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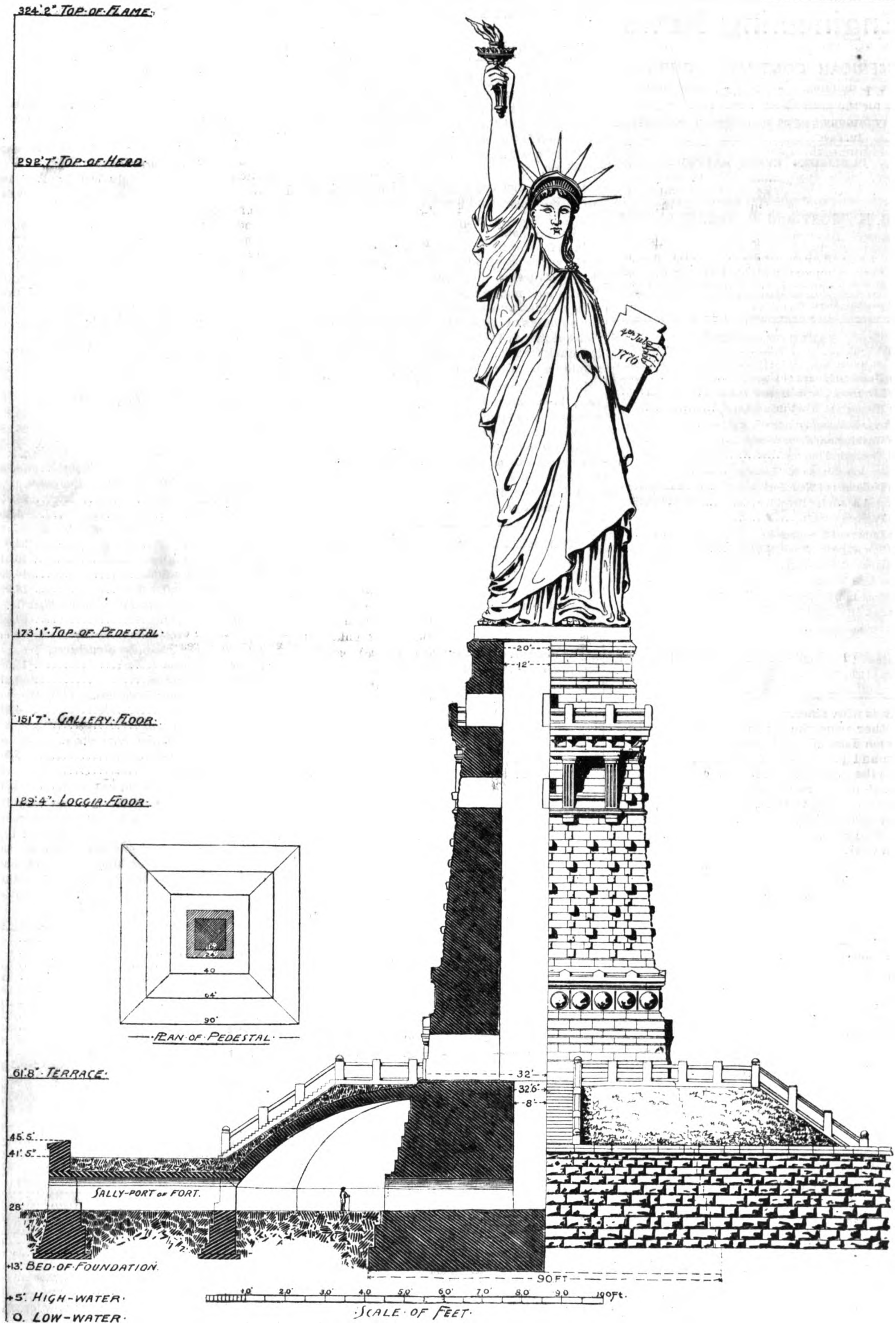


"LIBERTY ENLIGHTENING THE WORLD."

THE NIAGARA CANTILEVER BRIDGE.

As the American Society of Civil Engineers will, undoubtedly, on the occasion of their coming annual convention, visit this latest and most interesting type of American bridge construction, we reproduce, in this issue, all the descriptive matter accessible. For the very excellent illustrations used, we are indebted to the courtesy of the *Railroad Gazette*.

In Engineering News for 1883-84 will be found, scattered through many papers, about all the descriptive matter that has yet been published concerning the dimensions and erection details of this first true Cantilever bridge built upon American soil. But for the convenience of our readers we reproduce, in a condensed form, the great mass of this data.

The bridge was built by the Niagara Bridge Co., representing chiefly parties interested in the Michigan Central R. R. Co. It is located a very short distance above the famous Roebling railroad suspension bridge, and spans a deep gorge traversed by the rapid current of the Niagara River. The position rendered practically impossible any system of false works, and hence the cantilever type of bridge was peculiarly well adapted to the site.

The Chief Engineer of the Niagara Bridge Co. and the designer of the bridge, was Mr. C. C. Schneider, who had already made the plans for an almost identical structure, then lately built over the Frazer River, in British Columbia.

Upon April 11, 1883, a contract for its construction was signed, with the Central Bridge Company of Buffalo, N. Y., of which company Gen. Geo. S. Field was then President, and Mr. Edmund Hayes, Engineer. On April 15, 1883, excavations for the piers were commenced; on June 26, the first stone was laid in the foundations, which were finished on September 3. The anchorage piers were commenced on August 27, and completed October 1. The steel towers were finished on September 19, 1883, and the erection of the shore-arms of the cantilever commenced September 28. On October 29, work was begun on the river-arms of the cantilever; November 21, the center connection of the lower chord was made; on November 22, the center truss was finished, and on December 20, 1883, the bridge was opened to traffic with due formality.

The following statement of the general dimensions of the Niagara Cantilever Bridge was compiled by us from data furnished by Chief Engineer Schneider, and published in Engineering News of October 6, 1883:

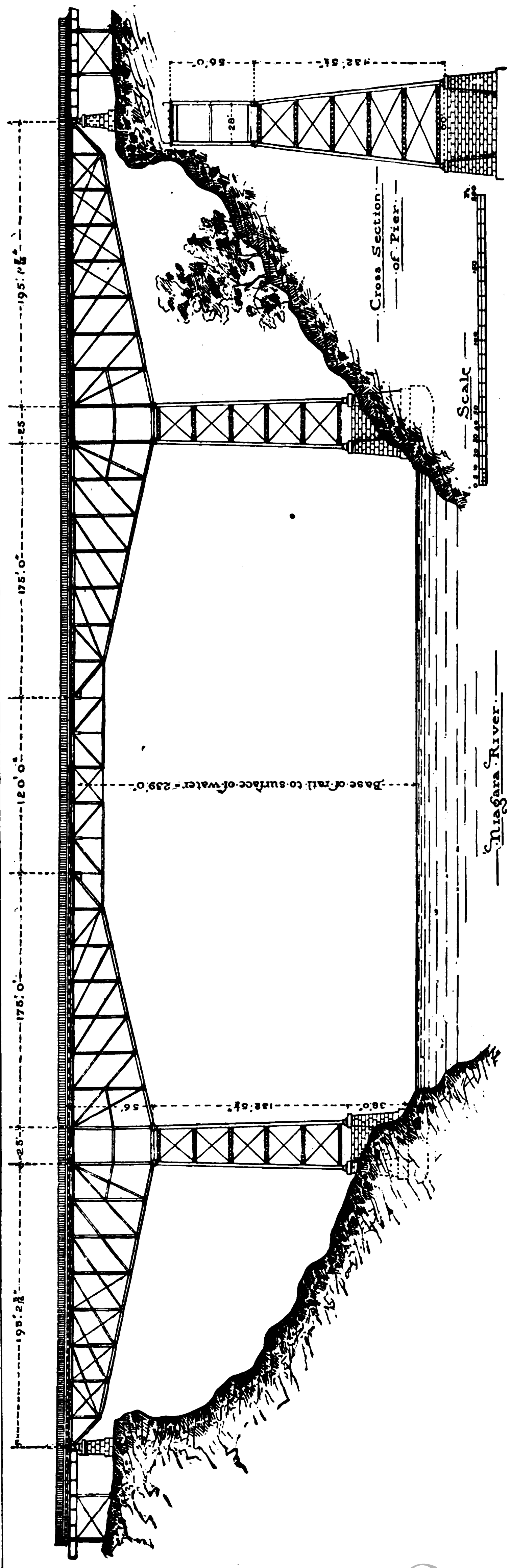
The general dimensions are as follows: Length of bridge proper, from center to center of end pins, 910 ft. 1⅜ in.; divided into two cantilevers of 395 ft. 2.5 in. each, and one intermediate span of 119 ft. 9 in. The towers are braced wrought-iron structures, 130 ft. 6½ in. high, resting upon masonry piers 39 ft. high; the foundations under the towers are of beton, 8 ft. thick, directly on the rock, forming a uniform, solid and enduring mass.

The trusses are two in number, 28 ft. apart between centers; the panels are 25 ft. long, excepting those of the intermediate span, which are 24 ft., and the end panels of the shore-arms of the cantilevers, which are 20 ft. 2.5 in. long. The depth of the cantilever trusses, over the towers, is 56 ft.; and at the ends, 21 ft. for shore ends, and 26 ft. at the river ends:

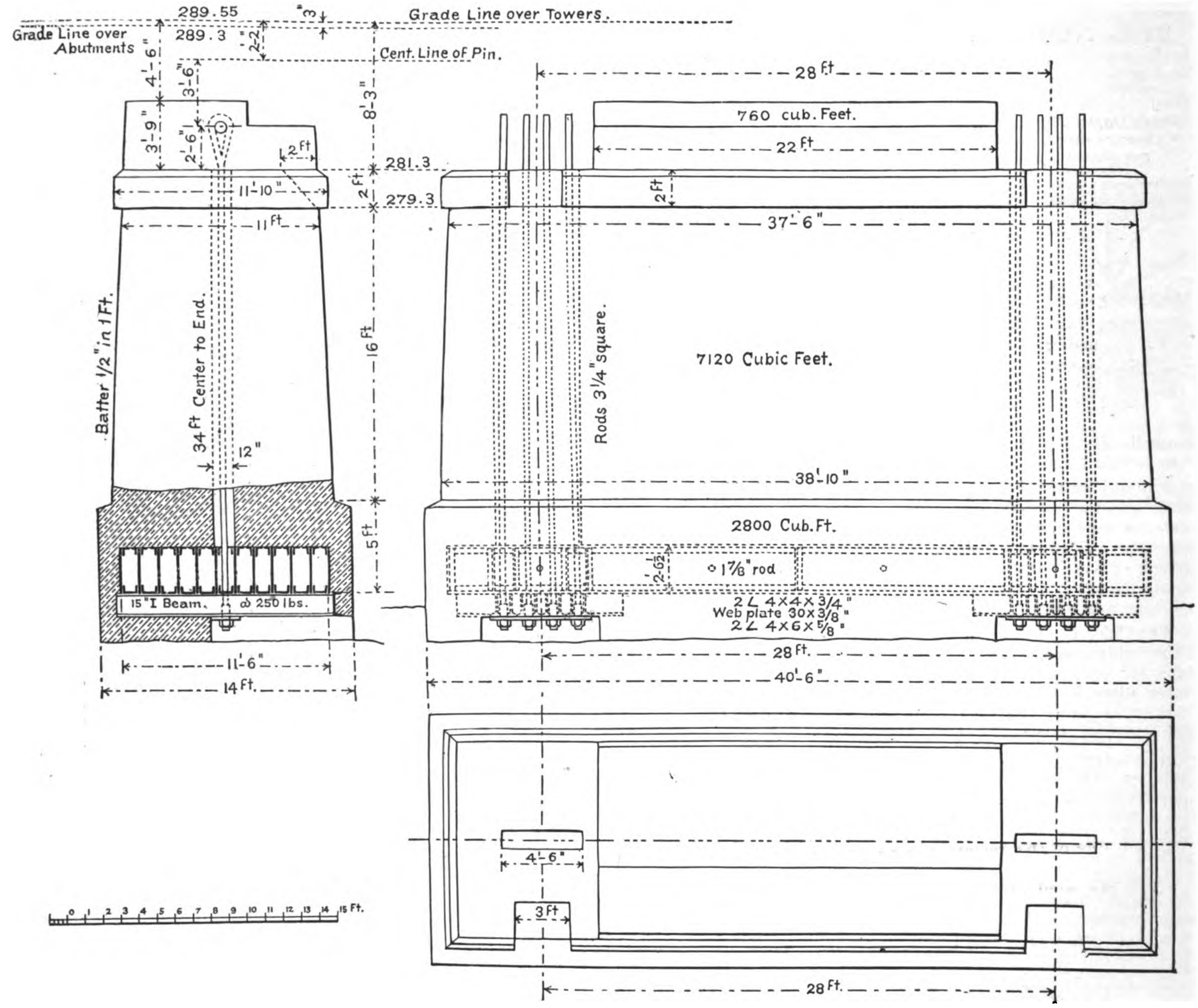
The structure has been proportioned to carry, in addition to its own weight, a freight train on each track at the same time, weighing one ton per lineal foot, with each train headed by two 76-ton consolidation engines. The factor of safety is 5. Wind bracing has been proportioned for a pressure of 30 lbs. per square foot on a surface twice the area of one face of the truss, plus area of floor system, plus the area of face of train taken at 10 ft. vertical height.

The material used in the superstructure is open-hearth steel and wrought-iron. Towers and heavy compression members, such as lower chords and center posts, are of steel, as are all the pins. All tension members are wrought-iron. The only use made of cast-iron is in the pedestals on the masonry and in filling-rings; the castings at the top of the towers are all steel.

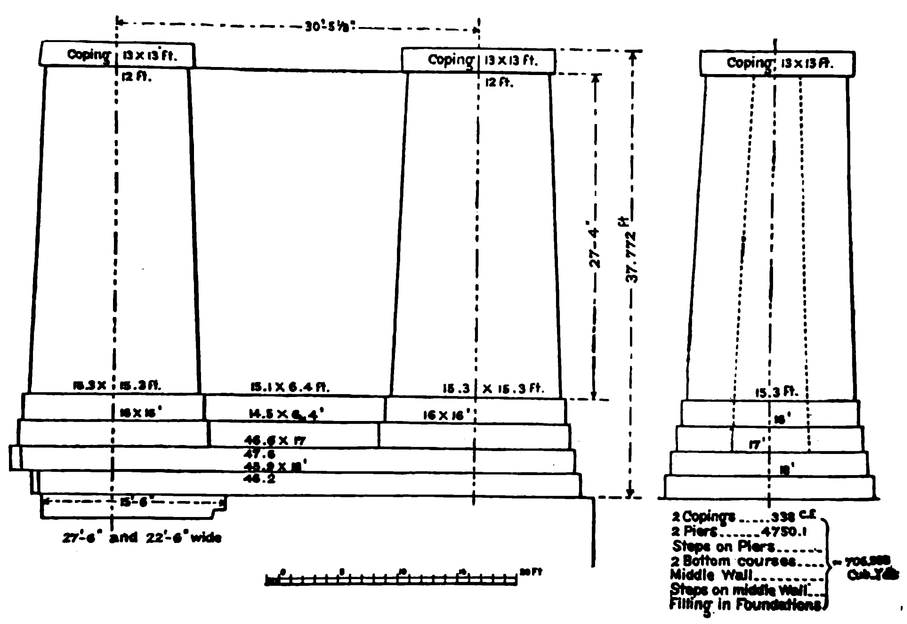
The whole of the superstructure is pin-connected. The towers contain four columns each, and each column is made up of plates and angles in sections of about 25 ft. in length, braced with horizontal struts and with tie-rods. The batter of columns at right angles to the center line of the bridge is 1 in 8. In the cantilever trusses, the lower chords and center posts are made of plates and angles latticed; the intermediate posts are made of 12 in. and 15 in. channels, latticed. The upper chords of the cantilevers are 8 in. eye-bars, the shore-arm having a compression member 18 in. deep, composed of plates and angles packed between the chord-bars.



NIAGARA FALLS CANTILEVER BRIDGE.



ANCHORAGE.



PIERS.

The shore ends of the cantilevers are attached to short links revolving on pins anchored to the masonry; these links serve as rockers and allow for the expansion and contraction of the shore ends of the cantilevers. Expansion joints are also provided for at the connection of the intermediate span with the river ends of the two cantilevers, the intermediate span being suspended from the extreme ends of the river arms.

The floor beams are 4 ft. deep, and are made of plates and angles; they are riveted to the posts. There are four lines of longitudinal stringers, resting on top of the floor beams; these stringers are plate girders 2 ft. 6 in. deep. The ties are white oak 9 in. by 9 in., spaced 18 in. between centers; every other tie projects to support a plank walk and hand-railing, which latter is made of cast-iron posts 6 ft. apart, and four longitudinal lines of 1¼ in. gas piping. The guard timbers are of white oak, 8 by 8 in.

All masonry is built of Queenstown limestone, in courses of 2 ft. rise. The piers for the towers are 12 ft. square under the coping, and have a batter of ½ in. to the foot; each pair of piers is connected by a wall 3 ft. 9 in. thick at the top, and battering the same as the piers.

The anchorage-piers are 11 ft. by 37 ft. 6 in. under coping, with a batter of ½ in. to the foot. They rest on a platform consisting of twelve iron plate girders, 2 ft. 6 in. deep and 36 ft. long; under these plate-girders are eighteen 15-in. I beams, through which the anchorage-bars pass, in such manner as to distribute the pressure over the entire mass of masonry. Each anchorage pier contains 460 cubic yards of masonry, weighing 2,000,000 lbs; as the maximum uplifting force from the cantilevers under the most unfavorable position of load is only 678,000 lbs., it will be seen that this upward force is amply counterbalanced.

The near approaches to the main structure, on both sides, are substantial iron trestle resting on masonry foundations erected upon solid rock.

The dimensions, etc., may be tabulated as follows:

Length over all, centers of end pins	910 ft. 1⅛ in.
Length center portion	119 ft. 9 in
Length each cantilever	395 " 2⅛ "
Height of wrought-iron towers	130 " 6⅛ "
Height of masonry piers	39 " 0 "
Depth of beton foundation	8 " 0 "
Length of panels, cantilevers	25 " 0 "
" " " center girder	24 " 0 "
Trusses apart between centers	28 " 0 "
Depth cantilever trusses, over towers	56 " 0 "
" " " river ends	26 " 0 "
" " " shore ends	21 " 0 "
Depth of floor beams	4 " 0 "
Depth longitudinal stringer	2 " 6 "
Ties, white oak, 18 in. apart	9 in. by 9 in.
Guard timbers, white oak	8 in. by 8 in.

The total quantity of material used in the bridge and towers, exclusive of the approaches, is as under:

Steel	1,272,900 lbs.
Wrought-iron	3,093,000 lbs.
Cast-iron	126,000 lbs.
Total	4,491,000 lbs.
*Timber in floor	154,000 ft. B. M.
Beton in foundations	31,100 cubic ft.
Masonry in piers	2,800 cubic yds.
Do. anchorage piers	900 cubic yds.

The Niagara River at the crossing point, is about 450 ft. wide, the depth of water is not certainly known, but the current is exceedingly rapid; the distance from the base of rail on the finished bridge, to the surface of water is 239 ft. (See general elevation). The following was the method of erection pursued:

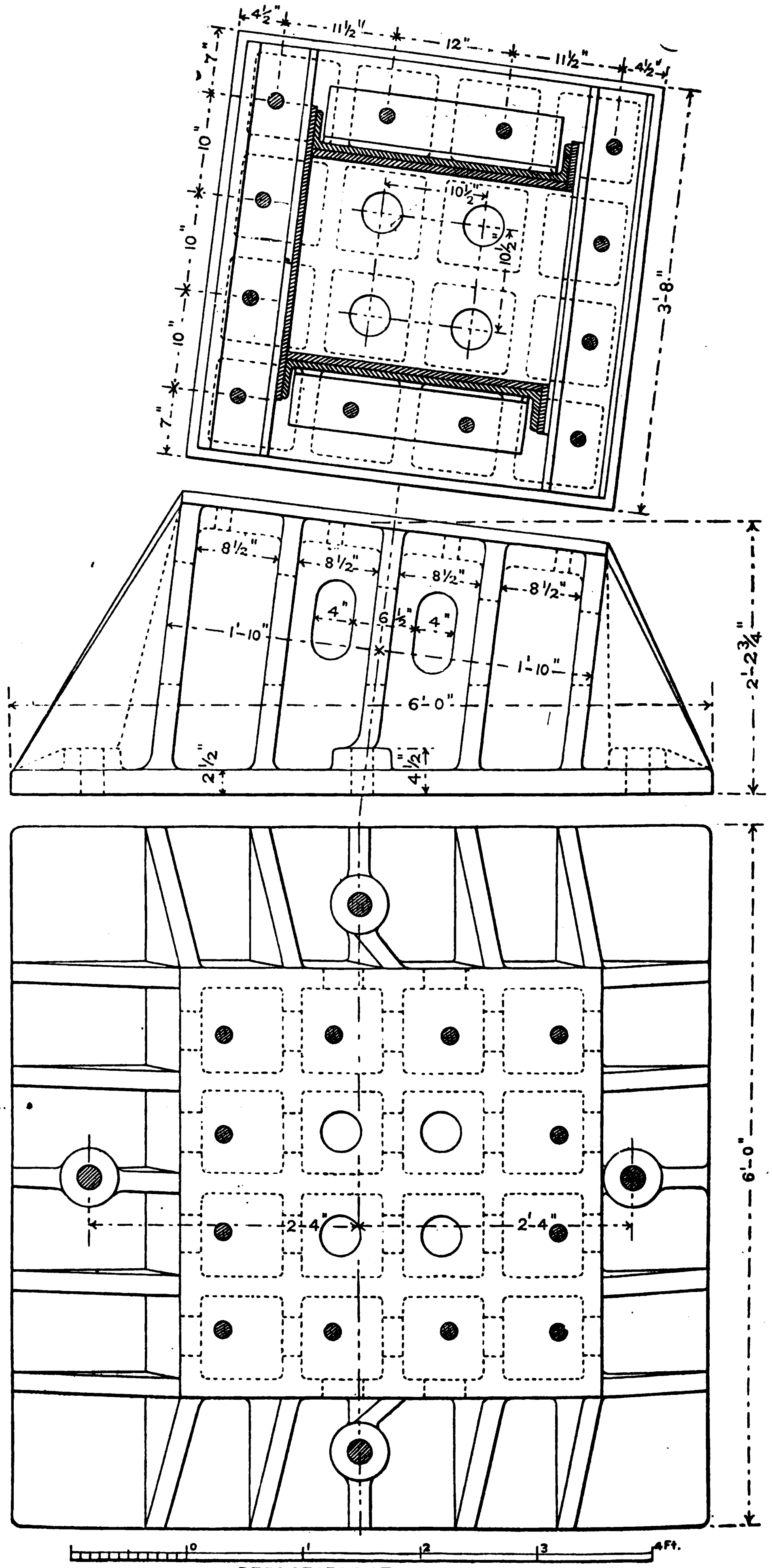
The steel tower having been first erected upon masonry foundations in the solid rock, the shore-arms of the cantilevers were built from wooden false-works, as being the most economical method, and, from the arrangement, perfectly feasible.

The anchorage piers of the shore cantilevers are so fully shown in the illustrations, that little description is needed, beyond what we have already said. The same remark may be made of the details of the towers and their foundations; only explaining that in the "strain-diagram of the towers," the sectional areas of the members are shown in sq. inches, on the right hand side of the diagram, while on the left hand side is given the "strain in pounds produced by the maximum possible loading due to the combined effects of wind pressure and ~~live and~~ dead loads:" "l" denotes strains due live load; "d," strains due dead load; "w," strains from wind pressure; — denotes tension + compression.

The top line of the rectangle drawn above the towers denotes the horizontal center line at which the wind pressure acts on the top chord, which is some little distance above the top chord of the cantilever. The lattice bracing, which enables the cantilever to keep its form against lateral distortion, is not shown in this diagram. The estimated maximum wind pressure on the top and bottom chords respectively, are shown on the diagram in pounds pressure: the figures being written horizontally at the upper and lower right hand corners of the rectangle denoting the cantilever. The maximum wind pressure has been assumed at 30 lbs. per square foot on a surface twice the area of one face of the truss, plus area of floor system, plus the area of face of train taken at 10 ft. vertical height.

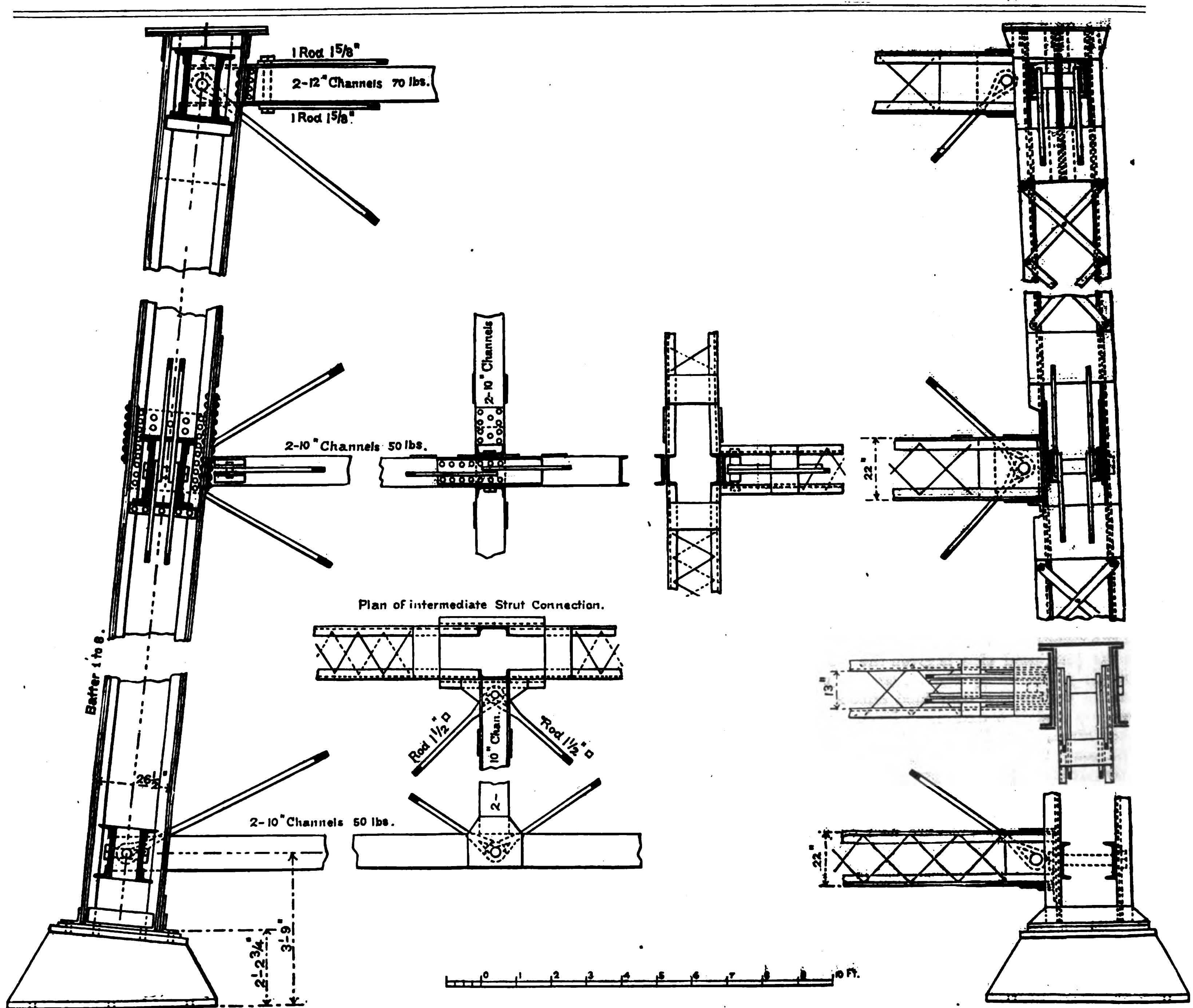
In the erection of the the river-arms of the cantilevers, two travellers were used, which are illustrated and described in ENGINEERING NEWS of March 1, 1884. This portion of the plant was very well designed, and in its use lies the secret of the very rapid connecting together of the different members of the river portion of the bridge. These travellers overhung the finished panels of the structure, 40 ft., and were provided with double derricks and hoisting engines for handling the parts, (the heaviest member weighed 12,000 lbs.) and swinging platforms for the safety and convenience of the workmen. Six cast-iron wheels, each 14 in. in diameter and 8 in. face, ran upon two of the longitudinal stringers of the floor-system, and supported the traveller, and permitted its rapid advance, as the bridge was built out panel by panel. The total erection was done under the direct supervision of Mr. S. V. Ryland, who had long previous experience in this delicate branch of the art of bridge construction, with the firm of Kellogg & Maurice, and who is at this date in charge of the erection of the St. John's cantilever bridge, in New Brunswick.

The principles upon which this bridge was designed are too well known to the engineering fraternity to need an extended description here. But at the risk of some repetition we will mention that the Niagara Bridge in question is made up of two towers, founded on the opposite banks of the river, and each supporting, near its center, a girder with a horizontal top and an inclined bottom chord; these two girders do not meet at the middle of the river by about 120 ft., and between and connecting them is a straight suspended truss. In the present case, the shore arms of the main girders were built by means of false works, as soon as the towers were completed; though had it been necessary, the design would have permitted the use of the same method of erection adopted in the building of the river-arms.



PEDESTALS FOR TOWERS.

The shore-arms or cantilevers being first finished, their extreme ends were securely anchored, by the links, pins and bottom platform of built-beams, shown in the anchorage plans, to a mass of masonry, that in its dead weight, far exceeded the lifting tendency of the dead and live loads upon the river cantilevers. With the shore-arms firmly held down, it was possible, by the design of the truss, to build out the river-arms, panel by panel, until the whole space was spanned by



DETAILS OF STEEL TOWERS.

the meeting of the two river-arms and the intermediate truss; this portion of the work being carried on simultaneously from both sides of the river. Expansion and contraction are provided for, in the short links, surmounting the main anchorage links, and by the links "A" at the ends of the river-arms, which latter form the sole vertical connection between the cantilevers and the suspended central truss. To obtain lateral continuity in the three truss members forming the whole bridge, and to resist wind or lateral pressure, the following plan was adopted: The pin on the lower end of the link "A" is connected by horizontal slotted bars to the end of the cantilever, in such manner that the center truss slides between guides firmly attached to the cantilever, and as the connection is further secured by wind braces (shown in plan in the illustration of the river-arm), any lateral motion in the central truss is impossible without first shearing off these guides.

By making use of the stiffened bottom chord of the center truss, this part of the bridge was connected in the same way as were the cantilevers proper.

The natural features of the bridge-site, the rapidity of erection, the comparative economy in cost, and the perfect safety with which the whole work was done, make this structure mark an important epoch in bridge construction in America.

RURAL WATER SUPPLY.

BY CHARLES L. HETT, ASSOC. MEM. INST. C. E.

IV.

GAS, STEAM, AND HOT AIR ENGINES FOR SMALL WATER WORKS.*

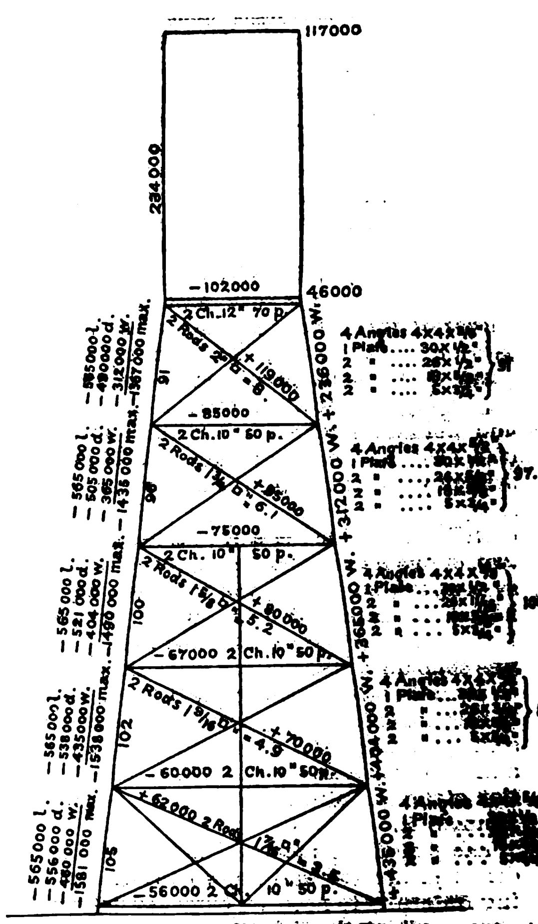
In foregoing articles the direct application of the forces of nature to the purpose of raising water, have been principally treated of.

We now propose to consider those cases in which the combustion of coal, or its constituents, are directly or indirectly employed to produce the necessary power.

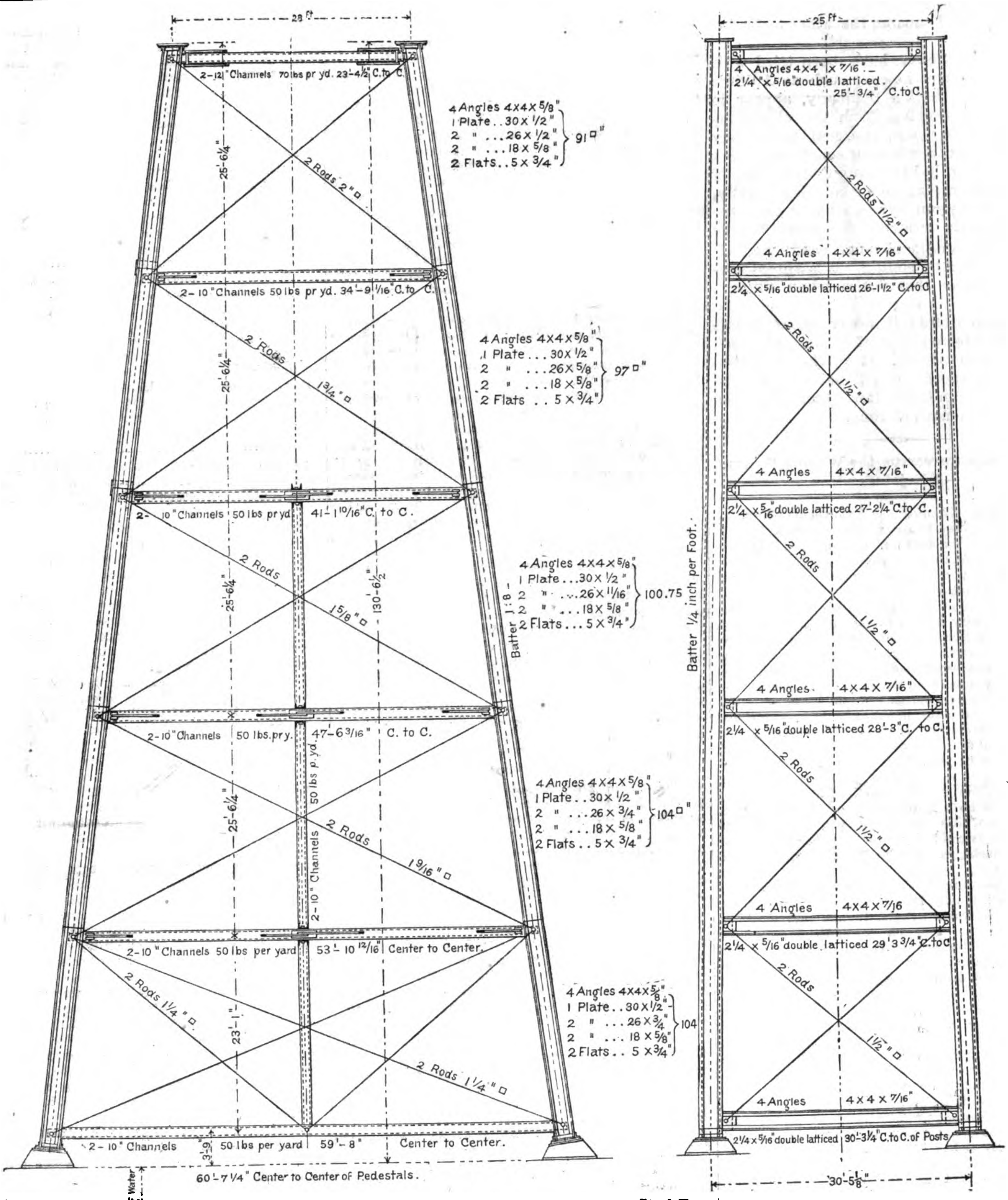
In the neighborhood of large towns there are many residences to which gas is laid on; but which are beyond the area served by the towns water works.

The water required for domestic purposes is commonly pumped up either by hand or horse power from a well on the premises. When an engineer is called in he frequently finds that the existing pumps are sufficient, and a gas-engine arranged so as to drive them, will be all that is required. The gas-engine of the earliest days was the Lenoir; in which a mixture of air and gas was exploded at each end of the cylinder by means of electricity. These alternate explosions

* There is now for sale in the United States a considerable variety of small gas, steam and hot air engines for pumping purposes. In New York City, where the Croton water does not rise to even the second floor of the houses, these engines are universally used for filling reservoirs on the roof or upper story of the buildings.—(*Ed. Eng. News.*)



Strain Diagram of Tower.



Steel Towers.

NIAGARA FALLS CANTILEVER BRIDGE.

forced the piston backwards and forwards in the same manner in which the steam acts in a steam engine. Many improvements have been introduced during the last twenty years, and now there are several makers who offer efficient gas-engines to the purchasing public, and who are willing to guarantee them for six months. The first really commercially successful gas-engine was the Otto, of which numbers are in use. The connections of the engine and pump is too simple a matter to require anything but a passing notice. One important point is to arrange the gear, so that the original mode of working can be temporarily reverted to in case of an accident to the gas-engine or mains.

There are other country houses, situated at a distance from any water power, which are not supplied with gas, and are so sheltered by trees that the power of the wind cannot be utilized. Under these circumstances the choice is, leaving animal power out of the question, limited to steam and hot-air engines. Each has advantages peculiar to itself; the former is to be preferred when it can be placed in the charge of an experienced driver, but where such aid is not at hand, the latter would have the preference owing to the impossibility of an explosion.

FILTRATION.*

This subject may be divided into two sections, viz.:—The filtration of water in bulk before it enters the service reservoir, and the purification of the water after its delivery on the premises of the consumer, or in other words, that which is done by the water companies and their customers respectively.

For large works sand filtration still takes the leading place, although other mediums have been tried. Magnetic carbide was used in several instances, but now nothing is heard of it. The Antwerp Water Company are now trying spongy iron on a large scale, and so far their experiment is very satisfactory.

Household filters are most commonly furnished with animal carbon, which answers admirably when new. Recent evidence given before a Royal Commission shows that neglected animal charcoal forms a nursery for minute organisms, whose presence in potable water is most objectionable. In London and other large towns cistern and other filters, whose purifying medium is animal charcoal, obtained from and kept in proper order by the maker's employes, leave little to be desired. For country use I should not think it suitable, and should prefer a filter in which no organic substance is used. It would do no harm if neglected, even if it did no good. The two filters of this class with which we are acquainted, are the spongy iron and the magnetic

* There are numerous examples of Filtration of water in large and small quantity in this country, and new and improved methods are being studied continually. The business now is principally in the possession of two companies, The Farquhar Filter Co., New York City, and the Newark Filtering Co., of Newark, N. J.—(*Ed. Eng. News.*)

THE NIAGARA CA

DESIGNED BY C. C. SCHNEIDER, M. AM. SOC. C. E., CHIEF ENGINEER NIAGA

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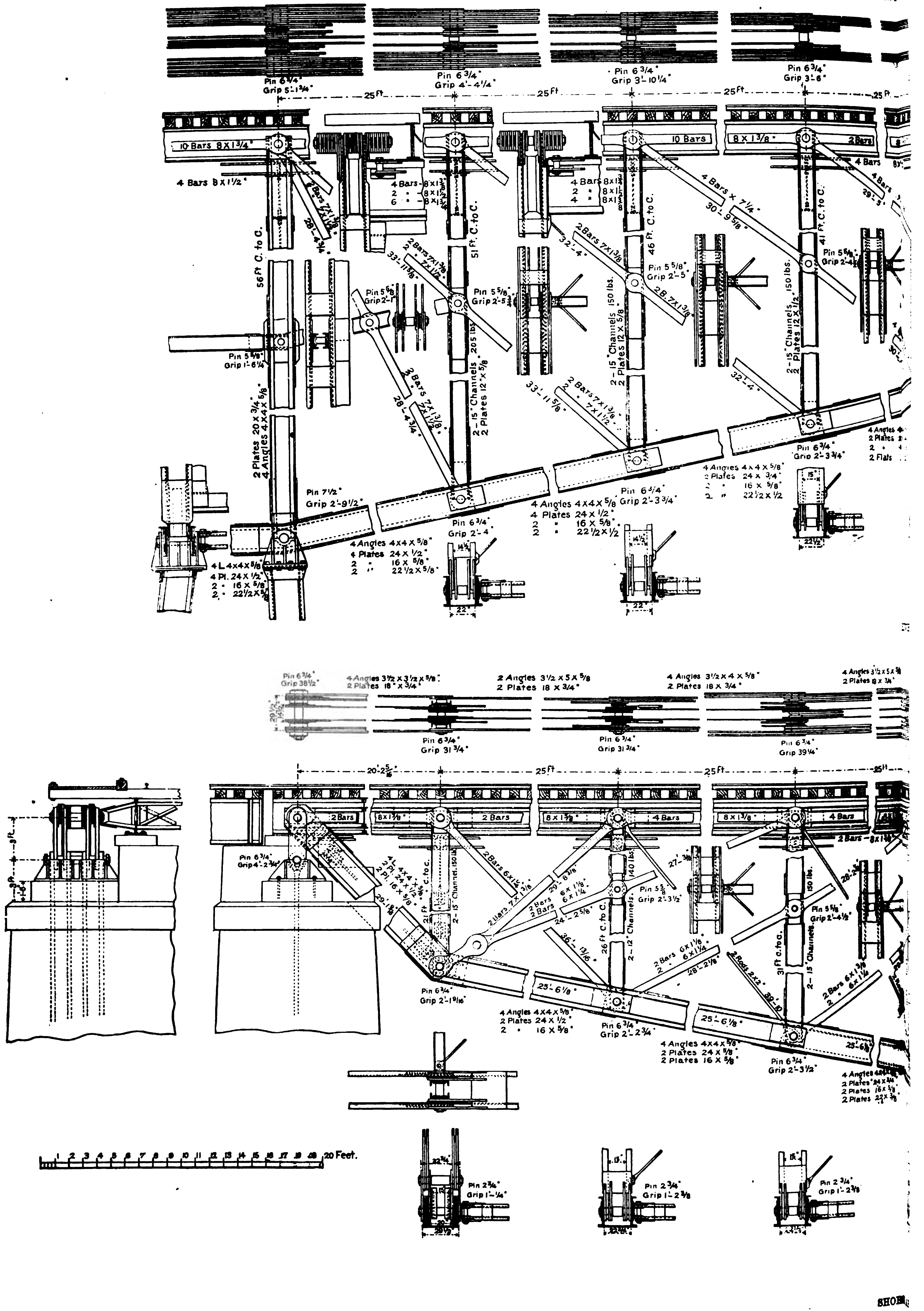

SHOE

…ANTILEVER BRIDGE

…ARA BRIDGE CO. THE CENTRAL BRIDGE CO., OF BUFFALO, CONTRACTORS.

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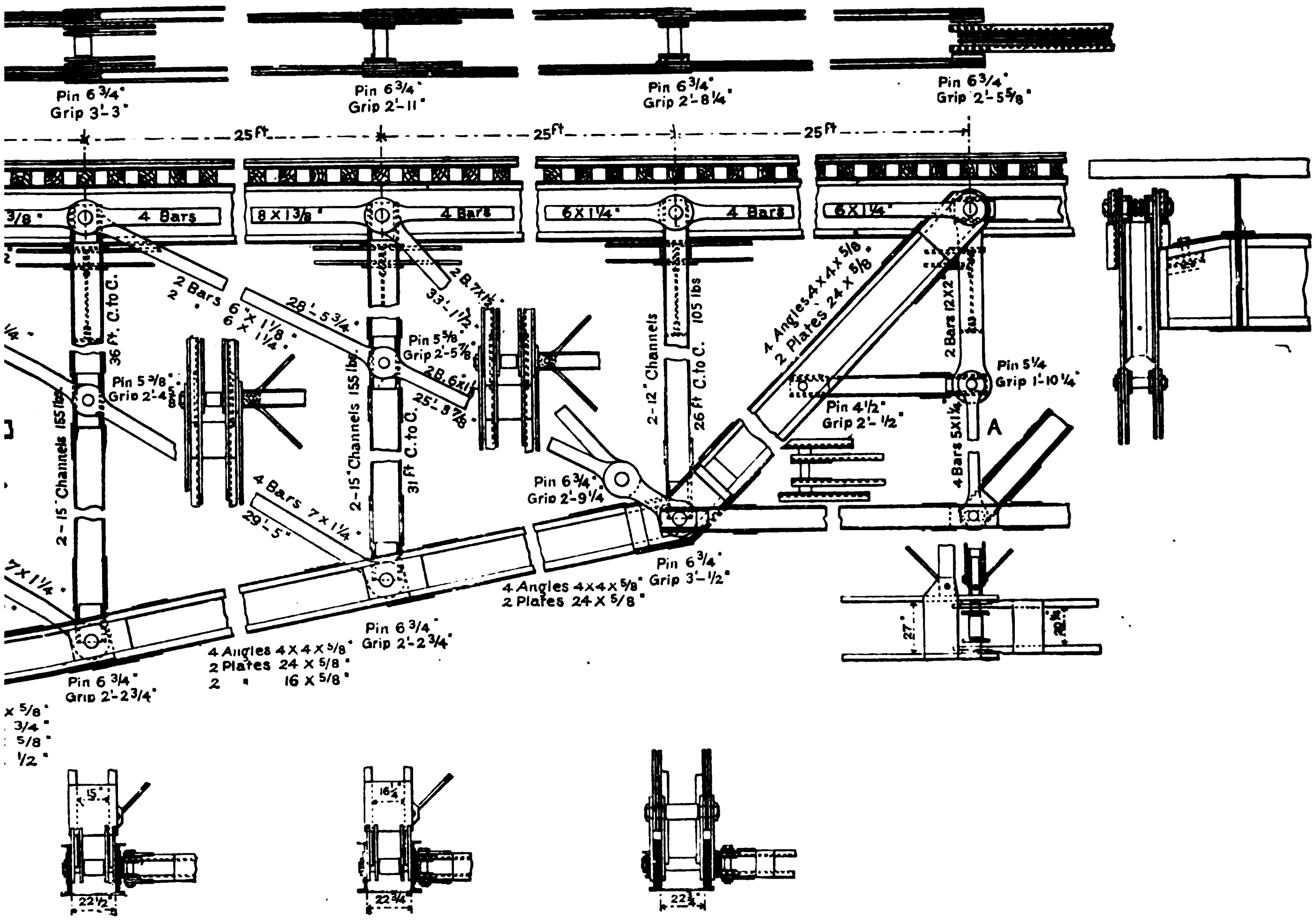
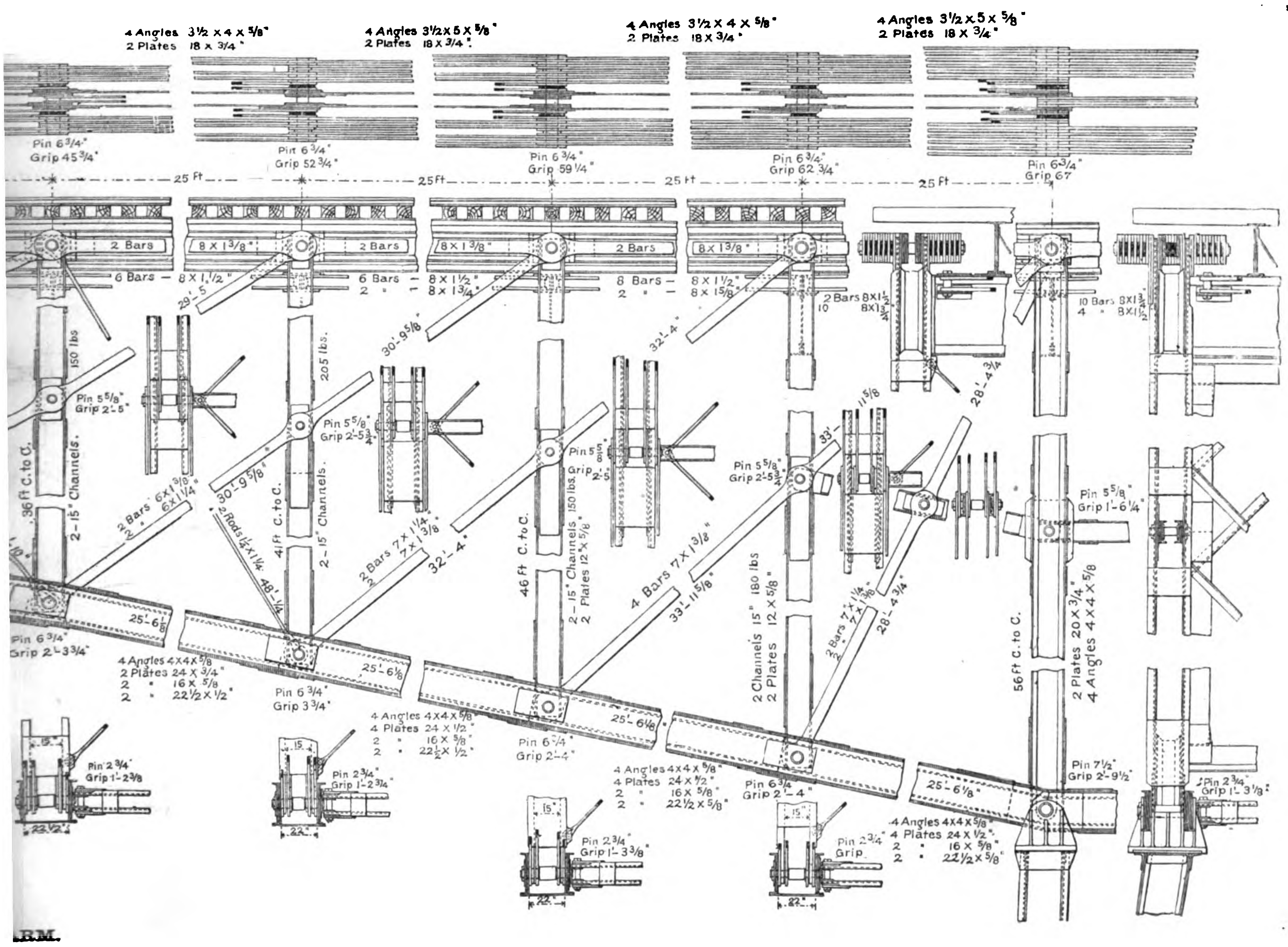


RIVER ARM.



…ARM.