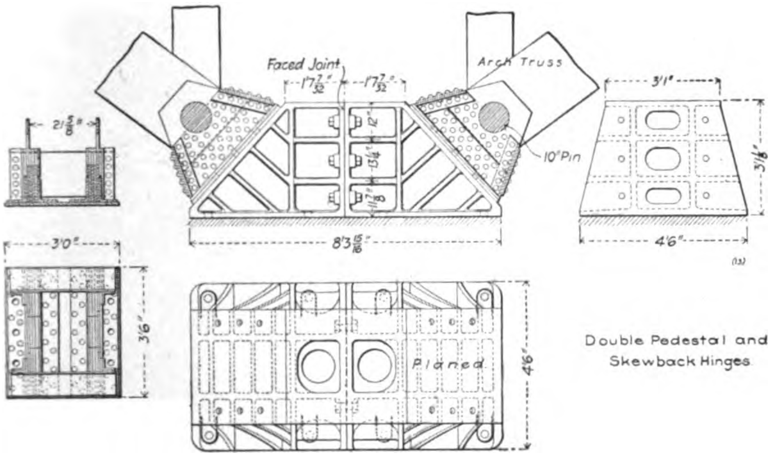
and supporting the lower chords by cross pieces and camber wedges on double lines of inclined stringers parallel to them and notched over their caps. The pile caps projected 9 feet beyond



Double Pedestal and Skewback Hinges

the upper falsework on each side, to carry the standard-gauge traveler tracks. Alternate panels of the falsework were X-braced longitudinally to make towers.

The wooden traveler had a strident two-bent tower about 84 x 50 x 72 feet in extreme dimensions. It had a clearance about 60 feet wide and 62 feet high. The tops of the braced posts were connected by and braced to combination Howe trusses 10 feet deep and 80 feet long, from which hoisting tackles could be suspended. These trusses supported a cantilever overhang 23 feet long on the rear side of the traveler, which was proportioned for a 10,000-pound load at the extremity. Guyed working platforms were cantilevered out from the outsides of the traveler posts just above the tracks. Material was delivered on top of the finished structure, and the traveler receded from it after setting the long floor-beams and stringers in place from its overhang.

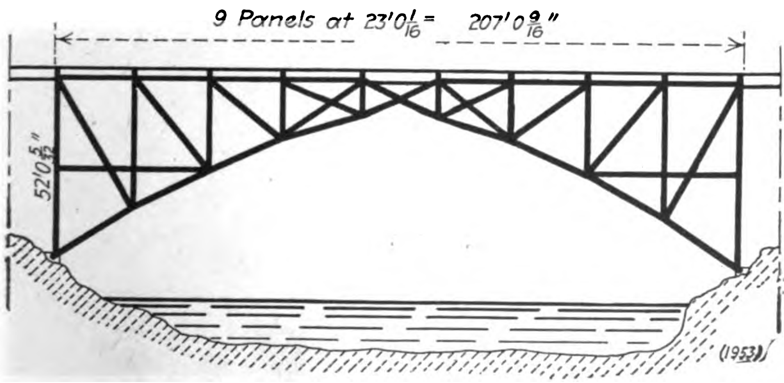
The single-track deck bridge of the Superior Division of the Chicago, Milwaukee and St. Paul Railway, across the Menominee River, near Iron Mountain, Michigan, replaces a deck Pratt truss bridge of 225-feet span which had become too light for the service. It has short plate girder approaches and a 207-foot skew three-hinge spandrel-braced main arch span, with a rise of about 46 feet, center to center cf crown, and skewback pins, and about 52 feet, center to center of top and bottom chords. The trusses are 22 feet apart on centers, and are connected by transverse

SINGLE-TRACK, 225-FOOT SPAN ACROSS MENOMINEE RIVER.

struts at lower chord panel points and at intermediate points of the two longest vertical posts, by top and bottom lateral X-bracing, and by X-bracing sway angles. The bottom struts and lateral diagonals have I-shape cross sections made of pairs of angles, back to back, latticed and riveted to horizontal connection plates on both flanges of the bottom chords. The top lateral diagonals are single angles riveted to horizontal connection plates, engaging the bottom flanges of the floorbeams and the top flanges of the top chords.

The top and bottom chords are made of built channels, latticed, and all vertical and diagonal web members are made of pairs of channels latticed, except the diagonals in the panel next the center, which are made with eye-bars. All connections are riveted, except at the crown and skewback hinges, which have $9\frac{3}{8}$-inch pins, and at the eye-bars, which have 4 5-16-inch pins. The floorbeams have their top flanges flush with the bottom flanges of the top chords, and are connected with 42 rivets in each end to the webs of the vertical posts. The stringers are seated across the floorbeams, and have their top flanges stayed with diagonal braces to the top flanges of the top chords. The top and bottom chords converge to intersect at the crown hinge pin about 6 feet below the center line of the horizontal part of the top chord. The trusses are in vertical planes, and the skewback pins are set in cast-steel pedestals with horizontal and inclined bearings on the concrete abutments, which are built on the solid granite banks of the river.

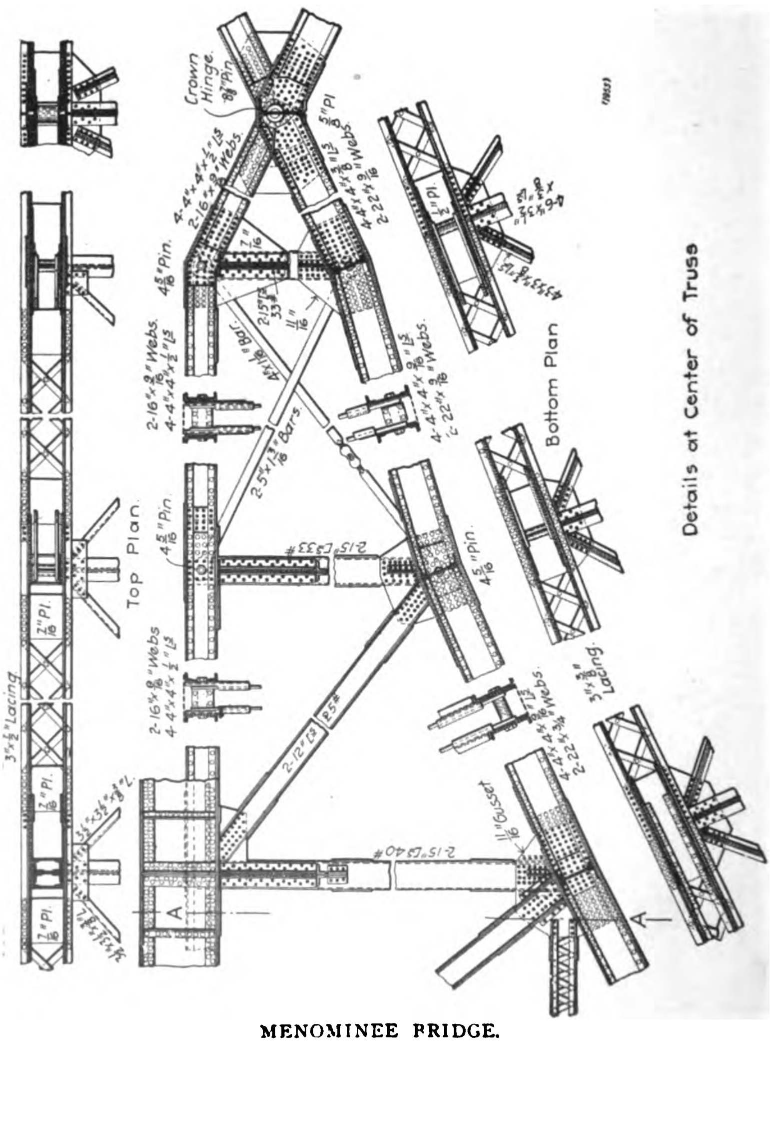
The bridge was built to Cooper's specifications of 1901, and was proportioned for a 7000-pound train load preceded by two $177\frac{1}{2}$-ton consolidation locomotives, with 25,000, 50,000 and 32,500



MENOMINEE SINGLE-TRACK BRIDGE.

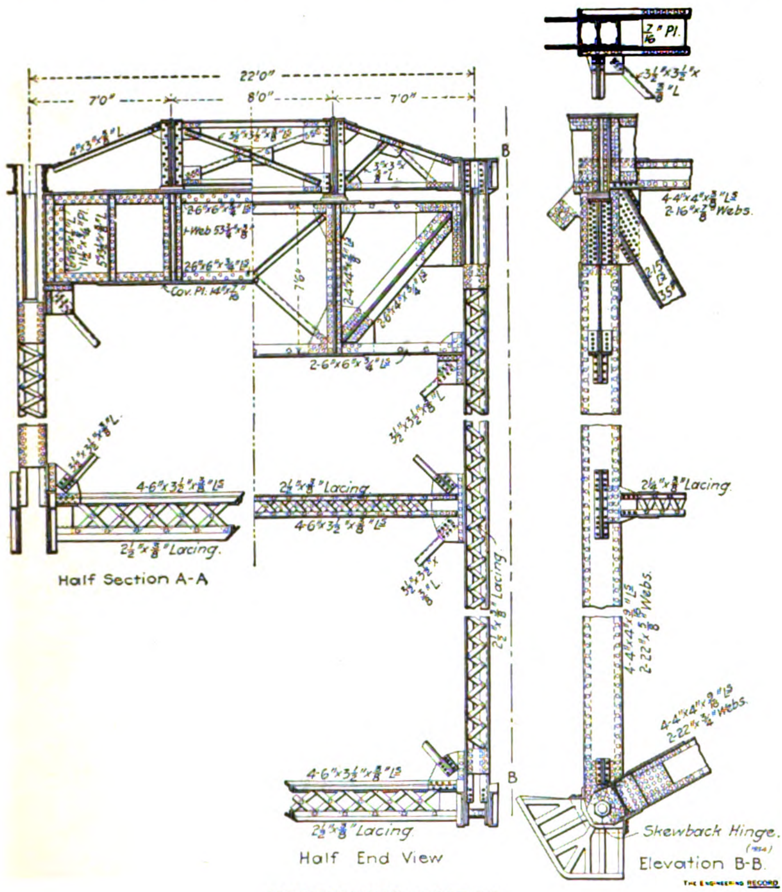
pounds loads, respectively, on each truck, driver and tender axle. It was built of medium steel, and weighed about 650,000 pounds. The heavy loading was assumed to provide for iron-ore traffic.

The first design was for the crown hinge pin in the line of the parabolic lower chord, but this gave such large reversed stresses in the web members that the lower chord curve was changed to a hyperbola, and the crown hinge pin was placed midway between the top and bottom chords, thus avoiding the large reversed stresses and securing a much lighter structure for the



MENOMINEE BRIDGE.

same strength. A third design was made for a two-hinged arch with a hyperbolic lower chord, and, as the weight was computed to be between the weights of the first two, it was abandoned in favor of the second one, which was constructed as here illustrated. The principal advantages of the adopted design are



MENOMINEE BRIDGE.

economy, simplicity of shop work and erection and the absence of ambiguity of stress in any of the members.

The bridge was built without interfering with the traffic on the 255-foot deck Pratt truss span on the same site which was built in 1885. It was erected by the cantilever method, with temporary anchorages for the semi-spans, one of which was secured to a box filled with sand, and the other to beams set in the solid rock. The anchor bars were pin-connected to the tops of the end posts through temporary web plates, which were afterward cut off. Adjustment was provided by a screw toggle near each anchor, and no difficulty whatever was experienced in making the center connection.

The single-track bridge of the Canadian Pacific Railway across the Salmon river has a 270-foot, three-hinge spandrel braced arch span and short plate girder approaches. The trusses are 60 feet $3\frac{3}{8}$ inches deep at the ends, 10 feet $6\frac{3}{8}$ inches deep at the crown and 16 feet apart at the horizontal top chords, on center lines. They are battered 1:10, so as to be 28 feet apart at skew-backs. The abutments of ashlar masonry are seated in terraces cut out of the steep hill sides about half way up, so as to carry the track at an elevation of about 123 feet above the water and give the trusses a center clearance of about 110 feet above summer water level. The trusses have a 30-foot panel at each end, a 10-foot panel each side of the crown hinge, and ten intermediate 20-foot panels.

The top chord has a rectangular trough shape cross section made throughout with a pair of 12-inch channels and a 22-inch top cover plate 5-16-inch thick at the crown and ends and 9-16-inch thick at the quarters. The bottom chords are made with two built channels, latticed on both flanges. The channels have a 24-inch web plate, a $6\frac{1}{2}$ x 4-inch top flange angle and a $4\frac{1}{2}$ x 4-inch bottom flange angle, and, except in the center four panels, are reinforced by a 13-inch web plate between the flange angles. All web members are made of pairs of built channels, latticed, with their webs transverse to the bridge axis, and are field riveted at both ends to wide gusset plates field riveted to the insides of the chord webs. The web plates of the vertical and inclined posts do not extend quite to the extremities of the members, but are cut off to clear the connection plates. The ends of the angles project beyond them to form jaws, which, in the vertical posts, engage the insides, and in the inclined posts engage the outsides of the truss connection plates so that they clear at intersections. At the ends of the trusses the longest web members are stayed at their middle points by longitudinal struts composed of a pair of 6-inch channels, latticed, which are field riveted to them at intersections and approximately bisect the angles between the top and bottom chords.

The top chords are spliced with web and cover plates in each panel. The splices are made on the side towards the center, and be 337.55 ft. long, c. to c. of piers, with a depth of 27 ft. 6 ins. at the ends and 67 ft. 6 ins. at the middle.

The bridge will be a four-track, double-deck structure, with four lines of trusses, spaced 17 ft. 8 ins. c. to c. at the sides and 18 ft. c. to c. at the middle. On the lower deck will be two tracks (in the center and one side bay), with a 6½-ft. sidewalk in the other side bay; this latter bay has vertical lateral bracing, which accounts for the narrowness of the sidewalk. On the upper deck will also be two tracks, one of which is over the sidewalk, the other side bay on this deck being closed by vertical lateral bracing. The braced bays (or transverse panels) in the two decks are thus diagonally opposite one another, as is shown by the cross-section of the channel span, in Fig. 6. In the shorter spans, the floor beams of the upper deck are placed a few feet below the top chords, and a shallow system of vertical lateral bracing is placed in one of the side bays of this deck. This is shown on the cross-section of the shorter spans, Fig. 6. The floor system consists of plate girder floor beams, with six lines of plate girder stringers under each track on the lower deck, and four lines of similar stringers under each track on the upper deck. The two tracks on the lower deck will carry the trains of the Allegheny Valley Division and also connect with the present system of surface tracks for local switching service. The two tracks on the upper deck will carry the main line trains, both passenger and freight, the bridge forming a link in the track elevation work now in progress through Pittsburg and Allegheny.

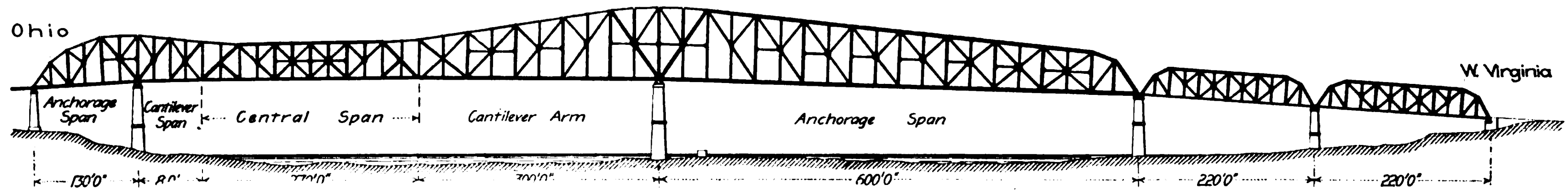


FIG. 7. UNSYMMETRICAL CANTILEVER HIGHWAY BRIDGE AT MARIETTA, O.; OHIO RIVER BRIDGE & FERRY CO.
C. L. Strobel, M. Am. Soc. C. E., Chicago, Consulting Engineer; American Bridge Co., New York, N. Y., Contractors.

The material for the trusses and lateral system, under the railway company's specifications of 1897, will be open-hearth medium steel, with an ultimate strength of 66,000 lbs. (allowing a variation of 4,000 lbs. either way), and an elastic limit not less than 55% of the ultimate strength. The allowable percentage of elongation is that obtained by dividing the ultimate strength into the constant 1,500,000; the percentage of reduction of area is obtained by dividing the ultimate strength into the constant 2,800,000. The material for the floor system will be soft steel, with an ultimate strength of 50,000 lbs., allowing a variation of 4,000 lbs. either way. The shop rivets are to be of soft steel and the field rivets of wrought iron. All rivets will be ⅞-in. diameter, except ¾-in. rivets in angles ⅜ × 3 × 3 ins. Holes in floor beams and stringers, in metal up to ½-in. thick, are punched to size; while all other holes are punched ⅛-in. smaller than the diameter of the rivet and then reamed to size. All field connections are reamed to cast-iron templets at the shop, or reamed after the parts are assembled. The live load for the floor system on each track is taken as 5,000 lbs. per lin. ft., plus a concentrated weight of 50,000 lbs.

The bridge was designed by the Engineering Department of the Pennsylvania Lines West of Pittsburg. The masonry work was done last year, the contractor being the Drake & Stratton Co., of Pittsburg, Pa. The contract for the superstructure was let to the American Bridge Co., of New York, and work on the erection has been commenced. The contract called for its completion about the end of July, 1902. The estimated weight of material in the superstructure is 6,800 tons, and the total cost of both substructure and superstructure is estimated at $1,000,000.

CANTILEVER BRIDGE OVER THE OHIO RIVER AT MARIETTA, O.

A cantilever highway bridge of peculiar design is under construction over the Ohio River at Marietta, O., by the Ohio River Bridge & Ferry Co., of which Mr. B. G. Dawes is president. The company now operates a steam ferry, and is interested in an electric railway on the south side of the river (opposite Marietta), running from the bridge site to Parkersburg, W. Va. The design, shown in Fig. 7, was prepared by Mr. C. L. Strobel, M. Am. Soc. C. E., who is the Consulting Engineer of the company, and the contract for the superstructure has been awarded to the American Bridge Co., the date for its completion being Jan. 1, 1903.

As above noted, the design is somewhat peculiar. The length of the south anchorage span is 600 ft., while that of the north anchorage span is only 130 ft. This arrangement resulted from the necessity of maintaining two navigable channels (the position of the three channel piers being fixed by the War Department), and by the fact that the south approach is a viaduct with a sharp curve, giving very little room for the anchorage span between the channel pier and the curve. The main channel span is 650 ft. c. to c. of piers, and this length is composed of a 300-ft. south cantilever arm, an 80-ft. north cantilever arm, and a 270-ft. central suspended span. The 300-ft. arm had, of course, to be made as heavy as though the span was to be 870 ft. instead of 650 ft., and the erection of this 300-ft. arm and of half the 270-ft. suspended span by projection will be the same operation as though the span was symmetrical and 870 ft. long instead of unsymmetrical and 650 ft. long. There are two lines of pin-connected trusses 28 ft. c. to c., the trusses having 30-ft. panels. The truss depth is 40 ft. at the end posts of the 600-ft. anchorage span, and 90 ft. over the middle channel pier. The clear headway at portals is 17 ft. 6 ins. The central suspended 270-ft. span is level, but the long and short anchorage spans have grades of 3% and 6%, respectively.

The width is 25 ft. 2 ins. c. to c. of railings, and includes a 4½-ft. sidewalk and a roadway, with a street railway track at one side of the latter. The floor system, Fig. 8, consists of plate girder floor beams between the truss posts, and three lines of I-beam stringers supporting subfloor beams spaced about 10 ft. c. to c. Timber stringers carry the ties for the street railway track, while the joists for the roadway are laid on cushion timbers or bolsters upon the floor beams, so as to bring the planking flush with the tops of the rails. These rails are of T-section, 4⅝ ins. high, with wooden paving blocks next to the rail. The sidewalk is carried in a similar manner, and provision is made for building a sidewalk outside the trusses at some future time, and increasing the width of the roadway between the trusses accordingly.

The live load assumed for the floor throughout and for the plate girders in the viaduct is 80 lbs. per sq. ft., or an electric railway eight-wheel car of 30 tons or a steam roller of 15 tons. For the trusses it is 60 lbs. per sq. ft. on roadway and sidewalk. The material used is open-hearth medium steel, and the estimated weight of the superstructure (including the two approach spans and the viaduct) is 2,400 tons.

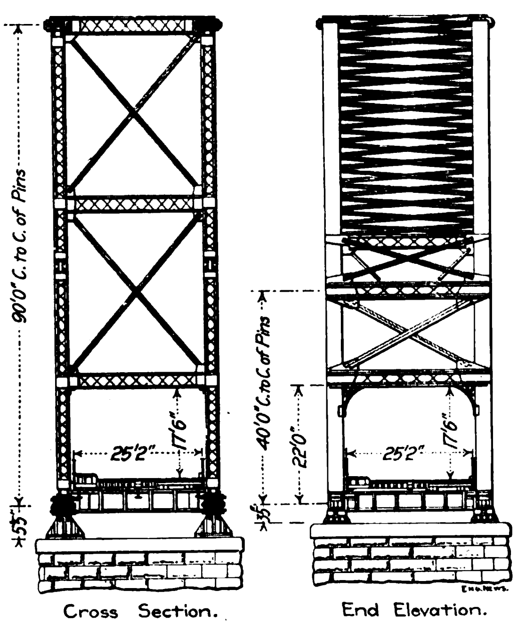


Fig. 8. Cross-Sections of Ohio River Bridge.

The approaches comprise two pin-connected through truss spans of 220 ft. each, on the south side; and a plate girder viaduct 640 ft. in length on the north or Marietta side. The piers and abutments are of stone masonry. The channel piers rest upon piles, cut off at the bed of the river; cofferdams were built around the piles, and after excavating all loose material concrete was rammed between and over the piles. The pier masonry was then built upon the concrete. The substructure work has been done by the company by day labor, under the direction of Mr. T. M. Ripley, Assoc. M. Am. Soc. C. E., Resident Engineer.

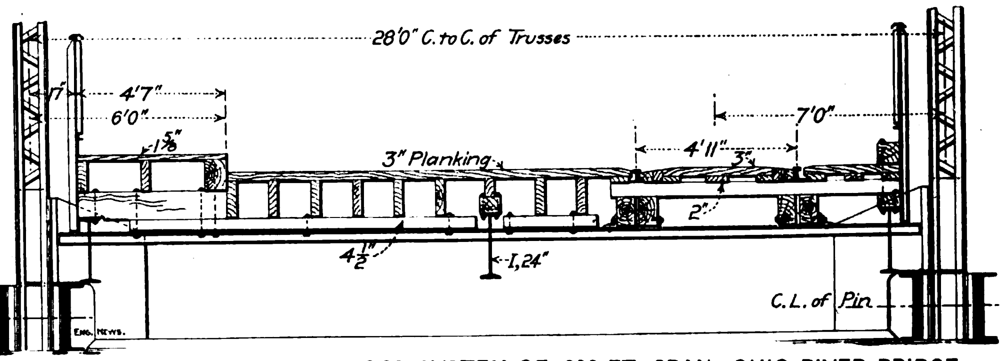


FIG. 9. CROSS-SECTION OF FLOOR SYSTEM OF 600-FT. SPAN; OHIO RIVER BRIDGE, MARIETTA, O.

THREE-HINGED STEEL ARCH BRIDGE; CHICAGO, MILWAUKEE & ST. PAUL RY.

In Fig. 9 is shown a three-hinged arch bridge of 207 ft. span now being built over the Menominee River, on the Superior Division, near Iron Mountain, Mich. This structure will replace a deck span of the Pratt type, 255 ft. long, which was built about 17 years ago, and is too light for the present traffic. The river banks are of granite, and the location was considered to present ideal conditions for an arch bridge, requiring a minimum amount of masonry. All of the substructure will be of concrete, and this is being built by the railway company's forces, as is usual for this kind of work on the C., M. & St. P. Ry., very little substructure work being done by contract.

The superstructure has been proportioned throughout generally in accordance with Cooper's specifications for railway bridges (1901 edition),

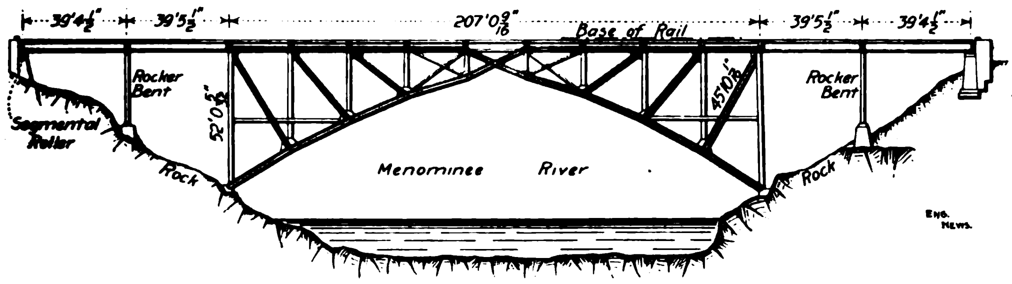


FIG. 10. THREE-HINGED STEEL ARCH BRIDGE; CHICAGO, MILWAUKEE & ST. PAUL RY.
C. F. Loweth, M. Am. Soc. C. E., Engineer and Superintendent of Bridges and Buildings; Phoenix Bridge Co., Phoenixville, Pa., Contractors.

and for a live load of two consolidation Class E-50 locomotives. For these the weights assumed by the specifications are 25,000 lbs. on each truck axle, 50,000 lbs. on each driving axle, and 32,500 lbs. on each tender axle. The distributed load or trainload behind the engines was taken

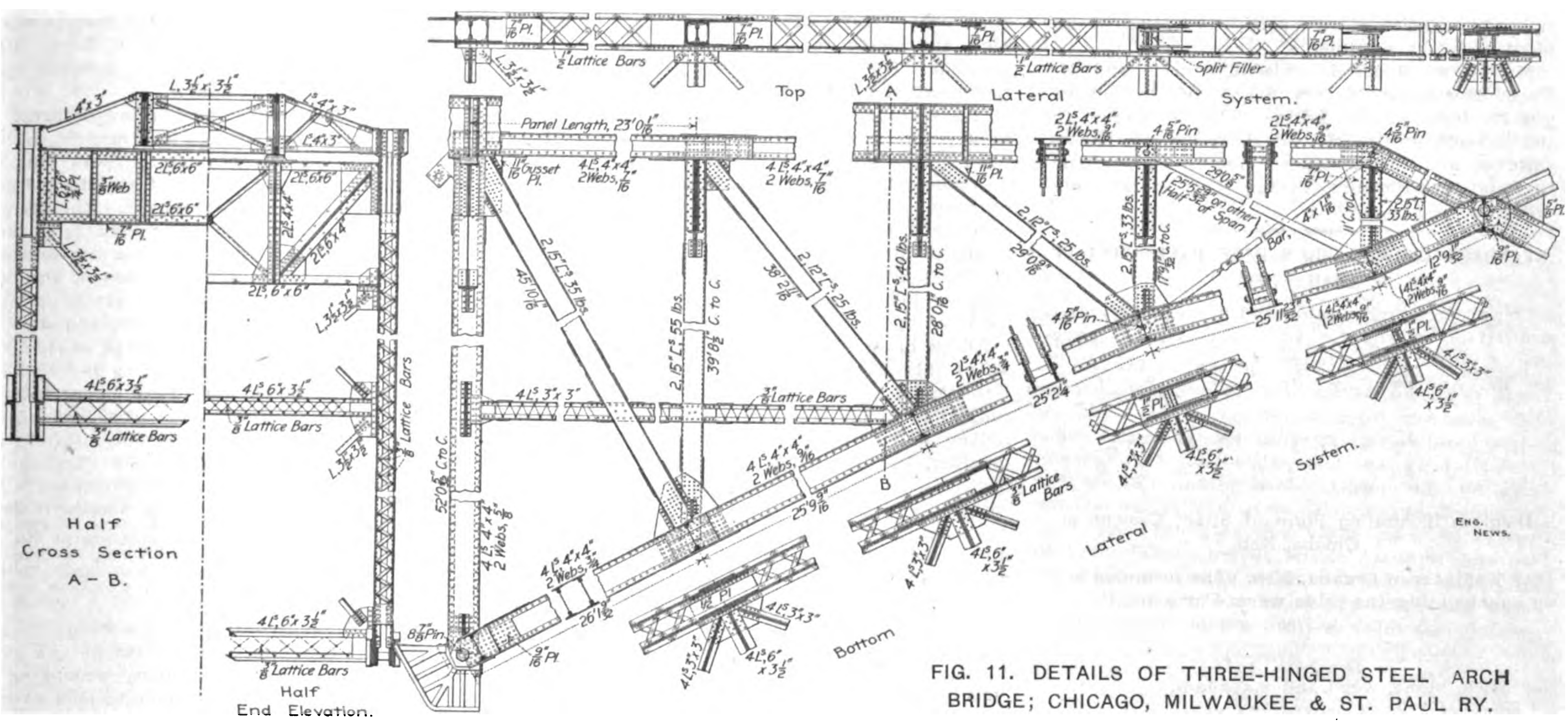


FIG. 11. DETAILS OF THREE-HINGED STEEL ARCH BRIDGE; CHICAGO, MILWAUKEE & ST. PAUL RY.

as 7,000 lbs. per lin. ft.; this unusually heavy train load being adopted in order to provide for a heavy ore traffic. The steel will be of the grade commonly known as medium steel, with a tensile strength of 60,000 to 68,000 lbs. All rivet holes will be reamed, except in the lacing and laterals. The bridge was designed in the office of and under the direction of Mr. C. F. Loweth, M. Am. Soc. C. E., Engineer and Superintendent of Bridges and Buildings, Chicago, Milwaukee & St. Paul Ry. The superstructure is being built by the Phoenix Bridge Co., of Phoenixville, Pa., and was to be ready for traffic in the early autumn.

As shown by the detail drawing, Fig. 10, the bridge has two arched deck trusses, 22 ft. c. to c. Each arch is divided into nine panels of 23 ft 1-16-in., and has a rise of about 52 ft. The hinge pins are 8⅞ ins. diameter, with cast-steel skewbacks, while the pins for the eyebar members in the middle panels are 4 5-16 ins. diameter. The chords have double webs, with outside flange angles, and top and bottom latticing. The posts and diagonals forming the web members are composed of pairs of channels, except in the middle panels, where pairs of eyebars are used. The end posts are similar to the chords, except that the flange angles are on the inside, and at the top of the post will be noted a special pin plate for the attachment of temporary anchor bars during erection. These plates will afterwards be cut off.

The floor beams are plate girders fitted between the tops of the posts, except that the end floor beams are trusses. Upon these are plate girder stringers 8 ft. apart, with lateral bracing between them, and outside struts or braces to the top chords. The total weight of metal in the main span, exclusive of approaches, will be about 240 tons.

The approach on each side consists of two plate girder spans of 39 ft. 4½ ins. and 39 ft. 5½ ins., supported by an intermediate rocker bent, and having segmental roller bearings on the abutments. The weight of metal in the approaches will be about 75 tons.

The river is crossed on the skew, and it was impossible to shift the old bridge to a new temporary location without building expensive approaches. The new bridge had therefore to be designed so as to admit of its erection while keeping the old bridge in use. These conditions limited the design in certain ways, including the panel lengths, distance between trusses, etc.

1,800-FT. CANTILEVER BRIDGE OVER THE ST. LAWRENCE RIVER AT QUEBEC, CANADA.

The longest span bridge in the world is the Quebec Bridge now under construction across the St. Lawrence River, about seven miles up stream from the city of Quebec. This bridge has a channel span of 1,800 ft., or a clear span 90 ft. longer than the main span of the great Forth Bridge in Scotland. At the present time the substructure for this bridge is about completed, and the American contractors for the superstructure, the Phoenix Bridge Co., of Phoenixville, Pa., are manufacturing the steel work for the superstructure. A fairly good notion of the size and appearance of this great structure are had from Fig. 12, which is reproduced from the "Canadian Engineer." In an early issue we shall describe the substructure of the Quebec Bridge in some detail, and later a full description of the superstructure will be published. At the present time, therefore, we shall give only the main structural features of the great work now being carried out by our Canadian neighbors.

The Quebec Bridge is being constructed over the narrowest portion of the St. Lawrence River between Montreal and Quebec, about 6½ miles west of the commercial center of the latter city. The river at this point flows between high rocky cliffs on both sides, the waterway being about 1,900 ft. at low tide, and about 2,500 ft. at extreme high tide, the tidal rise varying from a minimum of about 14 ft. to a maximum of 20 ft. The maximum depth of water in the channel is about 180 ft., the tidal current being 6 to 7 knots an hour. The depth of water decreases rapidly towards the main river piers, where at extreme low tide it is 10 ft. deep, the maximum depth at high tide being 30 ft. These piers are 1,800 ft. apart between centers.

The channel will be crossed with a suspended span and two cantilever arms, making an unsupported structure 1,800 ft. long between center of main piers, which will be the longest span in the world. The length of anchor arms on each side of the main span will be 500 ft., with one approach span of 220 ft. at each end between anchor piers and terminal abutments. The total length of the structure, including abutments, will be 3,300 ft. A clear headway of 150 ft. between

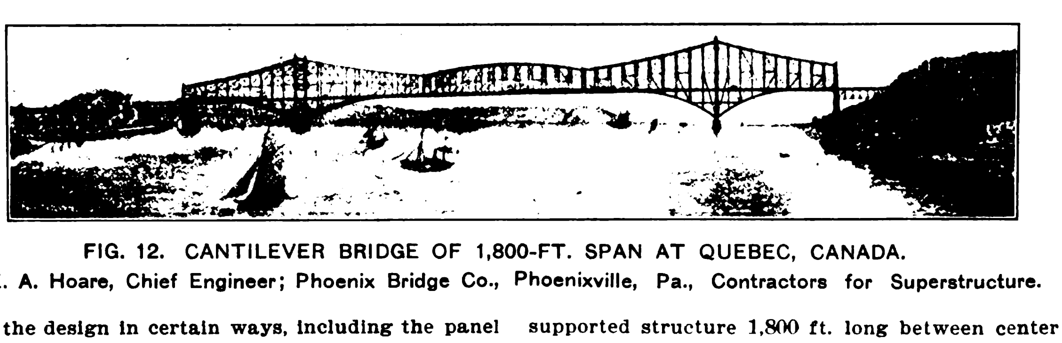


FIG. 12. CANTILEVER BRIDGE OF 1,800-FT. SPAN AT QUEBEC, CANADA.
E. A. Hoare, Chief Engineer; Phoenix Bridge Co., Phoenixville, Pa., Contractors for Superstructure.