGE CO.,

By C. Macdonald,

CHICAGO, ST. LOUIS & NEW ORLEANS
RAILROAD COMPANY.

By STUYVESANT FISH,

Vice-President.

(L. S.) E. T. H. GIBSON,

Secretary C. & N. O. R. R. Co.

SPECIFICATIONS FOR BRIDGE ACROSS THE OHIO RIVER, AT CAIRO, ILLS.

GENERAL DESCRIPTION.

The bridge will consist of two channel spans, seven river spans and three approach spans. There will be eleven masonry piers in the river, founded on pneumatic caissons, these eleven piers supporting the ten channel and river spans; and three smaller piers, founded on piles, supporting the approach spans.

The **STRUCTURE** of the bridge will be understood to include those thirteen piers, both masonry and foundations.

The **SUPERSTRUCTURE** will include the twelve spans above named.

Full detailed plans of both substructure and superstructure will be furnished by the Engineer of the bridge.

The work shall be built in all respects according to these plans. The contractor, however, will be expected to verify the correctness of the plans and will be required to make any changes in the work which are necessitated by errors in these plans without extra charge, where such errors can be discovered by inspection of the plans.

SUBSTRUCTURE.

The three piers next to the Illinois shore, which support the two main channel spans, will finish 32 feet thick, and 29 feet long between shoulders, and 41 feet long over all under coping. The other seven river piers will measure 16 feet thick, 25 feet long between shoulders, and 35 feet long over all under the coping. The three shore piers will measure 8 feet thick, 20 feet long between shoulders, and 28 feet long over all under the coping.

The masonry of the ten channel and river piers shall begin 25 feet below low water, or at elevation 73 above the assumed datum.

The masonry of the shore piers shall begin 10 feet below the natural surface of the ground.

The pneumatic foundations of the river piers shall be sunk 75 feet below low water, or to an elevation 25 feet above datum, unless otherwise specially directed.

PNEUMATIC FOUNDATIONS.

The pneumatic caissons for the three channel piers will be 30 feet wide and 70 feet long. Those of the seven river piers 24 feet wide and 40 feet long.

The caissons will be surmounted by a timber crib work which shall make the total height from cutting edge to top of crib work 50 feet, the sides being vertical and the top of the crib finished of the same dimensions as the caisson.

The caissons and crib work shall be built of thoroughly sound yellow pine timber or such other timber as may be approved by the Engineer of the bridge.

and shall be planked on the outside with two thicknesses of three-inch oak plank, the inner thickness being put on at an angle of 45 degrees. The timber work shall be accurately and closely framed, the timbers being shod so as to secure immediate contact throughout, and the inner course of plank being planed to uniform thickness so as to secure an exact fit for the outer course. The timbers shall be bolted together with long rods and with drift bolts, as shown on the plans.

The cutting edge of the caissons shall be of iron and of the form shown on the plan. An iron working shaft shall be built into the caisson and crib work for a height of 20 feet above the roof of the working chamber, which distance may include the shell of the air lock. A supply shaft, 24 inches in diameter, shall also be built into the caisson, crib work and masonry. One four-inch air pipe, one five-inch water pipe and two four-inch discharge pipes shall also be built into the caisson, crib work and masonry.

The space above the working chamber and within the outer walls of the caisson and crib work shall be filled with concrete. The concrete within two feet of the top of the roof of the working chamber shall be formed of Portland cement and sand, three parts of sand to one part of cement, into which small stones may be rammed after it is put in position. The upper one foot of the concrete shall be formed in the same way. The remainder of the concrete shall be made of Louisville cement, sand and stone, two parts of sand to one of cement, and not over 60 per cent. of the whole volume in broken stone, the amounts of cement not to exceed two barrels per cubic yard. In Portland cement, the sand and cement shall be mixed together dry, then run through a satisfactory machine mixer. The mass of concrete shall always be thoroughly rammed after being put in position. The Louisville cement concrete shall be worked in a mixer approved by the Engineer.

The caissons shall be sunk to the height specified above and shown on plans, unless otherwise specially directed by the Engineer, and shall not vary more than fifteen inches from correct position. The sand shall be excavated by the process used at the Rulo and Omaha bridges, unless some other plan is approved specially. When the required depth is obtained, the caissons shall be filled with concrete, the lower two feet of concrete reaching to the shoulder of the cutting edge and to the cross beams shall be formed of Portland cement and sand, three of sand to one of cement. The remainder of the filling may be of Louisville cement, sand and stone, in the proportion mentioned above. The working shaft and supply shaft and pipes shall not be filled, but shall be closed at the ends with iron or wooden bulk heads.

PILE FOUNDATIONS.

The piles shall be arranged according to detailed plans to be furnished by the Engineer. They shall be straight, and of good, sound white or hurr oak or cypress or other hard wood that may be driven to refusal without splitting; they shall be at least eleven inches in diameter at the small end.

They shall be driven in a pit excavated about twelve feet deep and so as not to go more than one-half inch at the last blow of a hammer weighing 3,000 lbs., and falling twenty-five feet. They shall be cut off level and finished clear of splinters.

Concrete made of Portland cement and mixed as prescribed elsewhere in these

specifications shall be placed between the piles and shall be well rammed and shall extend at least two feet below the head of the piles and two feet above them and shall then be perfectly leveled off.

On this concrete foundation, when it has become well set, shall be built masonry piers according to the general plans now furnished, and more detailed plans to be furnished by the Engineer in charge, after which the pit shall be refilled with earth well rammed.

MASONRY.

The stone must be strong, compact, and of uniform quality and appearance and free from any defect, that, in the judgment of the Engineer, may impair its strength or durability.

The stone from the quarries in Bedford, Indiana, will be acceptable stone for dimension work. The Engineer may authorize the acceptance of other stone, which, in his judgment, is equal in quality and similar in appearance to the Bedford stone. The corner stone in each course of the upstream nose of the ten river piers shall be of granite.

There shall be no courses less than sixteen inches in thickness, and no course shall be thicker than the one immediately beneath it.

The joints shall be broken at least fifteen inches; each bed of every stone shall be at least one and a half times the thickness of the course in both directions, and there shall be none less than thirty inches, and no stone shall have an overhanging top bed.

The stretchers shall not be less than four feet, nor more than seven feet long. Stretchers of the same width shall not be placed together vertically.

The headers shall be from five to six feet long; every second or third stone in each course must be a header, and there shall be at least five headers in each course between the shoulders. They must hold 75 per cent. size from face to back.

The joints of the face stones shall be cut 12 inches back from the face. The horizontal joints shall average $\frac{1}{4}$ inch and shall never be less than $\frac{1}{8}$ inch.

No leveler shall be put under a stone to bring it up to the proper level.

No hammering will be allowed after the course is set; if any inequalities occur, they must be carefully pointed off.

All stones, whether face, coping or backing, shall be laid with the natural beds horizontal and in full fresh beds of mortar, mixed fresh as required for work. All stone must be carefully cleaned and moistened before being laid and no mortar bed shall be laid on any stone already set until the latter has been thoroughly cleaned and wet.

Each course must be completed and the mortar in the vertical joints well rammed before the next one is begun.

The face work shall be in Ashlar (rock face), but no projection greater than three inches will be allowed nor will any hollow stone.

The upstream stringings below high water shall be fine pointed to one-half inch.

The top coping and the coping of the projecting stringings shall be bush-hammered throughout.

The top coping shall have a wash 12 inches wide and 4 inches high. The

coping shall be made according to special plans, so as to give proper bearing for the bridge seats.

There shall be a draft line of three inches on the corners of the piers and along the lower edge of the belting course under the coping.

The face stones of every course of the upstream stringings between high water and low water shall be dowelled into those of the course below with round dowels of $\frac{1}{4}$ -inch iron, extending six inches into each course; the dowels shall be placed from 8 to 12 inches back from the face and six inches on each side of every joint. The stones of the upper course shall be drilled through before setting, after which the drill hole shall be extended six inches into the lower course; a small quantity of mortar shall then be put into the hole, the dowel dropped in and driven home and the hole filled with mortar and rammed. The three courses below the coping shall have the joints bedded with cramps of $\frac{1}{4}$ -inch round iron, 20 inches long between shoulders, the ends being sunk three inches into each stone.

The dimension stone shall be laid in Portland cement mortar of two parts of sand and one part of cement. The backing shall be laid in mortar of American cement of two parts of sand and one part of cement.

The Portland cement shall be an imported cement, equal in quality to O. F. Allen & Sons' best quality, and the American cement shall be equal to the best grade of Louisville cement.

When masonry is laid up in freezing weather, the backing shall be laid in Portland cement, three parts of sand and one part of cement, and such other precautions taken against freezing as the Engineer may direct.

The joints of the face stones shall be picked out and pointed in cold weather, with two parts of sand and one part of Portland cement, which shall be driven in with a caulking iron.

SUPERSTRUCTURE.

All parts except nuts, screws, wall pedestal plates and ornamental work will be of steel. The nuts and screws may be of wrought iron, the pedestal plates and ornamental work of cast iron.

MATERIALS.

All materials shall be subject to inspection at all times during their manufacture, and the Engineer and his inspectors shall be allowed free access to any of the works in which any portion of the material is made. Timely notice shall be given to the Engineer so that his inspectors may be on hand.

Steel may be made by the open hearth or by the Bessemer process, but no steel shall be made at works which have not been in successful operation for at least one year. Steel made by the Clapp-Griffiths process will not be accepted. All melts shall be made from uniform stock low in phosphorus, and the manufacturer shall furnish satisfactory evidence to the Engineer that this class of material is being employed, it being understood that the finished product is to be one in which the phosphorus does not average more than 5-100 of one per cent., and never exceed 1-10 of one per cent.

A sample bar $\frac{1}{4}$ -inch in diameter shall be rolled from every melt; the method of obtaining the piece from which the sample bar is rolled shall be the same for all

samples, and the amount of work on this sample bar shall be as nearly as practicable the same as on the finished product. The laboratory tests shall be made on this sample bar in its natural state without annealing.

The laboratory tests of steel made on the sample bar shall show an elastic limit of not less than 40 000 pounds per square inch, an ultimate strength of not less than 67 000 pounds nor more than 75 000 pounds, an elongation of at least 20 per cent. in a length of eight inches, and a reduction of at least 42 per cent. at the point of fracture—this elongation and reduction being the minimum and not the average requirements. In a bending test, the sample bar shall bend 180 degrees and close back against itself without showing crack or flaw on the outside of the curve. Steel having an ultimate strength of 60 000 pounds per square inch will be accepted for rivets.

Should the contractor desire to use British steel, the quenching and bending tests specified in the Hawksbury Bridge specifications will be required, and the elastic limit requirement may be waived.

Every piece of steel shall be stamped with a number identifying the melt, and a statement of the results of the laboratory tests of each melt shall be furnished by the contractor, certified by some person acceptable to the Engineer and accompanied by the tested specimens. Tests shall also be made from time to time on samples cut from finished plates, shapes and bars, which shall show results substantially conforming to those shown by the sample tests of the same melts.

All sheared edges or punched holes in steel work shall be subsequently planed or drilled out, so that none of the rough surface is ever left upon the work. Steel for pins shall be sound and entirely free from piling, and pins more than four inches in diameter shall be drilled through the axis.

RIVETED WORK.

All plates, angles and channels shall be carefully straightened before they are laid out; the rivet holes shall be carefully spaced in truly straight lines; the rivet heads shall be of hemispherical pattern, and the work shall be finished in a neat and workman-like manner. Surfaces in contact shall be painted before they are put together. The dimensions given for rivets on the plans are the diameters of the rivets before driving.

Power riveters shall be direct acting machines, capable of exerting a yielding pressure and holding on to the rivet when the upsetting is completed.

The several parts of each member shall be assembled and the holes shall be drilled; the sharp edge of the drilled hole shall be trimmed so as to make a slight fillet under the rivet head, and the pieces shall be riveted together without taking apart. Should the contractor desire, the parts may be punched with a punch at least 3/32-inch smaller than the diameter of the rivet as given on the plans, working in a die only 1/64-inch larger than the rivet; the several parts of the member shall then be assembled and the holes reamed so that at least 1/16-inch of metal is taken out all around, and the sharp edge of the reamed hole shall be trimmed and the pieces riveted together as above. All rivets shall be of steel; the rivet holes shall be of such size that the rivets will fill the hole before driving, and whenever

possible, they shall be driven by power. All bearing surfaces shall be truly faced. The chord pieces shall be fitted together in the shop in lengths of at least five panels, and marked; when so fitted there shall be no perceptible wind in the length laid out. The pin-holes shall be bored truly so as to be at exact distances, parallel with one another, and at right angles to the axis of the member.

The holes for the rivets connecting the floor-beams with the posts and bolsters and the stringers with the floor-beams, and, in general, the holes for all rivets which must be driven after erection, shall be accurately drilled to an iron templet. The holes for the rivets connecting the floor-beams with the posts shall be one inch in diameter, and the rivets of corresponding diameter. The pin-holes in the vertical posts shall be truly parallel with one another and at right angles to the axis of the posts. The posts shall be straight and free from wind.

FORGED WORK.

The heads of eye-bars shall be formed by upsetting and forging into shape by such process as may be accepted by the Engineer. No welds will be allowed. After the working is completed, the bars shall be annealed by heating them to a uniform dark red heat throughout their entire length, and allowing them to cool slowly. The form of the heads of steel eye-bars may be modified to suit the process in use at the contractor's works, but the form of head adopted must be such as to meet the requirements of the tests of full-sized bars.

The heads and the enlarged ends for screws in laterals, suspenders and counters shall be formed by upsetting by a process acceptable to the Engineer.

TESTS OF FULL-SIZED STEEL BARS.

Thirty full-sized eye-bars of sections and lengths used in the actual work shall be selected from bars made for the bridge by the Inspector for testing; each of these full-sized bars shall be strained till an elongation of ten per cent. is obtained, and, if possible, broken; if broken, the fracture shall occur in the body of the bar and shall show a uniform and ductile quality of material.

The contractor will be required to furnish facilities for testing the full-sized bars within a reasonable distance of his works. Should the contractor be unable to furnish such facilities, he shall be required to furnish bars of 20 per cent. larger section than those called for, without charge for the increased weight.

The full-sized bars shall be selected from time to time as the work proceeds, the last bar not to be selected till all the eye-bars are manufactured. The tests shall be made from time to time as the bars are selected. When three bars have been tested, the bars manufactured up to the time of the selection of these three test bars shall be accepted or rejected on the results of such tests, and the same shall be done again when three more bars are tested. In these tests, the failure of one bar to develop a stretch of eight per cent., or of the lot to develop an average stretch of ten per cent., before breaking, shall be sufficient reason for rejecting the lot from which these bars are taken. A failure to break in the body of the bar shall not be a sufficient ground for condemnation if it does not occur in more than one-third of the bars tested, but the above requirements as to elongation shall apply to the bars so breaking in the head, as well as to the others. The Engineer shall, however,

examine carefully into the cause of breakage of any bar which does not meet the requirements, and, if the defect is explained, may order additional tests, and make the acceptance dependent on further results.

MACHINE WORK.

The bearing surfaces in the top chord shall be truly faced. The ends of the stringers and of the floor-beams shall be squared in a face. All surfaces so designated on the plans shall be planed. All sheared and punched edges shall be planed or bored out.

All pins shall be accurately turned to a gauge, and shall be of full size throughout; pin-holes shall be bored to fit the pins, with a play not exceeding $\frac{1}{16}$ of an inch. These clauses apply to all lateral connections as well as to those of the main trusses. Pins shall be supplied with pilot nuts for use during erection.

All screws shall have a truncated V thread, United States standard size.

MISCELLANEOUS.

All workmanship and material, whether particularly specified or not, must be of the best kind now in use in first-class bridge work. Flaws, ragged edges, surface imperfections, or irregular shapes will be sufficient ground for rejection; rough and irregularly finished work will not be accepted.

Machine-finished surfaces shall be coated with white lead and tallow before shipment; all other parts shall be given a coat of hot boiled linseed oil.

ERECTION.

The contractor will be required to erect the superstructure, furnishing all necessary false work, tools and appliances of every description, and to deliver the same to the Railroad Company complete in all respects, ready for the ties and painting. Such surfaces as are in immediate contact or will otherwise become inaccessible shall be painted by the contractor during erection. The superstructure will remain at the contractor's risk until the erection is completed. Each span shall be accurately adjusted so that the lateral system is perfectly straight and the counters are properly strained. All nuts shall be set up tight and checked.

MISCELLANEOUS.

All piles, false work, and other obstructions shall be removed to the natural bed of the river, and this shall be done as fast as the foundations are completed so as to leave a clear river bed to receive the mattress or other protection work which the Railroad Company may wish to put in.

No material will be paid for which does not form a part of the permanent structure.

All expense of testing, other than the salary of the shop inspector, shall be borne by the contractor.

March 13, 1887.

Geo. S. Moulton,

E. L. Corbitt,

Engineers.

Union Iron Co.,

By Geo. S. Field.

APPENDIX H.

CONTRACT MARCH 9, 1889.

CONTRACT FOR SUBSTRUCTURE OF ILLINOIS APPROACH
TO THE BRIDGE ACROSS THE OHIO RIVER
AT CAIRO, ILLS.

THIS AGREEMENT, made and entered into on this the ninth day of March, 1889, by and between GEORGE S. FILLIS, EDWARD HAYES, C. S. MARBLE, and CHARLES MACDONALD, who, as individuals, and also as a partnership firm, doing business under the firm name of the UNION BRIDGE COMPANY of New York, contract, as hereinafter set forth, as parties of the first part, and THE ILLINOIS CENTRAL RAILROAD COMPANY, a corporation existing under the laws of Illinois, which contracts, as hereinafter set forth, as party of the second part, WITNESSETH, as follows:

FIRST. The parties of the first part aforesaid, contract and agree with the party of the second part aforesaid, that they will, according to the plans and annexed specifications, and under the directions of the Chief Engineer of the bridge, construct that part of the approach on the Illinois side to the railroad bridge of the Chicago, St. Louis and New Orleans Railroad Company across the Ohio River at Cairo, in the State of Illinois, which is hereinafter specified, upon the terms and conditions following, to wit:

SECOND. The parties of the first part agree to furnish the necessary materials, means and appliances, and to perform and do, in accordance with the plans and specifications aforesaid, and under the direction of the Chief Engineer aforesaid, and within the time herein fixed, the work of constructing the seventeen piers of said approach in the manner described in the accompanying specifications, for four and four-tenths (4 $\frac{4}{10}$) cents per pound for steel, three (3) cents per pound for the cast iron, eight dollars and a half (\$8.50) per cubic yard for the concrete used therein, twenty-five (25) cents per cubic yard for the necessary earth excavations, and thirty-five (35) cents per lineal foot for the necessary piles left in the completed work, subject to the provisions of the specifications.

THIRD. The work herein specified shall be executed under the direction of the Chief Engineer of the bridge and his assistants, by whose measurements and calculations of the quantities and amount of the several kinds of work done and materials furnished the monthly estimates shall be made and the final estimate determined, and said Chief Engineer shall have power to reject all work and materials which in his opinion shall not be in accordance with the plans and specifications hereto attached, and with the spirit of this agreement. During the progress of the work he shall determine any questions as to what is required by the plans and specifications, and he shall decide whether the work is from time to time proceeding with such diligence as to insure the completion of the several parts, and of the

whole work upon the said approach, including the superstructure, by the time mentioned in this contract; and if, in the opinion of said Chief Engineer, said work or any part thereof shall not be so proceeding, he shall require such additional force the failure of the parties of the first part to comply with such requirements, to be put upon the same within such time as he may in writing designate, and upon said Chief Engineer may put upon said work the additional force so required at the expense of the parties of the first part.

On the said Chief Engineer, upon the failure of the parties of the first part to comply with such requirements or any of them within the time so designated, or of their failure to perform any of their covenants or agreements as herein covenanted or agreed, for thirty days after notice of the breach thereof, may, and on the demand of the party of the second part shall, declare that the parties of the first part have broken this contract and have failed to comply with its terms, and thereupon said parties of the first part shall forfeit all claim to the reserved fund or any part thereof which is hereinafter mentioned, and this contract shall be, by their said default so declared, terminated.

FOURTH. The work shall be at all times under the supervision of the said Chief Engineer of said bridge and his assistant engineers, all of whom are to be appointed by the second party, and said Chief Engineer shall have authority to discharge disorderly or inefficient foremen or other employees of the parties of the first part engaged in said work, if in his judgment their presence or employment upon the work is detrimental to its character, progress or interests; provided, the parties of the first part fail to discharge them upon his request to do so.

FIFTH. The work on said foundations and piers shall be continued without unnecessary delay to completion, and there shall be no unnecessary delay in furnishing the materials or in any part of the work of construction, or any haste in the work or any part thereof which may affect injuriously the stability of the foundations, piers or superstructure or any part thereof, nor shall any material mentioned in or allowed by the specifications be used which is not the best for the purpose used according to the opinion of the Chief Engineer of said bridge.

In case any change in the location, specifications or plans of said work, prior to its final completion is required by the party of the second part, the prices of the material furnished therefor or work done thereon shall not exceed those mentioned for similar material or work.

SIXTH. In case the entire work is not completed at the date provided for in the specifications, the parties of the first part shall pay to the party of the second part, three hundred and fifty dollars (\$350) per day as liquidated damages for each and every day beyond said date that the said work remains incomplete.

SEVENTH. It is further agreed between the parties hereto, that the parties of the first part shall have no right or power to assign this contract in whole or part,

nor to assign any right arising thereunder; and in case of the insolvency or bankruptcy of said parties of the first part or any of them prior to the final completion of said work there shall be nothing due them under this contract, save for such parts of material furnished and accepted and for work theretofore done that had not been at that time estimated, or if estimated, had not been paid, but the failure, from insolvency, to progress with or finally complete said work and its several parts, or either of them, as and at the dates herein mentioned, or the failure, from any cause, to finally complete said approach as herein contracted, shall, *ipso facto*, be a forfeiture of the reserved fund, and neither of said parties of the first part, nor any assignee in bankruptcy or otherwise, shall have any right or claim thereto, or to any part thereof. And it is further agreed, that no part of the work mentioned herein shall be added or in any way removed from the control of the parties of the first part, under the direction and supervision of the Chief Engineer as aforesaid, except with the express approval in writing of the said Chief Engineer.

EIGHTH. The character of the work, the kind of materials furnished, and all the other requirements of the annexed specifications and plans, and the times limited for the completion of each part and of the whole, are agreed to be essential parts of this contract.

NINTH. The terms of payment for the work shall be as follows: During the progress of the work, the Chief Engineer shall cause estimates to be made of the work done and materials delivered during each calendar month, and about the 15th day of the succeeding month the amount of the same shall be paid to the parties of the first part, less, however, a reserve fund of ten (10) per cent., which reserve fund shall be held by the second party as security for the completion of the whole work and its several parts, and if at the times herein contracted, each and every part of the substructure of said approach has been built in accordance with the specifications and plans, and is delivered up to the second party free from all liens and claims, and if the parties of the first part have done and performed all their covenants and undertakings herein, then the party of the second part is to pay over to the parties of the first part all of said reserve fund.

It is agreed that, after the completion of the entire work in accordance with the specifications and directions of the Chief Engineer, and before the final settlement is made, any differences or controversies arising under this contract between the parties hereto may be finally settled by a body of arbitrators, consisting of three persons: one to be the Chief Engineer of said bridge, one to be named by the contractors, to-wit, the parties of the first part, and the third to be selected by the other two. The arbitrators shall judge by a majority vote, and their decision shall be final and binding on both parties, and their award shall be performed within fifty (50) days after the work is finally completed and accepted and the award an-

nounced; but the party asking said arbitration shall, in writing, specify the particular thing to be arbitrated, and the arbitrators shall be confined to the things so specified by the one or both parties.

TEN. It is further agreed that no material shall be estimated until delivered at the bridge site, except steel for the cylinder shells, which shall be estimated when delivered at the shops of the party of the second part; and such steel shall be marked and set apart for use in said work, and the parties of the second part shall have a special lien thereon to the extent of the advances thus made; nor shall any material be paid for on final estimate or otherwise which does not form an actual part of the finished structure, or is not of the class and quality required by the specifications.

In making monthly estimates, the steel delivered at the shop, but not completed, shall be estimated at fifty (50) per cent. of the erected price, and the steel manufactured at the shop at sixty-five (65) per cent. of the erected price, and the steel delivered at Cairo at eighty (80) per cent. of the erected price.

No claim for extra work shall be paid unless it be presented within fifteen (15) days after the end of the month in which said work is performed, and then only when approved by the Chief Engineer as having been ordered by him to be done.

ELEVENTH. It is further agreed that the steel for each approach which said parties of the first part may ship from Chicago to Cairo over the Illinois Central Railroad, and also any necessary switching of the same at Cairo or East Cairo, or transferring across the Ohio River between the inclines at Cairo and East Cairo, and piles transported for a distance not exceeding fifty miles to Cairo or East Cairo, but not including any transfer of piles across the river, shall be carried and done without unreasonable delay, and without cost to said parties of the first part, but all losses or damages during such transportation, switching or transfer shall be borne alone by said party of the first part.

TWELFTH. The parties hereto, respectively covenant and agree in behalf of themselves, their representatives and successors.

IN WITNESS WHEREOF, the parties of the first part as individuals, and also as a partnership firm, have hereto set their several and their partnership names and private seals, and the party of the second part has caused its corporate name to be hereto signed, and its corporate seal to be hereto affixed, this the day and year first above written.

Geo. S. FIELD. [L. S.]
 EDMUND HAYES. [L. S.]
 C. S. MAURICE. [L. S.]
 C. MACDONALD. [L. S.]

UNION BRIDGE CO.,
 By C. Macdonald.

ILLINOIS CENTRAL RAILROAD COMPANY,
 By Strydomant Fish, President.

[L. S.]
 Attest: A. G. HACKETT, Secretary.

SPECIFICATIONS FOR ILLINOIS APPROACH TO THE BRIDGE ACROSS THE OHIO RIVER, AT CAIRO, ILLINOIS.

GENERAL DESCRIPTION.

The Illinois approach will consist of seventeen deck spans of 150 feet each, and one of 165 feet, supported on seventeen steel cylinder piers.

Beyond this approach of permanent bridge construction, there will be timber trestle work which is not included in this contract.

SUBSTRUCTURE.

The substructure will comprise the seventeen steel cylinder piers named above. Each pier will consist of two cylinders eight feet in diameter, composed of soft steel shells filled with concrete, and resting on pile foundations.

The steel plates shall be one-half inch thick and five feet wide, with the edges planed and spliced on the inside, as shown on detail plans furnished. The steel shall have an ultimate strength of 35 000 to 42 000 pounds per square inch. The rivet holes may be punched, but the faced edges shall be exactly fitted so as to come in close contact when put together. The entire work shall be painted with one coat of Cleveland Iron Clad Paint (brown or purple brand), before leaving the shop, and all parts that come in contact, including the faced edges, shall be painted at the time of erection. The two steel cylinders shall be connected by a cross frame, as shown in the drawings.

An excavation shall be made at the site of each cylinder in the form of a truly circular pit eight feet below the surface of the ground. In this pit twelve piles shall be driven, the arrangement being according to the plan furnished, the piles not to be more than 24 nor less than 20 inches between centers, and the distance between the outer piles and the cylinder shells never to be less than six inches. The piles shall be straight, of good, sound, white or hurr oak, and at least eleven inches in diameter at the small end. They shall be driven to the satisfaction of the Engineer. They shall be cut off square and finished without splinters. The bill of piles shall be agreed upon between the Resident Engineer and the contractor, and the lengths estimated in the work shall never be more than two feet less than the billed length of the pile, except when a pile is injured in driving.

The lower portion of the pits shall then be filled with concrete to an elevation fixed by the Engineer for the bottom of the steel shell. The steel shells shall then be set up accurately and riveted together, including the cross frames complete. The Engineer may, however, authorize the use of bolts in place of rivets if satisfied that the work will be equally durable. The entire shells shall then be filled with concrete, which shall be thoroughly rammed, special care being taken to fill the spaces among the piles thoroughly. The shells below the natural surface of the ground shall then be encased in concrete six inches thick. The

upper two feet of the concrete shall be of Portland cement and sand, three parts of sand to one of cement, into which stone may be rammed after it is put in position. The concrete outside of the shells shall be made in the same way. The remainder of the concrete shall be of Louisville cement, sand and stone, two parts of sand to one of cement and not over 60 per cent. of the whole volume in broken stone. In Portland cement concrete the sand and cement shall be mixed together dry, and then run through a satisfactory machine mixer. The mass of concrete shall always be thoroughly rammed after being put in position. The Louisville cement concrete shall be worked in a mixer approved by the Engineer, who also shall have the right to change the method of mixing.

Steel anchor bolts not less than five feet long shall be built into the upper portion of the concrete in exactly the position directed by the Engineer. The surface of the concrete shall be leveled off true and finished with a trowel or straight-edge one-half an inch higher than the edge of the steel shell.

A cast-iron or steel cap shall subsequently be put on with suitable bored or drilled holes fitting over the anchor-bolts, this cap to be set on a full mortar bed and brought down to a perfect bearing with a maul.

The earth excavated from the pits shall not be left in heaps, but shall be leveled off according to the directions of the Engineer.

SUPERSTRUCTURE.

PLANS.

Full detail plans, showing all dimensions, are now in the office of the Engineer, and are marked for identification as parts of this contract, A, B, C and D. The work shall be built in all respects according to these plans. The contractor, however, will be expected to verify the correctness of the plans, and will be required to make any changes in the work which are necessitated by errors in these plans, without extra charge where such errors could be discovered by an inspection of the plans.

MATERIALS.

All parts except nuts, rivets and wall pedestal plates will be of steel. The nuts and rivets may be of wrought-iron and the pedestal plates of cast-iron.

All materials shall be subject to inspection at all times during their manufacture, and the Engineer and his inspectors shall be allowed free access to any of the works in which any portion of the material is made. Timely notice shall be given to the Engineer, so that his inspectors may be on hand.

Steel may be made by the open hearth or by the Bessemer process, but no steel shall be made at works which have not been in successful operation for at least one year. Steel made by the Clapp-Griffiths process will not be accepted. All metals shall be made from uniform stock low in phosphorus, and the manufacturer shall furnish satisfactory evidence to the Engineer that this class of material is being employed, it being understood that the finished product of open hearth steel is to be one in which the phosphorus does not average more than eight

one-hundredths of one per cent., and never exceeds one-tenth of one per cent., and in the finished product of Bessemer steel the average of phosphorus shall not be more than six-tenths of one per cent., and the maximum not more than seven-tenths of one per cent.

A sample bar having one square inch cross-section shall be cut from the finished product of every melt. The laboratory tests shall be made on this sample bar in its natural state without annealing.

The laboratory tests of steel for the chords, posts, bolsters, cross frames and rivets, made from the sample bar, shall show an ultimate strength of not less than 56,000, nor more than 82,000 pounds per square inch; an elongation of at least 25 per cent. in a length of eight inches and a reduction of area of 48 per cent. at point of fracture. In a bending test, the sample bar shall bend 180 degrees and close back against itself without showing crack or flaw on the outside of the curve.

The laboratory tests of steel for the floor beams, stringers, pins, eye-bars and lateral rods made on the sample bar shall show an elastic limit of not less than 35,000 pounds per square inch; an ultimate strength of not less than 53,000 pounds nor more than 79,000; an elongation of at least 22 per cent. in a length of eight inches, and a reduction of at least 45 per cent. at the point of fracture; this elongation and reduction being the minimum and not the average requirements. In a bending test the sample bar shall bend 180 degrees and close back on itself without showing crack or flaw on the outside of curve.

Every piece of steel shall be stamped with a number identifying the melt, and a statement of the results of the laboratory tests of each melt shall be furnished by the contractor, certified by some person acceptable to the Engineer, and accompanied by the tested specimens. Should the manufacturer make tests of bars rolled from sample ingots, certified copies of the report of said tests shall also be furnished to the Engineer.

All sheared edges or punched holes in the floor system shall subsequently be planed or drilled out so that none of the rough surface is ever left upon the work. Steel for pins shall be sound and entirely free from piping, and pins more than four inches in diameter shall be drilled through the axis.

Nuts, swivels and clevises shall be strong enough to break the members to which they are attached.

Cast-iron shall be of the best quality, of tough gray iron.

RIVETED WORK.

All plates, angles and channels shall be carefully straightened before they are laid out; the rivet holes shall be carefully spaced in truly straight lines; the rivet heads shall be of hemispherical pattern, and the work shall be finished in a neat

and workmanlike manner. Surfaces in contact shall be painted before they are put together. The dimensions given for rivets on the plans are the diameters of the rivets before driving.

Power riveters shall be direct acting machines capable of exerting a yielding pressure and holding on to the rivet when the upsetting is completed.

The several parts of the stringers and the floor beams shall be assembled and the holes shall be drilled, the sharp edges of the drilled holes shall be trimmed so as to make a slight fillet under the rivet head, and the pieces shall be riveted together without taking apart. Should the contractor desire, the parts may be punched with a punch at least three thirty-seconds of an inch smaller than the diameter of the rivet as given on the plans, working in a die only one sixty-fourth of an inch larger than the punch; the several parts of the members shall then be assembled and the holes reamed so that at least one-sixteenth of an inch of metal is taken out all around, the sharp edge of the reamed hole shall be trimmed and the pieces riveted together as above.

All rivets shall be of steel. The rivet holes shall be of such size that the rivet will fill the hole before driving, and whenever possible the rivets shall be driven by power. All bearing surfaces shall be truly faced. The pin-holes shall be bored truly so as to be at exact distances, parallel with one another, and at right angles to the axis of the posts. The posts shall be straight and free from wind.

The holes for all rivets which must be driven after erection shall be accurately drilled to an iron template.

FORGED WORK.

The heads of eye-bars shall be formed by upsetting and forging into shape by such process as may be accepted by the Engineer. No welds will be allowed. After the work is completed the bars shall be annealed by heating them to a uniform dark red heat throughout their entire length, and allowing them to cool slowly. The form of the heads of steel eye-bars may be modified to suit the process at the contractor's works, but the form of the head adopted must be such as to meet the requirements of the tests of full-sized bars.

The heads and the enlarged ends for screws in laterals, suspenders and counters, shall be formed by upsetting by a process acceptable to the Engineer.

TESTS OF FULL-SIZED STEEL BARS.

Ten full-sized eye-bars of sections and lengths used in the actual work, shall be selected from bars made for the bridge by the inspector for testing. Each of these full-sized bars shall be strained till broken. When broken the fracture shall occur in the body of the bar and shall show a uniform and ductile quality of material.

The full-sized bars shall be selected from time to time as the work proceeds, the

last bar not to be selected till all the eye-bars are manufactured. The tests shall be made from time to time as the bars are selected. When three bars have been tested, the bars manufactured up to the time of the selection of these three test bars, shall be accepted or rejected on the results of such tests, and the same shall be done again when three more bars are tested. In these tests the failure of one bar to develop a stretch of eight per cent., or of the lot to develop an average of ten per cent. before breaking, shall be sufficient reason for rejecting the lot from which these bars are taken. A failure to break in the body of the bar shall not be a sufficient ground for condemnation if it does not occur in more than one-third of the bars tested; but the above requirements as to elongation shall apply to the bars so breaking in the head, as well as to the others. The Chief Engineer shall, however, examine carefully into the cause of breakage of any bar which does not meet the requirements, and if the defect is explained may order additional tests, and make the acceptance dependent on further results.

MACHINE WORK.

The bearing surfaces in the top chord shall be truly faced. The ends of the stringers and of the floor beams shall be squared in a face. All surfaces so designated on the plans shall be planed. All sheared and punched edges shall be planed or bored out.

All pins shall be accurately turned to a gauge and shall be full size throughout. Pin-holes shall be bored to fit the pins with a play not exceeding one-fiftieth of an inch. These clauses apply to all lateral connections as well as to those of the main trusses. Pins shall be supplied with pilot nuts for use during erection, four for each size of pin.

All screws shall have a truncated V thread, United States standard sizes.

MISCELLANEOUS.

All workmanship and materials whether particularly specified or not must be of the best kind now known in first-class bridge work. Flaws, ragged edges, surface imperfections or irregular shapes will be sufficient ground for rejection. Rough and irregularly finished work will not be accepted.

Machine-finished surfaces shall be coated with white lead and tallow before shipment. All other parts shall be given a coat of Cleveland Iron Clad Paint, purple brand.

TIME.

Work shall be begun on the substructure as soon as the proper materials can be collected for this purpose, and shall be finished in season to admit of the final completion of the entire work of constructing the Illinois approach to the said bridge, including the superstructure, by the time herein limited for that purpose, namely, July first, 1889.

CONTRACT FOR SUPERSTRUCTURE OF ILLINOIS APPROACH
TO THE BRIDGE ACROSS THE OHIO RIVER,
AT CAIRO, ILLINOIS.

THIS AGREEMENT, made and entered into on this the ninth day of March, 1889, by and between GEORGE S. FIELDS, EDMUND HAYES, C. S. MATTHEW and CHARLES MACDONALD, who, as individuals, and also as a partnership firm, doing business under the firm name of the UNION BRIDGE COMPANY, of New York, contract, as hereinafter set forth, as parties of the first part, and the ILLINOIS CENTRAL RAILROAD COMPANY, a corporation existing under the laws of Illinois, which contracts, as hereinafter set forth, as party of the second part, WITNESSETH, as follows:

FIRST. The parties of the first part aforesaid, contract and agree with the party of the second part aforesaid, that they will, according to the plans and annexed specifications, and under the directions of the Chief Engineer of the bridge, construct that part of the approach on the Illinois side to the railroad bridge of the Chicago, St. Louis and New Orleans Railroad Company across the Ohio River at Cairo, in the State of Illinois, which is hereinafter specified, upon the terms and conditions following, to-wit:

SIXTH. The parties of the first part agree to furnish the materials and manufacture and erect, in accordance with the plans and specifications aforesaid, and under the directions of the Chief Engineer aforesaid, and within the time herein fixed, the superstructure of said approach, consisting of seventeen spans of one hundred and fifty (150) feet each, and one span of one hundred and five (105) feet, for four and four-tenths ($4\frac{4}{10}$) cents per pound erected complete.

THIRD. The work herein specified shall be executed under the direction of the Chief Engineer of the bridge, and his assistants, by whose measurements and calculations of the quantities and amount of the several kinds of work done and materials furnished the monthly estimates shall be made and the final estimate determined, and said Chief Engineer shall have power to reject all work and materials which, in his opinion, shall not be in accordance with the plans and specifications hereto attached, and with the spirit of this agreement. During the progress of the work he shall determine any questions as to what is required by the plans and specifications, and he shall decide whether the work is from time to time proceeding with such diligence as to insure the completion of the several parts, and of the whole work as herein contracted and by the time mentioned in this contract; and if, in the opinion of said Chief Engineer, said work, or any part thereof, shall not be so proceeding, he shall require such additional force to be put upon the same within such time as he may, in writing, designate, and upon the failure of the parties of the first part to comply with such requirements, the said Chief Engineer may put upon said work the additional force so required at the expense of the parties of the first part.

Or the said Chief Engineer, upon the failure of the parties of the first part to comply with such requirements or any of them within the time so designated, or of their failure to perform any of their covenants or agreements as herein covenanted

or agreed, for thirty days after notice of the breach thereof, may, and on the demand of the party of the second part shall, declare that the parties of the first part have broken this contract and have failed to comply with its terms, and thereupon said parties of the first part shall forfeit all claim to the reserved fund or any part thereof which is hereinafter mentioned, and this contract shall be, by their said default so declared, terminated.

FOURTH. The work shall be at all times under the supervision of the said Chief Engineer of said bridge and his assistant engineers, all of whom are to be appointed by the second party, and said Chief Engineer shall have authority to discharge disorderly or inefficient foremen or other employees of the parties of the first part engaged in said work, if in his judgment their presence or employment upon the work is detrimental to its character, progress or interests; provided, the parties of the first part fail to discharge them upon his request to do so.

FIFTH. The work on said superstructure shall be continued without unnecessary delay to completion, and there shall be no unnecessary delay in furnishing the materials, or in any part of the work of construction, or any haste in the work or any part thereof which may affect injuriously the stability of the foundations, piers or superstructure, or any part thereof, nor shall any material mentioned in, or allowed by, the specifications be used which is not the best for the purpose used according to the opinion of the Chief Engineer of said bridge.

In case any change in the location, specifications or plans of said work, prior to its final completion, is required by the party of the second part, the prices of the material furnished therefor, or work done thereon, shall not exceed those mentioned for similar material or work.

SIXTH. In case the entire work is not completed at the date provided for in the specifications, the parties of the first part shall pay to the party of the second part three hundred and fifty dollars (\$350) per day as liquidated damages for each and every day beyond said date that the said work remains incomplete.

SEVENTH. It is further agreed between the parties hereto, that the parties of the first part shall have no right or power to assign this contract in whole or part, nor to assign any right arising thereunder; and in case of the insolvency or bankruptcy of said parties of the first part, or any of them, prior to the final completion of said work, there shall be nothing due them under this contract, save for such parts of material furnished and accepted, and for work theretofore done that had not been at that time estimated, or if estimated, had not been paid, but the failure, from insolvency, to progress with or finally complete said work and its several parts, or either of them, as and at the dates herein mentioned, or the failure, from any cause, to finally complete said approach as herein contracted, shall, *ipso facto*, be a forfeiture of the reserved fund, and neither of said parties of the first part, nor any assignee in bankruptcy or otherwise, shall have any right or claim thereto, or to any part thereof. And it is further agreed, that no part of the work mentioned herein shall be sublet or in any way removed from the control of the parties of the first part, under the direction and supervision of the Chief Engineer as aforesaid, except with the express approval in writing of the said Chief Engineer.

EIGHTH. The character of the work, the kind of materials furnished, and all the other requirements of the annexed specifications and plans, and the times limited for the completion of each part and of the whole, are agreed to be essential parts of this contract.

NINTH. The terms of payment for the work shall be as follows: During the progress of the work, the Chief Engineer shall cause estimates to be made of the work done and materials delivered during each calendar month, and about the 15th day of the succeeding month the amount of the same shall be paid to the parties of the first part, less, however, a reserved fund of ten (10) per cent., which reserved fund shall be held by the second party as security for the completion of the whole work and its several parts, and if at the times herein contracted, each and every part of the superstructure of said approach has been built in accordance with the specifications and plans, and is delivered up to the second party free from all liens and claims, and if the parties of the first part have done and performed all their covenants and undertakings herein, then the party of the second part is to pay over to the parties of the first part all of said reserved fund.

It is agreed that, after the completion of the entire work in accordance with the specifications and directions of the Chief Engineer, and before the final settlement is made, any differences or controversies arising under this contract between the parties hereto may be finally settled by a body of arbitrators, consisting of three persons: one to be the Chief Engineer of said bridge, one to be named by the contractors, to wit, the parties of the first part, and the third to be selected by the other two. The arbitrators shall judge by a majority vote, and their decision shall be final and binding on both parties, and their award shall be performed within fifty (50) days after the work is finally completed and accepted and the award announced; but the party asking said arbitration shall in writing specify the particular thing to be arbitrated, and the arbitrators shall be confined to the things so specified by the one or both parties.

TENTH. It is further agreed that no material shall be estimated until delivered at the bridge site, except steel for the superstructure, which shall be estimated when delivered at the shops of the party of the second part; and such steel shall be marked and set apart for use in said work, and the parties of the second part shall have a special lien thereon to the extent of the advances thus made; nor shall any material be paid for on final estimate or otherwise which does not form an actual part of the finished structure or is not of the class and quality required by the specifications.

In making monthly estimates, the steel delivered at the shop but not completed shall be estimated at fifty (50) per cent. of the erected price, and the steel manufactured at the shop at sixty-five (65) per cent. of the erected price, and the steel delivered at Cairo at eighty (80) per cent. of the erected price.

No claim for extra work shall be paid unless it be presented within fifteen (15) days after the end of the month in which said work is performed, and then only when approved by the Chief Engineer as having been ordered by him to be done.

ELEVENTH. It is further agreed that the steel for such approach which said parties of the first part may ship from Chicago to Cairo over the Illinois Central Railroad, and also any necessary switching of the same at Cairo or East Cairo or transferring across the Ohio River between the inclines at Cairo and East Cairo, shall be carried and done without unreasonable delay and without cost to said parties of the first part, but all losses or damage during such transportation, switching or transfer shall be borne alone by said party of the first part.

TWELFTH. The parties hereto respectively covenant and agree in behalf of themselves, their representatives and successors.

IN WITNESS WHEREOF, the parties of the first part as individuals, and also as a partnership firm, have hereunto set their several and their partnership names and private seals, and the party of the second part has caused its corporate name to be hereto signed, and its corporate seal to be hereto affixed, this the day and year first above written.

Geo. S. Field.	[L. S.]
Ernest Mayer.	[L. S.]
C. S. Macdonald.	[L. S.]
C. Macdonald.	[L. S.]

Union Bridge Co.,
By C. Macdonald.

ILLINOIS CENTRAL RAILROAD COMPANY,
By Seymour Fish,
President.

[L. S.]

Attest:

A. G. HICKSTAY,
Secretary.

SPECIFICATIONS FOR ILLINOIS APPROACH TO THE BRIDGE ACROSS THE OHIO RIVER, AT CAIRO, ILLINOIS.

GENERAL DESCRIPTION.

The Illinois approach will consist of seventeen deck spans of 110 feet each, and one of 195 feet, supported on seventeen steel cylinder piers.

Beyond this approach of permanent bridge construction, there will be timber trestle work which is not included in this contract.

SUBSTRUCTURE.

The substructure will comprise the seventeen steel cylinder piers named above.

Each pier will consist of two cylinders eight feet in diameter, composed of soft steel shells filled with concrete, and resting on pile foundations.

The steel plates shall be one-half inch thick and five feet wide, with the edges planed and spliced on the inside, as shown on detail plans furnished. The steel shall have an ultimate strength of 35 000 to 60 000 pounds per square inch. The rivet holes may be punched, but the faced edges shall be exactly fitted so as to come in close contact when put together. The entire work shall be painted with one coat of Cleveland Iron Clad Paint (brown or purple brand), before leaving the shop, and all parts that come in contact, including the faced edges, shall be painted at the time of erection. The two steel cylinders shall be connected by a cross frame as shown in the drawings.

An excavation shall be made at the site of each cylinder in the form of a truly circular pit eight feet below the surface of the ground. In this pit twelve piles shall be driven, the arrangement being according to the plan furnished, the piles not to be more than 24 nor less than 20 inches between centers, and the distance between the outer piles and the cylinder shells never to be less than six inches. The piles shall be straight, of good, sound, white or burr oak, and at least eleven inches in diameter at the small end. They shall be driven to the satisfaction of the Engineer. They shall be cut off square and finished without splinters. The bill of piles shall be agreed upon between the Resident Engineer and the contractor, and the lengths estimated in the work shall never be more than two feet less than the billed length of the pile, except when a pile is injured in driving.

The lower portion of the pits shall then be filled with concrete to an elevation fixed by the Engineer for the bottom of the steel shell. The steel shells shall then be set up accurately and riveted together, including the cross frames complete. The Engineer may, however, authorize the use of bolts in place of rivets if satisfied that the work will be equally durable. The entire shells shall then be filled with concrete which shall be thoroughly rammed, special care being taken to fill the spaces among the piles thoroughly. The shells below the natural surface of the ground, shall then be encased in concrete six inches thick. The upper two feet of the concrete shall be of Portland cement and sand, three parts of sand to one of cement

into which stone may be rammed after it is put in position. The concrete outside of the shells shall be made in the same way. The remainder of the concrete shall be of Louisville cement, sand and stone, two parts of sand to one of cement, and not over 60 per cent. of the whole volume in broken stone. In Portland cement concrete the sand and cement shall be mixed together dry, and then run through a satisfactory machine mixer. The mass of concrete shall always be thoroughly rammed after being put in position. The Louisville cement concrete shall be worked in a mixer approved by the Engineer, who also shall have the right to change the method of mixing.

Steel anchor bolts not less than five feet long shall be built into the upper portion of the concrete in exactly the position directed by the Engineer. The surface of the concrete shall be leveled off true and finished with a trowel or straight edge one-half an inch higher than the edge of the steel shell.

A cast-iron or steel cap shall subsequently be put on with suitable bored or drilled holes fitting over the anchor bolts, this cap to be set on a full mortar bed and brought down to a perfect bearing with a maul.

The earth excavated from the pits shall not be left in heaps, but shall be leveled off according to the directions of the Engineer.

SUPERSTRUCTURE.

PLANS.

Full detail plans, showing all dimensions, are now in the office of the Engineer, and are marked for identification as parts of this contract, A, B, C and D. The work shall be built in all respects according to these plans. The contractor, however, will be expected to verify the correctness of the plans and will be required to make any changes in the work which are necessitated by errors in these plans, without extra charge where such errors could be discovered by an inspection of the plans.

MATERIALS.

All parts, except nuts, bolts and wall pedestal plates, will be of steel. The nuts and bolts may be of wrought-iron, and the pedestal plates of cast-iron.

All materials shall be subject to inspection at all times during their manufacture, and the Engineer and his inspectors shall be allowed free access to any of the works in which any portion of the material is made. Timely notice shall be given to the Engineer so that his inspectors may be on hand.

Steel may be made by the open hearth or by the Bessemer process, but no steel shall be made at works which have not been in successful operation for at least one year. Steel made by the Chapp-Griffiths process will not be accepted. All melts shall be made from uniform stock low in phosphorus, and the manufacturer shall furnish satisfactory evidence to the Engineer that this class of material is being employed, it being understood that the finished product of open hearth steel is to be one in which the phosphorus does not average more than eight one-hundredths of one per cent., and never exceeds one-tenth of one per cent., and in the finished

product of Bessemer steel, the average of phosphorus shall not be more than six-tenths of one per cent., and the maximum not more than seven-tenths of one per cent.

A sample bar having one square inch cross-section shall be cut from the finished product of every melt. The laboratory tests shall be made on this sample bar in its natural state without annealing.

The laboratory tests of steel for the chords, posts, bolsters, cross frames and rivets, made from the sample bar, shall show an ultimate strength of not less than 56 000, nor more than 62 000 pounds per square inch; an elongation of at least twenty-five per cent. in a length of eight inches and a reduction of area of 45 per cent. at point of fracture. In a bending test, the sample bar shall bend 180 degrees and close back against itself without showing crack or flaw on the outside of the curve.

The laboratory tests of steel for the floor beams, stringers, pins, eye-bars and lateral rods made on the sample bar shall show an elastic limit of not less than 38 000 pounds per square inch; an ultimate strength of not less than 61 000 pounds nor more than 70 000; an elongation of at least 22 per cent. in a length of eight inches, and a reduction of at least 45 per cent. at the point of fracture; this elongation and reduction being the minimum and not the average requirements. In a bending test the sample bar shall bend 180 degrees and close back on itself without showing crack or flaw on the outside of the curve.

Every piece of steel shall be stamped with a number identifying the melt, and a statement of the results of the laboratory tests of each melt shall be furnished by the contractor, certified by some person acceptable to the Engineer, and accompanied by the tested specimens. Should the manufacturer make tests of bars rolled from sample ingots, certified copies of the report of said tests shall also be furnished to the Engineer.

All sheared edges or punched holes in the floor system shall subsequently be planed or drilled out so that none of the rough surface is ever left upon the work. Steel for pins shall be sound and entirely free from piping, and pins more than four inches in diameter shall be drilled through the axis.

Nuts, rivets and clevises shall be strong enough to break the members to which they are attached.

Cast-iron shall be of the best quality, of tough grey iron.

RIVETED WORK.

All plates, angles and channels shall be carefully straightened before they are laid out; the rivet holes shall be carefully spaced in truly straight lines; the rivet heads shall be of hemispherical pattern, and the work shall be finished in a neat and workmanlike manner. Surfaces in contact shall be painted before they are put

together. The dimensions given for rivets on the plans are the diameters of the rivets before driving.

Power riveters shall be direct acting machines capable of exerting a yielding pressure and holding on to the rivet when the upsetting is completed.

The several parts of the stringers and floor beams shall be assembled and the holes shall be drilled, the sharp edges of the drilled holes shall be trimmed so as to make a slight fillet under the rivet head, and the pieces shall be riveted together without taking apart. Should the contractor desire, the parts may be punched with a punch at least three thirty-seconds of an inch smaller than the diameter of the rivet as given on the plans, working in a die only one sixty-fourth of an inch larger than the punch; the several parts of the members shall then be assembled and the holes reamed so that at least one-sixteenth of an inch of metal is taken out all around, the sharp edge of the reamed hole shall be trimmed and the pieces riveted together as above.

All rivets shall be of steel. The rivet holes shall be of such size that the rivet will fill the hole before driving, and whenever possible the rivets shall be driven by power. All bearing surfaces shall be truly faced. The pin-holes shall be bored truly so as to be at exact distances, parallel with one another, and at right angles to the axis of the posts. The posts shall be straight and free from wind.

The holes for all rivets which must be driven after erection shall be accurately drilled to an iron template.

FORGED WORK.

The heads of eye-bars shall be formed by upsetting and forging into shape by such process as may be accepted by the Engineer. No welds will be allowed. After the work is completed the bars shall be annealed by heating them to a uniform dark red heat throughout their entire length, and allowing them to cool slowly. The form of the heads of steel eye-bars may be modified to suit the process at the contractor's works, but the form of the head adopted must be such as to meet the requirements of the tests of full-sized bars.

The heads and the enlarged ends for arrows in laterals, suspenders and counters, shall be formed by upsetting by a process acceptable to the Engineer.

TESTS OF FULL-SIZED STEEL BARS.

Ten full-sized eye-bars of sections and lengths used in the actual work, shall be selected from bars made for the bridge by the inspector for testing. Each of these full-sized bars shall be strained till broken. When broken the fracture shall occur in the body of the bar and shall show a uniform and ductile quality of material.

The full-sized bars shall be selected from time to time as the work proceeds, the last bar not to be selected till all the eye-bars are manufactured. The tests shall be made from time to time as the bars are selected. When three bars have been tested,

the bars manufactured up to the time of the selection of these three test bars, shall be accepted or rejected on the results of such tests, and the same shall be done again when three more bars are tested. In these tests the failure of one bar to develop a stretch of eight per cent., or of the lot to develop an average of ten per cent. before breaking, shall be sufficient reason for rejecting the lot from which these bars are taken. A failure to break in the body of the bar shall not be a sufficient ground for condemnation if it does not occur in more than one-third of the bars tested; but the above requirements as to elongation shall apply to the bars so breaking in the head, as well as to the others. The Chief Engineer shall, however, examine carefully into the cause of breakage of any bar which does not meet the requirements, and if the defect is explained may order additional tests, and make the acceptance dependent on further results.

MACHINE WORK.

The bearing surfaces in the top chord shall be truly faced. The ends of the stringers and of the floor beams shall be squared in a face. All surfaces as designated on the plans shall be planed. All sheared and punched edges shall be planed or bored out.

All pins shall be accurately turned to a gauge and shall be full size throughout. Pin-holes shall be bored to fit the pins with a play not exceeding one-fiftieth of an inch. These clauses apply to all lateral connections as well as to those of the main trusses. Pins shall be supplied with pilot nuts for use during erection, four for each size of pin.

All screws shall have a truncated V thread, United States standard size.

MISCELLANEOUS.

All workmanship and materials whether particularly specified or not must be of the best kind now known in first-class bridge work. Flaws, ragged edges, surface imperfections or irregular shapes will be sufficient ground for rejection. Rough and irregular finished work will not be accepted.

Machined surfaces shall be coated with white lead and tallow before shipment. All other parts shall be given a coat of Cleveland Iron Clad Paint, purple brand.

TIME.

Work shall be begun on the substructure as soon as the proper materials can be collected for this purpose, and shall be finished in season to admit of the final completion of the entire work of constructing the Illinois approach to the mid bridge, including the superstructure, by the time herein limited for that purpose, namely, July first, 1889.

CONTRACT FOR SUBSTRUCTURE OF KENTUCKY APPROACH
TO THE BRIDGE ACROSS THE OHIO RIVER,
AT CAIRO, ILLINOIS.

THIS AGREEMENT, made and entered into on this the ninth day of March, 1889, by and between GEORGE S. FIELD, EDWARD HAYES, C. S. MANNING and CHARLES MANNING, who as individuals and also as a partnership firm doing business under the firm name of the FARMER BRIDGE COMPANY, of New York, contract as hereinafter set forth as parties of the first part, and THE CHICAGO, ST. LOUIS AND NEW ORLEANS RAILROAD COMPANY, a corporation existing under the laws of Kentucky, Tennessee, Mississippi and Louisiana, and acting herein under authority granted by the State of Kentucky, which contracts as hereinafter set forth as party of the second part, witnesses as follows:

FIRST. The parties of the first part aforesaid contract and agree with the party of the second part aforesaid, that they will, according to the plans and annexed specifications, and under the directions of the Chief Engineer of the bridge, construct that part of the approach on the Kentucky side to the railroad bridge of the party of the second part across the Ohio River, at East Cairo, in Ballard County, in the State of Kentucky, which is hereinafter specified, upon the terms and conditions following, to wit:

SECOND. The parties of the first part agree to furnish the necessary materials, means and appliances, and to perform and do in accordance with the plans and specifications aforesaid, and under the direction of the Chief Engineer aforesaid, and within the time herein fixed, the work of constructing the twenty-one piers of said approach in the manner described in the accompanying specifications, for four and four-tenths ($4\frac{4}{10}$) cents per pound for steel, three (3) cents per pound for the cast-iron, eight dollars and a half (\$8.50) per cubic yard for the concrete used therein, twenty-five (25) cents per cubic yard for the necessary earth excavations, and thirty-five (35) cents per linear foot for the necessary piles left in the completed work, subject to the provisions of the specifications.

THIRD. The work herein specified shall be executed under the direction of the Chief Engineer of the bridge and his assistants, by whose measurements and calculations of the quantities and amount of the several kinds of work done and materials furnished the monthly estimates shall be made and the final estimate determined, and said Chief Engineer shall have power to reject all work and materials which in his opinion shall not be in accordance with the plans and specifications hereto attached, and with the spirit of this agreement. During the progress of the work he shall determine any questions as to what is required by the plans and specifications, and he shall decide whether the work is from time to time proceeding with such diligence as to insure the completion of the several parts, and of the whole work upon the said approach, including the superstructure, by the time mentioned in this contract; and if, in the opinion of said Chief Engineer, said work or

any part thereof shall not be so proceeding, he shall require such additional force to be put upon the same within such time as he may in writing designate, and upon the failure of the parties of the first part to comply with such requirements, the said Chief Engineer may put upon said work the additional force so required at the expense of the parties of the first part.

OR the said Chief Engineer, upon the failure of the parties of the first part to comply with such requirements or any of them within the time so designated, or of their failure to perform any of their covenants or agreements as herein covenanted or agreed, for thirty days after notice of the breach thereof, may, and on the demand of the party of the second part shall, declare that the parties of the first part have broken this contract and have failed to comply with its terms, and thereupon said parties of the first part shall forfeit all claim to the reserved fund or any part thereof which is hereinafter mentioned, and this contract shall be, by their said default so declared, terminated.

FOURTH. The work shall be at all times under the supervision of the said Chief Engineer of said bridge and his assistant engineers, all of whom are to be appointed by the second party, and said Chief Engineer shall have authority to discharge disorderly or inefficient foremen or other employees of the parties of the first part engaged in said work, if in his judgment their presence or employment upon the work is detrimental to its character, progress or interests; provided, the parties of the first part fail to discharge them upon his request to do so.

FIFTH. The work on said foundations and piers shall be continued without unnecessary delay to completion, and there shall be no unnecessary delay in furnishing the materials or in any part of the work of construction, or any lapse in the work, or any part thereof, which may affect injuriously the stability of the foundations, piers or superstructure, or any part thereof; nor shall any material mentioned in or allowed by the specifications be used which is not the best for the purpose used according to the opinion of the Chief Engineer of said bridge.

IN case any change in the location, specifications or plans of said work, prior to its final completion, is required by the party of the second part, the prices of the material furnished therefor or work done thereon shall not exceed those mentioned for similar material or work.

SIXTH. In case the entire work is not completed at the date provided for in the specifications, the parties of the first part shall pay to the party of the second part three hundred and fifty dollars (\$350) per day as liquidated damages for each and every day beyond said date that the said work remains incomplete.

SEVENTH. It is further agreed between the parties hereto that the parties of the first part shall have no right or power to assign this contract in whole or part, nor to assign any right arising thereunder; and in case of the insolvency or bankruptcy of said parties of the first part or any of them prior to the final completion of said work there shall be nothing due them under this contract, save for such parts of material furnished and accepted, and for work therefor done, that had not been at that time estimated, or if estimated, had not been paid, but the failure from insolvency to progress with or finally complete said work and its several

parts, or either of them, as and at the times herein mentioned, or the failure from any cause to finally complete said approach as herein contracted, shall *ipso facto*, be a forfeiture of the reserved fund, and neither of said parties of the first part, nor any assignee in bankruptcy or otherwise, shall have any right or claim thereto or to any part thereof. And it is further agreed that no part of the work mentioned herein shall be sublet or in any way removed from the control of the parties of the first part under the direction and supervision of the Chief Engineer, as aforesaid, except with the express approval in writing of the said Chief Engineer.

EIGHTH. The character of the work, the kind of materials furnished, and all the other requirements of the annexed specifications and plans, and the times limited for the completion of each part and of the whole, are agreed to be essential parts of this contract.

NINTH. The terms of payment for the work shall be as follows: During the progress of the work the Chief Engineer shall cause estimates to be made of the work done and materials delivered during each calendar month, and about the 15th day of the succeeding month the amount of the same shall be paid to the parties of the first part, less, however, a reserved fund of ten (10) per cent., which reserved fund shall be held by the second party as security for the completion of the whole work and its several parts, and if at the times herein contracted each and every part of the substructure of said approach has been built in accordance with the specifications and plans and is delivered up to the second party free from all liens and claims, and if the parties of the first part have done and performed all their covenants and undertakings herein, then the party of the second part is to pay over to the parties of the first part all of said reserved fund.

IT is agreed that after the completion of the entire work in accordance with the specifications and directions of the Chief Engineer, and before the final settlement is made, any differences or controversies arising under this contract between the parties hereto may be finally settled by a body of arbitrators consisting of three persons: one to be the Chief Engineer of said bridge, one to be named by the contractors, to-wit, the parties of the first part, and the third to be selected by the other two. The arbitrators shall judge by a majority vote, and their decision shall be final and binding on both parties, and their award shall be performed within fifty (50) days after the work is finally completed and accepted and the award announced; but the party asking said arbitration shall in writing specify the particular thing to be arbitrated, and the arbitrators shall be confined to the thing so specified by the one or both parties.

TENTH. It is further agreed that no material shall be estimated until delivered at the bridge site, except steel for the cylinder shells, which shall be estimated when delivered at the shops of the party of the second part; and each steel shall be marked and set apart for use in said work, and the parties of the second part shall have a special lien thereon to the extent of the advances thus made; nor shall any material be paid for on final estimate or otherwise which does not form an actual part of the finished structure or is not of the class and quality required by the specifications.

In making monthly estimates, the steel delivered at the shop but not completed shall be estimated at fifty (50) per cent. of the erected price, and the steel manufactured at the shop at sixty-five (65) per cent. of the erected price, and the steel delivered at Cairo at eighty (80) per cent. of the erected price.

No claim for extra work shall be paid unless it be presented within fifteen (15) days after the end of the month in which said work is performed, and then only when approved by the Chief Engineer as having been ordered by him to be done.

EXEMPTION. It is further agreed that the steel for such approach which said parties of the first part may ship from Chicago to Cairo over the Illinois Central Railroad, and also any necessary switching of the same at Cairo or East Cairo, or transferring across the Ohio River between the inclines at Cairo and East Cairo, and piles transported for a distance not exceeding fifty miles to Cairo or East Cairo, but not including any transfer of piles across the river, shall be carried and done without unreasonable delay and without cost to said parties of the first part, but all losses or damage during such transportation, switching or transfer shall be borne alone by said party of the first part.

TWELFTH. The parties hereto respectively covenant and agree in behalf of themselves, their representatives and successors.

In WITNESS WHEREOF, the parties of the first part as individuals, and also as a partnership firm, have hereunto set their several and their partnership names and private seals, and the party of the second part has caused its corporate name to be hereto signed, and its corporate seal to be hereto affixed, this the day and year first above written.

Geo. S. Field,	[L. S.]
Edmund Hayes,	[L. S.]
C. S. Maclure,	[L. S.]
C. Macdonald,	[L. S.]

UNION BRIDGE CO.,
By C. Macdonald,

CHICAGO, ST. LOUIS AND NEW ORLEANS RAILROAD COMPANY,
[L. S.] By STEPHEN FISH,
President.

Attest:

E. T. H. Gibson,
Secretary C. & N. O. R. R. Co.

SPECIFICATIONS FOR KENTUCKY APPROACH TO THE BRIDGE ACROSS THE OHIO RIVER, AT CAIRO, ILLINOIS.

GENERAL DESCRIPTION.

The Kentucky approach will consist of twenty-one deck spans of 150 feet each, and one of 105 feet, supported on twenty-one steel cylinder piers.

Beyond this approach of permanent bridge construction, there will be timber trestle work which is not included in this contract.

SUBSTRUCTURE.

The substructure will comprise the twenty-one steel cylinder piers named above.

Each pier will consist of two cylinders eight feet in diameter, composed of soft steel shells filled with concrete, and resting on pile foundations.

The steel plates shall be one-half inch thick and five feet wide, with the edges planed and spliced on the inside, as shown on detail plans furnished. The steel shall have an ultimate strength of 35,000 to 62,000 pounds per square inch. The rivet holes may be punched, but the faced edges shall be exactly fitted so as to come in close contact when put together. The entire work shall be painted with one coat of Cleveland Iron Chloride Paint (brown or purple brand) before leaving the shop, and all parts that come in contact, including the faced edges, shall be painted at the time of erection. The two steel cylinders shall be connected by a cross-frame as shown in the drawings.

An excavation shall be made at the site of each cylinder in the form of a truly circular pit eight feet below the surface of the ground. In this pit twelve piles shall be driven, the arrangement being according to the plan furnished, the piles not to be more than 24 nor less than 20 inches between centers, and the distance between the outer piles and the cylinder shells never to be less than six inches. The piles shall be straight, of good, sound white or burr oak, and at least eleven inches in diameter at the small end. They shall be driven to the satisfaction of the Engineer. They shall be cut off square and finished without splinters. The bill of piles shall be agreed upon between the Resident Engineer and the contractor, and the lengths estimated in the work shall never be more than two feet less than the billed length of the pile, except when a pile is injured in driving.

The lower portion of the pits shall then be filled with concrete to an elevation fixed by the Engineer for the bottom of the steel shell. The steel shells shall then be set up accurately and riveted together, including the cross-frames complete. The Engineer may, however, authorize the use of bolts in place of rivets, if satisfied that the work will be equally durable. The entire shells shall then be filled with concrete, which shall be thoroughly rammed, special care being taken to fill the spaces among the piles thoroughly. The shells below the natural surface of

the ground shall then be encased in concrete six inches thick. The upper two feet of the concrete shall be of Portland cement and sand, three parts of sand to one of cement, into which stone may be rammed after it is put in position. The concrete outside of the shells shall be made in the same way. The remainder of the concrete shall be of Louisville cement, sand and stone, two parts of sand to one of cement, and not over 60 per cent. of the whole volume in broken stone. In Portland cement concrete the sand and cement shall be mixed together dry and then run through a satisfactory machine mixer. The mass of concrete shall always be thoroughly rammed after being put in position. The Louisville cement concrete shall be worked in a mixer approved by the Engineer, who also shall have the right to change the method of mixing.

Steel anchor-bolts not less than five feet long shall be built into the upper portion of the concrete in exactly the position directed by the Engineer. The surface of the concrete shall be leveled off true and finished with a trowel or straight edge one-half an inch higher than the edge of the steel shell.

A cast-iron or steel cap shall subsequently be put on with suitable cores or drilled holes fitting over the anchor-bolts, this cap to be set on a full mortar bed and brought down to a perfect bearing with a maul.

The earth excavated from the pits shall not be left in heaps, but shall be leveled off according to the directions of the Engineer.

SUPERSTRUCTURE.

PLANS.

Full detail plans, showing all dimensions, are now in the office of the Engineer, and are marked for identification as parts of this contract, A, B, C and D. The work shall be built in all respects according to these plans. The contractor, however, will be expected to verify the correctness of the plans, and will be required to make any changes in the work which are necessitated by errors in these plans, without extra charge, where such errors could be discovered by an inspection of the plans.

MATERIALS.

All parts except nuts, rivets and wall pedestal plates will be of steel. The nuts and rivets may be of wrought-iron, and pedestal plates of cast-iron.

All materials shall be subject to inspection at all times during their manufacture, and the Engineer and his inspectors shall be allowed free access to any of the works in which any portion of the material is made. Timely notice shall be given to the Engineer, so that his inspectors may be on hand.

Steel may be made by the open hearth or by the Bessemer process, but no steel shall be made at works which have not been in successful operation for at least one year. Steel made by the Clapp-Griffiths process will not be accepted. All melts shall be made from uniform stock low in phosphorus, and the manufacturer shall furnish satisfactory evidence to the Engineer that this class of material is being employed, it being understood that the finished product of open hearth steel

is to be one in which the phosphorus does not average more than eight one-hundredths of one per cent., and never exceeds one-tenth of one per cent., and in the finished product of Bessemer steel the average of phosphorus shall not be more than six-tenths of one per cent., and the maximum not more than seven-tenths of one per cent.

A sample bar having one square inch cross section shall be cut from the finished product of every melt. The laboratory tests shall be made on this sample bar in its natural state without annealing.

The laboratory tests of steel for the chords, posts, bolsters, cross-frames and rivets made from the sample bar shall show an ultimate strength of not less than 56 000 nor more than 62 000 pounds per square inch; an elongation of at least 25 per cent. in a length of eight inches, and a reduction of area of 48 per cent. at point of fracture. In a bending test the sample bar shall bend 180 degrees and close back against itself without showing crack or flaw on the outside of the curve.

The laboratory tests of steel for the floor beams, stringers, pins, eye-bars and lateral rods made on the sample bar shall show an elastic limit of not less than 38 000 pounds per square inch; an ultimate strength of not less than 62 000 pounds, nor more than 70 000; an elongation of at least 22 per cent. in a length of eight inches, and a reduction of at least 42 per cent. at the point of fracture; this elongation and reduction being the minimum and not the average requirements. In a bending test the sample bar shall bend 180 degrees and close back on itself without showing crack or flaw on the outside of the curve.

Every piece of steel shall be stamped with a number identifying the melt, and a statement of the results of the laboratory tests of each melt shall be furnished by the contractor, certified by some person acceptable to the Engineer, and accompanied by the tested specimens. Should the manufacturer make tests of bars rolled from sample ingots, certified copies of the report of said tests shall also be furnished to the Engineer.

All sheared edges or punched holes in the floor system shall subsequently be planed or drilled out so that none of the rough surface is ever left upon the work. Steel for pins shall be sound and entirely free from piping, and pins more than four inches in diameter shall be drilled through the axis.

Nuts, washers and clevises shall be strong enough to break the members to which they are attached.

Cast-iron shall be of the best quality of tough gray iron.

RIVETED WORK.

All plates, angles and channels shall be carefully straightened before they are laid out; the rivet holes shall be carefully spaced in truly straight lines; the rivet heads shall be of hemispherical pattern, and the work shall be finished in a neat and

workmanlike manner. Surfaces in contact shall be painted before they are put together. The dimensions given for rivets on the plans are the diameters of the rivets before driving.

Power riveters shall be direct-acting machines capable of exerting a yielding pressure and holding on to the rivet when the upsetting is completed.

The several parts of the stringers and floor beams shall be assembled and the holes shall be drilled, the sharp edges of the drilled holes shall be trimmed so as to make a slight fillet under the rivet head, and the pieces shall be riveted together without taking apart. Should the contractor desire, the parts may be punched with a punch at least three thirty-seconds of an inch smaller than the diameter of the rivet as given on the plans, working in a die only one sixty-fourth of an inch larger than the punch; the several parts of the members shall then be assembled, and the holes reamed so that at least one-sixteenth of an inch of metal is taken out all around, the sharp edge of the reamed hole shall be trimmed, and the pieces riveted together as above.

All rivets shall be of steel. The rivet holes shall be of such size that the rivet will fill the hole before driving, and whenever possible the rivets shall be driven by power. All bearing surfaces shall be truly faced. The pinholes shall be bored truly so as to be at exact distances, parallel with one another, and at right angles to the axis of the posts. The posts shall be straight and free from wind.

The holes for all rivets which must be driven after erection shall be accurately drilled to an iron template.

FORGED WORK.

The heads of eye-bars shall be formed by upsetting and forging into shape by such process as may be accepted by the Engineer. No welds will be allowed. After the work is completed the bars shall be annealed by heating them to a uniform dark red heat throughout their entire length, and allowing them to cool slowly. The form of the heads of steel eye-bars may be modified to suit the process at the contractor's works, but the form of the head adopted must be such as to meet the requirements of the test of full-sized bars.

The heads and the enlarged ends for screws in laterals, suspenders and counters shall be formed by upsetting by a process acceptable to the Engineer.

TESTS OF FULL-SIZED STEEL BARS.

Ten full-sized eye-bars of sections and lengths used in the actual work shall be selected from bars made for the bridge by the inspector for testing. Each of these full-sized bars shall be strained till broken. When broken the fracture shall occur in the body of the bar, and shall show a uniform and ductile quality of material.

The full-sized bars shall be selected from time to time as the work proceeds, the last bar not to be selected till all the eye-bars are manufactured. The tests shall

be made from time to time as the bars are selected. When three bars have been tested, the bars manufactured up to the time of the selection of these three test bars shall be accepted or rejected on the results of such tests, and the same shall be done again when three more bars are tested. In these tests the failure of one bar to develop a stretch of eight per cent., or of the lot to develop an average of ten per cent. before breaking, shall be sufficient reason for rejecting the lot from which these bars are taken. A failure to break in the body of the bar shall not be a sufficient ground for condemnation if it does not occur in more than one-third of the bars tested; but the above requirements as to elongation shall apply to the bars so breaking in the head, as well as to the others. The Chief Engineer shall, however, examine carefully into the cause of breakage of any bar which does not meet the requirements, and if the defect is explained, may order additional tests, and make the acceptance dependent on further results.

MACHINE WORK.

The bearing surfaces in the top chord shall be truly faced. The ends of the stringers and of the floor beams shall be squared in a face. All surfaces so designated on the plans shall be planed. All sheared and punched edges shall be planed or bored out.

All pins shall be accurately turned to a gauge, and shall be full size throughout. Pinholes shall be bored to fit the pins with a play not exceeding one-fiftieth of an inch. These clauses apply to all lateral connections as well as to those of the main trusses. Pins shall be supplied with pilot nuts for use during erection, four for each size of pin.

All screws shall have a truncated V thread, United States standard sizes.

MISCELLANEOUS.

All workmanship and materials, whether particularly specified or not, must be of the best kind now known in first-class bridge work. Flaws, ragged edges, surface imperfections or irregular shapes will be sufficient ground for rejection. Rough and irregularly finished work will not be accepted.

Machine-finished surfaces shall be coated with white lead and tallow before shipment. All other parts shall be given a coat of Cleveland Iron Clad Paint, purple brand.

TIME.

Work shall be begun on the substructure as soon as the proper materials can be collected for this purpose, and shall be finished in season to admit of the final completion of the entire work of constructing the Kentucky approach to the said bridge including the superstructure, by the time herein limited for that purpose, namely, July first, 1888.

CONTRACT FOR SUPERSTRUCTURE OF KENTUCKY
APPROACH TO THE BRIDGE ACROSS THE
OHIO RIVER, AT CAIRO, ILLINOIS.

THIS AGREEMENT, made and entered into on this the ninth day of March, 1889, by and between GEORGE S. FIELD, EDWARD HAYES, C. S. MATRICE and CHARLES MACDONALD, who as individuals and also as a partnership firm doing business under the firm name of the UNION BRIDGE COMPANY, of New York, contract as hereinafter set forth as parties of the first part, and THE CHICAGO, ST. LOUIS AND NEW ORLEANS RAILROAD COMPANY, a corporation existing under the laws of Kentucky, Tennessee, Mississippi and Louisiana, and acting herein under authority granted by the State of Kentucky, which contracts as hereinafter set forth as party of the second part, WITNESSETH as follows:

FIRST. The parties of the first part aforesaid contract and agree with the party of the second part aforesaid, that they will, according to the plans and annexed specifications, and under the directions of the Chief Engineer of the bridge, construct that part of the approach on the Kentucky side to the railroad bridge of the party of the second part across the Ohio River at Cairo, in Ballard County, in the State of Kentucky, which is hereinafter specified, upon the terms and conditions following, to wit:

SECOND. The parties of the first part agree to furnish the materials and manufacture and erect, in accordance with the plans and specifications aforesaid, and under the directions of the Chief Engineer aforesaid, and within the time herein fixed, the superstructure of said approach, consisting of twenty-one spans of one hundred and fifty (150) feet each, and one span of one hundred and five (105) feet, for four and four-tenths (4 $\frac{4}{10}$) cents per pound, erected complete.

THIRD. The work herein specified shall be executed under the direction of the Chief Engineer of the bridge and his assistants, by whose measurements and calculations of the quantities and amount of the several kinds of work done and materials furnished the monthly estimates shall be made and the final estimate determined, and said Chief Engineer shall have power to reject all work and materials which in his opinion shall not be in accordance with the plans and specifications hereto attached, and with the spirit of this agreement. During the progress of the work he shall determine any questions as to what is required by the plans and specifications, and he shall decide whether the work is from time to time proceeding with such diligence as to insure the completion of the several parts, and of the whole work as herein contracted and by the time mentioned in this contract; and if, in the opinion of said Chief Engineer, said work, or any part thereof shall not be so proceeding, he shall require such additional force to be put upon the same within such time as he may in writing designate, and upon the failure of the parties of the first part to comply with such requirements, the said Chief Engineer may put upon said work the additional force so required at the expense of the parties of the first part.

Or the said Chief Engineer, upon the failure of the parties of the first part to comply with such requirements or any of them within the time so designated, or of their failure to perform any of their covenants or agreements as herein covenanted or agreed, for thirty days after notice of the breach thereof, may, and on demand of the party of the second part shall, declare that the parties of the first part have broken this contract and have failed to comply with its terms, and thereupon said parties of the first part shall forfeit all claim to the reserved fund or any part thereof which is hereinafter mentioned, and this contract shall be, by their said default so declared, terminated.

FOURTH. The work shall be at all times under the supervision of the said Chief Engineer of said bridge and his assistant engineers, all of whom are to be appointed by the second party, and said Chief Engineer shall have authority to discharge disorderly or inefficient foremen or other employees of the parties of the first part engaged in said work, if in his judgment their presence or employment upon the work is detrimental to its character, progress or interests; provided, the parties of the first part fail to discharge them upon his request to do so.

FIFTH. The work on said superstructure shall be continued without unnecessary delay to completion, and there shall be no unnecessary delay in furnishing the materials or in any part of the work of construction, or any hindrance in the work, or any part thereof, which may affect injuriously the stability of the foundations, piers or superstructure, or any part thereof; nor shall any material mentioned in or allowed by the specifications be used which is not the best for the purpose used according to the opinion of the Chief Engineer of said bridge.

In case any change in the location, specifications or plans of said work, prior to its final completion, is required by the party of the second part, the prices of the material furnished therefor or work done thereon shall not exceed those mentioned for similar material or work.

SIXTH. In case the entire work is not completed at the date provided for in the specifications, the parties of the first part shall pay to the party of the second part three hundred and fifty dollars (\$350) per day as liquidated damages for each and every day beyond said date that the said work remains incomplete.

SEVENTH. It is further agreed between the parties hereto that the parties of the first part shall have no right or power to assign this contract in whole or part, nor to assign any right arising thereunder; and in case of the insolvency or bankruptcy of said parties of the first part or any of them prior to the final completion of said work there shall be nothing due them under this contract, save for such parts of material furnished and accepted, and for work theretofore done that had not been at that time estimated, or if estimated, had not been paid, but the failure from insolvency to progress with or finally complete said work and its several parts, or either of them, as and at the date herein mentioned, or the failure from any cause to finally complete said approach as herein contracted, shall *ipso facto* be a forfeiture of the reserved fund, and neither of said parties of the first part, nor any assignee in bankruptcy or otherwise, shall have any right or claim thereto or to any part thereof. And it is further agreed that no part of the work mentioned herein shall be sublet

or in any way removed from the control of the parties of the first part under the direction and supervision of the Chief Engineer, as aforesaid, except with the express approval in writing of the said Chief Engineer.

EIGHTH. The character of the work, the kind of materials furnished, and all the other requirements of the annexed specifications and plans, and the times limited for the completion of each part and of the whole, are agreed to be essential parts of this contract.

NINTH. The terms of payment for the work shall be as follows: During the progress of the work the Chief Engineer shall cause estimates to be made of the work done and materials delivered during each calendar month, and about the 15th day of the succeeding month the amount of the same shall be paid to the parties of the first part, less, however, a reserved fund of ten (10) per cent., which reserved fund shall be held by the second party as security for the completion of the whole work and its several parts, and if at the times herein contracted, each and every part of the superstructure of said approach has been built in accordance with the specifications and plans, and is delivered up to the second party free from all liens and claims, and if the parties of the first part have done and performed all their covenants and undertakings herein, then the party of the second part is to pay over to the parties of the first part all of said reserved fund.

It is agreed that, after the completion of the entire work in accordance with the specifications and directions of the Chief Engineer, and before the final settlement is made, any differences or controversies arising under this contract between the parties hereto may be finally settled by a body of arbitrators consisting of three persons: One to be the Chief Engineer of said bridge, one to be named by the contractors, to-wit, the parties of the first part, and the third to be selected by the other two. The arbitrators shall judge by a majority vote, and their decision shall be final and binding on both parties, and their award shall be performed within fifty (50) days after the work is finally completed and accepted and the award announced; but the party asking said arbitration shall in writing specify the particular thing to be arbitrated, and the arbitrators shall be confined to the thing so specified by the one or both parties.

TENTH. It is further agreed that no material shall be estimated until delivered at the bridge site, except steel for the superstructure, which shall be estimated when delivered at the shops of the party of the second part; and such steel shall be marked and set apart for use in said work, and the parties of the second part shall have a special lien thereon to the extent of the advances thus made; nor shall any material be paid for on final estimate or otherwise which does not form an actual part of the finished structure or is not of the class and quality required by the specifications.

In making monthly estimates, the steel delivered at the shop but not completed shall be estimated at fifty (50) per cent. of the erected price, and the steel manufactured at the shop at sixty-five (65) per cent. of the erected price, and the steel delivered at Cairo at eighty (80) per cent. of the erected price.

No claim for extra work shall be paid unless it be presented within fifteen (15)

days after the end of the month in which said work is performed, and then only when approved by the Chief Engineer as having been ordered by him to be done.

EXCISES. It is further agreed that the steel for such approach which said parties of the first part may ship from Chicago to Cairo over the Illinois Central Railroad, and also any necessary switching of the same at Cairo or East Cairo, or transferring across the Ohio River between the inclines at Cairo and East Cairo, shall be carried and done without unreasonable delay and without cost to said parties of the first part, but all losses or damage during such transportation, switching or transfer shall be borne alone by said party of the first part.

TWELFTH. The parties hereto respectively covenant and agree in behalf of themselves, their representatives and successors.

IN WITNESS WHEREOF, the parties of the first part as individuals, and also as a partnership firm, have hereto set their several and their partnership names and private seals, and the party of the second part has caused its corporate name to be hereto signed, and its corporate seal to be hereto affixed, this the day and year first above written.

Geo. S. Field.	[L. S.]
Edmund Hayra.	[L. S.]
C. S. Maerck.	[L. S.]
C. Macdonald.	[L. S.]

UNION BRIDGE CO.,

By C. Macdonald.

CHICAGO, ST. LOUIS AND NEW ORLEANS RAILROAD COMPANY,

[L. S.]

By Stuyvesant Fish,

President.

Attest:

E. T. H. Gibson,

Secretary C. St. L. & N. O. R. R. Co.

SPECIFICATIONS FOR KENTUCKY APPROACH TO THE BRIDGE ACROSS THE OHIO RIVER, AT CAIRO, ILLINOIS.

GENERAL DESCRIPTION.

The Kentucky approach will consist of twenty-one deck spans of 150 feet each, and one of 105 feet, supported on twenty-one steel cylinder piers.

Beyond this approach of permanent bridge construction, there will be timber trestle work which is not included in this contract.

SUBSTRUCTURE.

The substructure will comprise the twenty-one steel cylinder piers named above.

Each pier will consist of two cylinders eight feet in diameter, composed of soft steel shells filled with concrete, and resting on pile foundations.

The steel plates shall be one-half inch thick and five feet wide, with the edges planed and spliced on the inside, as shown on detail plans furnished. The steel shall have an ultimate strength of 35 000 to 42 000 pounds per square inch. The rivet holes may be punched, but the faced edges shall be exactly fitted so as to come in close contact when put together. The entire work shall be painted with one coat of Cleveland Iron Clad Paint (brown or purple brand) before leaving the shop and all parts that come in contact, including the faced edges, shall be painted at the time of erection. The two steel cylinders shall be connected by a cross-frame as shown in the drawings.

An excavation shall be made at the site of each cylinder in the form of a truly circular pit eight feet below the surface of the ground. In this pit twelve piles shall be driven, the arrangement being according to the plan furnished, the piles not to be more than 24 nor less than 20 inches between centers, and the distance between the outer piles and the cylinder shells never to be less than six inches. The piles shall be straight, of good sound white or burr oak, and at least eleven inches in diameter at the small end. They shall be driven to the satisfaction of the Engineer. They shall be cut off square and finished without splinters. The bill of piles shall be agreed upon between the Resident Engineer and the contractor, and the lengths estimated in the work shall never be more than two feet less than the billed length of the pile, except when a pile is injured in driving.

The lower portion of the pits shall then be filled with concrete to an elevation fixed by the Engineer for the bottom of the steel shell. The steel shells shall then be set up accurately and riveted together, including the cross-frames complete. The Engineer may, however, authorize the use of bolts in place of rivets, if satisfied that the work will be equally durable. The entire shells shall then be filled with concrete, which shall be thoroughly rammed, special care being taken to fill the spaces among the piles thoroughly. The shells below the natural surface of

the ground shall then be encased in concrete six inches thick. The upper two feet of the concrete shall be of Portland cement and sand, three parts of sand to one of cement, into which stone may be rammed after it is put in position. The concrete outside of the shells shall be made in the same way. The remainder of the concrete shall be of Louisville cement, sand and stone, two parts of sand to one of cement, and not over 60 per cent. of the whole volume in broken stone. In Portland cement concrete the sand and cement shall be mixed together dry and then run through a satisfactory machine mixer. The mass of concrete shall always be thoroughly rammed after being put in position. The Louisville cement concrete shall be worked in a mixer approved by the Engineer, who also shall have the right to change the method of mixing.

Steel anchor bolts not less than five feet long shall be built into the upper portion of the concrete in exactly the position directed by the Engineer. The surface of the concrete shall be leveled off true and finished with a trowel or straight-edge one-half an inch higher than the edge of the steel shell.

A cast-iron or steel cap shall subsequently be put on with suitable bored or drilled holes fitting over the anchor-bolts, this cap to be set on a full mortar bed and brought down to a perfect bearing with a maul.

The earth excavated from the pits shall not be left in heaps, but shall be leveled off according to the directions of the Engineer.

SUPERSTRUCTURE.

PLANS.

Full detail plans, showing all dimensions, are now in the office of the Engineer, and are marked for identification, as parts of this contract, A, B, C and D. The work shall be built in all respects according to these plans. The contractor, however, will be expected to verify the correctness of the plans, and will be required to make any changes in the work which are necessitated by errors in these plans, without extra charge where such errors could be discovered by an inspection of the plans.

MATERIALS.

All parts except nuts, swivels and wall pedestal plates will be of steel. The nuts and swivels may be of wrought-iron, and the pedestal plates of cast-iron.

All materials shall be subject to inspection at all times during their manufacture, and the Engineer and his inspectors shall be allowed free access to any of the works in which any portion of the material is made. Timely notice shall be given to the Engineer, so that his inspectors may be on hand.

Steel may be made by the open hearth, or by the Bessemer process, but no steel shall be made at works which have not been in successful operation for at least one year. Steel made by the Clapp-Griffiths process will not be accepted. All melts shall be made from uniform stock low in phosphorus, and the manufacturer shall furnish satisfactory evidence to the Engineer that this class of material is being employed, it being understood that the finished product of open hearth steel is to be one in which the phosphorus does not average more than eight one-hundredths of

one per cent., and never exceeds one-tenth of one per cent., and in the finished product of Bessemer steel the average of phosphorus shall not be more than six-tenths of one per cent., and the maximum not more than seven-tenths of one per cent.

A sample bar having one square inch cross section shall be cut from the finished product of every melt. The laboratory tests shall be made on this sample bar in its natural state without annealing.

The laboratory tests of steel for the chords, posts, bolsters, crossframes and rivets made from the sample bar shall show an ultimate strength of not less than 46 000 nor more than 62 000 pounds per square inch; an elongation of at least 25 per cent. in a length of eight inches and a reduction of area of 45 per cent. at point of fracture. In a bending test the sample bar shall bend 180 degrees and close back against itself without showing crack or flaw on the outside of the curve.

The laboratory tests of steel for the floor beams, stringers, pins, eye-bars and lateral rods made on the sample bar shall show an elastic limit of not less than 38 000 pounds per square inch; an ultimate strength of not less than 63 000 pounds nor more than 70 000; an elongation of at least 22 per cent. in a length of eight inches, and a reduction of at least 45 per cent. at the point of fracture; this elongation and reduction being the minimum and not the average requirements. In a bending test the sample bar shall bend 180 degrees and close back on itself without showing crack or flaw on the outside of the curve.

Every piece of steel shall be stamped with a number identifying the melt, and a statement of the results of the laboratory tests of each melt shall be furnished by the contractor, certified by some person acceptable to the Engineer, and accompanied by the tested specimens. Should the manufacturer make tests of bars rolled from sample ingots, certified copies of the report of said tests shall also be furnished to the Engineer.

All sheared edges or punched holes in the floor system shall subsequently be planed or drilled out so that none of the rough surface is ever left upon the work. Steel for pins shall be sound and entirely free from piping, and pins more than four inches in diameter shall be drilled through the axis.

Nuts, screws and clevises shall be strong enough to break the members to which they are attached.

Cast-iron shall be of the best quality of tough gray iron.

RIVETED WORK.

All plates, angles and channels shall be carefully straightened before they are laid out; the rivet holes shall be carefully spaced in truly straight lines; the rivet heads shall be of hemispherical pattern, and the work shall be finished in a neat and workmanlike manner. Surfaces in contact shall be painted before they are put together. The dimensions given for rivets on the plans are the diameters of the rivets before driving.

Power riveters shall be direct acting machines capable of exerting a yielding pressure and holding on to the rivet when the upsetting is completed.

The several parts of the stringers and floor beams shall be assembled and the holes shall be drilled, the sharp edges of the drilled holes shall be trimmed so as to make a slight fillet under the rivet head, and the pieces shall be riveted together without taking apart. Should the contractor desire, the parts may be punched with a punch at least three thirty-seconds of an inch smaller than the diameter of the rivet as given on the plans, working in a die only one sixty-fourth of an inch larger than the punch; the several parts of the members shall then be assembled, and the holes reamed so that at least one-sixteenth of an inch of metal is taken out all around, the sharp edge of the reamed hole shall be trimmed, and the pieces riveted together as above.

All rivets shall be of steel. The rivet holes shall be of such size that the rivet will fill the hole before driving, and whenever possible the rivets shall be driven by power. All bearing surfaces shall be truly faced. The pinholes shall be bored truly so as to be at exact distances, parallel with one another, and at right angle to the axis of the posts. The posts shall be straight and free from wind.

The holes for all rivets which must be driven after erection shall be accurately drilled to an iron template.

FORGED WORK.

The heads of eye-bars shall be formed by upsetting and forging into shape by such process as may be accepted by the Engineer. No welds will be allowed. After the work is completed the bars shall be annealed by heating them to a uniform dark red heat throughout their entire length, and allowing them to cool slowly. The form of the heads of steel eye-bars may be modified to suit the process at the contractor's works, but the form of the head adopted must be such as to meet the requirements of the tests of full-sized bars.

The heads and enlarged ends for screws in laterals, suspenders and cowlers shall be formed by upsetting by a process acceptable to the Engineer.

TESTS OF FULL-SIZED STEEL BARS.

Ten full-sized eye-bars of sections and lengths used in the actual work shall be selected from bars made for the bridge by the Inspector for testing. Each of these full-sized bars shall be strained till broken. When broken the fracture shall occur in the body of the bar and shall show a uniform and ductile quality of material.

The full-sized bars shall be selected from time to time as the work proceeds, the last bar not to be selected till all the eye-bars are manufactured. The tests shall be made from time to time as the bars are selected. When three bars have been tested, the bars manufactured up to the time of the selection of those three test bars shall be accepted or rejected on the results of such tests, and the same shall be done

again when three more bars are tested. In these tests the failure of one bar to develop a stretch of eight per cent., or of the lot to develop an average of ten per cent. before breaking, shall be sufficient reason for rejecting the lot from which those bars are taken. A failure to break in the body of the bar shall not be sufficient ground for condemnation if it does not occur in more than one-third of the bars tested; but the above requirement as to elongation shall apply to the bars so breaking in the head, as well as to the others. The Chief Engineer shall, however, examine carefully into the cause of breakage of any bar which does not meet the requirements, and if the defect is explained may order additional tests, and make the acceptance dependent on further results.

MACHINE WORK.

The bearing surfaces in the top chord shall be truly faced. The ends of the stringers and of the floor beams shall be squared in a facet. All surfaces so designated on the plans shall be planed. All sheared and punched edges shall be planed or bored out.

All pins shall be accurately turned to a gauge and shall be full size throughout. Pinholes shall be bored to fit the pins with a play not exceeding one-fiftieth of an inch. These clauses apply to all lateral connections as well as to those of the main trusses. Pins shall be supplied with pilot nuts for use during erection, four for each size of pin.

All screws shall have a truncated V thread, United States standard sizes.

MISCELLANEOUS.

All workmanship and materials, whether particularly specified or not, must be of the best kind now known in first-class bridge work. Flaws, ragged edges, surface imperfections or irregular shapes will be sufficient ground for rejection. Rough and irregularly finished work will not be accepted.

Machine-finished surfaces shall be coated with white lead and tallow before shipment. All other parts shall be given a coat of Cleveland Iron Chloride Paint, purple brand.

TIME.

Work shall be begun on the substructure as soon as the proper materials can be collected for this purpose, and shall be finished in season to admit of the final completion of the entire work of constructing the Kentucky approach to the said bridge, including the superstructure, by the time herein limited for that purpose, namely, July first, 1889.

SUPPLEMENTAL AGREEMENT AS TO DATES OF COMPLETION OF MAIN BRIDGE AT CAIRO AND OF THE KENTUCKY APPROACH.

SUPPLEMENTAL AGREEMENT, made this 27th day of May, A. D. 1889, between GEORGE S. FIELD, EDWARD HAYES, C. S. MAURICE and CHARLES MACDONALD, who contract as individuals and also as a partnership firm doing business under the firm name of the UNION BRIDGE COMPANY of New York, parties of the first part, and the CHICAGO, ST. LOUIS AND NEW ORLEANS RAILROAD COMPANY, a corporation existing under the laws of Kentucky, Tennessee, Mississippi and Louisiana, party of the second part:

WHEREAS, By an agreement in writing heretofore made and entered into by and between the said parties of the first part and the party of the second part, bearing date the fourth day of May, A. D. 1887, the parties of the first part contracted and agreed with the party of the second part to construct a railroad bridge across the Ohio River between Ballard County in the State of Kentucky and Alexander County in the State of Illinois, in and by which said contract it was provided that the entire bridge, including all piers and spans and other work mentioned in said contract, should be completed on or before December 31st, 1889;

AND WHEREAS, By two separate subsequent contracts made and entered into by and between the said parties of the first part and the said party of the second part, bearing date the 9th day of March, A. D. 1889, the said parties of the first part contracted and agreed with the said party of the second part to construct the approach on the Kentucky side to the railroad bridge across the Ohio River, referred to and provided for in the contract of May 4, 1887, last above mentioned, in and by

which said two contracts of March 9, 1889, above referred to, it was in effect provided that the entire work of constructing the Kentucky approach to the said bridge, including both the substructure and the superstructure, should be completed by the first of July, 1889;

AND WHEREAS, The dates thus fixed in each of the said contracts for the completion of the main bridge across the Ohio River and of the Kentucky approach to the said bridge were inserted in the said contracts through some misapprehension and mistake, and contrary to the intention of the several parties thereto;

NOW, THEREFORE, For the purpose of correcting the said mistake and carrying into effect the true intention of the parties to the said contracts, it is hereby mutually agreed that the entire bridge across the Ohio River, mentioned and referred to in the contract of May 4, 1887, heretofore first above mentioned, including all piers and spans and other work mentioned in said contract, shall be completed on or before the first day of November, A. D. 1889, and the said contract of May 4, 1887, shall be held and construed to have the same force and effect as if it had in terms required the said bridge to be completed on or before November 1, A. D. 1889, instead of December 31, A. D. 1889; Provided, that if the condition of the river shall be such as to prevent the parties of the first part from having the structure completed and ready for traffic on or before the first day of November, A. D. 1889, the said parties of the first part shall not be liable for the liquidated damages of three hundred and fifty dollars per day specified in the said contract so long as the completion of the work is thus delayed; but no excuse shall be received for the non-completion of the bridge by the date fixed in said original contract of May 4, 1887.

It is further mutually agreed that the approach on the Kentucky side to the said main bridge across the Ohio River, provided for in the aforesaid contracts of

March 9, 1889, shall be completed on or before the first day of September, A. D. 1889, and the said two contracts of March 9, 1889, heretofore referred to, shall have the same force and effect as if they had in terms required the said Kentucky Approach to be completed on or before September 1, A. D. 1889, instead of July 1, A. D. 1889.

IN WITNESS WHEREOF, the parties of the first part as individuals, and also as a partnership firm, have hereto set their several and their partnership names and private seals, and the said party of the second part has caused its corporate name to be hereto signed and its corporate seal to be hereto affixed this day and year first above written.

Geo. S. Field, (SEAL.)

By Edward Hayes,

Att'y in Fact.

EDWARD HAYES, (SEAL.)

C. S. MAURICE, (SEAL.)

CHARLES MACDONALD, (SEAL.)

UNION BRIDGE COMPANY,

By C. Macdonald.

CHICAGO, ST. LOUIS AND NEW ORLEANS RAILROAD COMPANY,

By Stuyvesant Fish,

President.

[L. S.]

Attest:

E. T. H. Gibson,

Secretary.

APPENDIX I.

RECORD OF SINKING CAISSONS.

PIER II.

Date.	Elevations of Caisson from Mean Sea Level.					Feet in Water.	Total Height.	Elevations of Water.					Average Penetration of Pile.	Water Temp.	Depth of Water.	Tide.						Air Pressure.		Direction of Wind.	Sea Weight.	Surface Current.	Air Temp. at Surface.	Air Temp. at Bottom.	Remarks.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
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	N. E.	N. W.	S. E.	S. W.	Average.			N. E.	N. W.	S. E.	S. W.	Average.				Case.	Cell.	Manometer.	Wind.	Water.	Total.										Inland.	Overland.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
Mar. 1st.	287.45	287.50	287.55	287.60	287.61	1.00	1.00	287.50	287.55	287.60	287.65	287.61	1.00	287.50	287.55	287.60	287.65	287.61	287.66	287.71	287.76	287.81	287.86	287.91	287.96	288.01	288.06	288.11	288.16	288.21	288.26	288.31	288.36	288.41	288.46	288.51	288.56	288.61	288.66	288.71	288.76	288.81	288.86	288.91	288.96	289.01	289.06	289.11	289.16	289.21	289.26	289.31	289.36	289.41	289.46	289.51	289.56	289.61	289.66	289.71	289.76	289.81	289.86	289.91	289.96	290.01	290.06	290.11	290.16	290.21	290.26	290.31	290.36	290.41	290.46	290.51	290.56	290.61	290.66	290.71	290.76	290.81	290.86	290.91	290.96	291.01	291.06	291.11	291.16	291.21	291.26	291.31	291.36	291.41	291.46	291.51	291.56	291.61	291.66	291.71	291.76	291.81	291.86	291.91	291.96	292.01	292.06	292.11	292.16	292.21	292.26	292.31	292.36	292.41	292.46	292.51	292.56	292.61	292.66	292.71	292.76	292.81	292.86	292.91	292.96	293.01	293.06	293.11	293.16	293.21	293.26	293.31	293.36	293.41	293.46	293.51	293.56	293.61	293.66	293.71	293.76	293.81	293.86	293.91	293.96	294.01	294.06	294.11	294.16	294.21	294.26	294.31	294.36	294.41	294.46	294.51	294.56	294.61	294.66	294.71	294.76	294.81	294.86	294.91	294.96	295.01	295.06	295.11	295.16	295.21	295.26	295.31	295.36	295.41	295.46	295.51	295.56	295.61	295.66	295.71	295.76	295.81	295.86	295.91	295.96	296.01	296.06	296.11	296.16	296.21	296.26	296.31	296.36	296.41	296.46	296.51	296.56	296.61	296.66	296.71	296.76	296.81	296.86	296.91	296.96	297.01	297.06	297.11	297.16	297.21	297.26	297.31	297.36	297.41	297.46	297.51	297.56	297.61	297.66	297.71	297.76	297.81	297.86	297.91	297.96	298.01	298.06	298.11	298.16	298.21	298.26	298.31	298.36	298.41	298.46	298.51	298.56	298.61	298.66	298.71	298.76	298.81	298.86	298.91	298.96	299.01	299.06	299.11	299.16	299.21	299.26	299.31	299.36	299.41	299.46	299.51	299.56	299.61	299.66	299.71	299.76	299.81	299.86	299.91	299.96	300.01	300.06	300.11	300.16	300.21	300.26	300.31	300.36	300.41	300.46	300.51	300.56	300.61	300.66	300.71	300.76	300.81	300.86	300.91	300.96	301.01	301.06	301.11	301.16	301.21	301.26	301.31	301.36	301.41	301.46	301.51	301.56	301.61	301.66	301.71	301.76	301.81	301.86	301.91	301.96	302.01	302.06	302.11	302.16	302.21	302.26	302.31	302.36	302.41	302.46	302.51	302.56	302.61	302.66	302.71	302.76	302.81	302.86	302.91	302.96	303.01	303.06	303.11	303.16	303.21	303.26	303.31	303.36	303.41	303.46	303.51	303.56	303.61	303.66	303.71	303.76	303.81	303.86	303.91	303.96	304.01	304.06	304.11	304.16	304.21	304.26	304.31	304.36	304.41	304.46	304.51	304.56	304.61	304.66	304.71	304.76	304.81	304.86	304.91	304.96	305.01	305.06	305.11	305.16	305.21	305.26	305.31	305.36	305.41	305.46	305.51	305.56	305.61	305.66	305.71	305.76	305.81	305.86	305.91	305.96	306.01	306.06	306.11	306.16	306.21	306.26	306.31	306.36	306.41	306.46	306.51	306.56	306.61	306.66	306.71	306.76	306.81	306.86	306.91	306.96	307.01	307.06	307.11	307.16	307.21	307.26	307.31	307.36	307.41	307.46	307.51	307.56	307.61	307.66	307.71	307.76	307.81	307.86	307.91	307.96	308.01	308.06	308.11	308.16	308.21	308.26	308.31	308.36	308.41	308.46	308.51	308.56	308.61	308.66	308.71	308.76	308.81	308.86	308.91	308.96	309.01	309.06	309.11	309.16	309.21	309.26	309.31	309.36	309.41	309.46	309.51	309.56	309.61	309.66	309.71	309.76	309.81	309.86	309.91	309.96	310.01	310.06	310.11	310.16	310.21	310.26	310.31	310.36	310.41	310.46	310.51	310.56	310.61	310.66	310.71	310.76	310.81	310.86	310.91	310.96	311.01	311.06	311.11	311.16	311.21	311.26	311.31	311.36	311.41	311.46	311.51	311.56	311.61	311.66	311.71	311.76	311.81	311.86	311.91	311.96	312.01	312.06	312.11	312.16	312.21	312.26	312.31	312.36	312.41	312.46	312.51	312.56	312.61	312.66	312.71	312.76	312.81	312.86	312.91	312.96	313.01	313.06	313.11	313.16	313.21	313.26	313.31	313.36	313.41	313.46	313.51	313.56	313.61	313.66	313.71	313.76	313.81	313.86	313.91	313.96	314.01	314.06	314.11	314.16	314.21	314.26	314.31	314.36	314.41	314.46	314.51	314.56	314.61	314.66	314.71	314.76	314.81	314.86	314.91	314.96	315.01	315.06	315.11	315.16	315.21	315.26	315.31	315.36	315.41	315.46	315.51	315.56	315.61	315.66	315.71	315.76	315.81	315.86	315.91	315.96	316.01	316.06	316.11	316.16	316.21	316.26	316.31	316.36	316.41	316.46	316.51	316.56	316.61	316.66	316.71	316.76	316.81	316.86	316.91	316.96	317.01	317.06	317.11	317.16	317.21	317.26	317.31	317.36	317.41	317.46	317.51	317.56	317.61	317.66	317.71	317.76	317.81	317.86	317.91	317.96	318.01	318.06	318.11	318.16	318.21	318.26	318.31	318.36	318.41	318.46	318.51	318.56	318.61	318.66	318.71	318.76	318.81	318.86	318.91	318.96	319.01	319.06	319.11	319.16	319.21	319.26	319.31	319.36	319.41	319.46	319.51	319.56	319.61	319.66	319.71	319.76	319.81	319.86	319.91	319.96	320.01	320.06	320.11	320.16	320.21	320.26	320.31	320.36	320.41	320.46	320.51	320.56	320.61	320.66	320.71	320.76	320.81	320.86	320.91	320.96	321.01	321.06	321.11	321.16	321.21	321.26	321.31	321.36	321.41	321.46	321.51	321.56	321.61	321.66	321.71	321.76	321.81	321.86	321.91	321.96	322.01	322.06	322.11	322.16	322.21	322.26	322.31	322.36	322.41	322.46	322.51	322.56	322.61	322.66	322.71	322.76	322.81	322.86	322.91	322.96	323.01	323.06	323.11	323.16	323.21	323.26	323.31	323.36	323.41	323.46	323.51	323.56	323.61	323.66	323.71	323.76	323.81	323.86	323.91	323.96	324.01	324.06	324.11	324.16	324.21	324.26	324.31	324.36	324.41	324.46	324.51	324.56	324.61	324.66	324.71	324.76	324.81	324.86	324.91	324.96	325.01	325.06	325.11	325.16	325.21	325.26	325.31	325.36	325.41	325.46	325.51	325.56	325.61	325.66	325.71	325.76	325.81	325.86	325.91	325.96	326.01	326.06	326.11	326.16	326.21	326.26	326.31	326.36	326.41	326.46	326.51	326.56	326.61	326.66	326.71	326.76	326.81	326.86	326.91</

APPENDIX I.—CONTINUED.
RECORD OF SINKING CAISSONS.
PIER III.

[illegible]

APPENDIX I—CONTINUED.
RECORD OF SINKING CAISSONS
PIER IV.

DATE	Elevations of Curtain Wall above Mean Sea Level					Back to Main	Total Meters	Elevations of Gate, Internal Elevation, 1934					Average Pressure of Gate	Water Gauge	Depth Immersed	Waters						Air Pressure		Weather due to Air Pressure	Sea Weight	Surface in Contact	At 93, 100, 107, 114, 121, 128, 135, 142, 149, 156, 163, 170, 177, 184, 191, 198, 205, 212, 219, 226, 233, 240, 247, 254, 261, 268, 275, 282, 289, 296, 303, 310, 317, 324, 331, 338, 345, 352, 359, 366, 373, 380, 387, 394, 401, 408, 415, 422, 429, 436, 443, 450, 457, 464, 471, 478, 485, 492, 499, 506, 513, 520, 527, 534, 541, 548, 555, 562, 569, 576, 583, 590, 597, 604, 611, 618, 625, 632, 639, 646, 653, 660, 667, 674, 681, 688, 695, 702, 709, 716, 723, 730, 737, 744, 751, 758, 765, 772, 779, 786, 793, 800, 807, 814, 821, 828, 835, 842, 849, 856, 863, 870, 877, 884, 891, 898, 905, 912, 919, 926, 933, 940, 947, 954, 961, 968, 975, 982, 989, 996, 1003, 1010, 1017, 1024, 1031, 1038, 1045, 1052, 1059, 1066, 1073, 1080, 1087, 1094, 1101, 1108, 1115, 1122, 1129, 1136, 1143, 1150, 1157, 1164, 1171, 1178, 1185, 1192, 1199, 1206, 1213, 1220, 1227, 1234, 1241, 1248, 1255, 1262, 1269, 1276, 1283, 1290, 1297, 1304, 1311, 1318, 1325, 1332, 1339, 1346, 1353, 1360, 1367, 1374, 1381, 1388, 1395, 1402, 1409, 1416, 1423, 1430, 1437, 1444, 1451, 1458, 1465, 1472, 1479, 1486, 1493, 1500, 1507, 1514, 1521, 1528, 1535, 1542, 1549, 1556, 1563, 1570, 1577, 1584, 1591, 1598, 1605, 1612, 1619, 1626, 1633, 1640, 1647, 1654, 1661, 1668, 1675, 1682, 1689, 1696, 1703, 1710, 1717, 1724, 1731, 1738, 1745, 1752, 1759, 1766, 1773, 1780, 1787, 1794, 1801, 1808, 1815, 1822, 1829, 1836, 1843, 1850, 1857, 1864, 1871, 1878, 1885, 1892, 1899, 1906, 1913, 1920, 1927, 1934, 1941, 1948, 1955, 1962, 1969, 1976, 1983, 1990, 1997, 2004, 2011, 2018, 2025, 2032, 2039, 2046, 2053, 2060, 2067, 2074, 2081, 2088, 2095, 2102, 2109, 2116, 2123, 2130, 2137, 2144, 2151, 2158, 2165, 2172, 2179, 2186, 2193, 2200, 2207, 2214, 2221, 2228, 2235, 2242, 2249, 2256, 2263, 2270, 2277, 2284, 2291, 2298, 2305, 2312, 2319, 2326, 2333, 2340, 2347, 2354, 2361, 2368, 2375, 2382, 2389, 2396, 2403, 2410, 2417, 2424, 2431, 2438, 2445, 2452, 2459, 2466, 2473, 2480, 2487, 2494, 2501, 2508, 2515, 2522, 2529, 2536, 2543, 2550, 2557, 2564, 2571, 2578, 2585, 2592, 2599, 2606, 2613, 2620, 2627, 2634, 2641, 2648, 2655, 2662, 2669, 2676, 2683, 2690, 2697, 2704, 2711, 2718, 2725, 2732, 2739, 2746, 2753, 2760, 2767, 2774, 2781, 2788, 2795, 2802, 2809, 2816, 2823, 2830, 2837, 2844, 2851, 2858, 2865, 2872, 2879, 2886, 2893, 2900, 2907, 2914, 2921, 2928, 2935, 2942, 2949, 2956, 2963, 2970, 2977, 2984, 2991, 2998, 3005, 3012, 3019, 3026, 3033, 3040, 3047, 3054, 3061, 3068, 3075, 3082, 3089, 3096, 3103, 3110, 3117, 3124, 3131, 3138, 3145, 3152, 3159, 3166, 3173, 3180, 3187, 3194, 3201, 3208, 3215, 3222, 3229, 3236, 3243, 3250, 3257, 3264, 3271, 3278, 3285, 3292, 3299, 3306, 3313, 3320, 3327, 3334, 3341, 3348, 3355, 3362, 3369, 3376, 3383, 3390, 3397, 3404, 3411, 3418, 3425, 3432, 3439, 3446, 3453, 3460, 3467, 3474, 3481, 3488, 3495, 3502, 3509, 3516, 3523, 3530, 3537, 3544, 3551, 3558, 3565, 3572, 3579, 3586, 3593, 3600, 3607, 3614, 3621, 3628, 3635, 3642, 3649, 3656, 3663, 3670, 3677, 3684, 3691, 3698, 3705, 3712, 3719, 3726, 3733, 3740, 3747, 3754, 3761, 3768, 3775, 3782, 3789, 3796, 3803, 3810, 3817, 3824, 3831, 3838, 3845, 3852, 3859, 3866, 3873, 3880, 3887, 3894, 3901, 3908, 3915, 3922, 3929, 3936, 3943, 3950, 3957, 3964, 3971, 3978, 3985, 3992, 3999, 4006, 4013, 4020, 4027, 4034, 4041, 4048, 4055, 4062, 4069, 4076, 4083, 4090, 4097, 4104, 4111, 4118, 4125, 4132, 4139, 4146, 4153, 4160, 4167, 4174, 4181, 4188, 4195, 4202, 4209, 4216, 4223, 4230, 4237, 4244, 4251, 4258, 4265, 4272, 4279, 4286, 4293, 4300, 4307, 4314, 4321, 4328, 4335, 4342, 4349, 4356, 4363, 4370, 4377, 4384, 4391, 4398, 4405, 4412, 4419, 4426, 4433, 4440, 4447, 4454, 4461, 4468, 4475, 4482, 4489, 4496, 4503, 4510, 4517, 4524, 4531, 4538, 4545, 4552, 4559, 4566, 4573, 4580, 4587, 4594, 4601, 4608, 4615, 4622, 4629, 4636, 4643, 4650, 4657, 4664, 4671, 4678, 4685, 4692, 4699, 4706, 4713, 4720, 4727, 4734, 4741, 4748, 4755, 4762, 4769, 4776, 4783, 4790, 4797, 4804, 4811, 4818, 4825, 4832, 4839, 4846, 4853, 4860, 4867, 4874, 4881, 4888, 4895, 4902, 4909, 4916, 4923, 4930, 4937, 4944, 4951, 4958, 4965, 4972, 4979, 4986, 4993, 5000, 5007, 5014, 5021, 5028, 5035, 5042, 5049, 5056, 5063, 5070, 5077, 5084, 5091, 5098, 5105, 5112, 5119, 5126, 5133, 5140, 5147, 5154, 5161, 5168, 5175, 5182, 5189, 5196, 5203, 5210, 5217, 5224, 5231, 5238, 5245, 5252, 5259, 5266, 5273, 5280, 5287, 5294, 5301, 5308, 5315, 5322, 5329, 5336, 5343, 5350, 5357, 5364, 5371, 5378, 5385, 5392, 5399, 5406, 5413, 5420, 5427, 5434, 5441, 5448, 5455, 5462, 5469, 5476, 5483, 5490, 5497, 5504, 5511, 5518, 5525, 5532, 5539, 5546, 5553, 5560, 5567, 5574, 5581, 5588, 5595, 5602, 5609, 5616, 5623, 5630, 5637, 5644, 5651, 5658, 5665, 5672, 5679, 5686, 5693, 5700, 5707, 5714, 5721, 5728, 5735, 5742, 5749, 5756, 5763, 5770, 5777, 5784, 5791, 5798, 5805, 5812, 5819, 5826, 5833, 5840, 5847, 5854, 5861, 5868, 5875, 5882, 5889, 5896, 5903, 5910, 5917, 5924, 5931, 5938, 5945, 5952, 5959, 5966, 5973, 5980, 5987, 5994, 6001, 6008, 6015, 6022, 6029, 6036, 6043, 6050, 6057, 6064, 6071, 6078, 6085, 6092, 6099, 6106, 6113, 6120, 6127, 6134, 6141, 6148, 6155, 6162, 6169, 6176, 6183, 6190, 6197, 6204, 6211, 6218, 6225, 6232, 6239, 6246, 6253, 6260, 6267, 6274, 6281, 6288, 6295, 6302, 6309, 6316, 6323, 6330, 6337, 6344, 6351, 6358, 6365, 6372, 6379, 6386, 6393, 6400, 6407, 6414, 6421, 6428, 6435, 6442, 6449, 6456, 6463, 6470, 6477, 6484, 6491, 6498, 6505, 6512, 6519, 6526, 6533, 6540, 6547, 6554, 6561, 6568, 6575, 6582, 6589, 6596, 6603, 6610, 6617, 6624, 6631, 6638, 6645, 6652, 6659, 6666, 6673, 6680, 6687, 6694, 6701, 6708, 6715, 6722, 6729, 6736, 6743, 6750, 6757, 6764, 6771, 6778, 6785, 6792, 6799, 6806, 6813, 6820, 6827, 6834, 6841, 6848, 6855, 6862, 6869, 6876, 6883, 6890, 6897, 6904, 6911, 6918, 6925, 6932, 6939, 6946, 6953, 6960, 6967, 6974, 6981, 6988, 6995, 7002, 7009, 7016, 7023, 7030, 7037, 7044, 7051, 7058, 7065, 7072, 7079, 7086, 7093, 7100, 7107, 7114, 7121, 7128, 7135, 7142, 7149, 7156, 7163, 7170, 7177, 7184, 7191, 7198, 7205, 7212, 7219, 7226, 7233, 7240, 7247, 7254, 7261, 7268, 7275, 7282, 7289, 7296, 7303, 7310, 7317, 7324, 7331, 7338, 7345, 7352, 7359, 7366, 7373, 7380, 7387, 7394, 7401, 7408, 7415, 7422, 7429, 7436, 7443, 7450, 7457, 7464, 7471, 7478, 7485, 7492, 7499, 7506, 7513, 7520, 7527, 7534, 7541, 7548, 7555, 7562, 7569, 7576, 7583, 7590, 7597, 7604, 7611, 7618, 7625, 7632, 7639, 7646, 7653, 7660, 7667, 7674, 7681, 7688, 7695, 7702, 7709, 7716, 7723, 7730, 7737, 7744, 7751, 7758, 7765, 7772, 7779, 7786, 7793, 7800, 7807, 7814, 7821, 7828, 7835, 7842, 7849, 7856, 7863, 7870, 7877, 7884, 7891, 7898, 7905, 7912, 7919, 7926, 7933, 7940, 7947, 7954, 7961, 7968, 7975, 7982, 7989, 7996, 8003, 8010, 8017, 8024, 8031, 8038, 8045, 8052, 8059, 8066, 8073, 8080, 8087, 8094, 8101, 8108, 8115, 8122, 8129, 8136, 8143, 8150, 8157, 8164, 8171, 8178, 8185, 8192, 8199, 8206, 8213, 8220, 8227, 8234, 8241, 8248, 8255, 8262, 8269, 8276, 8283, 8290, 8297, 8304, 8311, 8318, 8325, 8332, 8339, 8346, 8353, 8360, 8367, 8374, 8381, 8388, 8395, 8402, 8409, 8416, 8423, 8430, 8437, 8444, 8451, 8458, 8465, 8472, 8479, 8486, 8493, 8500, 8507, 8514, 8521, 8528, 8535, 8542, 8549, 8556, 8563, 8570, 8577, 8584, 8591, 8598, 8605, 8612, 8619, 8626, 8633, 8640, 8647, 8654, 8661, 8668, 8675, 8682, 8689, 8696, 8703, 8710, 8717, 8724, 8731, 8738, 8745, 8752, 8759, 8766, 8773, 8780, 8787, 8794, 8801, 8808, 8815, 8822, 8829, 8836, 8843, 8850, 8857, 8864, 8871, 8878, 8885, 8892, 8899, 8906, 8913, 8920, 8927, 8934, 8941, 8948, 8955, 8962, 8969, 8976, 8983, 8990, 8997, 9004, 9011, 9018, 9025, 9032, 9039, 9046, 9053, 9060, 9067, 9074, 9081, 9088, 9095, 9102, 9109, 9116, 9123, 9130, 9137, 9144, 9151, 9158, 9165, 9172, 9179, 9186, 9193, 9200, 9207, 9214, 9221, 9228, 9235, 9242, 9249, 9256, 9263, 9270, 9277, 9284, 9291, 9298, 9305, 9312, 9319, 9326, 9333, 9340, 9347, 9354, 9361, 9368, 9375, 9382, 9389, 9396, 9403, 9410, 9417, 9424, 9431, 9438, 9445, 9452, 9459, 9466, 9473, 9480, 9487, 9494, 9501, 9508, 9515, 9522, 9529, 9536, 9543, 9550, 9557, 9564, 9571, 9578, 9585, 9592, 9599, 9606, 9613, 9620, 9627, 9634, 9641, 9648, 9655, 9662, 9669, 9676, 9683, 9690, 9697, 9704, 9711, 9718, 9725, 9732, 9739, 9746, 9753, 9760, 9767, 9774, 9781, 9788, 9795, 9802, 9809, 9816, 9823, 9830, 9837, 9844, 9851, 9858, 9865, 9872, 9879, 9886, 9893, 9900, 9907, 9914, 9921, 9928, 9935, 9942, 9949, 9956, 9963, 9970, 9977, 9984, 9991, 9998, 10005, 10012, 10019, 10026, 10033, 10040, 10047, 10054, 10061, 10068, 10075, 10082, 10089, 10096, 10103, 10110, 10117, 10124, 10131, 10138, 10145, 10152, 10159, 10166, 10173, 10180, 10187, 10194, 10201, 10208, 10215, 10222, 10229, 10236, 10243, 10250, 10257, 10264, 10271, 10278, 10285, 10292, 10299, 10306, 10313, 10320, 10327, 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11335, 11342, 11349, 11356, 11363, 11370, 11377, 11384, 11391, 11398, 11405, 11412, 11419, 11426, 11433, 11440, 11447, 11454, 11461, 11468, 11475, 11482, 11489, 11496, 11503, 11510, 11517, 11524, 11531, 11538, 11545, 11552, 11559, 11566, 11573, 11580, 11587, 11594, 11601, 11608, 11615, 11622, 11629, 11636, 11643, 11650, 11657, 11664, 11671, 11678, 11685, 11692, 11699, 11706, 11713, 11720, 11727, 11734, 11741, 11748, 11755, 11762, 11769, 11776, 11783, 11790, 11797, 11804, 11811, 11818, 11825, 11832, 11839, 11846, 11853, 11860, 11867, 11874, 11881, 11888, 11895, 11902, 11909, 11916, 11923, 11930, 11937, 11944, 11951, 11958, 11965, 11972, 11979, 11986, 11993, 12000, 12007, 12014, 12021, 12028, 12035, 12042, 12049, 12056, 12063, 12070, 12077, 12084, 12091, 12098, 12105, 12112, 12119, 12126, 12133, 12140, 12147, 12154, 12161, 12168, 12175, 12182, 12189, 12196, 12203, 12210, 12217, 12224, 12231, 12238, 12245, 12252, 12259, 12266, 12273, 12280, 12287, 12294, 12301, 12308, 12315, 12322, 12329, 12336, 12343, 12350, 12357, 12364, 12371, 12378, 12385, 12392, 12399, 12406, 12413, 12420, 12427, 12434, 12441, 12448, 12455, 12462, 12469, 12476, 12483, 12490, 12497, 12504, 12511, 12518, 12525, 12532, 12539, 12546, 12553, 12560, 12567, 12574, 12581, 12588, 12595, 12602, 12609, 12616, 12623, 12630, 12637, 12644, 12651, 12658, 12665, 12672, 12679, 12686, 12693, 12700, 12707, 12714, 12721, 12728, 12735, 12742, 12749, 12756, 12763, 12770, 12777, 12784, 12791, 12798, 12805, 12812, 12819, 12826, 12833, 12840, 12847, 12854, 12861, 12868, 12875, 12882, 12889, 12896, 12903, 12910, 12917, 12924, 12931, 12938, 12945, 12952, 12959, 12966, 12973, 12980, 12987, 12994, 13001, 13008, 13015, 13022, 13029, 13036, 13043, 13050, 13057, 13064, 13071, 13078, 13085, 13092, 13099, 13106, 13113, 13120, 13127, 13134, 13141, 13148, 13155, 13162, 13169, 13176, 13183, 13190, 13197, 13204, 13211, 13218, 13225, 13232, 13239, 13246, 13253, 13260, 13267, 13274, 13281, 13288, 13295, 13302, 13309, 13316, 13323, 13330, 13337, 13344, 13351, 13358, 13365, 13372, 13379, 13386, 13393, 13400, 13407, 13414, 13421, 13428, 13435, 13442, 13449, 13456, 13463, 13470, 13477, 13484, 13491, 13498, 13505, 13512, 13519, 13526, 13533, 13540, 13547, 13554, 13561, 13568, 13575, 13582, 13589, 13596, 13603, 13610, 13617, 13624, 13631, 13638, 13645, 13652, 13659, 13666, 13673, 13680, 13687, 13694, 13701, 13708, 13715, 13722, 13729, 13736, 13743, 13750, 13757, 13764, 13771, 13778, 13785, 13792, 13799, 13806, 13813, 13820, 13827, 13834, 13841, 13848,
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APPENDIX I—CONTINUED.
RECORD OF SINKING CAISSONS.
PIER V.

Date.	Distances in Feet from Base of Water to Level.					Sound in ft. Sec.	Total in feet.	Estimates of Sinking Horizontal Distances, Feet.					Average Perforation of Caisson.	Water Gauge.	Depth in feet.	Weights.						Air Pressure.		Reduction due to Air Pressure.	Net Weight.	Surface in Square feet.	Av. Wt. per Sq. Ft. of Soil Exposed to Pressure.	REMARKS.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
	N. E.	N. W.	S. E.	S. W.	Average.			N. E.	N. W.	S. E.	S. W.	Average.				Caisson.	Gravel.	Masonry.	Soil.	Water.	Total.	Indicated.	Calculated.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
June 7	Feet.	Feet.	226.05	225.97	225.98	225.96	225.99	Feet.	201.40

APPENDIX L—CONTINUED.
RECORD OF SINKING CAISSONS
PIER VI.

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APPENDIX I—CONTINUED.
RECORD OF SINKING CAISSONS.
PIER VII.

Date.	Elevations of Various Points above Mean Sea Level.					Read in ft. in.	Total height in ft.	Elevations of Base Horizontal Distances, 200 ft.					Average Pressure lb. per sq. in.	Water Gauge.	Depth in feet.	Weights						Air Pressure.		Reaction due to Air Pressure.	Net Weight.	Surface in Contact.	Air, cu. ft. per sq. ft. of Base Exposed to Friction.	REMARKS.		
	N. E.	N. W.	S. W.	S. E.	Average.			N. E.	N. W.	S. W.	S. E.	Average.				Caisson.	4th.	Masonry.	Steel.	Wood.	Total.	Inferred.	Calculated.							
July 23	.....	.....	.....	.....	289.39	Feet.	Feet.	288.56	289.50	289.33	289.06	289.69	.....	289.32	12.14	894	361	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Caisson towed to place at 5 p. m., July 24th. Commenced concreting at 7 a. m. Caisson grounded at 5 p. m.
24	.....	.....	.....	.....	275.27	.....	.....	288.56	289.7	289.9	288.6	289.40	.....	290.13	15.91	485	541	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
25	288.81	289.10	289.72	289.74	289.59	1.07	1.02	287.5	289.3	288.9	289.5	289.40	0.81	288.77	31.19	884	150	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
26	288.78	287.90	287.50	287.15	287.73	0.97	1.04	288.2	288.2	288.2	288.7	288.32	1.41	288.66	30.94	887	407	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Aug. 1	287.54	286.89	287.93	288.10	287.74	0.92	1.96	287.7	288.7	288.7	288.5	288.43	0.78	287.73	30.60	887	749	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2	287.54	286.89	287.93	288.10	287.74	0	1.96	288.2	288.7	288.1	288.3	288.80	1.10	287.59	29.32	887	749	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	.....	.....	.....	.....	287.62	0.68	2.94	.....	.....	.....	.....	288.98	1.36	288.98	29.36	887	750	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	287.48	286.73	287.75	287.62	287.54	0.68	3.19	.....	.....	.....	.....	288.17	1.03	288.73	29.19	887	778	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
5	287.48	286.73	287.75	287.62	287.48	0.68	3.20	288.0	288.7	288.7	279.8	288.25	1.88	288.24	28.74	887	988	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
6	287.60	286.87	287.53	287.88	287.62	0.60	3.41	288.1	287.3	288.6	288.1	288.35	0.78	287.63	28.18	887	1139	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	287.20	286.86	287.52	287.48	287.17	0.78	3.49	287.9	288.4	288.5	288.8	288.15	0.88	286.84	27.68	887	1284	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	286.77	286.85	286.97	286.58	286.47	0.80	3.49	287.2	288.8	288.9	288.3	288.35	1.88	284.22	27.83	887	1400	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	286.77	286.22	286.10	286.87	286.73	1.40	4.91	286.5	288.3	288.9	279.5	288.37	3.32	282.44	26.73	887	1489	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	286.68	286.20	286.08	286.59	286.79	0.87	8.88	271.7	288.4	288.8	274.8	271.17	19.39	282.74	21.98	887	1911	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	286.30	285.42	284.53	284.70	285.23	3.59	14.47	273.7	288.6	286.6	275.5	273.35	17.18	281.34	27.15	887	2657	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
12	285.94	285.28	285.63	285.90	285.74	0	15.93	277.8	278.6	278.9	277.8	278.48	24.36	280.70	27.94	887	2799	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
13	.....	.....	.....	.....	285.74	0	18.90	.....	.....	.....	.....	278.48	24.78	280.33	27.38	887	2975	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14	.....	.....	.....	.....	285.74	0	18.90	.....	.....	.....	.....	278.48	24.85	280.14	24.40	887	2988	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
15	285.33	285.25	285.43	285.60	285.74	0	19.30	277.5	278.5	271.4	278.8	275.45	25.38	280.51	23.21	887	3480	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
16	285.98	285.68	285.45	285.69	285.80	0.08	19.44	277.4	271.3	271.1	278.8	274.49	24.80	280.50	23.55	887	3604	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
17	285.98	285.65	285.45	285.80	285.55	0.18	19.11	.....	.....	.....	.....	274.25	24.88	280.45	24.59	887	3137	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
18	.....	.....	.....	.....	285.74	0	19.30	.....	.....	.....	.....	274.25	24.99	280.39	24.25	887	3016	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
19	.....	.....	.....	.....	285.74	0	19.30	.....	.....	.....	.....	274.97	25.18	280.45	23.91	887	3216	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
20	285.10	285.25	285.45	285.60	285.74	0	19.30	277.5	278.5	271.4	278.8	275.45	25.38	280.51	23.21	887	3480	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
21	285.98	285.68	285.45	285.69	285.80	0.08	19.44	277.4	271.3	271.1	278.8	274.49	24.80	280.50	23.55	887	3604	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
22	285.98	285.65	285.45	285.80	285.55	0.18	19.11	.....	.....	.....	.....	274.25	24.88	280.45	24.59	887	3137	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
23	.....	.....	.....	.....	285.55	0	20.11	.....	.....	.....	.....	272.90	24.35	280.15	27.68	887	3137	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
24	285.29	285.78	285.69	285.78	285.38	.....	20.36	271.4	288.4	276.3	275.9	271.35	21.99	280.46	41.39	887	3139	3425	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
25	285.94	285.28	285.63	285.90	285.74	0	20.39	.....	.....	.....	.....	273.30	24.94	280.58	42.68	887	3139	1660	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
26	286.01	285.50	285.61	285.73	285.80	1.38	20.86	288.8	288.9	288.9	272.3	289.35	25.45	280.73	47.95	887	3139	1660	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Sept. 1	286.60	284.80	284.50	285.35	285.17	16.63	24.49	287.8	286.7	288.9	279.2	288.47	33.28	280.46	38.68	887	3139	1660	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2	281.11	280.36	280.82	280.27	280.63	4.85	25.84	287.4	286.7	288.8	279.9	288.49	27.58	280.36	62.54	887	3139	1660	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
12	281.11	280.36	280.82	280.27	280.63	0	25.84	288.2	288.3	272.3	288.5	289.90	28.99	280.81	38.68	887	3160	1434	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
15	280.68	279.44	281.03	281.44	280.59	0.22	26.18	288.2	288.2	271.9	271.5	280.36	28.83	284.28	53.81	887	3162	2589	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
16	280.34	280.63	280.59	280.47	280.51	7.48	40.26	284.5	284.7	287.9	288.8	285.97	45.87	282.39	60.18	887	3162	2589	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oct. 1	278.33	275.64	276.97	277.47	278.71	6.59	52.95	261.6	267.0	268.5	259.1	268.45	21.54	282.48	65.68	887	3282	2189	29	279										

APPENDIX I.—CONTINUED.
RECORD OF SINKING CAISSONS.
PIER VIII.

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APPENDIX I.—CONTINUED.
RECORD OF SINKING CAISSONS.
PIER IX.

[illegible]

APPENDIX I.—CONTINUED.
RECORD OF SINKING CAISSONS
PIER X.

[illegible]

APPENDIX I—CONTINUED.
RECORD OF SINKING CAISSONS.
PIER XL.

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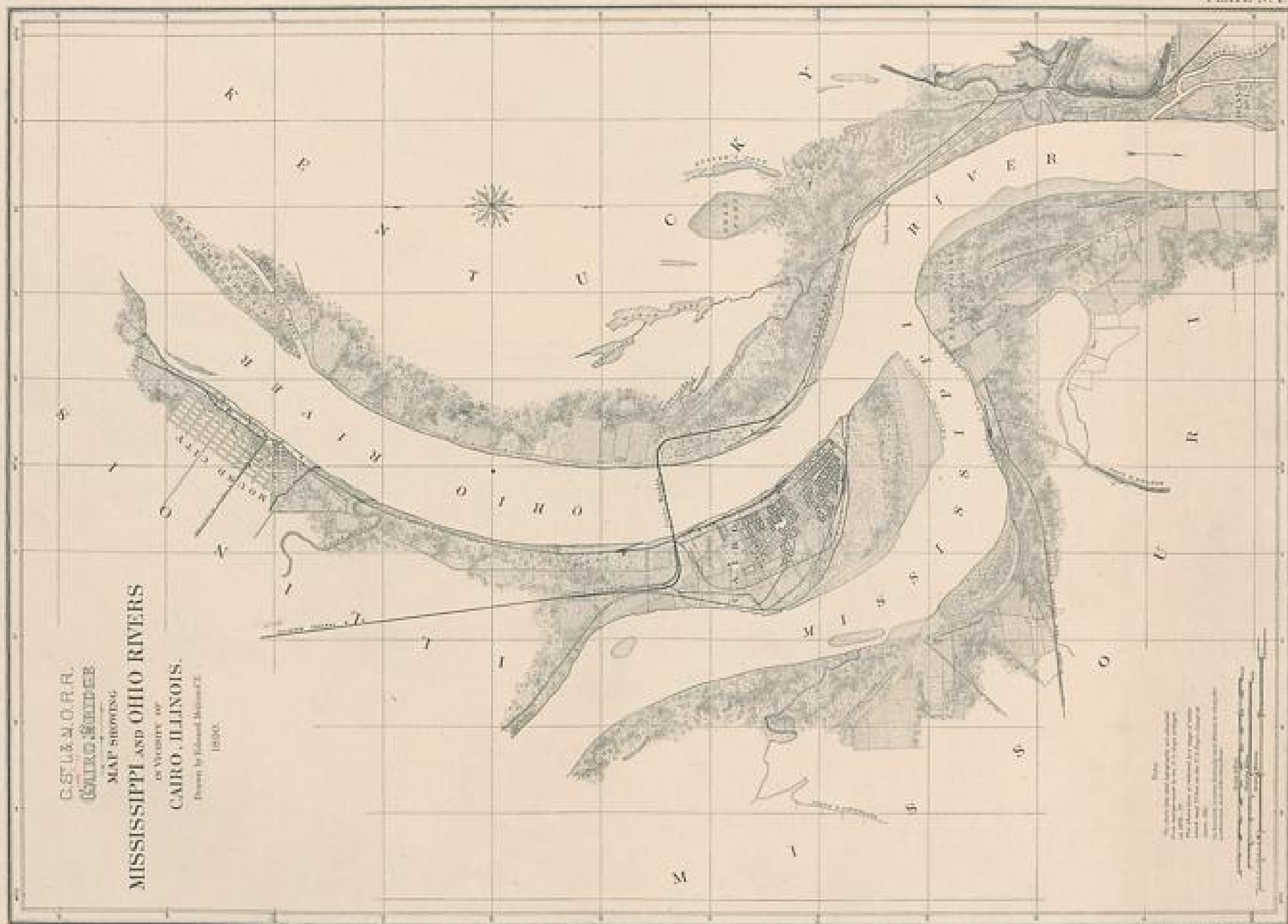
Original elevation of ground under caisson, 265.06. Cutting edge supported on logs above original surface of ground until Aug. 1905. Total drainage shows depth from first position of cutting edge

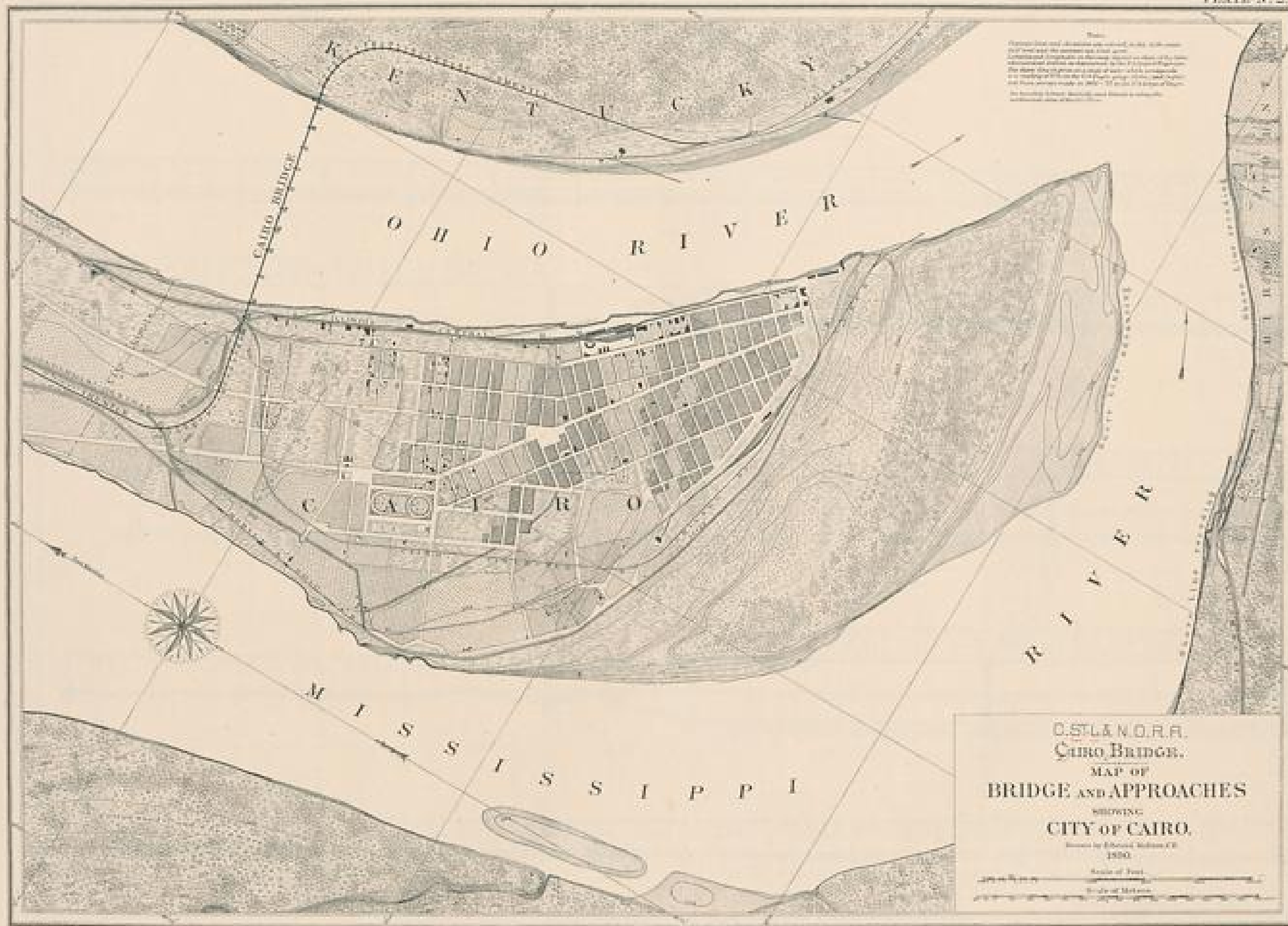
APPENDIX K. TESTS OF STEEL EYE-BARS.

TESTS OF FULL-SIZED EYE-BARS.														TESTS OF SAMPLE BARS FROM SAME HEATS.										REMARKS.	
Dimensions, Inches.								Results of Mechanical Tests.						Dimensions.											
Original.				After Test.				Reduction of Area, per cent.	Elongation.		Elastic Limit, lbs. per sq. inch.	Maximum Load, lbs. per sq. inch.	Place of Fracture.	Thickness.		Reduction, Per Cent.	Elongation, Per Cent.	Elastic Limit, lbs. per sq. inch.	Maximum Load, lbs. per sq. inch.	Per Cent. of Phosphorus.	Heat Number.				
Width.	Thickness.	Length, C. to C.	Gauged Length.	Width.	Thickness.	Width.	Thickness.		Inches.	Per Cent.				Inches.	After Testing, inches.										
For 3-318'-0" Bars																									
8	1 1/2	301.90	314	7.96	1.86	4.39	1.46	41.7	48.1	12.3	38000	81410	Body.	732	523	49.34	39.12	40130	80800	0.041	1435	Breaks in grip marks. Rest of above.			
8	1 1/2	300.40	312	7.97	1.87	5.39	1.96	46.3	54.8	18.1	31470	30510	"	.....	.....	.....	.....	.....	.....	.....	Not found.
8	1 1/2	300.30	312	7.98	1.87	6.01	1.96	49.8	54.8	18.1	30000	80000	"	.....	.....	.....	.....	.....	.....	.....	Not found.
8	1 1/2	301.45	312	7.96	1.89	7.61	1.93	8.9	34.8	7.4	31710	30000	"	749	564	54.60	34.71	45330	80000	0.048	1397				
8	1 1/2	309.90	312	7.96	1.89	7.61	1.93	42.8	35.8	9.9	30600	80000	"	749	564	54.60	34.71	45330	80000	0.048	1397				
6	1 1/4	301.90	312	6.92	1.84	4.64	0.82	49.4	55.3	15.9	37160	80000	"	747	559	51.20	37.60	47790	80000	0.057	1370				
6	1 1/4	305.90	312	7.95	1.82	6.21	0.81	44.3	38.2	10.9	35000	30070	"	740	552	52.11	39.00	45400	87790	0.050	1379				
6	1 1/4	306.20	312	6.90	0.89	4.73	0.78	39.2	39.2	14.4	40550	66040	"	734	569	52.43	37.54	43100	71930	0.060	1396				
6	1 1/4	311.70	312	4.92	1.00	.....	.....	.....	.....	.....	35226	30000	Thread of screw.	743	564	51.00	37.51	42020	80720	0.060	1405
6	1 1/4	306.28	312	6.95	1.79	4.36	1.15	49.4	32.9	18.1	30710	80000	Body.	.....	.....	.....	.....	.....	.....	.....	Not found.
6	1 1/4	321.70	312	6.95	1.69	4.44	1.15	49.3	31.2	14.3	30000	80000	"	.....	.....	.....	.....	.....	.....	.....	Not found.
For 1-318'-0" Bars																									
8	1 1/2	320.10	312	7.99	1.74	6.70	1.42	32.1	30.7	10.4	37307	30000	Body.	745	569	55.31	39.62	47700	80500	0.060	1404				
8	1 1/2	320.10	312	6.92	0.88	4.58	0.85	43.7	39.2	10.4	37307	30000	"	742	569	55.31	39.62	47700	80500	0.060	1404				
8	1 1/2	320.10	312	7.92	2.12	6.81	2.56	6.6	18.8	6.3	30000	30000	"	732	565	54.70	39.79	41190	80240	0.061	1397				
8	1 1/2	418.90	408	6.92	1.25	5.70	0.85	49.8	62.7	15.3	30000	30121	"	742	569	55.31	39.62	47700	80500	0.060	1404				
8	1 1/2	417.40	412	4.81	0.74	0.97	0.51	47.1	39.7	19.4	34000	60430	"	742	569	55.31	39.62	47700	80500	0.060	1404				
8	1 1/2	349.10	312	7.99	1.83	6.36	1.82	5.6	7.7	2.3	37000	41250	"	.....	.....	56.21	39.37	43140	70070	.....	1400	
8	1 1/2	349.10	312	7.92	1.89	5.97	1.99	43.1	42.4	10.4	30000	41000	"	.....	.....	56.75	39.37	47140	70070	.....	1400	
8	1 1/2	350.10	312	7.99	2.11	5.32	1.47	45.0	40.7	14.1	30000	60000	"	740	568	56.53	39.00	43070	80000	0.055	1401				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	36.4	11.0	30000	67000	"	733	567	49.14	37.54	43000	72070	0.055	1410				
8	1 1/2	350.10	312	7.99	1.74	5.43	1.23	45.1	3																

APPENDIX K—CONTINUED. TESTS OF STEEL EYE-BARS.

TESTS OF FULL-SIZED EYE-BARS.														TESTS ON SAMPLE BARS FROM SAME MELTS.										REMARKS.	
Dimensions, Inches.								Extent of Mechanical Tests.						Tests on Sample Bars from Same Melts.											
Nominal.		Original.				After Test.		Reduction of Area, per cent.	Elongation.		Elastic Limit, lbs. per sq. inch.	Maximum Load, lbs. per sq. inch.	Place of Fracture.	Dimensions.		Reduction, Per Cent.	Elongation, Per Cent.	Elastic Limit, lbs. per sq. inch.	Maximum Load, lbs. per sq. inch.	Per Cent. of Phosphorus.	Heat Number.				
Width.	Thickness.	Length, C. to C.	Griped Length.	Width.	Thickness.	Width.	Thickness.		Inches.	Per Cent.				Original, inches.	After Testing, inches.										
For 28-150" Bars.																									
5	11	300.02	276	5.00	1.37	5.00	0.98	47.3	32.4	12.1	34550	38550	Body.	1.912	1.574	49.1	25.6	60000	65000	.065	3012	Broke in grip marks.			
5	11	300.02	276	5.02	1.35	5.07	0.97	48.9	36.6	10.3	35000	37100	"	1.912	1.600	50.9	21.2	57000	62000	.060	3001				
5	11	300.03	276	5.00	1.36	5.23	0.95	47.5	36.7	10.3	40000	44800	"	1.904	1.578	51.7	27.5	58000	67500	.064	3047				
5	11	424.41	396	5.00	1.37	5.30	0.99	50.6	58.6	14.1	37800	50000	"	1.900	1.672	51.2	28.1	58000	67100	.055	3008				
5	11	424.42	396	5.01	1.37	4.11	1.07	55.9	60.9	15.4	38550	61100	"	1.942	1.608	55.9	26.8	58000	66500	.064	3045				
6	11	424.36	396	6.05	1.60	5.88	1.50	6.4	32.4	5.9	38750	56400	"	1.904	1.598	48.8	27.5	58000	67000	.064	3078	Broke in grip marks.			
6	11	424.36	396	6.02	1.61	4.60	1.14	65.6	61.6	15.5	40000	45000	"	1.918	1.595	44.8	27.5	60000	66000	.059	3078				
6	11	424.42	396	4.02	1.11	5.05	1.70	40.8	44.4	11.2	37500	46000	"	1.904	1.515	48.3	26.2	58000	66400	.061	3001				
6	11	424.42	396	6.00	1.60	4.91	1.25	39.9	58.1	18.2	37700	56400	"	1.924	1.526	48.9	27.5	58000	67000	.064	3078				
6	11	390.00	376	5.01	1.37	5.30	1.04	39.8	45.5	15.8	38400	49100	"	1.955	1.545	47.4	25.0	59500	66600	.061	3008				
5	11	390.01	376	5.00	1.37	4.80	1.34	4.4	18.0	4.7	38750	51500	"	1.948	1.565	45.9	25.0	59100	66100	.066	3044	Broke in grip marks. Retest of above. Broke in grip marks.			
5	11	375.11	360	4.97	1.35	5.75	0.92	66.4	12.6	5.0	42000	47000	"	1.948	1.565	45.9	25.0	59100	66100	.066	3044				
5	11	390.00	376	5.00	1.36	4.95	1.32	1.8	4.5	2.4	38000	48000	"	1.911	1.565	52.9	24.5	58000	65900	.061	3078				
5	11	390.00	376	5.00	1.34	5.08	.96	49.0	51.9	11.6	38500	49600	"	1.907	1.555	51.4	28.7	59500	67400	.058	1005				
5	11	375.03	360	4.93	1.35	5.60	.94	45.0	29.9	11.1	40010	41000	"	1.976	1.595	51.0	24.0	59000	66000	.051	978				
4	11	424.21	396	4.01	1.11	2.84	6.75	20.6	48.2	18.9	38000	46000	"	1.904	1.515	54.2	27.5	49000	60000	.054	1000	Broke in grip marks. Retest of above. Broke in grip marks.			
4	11	424.21	396	6.04	1.61	4.85	1.19	43.4	57.2	14.4	44000	56110	"	1.900	1.505	51.0	28.1	58000	65000	.058	1411				
4	11	424.21	396	6.02	1.61	...	...	...	...	...	...	...	Head.	1.900	1.505	48.3	25.0	49000	64400	.060	1120
4	11	424.41	396	5.01	1.37	5.68	6.62	50.9	54.2	13.7	31100	37000	Body.	1.916	1.574	55.1	28.7	39700	62000	.062	300				
4	11	424.21	396	5.00	1.36	4.18	1.09	33.4	47.7	14.1	34000	44400	"	1.900	1.565	51.4	25.4	42100	67000	.065	300				
3	11	390.00	376	5.00	1.37	5.67	6.66	45.0	58.0	12.0	35000	50500	"	1.900	1.567	62.8	25.0	41200	66700	1402	Broke in grip marks. Retest of above. Broke in grip marks.			
3	11	390.01	376	5.00	1.36	5.70	6.60	51.7	58.1	13.8	35000	49000	"	1.911	1.565	58.8	27.5	39700	65000	.058	302				
3	11	390.01	376	4.93	1.37	5.80	6.68	44.9	62.6	13.6	34500	49700	"	1.908	1.564	56.9	29.6	49000	67800	.062	1476				
3	11	390.00	376	4.93	1.37	5.72	6.67	46.1	46.1	14.5	36500	61100	"	1.908	1.564	56.9	29.6	49000	67800	.062	1476				
3	11	390.01	376	5.00	1.37	5.76	6.67	46.7	44.9	14.6	32700	58500	"	1.900	1.565	55.7	28.7	41100	64400	.052	303				
5	11	390.00	376	5.01	1.37	5.81	1.01	41.9	62.5	11.8	34750	49000	"	1.916	1.555	54.7	28.1	46100	65500	.060	3027	Broke in grip marks. Retest of above. Broke in grip marks.			
5	11	390.00	376	5.02	1.36	5.72	6.60	50.1	48.9	12.7	35000	56000	"	1.942	1.608	55.8	28.8	58000	66110	.064	3045				
5	11	390.00	376	5.01	1.36	5.68	6.61	50.4	50.7	13.1	31100	56000	"	1.954	1.608	52.1	25.0	58000	66000	.068	3048				
5	11	390.00	376	5.02	1.37	5.66	6.60	50.6	45.5	16.5	36000	56000	"	1.900	1.565	55.4	31.2	58000	64000	.060	3004				
5	11	390.00	376	5.02	1.36	5.75	6.65	47.8	61.5	15.9	34000	61000	"	1.935	1.608	52.0	26.8	58000	66000	.064	3050				
5	11	390.00	376	5.00	1.36	5.70	6.67	46.8	47.9	15.4	35700	60000	"	1.905	1.608	51.8	25.0	40010	66700	.060	3041	Broke in grip marks. Retest of above. Broke in grip marks.			
5	11	390.00	376	5.00	1.36	5.70	6.67	46.8	50.9	1.1	35000	56500	Head.	1.900	1.608	51.0	26.8	58000	66000	.064	3050				
5	11	390.02	376	5.00	1.36	5.69	6.60	49.8	48.5	17.4	35000	62000	Body.	1.904	1.578	51.7	27.5	58000	65000	.064	3042				
5	11	390.01	376	5.00	1.37	5.74	6.64	48.4	57.1	13.5	34500	59500	"	1.911	1.565	50.8	27.5	59700	65000	.050	300				
5	11	390.01	376	5.00	1.36	5.71	6.61	51.4	58.4	14.9	32200	55000	"	1.914	1.565	50.8	26.8	41200	64700	.062	301				
5	11	390.01	376	5.00	1.37	5.70	6.60	49.8	58.5	13.9	35450	58000	"	1.910	1.562	51.8	28.7	41500	66700	.060	305	Broke in grip marks. Retest of above. Broke in grip marks.			
5	11	390.01	376	4.97	1.35	5.70	6.60	49.8	6.7	5.7	35510	58400	Head.	1.904	1.561	48.4	25.5	41700	66000	.058	1000				
5	11	375.02	360	4.93	1.35	5.70	6.60	49.9	55.3	11.1	35500	60400	Body.	1.904	1.561	49.4	25.5	41700	66000	.058	1000				
5	11	390.00	376	5.00	1.36	5.69	1.60	48.9	55.7	12.9	37000	60000	"	1.926	1.574	54.1	27.5	37000	66000	.050	304				
For 1-100"-2" Bars.																									
4	11	255.18	228	6.04	1.36	3.0	1.0	31700	39000	Head.	1.904	1.435	45.9	26.8	38400	60000	.054	3000	Broke in grip marks. Retest of above. Broke in grip marks.			
4	11	210.25	180	5.98	1.35	4.33	0.97	65.2	21.3	11.8	38000	64100	Body.	1.904	1.445	45.9	26.8	38400	60700	.054	3000				
4	11	305.28	252	4.01	0.76	7.94	6.69	52.8	58.15	13.5	35100	56100	"	42000	61100	.062	4000				



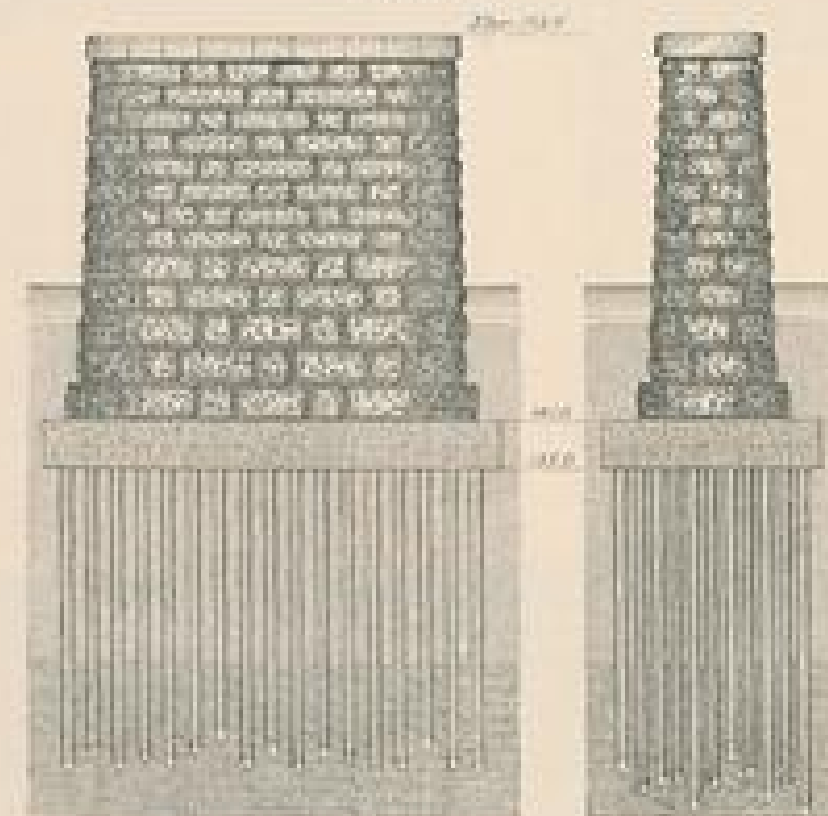


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PIERS LXII AND XIII.



PIER I.



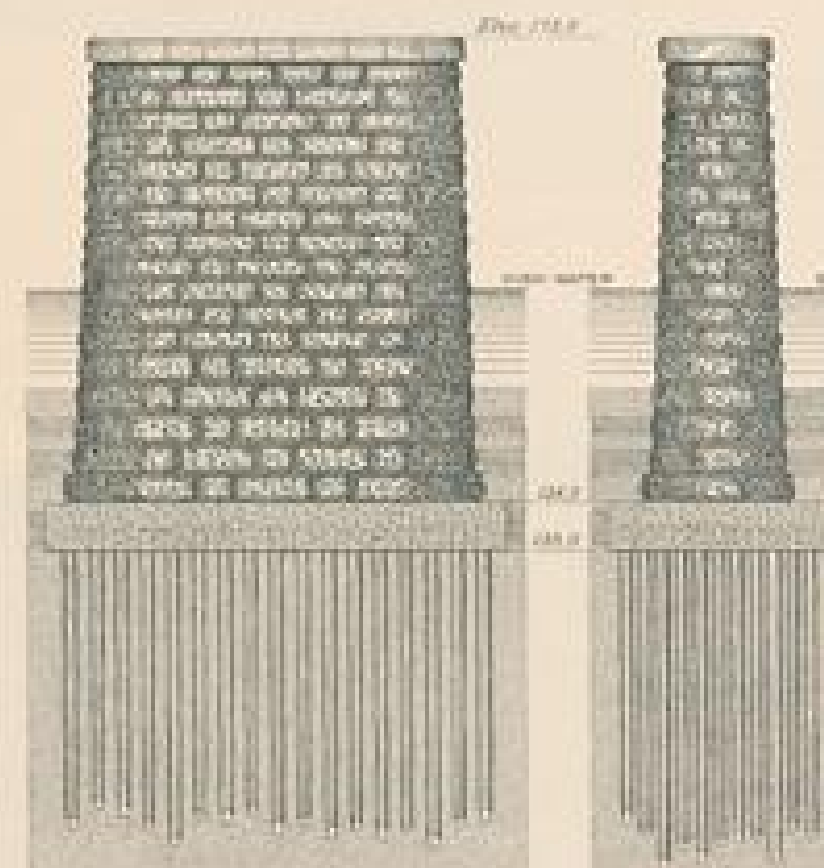
SIDE ELEVATION.

END ELEVATION.



PLAN.

PIER XIII.



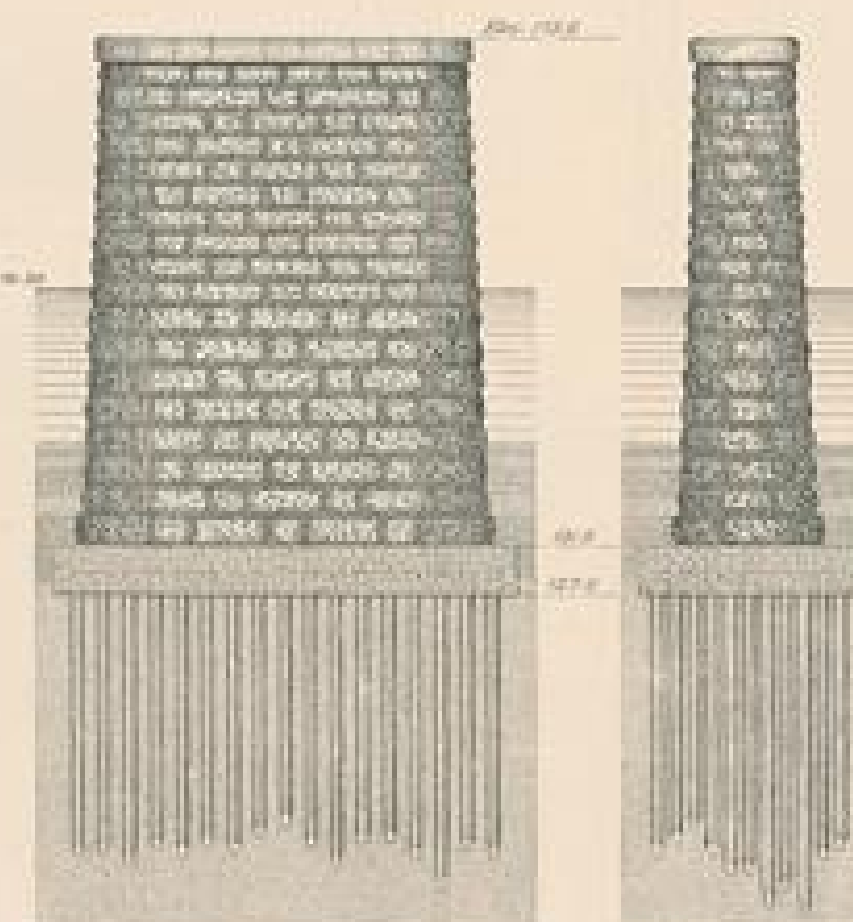
SIDE ELEVATION.

END ELEVATION.



PLAN.

PIER XII.



SIDE ELEVATION.

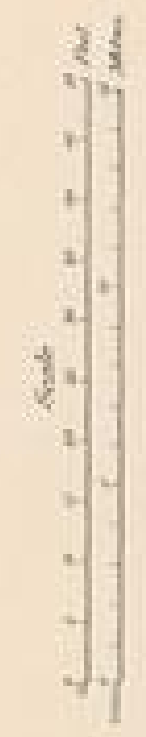
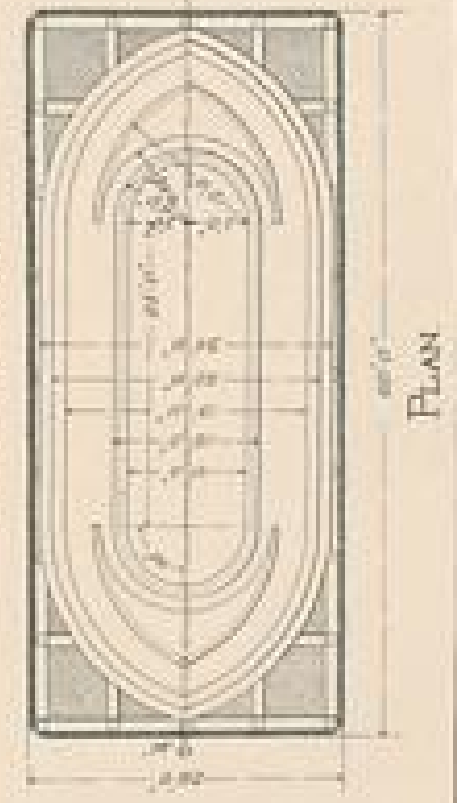
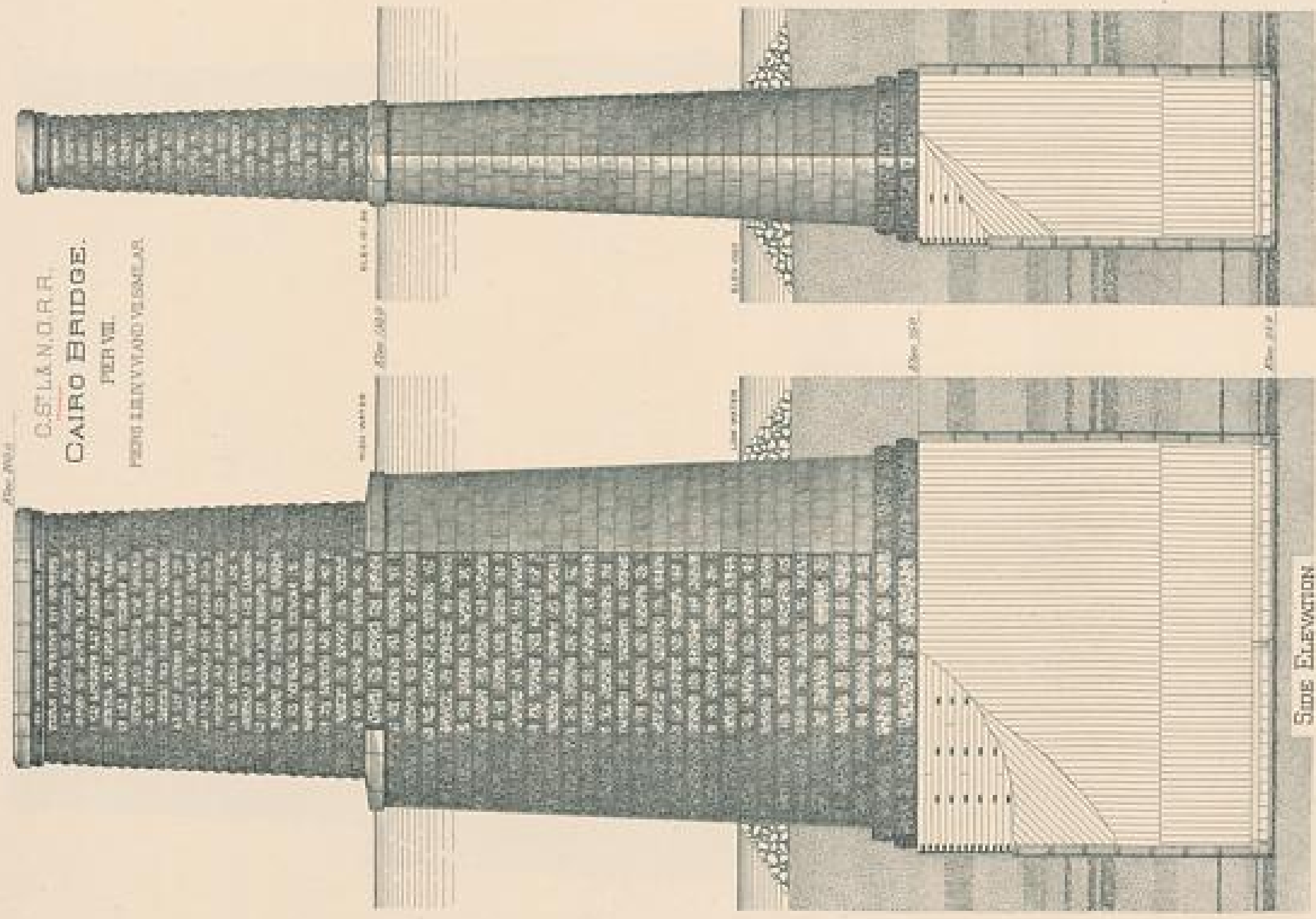
END ELEVATION.



PLAN.

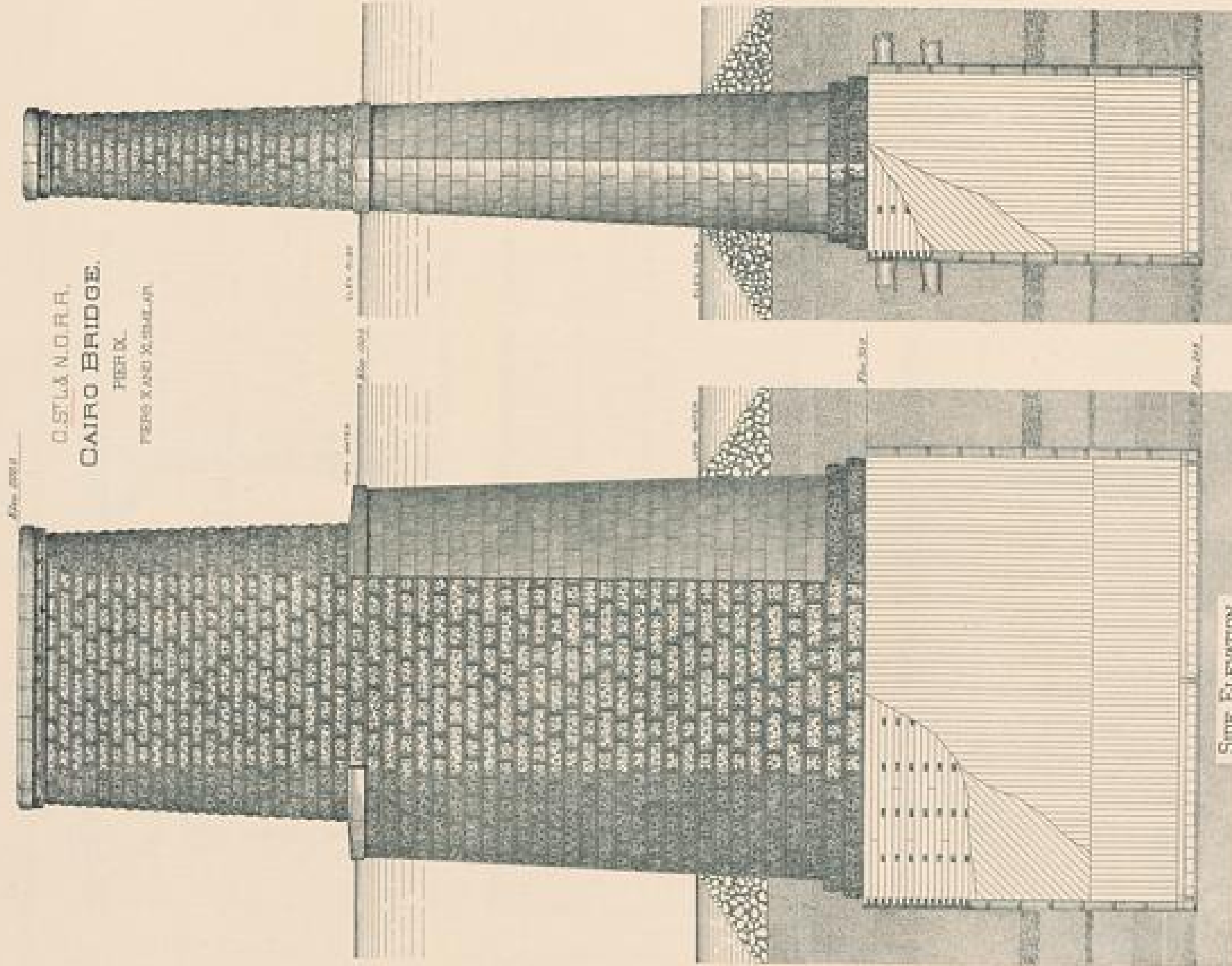
Section is 100 feet below Low Water
+ 100.00 + above mean tide at Bridge, Cairo

OSTLAND R.R.
CAIRO BRIDGE.
PIER VII.
FROM RIVER FRONT VIEW.

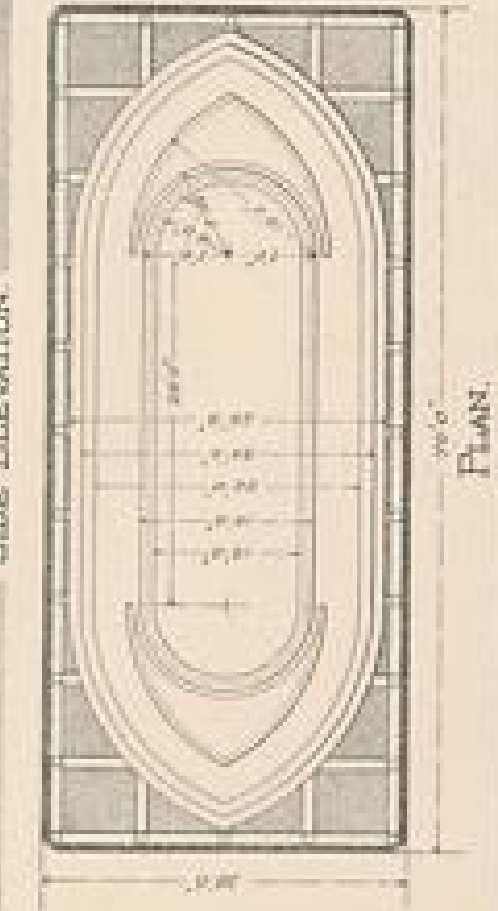


Section is 100 feet below Low Water
-100.00' - when mean tide at Cairo, Mo.

OSTIA N.O.R.R.
CAIRO BRIDGE.
PIER IX.
PIERS X AND XI, ELEVATION.



Side Elevation

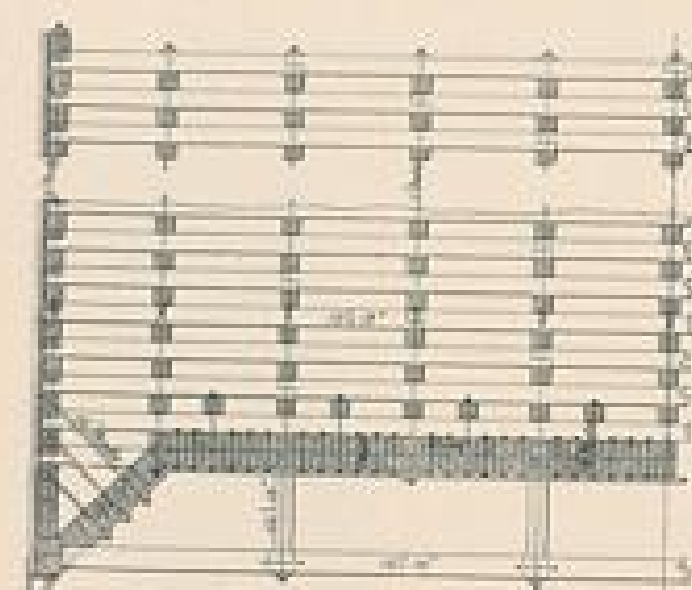


End Elevation

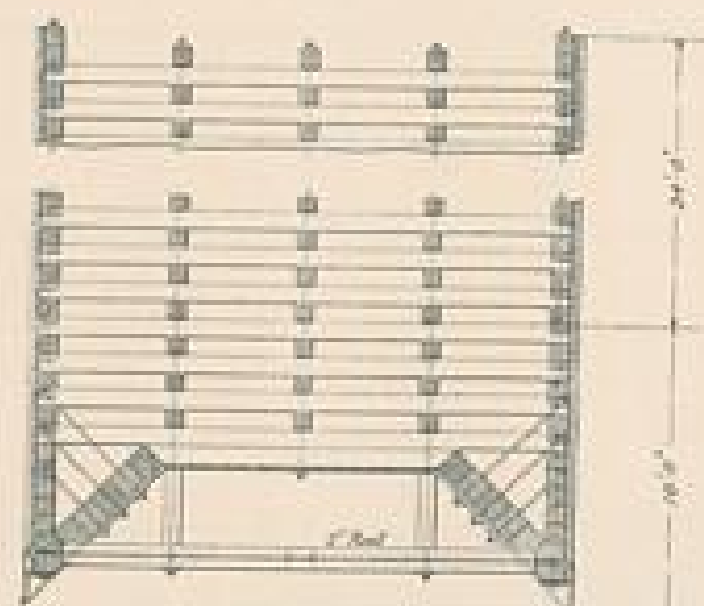


Reduced to 100 feet below Low Water.
100' 0" = actual mean tide at Bridge.

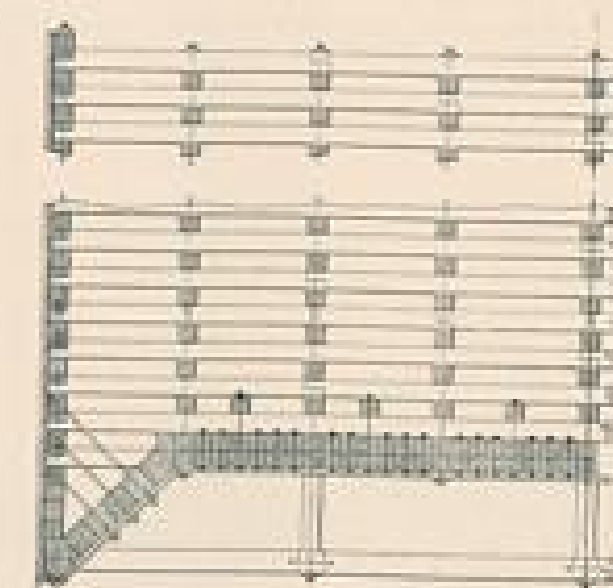
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CAIRO BRIDGE.
CAISSONS.



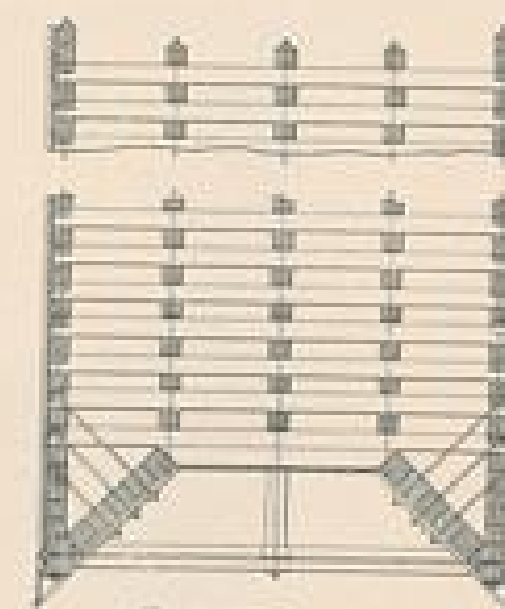
HALF LONGITUDINAL SECTION.



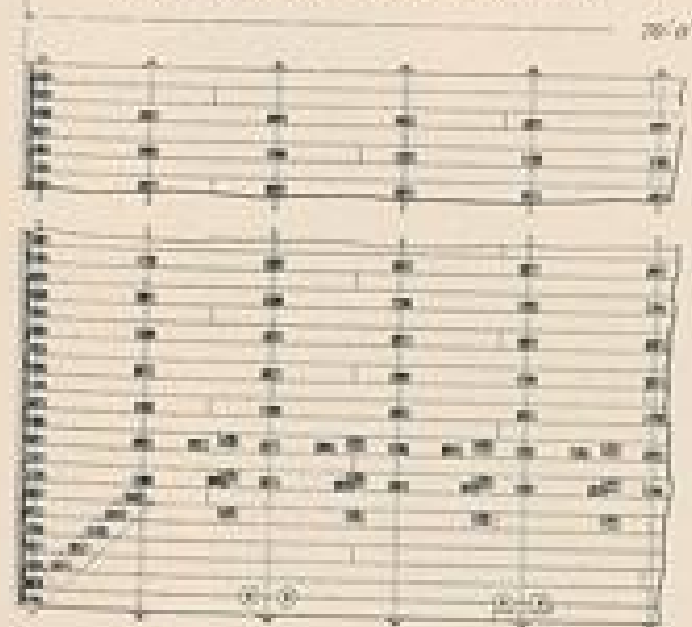
CROSS SECTION.



HALF LONGITUDINAL SECTION.

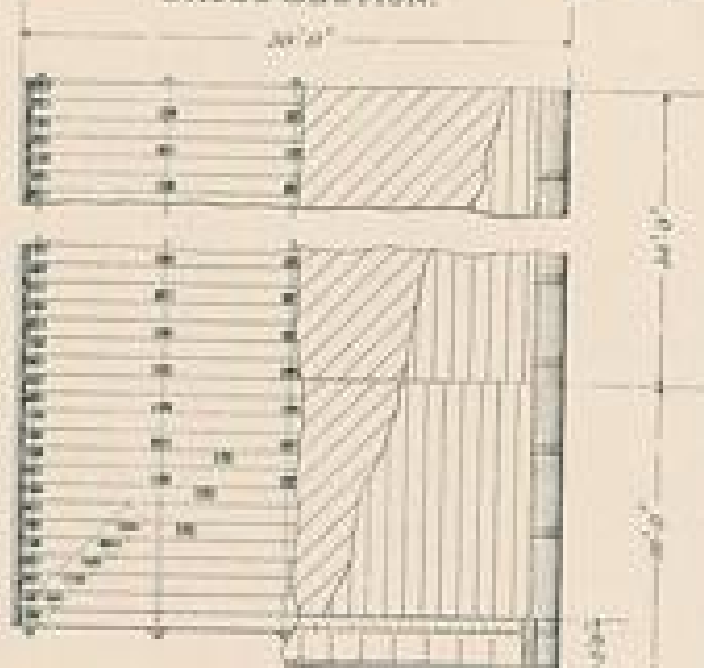


CROSS SECTION.

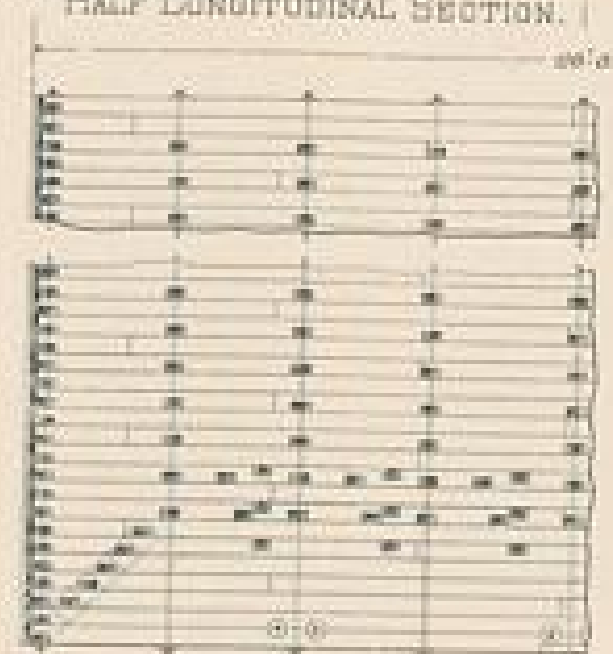


HALF SIDE ELEVATION.

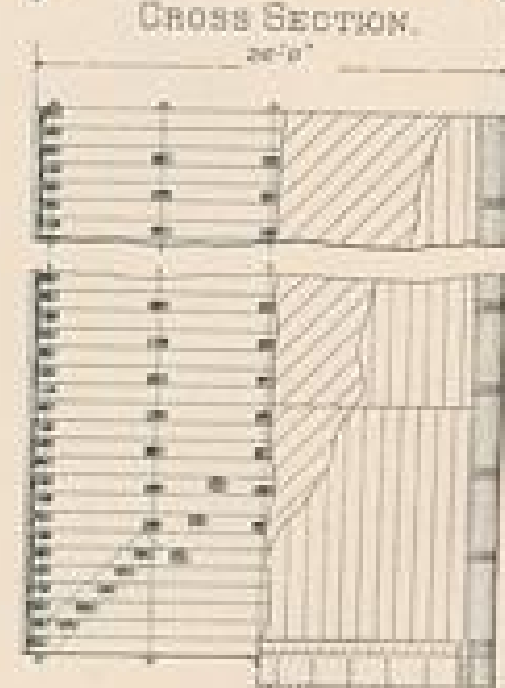
Casting, Ribs and Flanking removed.



END ELEVATION.



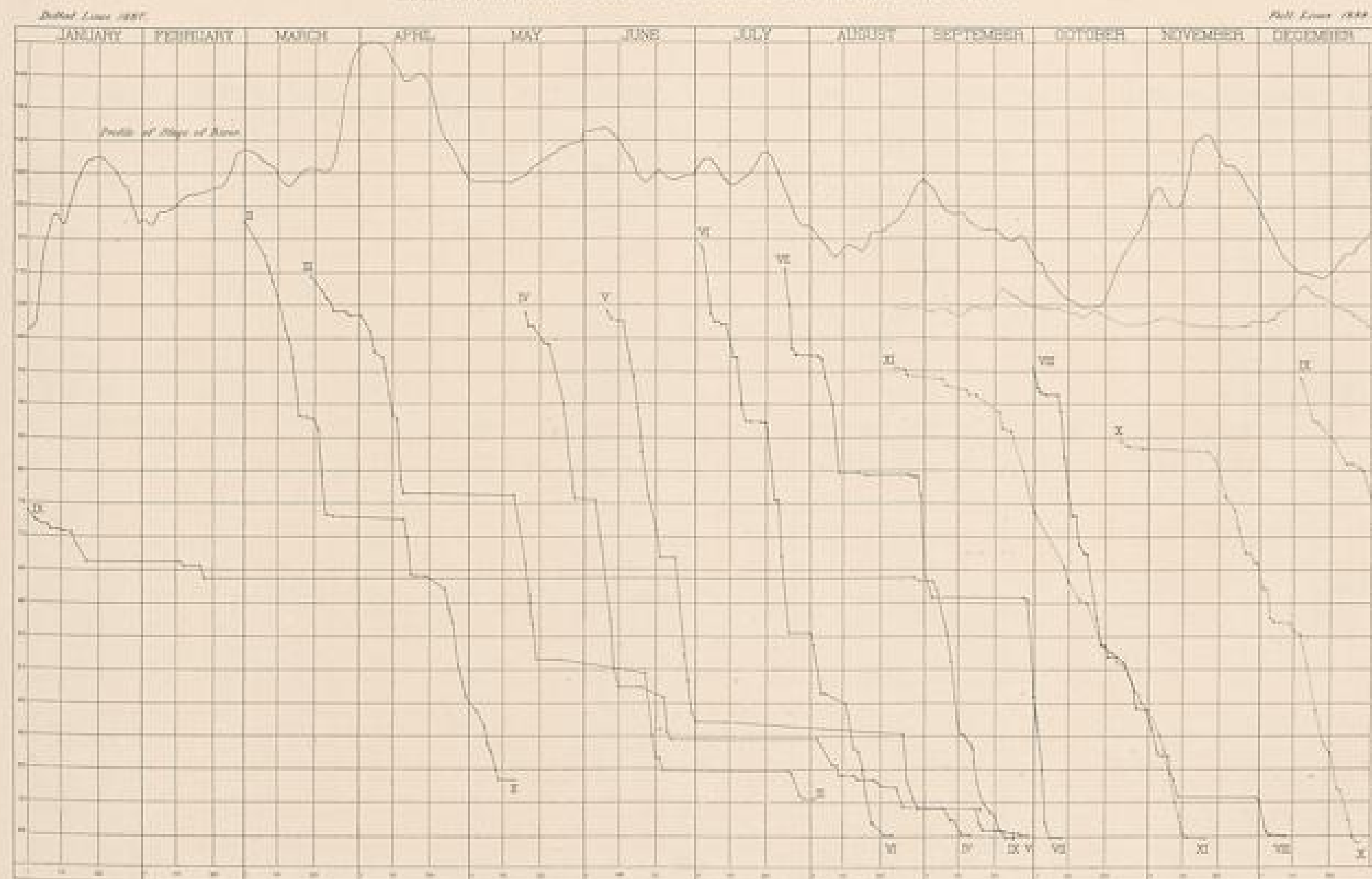
HALF SIDE ELEVATION.



END ELEVATION.

O. ST. L. & N. O. R.R. CAIRO BRIDGE.

DIAGRAM SHOWING RATE OF PROGRESS IN SINKING CAISSONS.



Depth in feet below Low Water
 100.00 - above mean low of river - 100

C. & N. O. R. R. CAIRO BRIDGE.

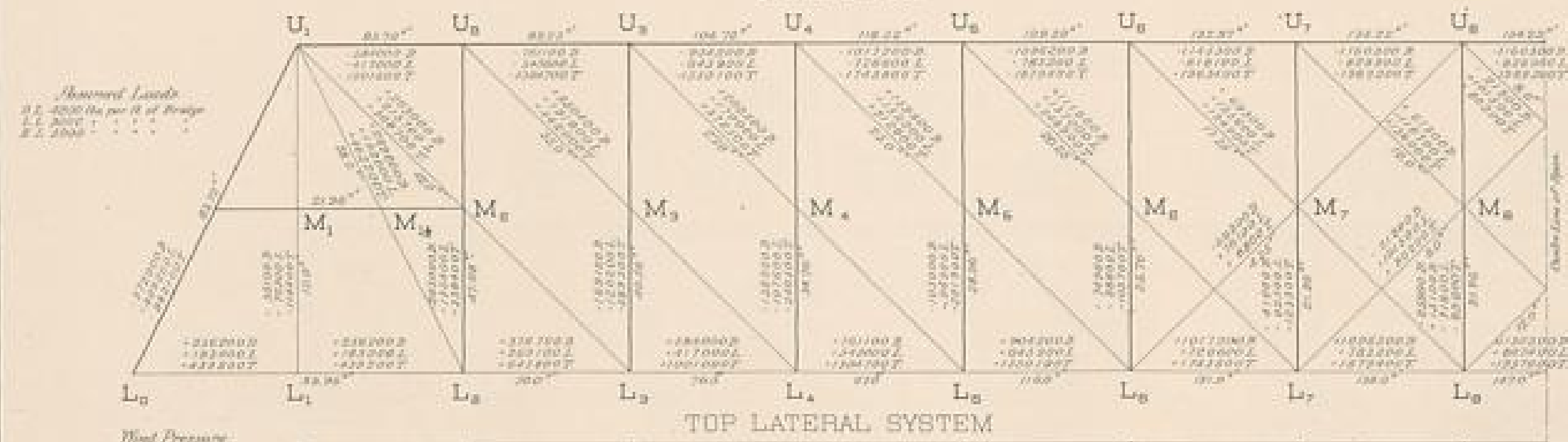
RECORD OF WATER STAGE OF THE OHIO RIVER AT CAIRO ILLINOIS.



Solid line is 100 feet above Low Water.
Dotted line is 100 feet above mean low of Illinois River.

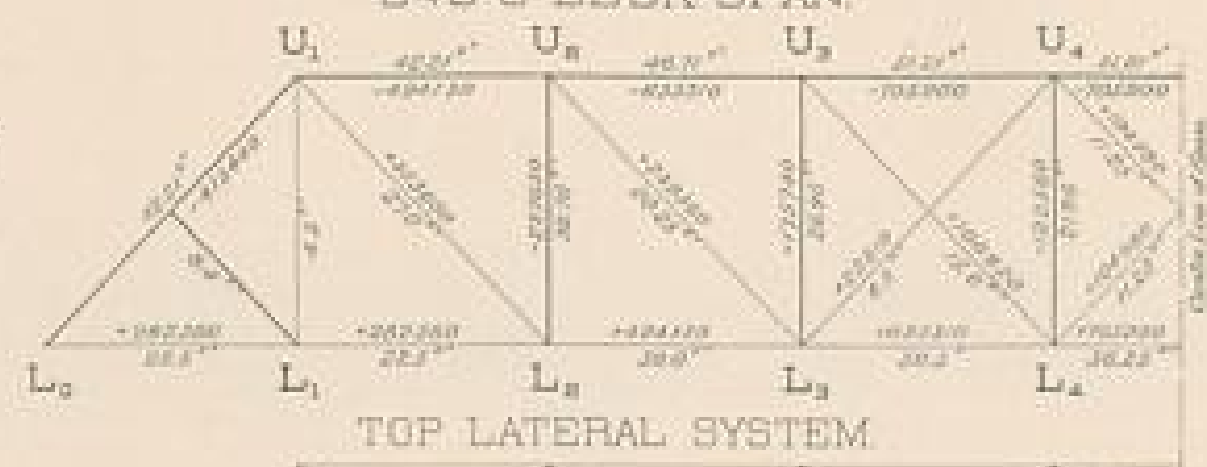
Copyright, 1900, by the U.S. Army, Corps of Engineers.

C. ST. L. & N. O. R. R.
CAIRO BRIDGE.
518'-0" THROUGH SPAN.
STRAIN SHEET.



848'-0" DECK SPAN.

Total Load - 5400 lbs. per ft. of Bridge, of which 2000 lbs. is treated as moving load on the end system.

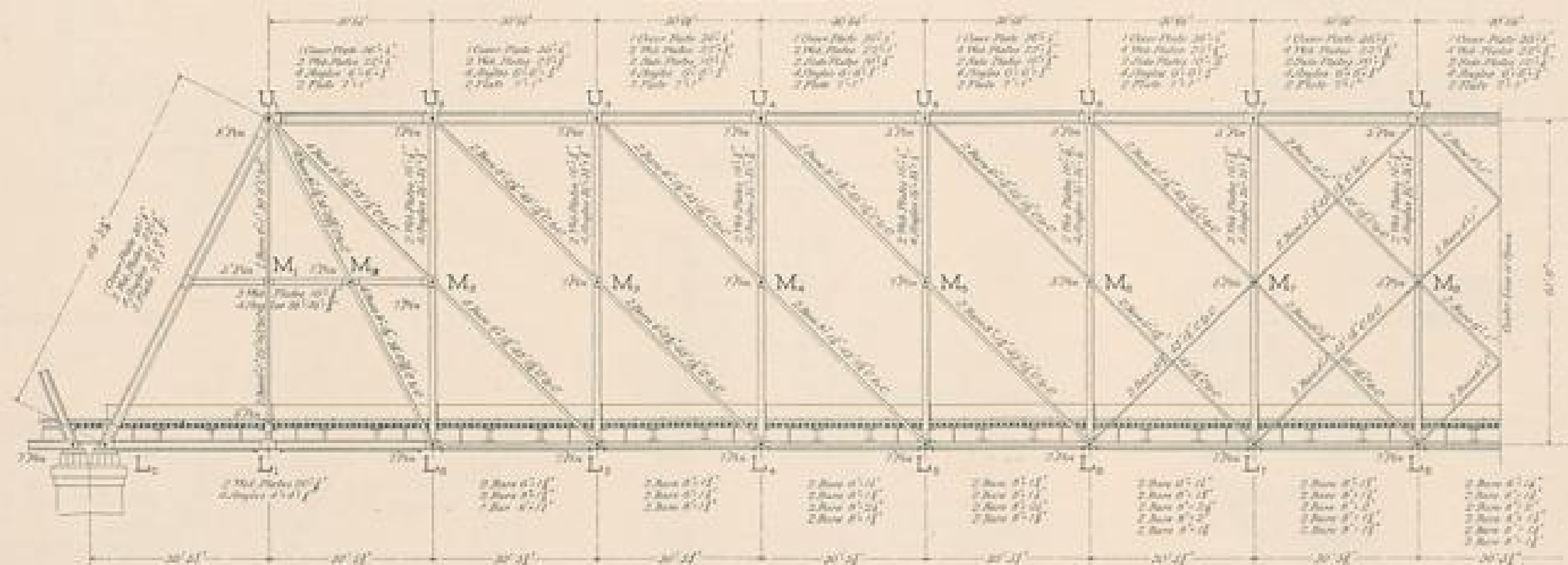


Wind Pressure
Top - 300 lbs. per ft.
Bottom - 200 " " " "

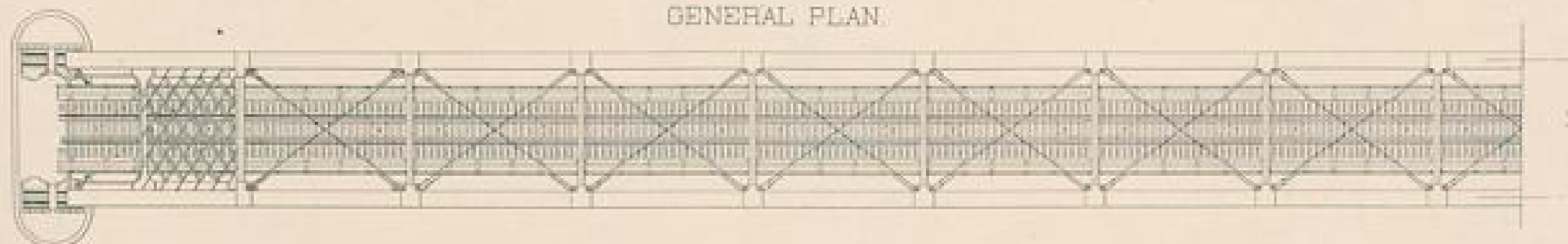


C. ST. L. & N. O. R. R.
CAIRO BRIDGE.
518'-0" THROUGH SPAN.

GENERAL ELEVATION



GENERAL PLAN

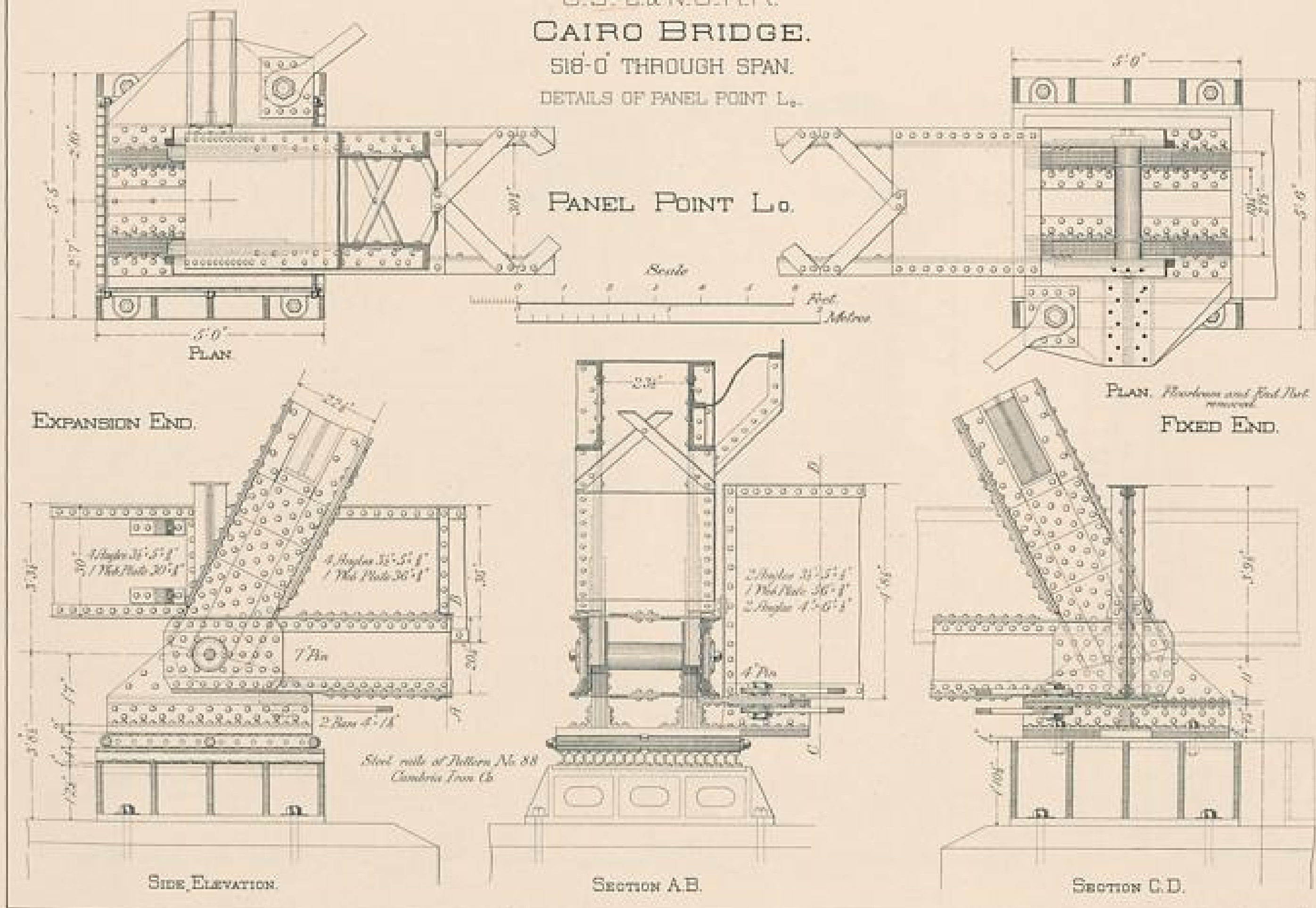


Scale

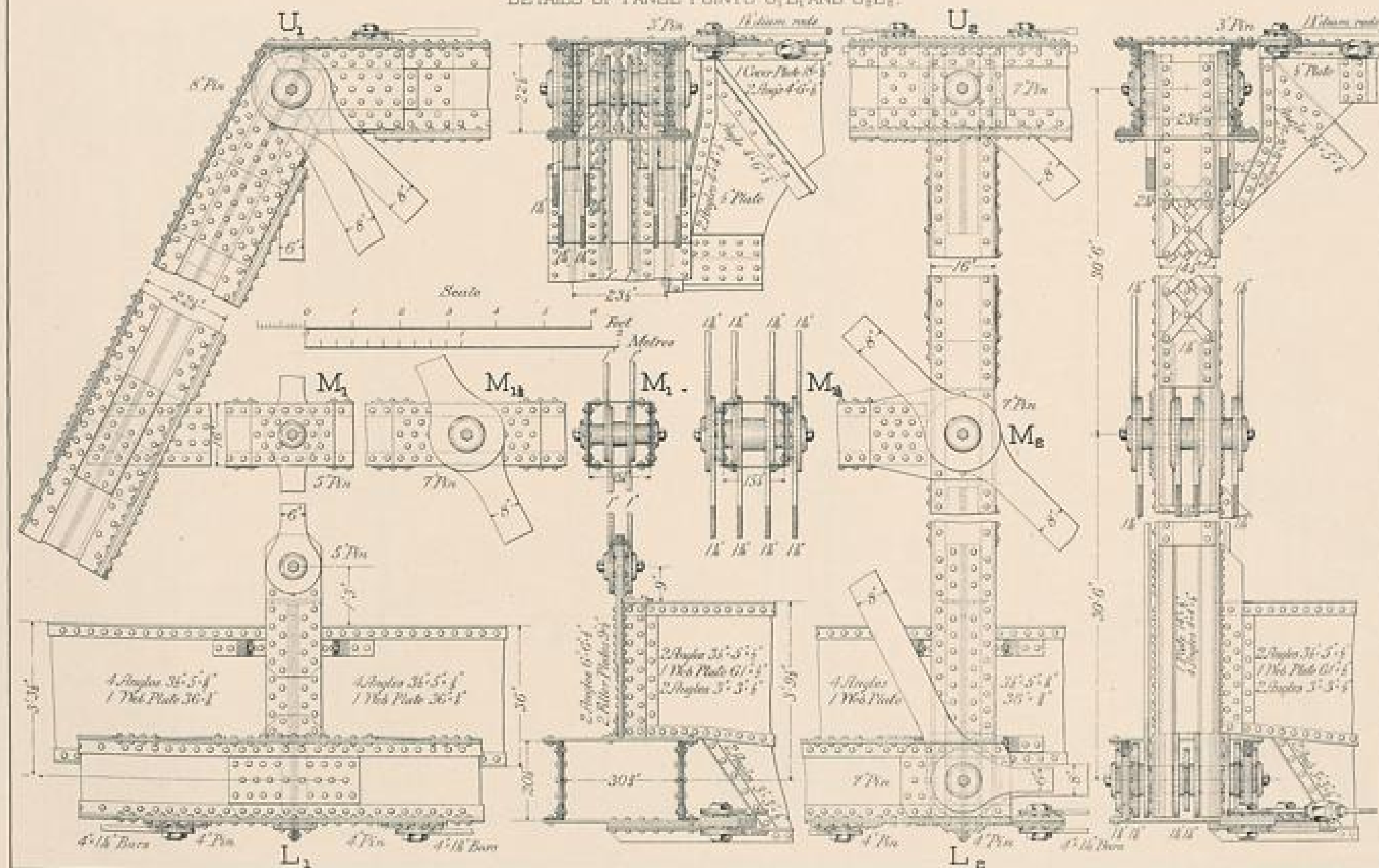
0 10 20 30 40 50 60 70 80 90 100 Feet

0 1 2 3 4 Miles

C. ST. L. & N. O. R. R.
CAIRO BRIDGE.
518'-0" THROUGH SPAN.
DETAILS OF PANEL POINT L.

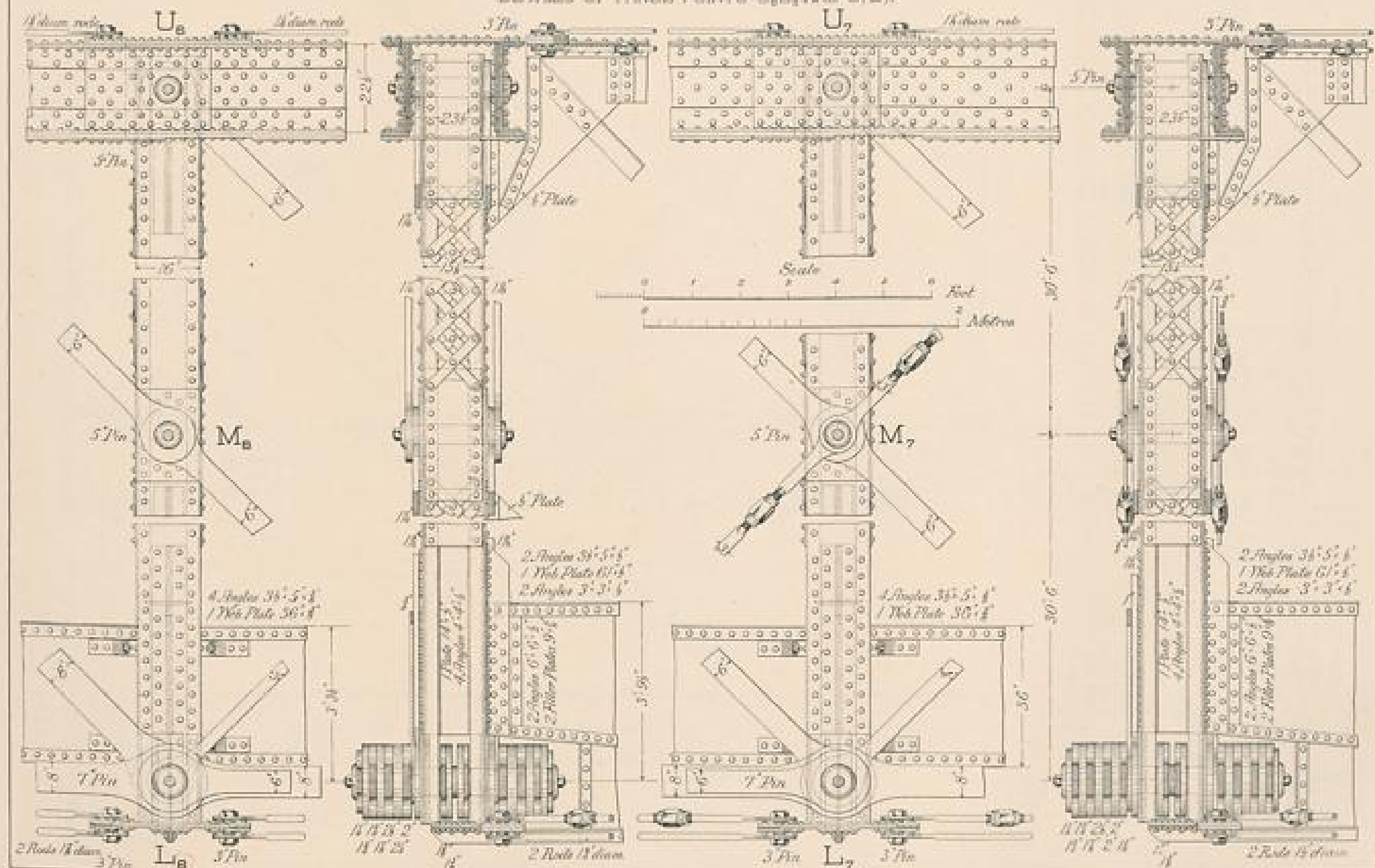


C. ST. L. & N. O. R. R.
CAIRO BRIDGE.
518-0' THROUGH SPAN.
DETAILS OF PANEL POINTS U_1 , L_1 , AND U_2 , L_2 .

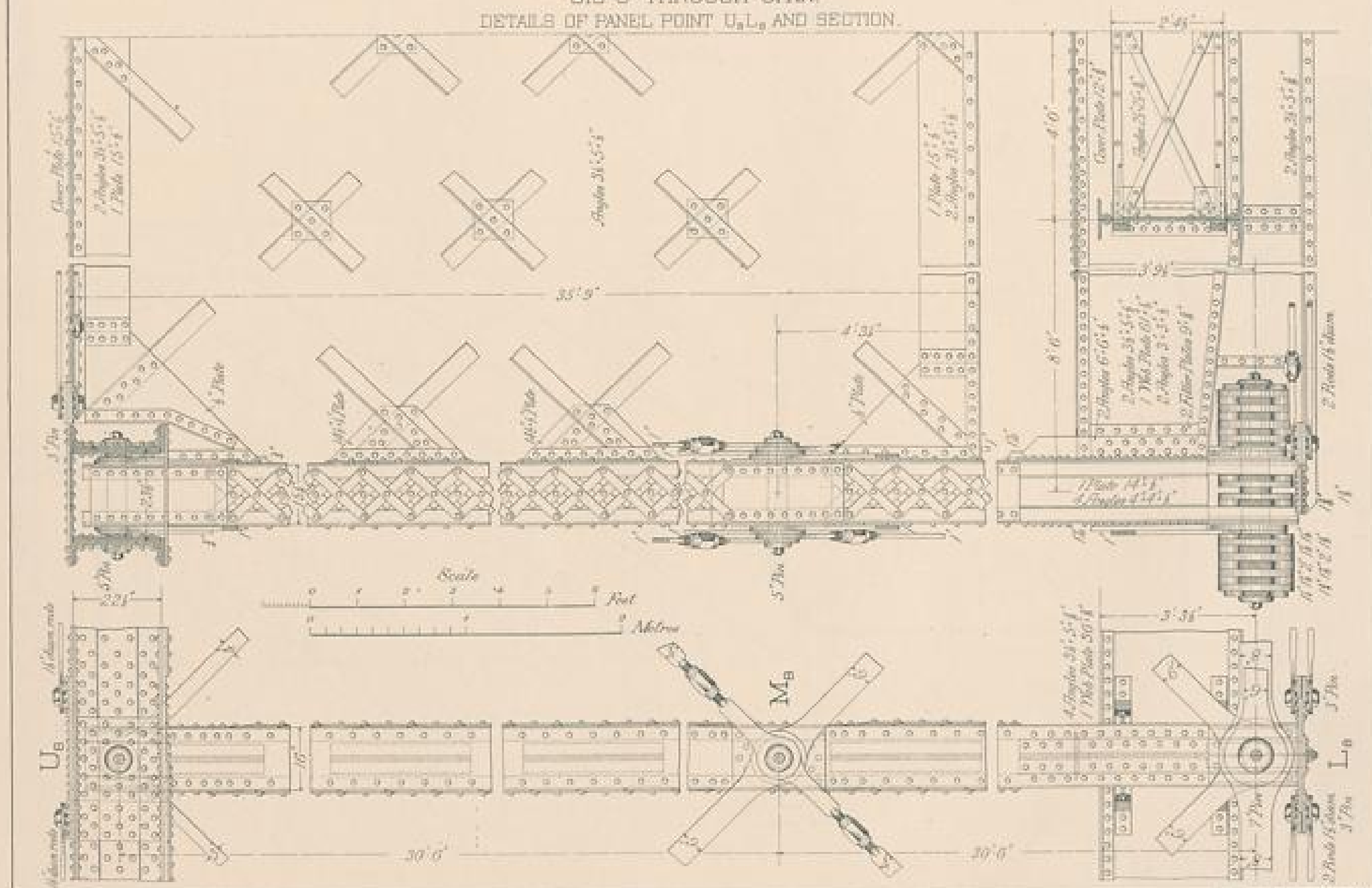


C.S.L. & N.O.R.R.
CAIRO BRIDGE.
518'-0" THROUGH SPAN.

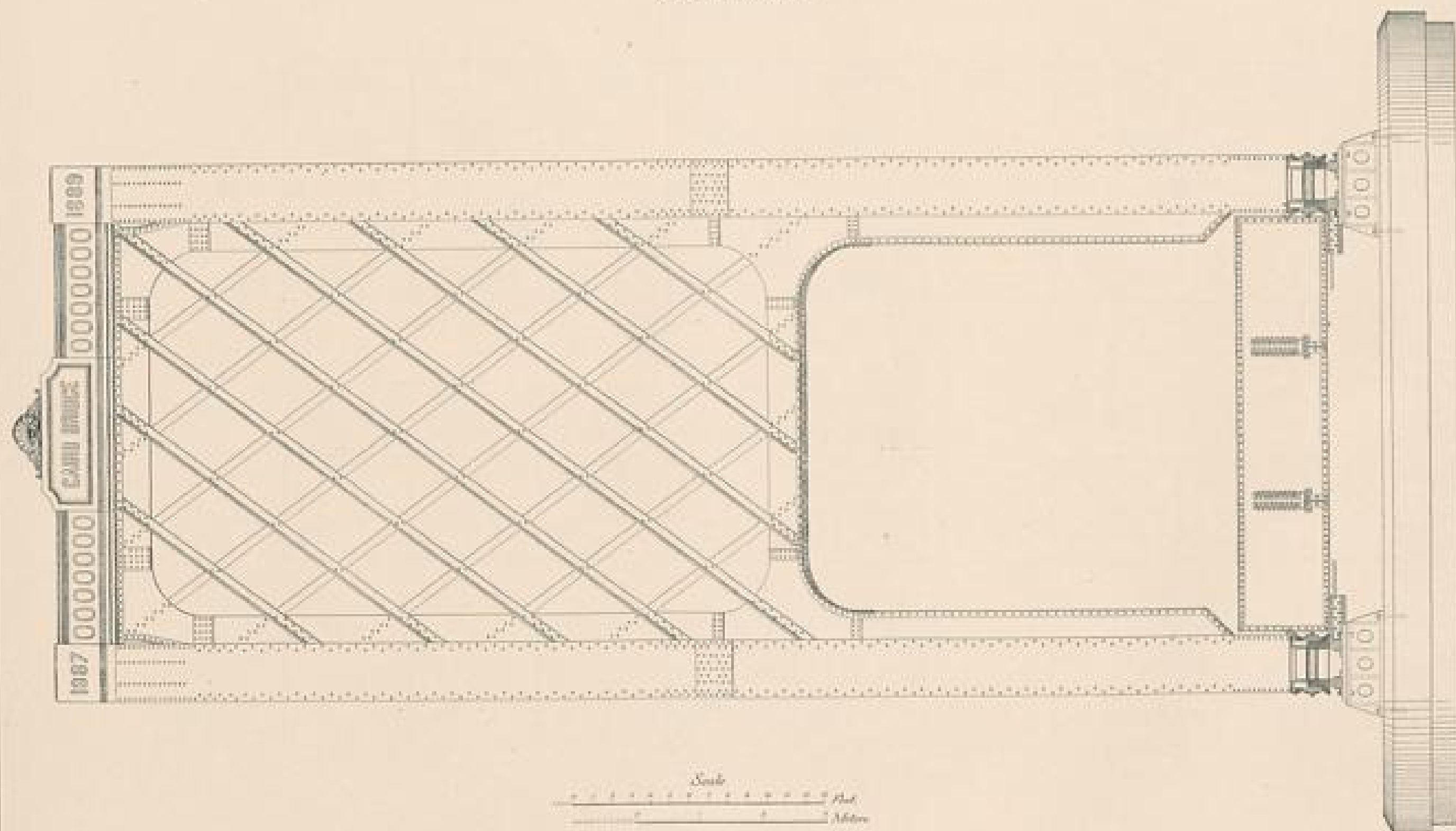
DETAILS OF PANEL POINTS U₆L₄ AND U₇L₇



C.S. L. & N.O. R.R.
CAIRO BRIDGE.
— 318'-0" THROUGH SPAN.
DETAILS OF PANEL POINT U, L, AND SECTION.

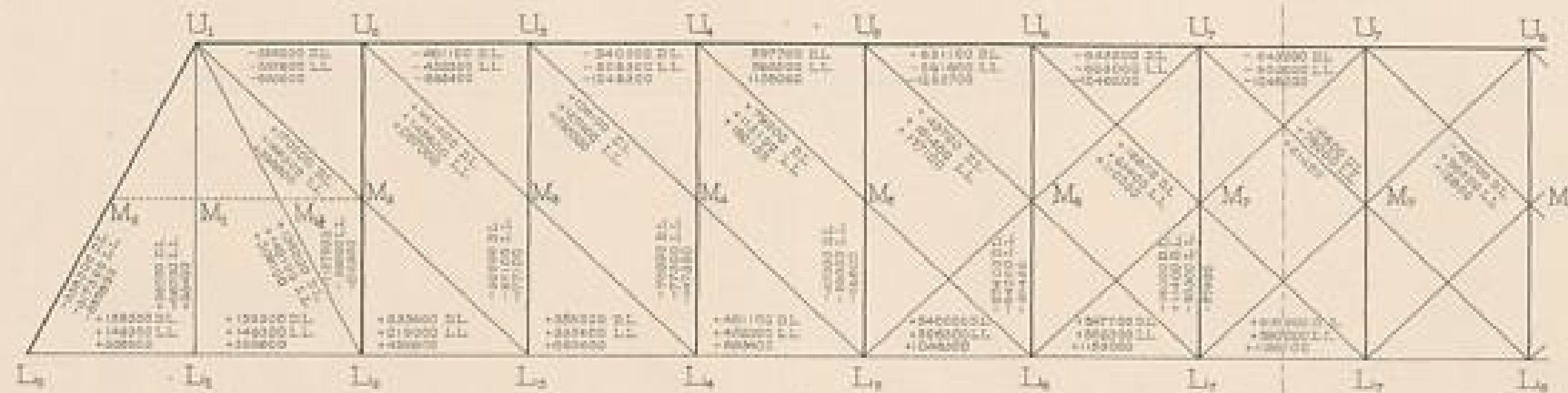


C. ST. L. & N. O. R. R.
CAIRO BRIDGE.
518'-0" THROUGH SPAN.
END ELEVATION.

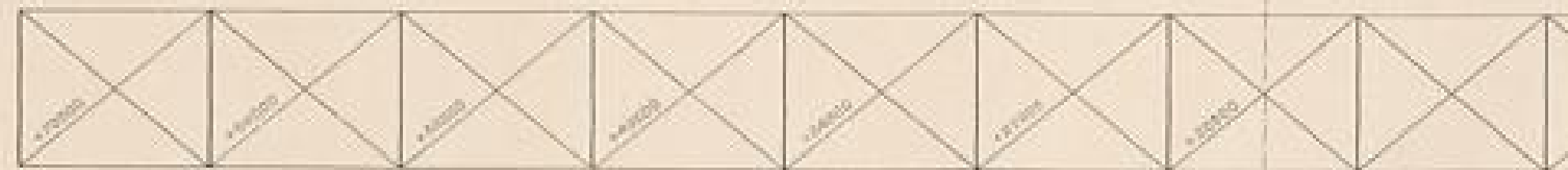


Assumed Loads
 DL 3200 lbs. per ft. of Bridge.
 LL 3000 " " " " " "
 EL 3000 " " " " " "

C. & N. O. R. R.
 CAIRO BRIDGE.
 400 FT THROUGH SPAN
 STRAIN SHEET



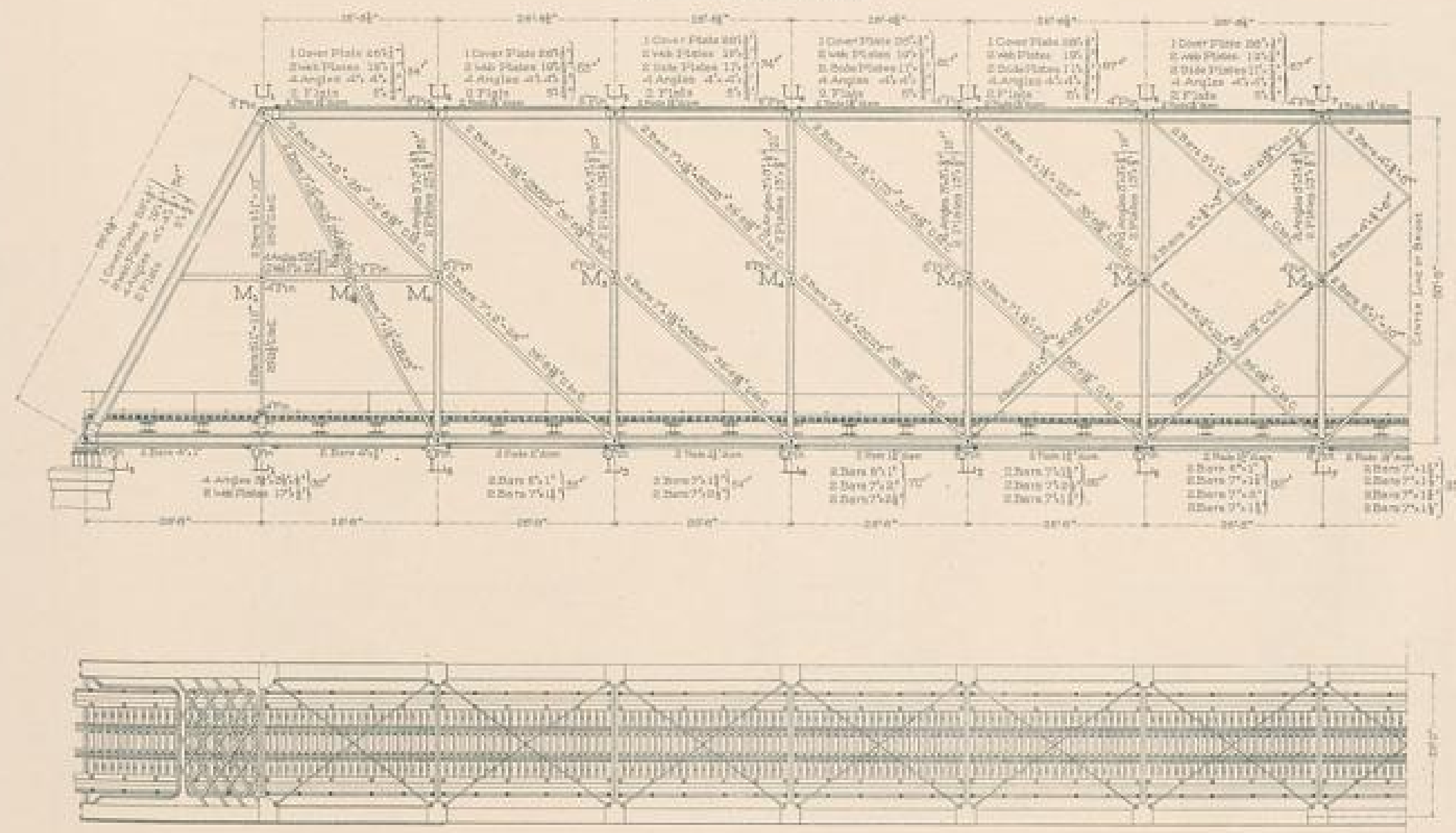
TOP LATERAL SYSTEM



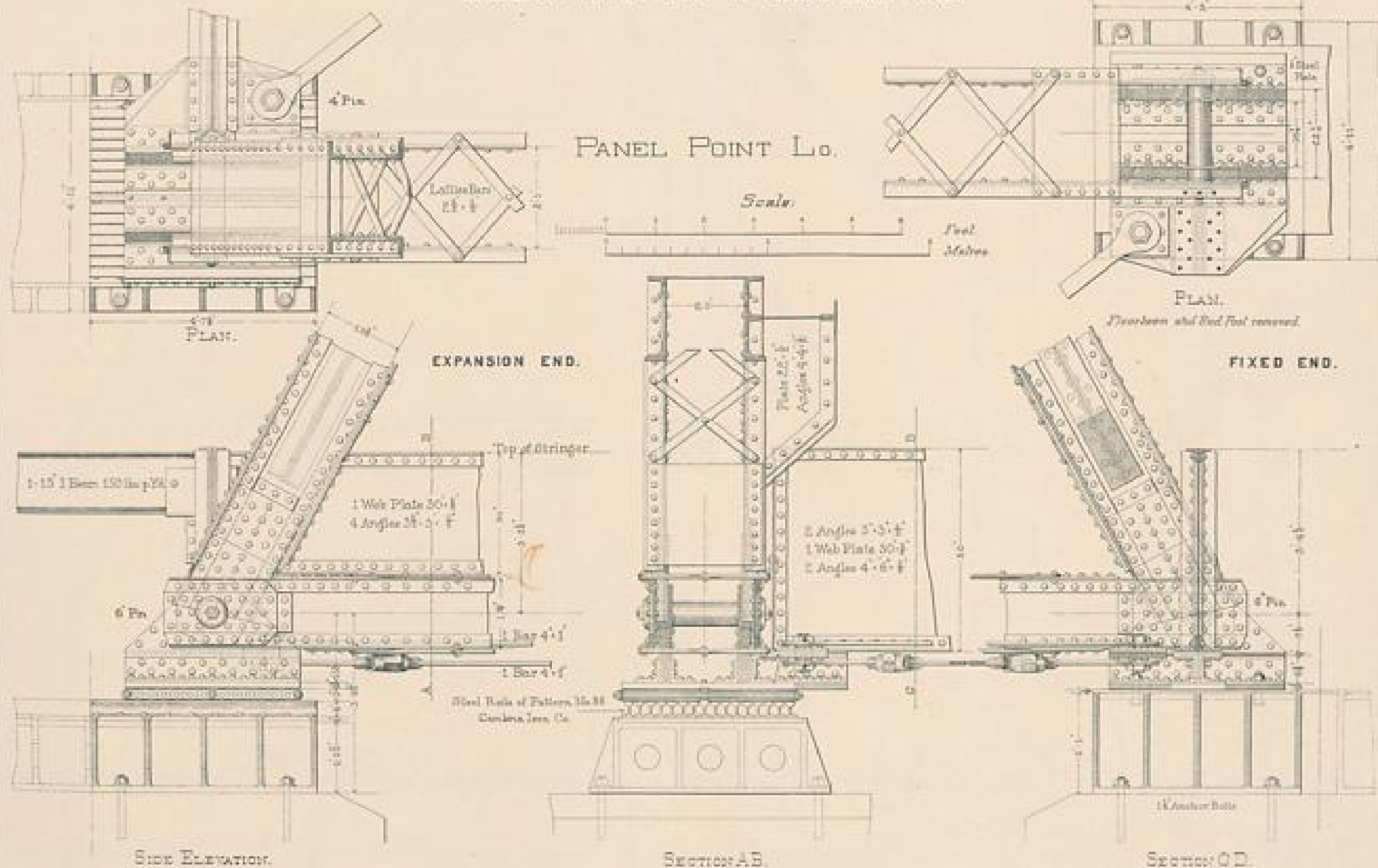
BOTTOM LATERAL SYSTEM



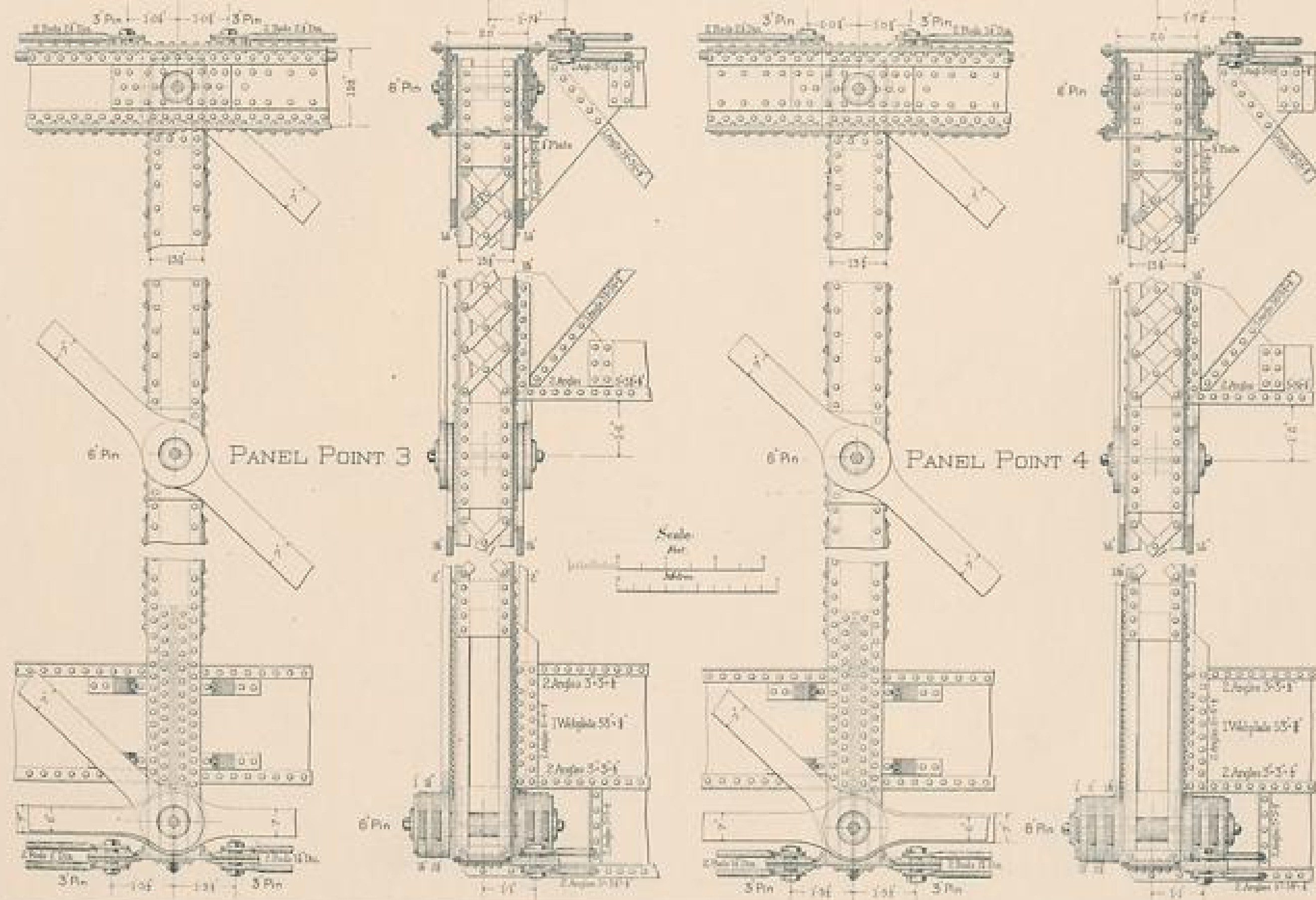
C.S.T. & N.O.R.R. CAIRO BRIDGE. GENERAL ELEVATION OF 400 FT SPAN.



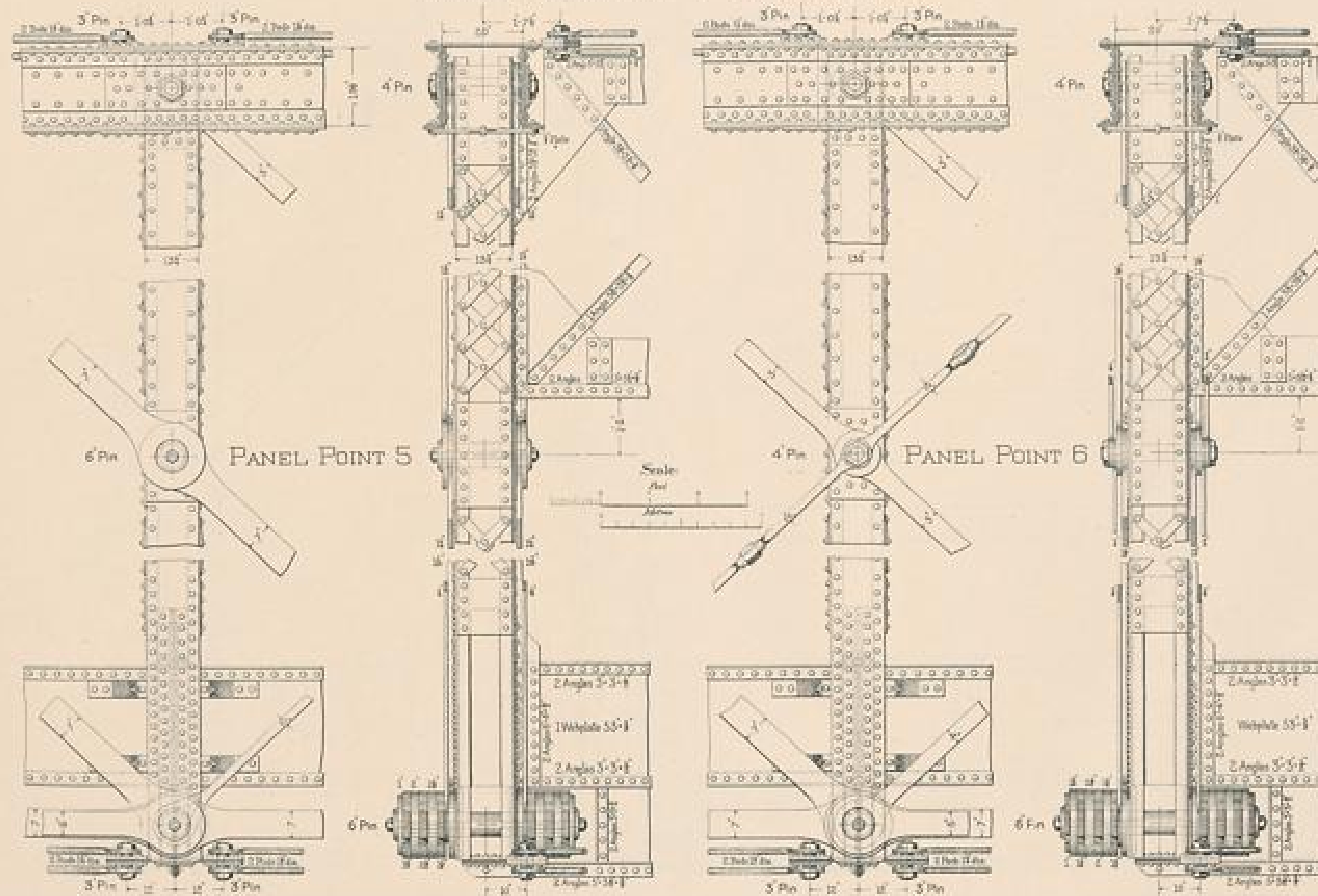
C. ST. L. & N. O. R. R.
CAIRO BRIDGE.
THROUGH SPAN 400' 0" BY C. TO C. END PINS.



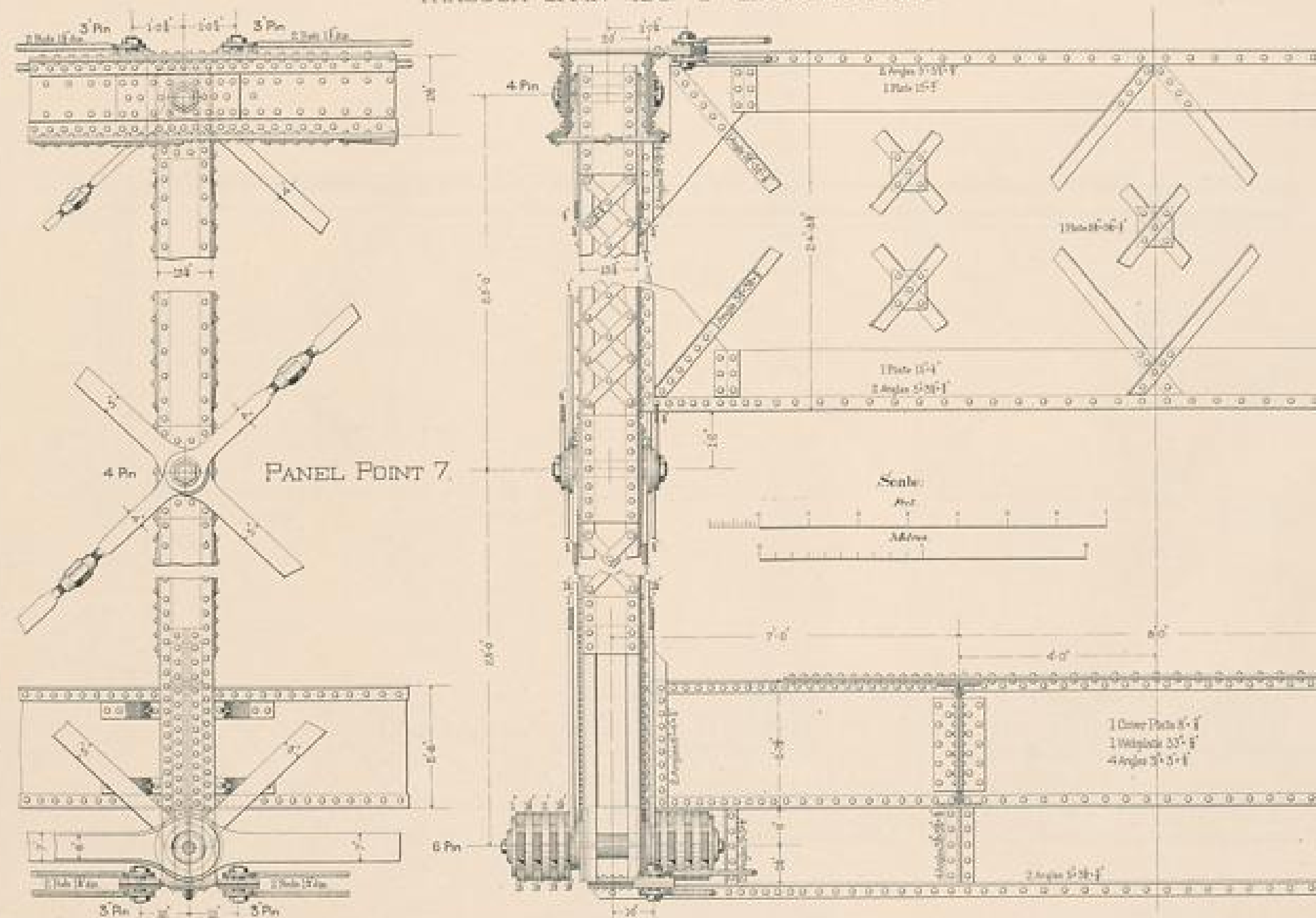
C. ST. L. & N. O. R. R.
CAIRO BRIDGE
THROUGH SPAN 400' C. TO C. END PINS.



C.S. L. & N.O. R.R.
CAIRO BRIDGE.
THROUGH SPAN 400' 0" C. TO C. END PINS.

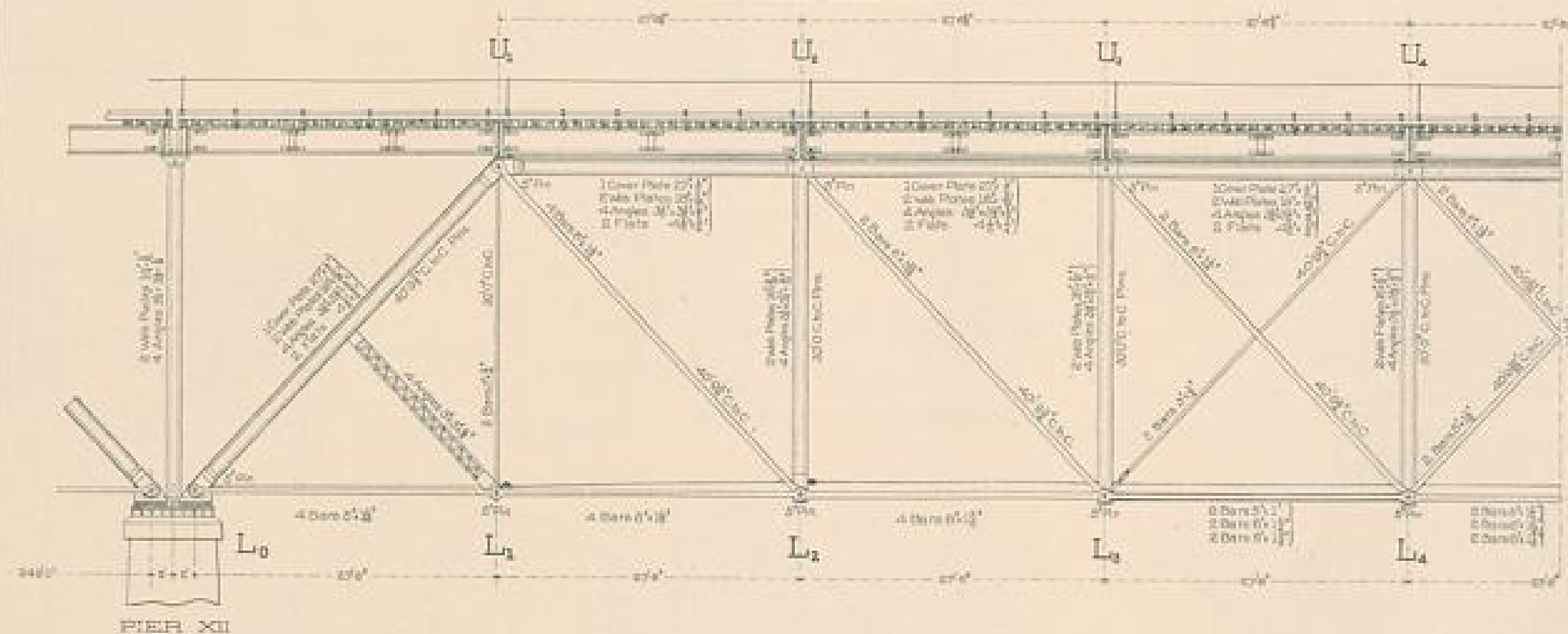


C. ST. L. & N. O. R. R.
CAIRO BRIDGE.
THROUGH SPAN 400' 0" C. TO C. END PINS.

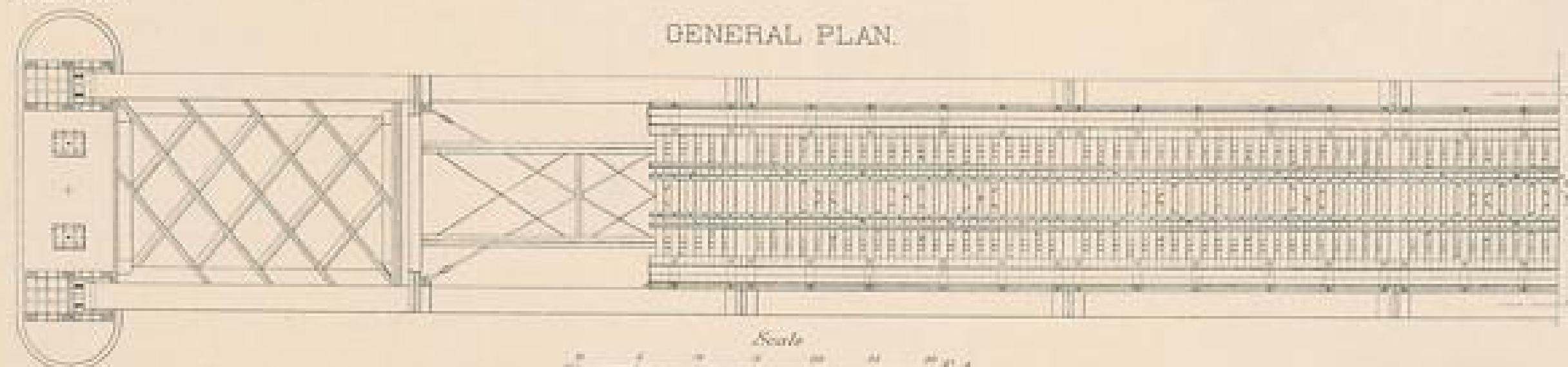


C. ST. L. & N. O. R. R.
CAIRO BRIDGE.
249'-0" DECK SPAN.

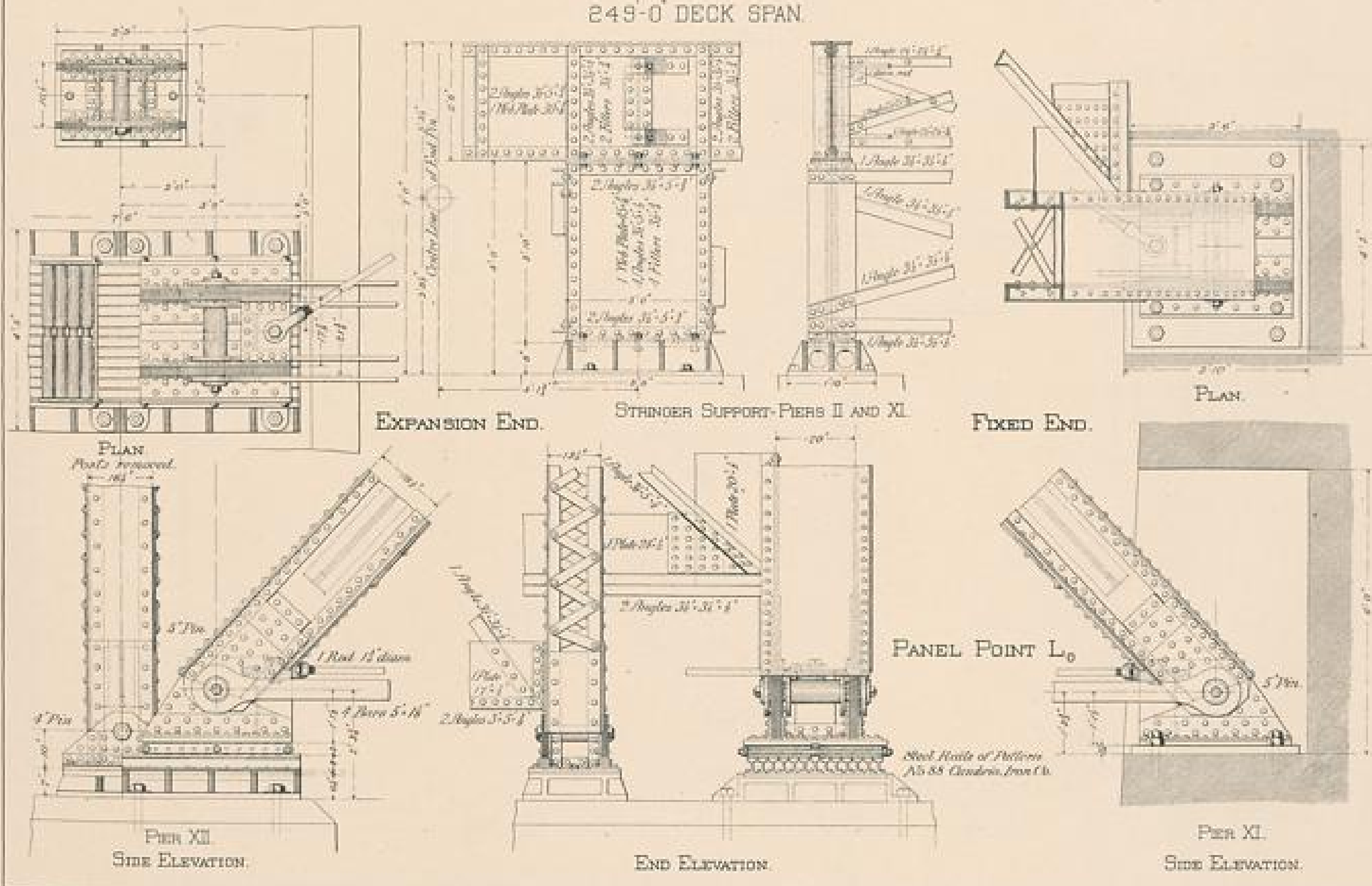
GENERAL ELEVATION.



GENERAL PLAN.

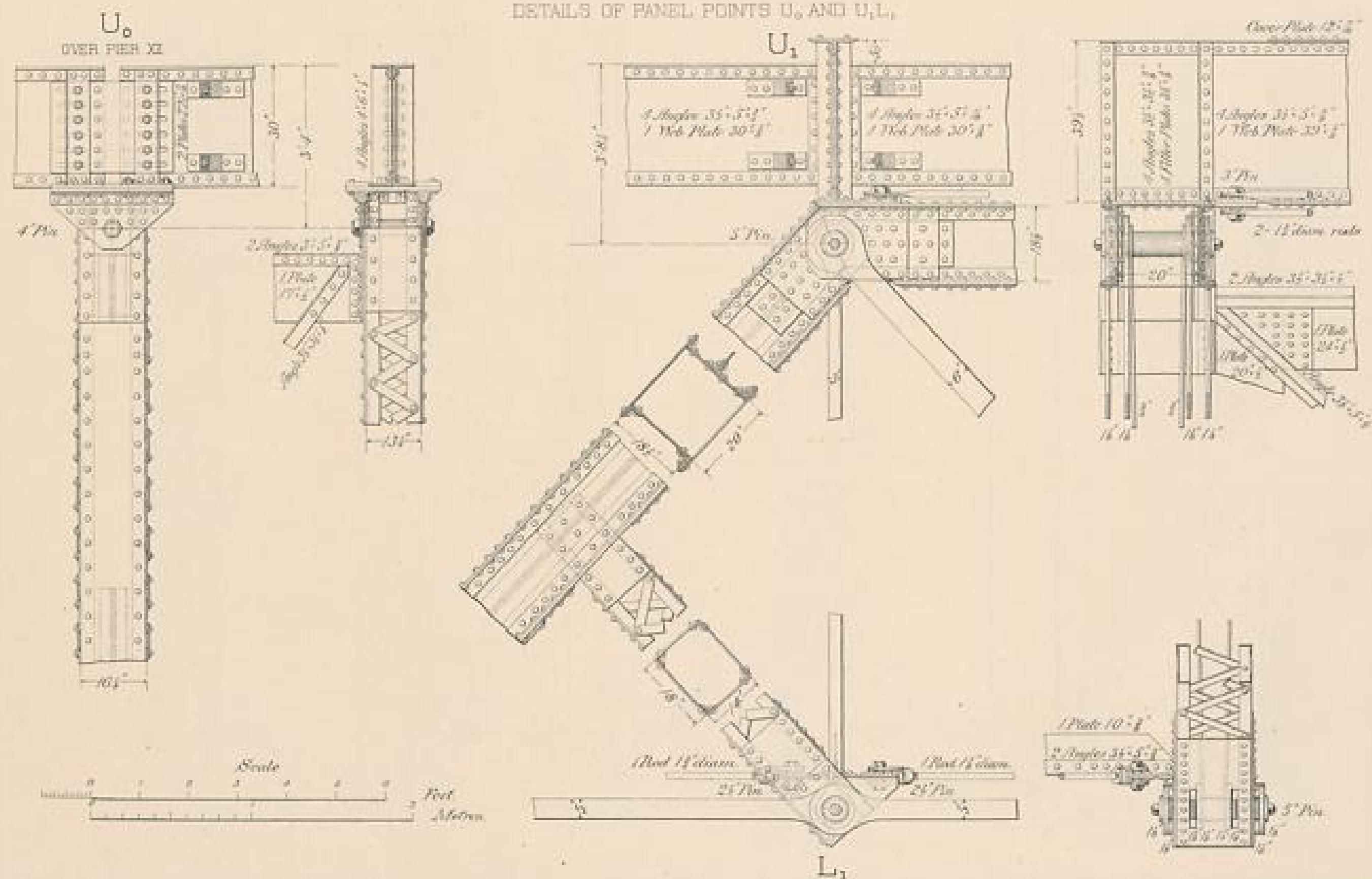


C. ST. L. & N. O. R. R.
CAIRO BRIDGE.
249'-0" DECK SPAN.



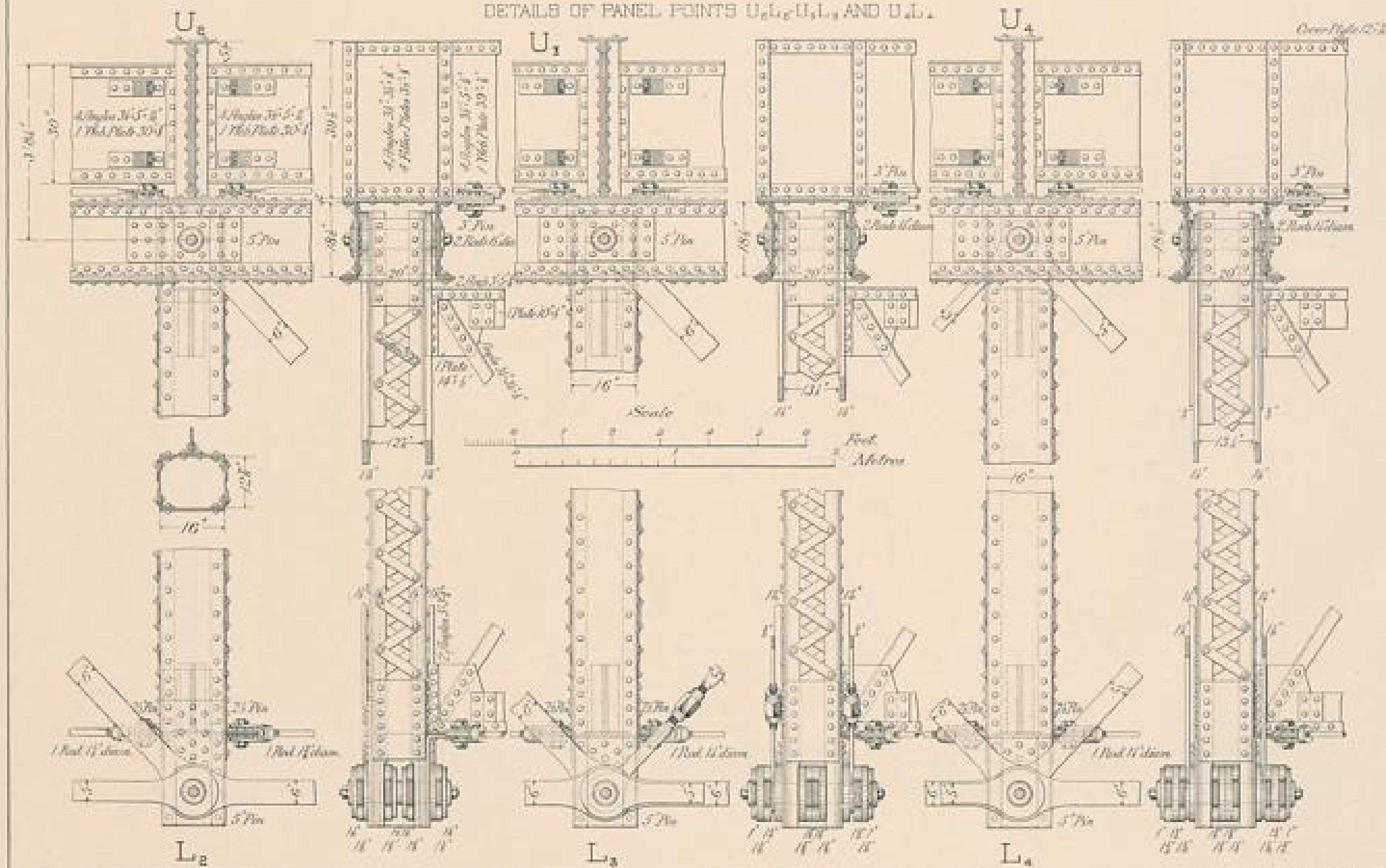
C. ST. L. & N. O. R. R.
CAIRO BRIDGE.
249'-0" DECK SPAN.

DETAILS OF PANEL POINTS U_0 AND U_1L_1

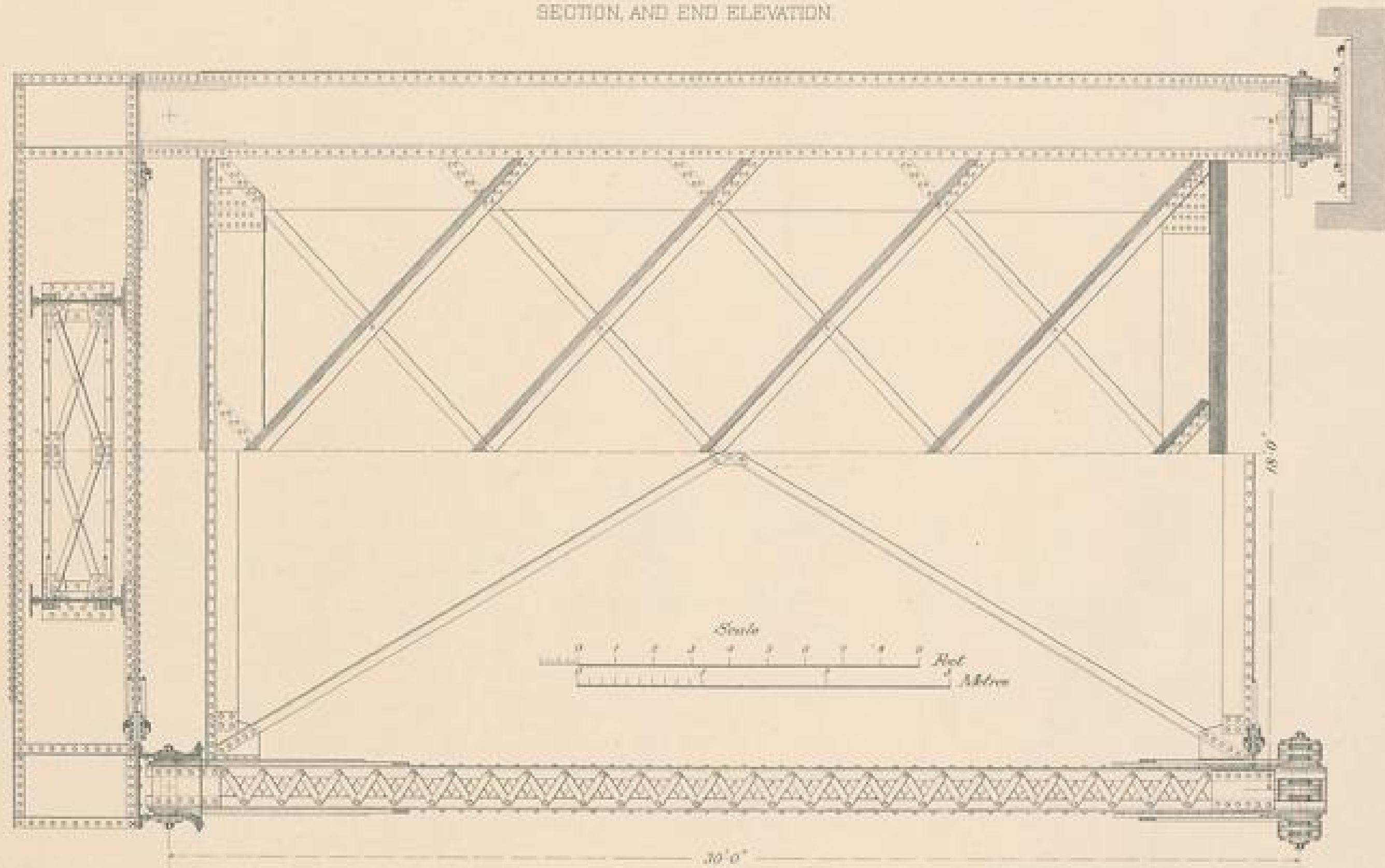


C. ST. L. & N. O. R. R.
CAIRO BRIDGE.
249'-0" DECK SPAN.

DETAILS OF PANEL POINTS U_2, L_2, U_3, L_3 AND U_4, L_4 .

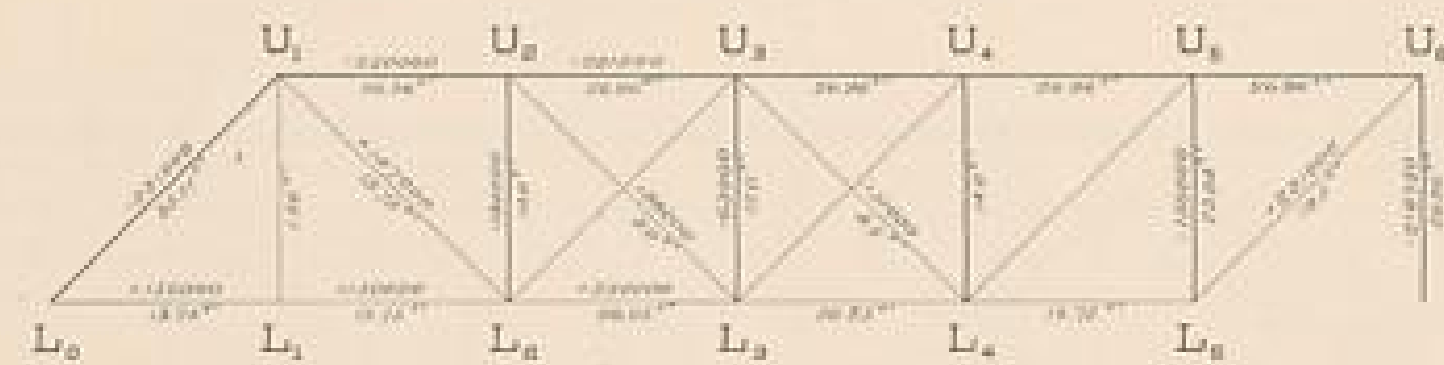


C. ST. L. & N. O. R. R.
CAIRO BRIDGE.
 249'-0" DECK SPAN.
 SECTION AND END ELEVATION



C. ST. L. & N. O. R. R.
CAIRO BRIDGE.
150'-0" DECK SPAN.
STRAIN SHEET.

Assumed Loads.
U. L. and D. 62,500 lbs per panel, per truss.
D. L. 10,000 " " " "



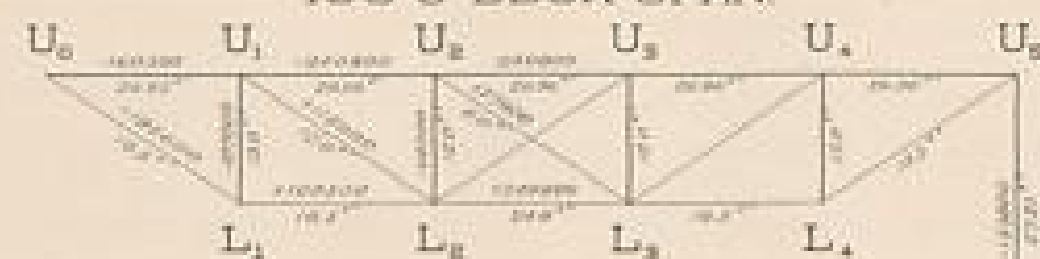
LATERAL SYSTEM



6000 lbs per ft. wind pressure

106'-3" DECK SPAN.

Assumed Total Load.
52,500 lbs per panel, per truss, full moving



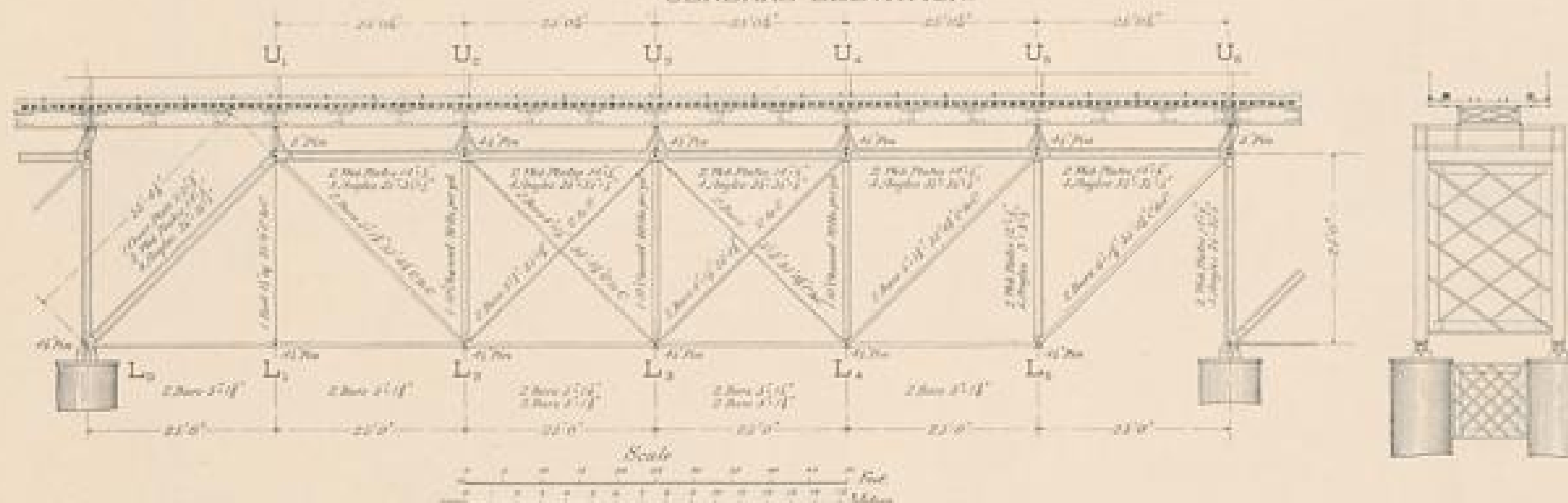
LATERAL SYSTEM.



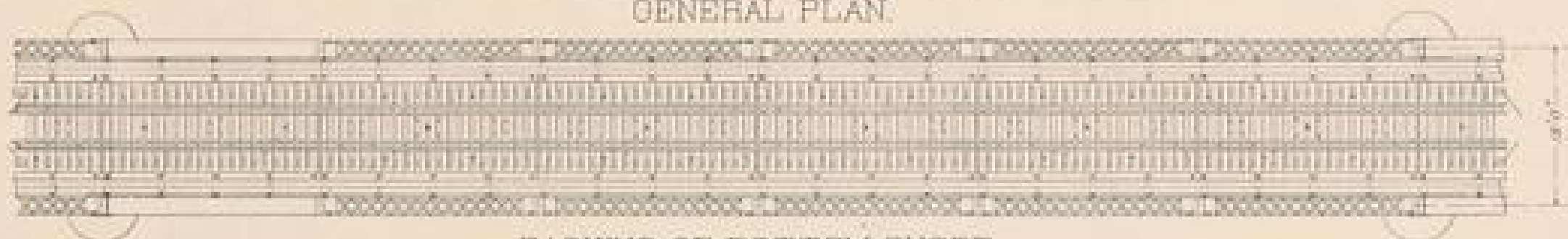
800 lbs per ft. wind pressure

O. ST. L. & N. O. R. R.
CAIRO BRIDGE.
150'-0" DECK SPAN.

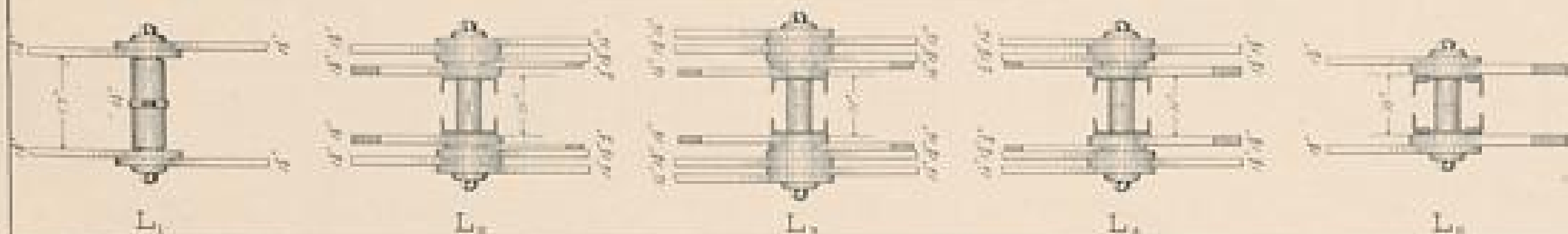
GENERAL ELEVATION.



GENERAL PLAN.



PACKING OF BOTTOM CHORD.

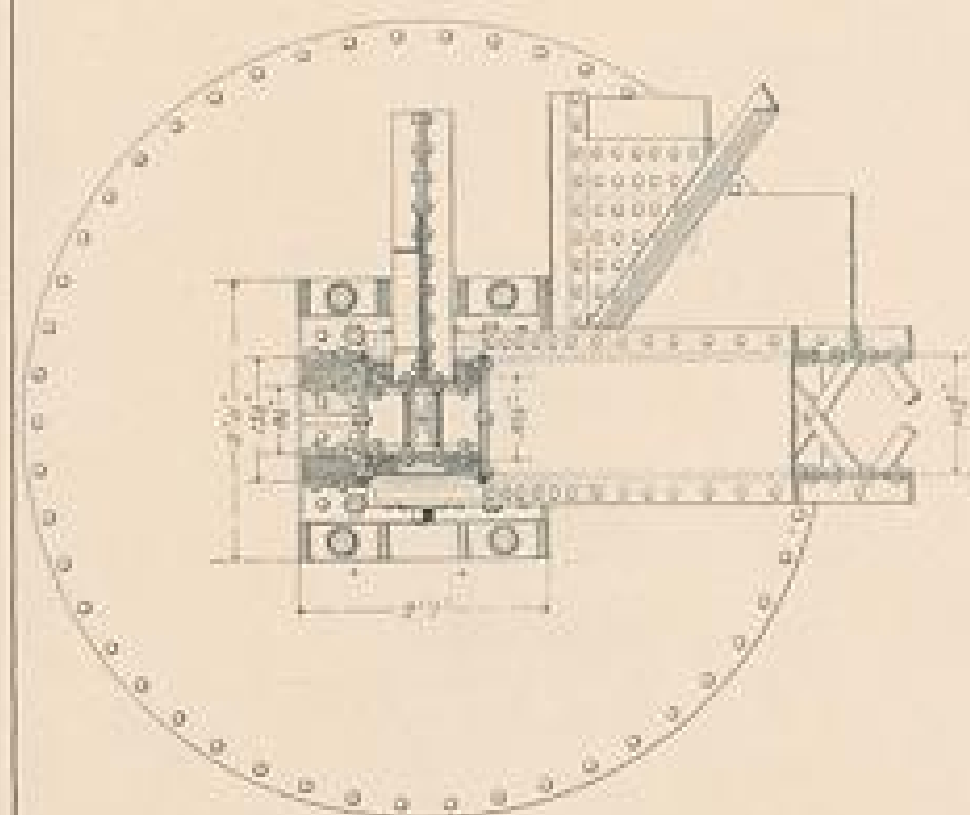


C. & N. O. R. R.

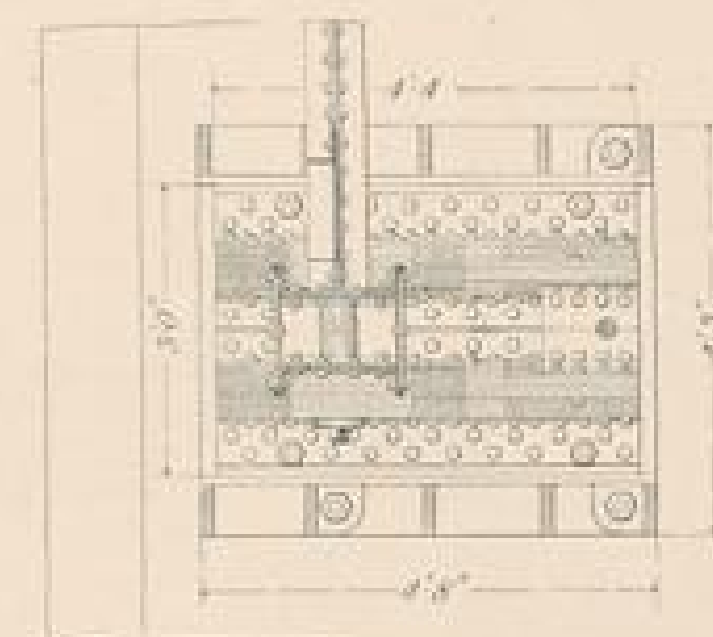
CAIRO BRIDGE.

150'-0" DECK SPAN.

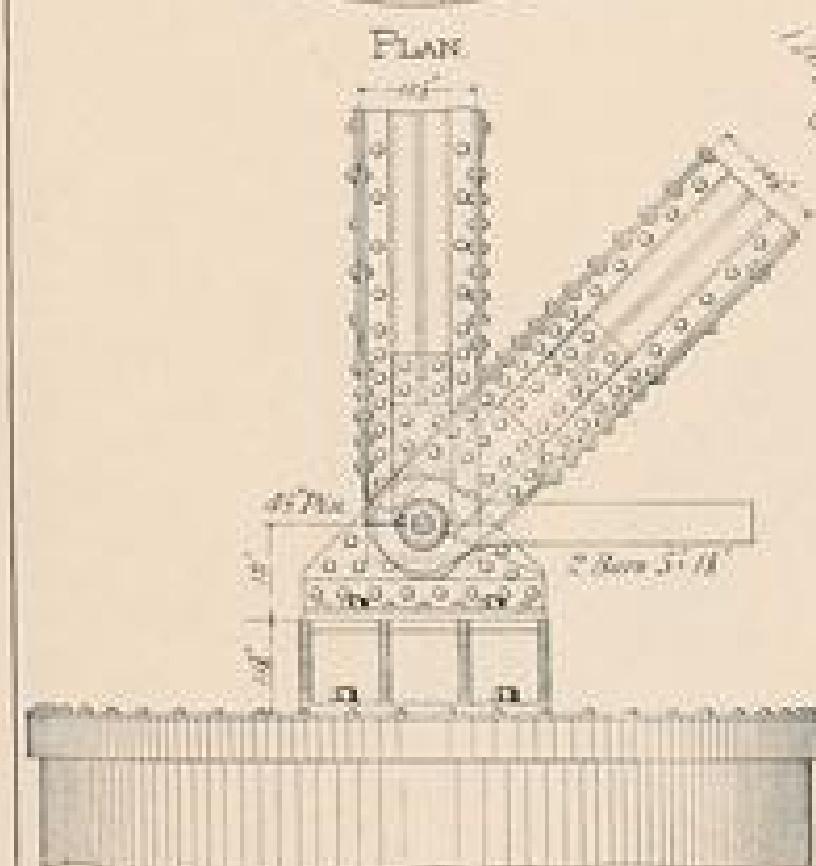
DETAILS OF PANEL POINTS L_0 AND L_{10} .



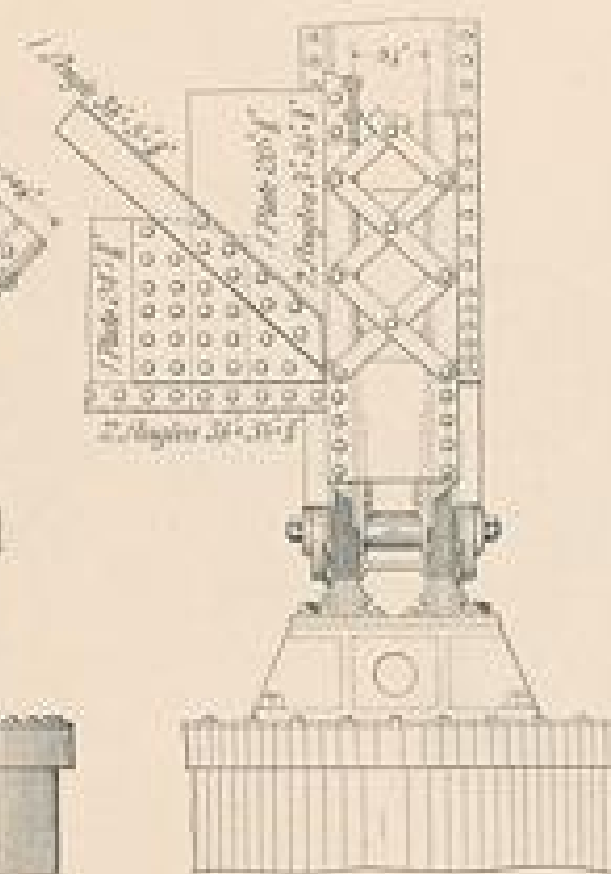
PLAN



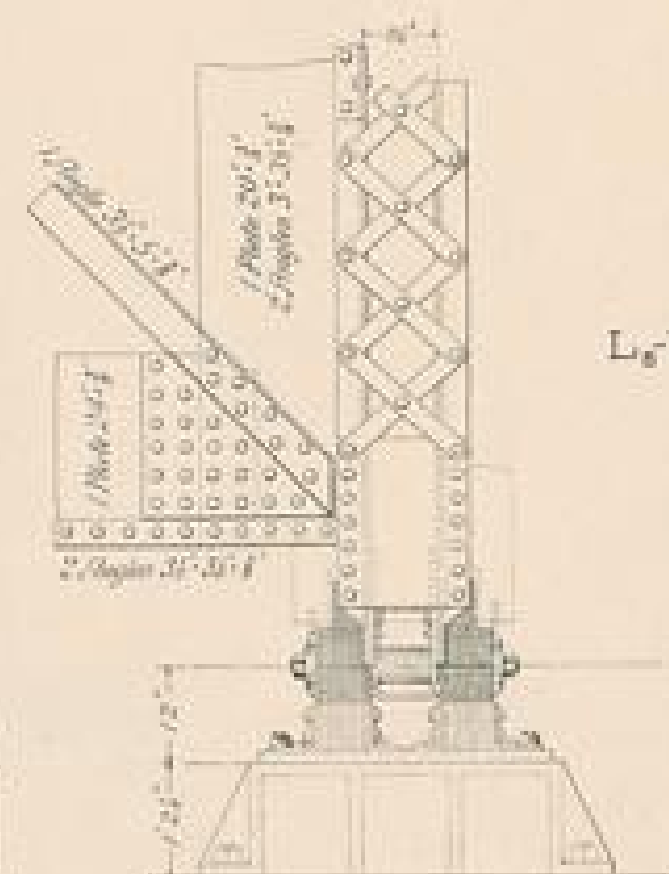
PLAN



SIDE ELEVATION- L_0 ON TANGENT.

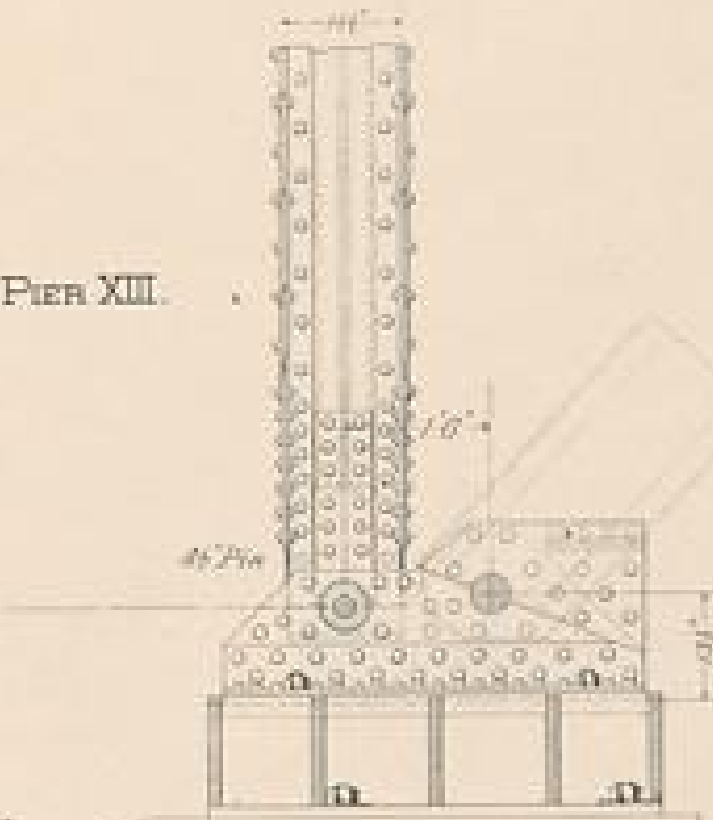


END ELEVATION.



END ELEVATION.

L_0 PIER XIII.

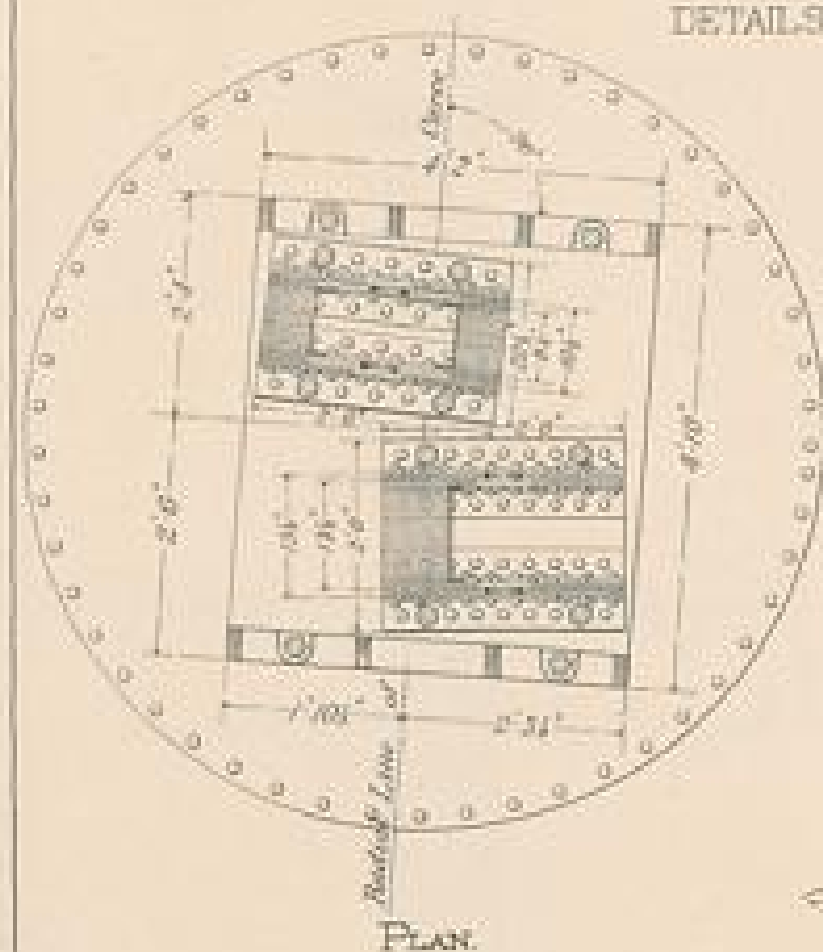


SIDE ELEVATION.

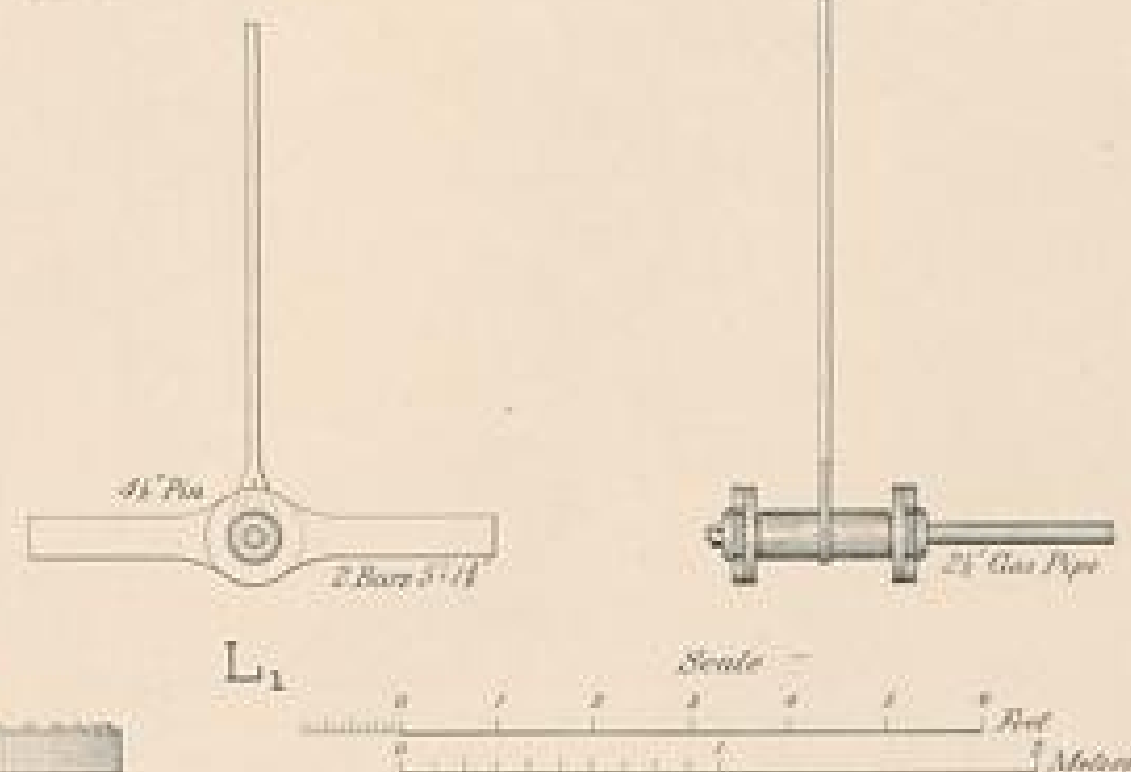
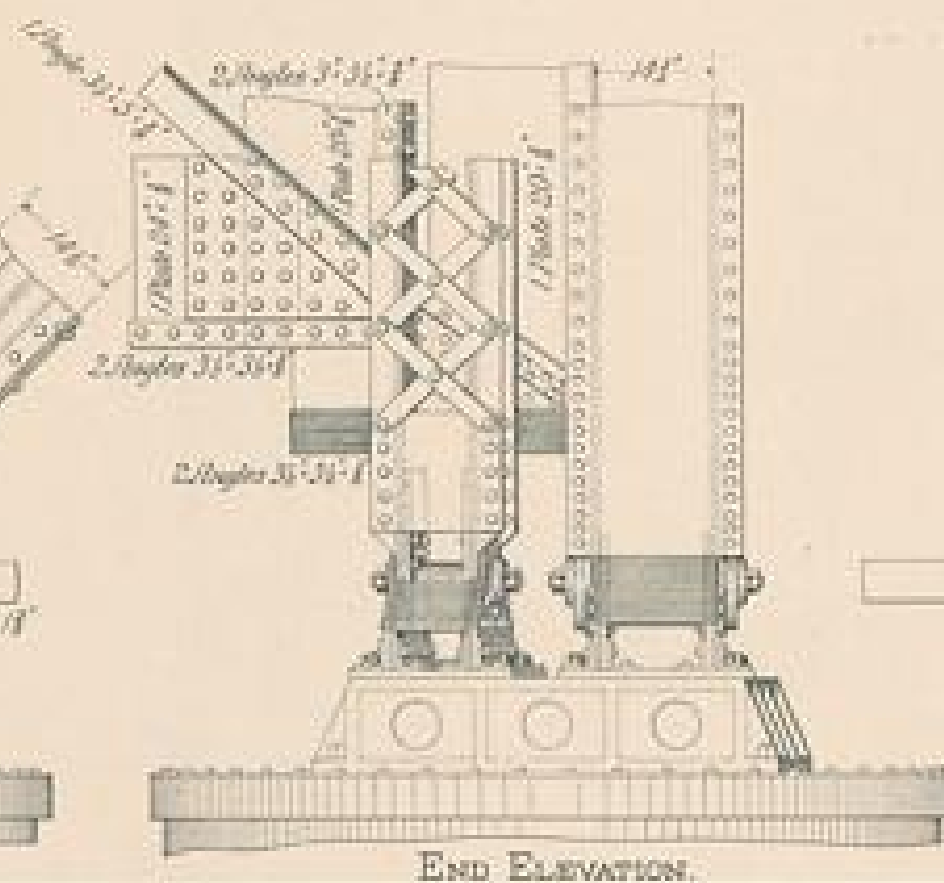
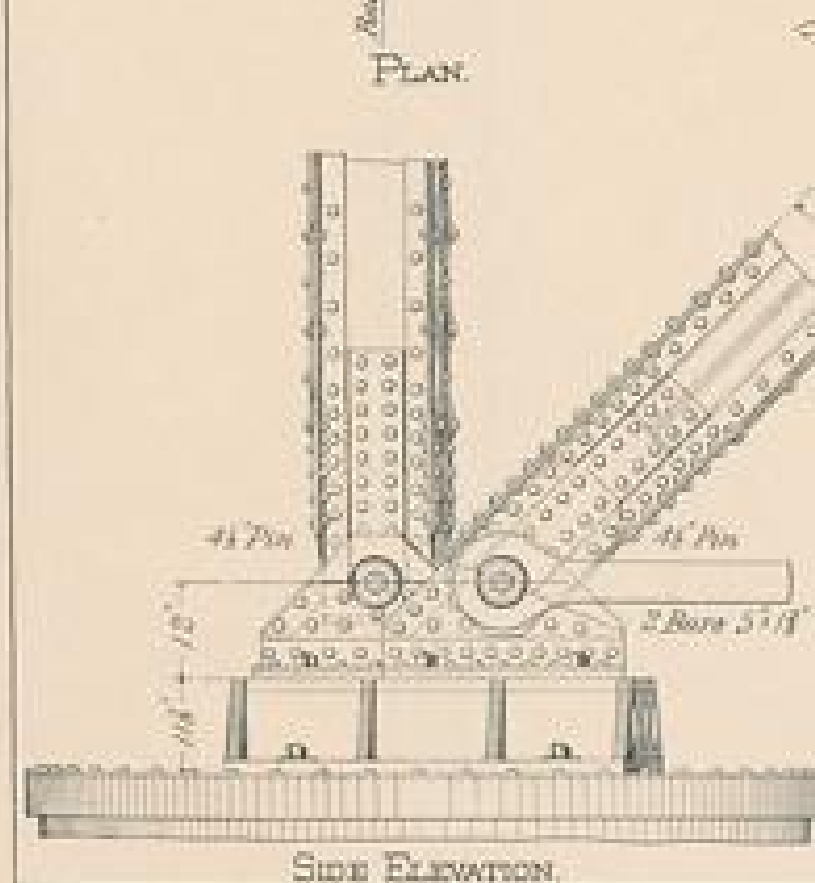
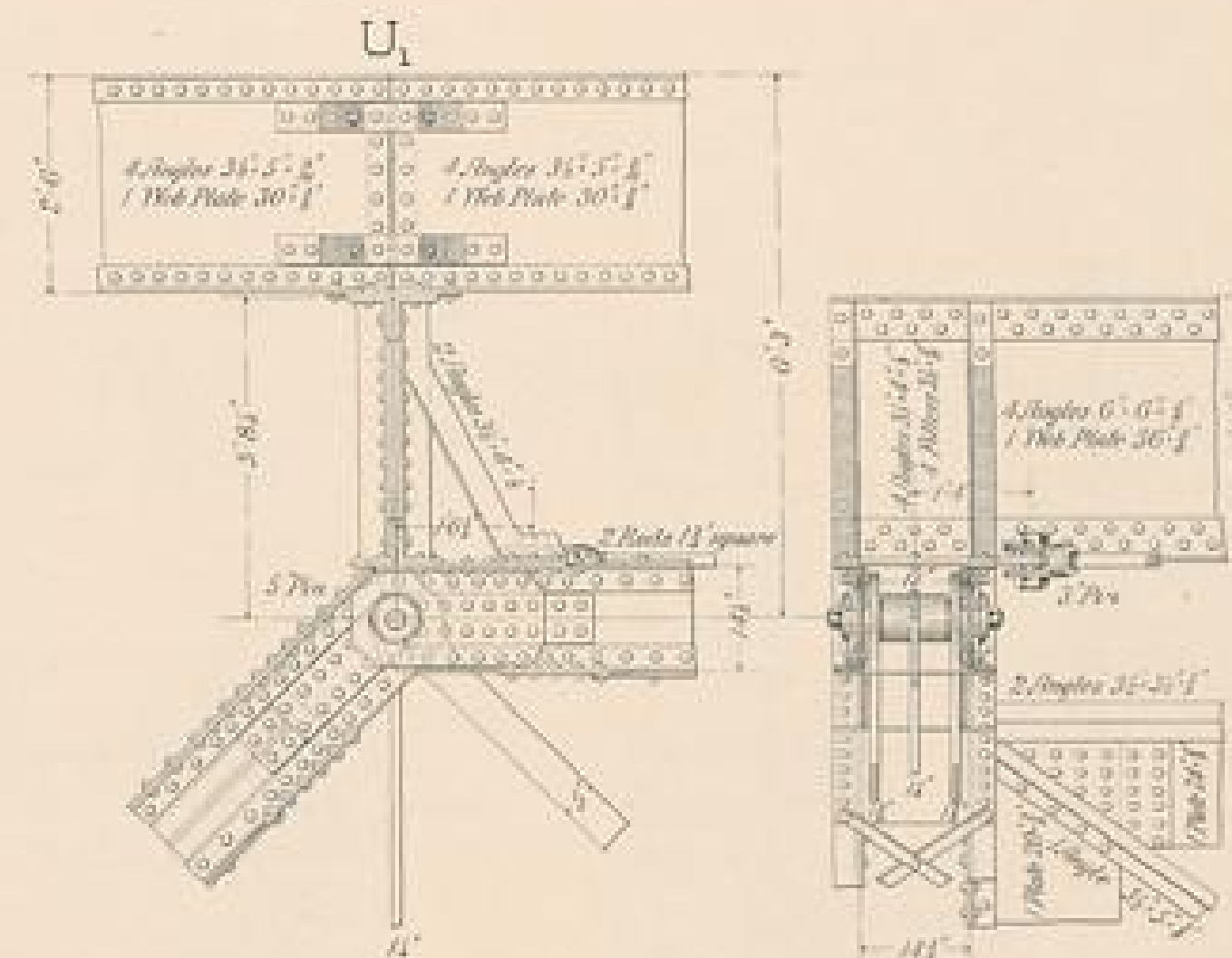
C. ST. L. & N. O. R. R.
CAIRO BRIDGE.

150'-0" DECK SPAN.

DETAILS OF PANEL POINTS L_0 AND U_1L_1 .

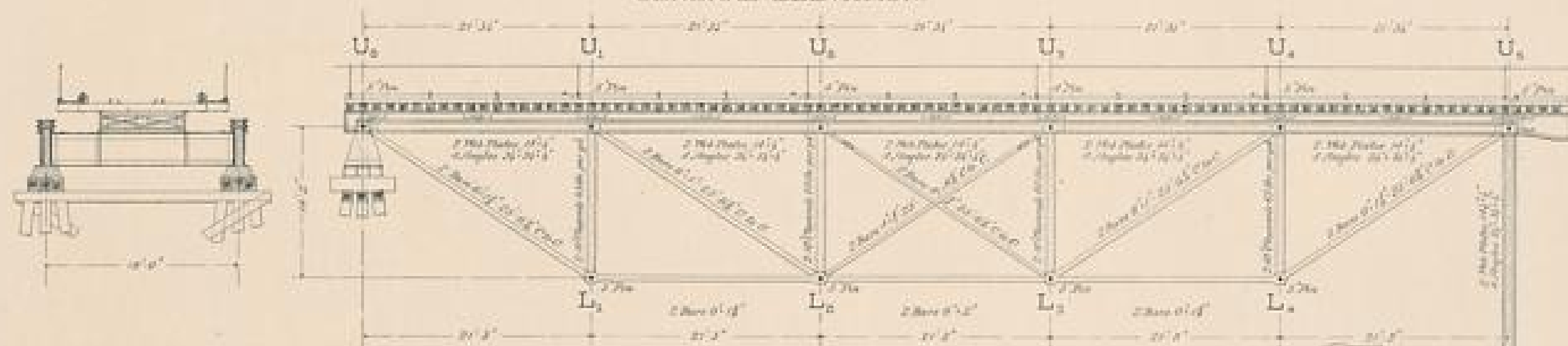


L_0 ON CURVE.



C. ST. L. & N. O. R. R.
CAIRO BRIDGE.
108-3 DECK SPAN.

Scale
Feet
Meters
GENERAL ELEVATION.



PACKING OF TOP CHORD.

