1890

# New York, Providence and Boston Railroad. Report to the General Manager, Upon the Construction of the Thames River Bridge and Approaches, at New London, Conn., by Alfred P. Boller, Chief Engineer

Alfred Pancoast Boller

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THE THAMES RIVER BRIDGE, NEW LONDON, CONN.

N. Y. P. & B. R. R.

# NEW YORK, PROVIDENCE AND BOSTON RAILROAD.

## REPORT TO THE GENERAL MANAGER,

UPON THE CONSTRUCTION OF

# THE THAMES RIVER BRIDGE AND APPROACHES,

## AT NEW LONDON, CONN.,

BY ALFRED P. BOLLER, - - CHIEF ENGINEER.

ENGINEERING OFFICES,
71 Broadway, New York.

J. W. MILLER, ESQ.,

GENERAL MANAGER, N. Y. P. & B. R. R.,

New York.

DEAR SIR:

I hand you herewith my report upon the construction of the Thames River Bridge, with the approaches thereto, at New London, Conn., together with a short historical account of the enterprise from its inception, which is worthy of record for the sake of the men whose courage and far-sightedness brought about such a great public improvement.

I take this occasion to express my grateful appreciation of your kindness and hearty support throughout this most difficult undertaking, as well as that of the whole staff of your operating department, who were ever willing, when called upon, to render all aid in their power, without whose co-operation the rapidity with which the work was performed and opened to travel would have been impossible.

I have the honor to remain,

Very truly yours,

ALFRED P. BOLLER,

*Chief Engineer.*

JANUARY 1, 1890.

## CONSTRUCTION CORPS.

ALFRED P. BOLLER, - - - - - - - - - Chief Engineer.

J. Albert Monroe, - - Resident Engineer.

Leverett S. Miller, - . - Assistant Engineer.

Robert Escobar, - - - Assistant Engineer.*

Arthur B. Corthell, - - - - Assistant Engineer.

M. Ward Easby, - - - Draughtsman.

E. Hicky, - - - - - - Draughtsman.

E. E. Buchanan, - - - Draughtsman.

Pittsburg Testing Laboratory - Inspector at Mills.

W. A. Nettleton, } Inspectors at

J. V. Hanna, } Shop and Erection.

P. S. Bliven, - - - - - Inspector Masonry.

Lester J. Corthell, - - Inspector Timber-work.

Thomas Robinson, - - - Inspector Masonry.

Fred. C. Fisk, - - - - - Land Agent.

Augustus Brandigee, - - - - Counsel.

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Contractors for River Bridge and Approach Superstructure, - - - - - - - Union Bridge Company, New York.

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## SUB-CONTRACTORS.

Masonry and Foundations, - Alex. McGaw and Warren Rosevelt, New York.

Machinery and Engine Work, - - - Joseph Edwards & Co., New York.

Erection of Superstructure, - - - - Baird Brothers, Pittsburg, Pa.

Contractors for East Approach, - - Boynton Brothers, Providence, R. I.

Contractors for West Approach, - Ingersoll, Nash & Co., Providence, R. I.

Contractor for Trestle Work, - - - - Warren Rosevelt, New York.

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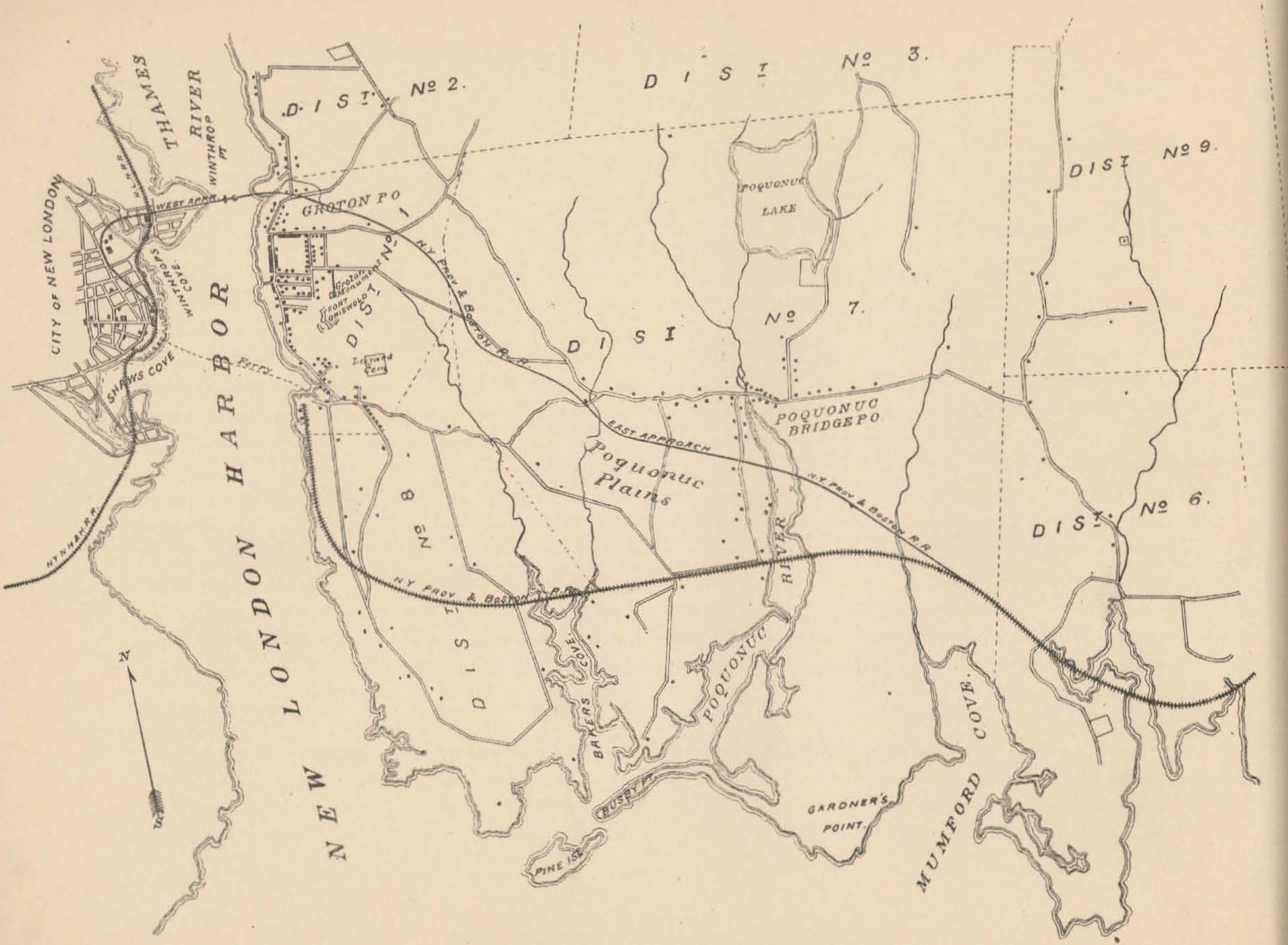
* Messrs. C. L. Cook and F. J. Boller were assistant engineers on the original surveys 1882, the former in charge of party.




APPROACHES TO THE THAMES RIVER BRIDGE,
NEW LONDON, CONN.

SCALE 1 INCH TO ½-MILE.

MARCH 9TH, 1889.

# PRELIMINARY.

EVER since the establishment of the "Shore Line route" between New York and Boston, about 1860, the desire to replace the ferry over the Thames River, at New London, with a bridge, has been ever present with the interested corporations forming the line. Thirty years ago, the then engineer of the "Stonington road," Mr. A. M. Matthews, was engaged in making surveys for the purpose, and did locate a line of approach from the Stonington road to the most probable location of the bridge crossing, dictated by local and topographical considerations. The soundings made through the ice by Mr. Matthews, during the winter of 1859, disclosed such a depth of water and of mud before hard bottom was reached, as to force the abandonment of the project, it being one beyond the engineering and financial resources of the day. Nothing further was done in the matter until the winter of 1882, when the great development of the Shore Line traffic impelled the group of roads forming the line to make another effort to attain the long desired bridge, which the marvelous development of modern engineering and the command of large financial resources made now a possible enterprise.

Application was made, accordingly, to the General Assembly of the State of Connecticut, for authority to bridge the Thames River, and, on April 6, 1882, a bill was finally approved, "Authorizing the New York, Providence and Boston Railroad Company to bridge the Thames River and extend its lines," as follows:

"SECTION 1.—The New York, Providence and Boston Railroad Company is authorized to construct and maintain a railroad bridge, with suitable openings, across the Thames River, not below Winthrop's Point, and also across any inlet thereof, and to locate, build and operate an extension of its road to and over said bridge, and to any railroad in the towns of New London or Waterford, and to take lands therefor in the mode and subject to the conditions of the statutes in relation to railroads, and of the general railroad law; provided that the tracks of any other railroad company shall not be crossed at grade without its consent.

"SECTION 2.—This resolution shall not take effect until a board of competent army and navy officers, designated by the Secretary of War and the Secretary of the Navy of the United States, shall approve the plans and a location for said bridge, which will not practically interfere with the navigation of said river for commercial or naval purposes, or the usefulness and efficiency of the navy yard upon the same, and the said company shall file in the office of the Secretary of this State notice of the time when it will make application for the designation of said board, and also copies of its proposed plans and location of said bridge, at least fifteen days before making said application."

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The Boston and Providence Railroad was completed to Providence in 1852. The Stonington Line to New London in 1858. The Shore Line, from New Haven to New London, was opened in 1852.

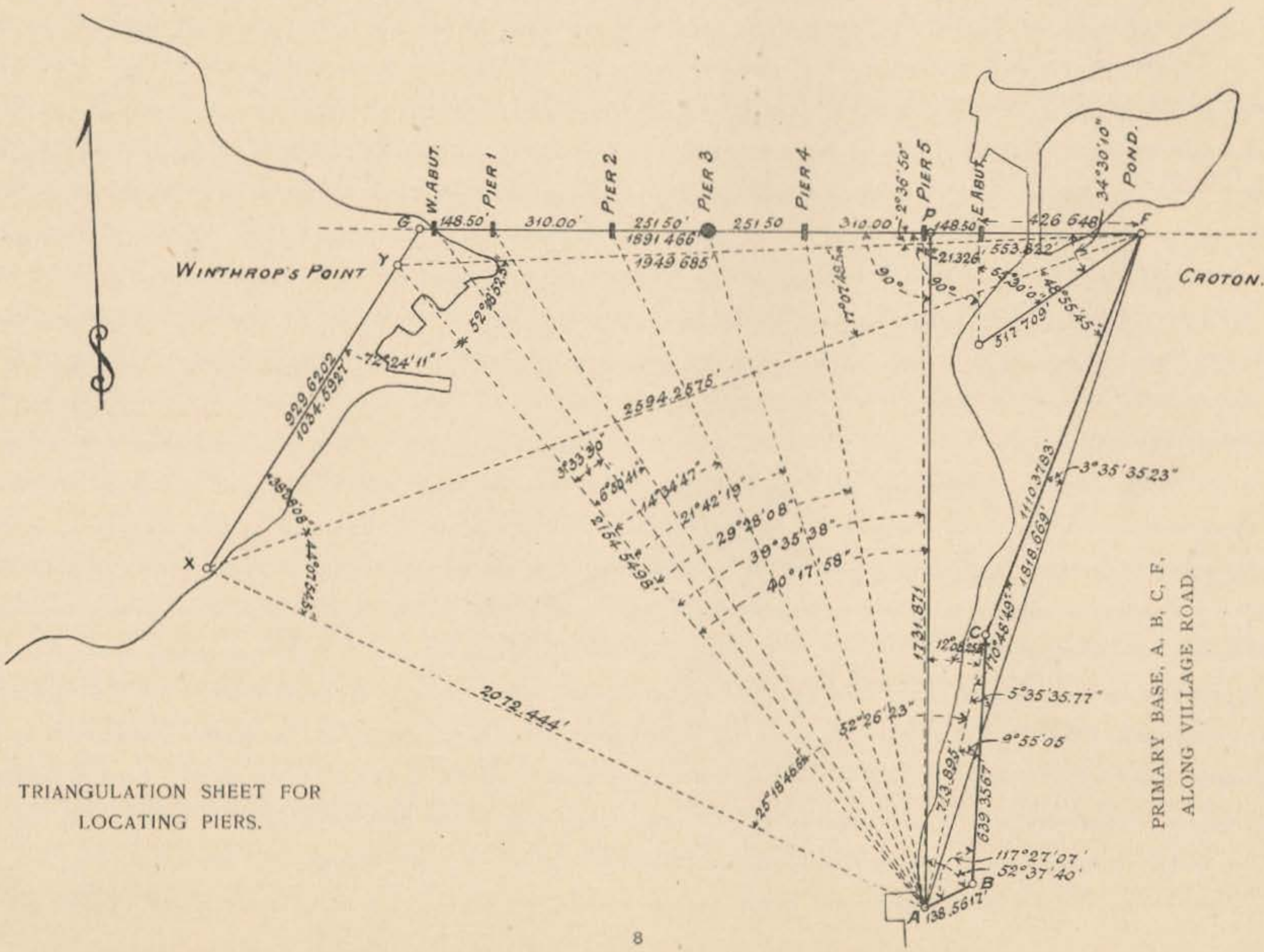
This bill was only passed after a bitter contest and a most persistent opposition by interested parties, who saw in their imagination the beautiful Harbor of the Thames destroyed, the City of New London ruined, and the little naval station of the Government above the contemplated crossing, abandoned to decay, and the dream of a great navy yard at New London forever dissipated. The politics of the State were affected by this contest, and every conceivable machinery of opposition was worked to defeat the passage of the bill. The bill, as passed, was a compromise measure, the opposition resting confidently upon the second section as a saving clause, in the final expectation that no Government commission, as provided, would ever agree to approve any plan of bridge below the naval station, as it was known high naval authority was strongly opposed to it.

As no national legislation in accordance with the provisions of this bill could be had before another year rolled around, it was deemed advisable to employ the intervening time in examining thoroughly the physical requirements of the enterprise, and have all plans and estimates prepared in anticipation of favorable action by Congress. To this end, the joint corporations appointed the following committee to conduct the investigation: President, Henry A. Whitney, Esq., on behalf of the Boston and Providence Railroad; Vice-President, Captain D. S. Babcock, of the New York, Providence and Boston Railroad, and Charles P. Clarke, Esq., Second Vice-President, representing the New York and New Haven Railroad, with George MacCulloch Miller, Esq., advisory counsel. This committee arranged with the writer to take charge of the investigation, and to make a thorough technical examination of the whole enterprise covering the question of the approaches from the Union Station in New London (at that time an exceedingly modest station building west of State Street) to connection with the Stonington Road near Mumford's Cove, a distance of about five miles, and to report the results of the examination at the earliest moment. The result of this work, so far as the bridge crossing was concerned, was embodied in a report to the committee with the necessary maps and plans, in the latter part of December, 1882, the final report upon the approaches being deferred until the bridge question itself was determined and Congressional action obtained. In a work of such magnitude as the one proposed, it was deemed advisable by all parties concerned that this report should be submitted to an independent engineering commission for criticism and recommendation, and to that end the following gentlemen were appointed to constitute such commission, by the respective corporations: For the New Haven Road, Charles C. Martin, Esq.; for the New York, Providence and Boston Railroad, O. Chanute, Esq., and for the Boston and Providence Road, Col. J. Albert Monroe. After numerous sittings and a personal visit to the proposed location, this commission on March 28, 1883, united in a report, approving the location and plans laid before them, together with the estimates of cost. In the meantime, on March 2, the Forty-seventh Congress, at its second session (chapter 94, Public Acts), had passed an Act authorizing the bridge, declaring it a post route, and in all points harmonious with the bill as passed by the Connecticut Legislature.

Under the requirements of both the State and National Acts, application was at once made by the New York, Providence and Boston Railroad Company for the appointment of the joint Army and Navy Commission, to pass upon the plans and location that had been prepared and approved by the company. In accordance therewith, there was appointed by the Secretary of War, on behalf of the Army, Gen. John Newton, Col. George H. Elliott and Major Walter McFarland, of the Engineers, and on behalf of the Navy, by the Secretary of the Navy, there was appointed Capt. Robert L. Phythian and Commander A. T. Mahan.

The Board organized at New London the following May, with General Newton as Chairman, and Lieut. John Millis, U. S. Engineers, as Recorder. Public hearings were had, and a final effort was made to defeat the project by the cities of New London and Norwich and the New York and New England Railroad Company (controlling the Norwich line steamboats), who did not oppose the bridge as an enterprise, but wanted one clear span of 1,500 feet, and 130 feet above the water. The dangers to navigation were frightfully portrayed by river men, and the current of the river rose in the testimony to that of a mill-race. After a patient attention to the opposition, some independent current observations and a careful revision of the proposed plan, the commission unanimously reported, July 25, to the Secretaries of War and Navy, approval of the plans as presented, with the exception that they raised the grade of the bridge six feet higher than the plans called for, and required that the rounded nosing shown on the pier plans should be changed on the north end to an ice breaker point starting one foot below low water to one foot above high water, two requirements that added proportionately to the cost of the work, the latter with no apparent reason, and destructive of architectural effect. All legal difficulties now being out of the way, so far as the bridge was concerned, attention was given to the resumption of the surveys and estimates for the approaches. The location of the bridge necessitated an approach of one mile through the city of New London and four miles through the town of Groton, a very rough and rugged district in which to build a railway. The exact location of the proposed new Union Station in New London was an important point to establish, and was settled finally, after much discussion, at the foot of the "Parade," where now built, as least disturbing to the existing order of things. Both approaches were expensive to build at best, that in New London requiring particular care in its location to avoid expensive buildings, and yet not sacrifice a proper alignment to initial economy. In the spring of 1884 the maps and profiles of the approach surveys were completed, and laid before the Rail Commissioners in conformity with the State law, by whom they were approved on the 15th May. The whole work, including right of way, was estimated to cost one and a quarter million dollars, the plan of the bridge being for single track, and the approaches double track. All technical and legal questions being now settled, the financial one alone remained for solution, and negotiations were commenced between the several interests involved for an apportionment of cost of building the bridge, and other matters incidental to a joint ownership of such a structure. Repeated meetings between the representatives of the railways concerned resulted in no agreement upon a financial basis, and the whole enterprise was allowed to drop, when, apparently, on the eve of accomplishment. It was evident that the difficulties of any tri-partite interest were insuperable, and it was useless to make further efforts in that direction. Thus matters stood for nearly four years, when, through the exertion of Mr. George M. Miller, who had succeeded the lamented Capt. D. S. Babcock as Vice-President of the New York, Providence and Boston Railroad Company, and who had been a most devoted advocate of the enterprise, that corporation determined to shoulder the whole financial burden of building the bridge, and in February, 1888, notified the writer to at once prepare for the commencement of the work, and to make comparative estimates for both single and double track structures, as it was exceedingly desirable to avoid a break in the double track line. As the original estimate for a single track structure had been made on a most liberal basis, on higher market prices than now ruling, and as the substructure work and masonry only required a slight expansion to meet double track requirements, to say nothing of the advance in the art of bridge building and the use of steel, even in the short interval of four years, it was computed that a double track bridge could be covered very nearly, if not quite, by the original estimate. The plans and specifications were modified accordingly, and invitations to tender for the whole work on a unit basis were issued to a selected few of the bridge building firms of the country. After a careful canvass of the bids submitted, the work was awarded to the Union Bridge Company, of New York, under a contract dated April 6, 1888.

During the succeeding summer, a relocation of the approaches was made, purchases of right of way vigorously prosecuted, and the whole work put under contract in the early fall, the Company reserving to themselves the ballasting and track laying. Circumstances having interfered with the right of condemnation under the order approving the location by the Railroad Commissioners, all parcels of property were secured by private negotiation, with the exception of six pieces, which were taken under condemnation as part of the bridge approaches.




TRIANGULATION SHEET FOR LOCATING PIERS.

PRIMARY BASE, A, B, C, F, ALONG VILLAGE ROAD.

## GENERAL DESCRIPTION.

The line of the west approach leaves the Union Station at the foot of the "Parade," or State Street, New London, bearing up through the blocks on the westerly side of Water Street, on a .0714 per cent. grade, crossing John, Douglass, Federal and Hallam Streets at grade, and edging along east side of Main Street as far as the north end of the Albertson & Douglass machine shop, where it curves to the right over a substantial timber trestle across the "Cove" on an 8½-degree curve, crossing Winthrop Street overhead, thence on a tangent in line with the bridge, crossing over the tracks of the New London Northern Railroad on a steel bridge two hundred feet long, thence over a temporary trestle to the west abutment of the River Bridge crossing the river on a level grade 38 feet above mean low water. On the Groton side, the line leaves the East Abutment continuing on the tangent, which swings by an easy curve of 2½ degrees to the right into the synclinal of the first drainage valley on an .08 per cent. grade, involving a cut of about half a mile averaging some 12 feet in depth, thence through a very rough country to the Poquonnoc Plains, crossing the Poquonnoc River on a steel girder-deck span of 60 feet in length, continuing to a junction with the old line at Poquonnoc Junction. The alignment secured was a remarkable one, for the country traversed, having only one curve as much as 4½ degrees, and no grades over 42 feet per mile. There are no highway grade crossings, steel girders being used for all railway crossings, and wooden bridges for all overhead highway bridges. The total distances are as follows:

| | | |
|---|---|---|
| From Union Station to West Abutment | 1.00 mile. | |
| From West Abutment to East Abutment | 0.27 | |
| From East Abutment to Poquonnoc Junction | 3.86 | 5.13 miles. |

The location of the bridge line, which was preliminary to that of the approaches, was made after a prolonged and thorough hydrographic survey of the river from Winthrop's Point (the lowest southern limit permitted by charter) for more than half a mile up the river, having in view the only feasible outlet on the Groton side, the avoidance of the improved property of East New London, and affecting the lands of the Northern Railroad as little as possible. The grade was determined primarily by the necessity of crossing Hallam Street at grade, and the tracks of the Northern Railroad by an overhead bridge within one-quarter of a mile of the river, while incidentally it was desirable that the bridge should be high enough to permit the passage of low-masted craft and tugs without opening the draw. On the Groton side, the heavy work in getting away from the river dictated as high a river crossing as the limitations on the New London side permitted.

The Thames River is properly an arm of Long Island Sound, extending some fourteen miles inland up to the city of Norwich, at which point empty into it the Shetucket and Yantic Rivers, draining steep and precipitous water-sheds, as does the Thames River itself, on either side, to within a short distance of its mouth. The Thames is a broad stream, with irregular shore lines for about one-third of its length from its mouth, whence it rapidly contracts to its head at Norwich. Winthrop's Point juts out into the river about three miles from the Sound, contracting the stream to a width of about fifteen hundred feet, and affording an upper and lower harbor, in either one of which the deepest draught vessels can anchor. The current is purely a tidal one, save when increased at the surface during spring freshets, or seasons of heavy rainfall, when the tributary streams are running abnormally full.

Current observations made after the completion of the work through the East Channel of the Draw, at about one-half ebb-tide on the afternoon of December 10, 1889, no wind blowing and the water smooth, gave the following results:

| | |
|---|---|
| Surface velocity | 1.188 miles per hour. |
| 10 feet below surface | 0.792 " " |
| 20 " " | 0.636 " " |
| 30 " " | 0.579 " " |
| 40 " " | 0.577 " " |

All velocities below surface are somewhat in excess of the real velocities at the depths noted, as the record staff was of the full depth given, and was influenced by the higher velocities on the upper portion. It is doubtful if the bottom velocity is much if any in excess of one-quarter mile per hour.

The rise and fall of the tide between mean high and low-water mark is $3\frac{6}{10}$ feet, with an extreme of about 6 feet at spring and neap tides. The bottom of the river is that characteristic of a tidal estuary, commencing with mud, stiffening through various degrees of consistency into clays, clay and fine sand mixed, clay, sand and shelly fragments, into pure sand, thence into gravel, increasing in coarseness until the boulders of the alluvial drift are reached, or ledges of the underlying rock, hard bottom in consequence being very irregular. The profile accompanying this report exhibits the depths of water and borings to hard bottom, while the table on following page gives the exact record across the river and at each pier

These borings and soundings were performed by Messrs. Spielman & Brush, Civil Engineers, of Hoboken, N. J., and were made on the driven-well principle of forcing a jet of water down a small pipe within a pipe of larger bore, the jet returning upward in the annular space between the pipes, carrying with it the material penetrated, which may be caught in vessels for examination and record. The pipes used were of ¾ and 2 inches bore for the inner and outer pipes respectively. This method, while a dangerous one to draw deductions from under many circumstances, where fine material may be washed up with no suggestion of a coarser one through which the tube might be passing, and by the washed-up samples being of an entirely different consistency from the material in *place*, still, in cases of this kind, the method serves an admirable purpose, since the geological character

## RECORD OF SOUNDINGS (IN PART) AT BRIDGE SITE—REFERRED TO MEAN LOW WATER DATUM, MEAN HIGH WATER BEING + 3.60.

| No. 0. | |
|---|---|
| Water | 0.00 |
| Coarse sand | 7.45 |
| Fine sand | 2.00 |
| Coarse sand | 11.00 |
| Fine sand, dark | 2.00 |
| Coarse sand, light | 7.00 |
| Mixed sand | 6.00 |
| Total depth | 35.45 |

| No. 1. | |
|---|---|
| Water | 0.80 |
| Coarse sand, dark | 6.00 |
| Coarse gravel and sand | 9.00 |
| Fine sand, dark | 8.00 |
| Total depth | 23.80 |

| No. 2. | |
|---|---|
| Water | 2.50 |
| Sand and gravel | 7.00 |
| Gravel | 4.00 |
| Very fine sand | 4.00 |
| Coarse sand | 22.00 |
| Total depth | 39.50 |

| No. 3. | |
|---|---|
| Water | 7.40 |
| Fine sand | 2.00 |
| Coarse gravel and sand | 17.00 |
| Coarse gravel and sand | 17.00 |
| Very fine sand | 8.00 |
| Total depth | 51.40 |

| No. 4. | |
|---|---|
| Water | 36.55 |
| Mud without driving | 15.00 |
| Clay and fine sand | 39.00 |
| Clay and coarse sand | 23.00 |
| Fine light sand | 2.00 |
| Total depth | 115.55 |

| No. 5. | |
|---|---|
| Water | 44.70 |
| Mud without driving | 22.00 |
| Clay and fine sand | 55.00 |
| Total depth | 121.70 |

| No. 6. | |
|---|---|
| Water | 55.50 |
| Mud without driving | 10.00 |
| Mud and blue clay | 53.50 |
| Fine sand | 4.00 |
| Total depth | 123.00 |

| No. 7. | |
|---|---|
| Water | 55.00 |
| Mud without driving | 35.00 |
| Clay and sand | 32.00 |
| Total depth | 122.00 |

| No. 8. | |
|---|---|
| Water | 53.80 |
| Mud without driving | 38.00 |
| Clay and sand | 29.70 |
| Total depth | 121.50 |

| No. 9. | |
|---|---|
| Water | 47.00 |
| Mud without driving | 25.00 |
| Clay | 15.00 |
| Sand and shells | 26.00 |
| Fine sand | 3.00 |
| Total depth | 116.00 |

| No. 10. | |
|---|---|
| Water | 45.00 |
| Mud without driving | 26.00 |
| Clay | 17.00 |
| Clay, sand and shells | 26.50 |
| Fine sand | 2.00 |
| Total depth | 116.50 |

| No. 11. | |
|---|---|
| Water | 33.00 |
| Mud without driving | 16.00 |
| Coarse sand and gravel | 9.00 |
| Sand and shells | 3.00 |
| Total depth | 65.00 |

| No. 12. | |
|---|---|
| Water | 27.50 |
| Mud without driving | 23.00 |
| Sand and gravel | 3.00 |
| Total depth | 53.50 |

| No. 13. | |
|---|---|
| Water | 17.00 |
| Mud without driving | 14.00 |
| Mud driven | 0.50 |
| Total depth | 31.50 |

| No. 14. | |
|---|---|
| Water | 15.80 |
| Mud without driving | 15.80 |
| Sand, gravel and shells | 4.00 |
| Total depth | 35.60 |

| No. 15. | |
|---|---|
| Water | 9.10 |
| Mud without driving | 5.00 |
| Sand and gravel | 1.90 |
| Total depth | 16.00 |

| No. 20. | |
|---|---|
| Water | 41.50 |
| Mud without driving | 36.50 |
| Clay and mud | 10.00 |
| Clay and sand | 13.00 |
| Total depth | 101.00 |

| No. 21. | |
|---|---|
| Water | 50.50 |
| Mud without driving | 36.50 |
| Clay, sand and shells | 23.00 |
| Sand and shells | 15.00 |
| Total depth | 125.00 |

| No. 27. | |
|---|---|
| Water | 57.00 |
| Mud without driving | 29.00 |
| Clay and mud | 9.00 |
| Clay, sand and shells | 33.00 |
| Total depth | 128.00 |

| No. 30. | |
|---|---|
| Water | 32.00 |
| Mud without driving | 23.00 |
| Mud and clay | 15.00 |
| Clay and shells | 22.00 |
| Fine sand | 4.00 |
| Coarse sand | 3.00 |
| Total depth | 109.00 |

| No. 32. | |
|---|---|
| Water | 43.00 |
| Mud without driving | 30.50 |
| Clay | 14.50 |
| Clay and sand | 15.00 |
| Clay | 5.50 |
| Total depth | 117.50 |

| No. 34. | |
|---|---|
| Water | 51.00 |
| Mud without driving | 20.00 |
| Clay and mud | 13.00 |
| Clay, shells and sand | 38.00 |
| Fine sand and shells | 6.00 |
| Total depth | 128.00 |

| No. 36 | |
|---|---|
| Water | 51.50 |
| Mud without driving | 20.50 |
| Clay and mud | 5.00 |
| Clay, shells and sand | 15.00 |
| Fine sand and shells | 10.00 |
| Clay | 21.00 |
| Sand and shells | 4.50 |
| Total depth | 127.50 |

| No. 38. | |
|---|---|
| Water | 52.50 |
| Mud without driving | 18.50 |
| Clay and mud | 15.00 |
| Clay, sand and shells | 25.00 |
| Fine sand and shells | 17.00 |
| Total depth | 128.00 |

| No. 41. | |
|---|---|
| Water | 53.00 |
| Mud without driving | 22.00 |
| Clay and mud | 10.00 |
| Clay, sand and shells | 41.00 |
| Total depth | 126.00 |

| No. 43. | |
|---|---|
| Water | 48.00 |
| Mud without driving | 18.00 |
| Clay and mud | 5.00 |
| Clay and sand | 54.50 |
| Total depth | 125.50 |

No. 0 at West Abutment (N. L. side).
Nos. 27, 40, 41, 43 at Pier 2.
Nos. 20, 29, 30, 31, 32 at Pier 4.
No. 15 at East Abutment.
Nos. 2 and 3 at Pier 1.
Nos. 33, 34, 35, 36, 37, 38, 39 at Pier 3.
Nos. 13, 14, 18, 19 at Pier 5.

Rock (probably boulders) was supposed to be reached at Nos. 41 and 43 and at Nos. 32, 30, 20, 11, 12, 13, 14, 15.

of the crossing could be determined from the surrounding country and from the well-known laws that govern deposits in streams. The extent of the deposits could be accurately determined, while their consistency could be judged in the light of the geological facts, and driving of test piles. The method is a rapid one, the deepest borings not requiring over a day, while from two to five borings were made where shallower. When the work was actually commenced, the upper mud proved to have much greater consistency than the borings indicated. It was of a peculiarly tenacious character, and stood readily on a slope of one to one, when dredged out for settling the cribs.

**Teredo and Limnoria.**—The operations of these destructive creatures are most entirely confined to the lower harbor, and even there they are only moderately active. So far as it was possible to discover, the waters around Winthrop's Point and above, seemed to be almost entirely free from them. Some, oak piles, reputed to have been driven fifteen to twenty years before, when pulled up were practically as sound as the day they were driven, showing merely some surface peppering, as it were, of the limnoria, with a very occasional short burrow of the teredo. The limnoria is the great pest of the New England shores, but does not work at great depths. Its ravages are external, slivering away the wood in fine particles from the outside, while the teredo burrows into the heart of timber (entering from the outside as fine as a needle), in which it grows, and destroys it through myriads of cells. A curious fact about the teredo is that it will not cross a seam, or break into the cell of a neighbor, although there may be the barest partition between. Neither creature works below the mud, or in foul or brackish water. The only sure preventive thus far discovered against the ravages of these pests, is the impregnation of the timber exposed with the dead oil of coal tar, a preventive that has been thoroughly demonstrated by a large number of tests through a series of years, in warm and tropical countries, where unprotected timber is destroyed completely in a single season. In the waters in and around New York, creosote has proved a perfect barrier against them. But it is essential that the creosoting should be properly done, and preferably a product of coal tar, there being a considerable difference of opinion about the efficacy of that obtained from wood distillation. The creosoted material used in the Thames River Bridge is impregnated with fourteen pounds of the oil to the cubic foot, under a pressure of 150 pounds per square inch, after the timber had been heated up to 250 degrees Fahr. in a vacuum of 26 inches.

**Location of Piers.**—To the proper location of the Piers, much thoughtful consideration was of necessity given, in the endeavor to harmonize real or imaginary navigation interests, economy of construction, and the selection of such points in the profile as promised best foundation conditions. Under any practicable arrangement, constructive or economic, less than three deep-water piers were unavoidable, involving at best long spans which would be in harmony also with probable government requirements. The arrangement of piers adopted provides for a Draw span 503 feet long, flanked on either side by a span of 310 feet and 150 feet, respectively, center measurements. The East Abutment was so placed as to utilize by embankment the material from the heavy cut just beyond the river. The axis of the piers in relation to the current chart may seem at first sight to be wrongly placed, but the chart must be studied in connection with the general map of the river, extending from the Naval Station to its mouth. From this it will be seen that the bridge line is as near as may be at right angles to the line of navigation and with the axis of the general trend of the current, and with the position of the Draw span as arranged, the openings are in almost a straight line from the Sound to the Naval Station, a stretch of over four miles, avoiding all questions of steerage way for large vessels and tows in making the passage of the Draw. Further, it was extremely desirable to have no skew-piers where such a large Draw was involved, which, fortunately, the sluggish tidal currents of the Thames made a matter of no moment, especially since the current becomes almost dissipated in the great depth of water by the time the bottom is reached, where any scouring strength is practically lost. The projection of Winthrop's Point out into the river forms a contracted vein, the current lines converging through the throat thus formed. This convergence is most marked on the west side at Piers I. and II., the river broadening rapidly either side of the Point. Such irregularity of current lines as there may be, will impinge against these piers with quiet effect. The area of the waterway left after deducting that of the Piers is substantially the same as that at the narrowest point on the neck, immediately south of the bridge line.

**Foundations.**—The financial limits, within which the enterprise would be a feasible one, made the study of the piers and their founding of the leading importance, involving questions of the gravest consideration. The stability and permanence of foundations in water are of the first importance, involving the placing of materials at great disadvantage as compared with work on land, and in them a close economy cannot prevail. The west abutment foundation and that for Pier I. are simple in their character, requiring no special comment. That for Pier V. and east abutment are so clearly shown upon the accompanying illustration that little need be said here concerning them. The soft material was dredged to hard bottom (boulders and gravel), solid double walled square timber curbs were sunk surrounding the foundation area, which was filled in with concrete, lowered in wedged-shaped buckets of a cubic yard capacity, placed and leveled by means of a diver. The horizontal section of these buckets, as hung from the chains, is rectangular, the ends right-angled triangles, points down, the long leg of the triangle being vertical, on which was hung from above the door, constituting a whole side of the bucket. This form of bucket has long answered an admirable purpose, enabling the concrete to be deposited instantaneously, and practically free from wash.

The submarine concreting was carried up to the level of the original river bottom, and surfaced off for the reception of the masonry platform. This concrete was made extra rich, two and one-half barrels of Portland cement to the yard of gravel being used, instead of two barrels, as provided for in open air concreting.

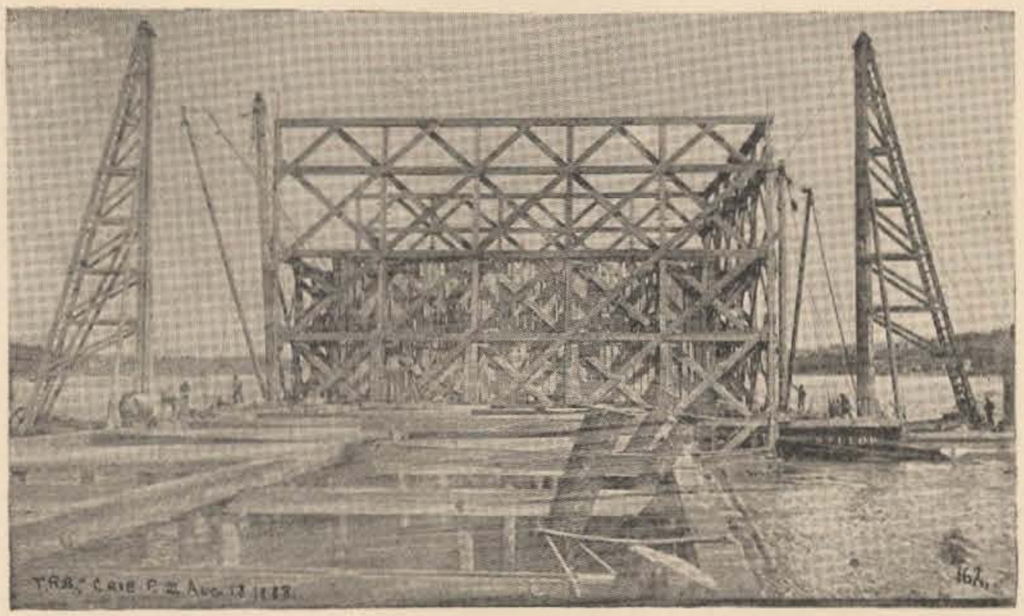
The great foundation difficulties, attached to Piers II., III., and IV., the Draw Pier, with the rest piers on either side. The borings had only reached rock or boulders, under Piers II. and IV., and then at depths of 130 feet, and 100 to 120 feet respectively, below datum (mean low water), with deposits of from 60 to 75 feet overlying the rock. At Pier III., the borings were carried to gravel and boulders, without reaching any suggestion of ledge rock, and the different borings taken were of very irregular depth. To reach the hard bottom, as the borings disclosed, by any of the pneumatic methods (excepting possibly at Pier IV.), was out of the question. Human labor could not be carried on, under the enormous pressures involved, to say nothing of the prodigious cost if practicable. To reach hard bottom through an open caisson either of metal or timber, sunk by means of internal dredging and weighting, and filling up the voids created with concrete deposited through the water was prohibitive through the cost, if indeed there were not grave questions as to the integrity of the concrete so deposited, and the great difficulty, if not impossibility, of dredging to a satisfactory bottom, particularly at Pier III., where the boulders were very irregular. To have stopped short of the gravel, boulders or rock, would involve a foundation on clay, which was not considered prudent. The use of isolated cylinders was considered and abandoned, if for no other reason than the great unbraced depth there would be from low water, to where they would be firmly held in the river bottom, some 70 to 80 feet. The only remaining method of founding which could be considered, and which was adopted, was that of a pile foundation, on which the masonry should be sunk in open caissons, which, owing to the unprecedented depth of water and material, involved novel methods of procedure. The piles must be driven from 100 to 130 feet below water — they must be driven true and straight; and cut off horizontally from 45 to 60 feet below water. They must be grouped in such a mass as to act as unit, and well collared at their upper ends, through the upper stratum of the mud, too soft for lateral support. They must be protected against the possibility of attack by marine worms. It was deemed judicious to adopt ten tons as the extreme loading on the piles, and to drive them with a 4,000-pound hammer, with a short fall and rapid blows. The plan contemplated the sinking of a massive square-timbered, double-wall curb, some 18 to 20 feet below the bed of the river, and surrounding the piled area, the mud within the curb being dredged out, and replaced with sand filling after the piles were driven. Such a filling thrown in loosely from above, would run in and fill every crevice and void among the piles, and embraced by the crib. The compacting of the bottom by closely driven piles, and the frictional support the piles afford to the narrow columns of sand, will, it is believed, prevent any substantial subsidence of the sand through the stiff mud and clay on which it rests. It was the original intention, when this plan was first thought out and adopted, to handle the work from a subsidiary staging, surrounding the foundation area on three sides, and by means of overhead trusses, to control the various operations of dredging, sinking the curbs, etc. But as that was a great expense, it was concluded, upon the revival of the enterprise, to abandon such temporary aids and save the cost towards the double track structure now desired, and boldly perform the work in the open river, with such aids as the permanent guard fenders would afford. In settling the curbs, it was first thought practicable to weight them down into place by dredging the material from within, but after testing the question on the curb for the east abutment, that method of procedure was abandoned, as the mud proved more tenacious, and had greater supporting power than the original borings indicated — and to have carried out the above plan would have involved extensive ballast pockets being built up on top of the curbs.

The dredging was therefore performed as an independent preliminary operation, with a clam-shell dredge, and carried down 18 to 23 feet below the river bottom, the material standing on a slope of one to one — being below datum (mean low water), 77 feet at Pier II., 68 feet at Pier III., and 58 feet at Pier IV.

**The Curbs** are framed from 12x12 hemlock timber, thoroughly drift-bolted together, and consist of a double-walled rectangular frame-work surrounding an open area to contain the piling. These walls are 8 feet apart, and form, with a uniting bottom, a ballast chamber for sinking. This bottom flares downward from the inner to the outer wall, as shown upon the accompanying plate, the voids between the timbers being well packed in with gravel and stone chips to solidify the mass and gain sinking weight. The outer walls are 23 feet deep, while the inner walls finish off on top, 4 feet less. The curbs are strengthened and stayed by transverse partition walls, forming interior cells, in which the piling is driven. The curb for

Pier III. is 71 feet square, with 16 interior cells 12 feet square, while the curbs for Piers II. and IV. are 50x80 exterior dimensions, with 8 cells 15 feet square.

As these curbs would finish at or below the river bottom, for the convenience of their handling and control, as a guide for the piling operations and regulation of the masonry caissons, a stout and well-braced temporary framework was carried up from the partition points of the inner and outer walls, to finish about one foot above high water, when the curbs were settled in place. One side of this framework was kept down sufficiently low to take the draught of the masonry caissons. Some little anxiety was had regarding the control of these curbs during sinking, as to place and level, since the leeway or clearance for the succeeding work was not over 3 feet in any direction, and a comparatively small difference of level at the



SINKING CURB, PIER III.

bottom would have a very marked effect upon the verticality of such a great depth of framework at the surface of the water. This sinking was performed, however, with great success, with the aid of the pile-driving machines and falls attached to the fenders, occupying but a few hours for either curb, and with the following result: At Pier II. curb settled 8 inches N. and 4 inches E. from true position; at Pier III., correct within 2 inches; at Pier IV., correct E. and W., and 4 inches out on the S. For level at Pier II., ends settled 12 inches out on one side, at the remaining piers from 4 to 10 inches out.

So soon as the curbs were settled in place, the pockets were filled with ballast sufficiently to hold them against any possible displacement, and so distributed as to correct irregularities of level as much as possible.

**Piling.**—The piles used were Michigan white pine and Southern yellow pine, as straight as it was possible to get them, and from 85 to 95 feet long. They held their size remarkably well, few measuring less than 9 inches at the point, and were 15 to 20 inches when cut off. The pile-driving scow used was 23 feet by 48 feet, with 70 feet leaders, and a 4,000 pound hammer run by a double drum Mundy 30 H. P. engine, with 10x16 cylinders. The first curb ready to receive the piling was that for Pier III. (center pier), in which piling was commenced August 27. This curb was to contain 640 piles, or 40 piles to a cell. Long as the piles were, when driven they would be from 30 to 40 feet below water, which involved the use of some kind of follower arrangement.

After several trials with ordinary socket connections between follower and pile, it was found impossible to keep from smashing the sockets, and before resorting to a more complicated system of following, a trial was made with a simple ringed oak follower, 16 inches square, with a 2-inch dowel in the end. This method proved so successful that it was adopted and carried out through the rest of the work. It was found that by carefully steadying the machine, holding the follower firm in the leaders and keeping it plumb, the descent of the pile was conveniently controlled under the *short*, quick blows of the hammer. The method adopted for the above foundation was to plant all the piles (excepting in one cell, left for introducing the saw), and then drive them to bearing. There was just hold enough in the bottom to support the piles leaving their heads above, or even with, the water. The planting and driving of these piles occupied about twenty days, barring one cell of 40 piles, which had to await the cutting off of the piles driven, after which this vacant cell was filled and cut.

As no sawing was ever performed in such deep water (from 47 to 51 feet according to stage of tide), the commencement of that operation was awaited with no little anxiety, not only as to the operation itself, but also maintaining a reasonable level plane of cut off, under the swells produced by tide and wind, at times quite heavy. The vertical saw shaft of 3-inch steel, was solidly backed by two 14x14 yellow pine timbers, well bolted together, to within 8 feet of the saw. This back-bearing timber was slung in the leaders of the pile-driver and hoisted up and down, according to the stage of the tide The saws were 50 inches in diameter, three-eighths of an inch thick, with the usual teeth.

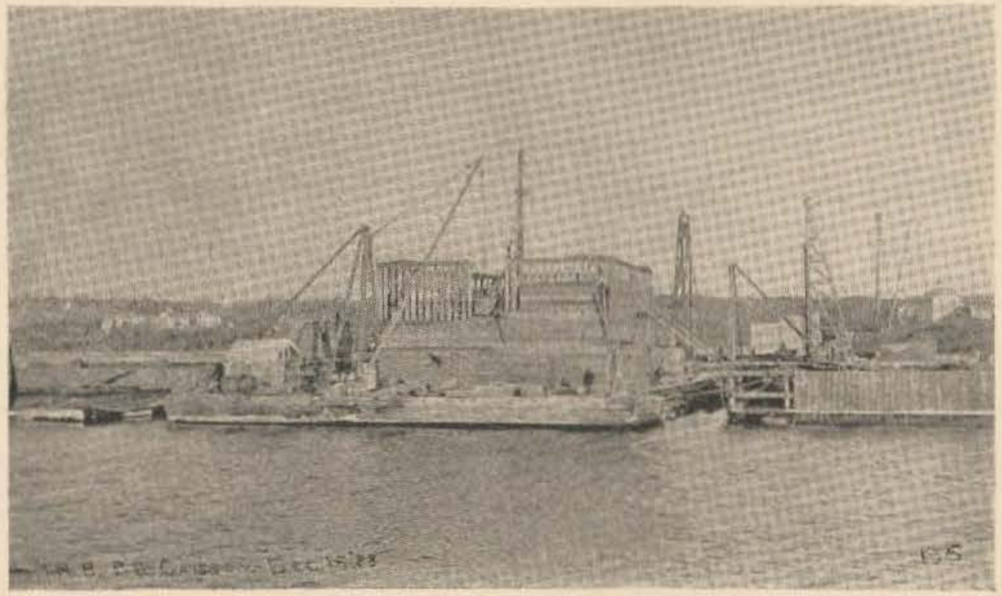
The driving pulley attached to upper end of shaft was 15 inches in diameter, and was driven direct from a 48-inch pulley on the engine shaft through a 10-inch belt. The shaft was run at a speed of about 400 revolutions. It was soon demonstrated that there would be no difficulty cutting off the piles, but it was also demonstrated that hunting up the piles to cut, with no visible guide to locate them, was quite a different matter. The saw would get started into two or more at a time, and the shaft would jam against the upper part of the pile. Backing out was not always an easy thing to do among piles so thickly driven, and the breaking of saws was becoming a serious annoyance. Progress was slow, and prospects were gloomy for the accomplishment of the work in any reasonable time, and resort was had to divers, two being constantly at work in alternate shifts. Their mission was to go down and locate the piles in reference to position of saw, attach a line to each pile that was to be sawed, come up and report direction in which to move the machine. After a little experience, piles began to come up with a reasonable speed, as high as 34 being cut off in one day (which was the exception), some days none, when the saw would get jammed, with resulting trouble and delay. Often the forenoon would promise a good day's cutting, and in the afternoon only one or two would be gotten off. Keeping the cut-off level was an exceedingly troublesome matter—there was no way of sighting from shore, the distance was too great, besides the shifting of the machine in every direction would be continually cutting off the view of the shaft. A level board was therefore attached to one side of the temporary framework that had been carried up from the curbs, with a mate on the opposite side, across which the ring on the shaft was sighted. By this method the piles were eventually cut off. As many of the yellow pine pile tops sank when cut, it was difficult to tell whether any had been missed, and the machine was passed back and forth in two directions, at right angles, shifting two feet each time.

The experience gained in the piling for foundation of Pier III. suggested certain modifications of procedure for Piers II. and IV., the building of their curbs, and their placing, being carried on during the piling operations at Pier III. Each of these piers were to have 368 piles, those for Pier II. being cut off 60 feet below high tide and those for Pier IV. 43 feet below. This last pier followed the center pier, and instead of filling all the cells before cutting, the piles were planted and driven in rows lengthwise with the curb, commencing at one side, each row being cut off as soon as driven, before another row was started. To each pile was attached a line, which was fastened to a guide timber stretching from end to end of the curb and resting on the frame work. This timber was shifted as each successive row was completed. It was found that by starting the saw at one end of the row and following the line as indicated by the attached cords, the work could be rapidly and continuously performed without the aid of divers, and none were again employed throughout the remainder of the piling. The leveling was sighted from carefully placed sight-boards fastened to the fenders outside the curb at either end, having a long slit one-eighth of an inch in width. The observer, standing on the fenders, could comfortably and with great accuracy keep the elevation ring on the saw shaft always in exact line, as was proved by the perfect level to which the masonry platforms settled for these two piers. The sawing off the piles at 60 feet was as readily performed as at 43 feet, but required about one-fifth greater steam pressure. The piles for Pier IV. were driven and cut off in thirty days, and those for Pier II., the last of the deep-water foundations, in about the same time. The piles brought up on hard bottom, or to refusal, under the following driving, from a 4,000-pound hammer:

| | Number of blows. | Average fall of hammer. |
|---|---|---|
| Pier II. | 60 | 3 feet. |
| Pier III. | 140 | 5 feet. |
| Pier IV. | 40 | 4 feet. |

**Sand Filling.**—As the foundation piles for each pier were finished, the whole interior of the curbs and ballast chambers were filled with bank sand in which more or less gravel was intermixed. This filling was at first spouted in through 9-inch tubes reaching nearly to river bottom, but they were soon abandoned for the more expeditious method of shoveling the sand overboard, the current being too sluggish to carry it off from where it belonged, care being exercised to unload at either end, as the tide ebbed or flowed. After the above interior filling, the space between the dredged excavation and the sides of the curb were likewise filled, partly with sand and partly with material dumped from scows brought down from the upper river, where the channel was being deepened by the Government. After the piers were built, this sand filling was carried five to ten feet up the sides of the masonry platforms, covering the outer walls of the curbs, and which the current is too feeble to scour or displace.

**The Caissons.**—During the progress of the foundation work the caissons were being prepared. These caissons are huge boxes in which the masonry is built in the open, sinking slowly as the successive courses are laid, until the boxes rest upon the prepared piling, the bottoms being part of the permanent work, while the sides are detached, and floated off after the masonry is safely above high water. The caissons used for East Abutment and Pier V. were on such a moderate and ordinary scale that they require no special comment. For the three deep-water piers, however, they were of unprecedented magnitude. For Pier III. they were 50 feet square and 50 feet deep, while for Piers II. and IV. they were 30 by 60 feet square, and 59 feet and 45 feet deep, respectively. The depth of the platforms or bottoms of the boxes were regulated by the maximum it was deemed



CAISSON, PIER II.

desirable to load the piles—viz., ten tons each, and by the practicable height of sides over which to hoist the heavy ashlar stones, many of four and five tons weight, which was fixed at 35 feet. Even with this height of sides it was found convenient to have a door in the upper portion of one of the sides for about one-third of its descent, when the door was closed up and material passed over the top. It would be a great convenience to build the sides of such deep caissons in two stories, erecting the second after the first had been sunk to within five or more feet of the top. In fact the original intention had been so to do, but changed at the request of the sub-contractor for this portion of the work, and who admitted afterward that the double-story plan would have given him less trouble and anxiety. The above arrangement of loads and sides brought the depth of the platforms at 23½ feet, 15½ feet and 9½ feet, respectively, for Piers II., III. and IV. These platforms were composed of 12-inch square hemlock timbers, laid in transverse courses. They were started on launching ways, until four courses were put together, when they were launched and finished afloat. The courses were securely drift-bolted together with $\frac{7}{8}$ square by 20-inch bolts, particularly around the sides, for four courses in, where every timber was bolted to each alternate under timber. The timbers had been sawed with great irregularity, involving more or less adzing to bring them in reasonably close contact, and the sides of the platform were carefully squared up. The final course of the platform, on which the masonry was to be started, consisted of a 6-inch calking deck of creosoted Carolina pine, very thoroughly spiked with 12x$\frac{5}{8}$-inch spikes, special care being given to the portion extending beyond the masonry. This deck was laid in Portland cement mortar, spread over the preceding course, which, in turn, was well calked with cotton yarn, which swells when wet. The finishing deck was calked with oakum. The squared-up ends and sides of the platform were cased in with two courses of 2-inch creosoted plank, breaking joint with each other, and secured in place with 6x$\frac{3}{8}$-inch ship metal spikes.

The caisson sides were very stoutly built, as they might be subject to very rough handling during process of sinking. The studs were 6x12. yellow pine, boxed into the calking deck two inches, and placed two feet centers. The corner posts were 12 inches square. The rods were 1⅛ inches diameter placed between every alternate pair of studs, the lower ends running through three courses of timber, the timber at each point being notched out from the side sufficiently to insert the nuts and washers, and previously to finishing up the creosoted casing, while the upper ends of the rods were carried through the top rail of 8x12 timber, drawing down on the top of the studding, which were boxed into the rail timber. The siding consisted of two-inch edged spruce plank, well calked. The internal bracing consisted of 12x12 waling timbers, starting 2½ feet above the deck, and spaced upward at convenient intervals. These wales were doubled up to take the thrust of the corner braces, and in case of the center pier caisson, as it was extremely desirable to omit *all* transverse bracing, a second arch brace was introduced, involving a third wale, to take up the thrust. The caissons for the side piers were transversely braced with timbers about 8 feet apart centers in plan, which were removed as fast as the masonry was built, against which the sides were blocked. All these caissons proved exceedingly tight, only a little leakage taking place through an occasional sun crack in the siding or a loose knot. A small steam syphon, run for a few minutes, took care of what little water that leaked through.

**The Masonry.**—The design of the piers and abutments has been studied architecturally, with reference to the general character of the work and local surroundings, form and mass being relied upon for all architectural value—no cut work being employed excepting the weathering course and pier ends near level of the water. The former was necessarily cut to make a sightly reduction in rapidly narrowing the piers, and the latter in order to obtain the desired form and properly unite the rounded and pointed ends with the square work above. The abutments, to avoid the use of heavy wings to catch the embankments, were so massed with return walls at either end as to allow the embankment material to flow around them, with very great resulting economy in masonry and foundation work. The embankments were compacted and placed around the abutments with great care, so as to reduce the thrust to a minimum. The north ends of the piers have cut stone ice breakers, to meet the requirements of the Board of Government officers, who, in their report to the Secretaries of War and Navy upon the plans, required that ice breakers should be built in the piers, starting from one foot below low water to one foot above high water. There was no engineering or other necessity for this, as the current is a tidal one, and a rounded nosing at either end was the proper finish for the piers. Ice never makes heavy in these waters, and the exceptional currents flowing south at the breaking up of winter, when the head waters are greatly swelled, are of not enough moment to be made of special account. Further, the fact that the main river piers are cased in, as it were, with long fenders, closely sheeted, preventing any ice coming near the masonry, would make ice breakers inoperative as such in any event. The design of the piers could have been greatly improved had it not been for this Government restriction. The rounded ends could have been carried up 8 to 10 feet higher, before breaking back into the rectangular shaft, giving the piers the effect of a longer base, the appearance of which they now lack.

The class of masonry adopted is quarry faced Ashlar in two feet courses for all face work, the hearting being concrete well rammed in place, except for the abutments, where rough backing was used, with concrete rammed in all voids. The Ashlar stone and coping used was brought from the Leetes Island, Conn., quarries. This stone is a coarse-grained reddish toned granite, its constituent parts being very irregularly mixed, which gives a peculiar rugged effect, much in keeping with works of this character. The rock face was preserved just as it came from the quarry, lack of uniformity of projection being avoided as much as possible. The outlines of the piers are sharply defined by two inch arris lines, as also the edges of the coping, the top surface of which is hammer dressed. The beds and builds of the ashlar stone, with the vertical joints were cut to lay to scant half inch joints, the vertical joints being cut back 12 inches, or as near as it was possible to keep the quarries to that minimum. The backs of the stone were left irregular just as they quarried, to lock well into the hearting.

The concrete was made from coarse beach pebbles, beach sand, with Burram Portland cement below water, and improved Union cement above. Two barrels of cement and six barrels of sand being used for each yard of gravel, with an additional half barrel of cement for concrete deposited under water. Mixtures were made in two yard batches, gauged by a frame on deck of the concrete scow, all mixing being performed by hand. The moisture was regulated with careful supervision, and applied by sprinkling pots so that the mortar should be thoroughly damp without being wet. The pebbles were all wetted before applying the sand and cement previously mixed dry. The weight of the concrete so made was 135 pounds per cubic foot, and the solid piers averaged below water 150 pounds per cubic foot, deduced from the flotation of the caissons. Above water, where the hearting formed but a small proportion of the solid, the weight, as near as could be computed, amounts to 160 pounds per cubic foot, the granite itself weighing 166 to 170 pounds.

**Behavior of Caissons.**—Owing to depth of caisson bottoms much care was required in their sinking, particularly for Piers II. and III., more especially the former, as it took eight courses of masonry to bring center of mass below center of displacement, and incessant watchfulness had to be exercised to prevent the caisson from toppling over, which at one time it came near doing. In addition to falls attached to either side, an extra derrick had to be employed for handling balancing stones, for the moment a stone was being set its weight had to be immediately offset by a counterweight on the opposite side. With Pier IV., with nearly two-thirds less depth of bottom than II., the equilibrium was readily maintained by a few pile logs lashed to either side and kept at water surface. The caissons were landed on their foundations remarkably dry, owing to the extraordinary care taken to secure tight bottoms and sides.

**Settlement of Piers.**—Where so much weight was involved, resting upon a great mass of water-soaked timber, composed of unsized sticks, just as they came from the mills, and on which drift bolting could have no appreciable drawing effect, it was to be expected that more or less settlement would occur. Just how much this settlement would be there was no means of knowing from precedent. It was always intended that the Draw Pier should be weighted, if possible, about double the weight of the Draw Span and Turn-table.

For the other piers, weighting was impracticable, owing to their comparative narrowness, besides which it was believed that compensation for settlement could be allowed for in the elevations of the courses sufficiently close for practical purposes, which proved to be the case.

*The following table shows the behavior of Piers II. and IV., the weights given being the resultant dead weight after making allowance for buoyancy of timber bottom, and are calculated from displacement of water:*

| Pier II. | | | | Pier IV. | | | |
|---|---|---|---|---|---|---|---|
| Date. | Course. | Weight. | Settlement. | Date. | Course. | Weight. | Settlement. |
| May 8..... | 16 | ........... ... | 0 | March 4.... | 16 | 0 | ......... .. |
| " 16:..... | 19 | 2,327,800 lbs. | 1 3/16" | " 7... | 18 | 2,276,500 lbs. | ¼" |
| " 25..... | 20 | 2,533,700 " | 2⅜" | " 19.... | 20 | 2,631,500 " | ½" |
| " 27..... | 22 | 2,763,500 " | 2½" | " 23.... | 22 | 2,861,500 " | ⅞" |
| June 3.... | 31 | 3,656,100 " | 3" | " 28.... | 28 | 3,426,500 " | 1 1/16" |
| | | | | April 11.... | 31 | 3,742,500 " | 1 11/16" |
| | | | | " 18.... | " | " | " |

| | Pier II. | Pier IV. |
|---|---|---|
| Number of timber joints in platform....... | 23 | 9 |
| Settlement per joint*..... .. ............... | ⅛" | 3/16" |
| Area of footing course, 20x54 ............. | 1,080 sq. ft. | 1,080 sq. ft. |
| Weight of masonry on *platform*........... | 4,192,650 lbs. | 3,976,900 lbs. |
| Pressure per square inch of footing........ | 27 lbs. | 25½ lbs. |
| Number of piles............. ............. | 368 | 368 |
| Probable area piles at cut-off, each........ | 150 sq. in. | 150 sq. in. |
| Total area pile heads.................. .... | 55,200 sq. in. | 55,200 sq. in. |
| Pressure per square inch on pile heads.. | About 80 lbs. | About 80 lbs. |

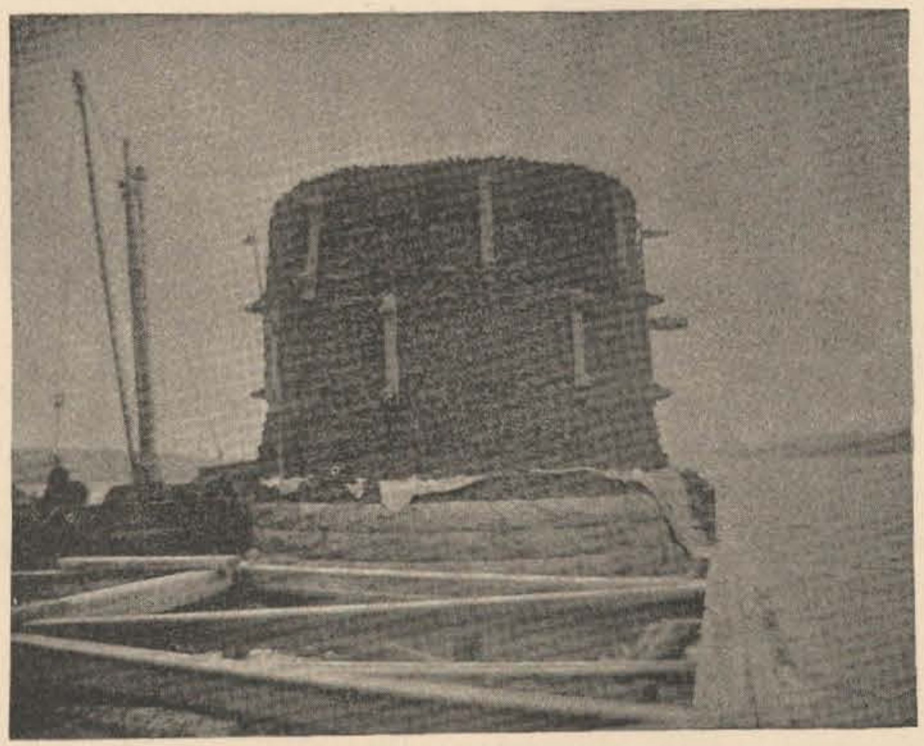
*This settlement allows nothing for sinking into pile heads, a quantity impossible to ascertain.

The above settlements are regarded as final, the levels being absolutely the same four months after the piers were finished, immediately after which the weight of the superstructure had been added.

**Weighting of Pivot Pier.**—Owing to the irregularity with which piles at Pier III. were sawed off, the weighting of that pier became doubly important, and after the landing of the pier on its foundation preparations were at once made for this loading. The only effective mode of getting a concentrated weight was with pig iron, and accordingly arrangements were made with Messrs. Hugh W. Adams & Co., of New York, to furnish as much of 3,000 tons of iron as was required. The whole quantity of iron was brought from furnaces in Tennessee and Alabama, transhipped at New York, barged by the Thames River Tow Boat Company to New London, loaded on the pier and unloaded therefrom in the space of two months. The iron was piled up in as solid a mass as possible to a height of 27 feet, calling for 2,700 net tons. The record of levels was made from time to time at the octant points of the pier. The pier had finished within three courses of the coping, 2¾ inches higher on the west than the east, and assuming that the plane of the masonry and bottom of the platform at that point were parallel, that difference of level measured the extent of pile variation of cut off, but the number of piles producing this variation was not known. Unfortunately, the level was not taken when the caisson was first landed, and it was impossible to record the exact settlement, due to weight of masonry; but as the pressure per square foot platform was substantially the same as for the other piers, an allowance of $\frac{1}{8}$ of inch per layer of timber cannot be far from the truth, which would give two inches settlement before weighting with iron. The effect of the pig iron loading alone was as follows:

| | | | | |
|---|---|---|---|---|
| February 22. | Average settlement with 1,344 tons | $1\frac{15}{16}$ | inches. | |
| February 26. | " " 1,848 tons | $\frac{3}{4}$ | " | additional. |
| March 4. | " " 2,672 tons | $1\frac{13}{16}$ | " | " |
| March 9. | " " 2,672 tons | $\frac{1}{4}$ | " | " |
| March 18. | " " 2,672 tons | 0 | " | " |
| April 11. | Iron all removed. | | | |
| | Total average settlement | $4\frac{3}{4}$ | inches. | |

Probably five inches is about the correct average, as the levels were taken under considerable difficulties, and on more or less rough surfaces. This would make, with the settlement estimated as above due to the masonry, a total of 7 inches. The extremes of settlements from the loading were $4\frac{5}{8}$ inches at the west and $5\frac{3}{4}$ inches at the east octant point, a difference of $1\frac{1}{8}$ inches, which, with the initial difference of level above noted, made a total of $3\frac{3}{8}$ inches difference of level to be cut out of the next succeeding course of masonry. It will be noted that the extreme settlements at east



LOADING PIER III. WITH PIG IRON.

and west octant points, with weight of masonry added, was 7¾ and 6⅝ inches, and as it is hardly possible for more than 3½ to 4 inches to be due to the crowding together of the platform timbers (¼ inch per course for 16 courses) the balance must be due to settlement in piles, less a small unknown quantity that represents some settlement probably in the masonry itself. The inequality of settlement between east and west sides arises from the fact that a large amount of weight was employed in crowding the high piles into the timber before the low piles were brought into bearing, when the compacting of the bearing on the high piles produced a greater resistance than was offered by the water soaked timber on the low piles, which yielded more readily to the increasing weight, until they, too, were solidly bearing. It is believed that all the piles under this pier have been forced to a bearing.

*Summing the data regarding Pier III., we have the following result:*

| | |
|---|---|
| Weight of masonry on surface of platform | 5,152,000 pounds. |
| Resultant weight of masonry and platform | 4,646,000 " |
| Weight of pig iron | 5,344,000 " |
| Total weight on piles | 9,990,000 " |
| Area of footing course 42 feet diameter | 1,385 square feet. |
| Pressure per square inch masonry alone on surface of platform | 26 pounds, nearly. |
| Pressure from pig iron per square inch at footing course | 27 pounds, nearly. |

These pressures, figured at the circular footing course, become very rapidly reduced per square inch on each succeeding course of timber downward, due to rectangular shape of platform and thickness of bottom.

| | |
|---|---|
| Number of timber joints in platform | 16 |
| Settlement per joint from masonry (estimated) | ⅛ inch. |
| Settlement per joint from pig iron (estimated) | ⅛ " |
| Crowding of piles in platform, high side (estimated) | 3½ " |
| Crowding of piles in platform, low side (estimated) | 1½ " |
| Number of piles | 639 |
| Pile area (based on 150 square inches per pile) | 95,850 square inches. |
| Total pressure on pile heads per square inch | 105 pounds, nearly. |

Or $7\frac{81}{100}$ tons per pile, assuming all bearing.

It will be noticed that although the weight treated is enormous (5,000 tons nearly) the unit pressures resulting therefrom are exceedingly low — leaving a very large margin for errors in deduction from the recorded settlements.

The estimated weights of Piers II., III. and IV., with weight of superstructure, and assumed moving load of 3,000 pounds per lineal foot of track, with the pressures resulting therefrom, are as follows:

| | Pier II. | Pier III. | Pier IV. |
|---|---|---|---|
| Resultant weight on pile heads of pier and platform | 1,828 tons. | 2,901 tons. | 1,871 tons. |
| Weight of superstructure | 310 " | 1,300 " | 310 " |
| Weight of moving load | 825 " | 939 " | 825 " |
| Total weight on piles | 2,963 tons. | 5,140 tons. | 3,006 tons |
| Weight per pile | 8.05 " | 8.04 " | $8\frac{3}{10}$ " |
| Pressure per square inch at footing course | 38 pounds. | 51½ pounds. | $38\frac{4}{10}$ pounds. |

# SUPERSTRUCTURE.

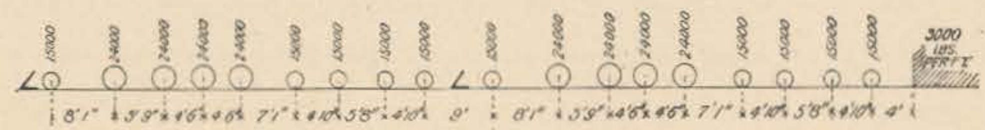
The superstructure, built for double tracks, is of the American type pin connection work, intended to cover the best results of modern practice, built wholly of steel, excepting lateral rods and a few minor parts, which are of wrought iron. It consists of two deck spans of 150 feet, and two fixed spans of 310 feet, symmetrically disposed on either side of the great swing Draw Span of 503 feet in length, forming the central feature of the work.

The deck spans of three trusses, 20 feet deep and 9 feet centers (so spaced that the tracks on 12 feet centers will bring an equal load on each truss), are designed on the triangular system, and are composed of five panels 24 feet 8 inches long, with intermediate posts supporting the upper chords 18 inches in depth, on which are notched 8x12 ties on 16-inches between centers. All compression members are of the usual latticed channel sections, the channels being compounded from plates and angles, excepting the intermediate posts, which are solid rolled sections. The double pin bearing at the ends, intended to insure a uniform distribution of pressure over the wall shoes and rollers during deflection or temperature movements, is the detail of special interest in this span.

The through fixed spans consist of two trusses on the Whipple system, 28 feet 4 inches centers (leaving 26 feet clear distance between trusses for tracks on 12 feet centers) wherein the modern practice of long panels and a single web system is fully developed, with the simplicity of detail growing out of the massing of sections, there being 13 panels of 23 feet 7 inches to the span. These spans are 45 feet deep at center for three panel lengths, thence sloping downward on either side at the rate of 5 feet to the panel to the end posts where the trusses are 25 feet deep, a form of construction conductive to economy by reducing the shear in the web system, to say nothing of a more sightly appearance than would result from trusses of a uniform depth throughout.

The swing span, with the same depth of truss at the ends as the adjacent fixed spans, slopes upwards towards the center where it attains a height of 71 feet, two-fifths the slope on either side of center being in a parabolic curve, the balance being a straight incline. The span is broken up into 21 panels, including the center panel of 20 feet 10⅞ inches, the other panels being 23 feet 10 inches. The web system is the same as that of the fixed spans up to within four panels of the center, which are covered by one large triangle with an intermediate sub-system for supporting the panel points. The great depth of trusses at this portion of the span rendered a continuation of the vertical posts not only a very uneconomical but unsightly arrangement.

The loads for which all the spans were proportioned, in addition to their own weight, consisted for each track of two consolidated engines with tenders covering a space of 103 feet, and weighing 171 tons, followed by train assumed to weigh 3,000 pounds per foot as per following diagram:



The lateral load produced by wind was considered to be equal to 500 pounds per lineal foot, along lower chord, and 300 pounds per foot for upper chord.

The unit working value of the proposed steel was taken as near as may be at one-fourth its elastic limit for all live load, and one-half its elastic limit for all dead load, or 10,000 and 20,000 pounds per square inch, respectively. The formulæ were used in proportioning sectional areas as follows:

| | |
|---|---|
| For all tension | $10{,}000\left(1+\frac{\text{min. total stress}}{\text{max. total stress}}\right)$. |
| For alternate tension or compression | $10{,}000\left(1-\frac{\text{min.}}{2.\ \text{max.}}\right)$. |
| Maximum in plate girder work, net section | 10,000 pounds per square inch. |
| Bending strain on pins | 22,500 " " " " |
| Shear on pins | $\frac{8}{10}$ tension formula. |
| Bearing on pins | 15,000 pounds per square inch. |
| Shear on shop rivets | 8,000 " " " " |
| Bearing on shop rivets | 15,000 " " " " |
| Field rivets | 50% to 75% of shop rivets. |
| Wind strains—tension | 20,000 pounds per square inch. |
| On posts, pin ends | $\left(10{,}000-60\frac{l}{r}\right)\left(1+\frac{\text{min.}}{\text{max.}}\right)$ |
| On chords | $\left(10{,}000-40\frac{l}{r}\right)\left(1+\frac{\text{min.}}{\text{max.}}\right)$ |

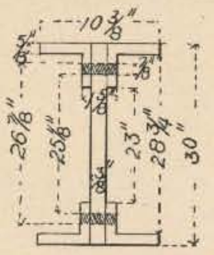
$l$ being length in inches and $r$ the radius of gyration.

Dead load, as well as live load, was computed as acting entirely on the loaded chord, that is along the top chord of the deck spans, and along the bottom chord of the through spans.

**The Flooring System** of the through spans is somewhat novel in its design, arising from the shape of the main cross girders and detail of the lateral connection, the rods being in pairs. The lower flanges of the girders bend in an easy curve from a point just beyond the outside stringers until meeting a tangent running sharply down from the point of union of the two flanges, an arrangement that permits of a light web, (since so much of the shear is thrown into the inclined flanges), the easy curving of the flanges permitting the shear to be transferred without violence, as well as avoiding the localization of strain on a few rivets, that a sharply bent flange implies. Further, the form of beam adopted avoids the great weakness inherent in a beam with a double bend in the lower flange, so often employed where beams are riveted between the posts, when it is important to economize headway, in which case the whole shear must come upon the web entirely, superadded to a "moment" due to the bent flange. The floor beam of the Thames River Bridge may be regarded as a truss, with a plate web for stiffness and counterbracing—the top flange becoming an upper chord, the inclined lower flanges the main end braces uniting the chords, through the medium of heel plates, by means of which the connection is made with the posts, to which the beams are thoroughly riveted. The objection to riveting beams unsymmetrically to the posts, that is, to one side, is overcome by the depth of connection, allowing of a deep union or diaphragm plate between the two sides of the posts, whereby the bending effect is reduced to an insignificant amount.

The strength of the flooring system is as follows:

*Stringers*—24 feet in length, composed of a web $30 \times \frac{3}{8}$ inches, and two angles for either flange $3\frac{1}{2} \times 5 \times \frac{5}{8}$ inches. The moment of inertia of this section is $\frac{1}{12}(10\frac{3}{8} \times 30^3) - \frac{1}{12}(8\frac{3}{4} \times 28\frac{3}{4}^3 + 1\frac{1}{4} \times 23^3)$ less rivet holes $= \frac{1}{12}(1\frac{5}{8} \times 26\frac{7}{8}^3 - 1\frac{5}{8} + 25\frac{1}{8}^3) = 4{,}429$.




A section that yields a working value on an extreme fibre strain of 9,000 pounds per square inch of 74,000 pounds (66,000 live and 8,000 dead), or 66 tons per pair of stringers, or per track of live load, equal to 5,500 pounds per foot—a loading somewhat in excess of the typical engine load assumed for the trusses; but there is no telling what the future may have in store for increased engine loads, the full force of which affects every stringer.

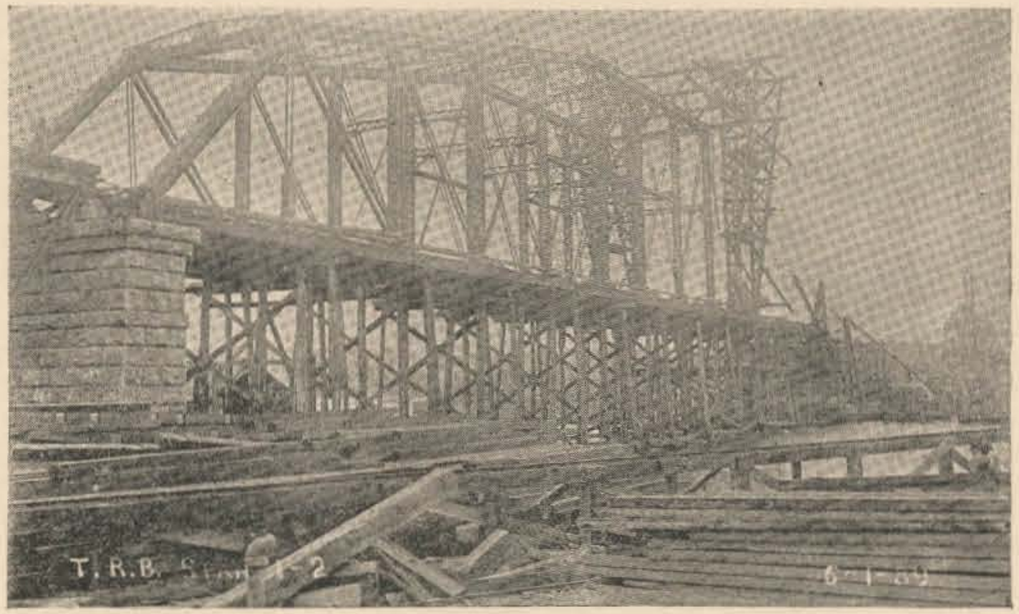
The maximum end shear under this load is 3,363 pounds per square inch. The stringers are secured to the ⅜-inch web of floor beam by 20 ⅞-inch field rivets, in addition to the eight shop driven rivets in the bottom brackets. Rating the former at a supporting value of 3,400 pounds per rivet, without counting the latter there results a total value of 74,000 pounds to support the extreme loading as above.

*Floor Beams* are 27 feet long between posts, 4 feet deep at center (over angle irons), with the load concentrated at the four stringer bearings on 6 feet centers. The web is ⅜ inch thick, flange angles 6x6x⅞ inches, rivets all ⅞, excepting the eight rivets at extreme ends of angles, which are 1 inch. The total load assumed is 228,000 pounds, of which 40,000 pounds is dead, or 57,000 pounds at each stringer (the amount of dead load uniformly distributed is too insignificant to be independently treated as such). The horizontal flange strain produced at first stringer bearing is $114{,}000 \times 4'\,6'' \div 3'\,9'' = 136{,}800$ pounds.

At second stringer bearing (and max.) $114{,}000 \times 10'\,6'' - 57{,}000 \times 6' \div 3'\,10''$ ($49'' - 3'' =$ C. G.) $= 220{,}000$ pounds, which, at 10,000 pounds unit strain per square inch, requires 22 *net* inches, afforded by 2 angles $6 \times 6 \times \frac{7}{8}$ and a flange plate of $14 \times \frac{1}{2}$ inches, yielding 26 gross inches, the rivets cutting 4 inches of section.

The longitudinal strain on the sloping flanges is $114{,}000 \times 4'\,6'' \div 3'\,6'' = 146{,}600$ pounds, requiring 15 net inches, given by the two 6-inch angles with 19 inches section, less nearly 2 inches cut out by rivet holes. This inclined flange unites with the horizontal top flange, through the medium of the central web and two outside cover plates, constituting, in fact, a riveted truss, in which the portion of the web between the inside stringers may be regarded as a continuous counterbrace, and the portion between the end reinforce cover plates and the outside stringer connections entirely omitted. The inclined flange strain is delivered to the end web and two covers through 19 rivets, strained only to 7,700 pounds each, or about one-half their full working value (there being three ⅜ bearing surfaces and quadruple shear), or a total of 160,000 pounds, against 146,600 pounds of strain transmitted.

The vertical component of the inclined flange, constituting the end shear of 114,000 pounds, is sustained by eight rivets in flanges worth 80,000 pounds, and eight rivets worth 4,500 pounds, making a total of 116,000 pounds. The least shear section consists of the web $28'' \times \frac{3}{8}'' + 2$ covers $12 \times \frac{3}{8} + 4$ vertical legs of flange angles, making $40\frac{1}{2}$ inches section against 114,000 pounds shear, or less than 3,000 pounds per square inch shear. If shear is considered entirely upon the web and cover plates, it amounts to 5,700 pounds per square inch. The beam is supported by and secured to the post by a pair of $4'' \times 6'' \times \frac{1}{2}''$ bracket angles, the rivets in beam being shop driven, and in double shear and bearing, which are worth 176,800 pounds, while the field rivets, securing bracket angles to posts 30 in number (with $\frac{1}{2}$-inch bearing), worth 4,000 pounds each, yield a total working value of 120,000 pounds. The corner gussets between posts and upper flanges are introduced simply as stiffeners, and are not rated as having any supporting value. Additional transverse and lateral stiffness is secured by a double angle iron strut, between lower flange angles and bottom of posts. The arrangement of beam support adopted permits of a neat detail for the connections of the double-lateral system employed, symmetrical with the chord pins, and as free from secondary strains as is possible to obtain.



RAISING SPAN II.

The general design of the trusses, and development of detail, are so clearly shown on the drawings accompanying this report that no special comment thereon is necessary. Much study was given to the general effect of every part, independent of technical requirements, and the integrity of design in wrought material was maintained throughout, wherever the suggestion of ornament was attempted, as in the portals, stiffening brackets, latticing of the transverse struts, and central finials of the Draw Span.

**The Draw Span** has been proportioned on the theory of the whole of the fixed load being carried at all times to the center pier, combined with the consideration of a live load, covering one arm alone, with a reaction of half the load on rest pier and half on center pier, and a live load covering both arms, with a reaction on rest piers of three-eighths the load, and five-eighths on center pier. The effect was also computed for locking down the ends of the draw, and an entering train on one arm while the other arm was loaded. The camber on either side of the center was computed on a basis of 40,000 feet radius, yielding $2\frac{5}{32}$ inches camber, and requiring an increased panel length of top chord of $\frac{7}{32}$ inches, at a depth of 30 feet, each panel being proportioned therefrom in proportion to the mean depth between panel points. The extensions and compressions of all the parts due to dead load were corrected on a basis of an assumed modulus of elasticity of 30,000,000 pounds. As a precaution to control the elevation of the free ends and provide for possibilities of shop errors or imperfections, an adjustment plate was inserted in the bottom chord, close to the feet of the center posts, the removal of which would drop the ends, or their replacement by thicker plates, would elevate them. Advantage of this adjustment had to be taken, as, when the blocks were struck and the draw hung free, it was found that the ends were too high, which investigation showed was due to the fact that the shop had added the thickness of the plates to the correct center measurements of the panels either side of center. The span was therefore blocked and jacked up on the false-works until the joint opened, when the plates were removed and span let down into place, when it hung almost true to its mathematical position, no end being more than one inch out. The whole weight of the draw is delivered to a rim bearing turn-table at four points, the supporting cross girders being so arranged as to distribute the weight in exact proportion to eight equidistant points on the circular drum, which, being 32 feet in diameter, divides into $12\frac{1}{2}$ feet segments, which measures the extent of distribution the drum is called upon to afford a uniform bearing on all the wheels under the influence of each segment.

This interval of distribution is, in fact, actually much reduced, owing to the breadth of the bearing plates of the cross girders upon the drum. The drum being 5 feet deep, with $6'' \times 6'' \times \frac{7}{8}''$ angle iron flanges and a $\frac{3}{4}$-inch web, having carefully fitted stiffeners, and splice plate unions between the separate segments, with the manner in which the track segments are composed and fastened, may be counted upon being absolutely rigid between the intervals of the applied loads, which do not exceed 10 feet. The whole weight rests upon 58 cast steel 20-inch wheels, with 10-inch face, of a metal as hard as could be faced in the lathe, weighing 800 pounds each. The estimated weight borne by these wheels is 1,300 tons, or $22\frac{41}{100}$ ton per wheel, being 4,400 pounds per lineal inch of face. The wheel treads are rolled steel plates bent to curve, and faced to true cone and bearing. The upper tread breaks joint with a heavy faced wrought segment $2\frac{1}{2}$ inches thick, which is attached to the flange angles of the drum. The lower tread breaks joints with, and is supported upon, a stoutly ribbed cast-iron track circle 12 inches deep, to which it is secured by set screws from below. The track circle in turn bears upon two broad steel faced plates, one inch thick, and breaking joint with each other, which distributes the pressure over the masonry, and constitute the leveling plates.

Extraordinary care was exercised to secure the lower tread absolutely level, have all bearings and surfaces as true as machines could make them, and no expense was spared to have the drum rigid and stiff, as the price of a smooth and easy working table. The live ring coupling the wheels is perfectly flexible, being composed of separate band pieces between each pair of wheels. The rack is of cast iron, with a face of ten inches, teeth of $3\frac{19}{32}$-inch pitch, and a pitch circle $34\frac{1}{3}$ feet in diameter, into which gears two shrouded pinions with thirteen teeth and 15-inch diameter pitch circle, having vertical shafts $5\frac{1}{2}$ inches diameter, working in heavy and strongly braced sleeves attached to the drum. The table is provided with both hand and steam power, the former through capstan bars, three for each shaft, engaging into capstan heads, attached to the multiplying gear driving the vertical shafts.

*The steam power* located within the drum consists of a pair of oscillating cylinders on a compact frame, 10 inches diameter, with 7-inch stroke setting at an angle of 120 degrees and working upon one crank shaft, running at a maximum velocity of 200 revolutions (averaging about 170), applying the power through two Frisbie friction clutches, the one driving the unlocking shaft, the other the turning shaft. The turning shaft, of $4\frac{1}{16}$ inches diameter, runs at a speed of nine turns per minute, gearing direct through a pair of beveled gears into the vertical drum shafts. The unlocking and rail lifting shaft is three inches in diameter, speeding 60 revolutions per minute, and gears by transverse shafting at the bridge ends into the pedestal feet, screwing up and down in the hub of a beveled gear wheel, forming a fixed nut.

The pedestal feet are broadened for a steady bearing, and have a wedge-shaped projection on under side, matching into a recess into the wall plates bolted on the rest piers, thus forming a secure lock when once in place. The rails are lifted by cams from the cross shaft two inches in diameter, rising through slots in the rail troughs. These troughs of plate and angle iron are the length of the rail and bolted to the ties, the rail being laid loose in them, with $\frac{1}{8}$ inch clearance. The rail continuity with the fixed spans is obtained by slicing the rails to facing points two feet in length, the points dropping into matched troughs on the fixed spans. Points are reversed for east and west bound tracks, the whole arrangement being similar to a split switch. Control of the draw is aided by friction brakes attached to the vertical shafts, and operated by steam, serving to steady it while running down the supporting screws. In addition to the brakes is provided, for use in high wind, a quick vertically acting latch at either end, controlled from the engine-room. The holding down locks at the ends, to prevent the rails rising when a train is on one arm should a train be entering the other, is operated by lever attachment from the rail lifting cams, and consists (two at either end) of steel forgings 4 inches wide by 7 inches deep, rotating on a $3\frac{1}{2}$-inch pin in a box supported from the end floor beams with four $1\frac{3}{4}$-inch bolts. The short end of the forging reacts upon a heavy 12-inch beam, in turn reacting upon the end floor beams of the fixed spans and the masonry, while the long end of the forging reacts through a bar with a toggle joint upon the under side of the end stringers of the draw through a framework of 6-inch channel bars. The maximum effect which this lock can be called upon to resist is in case two trains should be on the same arm of the draw at the same time, and assuming such loading to amount to 3,000 pounds per lineal foot of track, the holding down effort required at the opposite end would amount to one-sixteenth of the total loading, or 45,000 pounds for each track, which, in turn, affects the trusses of the draw, the same as if that weight was hung on each end in addition to the strains computed for the dead weight of the structure itself.

The minimum time of operating the draw is fifteen seconds for lifting rails and raising end screws, and two and a half minutes to open, which is varied at will of operator, more time being consumed in starting and slowing up in high winds.

*The signaling mechanism* of the bridge, devised by the Union Switch and Signal Company, is governed from a cabin erected in the bridge tower, and is an interlocking system, with electric safeguards which prevent the movement of the switches or signals after a train has entered the section protected. There are nine working levers, with additional space for others as required, and they will control two signals in each direction, the derailing locks and switches and the rail locks for the ends of the draw span. The signals are of the ordinary semaphore form, swallow tail blade for distant signal, and square ended blades for the home signal. On the New London side the distant signal is located 1,740 feet from the end of draw. The home signal is 710 feet from the end of the draw and the derailing switch 660 feet from the end of the draw. On the eastern approach the derailing switch is 760 feet from the end of the draw and the home signal 50 feet further, the distant signal being 1,870 feet. The last movement of the signal men before allowing the bridge to be opened, will be to unlock the rail ends resting on the fixed spans, a movement that is accomplished by an additional safeguard specially devised for this structure, called a "detector and rail lock." The ends of the rails carry a downward projecting bolt, which can enter its hole only when the rails are down in place and the track is continuous. Then the movement of a lever will move a bar extending underneath both tracks, which carries four bolts, one for each rail. These are machine fitted and enter the holes in the lug, locking the rail down in position. If the signal man is unable to throw these bolts he knows at once the end rails are not in place.

**The Steel** used is low grade or soft steel, that is, a metal not running over 65,000 to 68,000 pounds per square inch breaking strength. The original intention was to use none but "Open Hearth" metal, a requirement modified by the acceptance of Bessemer metal kept low in phosphorus, for certain of the compressive members, in order to gain time. In the Draw Span the Bessemer was confined to the vertical and inclined posts at center and center section of bottom chord. Open Hearth steel was preferred on account of the process insuring a uniform product and the control of its composition. Such steel is melted in large masses, can be retained molten for any desired time, affording abundant opportunity to test without undue haste, and the melt modified accordingly. Bessemer, on the other hand, is an exceedingly rapid process, with the resulting temptation to rush every operation, which means greater possibilities in chemical variation. Still, with all that, modern system and skill has largely guarded against such variations, and Bessemer is becoming more and more used in structural work with great confidence. In no bridge has greater care being exercised to secure a good and reliable steel, nor more careful workmanship put upon it at the shop. Close inspection followed it through every stage, from the testing of every ingot cast, through its condition as finished material, to the full-sized bridge member after manufacture. Appended hereto is a series of test records, Appendix G, being of peculiar interest and of great value, showing as it does in juxtaposition from the same heat the ingot test, the chemical composition, the finished material test and the full sized eye-bar test. From this it will be seen how greatly the elastic limit in the full sized bar falls away from that shown by the same steel in the specimen tests from the ingot and finished material, a variation nearly as great being shown in the ultimate strength. It was found, even with a liberal rejection of bars, impossible to depend upon an elastic limit greater than 85 to 90 per cent. of that shown by the specimen tests.

**Protection Fenders** are built around Piers II. III. and IV., with flaring wings, and pointed ends. Those for the rest piers are 180 feet long, while that for the Draw Pier is 570 feet long. They consist of a system of piling and framework of yellow pine timber, sheeted vertically with four and six inch plank, corners being protected with boiler-plate armatures. These fenders have exhibited an unexpected amount of stiffness against impact from vessels, when the great depth of water is considered and lack of lateral support of the upper mud of the bottom, resulting in some 50 to 70 feet of unbraced pile. The piles are all compounded or spliced to lengths of about 120 feet more or less, the joints being simple butt joints, with eight spruce scantlings 4 x 5 for splices 16 feet in length. These scantlings are spiked to the piles with eight spikes either side of joint. At each bent of piles (seven piles in a bent) are two raking or brace piles, securely bolted to the framework above water at convenient intersections, and to the heads of the outside piles. To these brace piles the great stiffness of the construction is primarily due.

APPENDIX A.

# COST.

The disbursements made in execution of this work, up to subgrade and laying of track, when the work was handed over to the regular organization of the company, have been as follows:

| | | | |
|---|---|---|---|
| **RIGHT OF WAY AND LANDS PURCHASED.** | | | |
| Eastern or Groton approach | $38,863 00 | | |
| Western or N. L. approach | 286,351 42 | $325,214 42 | |
| **CONSTRUCTION OF APPROACHES.** | | | |
| Graduation and masonry, east approach | 130,276 33 | | |
| Grading new highways, " | 5,827 37 | | |
| Girder bridges, steel, " | 9,715 34 | | |
| Highway bridges, wood, " | 4,623 24 | | |
| Stone ballast prepared, " | 6,508 14 | 156,450 42 | |
| Graduation and masonry, west approach | 37,066 31 | | |
| Bridges, steel, " | 19,872 85 | | |
| Bridges, wood trestle, " | 38,572 39 | | |
| Streets, sidewalks, etc., city work, west approach | 2,227 90 | 97,739 45 | |
| **THAMES RIVER BRIDGE.** | | | |
| Superstructure | 275,569 24 | | |
| Masonry | 141,813 09 | | |
| Foundations and grillages | 194,533 58 | | |
| Fenders and guards | 38,283 70 | | |
| Loading with pig iron | 8,289 98 | 658,489 59 | |
| **GENERAL ACCOUNT.** | | | |
| Rent, janitor, gas, ice | 899 31 | | |
| General supplies, instruments, etc | 1,116 25 | | |
| Sundry expenses | 2,900 30 | | |
| Steam launch, boats, repairs, etc | 756 71 | | |
| Transportation, livery, etc | 495 80 | | |
| Inspection and testing steel at mills and shop | 3,018 13 | | |
| Engineering, legal expenses, land agent, etc | 46,859 52 | 56,046 02 | 1,293,939 90 |

Not far from $100,000 in the above land purchases were unnecessary for the railway as originally intended, and not, therefore estimated for, but which circumstances (as delays for condemnation and probable future requirements) made it desirable to obtain.

# APPENDIX B.

ON the completion of the bridge, the following test was made under the direction of Mr. E. P. Dawley, Chief Engineer of the N. Y. P. & B. R. R., which, although below the basis of the design, employed all the available engines that could be spared for the purpose. Two trains were made up on the east side of the river and driven over the structure side by side. That on the west-bound track was composed of three engines in a space of 150 feet, and weighing 235 tons, followed by 155 feet of loaded passenger cars, weighing $59\frac{1}{2}$ tons, or a total of $294\frac{1}{2}$ tons in 305 feet. That on the east-bound track was composed of three engines, weighing 221 tons in 160 feet, followed by 330 feet of passenger cars, weighing 139 tons, or a total of 360 tons in 490 feet—of the passenger car load 150 feet weighed $59\frac{1}{2}$ tons, or same as on west-bound track. For both tracks, the total load with 150 feet of cars, was therefore 575 tons, in a space covering a 310-feet span—the engines on the two tracks being *vis-à-vis* with each other, as near as practicable. The greatest deflections recorded were as follows:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Easterly 310-feet span | N. Truss, | $2\frac{3}{8}$" | S. Truss, | $2\frac{1}{8}$" | Recovery perfect. | | |
| East Arm Draw, 240 feet | " | $1\frac{5}{8}$" | " | $2\frac{1}{8}$" | " | " | |
| West Arm Draw, 240 feet | " | $1\frac{1}{2}$" | " | $1\frac{3}{8}$" | " | " | less $\frac{1}{8}$" for S. Truss. |
| Westerly, 310-feet span | " | $2\frac{3}{8}$" | " | $2\frac{1}{4}$" | " | " | less $\frac{1}{8}$" for N. Truss. |

The easterly, 148-foot deck span deflected $\frac{15}{16}$" and the westerly deck span 1".

The maximum raise of unloaded draw arm was $2\frac{1}{2}$"—the opposite arm being loaded with six engines, with about 90 feet of cars. The 160-feet two truss through span on the west approach over the New London northern tracks—deflected $1\frac{1}{8}$" for north truss, and 1" for south truss, with complete recovery, lacking $\frac{1}{16}$" for north truss.

# APPENDIX C.

ON October 10, 1889, sixteen months after the commencement of the work, the "Thames River Bridge" was opened to travel with imposing ceremonies. Special trains of new vestibuled cars, built expressly for the "Shore Line Route," were run from both Boston and New York, filled with invited guests from the two great terminals and the intermediate cities and towns. The city of New London did its best to make the day a marked one in its annals, and the whole harbor was bright with bunting. The magnificent "Connecticut," of the New York and Providence Steamship Company, had been brought around and moored to the Union Station Dock. The ceremonies on the bridge were simple and appropriate to the occasion. The Draw was turned off, and the approaching trains from either side came to a halt on the adjacent spans, when presently the old-time ferryboat "Groton," that did duty so many years, ferrying trains over the river, with flags flying, steamed up the East passage, turned and came down the West passage, to the tune of "Auld Lang Syne," played by the band stationed on the Draw. The span was then swung into position, and the selected guests and officials marched to the center of the Draw, the Boston party headed by President Charles F. Choate, of the Old Colony R. R. Co., and the New York party by President Samuel D. Babcock and General Manager J. W. Miller, of the N. Y., P. & B. R. R., where they were received by the Chief Engineer, in the following presentation to President Babcock:

"It becomes my official duty, in which I take great pleasure on this eventful occasion, of handing over to you the trust with which I have been charged. This great work, which you and your associates so courageously undertook, is one in which I think we all may take a just pride—the men who planned, the men who executed, and the men who furnished the means. Personally I have to thank you for the cordial support you have ever extended to me, and the splendid confidence with which I have been favored. May the realization of an unbroken track in the favored Shore Line route more than fulfill the expectations of the New York, Providence and Boston Railroad Company." To which President Babcock replied as follows:

"I deem it a privilege to receive from you this graceful and substantial structure, and to compliment you on one of the greatest engineering successes of the century. The bridge will stand as a monument to your labor and skill. Although the company furnished the money, neither the directors nor the stockholders had the brains to do the great work. It is, indeed, a work that the company has every reason to be proud of. I accept the bridge on behalf of the New York, Providence and Boston Railroad Company."

After a few words from the Mayor of New London, the respective parties returned to their trains, which slowly, and side by side, moved back to the Union Depot. On disembarking, the guests were welcomed to an elaborate reception upon the "Connecticut," and with tongues loosened by unlimited refreshment, both solid and liquid, the hours intervening to the return trains were replete with the wit and wisdom that such surroundings naturally call forth. It would be a long list to note the names of the prominent guests present, which would cover all the leading railroad men in Eastern New England, the newspaper press, besides the host of friends of the "Shore Line Route to Boston."

APPENDIX D.

# SPECIFICATIONS.

**Covering the Construction of the Superstructure of a Double Track Steel and Iron Railway Bridge over the Thames River, at New London, Conn., for the Providence and Boston Railroad Co.**

There will be one draw span 503 long, two 310 ft. through spans and two 150 ft. deck spans, center to center of pier measurement. The spans will be composed of two trusses, 28 ft. 4 in. c. to c. of through spans, and 18 ft. c. to c. of deck spans.

All parts will be of steel, except swivels, light brace rods, rolled channel sections that may be used in posts, or struts, batten strips or ornamental work.

All material will be subject to inspection during the various processes of manufacture, and free access must be permitted for the Engineer or his Inspectors at any works where material is in process of manufacture. A notice of at least one week must be given to the Engineer, when his Inspectors may be on hand for performance of their duties.

*The Steel* used shall be made from the open hearth process and at works of established reputation. All melts must be made from uniform stock, low in phosphorus, satisfactory evidence of which must be furnished the Engineer. A sample bar must be rolled from each melt, not less than ¾ inches in diameter, the method of obtaining the same being uniform for all melts. Tests upon such samples to be made without annealing.

The laboratory tests upon these sample-bars shall show an ultimate strength of from 63 to 70,000 lbs. per sq. inch, an elastic limit of not less than 60 per cent. of parting limit, but not less than 40,000 lbs. per sq. inch, an elongation of 20 per cent. in eight inches, and a reduction of area not less than 40 per cent. at point of fracture. The cold bend test shall permit of the sample specimen being bent 180 degrees, within its own thickness, without sign of fracture on convex side.

Rivet steel shall have an ultimate strength of 60,000 lbs. per sq. inch.

Every piece of steel shall be stamped with a number identifying the melt, and full record of all laboratory tests kept. Tests shall be made from time to time on samples, cut from finished shapes, plates and bars, which must show results conforming substantially to test made on samples from same melt.

*Forged Work.*—The heads of eye-bars, swelled screw ends, the heads of suspenders and counter rods shall be formed by upsetting and under such process as will be acceptable to the Engineer—all welds debarred. On completion, such bars shall be thoroughly and uniformly annealed by heating them throughout to a dark red heat and allowing them to cool slowly. Any form of head used must develop the full strength of the bar on its normal section. Eye-bars must be straight before boring and holes must be in the center of the heads and on center lines of bars. A cluster of eye-bars for any panel-point must permit the passage of the pin without driving.

Twenty full-sized eye-bars, as used in the bridge, from as many different melts, shall be furnished by the Contractor for purposes of testing, with the facilities for so doing. These bars shall be tested to destruction, the behavior under varying stress noted, and shall break ultimately in body of bar, the fracture showing a uniform and ductile grain. Such bars must be selected throughout the progress of the work, the final tests being made on last batch of bars manufactured. A failure of the test-bars to develop a minimum stretch of 8 per cent. will be cause to reject bars made from the lot from which the bars were taken as representative, provided any failure exhibited appears not to be due to a purely local cause appertaining to the test-bar, when additional tests may be ordered.

*Riveted Work.*– All plates and shapes shall be carefully straightened before the work upon them is laid out. All rivet holes to be carefully spaced, so that when members are brought into position, the holes shall be truly opposite before rivets are driven—drifting will not be allowed. In all steel work holes shall be punched one-eighth smaller than the rivet required, the parts assembled and the holes reamed out to just fit the rivet before driving. All rivets shall be of steel, and surfaces in contact shall be thoroughly coated with boiled linseed oil before being put together. Power riveting to be alone used wherever possible. All abutting surfaces, including ends of stringers, shall be accurately faced (except in flanges of plate girders where joints are fully spliced) and every built member when completed must be out of wind, pin holes bored at right angles with true axis of member, and parallel with each other. Rivets to be driven in field shall be laid out with iron template, and accurately drilled to just pass the rivet cold. All rivets to have neatly cupped hemispherical heads.

*Pins* shall be accurately turned to gauge, with a clearance for pinholes of not over $\frac{1}{50}$ of an inch in main trusses and $\frac{1}{32}$ of an inch for lateral rods or secondary parts. They shall be furnished with sufficient pilot nuts to be used during erection.

*In General.*—It is the intention of these specifications to cover the best modern practice in bridge building, and any omissions defining the same must be regarded as if made. Imperfect work, ragged edges, surface imperfections, or imperfectly rolled shapes, will be sufficient cause for rejection.

Any steel from any cause requiring to be reheated, must be re-annealed.

Before shipment all machine-faced surfaces to be coated with white lead and tallow, the balance of the work being thoroughly coated with best quality of boiled linseed oil.

After erection, the structure to receive two coats of paint, composed of pure red lead* and boiled linseed oil, with such relief in black as the Engineer may direct. Timber for cross-ties and guards shall be first quality yellow pine, and shall be cut from untapped trees, true to size, free from sap, and shall be fastened and bolted as directed.

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* Afterwards changed to oxide of zinc and white lead, half-and-half.

APPENDIX E.

# SPECIFICATIONS.

**Covering the Construction of the Foundations and Masonry for a Double Track Railroad Bridge over the Thames River, at New London, Conn., for the New York, Providence and Boston Railroad Company.**

The work to be performed will consist in furnishing all materials and labor necessary for constructing five masonry piers and two abutments, and foundation work required thereby, together with all incidental temporary works required in the opinion of the Engineer, for the proper performance of said labor, and such staging as may be necessary to keep up the proper alignment. The general dimensions and sizes of piers and foundations are shown upon the plans on file in the office of the Chief Engineer of the Thames River Bridge; said dimensions and sizes may be varied more or less by direction or consent of the Engineer, during the progress of the work, as the exigencies of construction may demand.

For East abutment and Pier 5, the foundations will start from rock bottom; west abutment and Pier 1 will be founded on gravel, or on piles as the Engineer may determine. Piers 2, 3 and 4 will be founded upon piles cut off as near as practicable to mud line; hard bottom foundations will consist of concrete laid by means of divers, within a timber curb, out of which has been removed all soft overlying material, or in case of gravel, the same to be excavated to such point as the Engineer may determine.

In case piles are found expedient, for west abutment and Pier 1, they shall be driven 2 and 3 ft. centers, cut off to uniform level at least 5 ft. below low water, on which will be settled the masonry platform 30 inches thick. Piles shall be at least 8 inches at small end, 12 inches at butt, and of length and quality as ordered. Soft bottom foundations will consist of a double-walled curb or caisson of square timber, sunk 25 ft. more or less into the mud bottom, encasing a group of piles, the voids between the piles being filled up, as hereinafter described.

*Material* may be dredged by means of pumps or any excavating appliances approved by the Engineer, that the contractor may select, and which perform the work efficiently; but all dredged material must be disposed of by the contractor according to law, and he must exercise due care that dredged material is not allowed to re-deposit in part over the foundation, which might be the case should soft material be pumped up and discharged into the river too near the area of the foundation. Dredging must be carried to such depth below the level of caisson or curb bottom, so as to allow for swelling when piles are driven, as the Engineer may determine.

*Piles* (used for Piers 2, 3 and 4) shall be unbarked spruce or pine spars, straight and true, not less than eight inches diameter at point, and at least 90 feet long. The axis of any pile shall not deviate more than eight inches from a line struck between centers of head and point. They shall not be pointed for driving, but those for Pier 4 may be provided with a cast-iron shoe (of form and quality of metal as ordered, and to be furnished by the Company), as at that point it may be desirable to reach the rock, toeing the piles into it. All piles shall be driven with a hammer weighing not less than 4,000 pounds. The piles will be driven in leaders so arranged that vertical alignment of a pile, both above and below water, can be assured and determined. A follower of special construction, properly banded and connected, must be used, and be securely held in the leaders, so as to prevent lateral motion. Piles injured in driving must be drawn and replaced with sound ones. They will be cut off level with reference to Government datum, as shown on plans.

*The Curbs* for Piers 2, 3 and 4, surrounding the piles, shall be framed of square 12 × 12 spruce or hemlock timber, of form and dimensions as exhibited on the drawings. The timbers must break joint at partition points, and be secured with ⅞ drift bolts driven in ¾ holes, bored at an angle. Bolts to be generally 20 inches long, excepting at important intersection points, where they will be required to go through three courses of timber, screw bolts to be used wherever required, so as to bind the whole mass thoroughly together. The curbs will have an upper double frame, in three sections, and so arranged that when the curb is in final position the top of the frame will be sufficiently below low water as not to interfere with the draft of the pile-driving scow. The curbs for Pier 5 and east abutment serve simply to permit of the rock being laid bare and confine the concrete.

*For the Pile Foundations* the filling between the piles and curb walls will consist of clean beach sand and gravel up to within about five feet of the pile heads, as cut off, the balance of the filling may be concrete, as the Engineer will determine. For all other foundations the filling will consist of concrete, as shown upon the drawings.

*All concrete* laid under water must be done by means of divers when required, and laid from boxes of approved form, and all precaution taken to prevent washing until deposited in place.

The masonry for Piers 2, 3, 4, and east abutment, will be laid in an open caisson, also that for Pier 5, if desired by contractor. That for the west abutment and Pier 1 will be laid upon the previously prepared concrete bottom or pile foundation, in the open air.

*The platforms* supporting the masonry, and which form the bottom of the open caissons, shall be of suitable timber in transverse courses, as exhibited upon the drawings. The timber to be in long lengths, and breaking joint not closer than from eight to ten feet. Lengths should not be less than twenty feet, except when required for an end stick. Transverse courses in Piers 2 and 4 must be in one length. The timbers shall be drift-bolted together with ⅞ drift bolts, twenty inches long, driven in a ¾ hole bored at an angle as, follows:—The outside sticks at every intersection or to every stick under them; the next four timbers at every other intersection; all other sticks at every third intersection. In all cases a bolt shall be driven on either side of a joint.

The last course of every platform will be planked with six inch spruce plank, which shall be cut with calking edges, and thoroughly well spiked and calked. All the plank exposed outside the masonry will be creosoted as provided for below. The sides of the platforms will be covered with creosoted spruce plank (fifteen pounds of oil to the cubic foot of wood) and solidly fastened to the timbers with six inch composition spikes. The edges of the plank will be jointed, and when set in place they will be slushed with hot coal tar asphaltum and driven solidly together. All timber used shall be thorougly sound, merchantable stuff, free from shakes, loose knots or other imperfections.

*Caisson sides,* will be detachable for Piers 2, 3 and 4, and composed of vertical studding with iron straining bolts set as directed, with jointed plank sides of varying thickness, thoroughly well calked, the feet of the studs will be toed into the platform deck. Provision will be made for governing the descent of the caissons so that they may be under perfect control at all times; also for flooding with water by means of pumps, syphons or otherwise, so that they may be firmly grounded upon reaching the foundations.

*The masonry* will consist of first-class rock-range ashlar bridge masonry, in uniform courses, laid in cement mortar, in such form and dimensions as shown on the drawings.

*The stone* to be used shall be of a quality subject to the approval of the Engineer (granite preferred), be free from imperfections of any kind and satisfy all chemical and mechanical tests as to durability in salt water and strength. In any case granite will be required for the 18-inch coping course, and the coping of parapet walls of the abutment. Such granite must be of a light color and free from iron. In masonry above low water, no stones with stained surfaces will be permitted. Other than the pean-hammered work all stones shall be pitched off to line leaving a rock face, with no projections exceeding three inches. Below low water the rock face will be as the stone comes from the quarries. The arrises or corners of all courses marking outlines of piers or abutments, shall be distinctly defined by chisel draft, cut back two inches from the edge.

No course of stone to be less than 15 inches or more than 36 inches, and in no case is the thickness of a course to be made up with more than one stone. Courses must be so arranged that those composed of the largest stones will be placed at the bottom of the piers, and in no case shall a thick course be placed on top of a thinner one. The diminishing thickness of the courses must be progressive upward. All stone to be cut to lay on their natural beds, and the top surface of each stone must be parallel with its bed. The beds of face stone shall be dressed the entire width. Face stones shall be cut to one-half joints, having the vertical joints dressed back square, except for Pier 3, which shall be dressed to the radii of the circle for a distance of not less than 12 inches, except as otherwise specified. Headers shall be in the proportion of one head to two stretchers.

For masonry below water line, laid in caissons, vertical joints must be cut from 18 to 24 inches to take up the enormous water pressure in lower part of caisson, which must be braced against the masonry. All stone to be laid alternate header and stretcher, breaking joint with each other not less than 15 inches. Headers in no case to be less than 4 feet long nor 2½ times their depth, or less than 30 inches wide. Stretchers to have beds in width of not less than a quarter more than the rise, or in length less than 3 to 4 times the depth. Closure stones may necessitate some modification from the above requirements.

*Backing* shall be composed of concrete or large well-shaped stones, laid in cement mortar, as the Engineer may elect, and in no case shall more than two courses of backing be used for one course of face stone. The lower beds shall be pointed off level and even, and all high points shall be dressed from the top, before the stones are finally laid, so as to give the succeeding stone a firm bearing. The backing must be laid level with each course of face stone. No leveler shall be put under a stone to bring it to its proper height by raising it from its bed. It may be that it will be found desirable to carry up to a certain point the deep water piers after bed courses are laid, with a hollow interior; in which case, after the piers are grounded, such hollow places shall be filled with concrete. The whole work must be well bedded in cement mortar, and no open spaces whatever allowed.

Only the granite top course of the pier abutments and bridge seat stones will be rated as coping. All other pean-hammered work will be paid for by the square foot. Coping and bridge seat stones must be carefully selected and fully dimensioned, with hammered beds, builds and rises. On the narrow piers no more than two stones shall be used to make up full width of coping, and they must break joint at least two feet. Under bridge seats a single stone to be used. In order that the joints may properly be disposed, coping should not be cut until the position of the joints in the under courses be determined. On pivot pier coping will be cut to dimensions throughout, having all surfaces supporting wheel tread and center pin truly leveled and finely axed. The intermediate area between ring stones and center stone shall be neatly finished off in Portland cement.

*Clamps* of wrought iron 2x$\frac{3}{4}$, as may be directed, must be sulphured in (pure sulphur being used).

No masonry shall be laid in freezing weather without ample provisions for heating water, warming sand and the beds of stones, and such other precaution as may be necessary to counteract the effect of frost.

All stones shall be laid with a double lewis. Stones must not be dressed when set or otherwise shifted. Should it become necessary to move a stone after it has been once set, it must be raised from its bed, the old mortar scratched off, and a fresh mortar bed prepared, when it may be reset.

On completion of the work joints will be thoroughly scraped and pointed as may be directed.

*For all mortar* to be used under water, whether in the laying of masonry or making of concrete, Portland cement will be used. Mortar will consist of 1 part hydraulic cement, mixed in a dry state, with 2 parts clean river or bank sand, free from all loam. The entire quantity of water to be added, and the whole mass thoroughly incorporated. Mortar shall only be made in batches for immediate consumption, and none used that has commenced to set. For pointing, mortar shall be composed of 1 part cement to 1 of sand, and be made in very small quantities, being mixed with only enough water to bind the grains. For all masonry above low water, fresh water alone shall be used.

*Concrete* shall consist of hydraulic cement powder and clean sand free from loam, in proportions of 1 to 2 in bulk, with 4 parts of stone broken to pass through a 2½-inch ring and properly screened, or approved gravel. The stone shall be handled with forks and not with shovels, unless perfectly clean. Mixing shall be performed within a frame 12 inches deep, with a board bottom, the broken stones or gravel first spread out then the sand, and then the cement, the whole being moistened with a garden watering pot and only so much water used as will serve to moisten the grains. No pouring on of water in pailfuls will be permitted. The whole mass must be turned over and thoroughly mixed and worked until every stone is coated with mortar. When used under water, concrete will be deposited from boxes of approved form, and controlled by a diver if required by the Engineer. Above water it will be deposited in layers and well rammed. A portion of the concrete on top may be required to be made with small stones that will pass through an inch ring, in order to truly level the deposits.

Two barrels of cement per cubic yard of stone will be used in all concrete under water; other concrete will be proportioned and mixed as directed.

*All cement* shall be of the best quality, fresh burned and finely ground, the common standing a tensile test of at least 60 pounds per square inch, with 24 hours immersion, allowing 30 minutes to set. Portland cement shall be the best foreign brand obtainable and acceptable to the Engineer.

The right to change or modify plans of foundations and of masonry in general, or as to details, previous to commencement or during progress of the work, is reserved to the Engineer, provided, however, that such changes or modifications shall entail no loss upon the contractor by reason of previous expenditure.

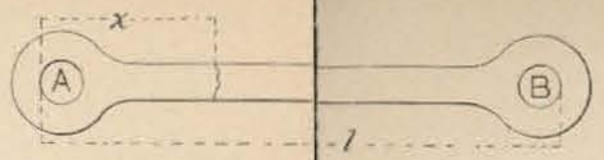
On completion of work all staging, dams, and temporary works to be removed.

APPENDIX F.

## TABLE SHOWING WEIGHTS OF METAL IN THE DIFFERENT TRUSS-SPANS.

| Group of Parts. | 164'6" Span, West Approach, C. to C. Pins, Through. | 148' Span, C. to C. Pins. River Bridge, Deck. | 306'7" Span, C. to C. of Pins, River Bridge, Through. | 497'7" Draw, C. to C. of Pins, River Bridge, Through. | Turn-table and Shafting, etc. |
|---|---|---|---|---|---|
| Trusses | 176,163 | 220,432 | 679,817 | 1,230,398 | |
| Flooring system | 142,517 | 14,414 | 292,462 | 433,974 | |
| Wind bracing | 15,542 | 6,589 | 53,193 | 111,528 | |
| Pedestals | 4,766 | 4,537 | 17,827 | ...... | |
| Wall plates | 2,644 | 3,124 | 16,694 | 5,698 | |
| Rollers | 1,262 | 1,078 | 2,235 | ....... | |
| Total weight | 342,894 | 250,174 | 1,062,228 | 1,781,598 | |
| Weight per Lineal Foot of Span. | | | | | |
| Trusses | 1,071 | 1,490 | 2,217 | 2,472 | |
| Wind bracing top chords | 95 | 45 | 174 | 224 | |
| Flooring system | 866 | 97 | 954 | 872 | |
| Total | 2,032 | 1,632 | 3,345 | 3,568 | |
| Locking gear, shafting, rail guides, turn shafts, gearing, etc. | | | | | 80,000 |
| Wall plates | | | | | 16,708 |
| Wheel treads | | | | | 10,740 |
| Track segments | | | | | 31,224 |
| Rack | | | | | 14,054 |
| Girders | | | | | 108,336 |
| Flooring | | | | | 9,170 |
| Drum and bracing | | | | | 69,070 |
| Live ring and rods | | | | | 9,264 |
| Center, etc. | | | | | 3,390 |
| Wheels | | | | | 44,156 |
| Parts | | | | | 6,718 |
| | | | | | 322,830 |

# FULL SIZED EYE BAR TESTS. THAMES RIVER BRIDGE, NEW LONDON, CONN.




OPEN HEARTH STEEL.

| Test No. | Heat No. | ¾-inch Round Tests. Elastic Limit. Per sq. inch. | ¾-inch Round Tests. Breaking Strain. Per sq. inch. | ¾-inch Round Tests. Elongation. Per cent. in 8 inches | ¾-inch Round Tests. Reduced Area. Per cent. | Finished Material Tests. Elastic Limit. Per sq. inch. | Finished Material Tests. Breaking Strain Per sq. inch. | Finished Material Tests. Elongation. Per cent. in 8 inches. | Finished Material Tests. Reduced Area. Per cent. | Chemical Analysis. C. | Chemical Analysis. Mn. | Chemical Analysis. P. | Dimensions. Section. | Dimensions. Area per sq. inch. | Dimensions. Length. | Size of Pin. A. | Size of Pin. B. | Size Head. A | Size Head. B. | Excess In. A. Per cent | Excess In. B. Per cent. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2,807 | 41,440 | 63,540 | 28.5 | 56.13 | 39,610 | 65,140 | 30.62 | 51.96 | .16 | .31 | .068 | 7.96x2.12 | 16.87 | 21'6.3" | 7½ | 7½ | 18.8x2.2 | 18.7x2.16 | 47. | 43.2 |
| 2 | 3,876 | 40,520 | 66,830 | 26.2 | 53.60 | 40,470 | 64,750 | 30.62 | 56.42 | .15 | .49 | .043 | 7.95x1.55 | 12.32 | 34'0.5" | 6 | 7½ | 17.0x1.69 | 18.4x1.67 | 50.6 | 47.5 |
| 3 | 2,808 | 41,240 | 66,480 | 26.5 | 59.07 | ........ | ....... | . ... | ..... | .22 | .40 | .055 | 7.96x1.40 | 11.14 | 34'0.2" | 6 | 7½ | 17.2x1.46 | 18.4x1.45 | 46.5 | 41.6 |
| 4 | 2,808 | " | " | " | " | 39,070 | 63,530 | 31.25 | 59.64 | " | " | " | 7.98x1.25 | 9.98 | 25'6.9" | 6 | 7½ | 17.3x1.35 | 18.5x1.31 | 52.6 | 44.1 |
| 5 | 2,808 | " | " | " | " | " | " | " | " | " | " | " | 8.00x1.25 | 10.00 | 24'9.55" | 6 | 6 | 17.6x1.27 | 17.3x1.38 | 33.4 | 41.8 |
| 6 | 2,808 | " | " | " | " | " | " | " | " | " | " | " | 7.85x1.23 | 9.66 | 21'9.45" | 7 | 6 | 17.3x1.38 | 17.5x1.32 | 48.8 | 56.8 |
| 7 | 3,730 | 43,480 | 64,410 | 29.25 | 57.28 | 38,050 | 64,070 | 29.37 | 56.81 | .25 | .48 | .058 | 6.95x2.51 | 17.44 | 24'1" | 6 | 6 | 16.2x2.47 | 16.2x2.48 | 44. | 44.8 |
| 8 | 3,730 | " | " | " | " | " | " | " | " | " | " | " | 6.95x2.48 | 17.24 | 24'1.1" | 6 | 6 | 16.2x2.48 | 16.1x2.50 | 46.4 | 46.2 |
| 9 | 3,883 | 42,210 | 66,300 | 26.25 | 60.20 | 39,250 | 63,310 | 27.5 | 44.52 | .18 | .43 | .070 | 7.10x2.49 | 17.68 | 24'1" | 6 | 6 | 16.1x2.53 | 16.1x2.57 | 44.2 | 46.5 |
| 10 | 3,883 | " | " | " | " | 37,660 | 62,700 | 21.80 | 58.00 | .14 | .39 | .079 | 7.03x2.25 | 15.82 | 24'1" | 6 | 6 | 15.8x2.26 | 16.2x2.23 | 39. | 43.5 |
| 11 | 3,883 | ....... | ........ | ..... | ..... | 39,700 | 64,400 | 30.00 | 53.74 | .18 | .43 | .070 | 7.06x2.05 | 14.47 | 24'1" | 6 | 6 | 16.0x2.14 | 16.1x2.14 | 47.6 | 49. |
| 12 | 8,575 | ....... | ........ | ..... | ..... | 44,500 | 60,060 | 23.10 | 54.90 | .14 | .... | .057 | 7.0 x2.05 | 14.35 | 24'1" | 6 | 6 | 15.9x2.08 | 15.8x2.1 | 43.2 | 43.1 |
| 13 | 3,771 | 40,040 | 63,880 | 29.37 | 57.49 | 38,650 | 62,120 | 25.00 | 61.20 | .20 | .44 | .050 | 6.97x1.74 | 12.13 | 35'85" | 6 | 6½ | 16.0x1.72 | 15.7x1.76 | 40.8 | 33.2 |
| 14 | 3,742 | 44,280 | 65,530 | 26.25 | 52.88 | 41,420 | 66,510 | 23.00 | 45.81 | .25 | .51 | .057 | 6.98x1.62 | 11.31 | 24'1" | 6 | 6 | 15.9x1.67 | 15.7x1.68 | 45. | 43.50 |
| 15 | 3,742 | " | " | " | " | " | " | " | " | " | " | " | 7.03x1.62 | 11.39 | 24'1" | 6 | 6 | 15.8x1.70 | 15.8x1.65 | 46. | 41.70 |
| 16 | 2,773 | ........ | ... .... | . . . | ..... | 37,210 | 65,410 | 26.87 | 54.68 | .21 | .48 | .050 | 7.00x1.43 | 10.00 | 38'4" | 6 | 6 | 16.1x1.46 | 15.5x1.52 | 47. | 44.00 |
| 17 | 8,500 | ........ | ........ | ..... | ..... | 43,490 | 65,214 | 28.70 | 54.00 | .14 | .39 | .079 | 7.01x1.38 | 9.67 | 24'1" | 6 | 6 | 16.0x1.40 | 15.9x1.47 | 44.5 | 50.10 |
| 18 | 3,741 | 44,280 | 65,530 | 26.25 | 52.88 | 38,680 | 68,250 | 23.00 | 46.44 | .20 | .50 | .076 | 6.98x1.31 | 9.14 | 24'1" | 6 | 6 | 15.9x1.35 | 16.0x1.36 | 45.90 | 48.50 |
| 19 | 3,729 | 43,020 | 68,640 | 26.62 | 49.53 | 37,150 | 63,450 | 30.00 | 58.61 | .21 | .60 | .046 | 7.00x1.32 | 9.24 | 24'1" | 6 | 6 | 16.0x1.37 | 15.9x1.36 | 48.00 | 45.40 |
| 20 | 3,883 | 42,210 | 66,300 | 26.25 | 60.20 | 39,500 | 64,100 | 31.50 | 57.40 | .18 | .43 | .070 | 7.11x1.24 | 8.8 | 24'1" | 6 | 6½ | 16.0x1.31 | 16x1.34 | 48.30 | 43.70 |
| 21 | 9,933 | 44,500 | 67,850 | 27.50 | 47.23 | 41,300 | 67,660 | 21.75 | 48.81 | .... | .... | .058 | 6.04x1.76 | 10.63 | 33'4" | 5½ | 5½ | 13.8x1.83 | 13.6x1.84 | 42.50 | 39.50 |
| 22 | 3,650 | 44,490 | 68,090 | 24.25 | 51.53 | 40,540 | 65,770 | 23.75 | 54.62 | .22 | .32 | .062 | 6.00x1.73 | 10.38 | 23'11" | 5 | 5¾ | 13.5x1.8 | 13.8x1.78 | 49.10 | 37.60 |
| 23 | 3,650 | " | " | " | " | " | " | " | " | " | " | " | 6.00x1.60 | 9.60 | 25'1" | 5 | 5¾ | 13.5x1.65 | 13.5x1.67 | 47.80 | 34.50 |
| 24 | 3,651 | 43,220 | 68,130 | 26.87 | 51.28 | 43,230 | 65,440 | 25.62 | 57.31 | .19 | .47 | .060 | 6.00x1.24 | 7.46 | 25'1" | 4¾ | 4¾ | 13.5x1.33 | 13.5x1.31 | 53.60 | 51.10 |
| 25 | 11,600 | 43,650 | 66,260 | 25.25 | 46.40 | 36,530 | 62,260 | 28.00 | 48.08 | .... | .... | .048 | 6.01x1.12 | 6.73 | 23'11" | 5½ | 5½ | 13.5x1.23 | 13.5x1.23 | 45.80 | 45.80 |
| 26 | 2,772 | 43,250 | 67,430 | 26.00 | 48.70 | 40,930 | 67,050 | 24.75 | 50.89 | .20 | .80 | .059 | 4.81x1.44 | 6.93 | 34'8" | 6 | 6 | 13.1x1.50 | 13.2x1.52 | 53.20 | 53.20 |
| 27 | 2,772 | " | " | " | " | " | " | " | " | " | " | " | 5.00x1.50 | 7.50 | 36'6" | 6 | 6 | 13.3x1.56 | 13.3x1.56 | 51.40 | 54.30 |
| 28 | 2,772 | " | " | " | " | " | " | " | " | " | " | " | 5.00x1.50 | 7.50 | 36'4" | 6 | 6 | 13.3x1.55 | 13.2x1.52 | 50.40 | 45.50 |
| 29 | 2,772 | " | " | " | " | " | " | " | " | " | " | " | 5.00x1.13 | 5.65 | 18'1" | 4 | 6 | 10.70x1.18 | 13.6x1.20 | 39.40 | 61.00 |
| 30 | 3,772 | ........ | ......... | ..... | ..... | ......... | ......... | ..... | ..... | .... | .... | .... | 4.00x1.50 | 6.00 | 36'5" | 6 | 6 | 11.1x1.51 | 11.2x1.51 | 27.80 | 30.30 |
| 31 | 3,742 | 44,550 | 66,530 | 24.75 | 57.10 | 38,760 | 67,900 | 26.87 | 46.47 | .25 | .51 | .057 | 4.95x1.23 | 6.09 | 20'0" | 4 | 7 | 10.90x1.29 | 14.20x1.25 | 45.70 | 47.20 |
| 32 | 3,738 | 44,540 | 65,220 | 26.87 | 51.17 | 37,870 | 67,970 | 24.75 | 51.47 | .19 | .53 | .059 | 4.93x1.24 | 6.11 | 20'0" | 4 | 7 | 10.90x1.33 | 14.1x1.34 | 49.60 | 54.80 |
| 33 | 2,773 | 42,140 | 65,080 | 27.75 | 53.49 | 37,210 | 65,410 | 26.87 | 54.68 | .21 | .48 | .050 | 3.85x0.71 | 4.89 | 34'7" | 6 | 7½ | 13.50x1.04 | 14.6x1.04 | 59.10 | 50.50 |

| Test No. | Strains Applied. Elastic Limit. Actual. | Strains Applied. Elastic Limit. Per sq. inch. | Strains Applied. Breaking Strain. Actual. | Strains Applied. Breaking Strain. Per sq. inch. | Location of Fracture. | Reduction of Area. Per cent. | Elongations. Per cent. in 12 inches. | Elongations. Measured. Feet. | Elongations. Measured. Per cent. | Elongations. Pin. A. Per cent. | Elongations. Pin. B. Per cent. | Character of Fracture. | Name of Maker. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 524,180 | 31,070 | 932,100 | 55,250 | 3' 8" from A. | 45.9 | 44.2 | 18 | 18.8 | 21.8 | 17.9 | Silky cup. | Carnegie. | |
| 2 | 377,325 | 30,630 | 738,340 | 59,930 | 7' 0" from B. | 45.6 | 41.7 | 31 | 19.3 | 17.9 | 18.6 | Silky at 45°. | " | 15 % gran. Fracture on each edge. |
| 3 | 332,450 | 29,840 | 613,920 | 55,100 | 21' 3" from B. | 44.9 | 40.0 | 31 | 18.7 | 23.7 | 17.1 | " " | " | 20 % gran. " " " |
| 4 | 326,335 | 32,700 | 599,645 | 60,080 | 13' 4" from B. | 40.5 | 36.2 | 22 | 16.5 | 16.2 | 21.8 | " " | " | 25 % gran. " " " |
| 5 | 344,690 | 34,470 | 473,190 | 47,320 | Head A. | ...... | ...... | .. | ...... | ...... | ... .. | ..................... | " | Broken in flaw not previously visible. |
| 6 | 377,325 | 39,060 | 628,200 | 65,030 | 2' 4" from B. | 45.4 | 28.3 | 18 | 11.8 | 14.9 | 18.6 | Silky cup. | " | 20 % gran. Fracture on each edge. Re-te |
| 7 | 489,505 | 28,068 | 956,575 | 54,840 | 6' 6" from B. | 55.2 | 43.3 | 21 | 17.9 | 19.6 | 25.7 | Silky. | | 10 % gran. each edge. Rejected. |
| 8 | 505,825 | 29,340 | 946,375 | 54,900 | 5' 2" from B. | 55.2 | 38.3 | 21 | 17.5 | 21.2 | 22.4 | " | " | " " " |
| 9 | 530,300 | 30,000 | 954,535 | 54,000 | 5' 6" from B. | 12.3 | 12.5 | 21 | 10.7 | 18.9 | 15.4 | Square gran. 100 %. | " | Rejected. |
| 10 | 475,230 | 30,040 | 895,385 | 56,600 | 4' 6" from A. | 49.9 | 39.1 | 12 | 16. | 19.9 | 17.2 | 30 % granular. | " | " |
| 11 | 460,950 | 31,850 | 836,240 | 57,650 | Head. | 12.9 | ...... | 21 | 12.6 | ...... | 20.4 | ........... ......... | ........... | Failed in head. |
| 12 | 564,970 | 39,370 | 934,140 | 65,100 | 5' 1" from B. | 45.6 | 36.60 | 21 | 16.9 | 20.4 | 18.6 | Silky cup. | Penn. S. Co. | Blooms rolled at Elmira mill. |
| 13 | 414,040 | 34,130 | 748,535 | 61,700 | 5' 6" from A. | 46.8 | 37.80 | 32 | 13.1 | 17.20 | 19.90 | Silky. 10 % granular. | Carnegie. | |
| 14 | 367,525 | 32,400 | 666,950 | 58,900 | 11' 7" from A. | 48.20 | 40.00 | 21 | 16.10 | 19.60 | 20.40 | Silky at 45°. | " | 10 % granular on one edge. |
| 15 | 367,122 | 32,230 | 666,950 | 58,550 | 8' 0" from A. | 42.40 | 38.30 | 21 | 15.80 | 18.70 | 21.20 | Silky, 45 %. | " | 10 % granular. |
| 16 | 395,680 | 39,570 | 673,070 | 67,300 | 6' 6" from A. | 44.50 | 34.20 | 35 | 14.20 | 17.90 | 16.60 | 50 % silky, 50 % gr. | " | |
| 17 | 334,490 | 34,590 | 534,380 | 55,260 | 18' from B. | 48.10 | 38.30 | 21 | 14.60 | 20.90 | 16.60 | Silky cup 45°. | Penn. S. Co. | Rolled at Elmira mill. |
| 18 | 307,975 | 33,700 | 558,855 | 61,140 | 9' 4" from A. | 44.40 | 35.80 | 21 | 14.40 | 18.70 | 13.60 | Silky at 45°. | Carnegie. | 30 % fracture. Granular. |
| 19 | 291,660 | 31,560 | 544,575 | 58,930 | 2' 11" from B. | 45.40 | 35.00 | 21 | 16.40 | 17.40 | 20.90 | " " 10 % gr. | " | |
| 20 | 295,740 | 33,570 | 544,875 | 61,800 | 5' 11" from B. | 43.60 | 39.10 | 21 | 17.70 | 18.10 | 19.40 | " " 10 % gr. | " | |
| 21 | 401,800 | 37,800 | 724,060 | 68,100 | 3' 4" from B. | 34.90 | 30.00 | 30 | 15.30 | 18.40 | 23.90 | 20 % silky. | Cambria. | Broke in clamp marks. |
| 22 | 336,530 | 32,400 | 652,675 | 62,870 | 3' 6, from A. | 40.20 | 29.10 | 21 | 14.50 | 16.90 | 19.50 | 90 % granular. | Carnegie. | |
| 23 | 328,375 | 34,200 | 613,920 | 63,900 | 4' 5" from A. | 42.10 | 33.30 | 22 | 15.70 | 18.10 | 20.00 | 60 % granular. | " | |
| 24 | 220,275 | 29,500 | 418,120 | 56,000 | 9' 3" from B. | 56.60 | 36.60 | 22 | 16.60 | 16.30 | 17.30 | 10 % granular. | " | |
| 25 | 250,870 | 37,270 | 438,515 | 65,160 | 6' 5" from A. | 44.10 | 38.30 | 21 | 21.10 | 22.40 | 20.40 | Silky at 45°. | Cambria. | |
| 26 | 324,295 | 46,800 | 418,120 | 60,300 | 2' 0" from A. | 45.60 | ..... | 29 | 3.50 | 13.70 | 1.90 | " " | Carnegie. | *Counter* with sleeve nut. |
| 27 | 254,945 | 33,990 | 487,465 | 65,000 | ......... ... | 45.00 | 35.80 | 31 | 18.00 | 9.90 | 11.60 | " " | " | " " " |
| 28 | 210,075 | 28,000 | 381,405 | 50,850 | 2' 4" from A. | 6.66 | 6.66 | 30 | 7.10 | 8.80 | 2.90 | Granular. | | " " " Broke in clamp |
| 29 | 203,955 | 36,100 | 379,365 | 67,100 | 2' 9" from A. | 48.30 | 36.70 | 15 | 18.40 | 30.60 | 8.90 | Silky at 45°. | " | Plain eyebar. |
| 30 | 203,955 | 33,990 | 397,720 | 66,286 | .. ......... | 47.50 | 33.33 | 32 | 21.00 | 16.60 | 19.50 | Irregular, silky. | " | *Counter* with sleeve nut. |
| 31 | 216,195 | 35,500 | 393,640 | 64,300 | 4' 10" from B. | 47.60 | 35.80 | 17 | 16.66 | 20.10 | 13.20 | Silky. 10 % granular. | " | Plain eyebar. |
| 32 | 214,155 | 35,050 | 330,415 | 54,070 | ....... ...... | ...... | ...... | 17 | 5.50 | ...... | ...... | Flaw in head. | " | Broke in visible flaw. |
| 33 | 216,195 | 44,200 | 326,335 | 66,730 | 23' 9" from B. | 44.20 | 33.33 | 31 | 18.60 | 10.90 | 10.30 | Silky 50 %, 45°. | " | 50 % cup fracture. |

## FINISHED MATERIAL TESTS.—O. H. STEEL BARS.

| Cut From. | | Heat No. | Area. | Elastic Limit. Per sq. inch. | Breaking Strain. Per sq. inch. | Elongation. Per cent. in 8 inches | Reduced Area. Per cent. | C. | Mn. | P. | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8"x1 9/16" | Bar. | 2,808 | .9832 | 40,480 | 64.280 | 30.62 | 60.19 | .22 | .40 | .055 | |
| 8"x1 9/16" | " | 3,829 | .9938 | 38,890 | 65,400 | 30.00 | 52.10 | .22 | .62 | .060 | |
| 8"x1¼" | " | 2,806 | 1.012 | 39,820 | 63,840 | 34.37 | 61.57 | .21 | .40 | .057 | |
| 8"x1¼" | " | 2,808 | 1.011 | 39,870 | 63,530 | 31.25 | 59.64 | .22 | .40 | .055 | |
| 8"x1¼" | " | 2,807 | 1.035 | 39,610 | 65,140 | 30.62 | 51.96 | .16 | .31 | .068 | |
| 8"x1¼" | " | 3,829 | 1.019 | 39,970 | 66,950 | 27.50 | 52.39 | .22 | .62 | .060 | |
| 8"x1¼" | " | 3,875 | 1.024 | 40,630 | 63,580 | 34.37 | 62.83 | .20 | .46 | .059 | |
| 8"x1¼" | " | 3,876 | 1.024 | 40,470 | 64,750 | 30.62 | 56.42 | .23 | .40 | .066 | |
| 8"x1¼" | " | 3,877 | 1.016 | 39,980 | 67,250 | 29.37 | 52.25 | .20 | .39 | .060 | |
| 7"x2½" | " | 3,883 | .5402 | 39,250 | 63,310 | 27.50 | 44.52 | .18 | .43 | .070 | Rejected on full size tests. |
| 7"x2¼" | " | 3,883 | .6320 | 41,300 | 64,520 | 28.25 | 49.51 | .18 | .43 | .070 | " " " |
| 7"x2¼" | " | 8,500 | .. .. | 37,660 | 62,700 | 21.80 | 58.00 | .14 | .39 | .079 | Penna. Steel Co., to replace 3883. |
| 7"x2 1/16" | " | 3,883 | .5402 | 39,700 | 64,420 | 30.00 | 53.74 | .18 | .43 | .070 | Rejected on full size tests |
| 7"x"2" | " | 3,883 | .6328 | 39.660 | 63,050 | 27.00 | 43.20 | .18 | .43 | .070 | " " " |
| 7"x1⅞" | " | 3,883 | .6296 | 40,180 | 63,850 | 27.00 | 49.30 | .18 | .43 | .070 | " " " |
| 7"x1⅞" | " | 8,575 | ...... | 44,500 | 60,600 | 23.18 | 54.90 | .14 | .... | .097 | Penna. Steel Co., to replace heat 3883. Cut from crop end, with rough edge. |
| 7"x1 11/16" | " | 3,742 | .5217 | 41,420 | 66,510 | 23.00 | 45.81 | .25 | .51 | .057 | |
| 7"x1 11/16" | " | 8,500 | ...... | 37,137 | 62,146 | 27.50 | 52.00 | .14 | .39 | .079 | Penna. Steel Co. |
| 7"x1 11/16" | " | 2,778 | .6719 | 37,210 | 65,410 | 26.87 | 54.68 | .21 | .48 | .050 | |
| 7"x1 11/16" | " | 3,771 | .6158 | 38,650 | 62,120 | 25.00 | 61.20 | .20 | .44 | .050 | |
| 7"x1 11/16" | " | 2,772 | .5476 | 41,360 | 69,400 | 20.00 | 32.70 | .20 | .80 | .059 | Rejected on full size tests. |
| 7"x1 11/16" | " | 2,772 | .7543 | 41,360 | 67,880 | 21.75 | 35.01 | .20 | .80 | .059 | " " " |
| 7"x1½" | " | 3,738 | .7224 | 38,480 | 63,680 | 31.00 | 61.46 | .19 | .53 | .059 | |
| 7"x1 7/16" | " | 3,738 | .7219 | 39,200 | 64,140 | 26.87 | 42.60 | .19 | .53 | .059 | |
| 7"x1 7/16" | " | 3,828 | .5281 | 37,870 | 63,820 | 23.75 | 41.91 | .19 | .41 | .059 | |
| 7"x1⅜" | " | 3,883 | .6344 | 40,670 | 63,840 | 28.50 | 51.47 | .18 | .43 | .070 | Rejected on full size tests. |
| 7"x1¼" | " | 3,883 | .5217 | 39,500 | 64,100 | 31.50 | 57.40 | .18 | .43 | .070 | " " " |
| 6"x2" | " | 3,725 | .7624 | 41,710 | 64,200 | 31.87 | 48.46 | .19 | .36 | .058 | |
| 6"x2" | " | 3,723 | .7734 | 44,090 | 66,070 | 30.00 | 48.50 | .23 | .40 | .049 | |
| 6"x2" | " | 3,724 | .7924 | 44,990 | 66,000 | 28.25 | 48.13 | .21 | .37 | .058 | |
| 6"x1¾" | " | 3,728 | .5090 | 38,310 | 64,350 | 28.75 | 51.62 | .20 | .47 | .050 | |

## FINISHED MATERIAL TESTS.—O. H. STEEL BARS.—(*Continued.*)

| | Cut From. | | Heat No. | Area. | Elastic Limit. Per sq. inch. | Breaking Strain. Per sq. inch. | Elongation. Per cent. in 8 inches | Reduced Area. Per cent. | C. | Mn. | P. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 457 | 6"x1⅝" | Bar. | 3,729 | .5027 | 39,190 | 64,650 | 25.50 | 51.00 | .21 | .60 | .046 | |
| " | 6"x1⅝" | " | 3,650 | .8362 | 40,540 | 65,770 | 23.75 | 54.62 | .22 | .32 | .062 | |
| | 6"x1⅝" | " | 11,592 | .7847 | 38,610 | 64,860 | 25.62 | 43.42 | .... | .... | .065 | Cambria Iron Works. |
| | 6"x1¾" | " | 11,592 | .9820 | 39,490 | 64 480 | 25.50 | 43.71 | .... | .... | .065 | " " " |
| | 6"x1½" | " | 11,219 | .7550 | 39,730 | 66,220 | 30.50 | 47.80 | ... | .... | .060 | " " " |
| | 6"x1¼" | " | 3,649 | .6484 | 45,500 | 64,390 | 31.25 | 57.50 | .22 | .47 | .053 | |
| | 6"x1¼" | " | 3,651 | .6570 | 43,230 | 65,440 | 25.62 | 57.31 | .19 | .47 | .060 | |
| | 6"x1¼" | " | 3,727 | .5090 | 49,200 | 63,000 | 24.00 | 54.68 | .26 | .42 | .053 | |
| | 6"x1⅛" | " | 11,600 | .7501 | 36,530 | 62,260 | 28.00 | 48.08 | .... | .... | .048 | Cambria Iron Works. |
| | 6"x1⅛" | " | 11,534 | .7571 | 41,600 | 67,220 | 27.00 | 51.30 | ... | .... | .054 | " " " |
| | 5"x1½" | " | 3,727 | .6335 | 39,150 | 66,300 | 27.25 | 53.76 | .26 | .42 | .053 | |
| | 5"x1½" | " | 3,729 | .6407 | 37,150 | 63,450 | 30.00 | 58.61 | .21 | .60 | .046 | |
| | 5"x1½" | " | 3,739 | .6490 | 37,440 | 66,020 | 27.50 | 53.88 | .20 | .52 | .063 | |
| | 5"x1 5/16" | " | 3,730 | .6321 | 38,050 | 64,070 | 29.37 | 56.81 | .25 | .48 | .058 | |
| | 5"x1¼" | " | 3,738 | .7842 | 37,870 | 67,970 | 24.75 | 51.47 | .19 | .53 | .059 | |
| | 5"x1¼" | " | 3,740 | .7681 | 39,390 | 67,700 | 28.00 | 48.03 | .21 | .51 | .064 | |
| | 5"x1¼" | " | 3,741 | .7730 | 38,680 | 68,250 | 23.00 | 46.44 | .20 | .50 | .076 | |
| | 5"x1¼" | " | 3,742 | .7650 | 38,760 | 67,900 | 26.87 | 46.47 | .25 | .51 | .057 | |
| | 5"x1¼" | " | 3,726 | .6417 | 39,900 | 69,970 | 23.18 | 51.33 | .23 | .39 | .053 | |
| | 5"x1¼" | " | 8,500 | ..... | 43,490 | 65,214 | 28.70 | 54.00 | .14 | .39 | .079 | Penna. Steel Co. To replace heat, 3,883. |
| | 5"x1⅛" | " | 9,933 | .7627 | 41,300 | 67,660 | 21.75 | 48.81 | ... | .... | .058 | Cambria Iron Works. |
| 457 | 5"x1" | " | 11,600 | .7509 | 36,490 | 62,860 | 29.00 | 54.15 | ... | ... | .048 | " " " |
| " | 5"x1" | " | 11,605 | .7487 | 37,950 | 67,980 | 27.75 | 51.97 | .... | ... | .053 | " " " |
| | 5"x1" | " | 2,772 | .5742 | 40,930 | 67,050 | 24.75 | 50.89 | .20 | .80 | .059 | |
| | 4"x1½" | " | 3,771 | .6404 | 37,480 | 64,020 | 29.00 | 59.20 | .20 | .44 | .050 | |
| 457 | 4"x4¼" | " | 11,590 | .7880 | 37,550 | 64,490 | 28.50 | 53.19 | .... | .... | .062 | Cambria Iron Works. |
| " | 4"x1¼" | " | 11,591 | .7742 | 37,200 | 62,260 | 27.75 | 44.76 | .... | .... | .057 | " " " |
| " | 2½"x⅝" | " | 11,605 | .9488 | 41,320 | 67,890 | 27.75 | 43.80 | ... | .... | .053 | " " " |
| | 1¾" round | " | 3,719 | .6518 | 40,660 | 64,440 | 27.50 | 49.40 | .24 | .49 | .048 | |

# FINISHED MATERIAL TESTS.—O. H. STEEL PLATES.

| | Cut From. | Heat No | Area. | Elastic Limit. Per sq. inch. | Breaking Strain. Per sq. inch. | Elongation Per cent. in 8 inches. | Reduced Area. Per cent. | C. | Mn. | P. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 482 and 483 | 47½"x⅜" plate. | 630 | .5272 | 37,600 | 69,800 | 23.00 | 51.59 | .27 | .40 | .070 | Park Bros. & Co. Sheared. |
| 482 and 483 | 47½"x⅜" " | 1,896 | .5796 | 41,070 | 65,220 | 25.00 | 44.08 | .18 | .56 | .058 | " " " |
| 482 and 483 | 47½"x⅜" " | 1,896 | .5868 | 41,930 | 65,620 | 24.50 | 41.48 | .18 | .56 | .088 | " " " |
| 482 and 483 | 44" x¾" " | 5,218 | .7547 | 40,220 | 67,310 | 29.00 | 50.14 | .19 | .62 | .065 | " " " |
| | 30" x⅜" " | 3,887 | .4252 | 40,450 | 65,620 | 23.25 | 53.97 | .20 | .43 | .060 | |
| | 30" x⅜" " | 3,731 | .4234 | 41,100 | 68,020 | 22.25 | 51.08 | .21 | .46 | .048 | |
| | 30" x⅜" " | 3,732 | .4350 | 40,460 | 64,370 | 27.50 | 55.06 | .16 | .47 | .051 | |
| 457 | 29½"x⅜" " | 266 | .4598 | 44,800 | 69,380 | 23.25 | 52.70 | .17 | .30 | .072 | Carbon Iron Co. |
| " | 29½"x⅜" " | 264 | .4389 | 43,890 | 66,990 | 21.75 | 46.39 | .18 | .40 | .085 | " " |
| " | 29½"x⅜" " | 280 | .3765 | 46,750 | 68,930 | 25.00 | 67.60 | .16 | .37 | .086 | " " |
| " | 29½"x⅜" " | 282 | .4267 | 46,870 | 67,730 | 22.00 | 53.24 | .16 | .38 | .088 | " " |
| | 25½"x½" " | 2,880 | .5075 | 41,780 | 65,620 | 27.00 | 57.34 | .20 | .41 | .071 | |
| 457 | 22" x½" " | 265 | .5920 | 42,910 | 65,870 | 28.00 | 59.29 | .16 | .35 | .079 | Carbon Iron Co |
| " | 22" x½" " | 262 | .5750 | 38,220 | 65,920 | 25.00 | 43.01 | .17 | .37 | .073 | " " |
| " | 22" x½" " | 278 | .6079 | 39,480 | 66,790 | 30.55 | 60.88 | .16 | .42 | .079 | " " |
| " | 20½"x1" " | 267 | .9585 | 43,020 | 67,050 | 26.25 | 46.25 | .17 | .38 | .078 | " " |
| " | 18" x⅝" " | 263 | .7053 | 38,850 | 66,630 | 29.00 | 49.97 | .16 | .38 | .076 | " " |
| " | 18" x⅝" " | 268 | .6625 | 41,650 | 72,290 | 27.00 | 56.98 | .12 | .39 | .083 | " " |
| " | 18" x⅝" " | 261 | .7235 | 37,320 | 66,000 | 30.00 | 59.29 | .16 | .42 | .076 | " " |
| | 16" x⅜" " | 3,765 | .4800 | 40,630 | 66,250 | 25.75 | 55.25 | .19 | .48 | .048 | |
| | 15" x¾" " | 3,886 | .6512 | 40,230 | 63,960 | 27.00 | 52.62 | .20 | .46 | .059 | |
| | 15" x¾" " | 3,888 | .6556 | 39,660 | 65,130 | 24.00 | 55.08 | .20 | .43 | .050 | |
| | 15" x½" " | 3,891 | .5812 | 42,670 | 66,590 | 26.75 | 54.76 | .20 | .45 | .067 | |
| 457 | 15" x⅜" " | 550 | .5790 | 41,800 | 67,360 | 26.00 | 51.42 | .17 | .34 | .080 | Carbon Iron Co. |
| " | 14" x½" " | 215 | .5268 | 37,590 | 71,940 | 24.00 | 47.08 | .21 | .46 | .066 | " " |
| | 14" x½" " | 3,729 | .4742 | 40,280 | 66,430 | 25.75 | 59.74 | .21 | .60 | .046 | |
| | 14" x½" " | 3,724 | .4574 | 42,850 | 71,060 | 25.00 | 55.40 | .21 | .37 | .058 | |
| | 13½"x½" " | 3,728 | .4579 | 43,020 | 70,320 | 22.50 | 45.86 | .20 | .47 | .050 | |
| 457 | 13" x½" " | 216 | .5635 | 38,880 | 66,810 | 25.50 | 53.15 | .16 | .54 | .061 | Carbon Iron Co. |
| " | 12" x⅝" " | 252 | .6746 | 38,990 | 66,550 | 21.25 | 47.27 | .16 | .34 | .075 | " " |
| | 9½"x½" " | 3,829 | .5464 | 41,180 | 68,450 | 24.50 | 58.07 | .22 | .62 | .060 | |
| 457 | 9" x⅜" " | 253 | .3975 | 44,780 | 67,930 | 24.50 | 52.10 | .18 | .39 | .064 | Carbon Iron Co. |
| " | 8" x⅜" " | 234 | .4297 | 45,150 | 66,330 | 29.25 | 50.27 | .21 | .38 | .073 | " " |

## FINISHED MATERIAL TESTS.—O. H. STEEL PLATES.—(*Continued.*)

| | Cut from. | Heat No. | Area. | Elastic Limit. Per sq. inch. | Breaking Strain. Per sq. inch. | Elongation. Per cent. in 8 inches. | Reduced Area. Per cent. | C. | Mn. | P. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1⅛" plate. | 3,768 | 1.483 | 37,150 | 67,430 | 19.75 | 46.91 | .20 | .38 | .054 | Sheared. For drum. |
| | 7/8" " | 2,880 | .9950 | 39,035 | 65,120 | 23.00 | 40.66 | .20 | .41 | .071 | " " " |
| | 7/8" " | 3,858 | .9486 | 38,370 | 64,730 | 24.25 | 48.13 | .20 | .32 | .048 | " " " |
| | 7/8" " | 2,779 | 1.121 | 40,410 | 64,050 | 25.50 | 40.56 | .20 | .64 | .053 | " " " |
| 482 | 7/8" " | 557 | .8816 | 41,180 | 65,340 | 29.25 | 51.53 | .16 | .35 | .076 | Carbon Iron Co. Univ. |
| | 3/4" " | 2,798 | .9064 | 36,800 | 56,380 | 26.50 | 52.28 | .14 | .29 | .046 | Sheared. For drum. |
| | 3/4" " | 2,799 | .9337 | 37,430 | 55,160 | 25.00 | 64.22 | .14 | .26 | .044 | " " " |
| | 3/4" " | 3,792 | 1.024 | 32,420 | 58,840 | 26.87 | 47.19 | .14 | .39 | .041 | " " " *Rejected.* |
| | 3/4" " | 3,776 | 1.129 | 38,880 | 61,030 | 26.50 | 52.17 | .20 | .46 | .054 | " " " |
| | 5/8" " | 2,779 | .9432 | 39,550 | 63,610 | 26.00 | 45.57 | .20 | .64 | .053 | " " " |
| 482 | 5/8" " | 560 | .8098 | 41,740 | 64,580 | 28.00 | 54.31 | .15 | .32 | .077 | Carbon Iron Co. Univ. |
| | 1/2" " | 2,778 | .59 | 40,170 | 65,590 | 26.50 | 50.49 | .21 | .39 | .064 | Sheared. For drum. |
| | 1/2" " | 4,499 | .6218 | 37,560 | 63,850 | 27.50 | 44.53 | .20 | .44 | .012 | " " " |
| | 1/2" " | 4,507 | .7544 | 40,560 | 63,100 | 31.87 | 56.26 | .21 | .60 | .014 | " " " |
| | 3/8" " | 498 | .5824 | 41,380 | 67,650 | 28.00 | 54.29 | .17 | .52 | .074 | Carbon Iron Co. Univ. |
| | 3/8" " | 1,544 | .7454 | 40,250 | 65,800 | 28.00 | 52.71 | .24 | .52 | .030 | " " " |
| | 3/8" " | 4,510 | .7384 | 40,630 | 64,060 | 27.50 | 52.97 | .19 | .90 | .016 | " " " |
| | 3/8" " | 2,713 | .8465 | 39,220 | 66,040 | 27.25 | 53.41 | .23 | .41 | .046 | " " " |
| 482 | 3/8" " | 558 | .6221 | 43,080 | 66,230 | 24.50 | 51.50 | .15 | .33 | .089 | " " " |
| 479 | 3/8" " | 565 | .5989 | 41,410 | 66,960 | 26.50 | 54.57 | .17 | .37 | .081 | " " " |
| 482 | 3/8" " | 569 | .6143 | 41,010 | 65,510 | 28.50 | 55.85 | .16 | .49 | .091 | " " " |
| 482 | 3/8" " | 525 | .5360 | 41,420 | 68,100 | 27.00 | 54.94 | .15 | .33 | .076 | " " " |
| 483 | 3/8" " | 552 | .5202 | 44,600 | 67,670 | 24.00 | 58.15 | .18 | .38 | .085 | " " " |
| 482 | 3/8" " | 553 | .6174 | 41,790 | 66,410 | 25.25 | 54.16 | .16 | .39 | .089 | " " " |
| 477 | 3/8" " | 555 | .6059 | 42,580 | 67,010 | 31.75 | 67.30 | .15 | .41 | .087 | " " " |
| 489 | 3/8" " | 574 | .5565 | 41,690 | 66,130 | 26.75 | 54.52 | .15 | .40 | .090 | " " " |
| 477 | 3/8" " | 554 | .5860 | 41,810 | 64,680 | 28.25 | 59.11 | .15 | .37 | .089 | " " " |
| 489 | 3/8" " | 572 | .5838 | 43,170 | 66,120 | 28.25 | 62.14 | .18 | .38 | .091 | " " " |
| | 3/8" " | 2,821 | .7503 | 42,580 | 66,840 | 25.50 | 53.82 | .19 | .39 | .049 | |
| | 3/8" " | 3,885 | .6494 | 43,500 | 69,960 | 21.50 | 44.62 | .16 | .49 | .039 | |
| 477 | 59½"x3/8" " | 630 | .5175 | 39,710 | 70,530 | 26.50 | 50.09 | .27 | .40 | .070 | Park Bros. & Co. Sheared. |
| 482 and 483 | 47½"x9/16" " | 5,218 | .5569 | 40,860 | 69,680 | 22.25 | 47.30 | .19 | .62 | .065 | " " " |
| | 47½"x9/16" " | 5,218 | .5594 | 41,120 | 69,900 | 20.25 | 49.17 | .19 | .62 | .065 | " " " |
| | 47½"x9/16" " | 5,218 | .5589 | 40,980 | 69,070 | 23.00 | 50.94 | .19 | .62 | .065 | " " " |

| | Cut From. | Heat No. | Area. | Elastic Limit. Per sq. inch. | Breaking Strain Per sq. inch. | Elongation. Per cent. in 8 inches. | Reduced Area. Per cent. | C. | Mn. | P. | Remarks. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 428 | 6"x6"x⅞" Ls | 3,720 | .8465 | 39,220 | 66,040 | 27.25 | 53.41 | .22 | .50 | .060 | | | |
| 428 | 6"x6"x⅞" " | 3,721 | .8713 | 39,370 | 66,450 | 33.00 | 52.48 | .25 | .47 | .049 | | | |
| 457 | 6"x6"x⅞" " | 713 | 1.270 | 35,430 | 62,910 | 27.00 | 40.24 | .20 | .59 | .065 | Pencoyd. | | |
| 457 | 6"x6"x⅞" " | 713 | 1.222 | 35,180 | 62,520 | 25.00 | 44.68 | .20 | .59 | .065 | | | |
| 457 | 6"x6"x⅞" " | 722 | 1.232 | 36,530 | 63,310 | 27.00 | 48.54 | .19 | .50 | .080 | | | |
| 457 | 6"x6"x⅞" " | 722 | 1.266 | 45,800 | 64,610 | 26.50 | 44.78 | .19 | .50 | .080 | | | |
| | 6"x6"x⅞" " | 7,691 | 1.014 | 35,310 | 59,170 | 28.75 | 52.66 | .16 | .49 | .065 | | | |
| | 6"x6"x⅛" " | 7,691 | 1.256 | 35,190 | 61,460 | 27.25 | 41.56 | .16 | .49 | .065 | | | |
| | 6"x6"x⅞" " | 7,691 | 1.264 | 35,600 | 61,310 | 27.00 | 49.92 | .16 | .49 | .065 | | | |
| | 6"x6"x⅞" " | 656 | 1.001 | 37,960 | 65,730 | 26.25 | 47.55 | .17 | .53 | .080 | Pencoyd. | | |
| | 6"x6"x⅞" " | 692 | 1.015 | 34,680 | 63,000 | 28.75 | 51.03 | .16 | .50 | .071 | " | Condemned. | |
| | 6"x6"x⅞" " | 692 | 1.409 | 34,770 | 63,030 | 30.00 | 50.18 | .16 | .50 | .071 | " | " | Re-test. |
| | 6"x6"x⅞" " | 692 | 1.345 | 35,540 | 68,020 | 28.75 | 50.48 | .16 | .50 | .071 | " | " | " |
| 476 | 6"x6"x¾" " | 2,049 | .747 | 39,420 | 62,920 | 26.75 | 42.97 | .18 | .56 | .056 | Phœnix. | | |
| 476 | 6"x6"x¾" " | 2,049 | .751 | 39,950 | 63,910 | 30.50 | 41.54 | .17 | .58 | .030 | " | | |
| 482–483 | 6"x4"x¾" " | 2,053 | .745 | 38,120 | 63,890 | 27.50 | 53.02 | .17 | .58 | .039 | " | | |
| | 6"x4"x½" " | 426 | .672 | 38,690 | 67,560 | 26.00 | 52.00 | .19 | .42 | .088 | Pencoyd. | | |
| 428 | 6"x4"x½" " | 3,722 | .6048 | 46,630 | 69,120 | 29.37 | 50.79 | .20 | .36 | .054 | | | |
| 428 | 5"x3½"x11/16" " | 3,728 | .6644 | 42,140 | 67,730 | 24.37 | 50.51 | .20 | .47 | .050 | | | |
| 489 | 5"x3½"x11/16" " | 2,066 | .685 | 37,950 | 64,230 | 27.75 | 48.90 | .19 | .47 | .030 | Phœnix. | | |
| | 5"x3½"x11/16" " | 2,773 | .6385 | 39,470 | 65,770 | 26.75 | 45.47 | .21 | .48 | .050 | | | |
| | 5"x3½"x11/16" " | 2,806 | .6438 | 40,230 | 66,940 | 26.25 | 44.08 | .21 | .40 | .057 | | | |
| | 5"x3½"x11/16" " | 2,807 | .7133 | 40,800 | 67,010 | 28.75 | 54.40 | .16 | .31 | .068 | | | |
| | 5"x3½"x⅝" " | 3,868 | .6583 | 39,500 | 64,100 | 31.50 | 57.40 | .20 | .55 | .071 | | | |
| | 5"x3½"x⅝" " | 3,828 | .6594 | 42,160 | 66,120 | 28.25 | 48.29 | .19 | .41 | .059 | | | |
| | 5"x3½"x⅝" " | 3,866 | .6615 | 40,820 | 65,000 | 25.75 | 50.80 | .21 | .55 | .069 | | | |
| | 5"x3½"x⅝" " | 3,869 | .6626 | 41,500 | 63,840 | 24.75 | 49.47 | .26 | .47 | .070 | | | |
| 482–483 | 5"x3½"x⅝" " | 2,051 | .607 | 37,560 | 61,120 | 27.50 | 52.06 | .18 | .70 | .047 | Phœnix. | | |
| | 5"x3½"x⅝" " | 3,867 | .5859 | 39,090 | 65,710 | 25.75 | 45.95 | .21 | .48 | .072 | | | |
| | 5"x3½"x⅝" " | 3,877 | .6727 | 40,730 | 64,070 | 27.50 | 48.82 | .20 | .39 | .060 | | | |
| | 5"x3½"x⅝" " | 2,808 | .6720 | 39,290 | 65,700 | 26.75 | 46.09 | .22 | .40 | .055 | | | |

| | Cut From. | Heat No. | Area. | Elastic Limit. Per sq. inch. | Breaking Strain. Per sq. inch. | Elongation. Per cent. in 8 inches. | Reduced Area. Per cent. | C. | Mn. | P. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 457 | 5"x3½"x⅝" L | 610 | .914 | 34,570 | 59,080 | 27.25 | 54.49 | .19 | .57 | .082 | Rejected. Pencoyd. |
| " | 5"x3½"x⅝" " | 478 | .858 | 38,460 | 65,970 | 24.50 | 45.69 | .19 | .57 | . . . | " Si. .049. |
| " | 5"x3½"x⅝" " | 594 | .813 | 40,100 | 68,640 | 24.50 | 43.67 | .19 | .50 | .083 | " |
| " | 5"x3½"x⅝" " | 610 | 1.039 | 35,030 | 60,830 | 27.00 | 50.24 | .19 | .57 | .082 | Rejected. " |
| " | 5"x3½"x⅝" " | 610 | 1.027 | 37,090 | 63,290 | 26.00 | 43.91 | .19 | .57 | .082 | Rejected. " |
| | 5"x3½"x⅝" " | 798 | .769 | 40,440 | 67,360 | 22.00 | 38.23 | .19 | .74 | .062 | " |
| | 5"x3½"x⅝" " | 799 | .746 | 38,270 | 63,200 | 24.25 | 49.33 | .19 | .76 | .059 | " |
| | 5"x3½"x⅝" " | 798 | .983 | 39,270 | 66,430 | 28.75 | 47.40 | .19 | .74 | .062 | " |
| | 5"x3½"x⅝" " | 799 | .967 | 39,970 | 67,220 | 25.00 | 41.37 | .19 | .76 | .059 | " |
| 482, 483 | 5"x3½"x⅝" " | 2,048 | .610 | 38,690 | 64,750 | 28.75 | 44.59 | .17 | .58 | .030 | Phœnix. |
| " " | 5"x3½"x⅝" " | 1,049 | .615 | 38,370 | 63.090 | 28.00 | 50.73 | .18 | .56 | .056 | " |
| 477, 478 | 5"x3½"x9/16" " | 2,053 | .557 | 38,960 | 64,270 | 29.75 | 54.39 | .17 | .58 | .039 | |
| " " | 5"x3½"x9/16" " | 2,051 | .543 | 38,300 | 64.090 | 25.00 | 52.67 | .18 | .70 | .047 | " |
| | 5"x3½"x9/16" " | 3,830 | .6660 | 40,390 | 67,940 | 23.25 | 40.42 | .21 | .44 | .062 | |
| | 5"x3½"x9/16" " | 3,828 | .5106 | 39,170 | 68,550 | 25.25 | 53.33 | .19 | .41 | .059 | |
| | 5"x3½"x9/16" " | 3,827 | .5180 | 39,960 | 65,300 | 26.25 | 50.43 | .18 | .54 | .060 | |
| 428 | 5"x3½"x⅜" " | 8,937 | .5398 | 43,820 | 69,440 | 30.62 | 52.27 | .15 | .58 | .050 | |
| 482, 483 | 5"x3"x9/16" " | 1,047 | .531 | 39,170 | 65,350 | 26.25 | 47.08 | .18 | .58 | .044 | |
| " " | 5"x3"x9/16" " | 1,047 | .545 | 40,730 | 64.590 | 26.50 | 43.12 | .18 | .58 | .044 | |
| | 5"x3"x⅜" " | 365 | .510 | 39,220 | 62,740 | 24.25 | 53.53 | .19 | .44 | .072 | Pencoyd. |
| 477, 8, 9 | 4"x3"x⅝" " | 2,049 | .625 | 43,000 | 62,720 | 27.00 | 51.04 | .18 | .56 | .056 | |
| | 4"x3"x⅜" " | 478 | .519 | 41,620 | 70,520 | 23.50 | 42.58 | .19 | .57 | . . . | Pencoyd. Si. .049. |
| | 3½"x3½"x⅝" " | 3,830 | .6615 | 40,210 | 65,300 | 27.50 | 54.65 | .21 | .44 | .062 | |
| | 3½"x3½"x⅝" " | 2,806 | .6603 | 39,370 | 65,420 | 29.50 | 45.48 | .21 | .40 | .057 | |
| | 3½"x3½"x⅝" " | 392 | .796 | 37,440 | 62,190 | 27.50 | 44.85 | .18 | .48 | .089 | Pencoyd. |
| | 3½"x3½"x⅝" " | 345 | .803 | 38,610 | 62,640 | 27.00 | 46.96 | .19 | .47 | .071 | " |
| | 3½"x3½"x⅝" " | 424 | .753 | 37,710 | 61,090 | 23.00 | 40.64 | .21 | .56 | .079 | " |
| | 3½"x3½"x9/16" " | 3,831 | .6014 | 40,410 | 65,680 | 29.50 | 47.12 | .21 | .56 | .060 | |
| | 3½"x3½"x½" " | 3,828 | .5247 | 41,930 | 67,840 | 26.50 | 45.97 | .19 | .41 | .059 | |
| 476, 482, 483 | 3½"x3½"x½" " | 2,048 | .462 | 39,830 | 64,290 | 27.50 | 46.97 | .17 | .58 | .030 | Phœnix. |
| | 3½"x3½"x½" " | 1,047 | .476 | 40,120 | 65,750 | 28.75 | 51.47 | .18 | .58 | .044 | " |

| | Cut From. | Heat No. | Area. | Elastic Limit. Per sq. inch. | Breaking Strain. Per sq. inch. | Elongation. Per cent. in 8 inches. | Reduced Area Per cent. | C. | Mn. | P. | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 476, 482, 483 | 3½"x3½"x½" L's | 1,048 | .458 | 40,170 | 67,030 | 26.25 | 45.41 | .19 | .62 | .038 | Phœnix. |
| 489, 478, 477 | 3½"x3"x⅜" " | 1,048 | .352 | 40,910 | 68,180 | 26.50 | 50.00 | .19 | .62 | .038 | " |
| 457, 458 | 3"x3"x⅜" " | 478 | .530 | 40,750 | 63,400 | 23.50 | 49.25 | .19 | .57 | .... | Pencoyd. Si .049. |
| 476, 477 | 3"x3"x⅝" " | 1,048 | .403 | 38,210 | 66,500 | 26.50 | 52.11 | .19 | .62 | .038 | Phœnix. |
| | 3"x3"x⅜" " | 3,884 | .5472 | 40,390 | 66,890 | 24.75 | 51.64 | .21 | .42 | .073 | |
| | 3"x3"x⅜" " | 2,773 | .4389 | 41,580 | 65,620 | 25.75 | 55.98 | .21 | .48 | .050 | |
| | 3"x3"x5/16" " | 2,048 | .308 | 41,230 | 67,210 | 23.25 | 50.65 | .17 | .58 | .030 | Phœnix. |
| | 3"x3"x5/16" " | 2,049 | .290 | 42,810 | 66,550 | 25.50 | 53.18 | .18 | .56 | .056 | " |
| | 3"x2½"x½" " | 2,785 | .5425 | 39,630 | 68,020 | 25.00 | 47.41 | .15 | .38 | .048 | |

## FINISHED MATERIAL TESTS.—IRON.

| Cut From. | Area. | Elastic Limit. Per sq. inch | Breaking Strain. Per sq. inch | Elongation. Per cent. in 8 inches. | Reduced Area. Per Cent. | REMARKS. |
|---|---|---|---|---|---|---|
| 13"x"2¼" plate. | .466 | 27,500 | 46,100 | 17.50 | 22.70 | Elmira Iron and Steel Rolling Mill Co., for wheel under treads. |
| 3"x1¼" bar. | 1.136 | 38,170 | 51,230 | 20.00 | 29.58 | Catasauqua Mfg. Co. High test. |
| 2"x¾" " | 1.572 | 32,570 | 51,720 | 30.00 | 39.24 | " " " |
| 1½"x⅝" " | .920 | 29,560 | 51,840 | 26.25 | 36.30 | " " " |
| 2⅛" round. | .801 | 34,080 | 50,440 | 25.00 | 39.57 | " " " |
| 2" square. | .785 | 31,210 | 50,950 | 25.00 | 42.16 | " " " |
| 2" " | .785 | 32,230 | 53,440 | 17.50 | 24.33 | " " " |
| 2" round. | .785 | 30,060 | 50,950 | 27.50 | 44.33 | " " " |
| 2" " | .801 | 31,840 | 52,930 | 21.25 | 27.47 | " " " |
| 2" " | .754 | 31,170 | 52,590 | 22.50 | 33.29 | " " " |
| 2" " | .817 | 31,580 | 50.180 | 28.75 | 48.71 | " " " |
| 1 13/16" " | .779 | 34,530 | 52,180 | 28.75 | 44.80 | " " " |
| 1¾" square. | .685 | 38,100 | 50,660 | 28.75 | 42.92 | " " " |
| 1¾" " | .785 | 32,220 | 50,950 | 30.00 | 49.55 | " " " |
| 1¾" " | .817 | 34,270 | 55,080 | 20.00 | 24.85 | " " " |
| 1⅝" " | .792 | 30,550 | 50,000 | 23.75 | 30.05 | " " " |
| 1⅝" " | .785 | 32,230 | 53,760 | 18.75 | 25.99 | " " " |
| 1⅝ round. | .754 | 32,890 | 51,990 | 25.00 | 39.79 | " " " |

## FINISHED MATERIAL TESTS.—IRON.—*(Continued.)*



| Cut From. | | Area. | Elastic Limit. Per sq. inch. | Breaking Strain. Per sq. inch. | Elongation. Per cent. in 8 inches. | Reduced Area. Per cent. | Remarks. |
|---|---|---|---|---|---|---|---|
| 1⅜" | round. | .773 | 34,930 | 52,000 | 25.00 | 41.91 | Catasauqua Manufacturing Co., High Test. |
| 1½" | square. | .795 | 30,060 | 51,070 | 23.75 | 38.99 | " " " " |
| 1½" | " | .795 | 35,220 | 50,180 | 25.00 | 40.75 | " " " " |
| 1½" | " | .882 | 30,720 | 50,790 | 25.00 | 47.84 | " " " " |
| 1½" | " | .779 | 33,120 | 52,760 | 22.50 | 30.55 | " " " " |
| 1½" | " | .773 | 33,640 | 52,520 | 26.25 | 42.17 | " " " " |
| 1½" | round. | .767 | 34,550 | 53,320 | 23.75 | 34.42 | " " " " |
| 1⅜" | square. | .811 | 31,200 | 52,520 | 22.50 | 44.07 | " " " " |
| 1⅜" | " | .774 | 34,240 | 53,100 | 28.00 | 42.90 | " " " " |
| 1⅜" | " | .779 | 32,090 | 52,500 | 27.00 | 40.18 | " " " " |
| 1⅜" | round. | 1.517 | 34,670 | 52,740 | 25.00 | 47.33 | " " " " |
| 1⅜" | " | 1.530 | 32,160 | 52,940 | 28.75 | 47.65 | " " " " |
| 1¼" | square. | 1.572 | 32,950 | 52,980 | 29.50 | 41.03 | " " " " |
| 1¼" | " | .776 | 34,790 | 53,350 | 26.25 | 40.33 | " " " " |
| 1¼" | " | .773 | 33,630 | 53,430 | 25.00 | 45.80 | " " " " |
| 1¼" | round. | 1.267 | 33,940 | 53,120 | 28.75 | 43.80 | " " " " |
| 1¼" | " | 1.263 | 33,650 | 53,040 | 28.75 | 42.68 | " " " " |
| 1¼" | square. | 1.262 | 33,430 | 53,800 | 30.00 | 43.42 | " " " " |
| 1¼" | " | 1.271 | 34,070 | 50,040 | 15.00 | 18.96 | " " " " |
| 1¼" | " | 1.266 | 35,390 | 51,740 | 19.00 | 21.33 | " " " " |
| 1⅛" | " | .785 | 35,670 | 54,520 | 27.50 | 40.64 | " " " " |
| 1⅛" | round. | .993 | 29,200 | 50,760 | 27.50 | 38.78 | " " " " |
| 1⅛" | " | 1.003 | 29,910 | 51,550 | 25.00 | 44.77 | " " " " |
| 1" | square. | .988 | 30,460 | 47,870 | 11.25 | 18.92 | " " " " |
| 1" | " | .980 | 33,670 | 52,950 | 26.25 | 39.49 | " " " " Re-test. |
| 1" | " | 1.004 | 30,330 | 50,550 | 27.00 | 51.59 | " " " " |
| 1" | " | .998 | 30,460 | 50,500 | 25.00 | 36.97 | " " " " |
| 1" | " | .990 | 32,300 | 51,520 | 27.50 | 44.65 | " " " " |
| 1" | " | .992 | 33,570 | 51,920 | 27.00 | 38.77 | " " " " |
| 1" | " | .981 | 31,600 | 51,380 | 25.75 | 43.43 | " " " " |
| ¾" | " | .544 | 31,430 | 53,220 | 25.00 | 42.83 | " " " " |
| 6" | channel. | .3680 | 32,610 | 55,440 | 22.50 | 31.39 | " " " Flange. |
| 6" | " | .6683 | 28,730 | 51,480 | 22.00 | 36.44 | " " " Web. |

## FINISHED MATERIAL TESTS.—BESSEMER STEEEL Ls.



| Cut From. | | Blow No. | Area. | Elastic Limit. Per square inch. | Breaking Strain. Per sq. inch. | Elongation. Per cent. in 8 inches. | Reduced Area. Per Cent. | C | Mn. | P. | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6"x6"x7/8" | L | 17,557 | .8486 | 40,300 | 68,410 | 26.25 | 45.37 | .17 | .55 | .060 | Carnegie, Phipps & Co. |
| 6"x6"x7/8" | " | 17,560 | .8471 | 40,960 | 67,340 | 27.50 | 44.47 | .16 | .63 | .068 | |
| 6"x6"x7/8" | " | 17,563 | .8336 | 38,990 | 64,780 | 26.00 | 43.69 | .16 | .61 | .066 | |
| 6"x6"x7/8" | " | 17,566 | .8516 | 40,630 | 69,460 | 25.62 | 42.95 | .16 | .65 | .057 | |
| 6"x6"x7/8" | " | 17,569 | .8812 | 41,990 | 68,090 | 25.00 | 45.53 | .18 | .57 | .064 | |
| 6"x6"x7/8" | " | 18,988 | .8336 | 40,550 | 66,500 | 31.25 | 50.75 | .17 | .56 | .055 | |
| 6"x4"x1/2" | " | 17,570 | .6087 | 42,880 | 67,360 | 26.25 | 46.66 | .16 | .65 | .060 | |
| 6"x4"x1/2" | " | 17,383 | .6064 | 40,240 | 64,650 | 26.87 | 51.51 | .17 | .57 | .055 | |
| 5"x3½"x5/8" | " | 17,713 | .7618 | 42,140 | 65,900 | 30.00 | 53.93 | .18 | .51 | .065 | |
| 5"x3½"x5/8" | " | 17,716 | .7625 | 43,540 | 67,540 | 30.62 | 48.77 | .17 | .60 | .056 | |
| 5"x3½"x5/8" | " | 17,732 | .7533 | 42,080 | 65,180 | 31.25 | 51.94 | .15 | .54 | .068 | |
| 5"x3½"x5/8" | " | 17,738 | .7618 | 41,150 | 66,160 | 30.62 | 47.90 | .18 | .61 | .059 | |
| 5"x3½"x5/8" | " | 2,809 | .6176 | 39,830 | 66,140 | 25.50 | 45.26 | .19 | .38 | .046 | |
| 5"x3½"x5/8" | " | 3,876 | .5844 | 40,040 | 67,420 | 26.00 | 42.50 | .15 | .49 | .043 | |
| 5"x3½"x5/8" | " | 20,883 | .6616 | 39,300 | 65,510 | 28.75 | 43.91 | .14 | .48 | .054 | |
| 5"x3½"x1/2" | " | 14,715 | .5018 | 40,160 | 63,770 | 27.25 | 57.67 | .16 | 42 | .071 | |
| 5"x3½"x1/2" | " | 14,717 | .4925 | 41,730 | 65,580 | 27.25 | 54.58 | .14 | .25 | .059 | |
| 5"x3½"x3/8" | " | 20,814 | .5546 | 43,370 | 66,720 | 26.50 | 47.35 | .15 | .72 | .059 | |
| 5"x3½"x3/8" | " | 17,726 | .5621 | 47,850 | 68,670 | 31.25 | 51.74 | .15 | .56 | .058 | |
| 4"x4"x3/4" | " | 17,874 | .6960 | 40,230 | 66,160 | 29.75 | 45.32 | .17 | .61 | .061 | |
| 4"x4"x3/4" | " | 17,850 | .7408 | 42,520 | 67,760 | 30.00 | 45.19 | .17 | .82 | .060 | |
| 4"x4"x3/4" | " | 17,854 | .7213 | 41,450 | 68,350 | 30.00 | 49.94 | .17 | .66 | .055 | |
| 4"x4"x3/4" | " | 17,858 | .7218 | 40,460 | 67,480 | 27.00 | 51.30 | .18 | .62 | .063 | |
| 4"x4"x3/4" | " | 17,870 | .7342 | 41,130 | 67,030 | 28.25 | 49.95 | .16 | .62 | .054 | |
| 4"x4"x3/4" | " | 17,882 | .7372 | 41,170 | 67,720 | 27.50 | 48.07 | .17 | .63 | .063 | |
| 4"x4"x3/4" | " | 17,886 | .7264 | 41,030 | 68,430 | 29.50 | 48.24 | .17 | .68 | .062 | |
| 4"x4"x3/4" | " | 21,089 | .7540 | 38,730 | 67,370 | 26.25 | 45.88 | .14 | .54 | .057 | |
| 4"x4"x5/8" | " | 21,088 | .6464 | 38,680 | 65,440 | 27.50 | 50.77 | .15 | .53 | .056 | |
| 4"x4"x5/8" | " | 21,091 | .6257 | 40,270 | 66,480 | 30.00 | 52.72 | .15 | .57 | .057 | |
| 4"x4"x1/2" | " | 19,701 | .6400 | 43,910 | 65,000 | 31.00 | 52.00 | .17 | .64 | .061 | |
| 4"x4,x1/2" | " | 17,910 | .4871 | 43,140 | 64,140 | 29.75 | 53.77 | .17 | .62 | .053 | |

# FINISHED MATERIAL TESTS.—BESSEMER STEEL Ls.—(*Continued.*)

| Cut From. | Blow No. | Area. | Elastic Limit. Per sq. inch. | Breaking Strain. Per sq. inch. | Elongation. Per cent. in 8 inches. | Reduced Area. Per cent. | C. | Mn. | P. | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|---|
| 4"x3"x⅝" L | 3,921 | .7105 | 40,960 | 65,450 | 25.25 | 46.16 | .15 | .49 | .047 | Carnegie, Phipps & Co. |
| 4"x3"x9/16" " | 5,045 | .4887 | 40,000 | 63,030 | 26.50 | 54.31 | .16 | .52 | .052 | |
| 4"x3"x½" " | 3,905 | .5175 | 40,770 | 63,670 | 27.50 | 60.87 | .15 | .53 | .045 | |
| 4"x3"⅜" " | 20,994 | .5890 | 37,350 | 67,910 | 26.75 | 53.80 | .15 | .52 | .055 | |
| 4"x3"x⅜" " | 2,782 | .4725 | 39,700 | 68,570 | 27.00 | 54.98 | .17 | .54 | .056 | |
| 4"x3"x⅜" " | 18,105 | .4907 | 45,040 | 66,030 | 28.75 | 51.56 | .15 | .60 | .060 | |
| 4"x3"⅜" " | 18,102 | .4969 | 44,880 | 64,820 | 29.75 | 52.67 | .16 | .59 | .062 | |
| 4"x3"x5/16" " | 17,918 | .4337 | 44,970 | 68,480 | 29.00 | 48.35 | .15 | .56 | .060 | |
| 4"x3"x5/16" " | 20,991 | .4832 | 44,500 | 66,330 | 30.75 | 56.72 | .16 | .61 | .055 | |
| 4"x3"x5/16" " | 3,921 | .3300 | 40,910 | 63,030 | 25.75 | 60.76 | .15 | .49 | .047 | |
| 3½"x3½"x½" " | 3,921 | .6850 | 37,960 | 62,340 | 27.00 | 47.63 | .15 | .49 | .047 | |
| 3½"x3½"x½" " | 3,920 | .8357 | 40,690 | 64,620 | 28.75 | 42.56 | .16 | .54 | .046 | |
| 3½"x3½"x½" " | 17,906 | .6144 | 43,950 | 69,180 | 29.75 | 52.07 | .16 | .61 | .055 | |
| 3"x3"x⅜" " | 17,926 | .6523 | 43,690 | 67,330 | 27.00 | 48.87 | .16 | .60 | .057 | |
| 3"x3"x⅜" " | 17,933 | .4610 | 46,640 | 67,240 | 28.00 | 56.81 | .17 | .65 | .063 | |
| 3"x3"x⅜" " | 18,043 | .6478 | 45,000 | 69,540 | 27.50 | 52.52 | .15 | .61 | .068 | |
| 3"x3"x⅜" " | 6,300 | .5265 | 40,270 | 65,530 | 25.00 | 51.34 | .17 | .49 | .044 | |
| 3"x3"x⅜" " | 19,283 | .5756 | 44,480 | 67,080 | 29.37 | 53.09 | .16 | .67 | .057 | |
| 3"x2½"x½" " | 2,780 | .5454 | 39,420 | 64,730 | 27.50 | 51.23 | .17 | .53 | .056 | |
| 3"x2½"x½" " | 1,843 | .5400 | 40,000 | 66,300 | 24.50 | 48.37 | .15 | .59 | .044 | |
| 3"x2"x⅜" " | 2,783 | .4562 | 39,460 | 63,570 | 25.00 | 56.88 | .15 | .55 | .053 | |
| 3"x2"x⅜" " | 2,786 | .4546 | 40,880 | 65,340 | 25.75 | 51.47 | .15 | .52 | .054 | |
| 2½"x2½"x⅜" " | 17,459 | .4734 | 41,190 | 64,010 | 27.00 | 52.70 | .14 | .65 | .061 | |
| 2½"x2½"x⅜" " | 17,510 | .4782 | 39,320 | 70,060 | 24.00 | 45.88 | .15 | .63 | .066 | |
| 2½"x2½"x⅜" " | 17,489 | .4884 | 40,750 | 67,570 | 27.00 | 53.81 | .15 | .69 | .062 | |
| 2½"x2½"x⅜" " | 17,504 | .5023 | 41,010 | 67,890 | 25.00 | 53.22 | .16 | .67 | .057 | |
| 2½"x2½"x⅜" " | 17,498 | .4950 | 40,410 | 67,070 | 26.75 | 56.14 | .15 | .65 | .054 | |

## FINISHED MATERIAL TESTS.—BESSEMER STEEL PLATES.



| Cut From. | Blow No. | Area. | Elastic Limit. Per sq. inch. | Breaking Strain. Per sq. inch. | Elongation. Per cent. in 8 inches. | Reduced Area Per cent. | C. | Mn. | P. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|
| 7/8" plate. | 2,948 | 1.031 | 40,740 | 65,180 | 25.50 | 42.27 | .20 | .39 | .062 | Carnegie, Phipps & Co. Sheared. |
| 1/2" " | 2,835 | .6350 | 40,790 | 64,810 | 26.00 | 53.37 | .20 | .49 | .060 | " |
| 5/8" " | 4,653 | .6287 | 38,150 | 65,220 | 26.00 | 55.05 | .20 | .62 | .033 | " |
| 5/8" " | 2,868 | .7477 | 39,460 | 69,950 | 29.00 | 45.43 | .20 | .54 | .062 | " |
| 30"x5/8" " | 14,760 | .3271 | 42,190 | 67,260 | 22.00 | 52.06 | .18 | .65 | .036 | |
| 28"x3/4" " | 19,281 | .5883 | 40,630 | 65,950 | 25.00 | 45.78 | .17 | .79 | .053 | |
| 28"x3/4" " | 19,281 | .6000 | 40,670 | 66,550 | 24.50 | 48.77 | .17 | .79 | .053 | |
| 28"x3/4" " | 19,281 | .6040 | 39,040 | 62,250 | 29.00 | 55.30 | .17 | .79 | .053 | |
| 28"x3/4" " | 18,311 | .6090 | 40,720 | 66,010 | 21.50 | 45.02 | .14 | .64 | .057 | |
| 28"x3/4" " | 18,302 | .6292 | 41,320 | 67,380 | 20.75 | 41.54 | .17 | .64 | .068 | |
| 28"x3/4" " | 18,305 | .6412 | 41,180 | 62,540 | 28.25 | 54.71 | .17 | .64 | .062 | |
| 28"x3/4" " | 18,335 | .6424 | 42,030 | 64,140 | 20.50 | 35.90 | .16 | .56 | .063 | |
| 28"x3/4" " | 18,332 | .6505 | 39,970 | 61,490 | 27.50 | 52.35 | .16 | .58 | .056 | |
| 28"x3/4" " | 18,326 | .5934 | 40,110 | 58,480 | 28.75 | 63.48 | .16 | .62 | .063 | |
| 28"x3/4" " | 18,308 | .5728 | 34,040 | 62,850 | 28.75 | 57.58 | .17 | .93 | .060 | |
| 28"x"3/4 " | 18,329 | .5648 | 40,540 | 66,920 | 26.25 | 45.29 | .15 | .63 | .060 | |
| 28"x3/4" " | 18,323 | .5652 | 42,290 | 61,580 | 24.00 | 53.79 | .16 | .59 | .055 | |
| 28"x3/4" " | 18,338 | .5627 | 41,410 | 65,050 | 25.00 | 47.43 | .15 | .57 | .055 | |
| 28"x1/2" " | 318 | .4900 | 41,230 | 68,780 | 24.50 | 51.06 | .16 | .69 | .055 | |
| 28"x1/2" " | 18,208 | .4300 | 41,400 | 63,490 | 25.75 | 55.68 | .18 | .62 | .069 | |
| 28"x1/2" " | 18,344 | .5194 | 41,780 | 64,110 | 30.00 | 54.93 | .16 | .60 | .060 | |
| 28"x1/2" " | 321 | .5717 | 40,440 | 66,640 | 24.00 | 52.42 | .15 | .72 | .054 | |
| 28"x3/8" " | 4,820 | .3690 | 40,110 | 64,220 | 23.75 | 56.61 | .15 | .45 | .054 | |
| 28"x3/8" " | 18,314 | .3762 | 41,200 | 64,200 | 24.00 | 57.60 | .17 | .82 | .060 | |
| 26"x1/2" " | 17,786 | .4950 | 42,020 | 68,890 | 23.00 | 52.89 | .16 | .61 | .038 | |
| 24"x7/8" " | 3,909 | .4964 | 40,290 | 64,470 | 24.00 | 54.72 | .15 | .52 | .042 | |
| 24"x3/8" " | 17,774 | .4533 | 41,460 | 64,160 | 23.75 | 51.39 | .17 | .51 | .033 | |
| 24"x7/8" " | 2,876 | .6314 | 39,910 | 66,760 | 23.25 | 49.64 | .20 | .51 | .070 | |
| 23"x3/4" " | 315 | .6898 | 39,000 | 61,620 | 31.25 | 59.32 | .15 | .75 | .058 | |
| 22"x7/8" " | 309 | .7368 | 39,490 | 64,870 | 26.25 | 51.17 | .14 | .69 | .054 | |
| 22"x7/8" " | 306 | .7276 | 40,410 | 66,240 | 27.50 | 54.16 | .15 | .65 | .055 | |

## FINISHED MATERIAL TESTS.—BESSEMER STEEL PLATES.—(*Continued.*)



| Cut From. | Blow No. | Area. | Elastic Limit. Per sq. inch | Breaking Strain. Per sq. inch. | Elongation. Per cent. in 8 inches. | Reduced Area. Per Cent. | C. | Mn. | P. | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|---|
| 22"x⅞" plate. | 303 | .7351 | 40,130 | 65,570 | 26.00 | 42.98 | .15 | .69 | .058 | Carnegie, Phipps & Co. |
| 22"x⅞" " | 312 | .6493 | 40,970 | 67,610 | 26.25 | 46.10 | .15 | .62 | .052 | |
| 22"x⅞" " | 334 | .6493 | 41,120 | 64,840 | 25.00 | 59.06 | .16 | .75 | .051 | |
| 22"x⅞" " | 323 | .6612 | 40,830 | 67,000 | 25.75 | 46.28 | .16 | .71 | .058 | |
| 22"x¾" " | 331 | .6295 | 41,140 | 67,190 | 27.75 | 52.14 | .16 | .74 | .059 | |
| 22"x¾" " | 326 | .6115 | 40,720 | 64,430 | 27.50 | 56.56 | .15 | .73 | .059 | |
| 22"x⅝" " | 346 | .5129 | 41,720 | 66,190 | 24.25 | 47.18 | .15 | .63 | .055 | |
| 22"x½" " | 17,959 | .4414 | 42,140 | 65,020 | 22.00 | 52.15 | .17 | .70 | .051 | |
| 21½"x⅝" " | 17,953 | .5380 | 40,520 | 64,130 | 26.75 | 53.16 | .16 | .59 | .061 | |
| 21"x⅜" " | 337 | .3778 | 41,290 | 66,700 | 27.50 | 52.80 | .14 | .71 | .055 | |
| 20½"x⅜" " | 364 | .4161 | 42,060 | 67,300 | 26.00 | 51.07 | .15 | .66 | .058 | |
| 20"x⅝" " | 17,920 | .5332 | 40,890 | 66,300 | 25.25 | 51.20 | .17 | .68 | .058 | |
| 20"x⅝" " | 17,912 | .5355 | 40,530 | 63,870 | 27.50 | 49.64 | .16 | .63 | .058 | |
| 20"x⅝" " | 17,817 | .5302 | 43,380 | 69,400 | 27.50 | 53.13 | .17 | .76 | .062 | |
| 20"x⅝" " | 17,834 | .5381 | 40,890 | 65,980 | 26.75 | 48.06 | .18 | .64 | .058 | |
| 20"x⅝" " | 17,924 | .5368 | 39,860 | 64,640 | 27.50 | 47.13 | .16 | .60 | .059 | |
| 20"x⅝" " | 17,838 | .6704 | 38,780 | 66,220 | 24.75 | 40.06 | .17 | .64 | .068 | |
| 20"x⅝" " | 17,840 | .6869 | 39,310 | 66,100 | 27.50 | 49.20 | .17 | .60 | .065 | |
| 20"x⅝" " | 17,852 | .5449 | 40,930 | 64,510 | 26.25 | 52.38 | .16 | .60 | .059 | |
| 20"x⅝" " | 17,904 | .5419 | 41,890 | 67,360 | 25.75 | 40.21 | .17 | .54 | .062 | |
| 20"x⅝" " | 17,864 | .5490 | 42,080 | 67,400 | 26.75 | 50.77 | .17 | .69 | .064 | |
| 20"x⅝" " | 17,888 | .5385 | 39,550 | 63,980 | 27.00 | 50.90 | .17 | .70 | .068 | |
| 20"x⅝" " | 17,820 | .5363 | 40,560 | 65,260 | 28.75 | 49.51 | .15 | .61 | .059 | |
| 20"x⅝" " | 17,884 | .5460 | 41,120 | 65,940 | 25.00 | 47.62 | .16 | .66 | .064 | |
| 20"x⅝" " | 17,896 | .5597 | 38,860 | 63,600 | 26.25 | 48.33 | .17 | .62 | .053 | |
| 20"x⅝" " | 17,856 | .5267 | 40,150 | 64,550 | 27.00 | 55.63 | .16 | .66 | .061 | |
| 20"x⅝" " | 17,844 | .5512 | 39,910 | 68,040 | 28.00 | 47.93 | .17 | .54 | .067 | |
| 20"x⅝" " | 17,836 | .5500 | 41,820 | 66,910 | 22.50 | 45.04 | .17 | .72 | .070 | |
| 20"x⅝" " | 17,935 | .5524 | 39,650 | 64,810 | 28.00 | 48.52 | .17 | .65 | .061 | |
| 20"x⅝" " | 17,892 | .5342 | 42,310 | 68,510 | 26.25 | 47.77 | .17 | .63 | .059 | |
| 20"x⅝" " | 17,830 | .5338 | 40,840 | 64,070 | 25.75 | 47.87 | .17 | .70 | .062 | |

| Cut From. | Blow No. | Area. | Elastic Limit. Per sq. inch. | Breaking Strain. Per sq. inch. | Elongation. Per cent. in 8 inches. | Reduced Area. Per cent. | C. | Mn. | P. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|
| 20"x⅝" plate. | 17,888 | .5344 | 39,950 | 63,620 | 26.00 | 51.25 | .17 | .70 | .068 | Carnegie, Phipps & Co. |
| 20"x⅝" " | 17,900 | .5469 | 38,240 | 67,560 | 29.50 | 50.87 | .17 | .68 | .059 | |
| 20"x⅝" " | 17,832 | .5416 | 41,540 | 65,550 | 26.25 | 47.60 | .17 | .64 | .063 | |
| 20"x⅝" " | 17,916 | .5258 | 41,270 | 66,560 | 27.75 | 47.79 | .16 | .64 | .059 | |
| 20"x⅝" " | 17,872 | .5297 | 41,340 | 68,340 | 26.50 | 45.99 | .17 | .75 | .063 | |
| 20"x⅝" " | 17,876 | .5420 | 41,330 | 65,780 | 25.25 | 47.64 | .16 | .60 | .061 | |
| 20"x⅝" " | 17,860 | .5418 | 41,350 | 64,050 | 26.25 | 48.34 | .18 | .54 | .057 | |
| 20"x⅝" " | 17,908 | .5445 | 41,510 | 67,400 | 26.25 | 49.94 | .16 | .64 | .056 | |
| 20"x⅝" " | 17,924 | .5368 | 39,860 | 64,640 | 27.50 | 47.13 | .16 | .60 | .059 | |
| 20"x7/16" " | 14,146 | .4706 | 42,500 | 66,300 | 25.00 | 49.00 | .17 | .35 | .067 | |
| 20"x5/16" " | 14,143 | .3088 | 40,160 | 64,770 | 23.75 | 60.07 | .15 | .50 | .070 | |
| 19"x⅝" " | 17,447 | .5518 | 39,140 | 66,600 | 24.00 | 48.88 | .16 | .50 | .061 | |
| 19"x⅜" " | 17,768 | .3975 | 40,750 | 65,910 | 22.50 | 51.70 | .17 | .69 | .049 | |
| 18½"x⅝" " | 361 | .6412 | 40,700 | 67,060 | 26.00 | 50.87 | .15 | .69 | .055 | |
| 18½"x⅝" " | 17,963 | .5456 | 41,790 | 66,900 | 26.25 | 50.35 | .16 | .68 | .065 | |
| x⅝" " | 17,949 | .5293 | 41,570 | 67,450 | 28.25 | 47.61 | .16 | .65 | .058 | |
| 18"x⅝" " | 17,928 | .5394 | 39,720 | 64,710 | 28.75 | 53.45 | .17 | .59 | .060 | |
| 18"x⅝" " | 17,955 | .5425 | 42,030 | 66,540 | 23.25 | 46.47 | .17 | .63 | .061 | |
| 18"x⅝" " | 17,119 | .4681 | 40,590 | 67,290 | 25.00 | 49.15 | .17 | .52 | .066 | |
| 18"x½" " | 17,939 | .4425 | 40,460 | 61,920 | 28.25 | 57.29 | .15 | .60 | .050 | |
| 18"x½" " | 17,951 | .4399 | 45,010 | 67,060 | 26.75 | 51.56 | .17 | .62 | .066 | |
| 18"x½" " | 5,046 | .4985 | 40,920 | 67,810 | 25.00 | 52.28 | .16 | .45 | .055 | |
| 18"x½" " | 14,149 | .5151 | 42,710 | 66,590 | 25.00 | 51.86 | .16 | .27 | .064 | |
| 18"x½" " | 14,238 | .5350 | 40,560 | 61,680 | 27.50 | 60.84 | .14 | .43 | .077 | |
| 18"x½" " | 14,241 | .5085 | 41,890 | 64,900 | 25.75 | 54.87 | .15 | .29 | .070 | |
| 18"x½" " | 14,851 | .5243 | 40,820 | 65,800 | 25.00 | 59.95 | .18 | .63 | .066 | |
| 18"x½" " | 14,855 | .5350 | 40,560 | 63,550 | 24.25 | 54.97 | .17 | .50 | .063 | |
| 18"x½" " | 14,856 | .5000 | 41,200 | 64,800 | 27.50 | 54.56 | .16 | .58 | .064 | |
| 18"x½" " | 14,860 | .4949 | 40,820 | 65,870 | 27.75 | 52.90 | .17 | .54 | .064 | |
| 18"x½" " | 15,680 | .5019 | 40,850 | 69,140 | 25.00 | 47.66 | .15 | .59 | .060 | |
| 18"x½" " | 17,943 | .4075 | 40,980 | 66,870 | 24.25 | 48.28 | .17 | .65 | .064 | |

## FINISHED MATERIAL TESTS.--BESSEMER STEEL PLATES.—(*Continued.*)

| Cut From. | Blow No. | Area. | Elastic Limit. Per sq. inch. | Breaking Strain. Per sq. inch. | Elongation. Per cent. in 8 inches. | Reduced Area. Per cent. | C. | Mn. | P. | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|---|
| 17"x½" plate. | 17,474 | .4238 | 41,530 | 62,060 | 28.75 | 58.26 | .16 | .59 | .053 | Carnegie, Phipps & Co. |
| 17"x½" " | 17,477 | .4488 | 39,440 | 59,550 | 28.25 | 58.24 | .15 | .52 | .062 | |
| 16½"x½" " | 5,615 | .5318 | 41,740 | 68,820 | 26.50 | 52.32 | .16 | .46 | .060 | |
| 16"x½" " | 17,444 | .5831 | 42,190 | 66,880 | 26.50 | 43.68 | .16 | .55 | .060 | |
| 16"x⅜" " | 17,471 | .4463 | 40,340 | 63,080 | 26.50 | 56.19 | .16 | .62 | .051 | |
| 16"x⅜" " | 17,419 | .3834 | 41,210 | 65,730 | 25.00 | 52.90 | .16 | .49 | .062 | |
| 16"x⅜" " | 17,465 | .3975 | 39,500 | 63,650 | 28.25 | 58.21 | .15 | .60 | .057 | |
| 15½"x⅜" " | 340 | .3953 | 42,000 | 68,810 | 22.50 | 52.87 | .15 | .60 | .055 | |
| 15"x¾" " | 358 | .6497 | 38,170 | 64,480 | 26.50 | 47.18 | .16 | .59 | .058 | |
| 15"x⅜" " | 17,450 | .4313 | 39,420 | 66,550 | 26.00 | 52.98 | .16 | .56 | .057 | |
| 15"x⅜" " | 17,453 | .4199 | 40,010 | 65,730 | 24.75 | 48.51 | .16 | .63 | .060 | |
| 14"x⅝" " | 17,456 | .5082 | 40,150 | 64,740 | 29.75 | 57.01 | .14 | .55 | .059 | |
| 14"x9/16" " | 343 | .5994 | 40,370 | 66,570 | 25.00 | 52.02 | .15 | .67 | .055 | |
| 14"x9/16" " | 340 | .5454 | 40,160 | 66,930 | 24.25 | 43.53 | .15 | .60 | .055 | |
| 14"x½" " | 13,817 | .5393 | 40,790 | 67,510 | 26.00 | 52.38 | .16 | .61 | .064 | |
| 14"x⅝" " | 13,799 | .4427 | 44,050 | 69,350 | 24.50 | 50.92 | .18 | .71 | .052 | |
| 14"x⅜" " | 352 | .3996 | 42,790 | 66,320 | 28.75 | 55.40 | .15 | .67 | .051 | |
| 13"x⅝" " | 349 | .6051 | 40,650 | 65,430 | 28.00 | 53.66 | .17 | .71 | .058 | |
| 13"x⅝" " | 3,346 | .6110 | 42,390 | 65,470 | 23.75 | 47.75 | .14 | .50 | .055 | |
| 13"x½" " | 1,425 | .5592 | 42,200 | 66,520 | 29.00 | 61.86 | .15 | .59 | .055 | |
| 12½"x⅞" " | 18,844 | .4596 | 41,780 | 69,300 | 22.00 | 43.89 | .15 | .62 | .049 | |
| 12"x⅝" " | 1,365 | .5917 | 41,410 | 67,600 | 25.75 | 45.72 | .17 | .75 | .038 | |
| 12"x7/16" " | 13,802 | .4558 | 43,880 | 69,990 | 22.50 | 52.66 | .17 | .74 | .064 | |
| 12"x7/16" " | 13,808 | .4566 | 42,930 | 67,680 | 22.50 | 53.83 | .16 | .42 | .061 | |
| 12"x7/16" " | 13,814 | .4557 | 43,670 | 66,060 | 28.25 | 54.38 | .18 | .41 | .069 | |
| 12"x⅜" " | 355 | .3613 | 42,070 | 66,980 | 26.75 | 55.16 | .15 | .60 | .057 | |
| 11"x¾" " | 17,480 | .6090 | 40,720 | 64,210 | 24.50 | 52.43 | .15 | .68 | .057 | |
| 11"x¾" " | 17,462 | .6278 | 39,660 | 64,030 | 28.75 | 47.82 | .15 | .52 | .060 | |
| 11"x¾" " | 17,468 | .5582 | 40,850 | 64,490 | 26.25 | 44.84 | .14 | .62 | .059 | |
| 11"x¾" " | 17,486 | .6278 | 39,020 | 64,030 | 28.50 | 47.04 | .15 | .63 | .057 | |
| 11"x½" " | 17,483 | .4385 | 41,070 | 66,360 | 24.50 | 49.27 | .15 | .68 | .063 | |

| Cut From. | | Blow No. | Area. | Elastic Limit. Per sq. inch. | Breaking Strain. Per sq. inch. | Elongation. Per cent. in 8 inches. | Reduced Area. Per cent. | C. | Mn. | P. | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11"x1/2" | plate. | 13,820 | .5393 | 40,790 | 67,510 | 26.00 | 52.38 | .17 | .60 | .054 | Carnegie, Phipps & Co. |
| 10 1/2"x3/8" | " | 1,362 | .3737 | 40,410 | 67,160 | 25.75 | 51.38 | .15 | .58 | .044 | |
| 10"x3/8" | " | 18,964 | .3654 | 41,050 | 66,780 | 22.75 | 52.02 | .17 | .59 | .052 | |
| 10"x3/8" | " | 17,492 | .4681 | 41,450 | 70,280 | 24.00 | 52.55 | .16 | .70 | .068 | |
| 9 1/2"x1/2" | " | 18,556 | .5432 | 40,320 | 66,280 | 24.50 | 54.43 | .15 | .60 | .058 | |
| 9"x3/4" | " | 13,832 | .7295 | 40,030 | 68,540 | 25.25 | 51.68 | .17 | .71 | .061 | |
| 8"x1/2" | " | 17,501 | .4752 | 42,090 | 65,660 | 28.75 | 54.59 | .17 | .58 | .063 | |
| 7 1/2"x1/2" | " | 1,417 | .5758 | 41,250 | 67,730 | 23.25 | 45.29 | .17 | .62 | .059 | |
| 7"x5/8" | " | 3,791 | 1.044 | 41,000 | 69,060 | 29.37 | 49.12 | .15 | .49 | .040 | |
| 7"x5/8" | " | 3,692 | 1.088 | 39,520 | 63,880 | 25.00 | 53.05 | .14 | .39 | .059 | |
| 7"x3/8" | " | 14,155 | .4599 | 50.010 | 68,500 | 31.25 | 52.75 | .15 | .53 | .064 | |
| 7"x5/16" | " | 14.170 | .4118 | 46,870 | 67,630 | 26.25 | 61.16 | .17 | .29 | .063 | |
| 7"x5/16" | " | 14,176 | .4110 | 45,380 | 66,860 | 24.75 | 59.25 | .15 | .27 | .064 | |
| 6"x3/4" | " | 4,934 | 1.024 | 40,870 | 66,900 | 26.87 | 47.21 | .15 | .41 | .056 | |
| 6"x5/8" | " | 14,179 | .6474 | 43,400 | 67,420 | 27.00 | 51.28 | .15 | .37 | .064 | |
| 6"x1/2" | " | 5,598 | .4850 | 40,420 | 66,600 | 25.00 | 54.00 | .16 | .47 | .057 | |
| 5"x5/8" | " | 17,068 | .9442 | 45,540 | 68,970 | 30.50 | 47.58 | .16 | .70 | .068 | |
| 5"x5/8" | " | 17,069 | .9405 | 46,490 | 69,860 | 28.00 | 47.73 | .16 | .64 | .066 | |
| 4"x7/8" | " | 18,357 | .5737 | 40,620 | 65,540 | 27.50 | 54.30 | .16 | .54 | .065 | |
| 3 1/2"x1/2" | " | 3,193 | .5575 | 41,250 | 67,980 | 25.00 | 56.14 | .14 | .58 | .055 | |
| 3 1/2"x1/2" | " | 18,962 | .5520 | 42,750 | 67,400 | 25.75 | 53.95 | .17 | .66 | .051 | |
| 3 1/2"x1/2" | " | 2,782 | .5575 | 41,610 | 66,370 | 28.75 | 56.95 | .17 | .54 | .056 | |
| 3"x5/8" | " | 20,741 | 1.857 | 40,090 | 66,070 | 30.50 | 44.97 | .15 | .54 | .057 | |
| 3"x1/2" | " | 20,920 | .5965 | 41,910 | 67,060 | 24.75 | 52.61 | .16 | .59 | .060 | |
| 3"x3/8" | " | 3,193 | 1.071 | 37,350 | 65,220 | 31.87 | 56.45 | .14 | .58 | .055 | |
| 3"x3/8" | " | 17,513 | 1.114 | 40,210 | 66,200 | 30.00 | 47.94 | .15 | .49 | .060 | |
| 2 1/2"x1/2" | " | 18,297 | .5218 | 37,760 | 67,270 | 23.25 | 44.60 | .14 | .62 | .058 | |
| 2 1/2"x1/2" | " | 18,294 | 1.225 | 40,980 | 66,040 | 25.50 | 41.22 | .16 | .62 | .061 | |
| 2 1/2"x1/2" | " | 1,504 | 1.263 | 39,590 | 69,760 | 28.00 | 47.01 | .17 | .69 | .052 | |
| 2 1/2"x7/16" | " | 15,695 | 1.083 | 40,160 | 66,290 | 26.25 | 45.84 | .16 | .63 | .060 | |
| 2 1/2"x7/16" | " | 15,701 | 1.087 | 40,750 | 68,080 | 23.25 | 40.20 | .16 | .51 | .066 | |

## FINISHED MATERIAL TESTS.– BESSEMER STEEL PLATES.—(*Continued.*)

| Cut From. | Blow No. | Area. | Elastic Limit. Per sq. inch. | Breaking Strain Per sq inch. | Elongation. Per cent. in 8 inches. | Reduced Area. Per cent. | C. | Mn. | P. | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|---|
| 2½"x7/16" plate. | 15,698 | 1.076 | 41,450 | 66,440 | 26.25 | 45.77 | .15 | .43 | .060 | Carnegie, Phipps & Co. |
| 2½"x⅜" " | 18,844 | .9176 | 44,680 | 68,570 | 28.00 | 49.50 | .15 | .62 | .049 | |
| 2½"x⅜" " | 20,823 | .8978 | 38,820 | 65,490 | 30.00 | 49.88 | .15 | .63 | .056 | |
| 2¼"x⅜" " | 18,288 | .8407 | 40,680 | 63,160 | 28.25 | 58.12 | .17 | .67 | .056 | |
| 2¼"x⅜" " | 18,291 | .8369 | 41,460 | 66,430 | 26.75 | 57.45 | .17 | .60 | .059 | |
| 2¼"x⅜" " | 18,285 | .8325 | 42,040 | 65,760 | 26.00 | 45.66 | .17 | .64 | .058 | |
| 2¼"x⅜" " | 20,829 | .8359 | 38,280 | 68,840 | 25.75 | 44.21 | .15 | .61 | .057 | |
| 2¼"x⅜" " | 20,883 | .8443 | 38,430 | 67,940 | 24.75 | 50.10 | .14 | .48 | .054 | |

## FINISHED MATERIAL TESTS.--BESSEMER STEEL I BEAMS.

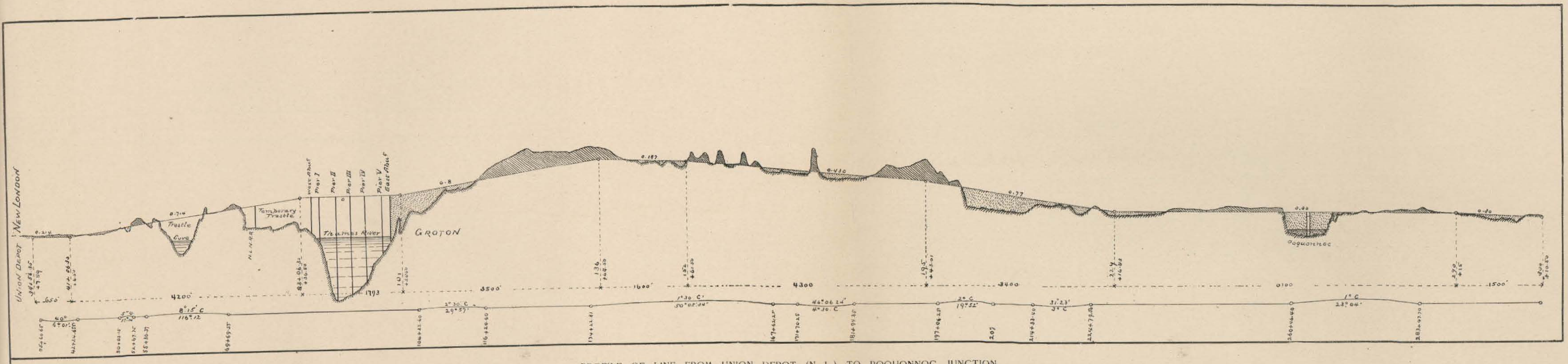
| | Cut From. | Blow No. | Area. | Elastic limit. Per sq. inch. | Breaking Strain. Per sq. inch. | Elongation. Per cent. in 8 inches. | Reduced Area. Per cent. | C. | Mn. | P. | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 481 | 15" I beams. | 13,844 | .9500 | 38,420 | 65,790 | 27.50 | 54.21 | .16 | .67 | .062 | Web. |
| | 15" " | 13,844 | 1.003 | 39,880 | 67,770 | 25.00 | 48.57 | .16 | .67 | .062 | Flange. |
| | 15" " | 13,844 | .9259 | 41,480 | 69,280 | 26.87 | 55.89 | .16 | .67 | .062 | Web. |
| | 15" " | 13,844 | .9413 | 41,220 | 68,630 | 24.37 | 43.24 | .16 | .67 | .062 | " |
| | 15" " | 9,457 | 1.046 | 38,960 | 65,010 | 28.12 | 52.59 | .10 | .63 | .066 | |
| | 15" " | 9,460 | 1.019 | 40,040 | 66,360 | 26.87 | 52.50 | .11 | .56 | .060 | |
| | 12" " | 9,931 | 1.001 | 38,760 | 65,080 | 30.62 | 51.21 | .14 | .57 | .058 | |
| | 12" " | 9,935 | .9964 | 38,040 | 64,130 | 28.75 | 50.85 | .15 | .46 | .059 | |
| | 9" " | 3,278 | .9889 | 40,300 | 65,930 | 26.25 | 46.60 | .14 | .62 | .057 | |
| | 6" " | 4,763 | .7721 | 39,890 | 66,380 | 28.12 | 50.32 | .15 | .48 | .046 | |

## FINISHED MATERIAL TESTS.—BESSEMER STEEL CHANNEL.

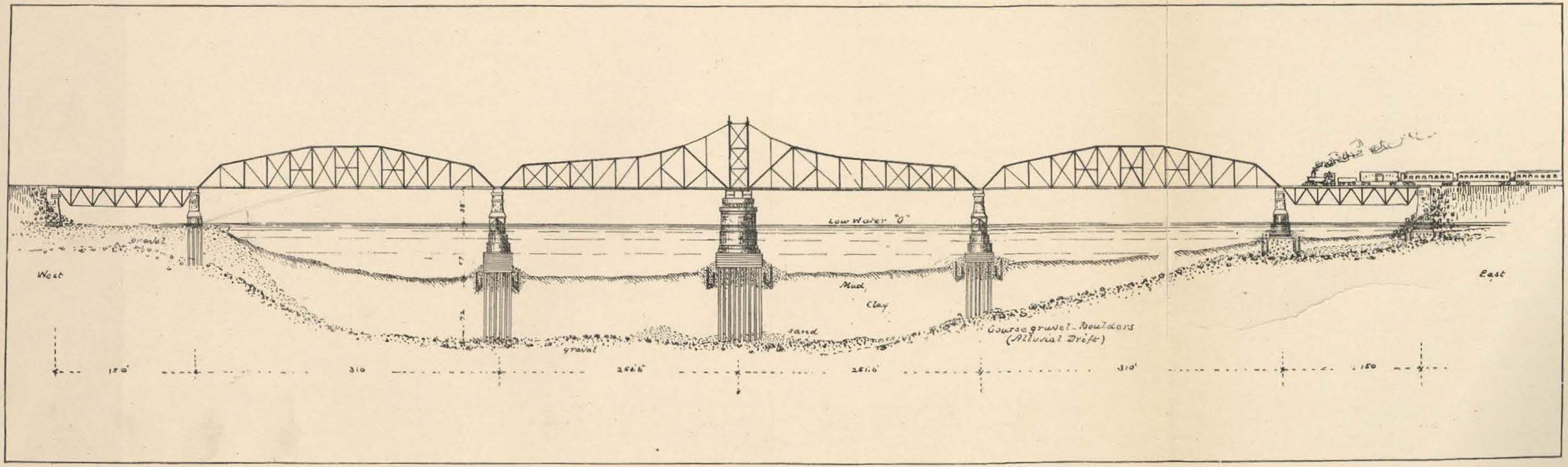
| Cut From. | Blow No. | Area. | Elastic Limit. Per sq. inch. | Breaking Strain. Per sq. inch. | Elongation. Per cent. in 8 inches. | Reduced Area. Per cent. | C. | Mn. | P. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|
| 12" channel. | 20,637 | .4802 | 43,730 | 63,200 | 24.25 | 54.45 | .16 | .60 | .052 | |
| 10" " x24½ lbs | 13,823 | .5310 | 40,680 | 67,800 | 25.00 | 57.80 | .16 | .50 | .069 | Web. |
| 10" " x24½ | 13,826 | .5332 | 39,010 | 65,400 | 27.00 | 55.36 | .18 | .75 | .070 | " |
| 10" " x24½ | 13,829 | .5362 | 40,100 | 65,280 | 27.00 | 50.32 | .17 | .69 | .063 | " |
| 9" " x16¾ | 13,835 | .4313 | 41,740 | 67,240 | 22.00 | 50.68 | .17 | .62 | .062 | Flange. |
| 9" " x16¾ | 13,838 | .3844 | 41,360 | 66,600 | 24.50 | 55.72 | .17 | .72 | .065 | Web. |
| 9" " x16¾ | 13,841 | .3875 | 41,290 | 65,800 | 24.50 | 57.31 | .17 | .63 | .065 | Flange. |
| 9" " x16¾ | 13,844 | .4455 | 40,410 | 69,590 | 25.00 | 47.25 | .16 | .67 | .062 | Web. |

## FINISHED MATERIAL TESTS.—BESSEMER STEEL BARS.

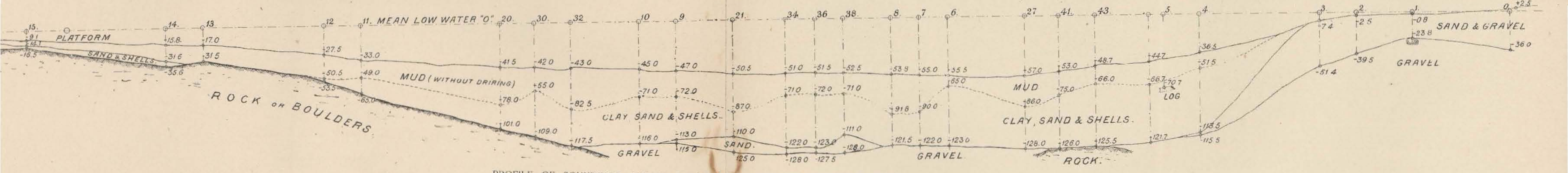
| Cut From. | Blow No. | Area. | Elastic Lim t. Per sq. inch. | Breaking Strain. Per sq. inch. | Elongation. Per cent. in 8 inches. | Reduced Area. Per cent | C. | Mn. | P. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|
| 2¼"x$\frac{5}{16}$" | 20,826 | .7642 | 38,730 | 66,740 | 25.00 | 44.37 | .14 | .64 | .058 | |
| 1¾" Round. | 4,748 | .8090 | 39,550 | 65,380 | 25.00 | 41.71 | .16 | .56 | .050 | |
| 1¾" " | 3,829 | .5217 | 40,060 | 69,000 | 12.50 | 19.77 | .22 | .62 | .060 | Rejected, ⅞ granular fracture |



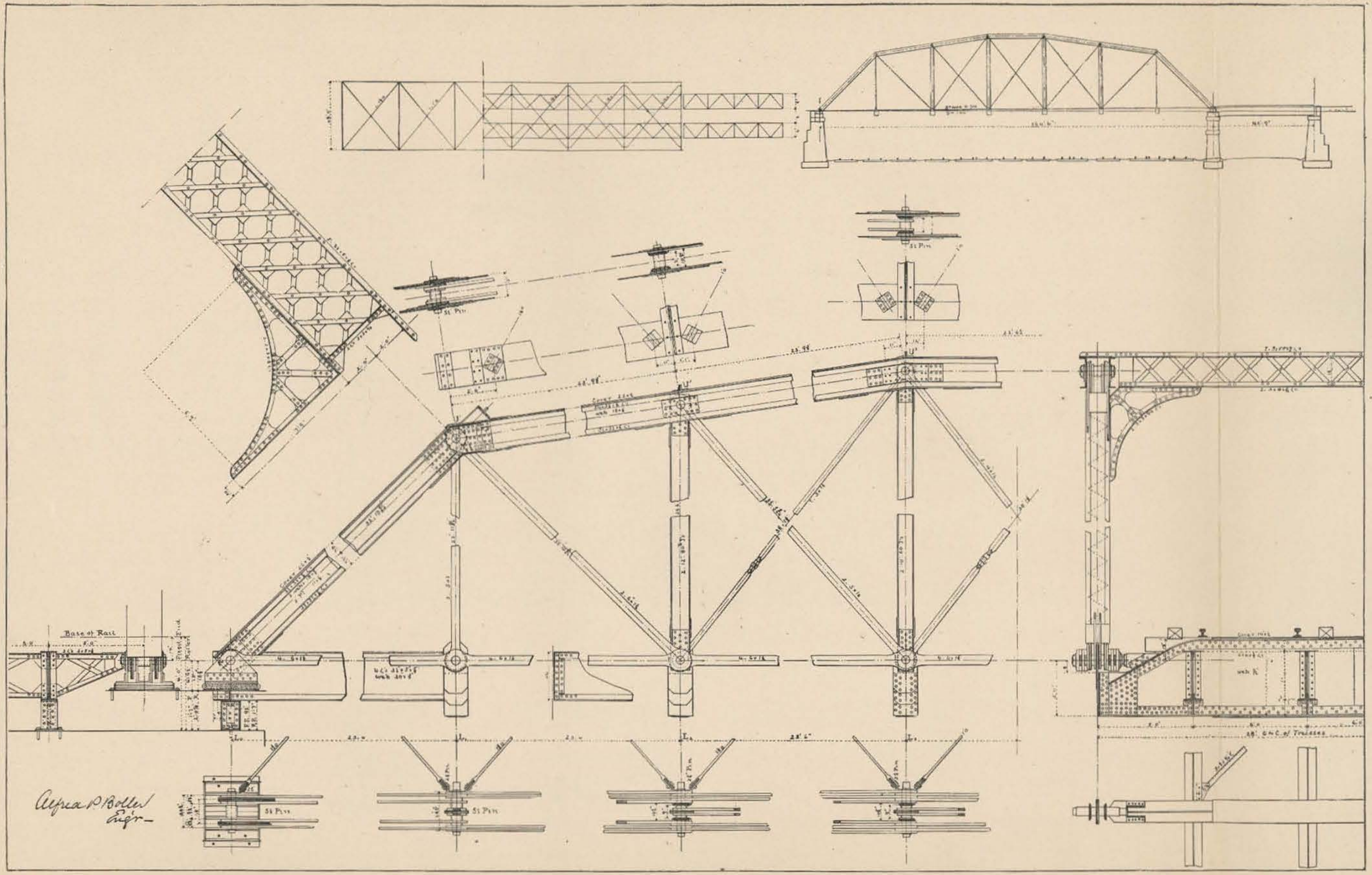

PROFILE OF LINE FROM UNION DEPOT (N. L.) TO POQUONNOC JUNCTION.



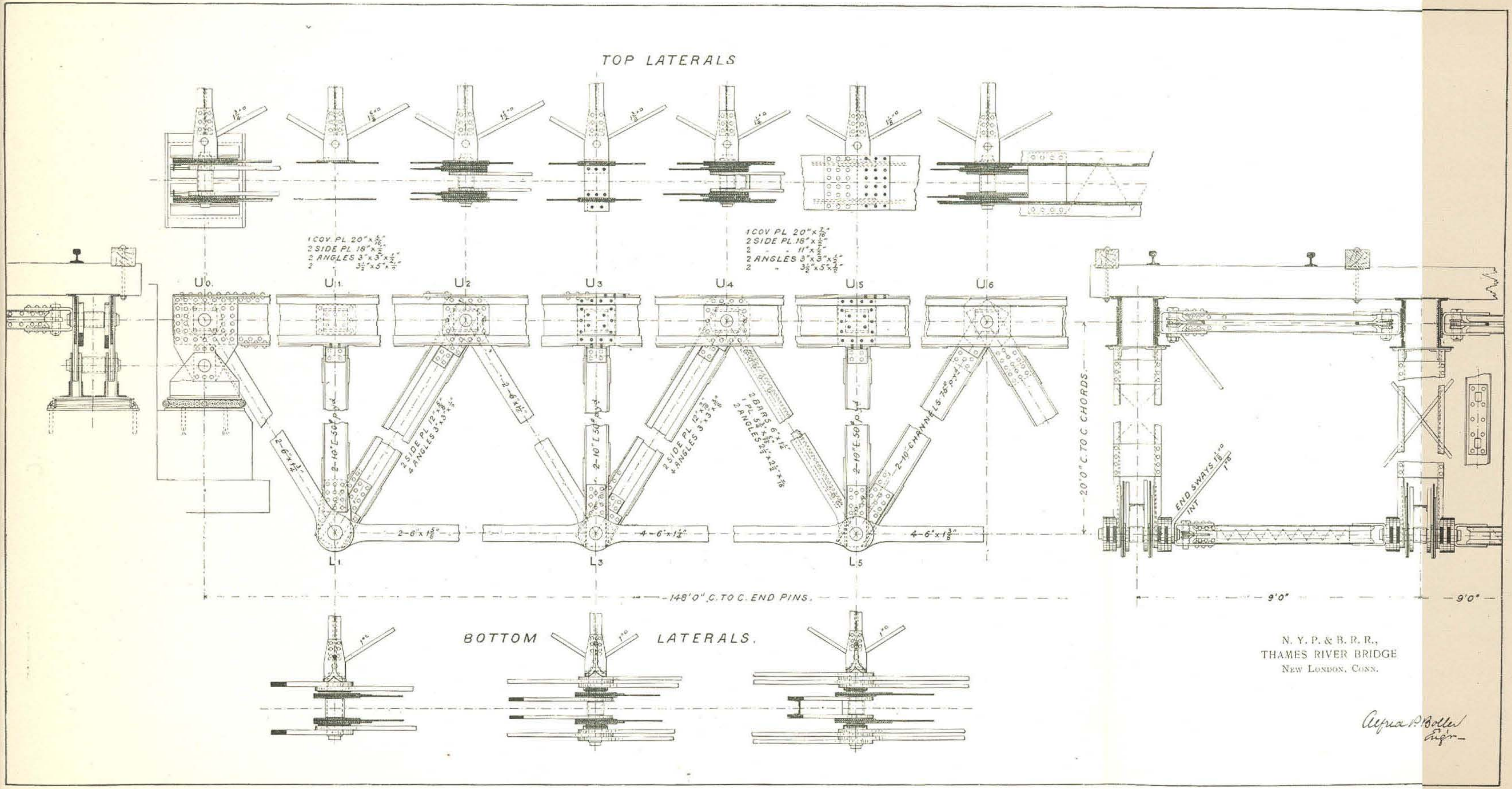

GENERAL ELEVATION OF THE THAMES RIVER BRIDGE.



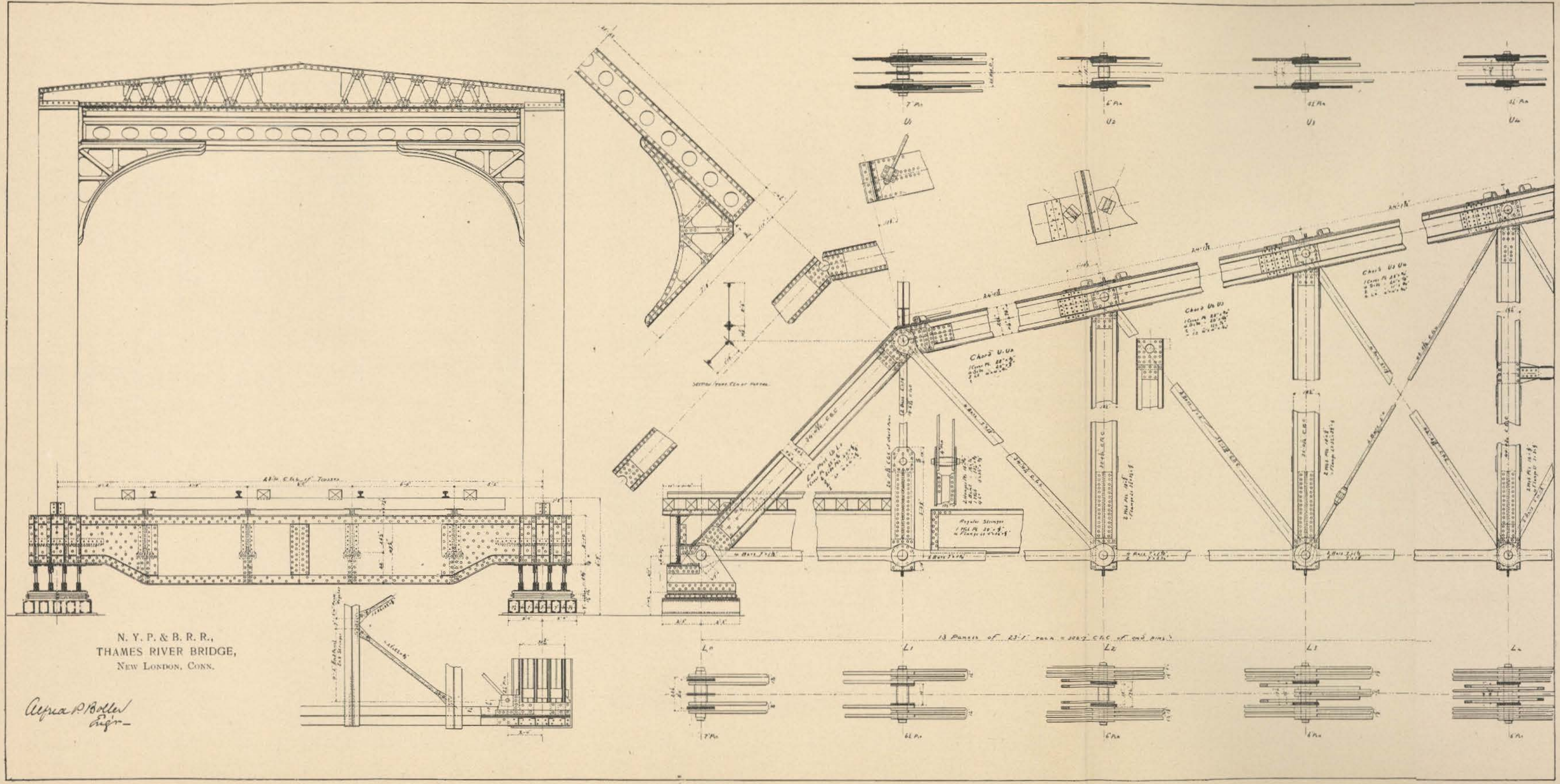

PROFILE OF SOUNDINGS ACROSS THE THAMES RIVER, AT WINTHROP POINT.



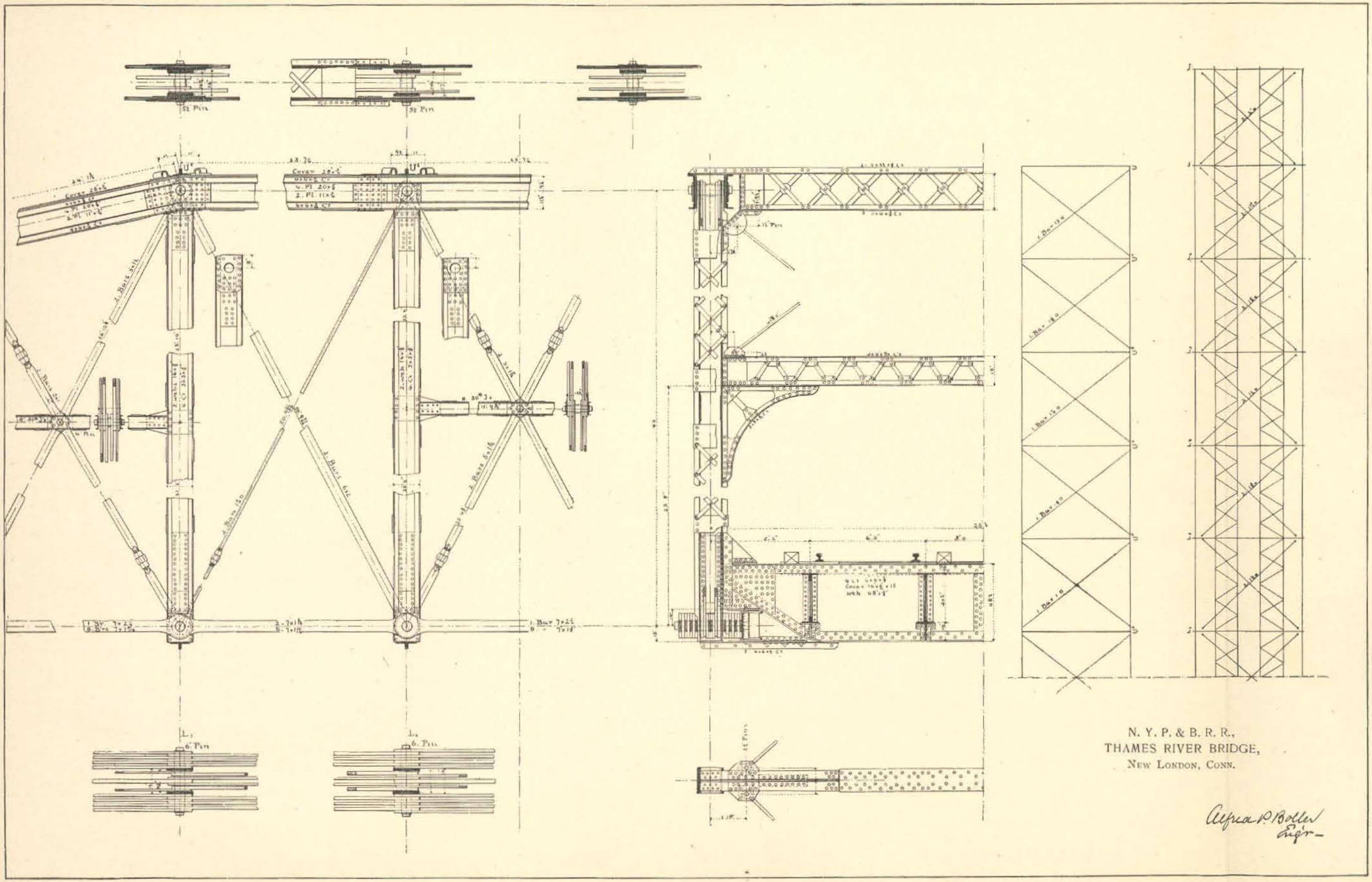

CROSSING OF THE NEW LONDON NORTHERN RAILROAD TRACKS.—WEST APPROACH.



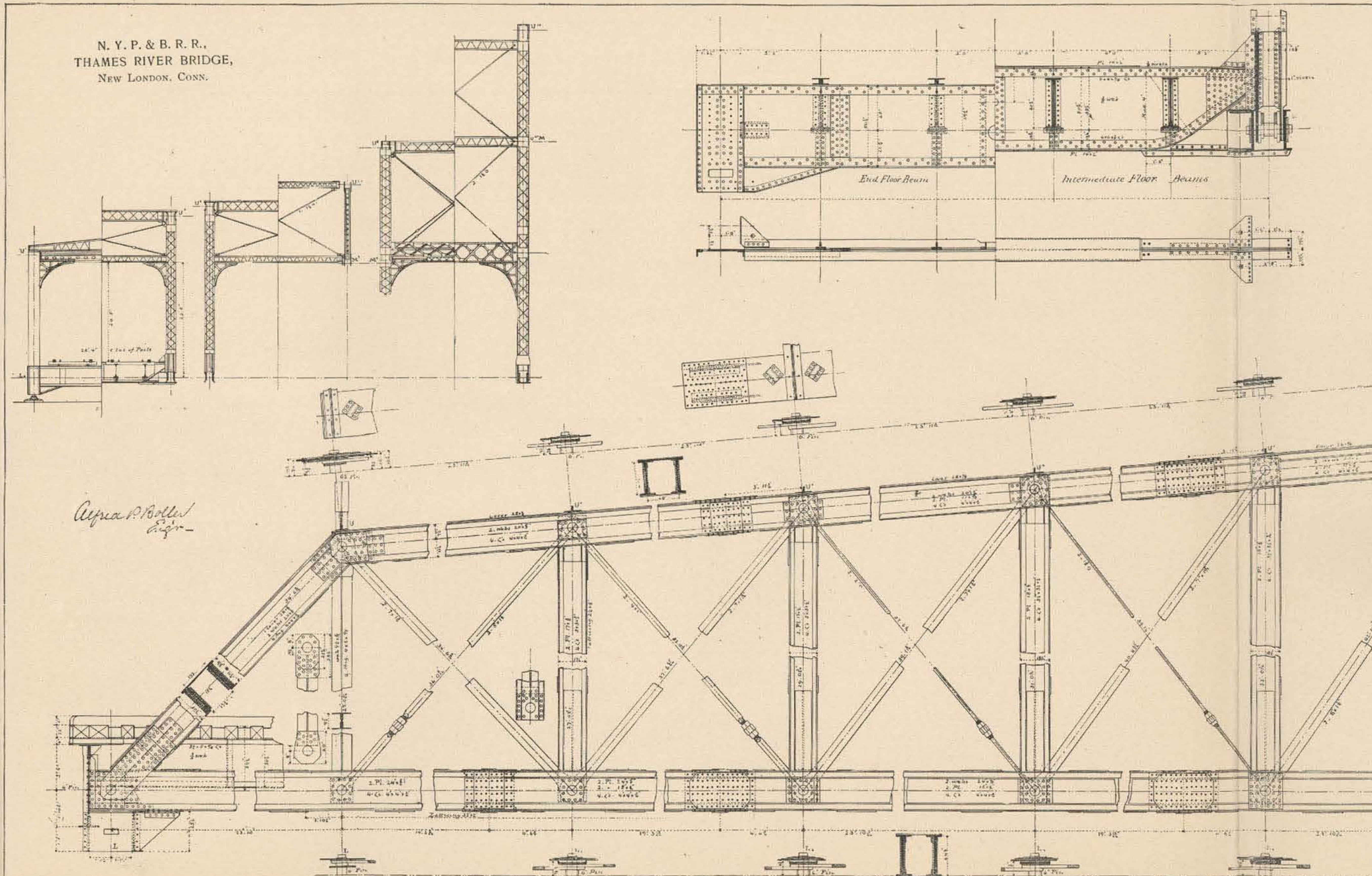

ONE HUNDRED AND FIFTY FEET DECK SPAN.



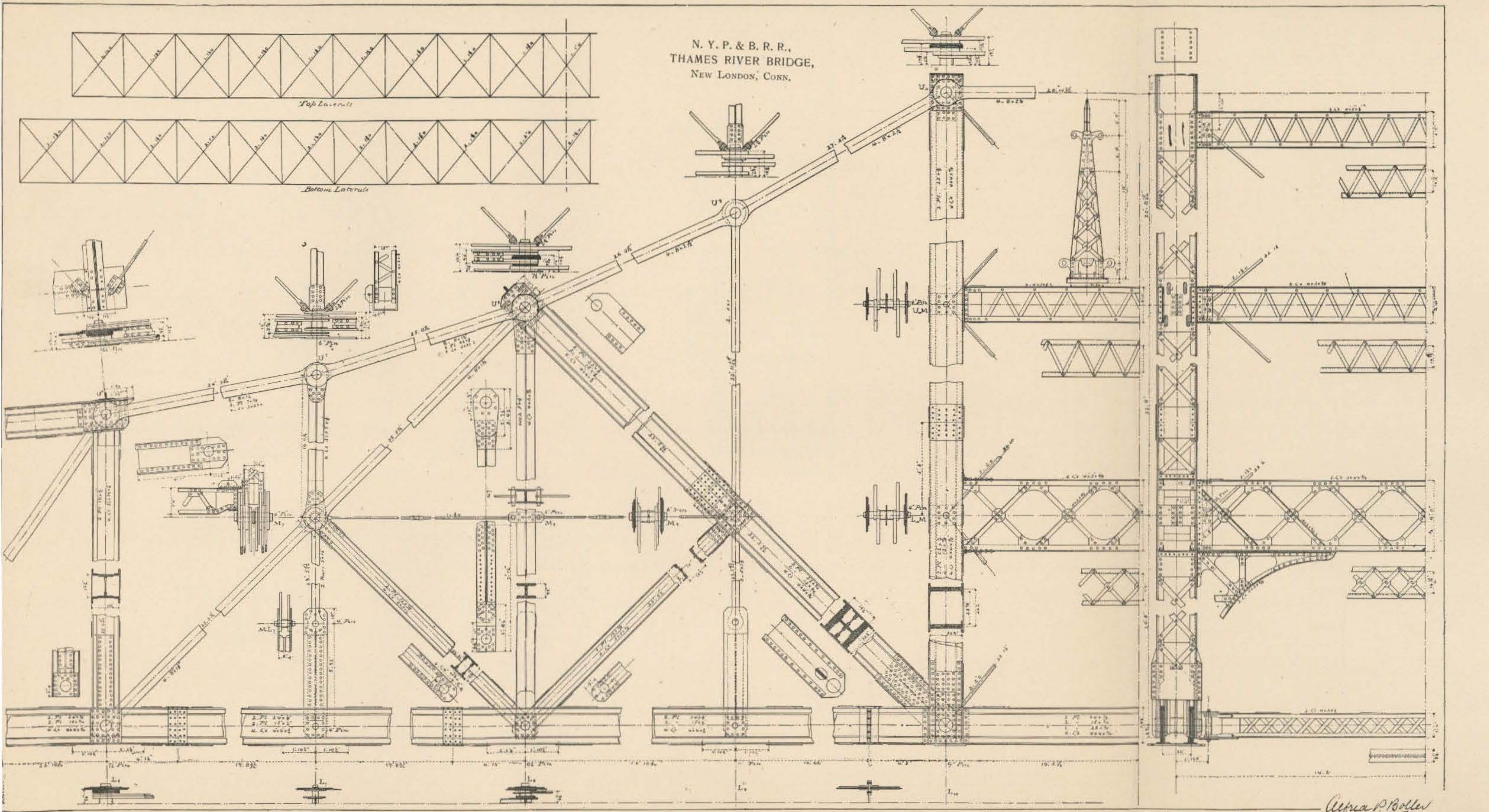

THREE HUNDRED AND TEN FEET THROUGH SPAN.



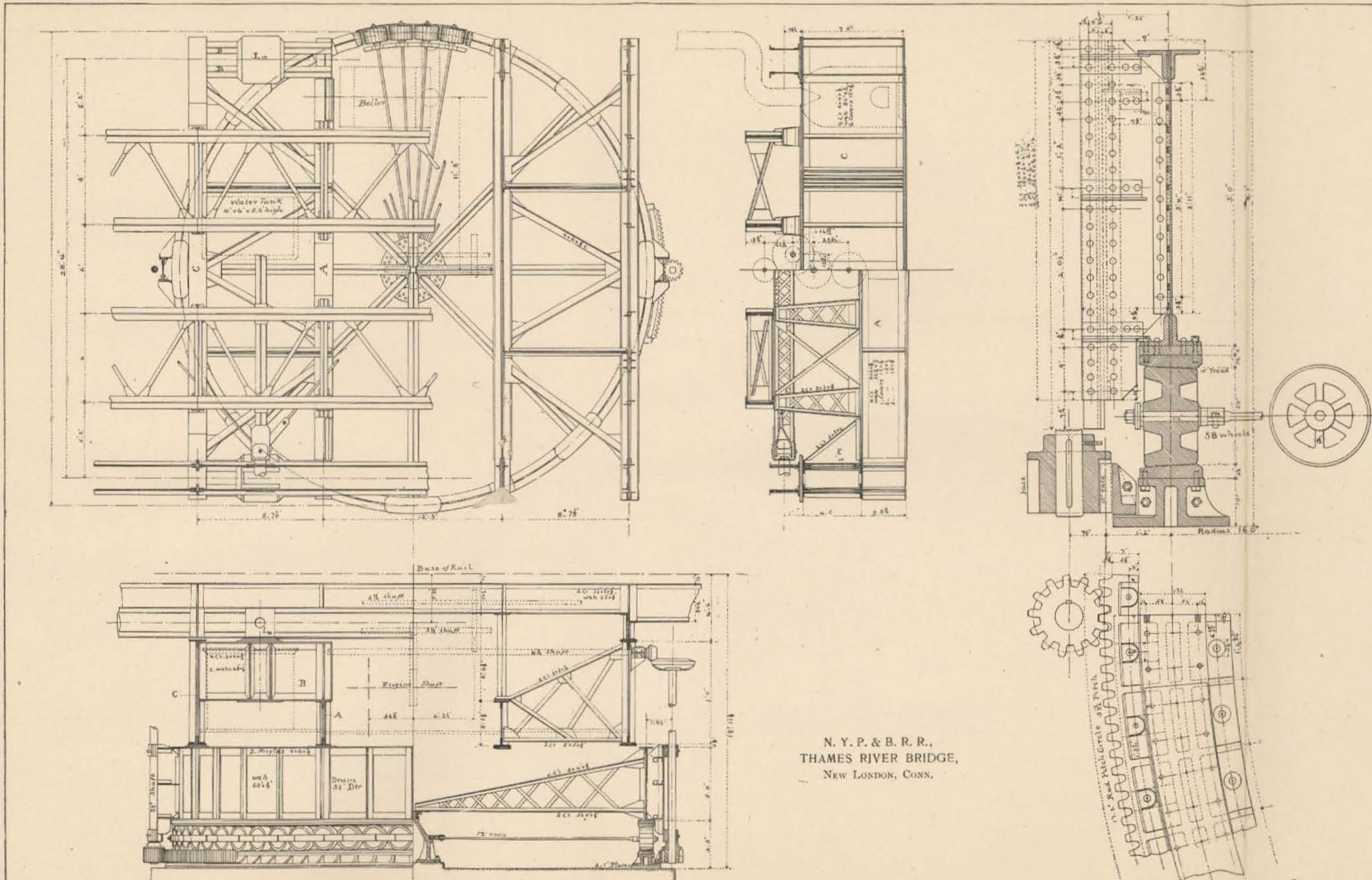

THREE HUNDRED AND TEN FEET THROUGH SPAN.




FIVE HUNDRED AND THREE FEET DRAW SPAN.

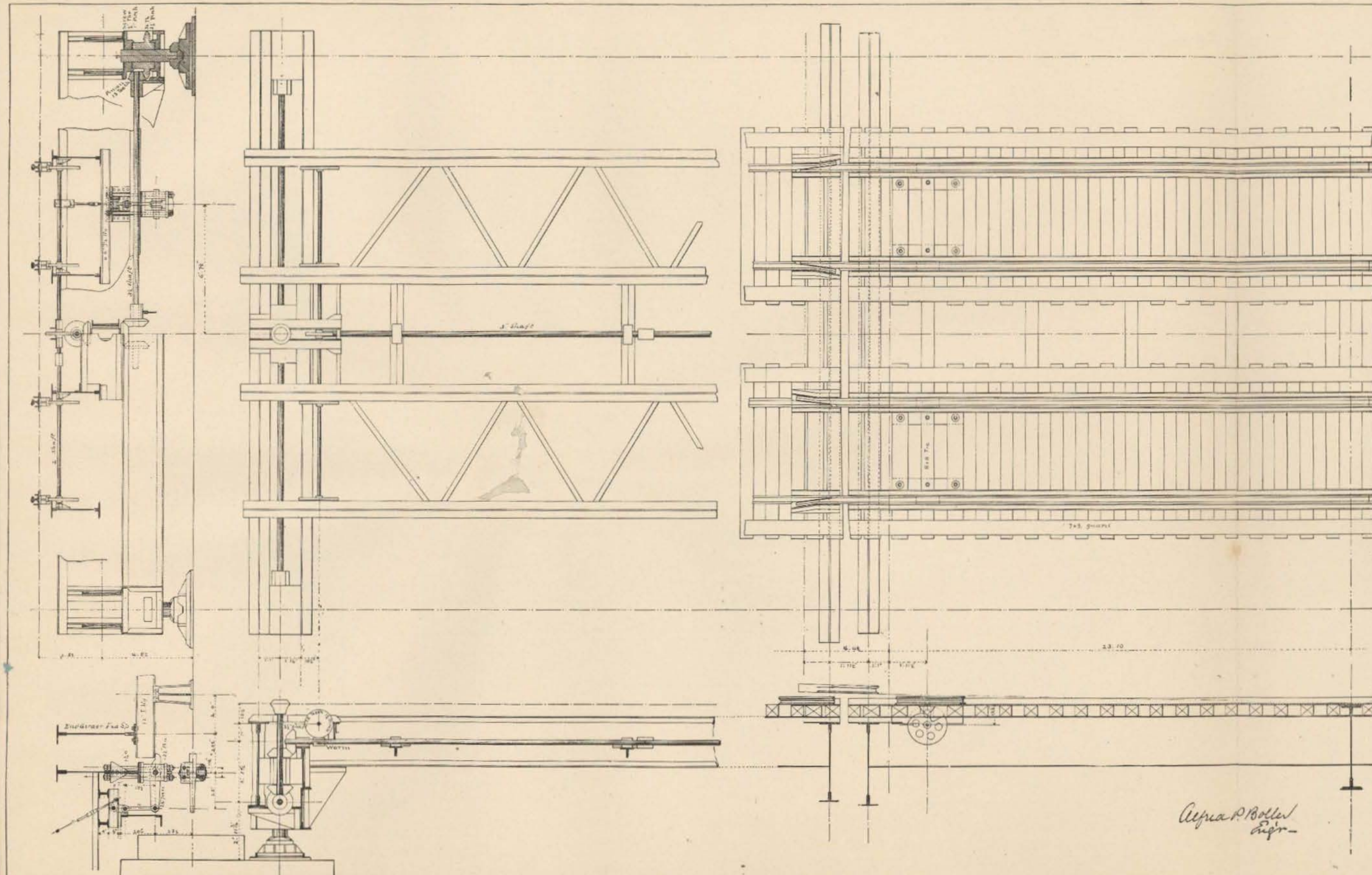



FIVE HUNDRED AND THREE FEET DRAW SPAN.

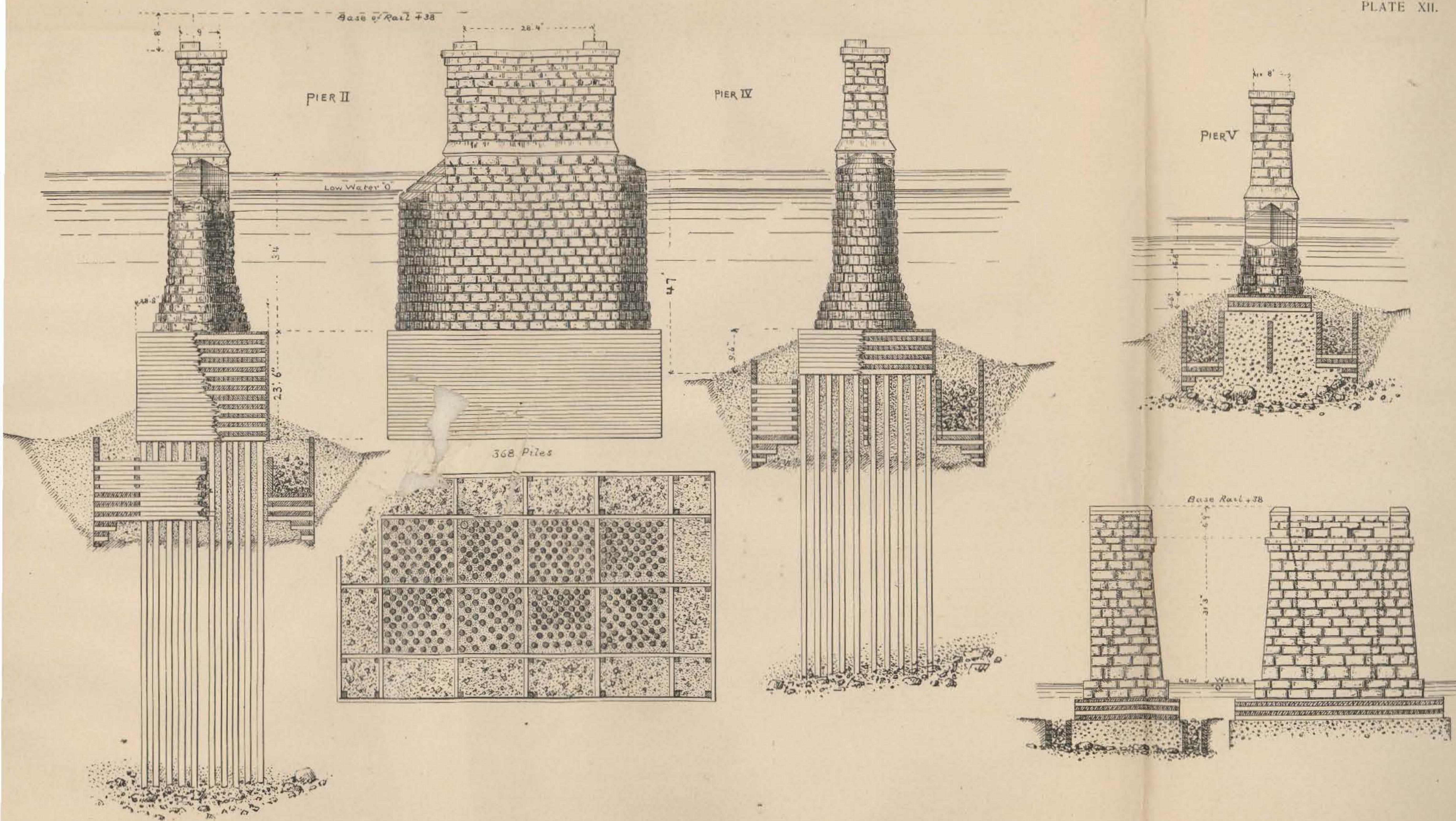



Alfred P. Boller Engr.

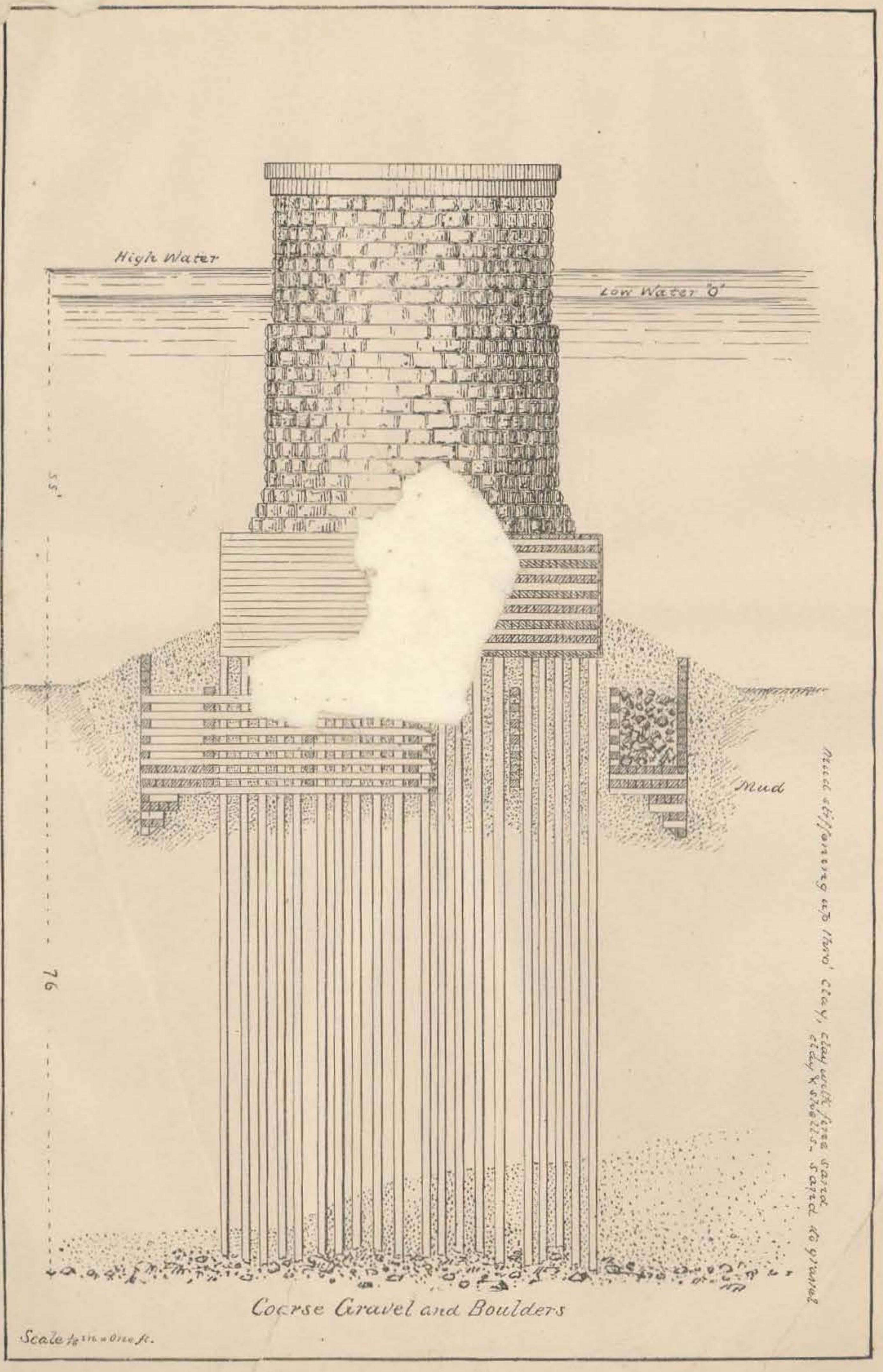
TURN TABLE AND GEARING.




END LOCKING GEAR AND RAIL LIFT.




MASONRY AND FOUNDATIONS.—PIERS II., IV., V. AND EAST ABUTMENT.


High Water
Low Water "0"
55'
76
Mud
Mud stiffening up thro' clay, clay with fine sand
clay & shells. sand to gravel
Coarse Gravel and Boulders
Scale 1/8 in = one ft.

PIVOT PIER.