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A Four-Truss Double-Deck Railroad Bridge.—I.

Bridge No. 1 of the eastern division of the Pittsburg, Fort Wayne and Chicago Railway crosses the Allegheny River between Pittsburg and Allegheny. It has five pin-connected through channel spans on masonry piers about 35 feet high above mean water level, and is about 975 feet long on center line between abutments of end spans. The faces of the north abutment and the sides of the four intermediate piers are parallel and make an angle of 81° 51' with the axis of the bridge. The south pier of the old bridge was remodeled and extended to serve as south abutment for the new structure and is at an angle of 91° 13' with axis of bridge. Two of the piers are 10 feet wide and about 58 feet long under the coping and the other two are 12 feet wide and about 66 feet long to provide seats for the heavier trusses of the long span.

Each span has four trusses, three of which are in the same straight lines from end to end of the bridge, and the fourth are in line for the four western spans, but divergent for the eastern span. Each of the trusses in each of the four western spans has the same length as the other three trusses of the same span but in the eastern span the lengths of the trusses from center to center of end pins vary from 164 feet 2 5/16 inches to 157 feet 10 7/16 inch. There are three spans of 156 feet ½ inch and one span of 333 feet 3⅝ inches. In these spans the centers of the trusses are 9 feet and 26 feet 8 inches from the axis of the bridge. The base of the lower rail is 6 feet 6⅞ inches, and the center of lower chord pins is 7 feet 2⅞ inches above the top of the pier masonry in the 333 feet span and 4 feet 2½ inches and 4 feet 11⅝ inches, respectively in the other spans. The bridge is cambered as a whole so as to give a continuous parabolic curve with a horizontal chord 983.96 feet long and a 12-inch center vertical ordinate to the base of rail. This is effected by varying the heights of the pier tops and making the inclined lines which connect the centers of the spans the chords of a parabolic curve. For the camber of each span the center ordinates vary from 0.16 to 0.337 feet and the ordinates between them and the rail base are made in the framing of the cross ties.

The floor is of soft steel and is designed to conform to the standard floor for the Pennsylvania Lines West of Pittsburg. The field rivets are of wrought iron, the shop rivets are of mild steel, and all the remainder of the superstructure is of medium steel designed according to the standard specifications of the railway for 1897, with the stresses increased 20 per cent. for medium steel members. In the 333-foot span the loading assumed is, for the outside trusses, 2,980 pounds dead and 3,750 pounds live per lineal foot and 37,500 pounds concentrated. For the inside trusses, 6,380 pounds dead and 7,500 pounds live per lineal foot and 75,000 pounds concentrated. Wind pressure is assumed at 50 pounds per square foot for the unloaded and 30 pounds per square foot for the loaded structure, and at 600 pounds per foot for moving load. For the floor system the load per track is assumed at 5,000 pounds per lineal foot and at 50,000 pounds concentrated and the dead load of the track at 300 pounds per lineal foot.

It was required that the bridge should carry two pairs of tracks at different fixed levels and the vertical clearance between them was too small to allow for floor beams deep enough to carry two tracks; therefore the bridge was designed with four trusses so as to secure single track floorbeams. The two vacant panels in the transverse sections have been arranged above and below and on opposite sides and are at present occupied by sway bracing, one of them being utilized for a sidewalk between the diagonals, and the other one being designed to receive a third track at the upper grade if necessary in the future. The upper deck is made according to the usual standard of the North West system with four lines of stringers to each track. In the lower floor two more lines of stringers are added for each track and the whole lower deck is covered with plank and protected by railings to permit the ready handling of trains by the yard crews.

In the 333-foot span the lower chord panels are 23 feet 9 11/16 inches long, except in the end panels, which vary on account of the skewed ends. The vertical end posts are 27½ feet high, and the center three vertical posts are 63½ feet high. The bottom chord is horizontal, and the top chord is horizontal in the center two panels and inclined elsewhere. In the center trusses the maximum top chord stress is 3,235,000 pounds and the corresponding cross sectional area is 292.5 square inches. Maximum bottom chord stress 3,064,000 pounds, section 237.5 square inches. End vertical post, 2,224,000 pounds, section 202.5 square inches. End diagonal tie, 2,427,000 pounds, section 190 square inches.

As seen by the cross section diagram each center truss carries half the load from three tracks, while each outside truss carries half the load from one track, therefore the stresses in the side trusses are much lighter than those just given. The maximum top and bottom chord stresses and sections are 1,563,000 pounds and 146 square inches and 1,469,000 pounds and 116.25 square inches respectively, and the stresses in the other members are in proportion.

The trusses are braced together by the two floor systems, one of which is just below the lower chord pin level and the other is about 17 feet in the clear above it, and by transverse girders between the tops of all vertical posts and by lateral diagonals in the planes of the top and bottom chords. There are besides solid web knee braces at both ends of all floorbeams and on both top and bottom flanges of the beams in the upper deck. On one side of the bridge the upper and on the other side of the bridge the lower outside panel of every bent between vertical posts is stiffened transversely by riveted X-braces, thus providing great resistance to lateral deformation.

The bottom laterals are flat plates ½ inch thick and from 6 to 14 inches wide. Each one is stiffened by a 5x3½x⅜-inch angle riveted to the upper side, between stringer intersections. The top laterals are single clevis ended bars from 1⅜ inches to 2 7/16 inches square. All lateral diagonals extend across three panels longitudinally and are connected to each of the four trusses, thus completely X-bracing each panel between trusses and floorbeams. The intermediate center floorbeams are proportioned for a maximum moment of 7,530,000 pounds and have a 31¾x11/16-inch web, two 6x 6x½-inch angles and three 16x½-inch plates, one full length, one 13 feet and one 10 feet long, in each flange. The outside and end floorbeams have somewhat lighter stresses and have the same depth of web and size of flange angles and plates, but are made with lighter metal.

The 26 feet 10¼-inch stringers have a maximum moment of 2,593,000 pounds and are made with a 26¾x⅜-inch web plate and two 6x6x 11/16-inch flange angles. The flange stress is 110,200 pounds and its area 14.4 square inches. The lower outside panel not occupied by a railroad track has a sidewalk with floorbeams 32½ inches deep, having 4x3½x⅜-inch flange angles. The two stringers outside the four track stringers in each of the two lower deck tracks are made with a 26¾-inch x ⅜-inch web and two 5x3½x⅜-inch flange angles. In all work it was required that all rivets were ⅞-inch in diameter, and that their holes were punched ¾-inch and reamed except where the material was ⅞-inch or more thick where they were drilled from the solid. All holes in flats were also drilled from the solid and all holes for field connections were reamed to cast iron templates.

The skew is taken up in the varying lengths of the end panels, so that the intermediate transverse members are all at right angles to the trusses and their connections to the vertical posts are central. The end floorbeams are skewed to correspond with the angle of the pier axis and the end panel stringers have varying lengths and oblique connection angles. The pedestals, shoes and bed plates are square with the trusses and skewed with the pier masonry so that the line connecting their center points forms an offset line as indicated by the end floor beam webs in the drawing of half the end elevation of the bridge.

The upper deck floor beams are only about 8 feet in the clear below the end top chord pins so that it is impossible to have portal bracing, the upper tracks are at this point half through and sway bracing is provided by the heavy solid web plate knee braces at the ends of the floor beams, by one panel of transverse X-bracing over the sidewalk and by the depth of the floorbeam connections. The elevation of the end of the span is not symmetrical about its center line beyond the outside of the center truss, B. One outside truss, D, is much heavier than the other outside truss A, and the transverse panel between trusses C and D is different from that between trusses A and B, but the variations correspond to those clearly shown in the intermediate vertical transverse sections.

The top chord pin U1 is only about 18 feet above the top of the upper deck floorbeam and there is no top lateral strut at that point. Top chord pin U2 is about 28 feet above the top of the upper deck floorbeam and the upper transverse bracing there consists of lattice girders about 7 feet deep with T shaped flanges and pairs of diagonal angles with their flanges riveted together at intersections. At U4 and 6 the bracing is similar except that the top and bottom flanges of the transverse lattice girder are replaced by light plate girders as shown in the detached detail of connections to truss. At vertical posts 3-5 and 7 there are diagonal tie connections to the post between the chord pins which are made as shown in the section at U7-L7 and the transverse upper bracing consists of light top struts with I-shaped cross sections and latticing of single 3x3-inch angles between the posts, which is made in each case as deep as the train clearance allows.

The vertical end posts of the center trusses are each made with one 48x½-inch cover plate, four 36x¾-inch web plates, eight 6x4x¾-inch flange angles and four 5x¾-inch flange reinforcement plates. The distance between the inside webs is a little greater than that between them and the outside ones, and their flange angles are riveted on opposite sides, as is shown for the top chord sections to which the end posts correspond, in a manner to make each web with its flanges resemble a Z-bar and promote the facility of shop assembling and riveting. The inner flanges are stayed by ½-inch top and bottom tie plates 51 inches long and by zigzag 5x⅜-inch lattice bars. At the pin bearings each web is reinforced by two full width ¾-inch plates on each side, giving a combined length of 13½ inches bearing for the four supports of each 9-inch pin. The ends of the post are cut to bisect the angles made with the top and bottom chords and are milled to ¼-inch clearance from the center line of the chord pin and have jaw plates merely to hold the members in position, the bearings being made with half holes exclusively.

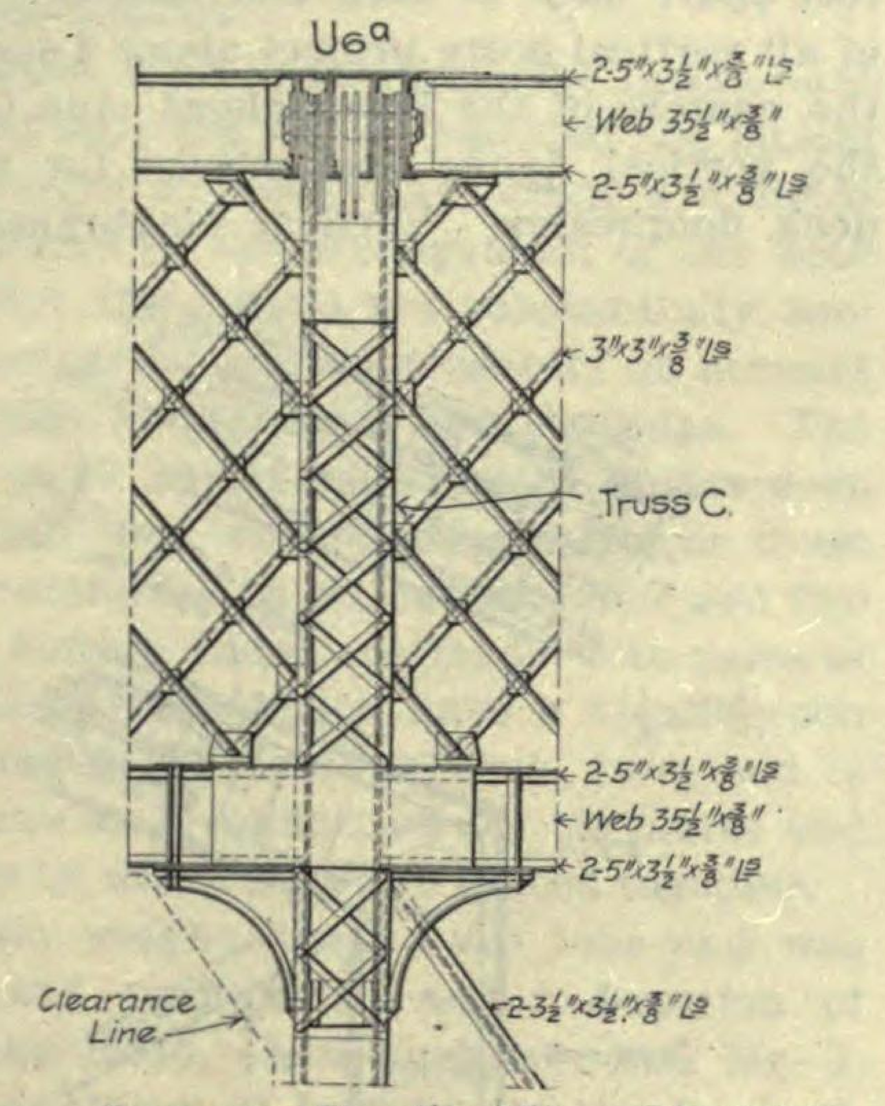
The webs are connected with horizontal diaphragm plates about 4 feet from the pin centers and by a vertical diaphragm in the plane of the center line of the chord pins which extends from the top of the upper to the bottom of the lower upper deck floorbeam knee brace. The shoe has four webs in the planes of the end post webs and of corresponding thicknesses. They are connected, as shown in the end elevation of the span, by a vertical diaphragm in the plane of the center line of the lower chord pin, and the outside webs are field-riveted to the end vertical web stiffener angles of the end floorbeam. This is seated on the edge of the base plate, which is 71 inches wide, 76½ inches long and is planed to a thickness of 1¼ inches.

At the expansion end of the truss the shoe is seated on thirteen 9-inch segmental rollers and has on each side a 11x⅜-inch vertical plate to enclose the ends of the rollers. The ends of the rollers are attached by stud bolts to pairs of horizontal bars, the upper one of which is hooked at the ends to engage the lower one and prevent the motion of the rollers beyond a fixed angle. The rollers are grooved for 3¾x⅝-inch top and bottom center guide bars and rest on fourteen ⅞-inch flat bars 4 and 5 inches wide and 71 inches long on a 71x77x1⅜-inch bed plate, which is riveted across the top flanges of ten 12-inch I-beams 10 feet 1½ inches long. These beams form a top grillage which receives the shoe for the adjacent span and is supported on two bottom grillages of I-beams at right angles to it.

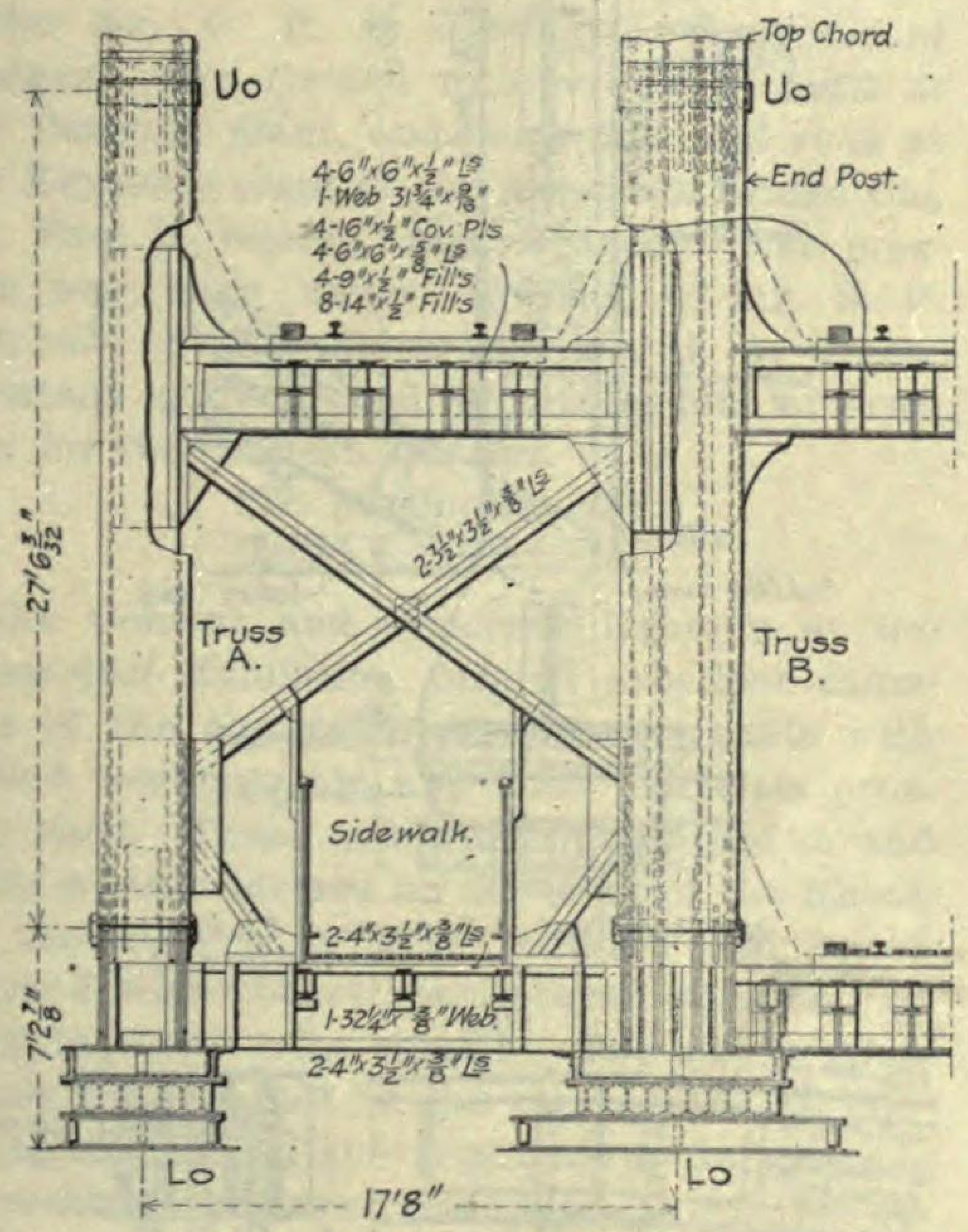
The bottom grillage has nine 12-inch I-beams 10½ feet long countersunk-riveted to 72x⅞-inch top and bottom plates 11 and 12 feet long, and has a ⅛-inch lead filler plate between the base plate and the masonry. In both grillages the spaces between the beam webs are closed by 12-inch channels across the ends of the beams with their flanges turned out, and in the same planes as the beam flanges and their webs connected to the webs of the outside beams by short vertical angles. The webs of the grillage beams are connected by a vertical transverse diaphragm on the center line, which consists of a ⅜-inch plate and two 3x3-inch angles in each space. At the fixed end of the span the shoe is the same and the arrangement is like that at the expansion end except that the nest of rollers is replaced by a third or upper grillage made similar to the lower one with nine 10-inch I-beams 5 feet long parallel to those in the bottom grillage and having a cap plate somewhat larger than the base plate of the shoe.

The end section of top chord is made in a two-panel length of nearly 53 feet, and is composed of one 48x½-inch cover plate, eight 6x4x¾-inch angles, two 36x¾-inch and two 36x13/16-inch web plates and four 5x¾-inch flange reinforcement plates, making a total sectional area of 207 square inches. The second section of top chord reaches from U2 to U4 and has its section increased 63 square inches by reinforcing the web plates, the thicknesses of the other materials remaining the same. The remainder of the top chord is made in three two-panel sections and has a uniform cross section which is increased 22½ square inches more by thickening the web plates to 4⅜ inches.

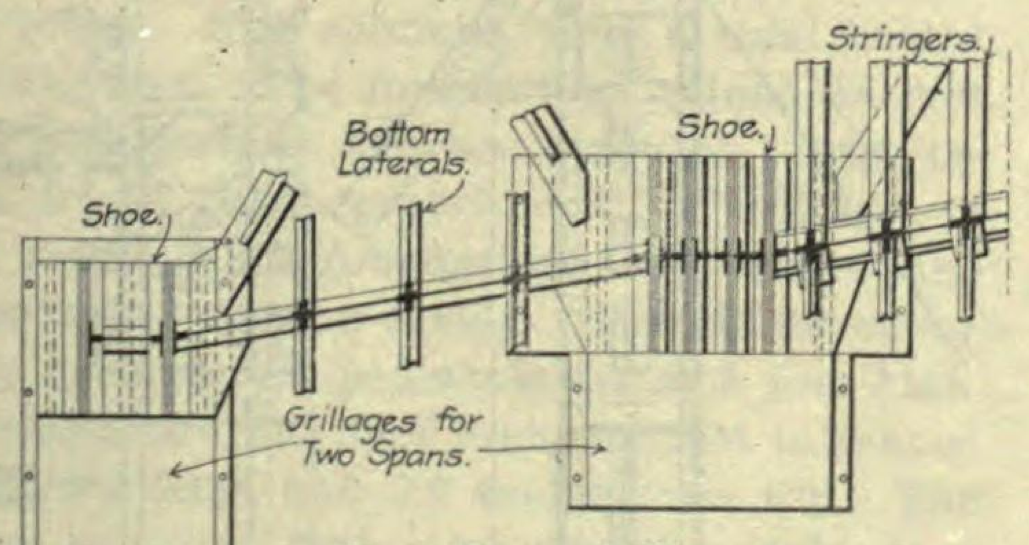
Except as noted the construction of the top chord corresponds to that described for the end post, with end transverse diaphragm plates connecting the webs and half-hole bearings for the 9-inch pins at U0-U2-U4 and U6. At each of



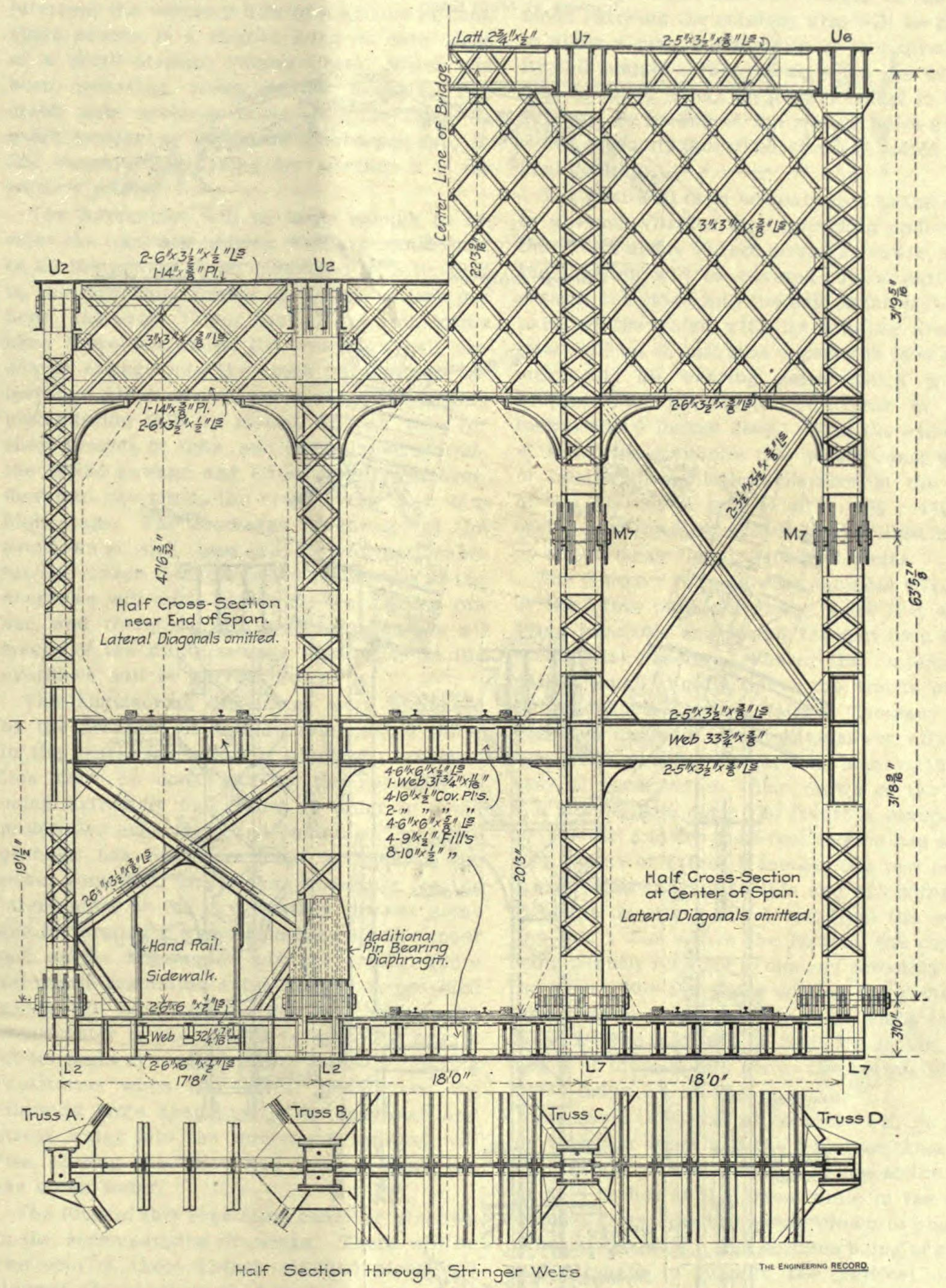
Transverse Elevation of Top of Post U6.L6. with Plate Girder Struts.



Half Elevation at Expansion End.



Half Plan at Pier.



Half Section through Stringer Webs

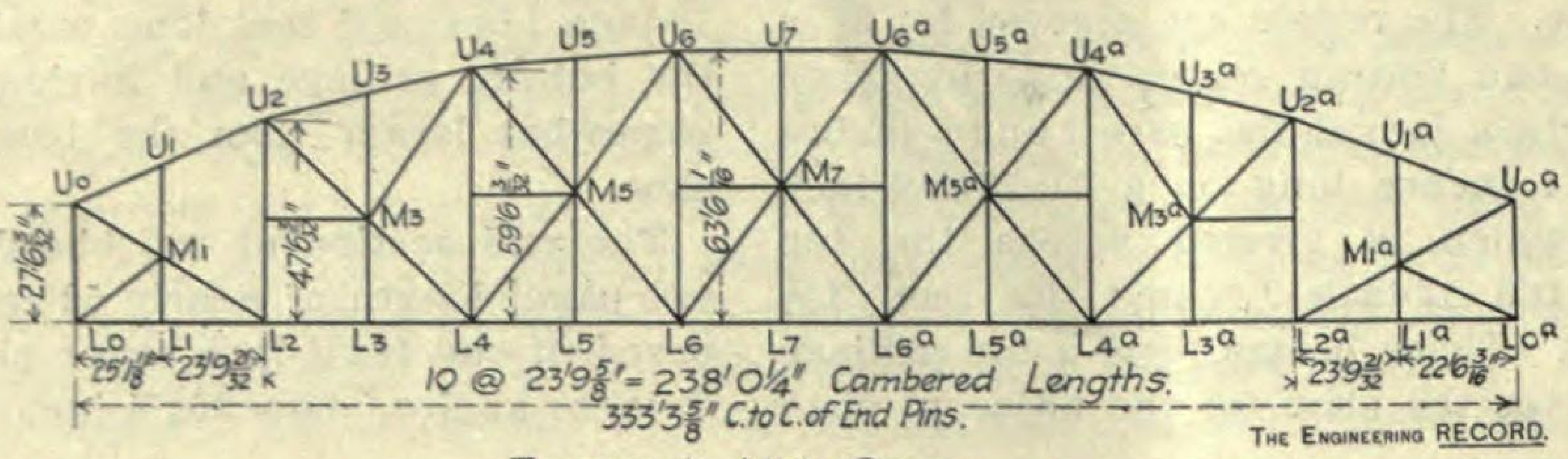
THE ENGINEERING RECORD.

DETAILS OF FORT WAYNE BRIDGE.

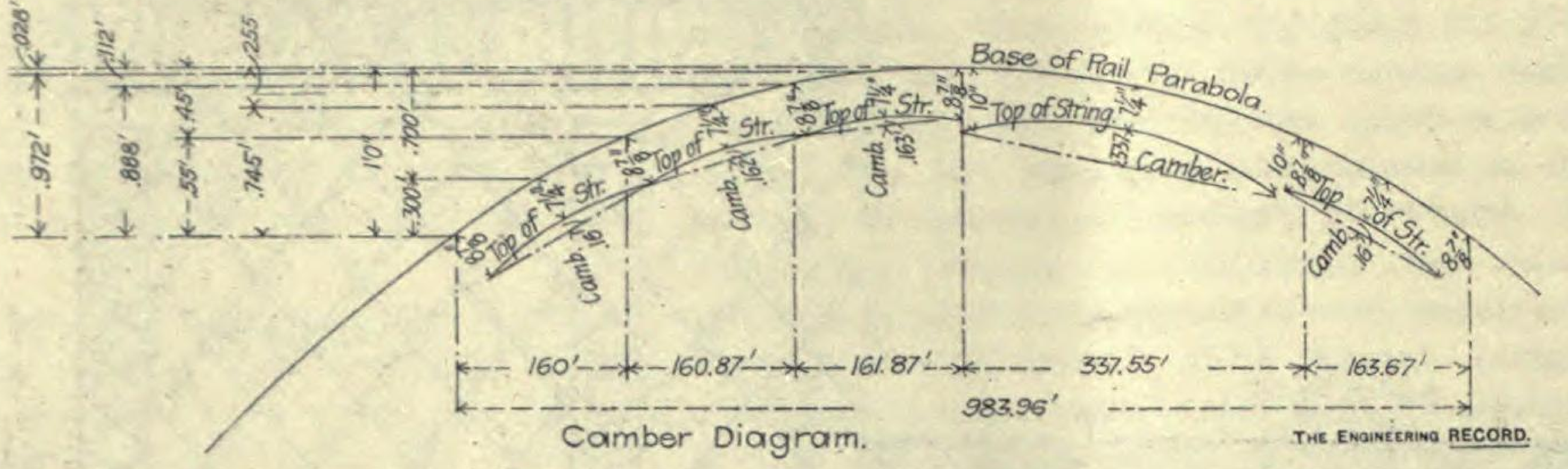
these points the inclination changes and the joint is protected by a thin splice plate over the top flange cover plates. This plate is extended beyond the flanges to serve as a connection plate for the top lateral rods and transverse bracing and at U3-U4-U5-U6 and U7 there are similar narrower plates riveted to the upper sides of the bottom flanges of the top chord angles to receive the lower flange connections of the I-shaped top lateral struts. There are no top chord pins at U3-U5 and U7 and the tops of the vertical posts are flange riveted to the lower flanges of the top chords.

The transverse strut at U2 is shallow and is not connected to the bottom flange of the top chord. All of the other transverse struts have an intermediate pair of horizontal flange angles which are connected to the lower flange of the top chord. At U4 and U6 the top lateral strut has an I-shaped upper member as deep as the top chord, and flush with it, and a rectangular lower member with top, bottom and side plates, the latter extending across the faces of the vertical posts and riveted to them. The vertical posts U2-L2, U4-L4 and U6-L6 have continuous sections from top to bottom and are made of built channels, latticed and have two 32-inch web plates and four 4x4-inch flange angles.

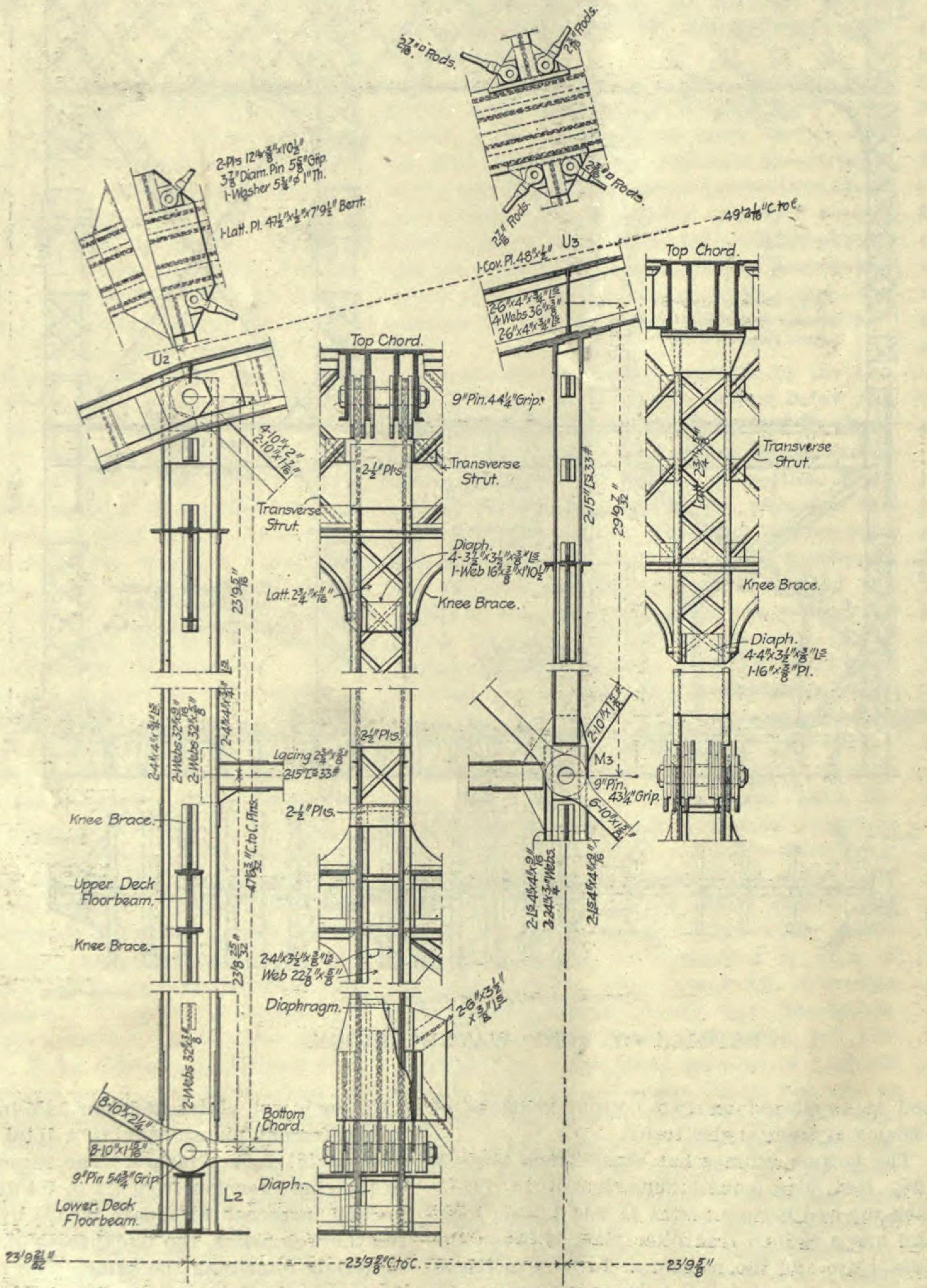
The intermediate vertical posts are made in two sections each. The lower section is similar to those at L2 L4 and L6, but the upper portions are merely struts to carry the top chords and are made of pairs of 15-inch channels about 2 feet apart back to back and latticed. The feet of all vertical posts project about 4 feet beyond the centers of the lower chord pins to receive the vertical flange connections for the lower deck floorbeams. Vertical diaphragms in the planes of the chord pins connect the post webs above and below the pins and wide horizontal connection plates are riveted to the lower ends of the posts to receive the bottom lateral diagonals. The lower ends of all the vertical posts



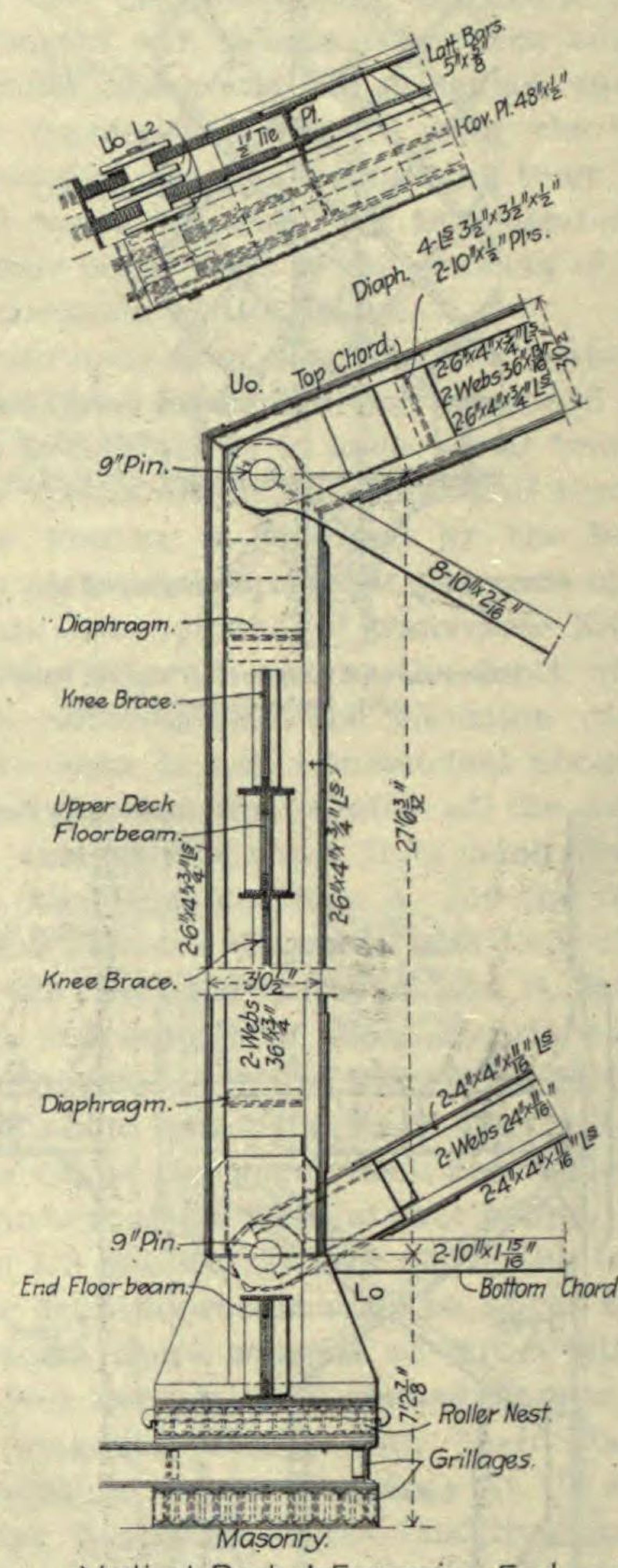
Trusses in Main Span.



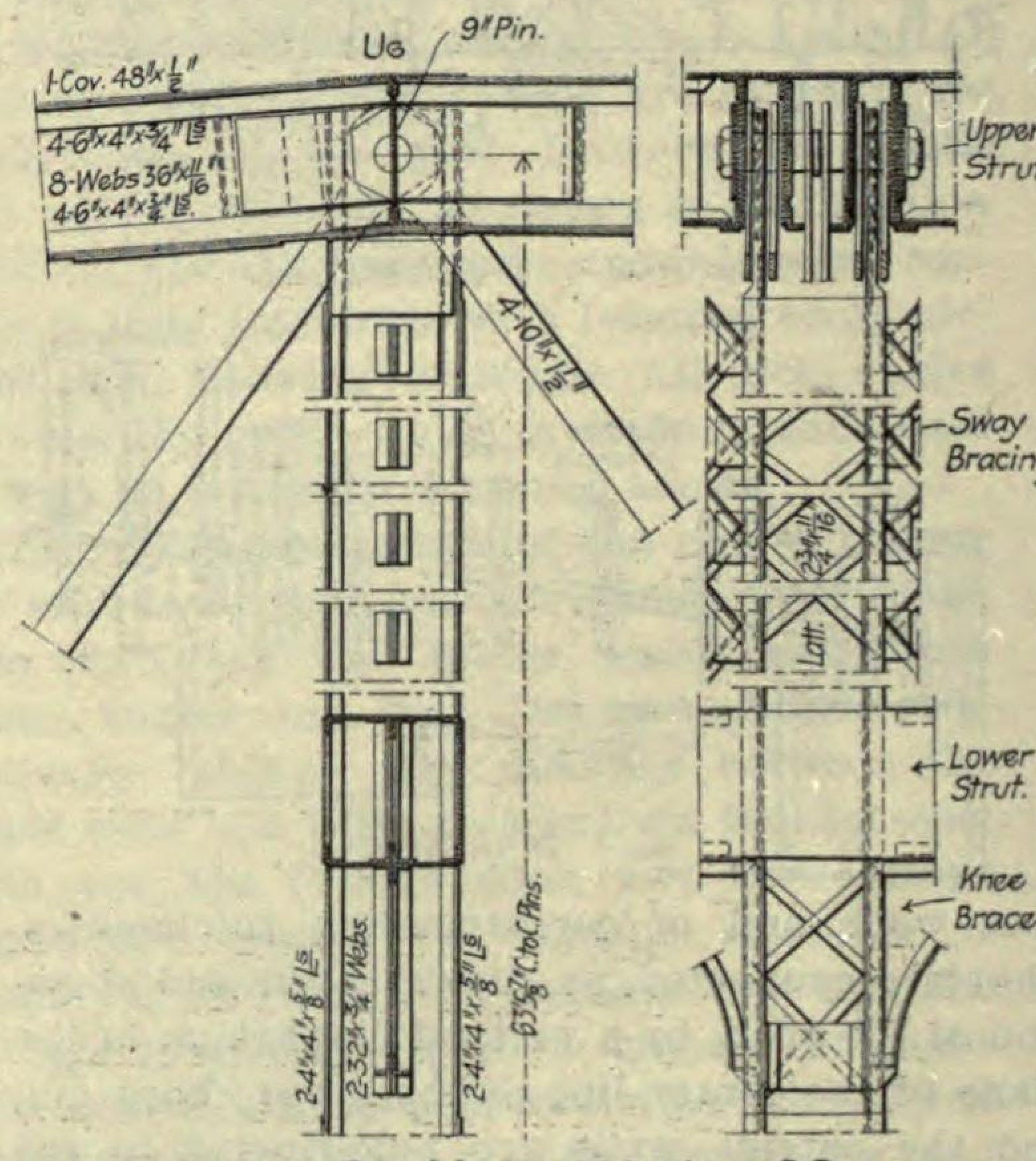
Camber Diagram.



Sway Bracing at End and at Intermediate Panel Point.



Vertical Post at Expansion End



Sway Bracing near Center of Span

DETAILS OF FORT WAYNE BRIDGE.

are similar to that of post U2-L2 except that the latter has the bottom tie plates extended to receive an additional pair of outside vertical diaphragms and there is a center diaphragm, all carried down to the pin center and reinforced with side plates so as to make, with the two main webs, five bearings for the pin. The other vertical posts have only two pin bearings each, one in each main web. All the truss pins are 9 inches in diameter and have shouldered ends with 1-inch washers and octagon nuts. Pin L7 has a 74-inch grip and carries twenty 10x2⅜-inch eyebars.

The outside trusses resemble the inside ones except that they are lighter and that the lateral and transverse member connections are different on account of the arrangement of the floor systems, but the details are substantially similar and are varied only as necessary on account of their relative functions and positions. The top chord is 36 inches wide and 36 inches deep and has only two webs, throughout, but these webs are reinforced in six panels. The end two panels of bottom chord are made with pairs of 10x1 3/16-inch bars which have a 3½x3½-inch angle riveted to the inside of each, from end to end, to serve as a connection for tie plates and lattice bars by which they are braced together.

This span weighs about 3,000 tons and was designed and constructed under direction of Mr. Thomas Rodd, chief engineer, and Mr. J. C. Bland, engineer of bridges for the Pennsylvania Lines West of Pittsburg. The inspection was performed by the railroad company's force under Mr. C. P. B. Buchanan, inspector of bridges. The riveted members were built at the Pencoyd plant, and bars, pins and rods at the Keystone plant of the American Bridge Co., Mr. Paul L. Wolfel, chief engineer. The erection was done under direction of Mr. S. P. Mitchell, chief engineer and Mr. H. A. Green, assistant engineer and superintendent of erection for the western district.

(To be Continued.)

The Cement and Concrete Exhibits at the Düsseldorf Exhibition furnish excellent examples of the admirable results obtainable with skilled workmanship and good materials properly used. These exhibits are grouped in and about a large terrace on the bank of the Rhine. At the head is a large fountain and basin, adorned with concrete sculptural work and on each flank is a lofty column. The steps, balustrades and arcades of the terrace are all concrete, and one of the neighboring buildings is a concrete structure resembling in exterior appearance some of the city halls in small German towns. The columns have a total height of 114¾ feet. The foundations extend 18 feet below the surface and are made of 1 part cement to 10 parts gravel, with a grillage of steel beams; the foundations are square and measure 42.7 feet on a side. The rather elaborately ornamented pedestals are 40.3 feet high. The shafts are 52.1 feet high, 7.4 feet in diameter at the base and 6.2 feet at the top. The bottom portion, with ornamental reliefs, is a ring of rammed 1:5 concrete while above the work is a succession of rings of similar concrete with a 1:2 plain mortar facing; the rings are about 3.2 feet high, and each has six vertical and three horizontal steel rods as reinforcement. The shaft has an ornamental capital with a metal dome surmounted by a large concrete figure. Another special feature of the exhibits is a 1:4:4 concrete bridge of 98.4 feet span, and but 6.56 feet rise. The arch is 2.3 feet thick at the springing and 2.13 feet at the crown, and showed no appreciable deflection under a load of over 90 pounds per square foot.

A Concrete-Steel Sewer.

A contract was awarded a short time ago by the Board of Public Works of Harrisburg, Pa., for the construction of a concrete-steel sewer, which is among the most interesting works of the kind recently designed. The plans and specifications for the work were prepared by Mr. James H. Fuertes, M. Am. Soc. C. E., consulting engineer to the Board, and the construction will be under his general supervision. In a general way the problem was the design of a sewer to intercept the ordinary flow of a system of combined sewers in a district lying on both sides of a small stream, Paxton Creek, which has been receiving these liquids directly. The creek now receives about twenty times as much sewage as should be discharged into it, and consequently during dry weather it is extremely offensive.

The interceptor will be large enough to receive the total flow, during ordinary rainstorms, of all the sewers to be connected with it; that is, the flow from storms of ¼-inch or less per hour. As about 95 per cent. of the rainstorms have these low rates, the overflows will discharge sewage into the creek only at rare intervals. About twenty per cent. of the annual precipitation falls in storms of high rate for short periods of time, and during such storms, the mixed sewage and street water will overflow into the creek, the creek being then at a high stage. The discharge of sewage at the overflows at such times will be unobjectionable for the reason that the heavy discharges at the overflows will cease before the creek floods run out, and therefore as the creek subsides all traces of the dilute sewage discharged at the overflows will be carried away.

The engineering difficulties were increased by the presence of considerable ground water in the gravel formation in which the construction must be done, and by the necessity of using extremely flat grades in order to avoid prohibitive excavation and pumping. The grade problem has been overcome by making the sewer somewhat larger than necessary for the interception of the dry weather sewage alone and by forming a connection between the upper end of the interceptor and the creek, where automatic regulating gates have been provided which will admit during dry weather enough creek water to the conduit to keep the flow in all its parts at a self-flushing velocity. During rainstorms when the lateral sewers are discharging large quantities of both sewage and street water into the interceptor, a float will rise, closing the valve and thus shutting out the creek water.

The form of this regulating chamber is shown in the accompanying drawings. There will be two sets of three 12-inch vitrified pipes laid through the concrete head wall to serve as inlets for the creek water, one set 4 feet higher than the other. Before entering the regulating chamber proper the water will pass through a large rectangular silt basin in order to allow as little suspended matter as possible to get into the sewer. This silt basin in largest internal dimensions will be 20x8 feet and 12 feet deep. A grating of steel bars spaced 1¼ inches apart will prevent large floating articles from entering the inner chamber. After being roughly screened in this manner, the water will pass through the rectangular cast iron orifice tube into the regulating chamber proper.

The valve regulating the quantity of creek water allowed to enter the sewer is in general principle the usual form adopted for such purposes, the opening of the valve being automatically controlled by a galvanized iron float. As the float rises the rotating valve closes. The chief difficulty with such valves heretofore has been in getting the valve to slide smoothly and accurately on its seat, some very careful adjustment and machining being usually necessary to accomplish this. In the design here adopted a great deal of this is avoided. The rotating arm will be attached to the concrete wall of the float well by means of a short length of angle iron, the holes through which it is bolted to the latter being slotted so as to permit a vertical adjustment. The horizontal leg of this angle, and the flanges of the trunnions carrying the rotating arm will be slotted to allow a play horizontally in two directions. By this simple arrangement, when the valve is first installed it can be loosely bolted in place, adjusted by means of the slotted holes until it works perfectly, and then securely bolted to its final position.

The float well is to be connected to the sewer by a 4-inch vitrified pipe extending underneath the invert about 10 feet down the sewer, where the opening will be covered by a cast iron grating cemented into the bell of the pipe. All parts of the valve with its rotating arm and lever will be of cast iron except the face of the valve and all wearing parts, which will be bronze. The galvanized iron float is 11x24 inches and 9 inches deep. With the exception of the brick manholes this whole construction of inlet and regulating chamber at the head of the interceptor will be of 1 : 2½ : 4½ concrete, reinforced as shown in the illustrations by 3-inch mesh No. 10 expanded metal.

The contract for this work includes 6,780 feet of the 5-foot parabolic sewer, 7,635 feet of the 4-foot parabolic sewer and 385 feet of a 5-foot rectangular section where the interceptor passes longitudinally under the tracks of the Philadelphia & Reading Railway Company. The design of the main intercepting sewer, although somewhat unusual in section, is nevertheless easy of construction. The crown of the arch is a simple parabola. The invert is rounded in the middle, and for the 5-foot section has an inside radius of 2 feet 6 inches, the rest of the invert being tangent to this and extending out to points on either side 3 feet from the center line and 1 foot above the bottom, the corners being slightly rounded to connect smoothly with the arch. For the 4-foot section the radius of the invert is 2 feet and the total width to the ends of the tangents, 4 feet 9.4 inches, the height of these points above the bottom of the invert being 9.4 inches.

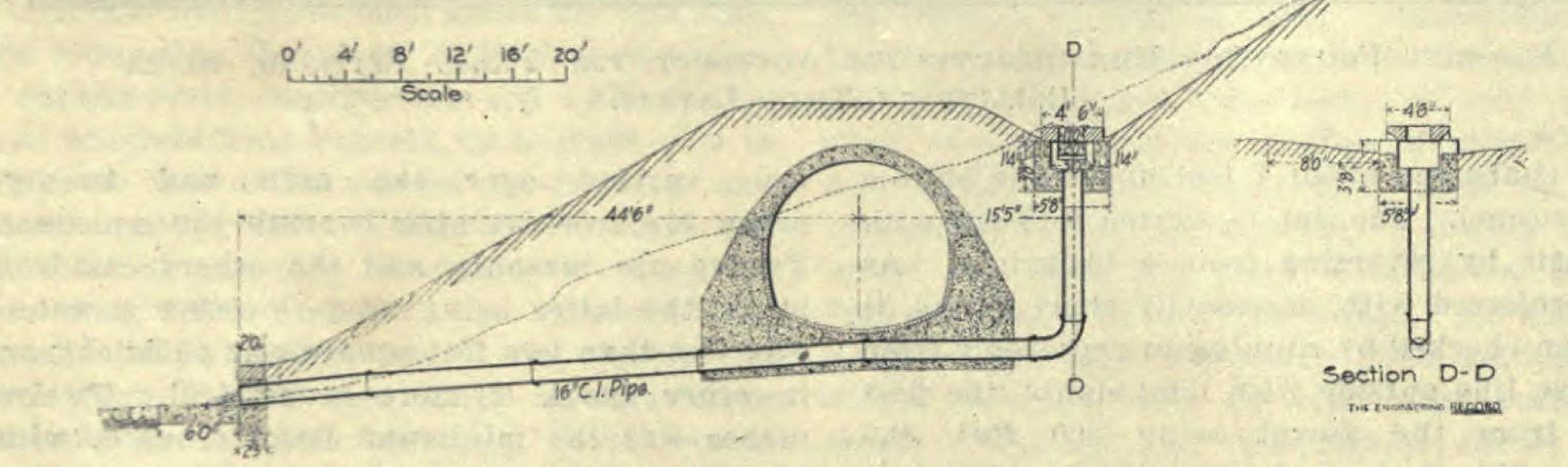
The same thickness of concrete will be used for both the 4-foot and the 5-foot sections. In the invert it increases from 5 inches at the center to 6 inches at the sides, while in the arch it varies from 5 inches at the crown to about 9 inches at the base. The sections being of abundant strength to support the vertical loads which will come upon the sewers, it was not considered necessary to place the expanded metal along the exact lines of greatest tension. It may be stated that throughout the designs, the use of expanded metal was so arranged that there would be no waste—either whole or half sheets being used in all cases. An interesting peculiarity in regard to the section adopted for this sewer is the fact that it will give practically the same discharge as a circular sewer of the corresponding diameter. More exactly stated, the 5-foot parabolic section running full will discharge 54 cubic feet per second, while a 5-foot circular sewer of the same material under the same conditions of grade would discharge about 3.7 per cent. more, or 56 cubic feet per second.

Where the interceptor passes under the tracks of the Philadelphia & Reading Railway, for a distance of 385 feet, a rectangular section

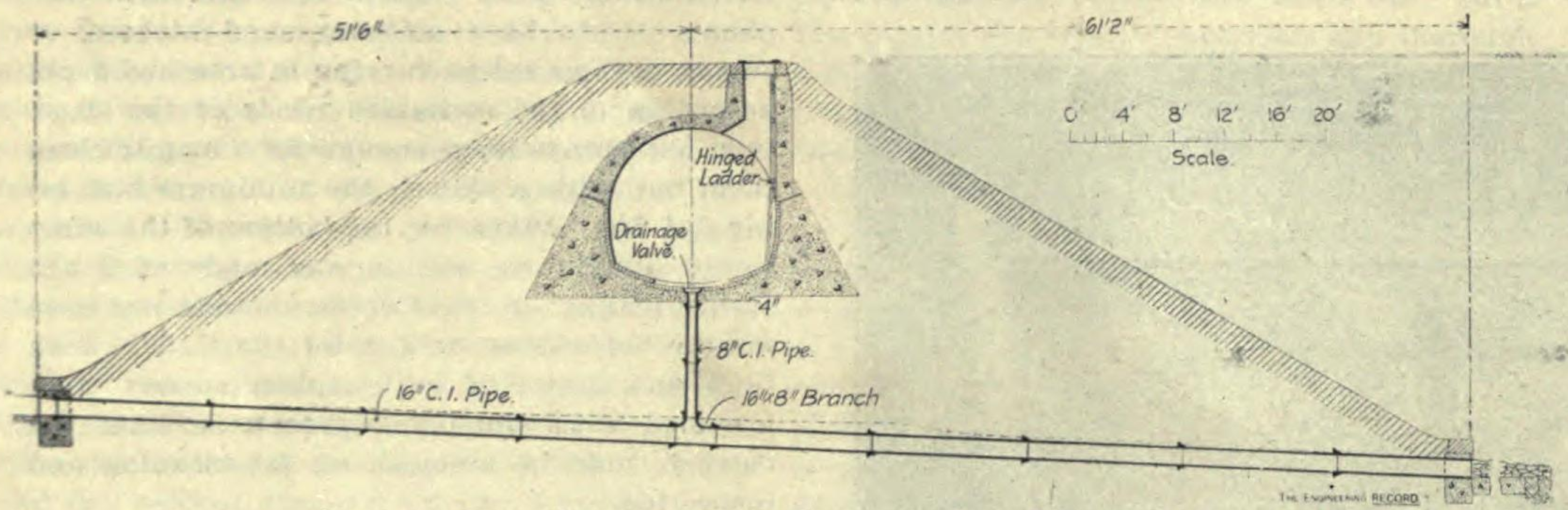
Pipe culverts were usually laid on a straight line from end to end, but wherever this was not feasible the change of direction was, with one or two exceptions, reduced to one vertical curve made by means of a standard special casting. In all cases the pipes were laid in trenches cut below the original surface of the earth. Where the aqueduct is in excavation this generally permitted the culvert to be placed very close to the bottom of the aqueduct and in many cases the pipe was partially or wholly included in the masonry of the aqueduct bottom. Where the aqueduct is on embankment the culvert is sometimes a considerable distance below the bottom of the aqueduct, and, if blow-offs occurred in such positions, the connection from the blow-off valve to the culvert was made with a vertical cast iron pipe composed of short lengths, with bell and spigot joints, arranged to allow for a slight settlement. In one place where the aqueduct is built partly in excavation and partly on embankment, along the side of a very steep hill, the inlet to a pipe culvert is a vertical pipe 13 feet high, the water dropping through this pipe to a nearly horizontal pipe passing beneath the aqueduct. Typical masonry culverts were illustrated in The Engineering Record for May 4, 1901; two of the accompanying drawings show the pipe culverts.

At 13 free-draining culverts under the aqueduct, connecting with suitable water courses, blow-off valves were set in the bottom of the aqueduct to aid in draining out ground water during construction and removing dirty water during the periodic washings of the aqueduct after it shall have been put into service. In one part of the line where there was an unusually long distance between two culverts, a blow-off was provided although there was no water course into which it could discharge. Advantage was taken of a large gravel pit to turn the discharge into the permeable material, through which it could drain away, without detriment to anyone, reaching finally a lower and somewhat distant brook. Although several large brooks cross the line of the aqueduct, at only one or two of them will it be practicable to discharge such considerable quantities of water as would be of material assistance in emptying a portion of the aqueduct, and even then the water would have to be let out with great care in order not to flood or otherwise injure private property. These blow-off or drainage valves have a clear opening of 8 inches diameter, and consist of a pipe casting on the top of which is a bronze seat ring for the disk, which is raised about 2½ inches, when the valve is opened, by a screw with a pilot point, operated by a wrench from above. Each valve is set in a small depression formed in the invert so that no part of the valve except the top of the screw projects above. At each blow-off is a manhole fitted with a hinged ladder, the lower part of which can be held in a horizontal position so as to serve as a platform from the end of which a man can reach the valve with a long wrench. The arrangement of manhole, valve and ladder is shown in one of the illustrations.

Where the first inverted siphon crosses the Sudbury River, however, it will be feasible to discharge large quantities of water, and so at this place two 16-inch blow-off pipes will be connected to the steel pipe now being laid and provision made for similar blow-offs from the other two pipes to be laid in the future. In the second, or Happy Hollow, siphon 10-inch blow-offs will be provided, but these will have to discharge through a pipe line 854 feet long and a ditch about 1,800 feet long, the water finally reaching the Sudbury River. The gradient of the lower portion of the aqueduct being so flat, the level of high water in the Weston Reservoir reaches nearly eight miles upstream from the channel chamber, or to a point 9,812 feet upstream from the Sudbury River siphon and just above the beginning of the 13-foot aqueduct at the railroad crossing. This condition of course complicates the problem of emptying the aqueduct.



SPECIAL PIPE CULVERT.



TYPICAL PIPE CULVERT, WITH BLOW-OFF AND MANHOLE.

The manholes mentioned above were placed not only at each blow-off, but also at such intermediate points as to make the distance between two manholes usually about a quarter of a mile. Each manhole has a granite coping and is provided with a steel cover locked down with one of the waterworks standard padlocks. The padlock is arranged to hang under the cover so as to be accessible to the man inside seeking to get out, but is fitted with a short chain so that it can be drawn up through a slot in the cover and unlocked from the outside. By this arrangement also the locks are less exposed. The ladder folds up out of the waterway when not in use. The lower, or hinged, part is provided with counterweights hung on "giant metal" chains, so as to move easily, and is so arranged that it can be reached and operated from either the inside or the outside.

At Station 17, on the 10-foot diameter aqueduct, and at Station 214, on the 13-foot 2-inch diameter aqueduct, are gauging manholes, to be covered with neat masonry superstructures and fitted with guide boards and other appliances for the convenient use of current meters, for making measurements of the flows in the aqueduct.

To aid in determining locations inside the aqueduct during inspection and cleaning, after the aqueduct is in service, white glazed tiles 2¼x4 inches and ½ inch thick, with black figures and letters, are being placed in the side wall at the springing line, at every 100-foot station and wherever highways cross over or culverts are built under the aqueduct. Tiles of this description were set in the Wachusett Aqueduct and have been found satisfactory in four or five years of service.

(To be continued.)

A Four-Truss Double-Deck Railroad Bridge.—II.

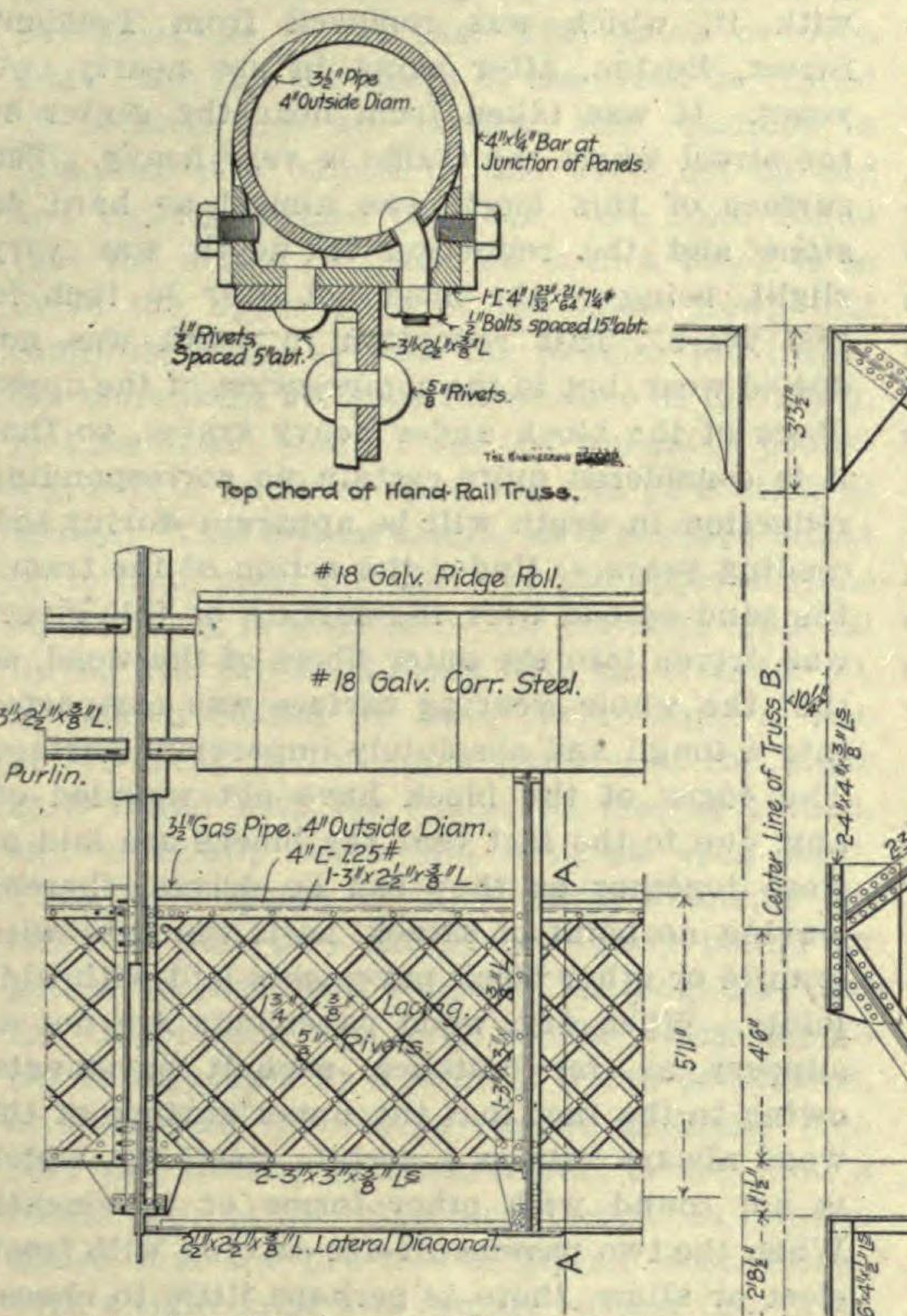
The three western spans of bridge No. 1 of the Pittsburg, Fort Wayne & Chicago Railway across the Allegheny River between Pittsburg and Allegheny are duplicates, each 156 feet ½ inch long from center to center of end pins. Each has four trusses and carries four tracks arranged the same as those of the 333-foot span which was described in The Engineering Record of October 11. The design of trusses, details of members and connections differ from those of the long span, but the floor system is the same and is continuous with that, and the specifications are the same. The loading assumed was the same except that the dead loads for the center and outside trusses were taken at 4,000 and 1,830 pounds per lineal foot respectively. The superstructure was made of open hearth steel, having a ductility so great that a punched hole 1½ inches from the sheared edge of a plate could be drifted to a 50 per cent. greater diameter without cracking. Soft steel in the floor had an ultimate unit strength of 58,000 plus or minus 4,000 pounds. Medium steel for the rest of the superstructure had a unit strength of 66,000 plus or minus 4,000 pounds: rivet steel, 54,000 plus or minus 4,000 pounds. The minimum elastic limit was 55 per cent. of the ultimate strength. The percentage of elongation in 8 inches was required to be 1,500,000 ÷ ultimate strength. The percentage of reduction of area at the point of fracture was 2,800,000 ÷ ultimate strength. Full size test eyebars were required to break in the body; to stretch 12 per cent. in a gauged length of 10 feet; and to show a minimum ultimate strength of 62,000 pounds—9,000x(area ÷ perimeter).

All pins as well as eyebars and other forgings were annealed. Up to a diameter of 7 inches the pins were rolled and all pins were allowed 1/32-inch clearance and their holes were required to be bored within 1/32 inch of the required position. The end vertical connection flange angles for all stringers and floorbeams were fitted within 1/16 inch of exact position and then milled. All splice rivet holes in chord pieces were reamed while the pieces were bolted together in the shops in four or more sections.

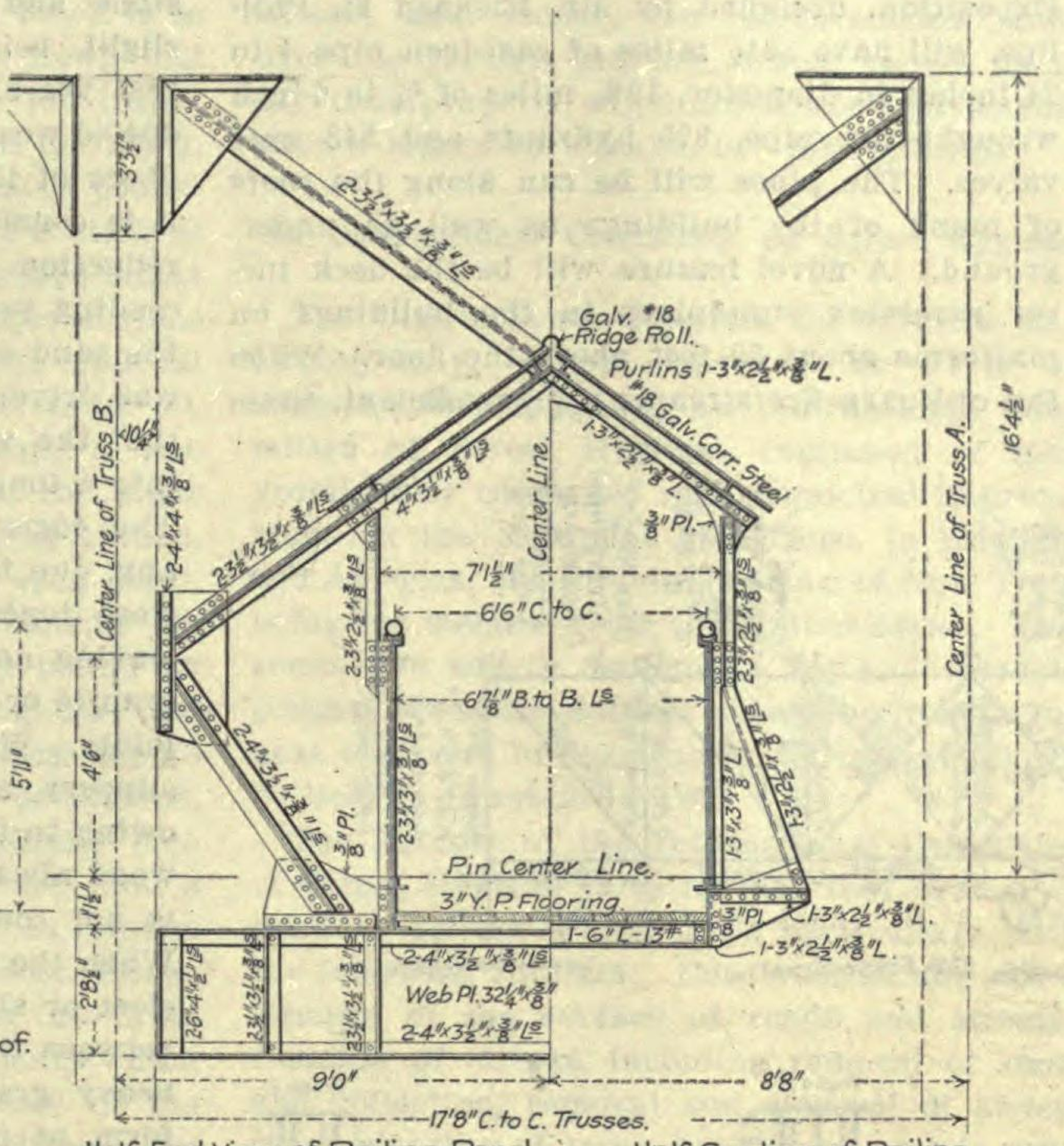
The single intersection pin-connected Pratt trusses are 26 feet deep on centers and are divided into two end panels of varying lengths and five intermediate panels 22 feet 3½ inches long. The two decks and the four trusses divide the cross section of the span into six panels, of which the upper right hand and the lower left hand ones are X-braced and the remaining ones are occupied by the tracks as in the long span, and are without transverse vertical bracing except what is afforded by the solid plate knee braces on the upper and lower sides of the ends of the upper deck floorbeams.

Owing to the arrangement of tracks and the clearance for trains the end elevation of the span necessarily corresponds almost precisely in general appearance with the cross section, and there are no portals or special end struts. The masonry coping is level in all cases and the webs are connected at the foot and at the upper deck floorbeam by vertical transverse diaphragms. The end post has the inner flange, and the intermediate posts have both flanges, braced by intersecting lattice bars riveted together at points of contact. Horizontal connection plates are field-riveted to the feet of the intermediate posts to receive the bottom lateral diagonals.

The shoes are about 4½ feet high over all and have a 52x66-inch base plate and three webs, which give a combined length of 10 inches pin bearing. The main bearing plates have half holes, but the outside plates of the outside webs are only ½ inch thick and are extended to have full holes and lock the shoe to the similar full-hole jaw plates on the opposite sides of the corresponding webs of the end posts. The end floorbeams are riveted to the shoes through their end vertical web-stiffener angles and through the horizontal connection plates of the lower lateral diagonals which are field riveted to the bottom flanges of the floorbeams and base plates of the shoes. The expansion end shoes are seated on nests of segmental rollers with their end frames locked as described for the long span and the rollers are seated on a rack made of 13 1¼-inch thick transverse bars on a 52x1¼x78-inch base plate with a ⅛-inch sheet lead cushion between it and the cut stone pier coping.



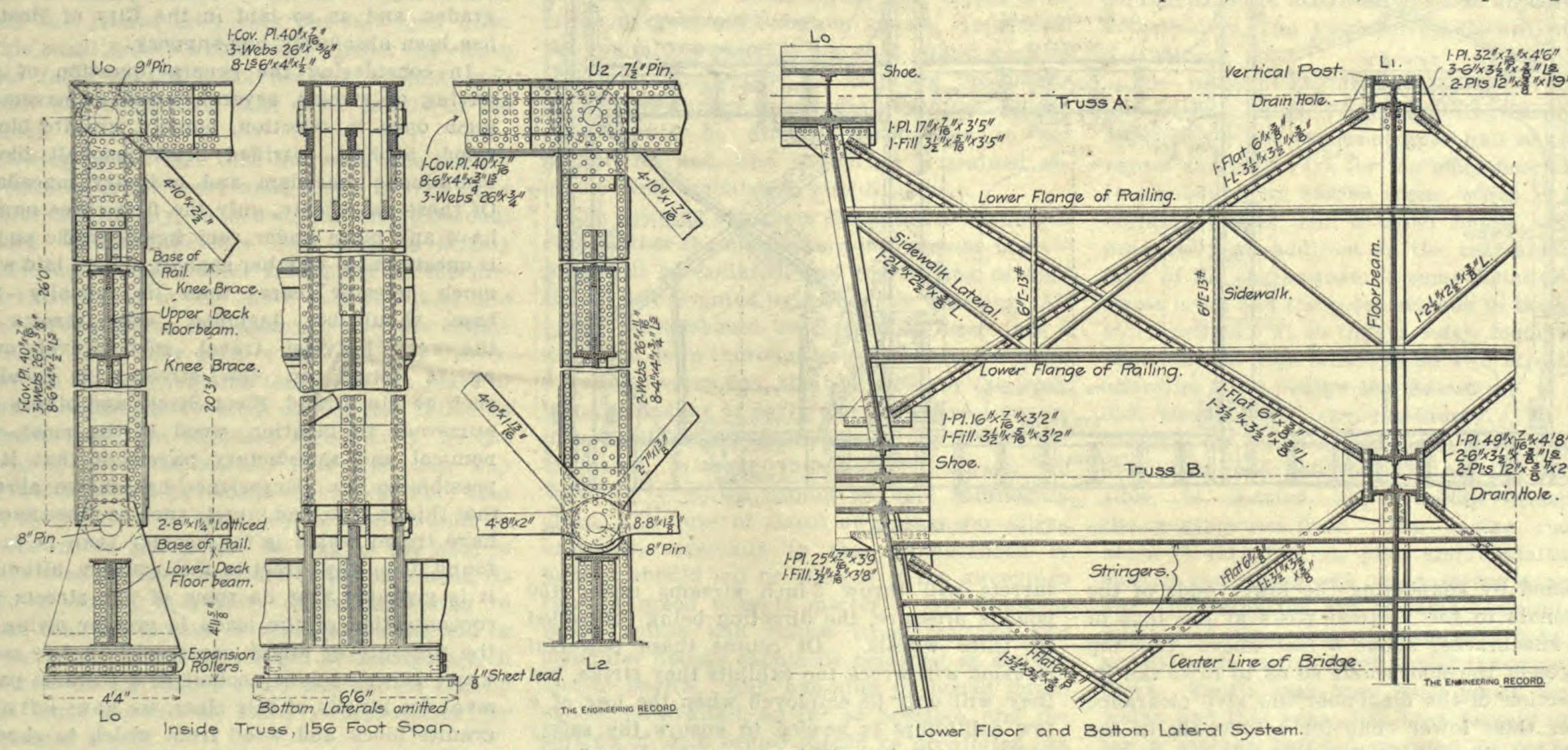
Outside View of Section of Railing and Roof.



Half End View of Railing Panel with Section of Roof and Sidewalk.

Half Section of Railing, Sidewalk and Roof at A-A.

Foot Bridge and Shelter.



Inside Truss, 156 Foot Span.

Lower Floor and Bottom Lateral System.

DETAILS OF FORT WAYNE BRIDGE.

The top chord is made in three sections, the center one having a length of a little more than three panels to bring the splices beyond the pin reinforcement plates. The maximum cross section has one 40x7/16-inch cover plate, six 26x¾-inch webs, eight 6x4x¾-inch flange angles and two 5x¾-inch and one 9x¾-inch flange reinforcement plates. The hip pins are 9 inches, all the other top chord pins are 7½ inches and all the bottom chord pins are 8 inches in diameter.

The webs of the vertical posts are connected and stiffened at the floorbeam connections, by vertical diaphragms made with ⅝-inch plates and two pairs of 4x3½ and 5x3-inch angles at top and bottom respectively. The bottom diaphragm is only 33 inches long and receives the 38 field driven floorbeam connection rivets in four vertical rows. The top diaphragm is 9½ feet long and receives an equal number of floorbeam rivets and the rivets for the kneebrace brackets. All the intermediate vertical posts have two webs and four 4x4-inch angles, and have full pin holes at both ends. The main diagonals are 10-inch and the bottom chords are 8-inch eyebars, those in the end panels of the latter being stiffened by lattice bars on 3x 2½-inch horizontal angles riveted to their inner faces. The trusses are cambered by making the top chord panel lengths ⅜ inch longer than the bottom chord panel lengths. The outside trusses correspond to the center ones, but are lighter and the maximum top chord section is one 32x⅝-inch cover plate, two 26x½-inch web plates, two 4x4x7/16-inch top flange and two 6x4x7/16-inch bottom flange angles and two 7x¾-inch bottom flange reinforcement flats.

differences in size of expansion rockers and depth of shoes are made up by the use of grillages. In the center trusses the top chords and end posts are 40 inches wide and 26 inches deep, made with three webs throughout. The end posts have half-hole bearings on the chord pins and are locked to them with jaw plates on the outside webs. The hip joint is made on the pin center and is mitered with ½ inch clearance but all other top chord joints are made to butt and are covered, but not fully spliced, with riveted web and cover plates. In the end posts and in the other vertical posts

The top lateral diagonals are pairs of 3 and 4-inch flat bars with sleeve nut adjustments and eyebar heads which have 3-inch and 3½-inch vertical pins through connection plates riveted to the top flanges of the top chords and transverse lateral struts. The lower lateral diagonals are single 6x⅜-inch flat bars field-riveted to horizontal connection plates on the bottoms of the vertical posts and to the bottom flanges of the stringers at their intersections.

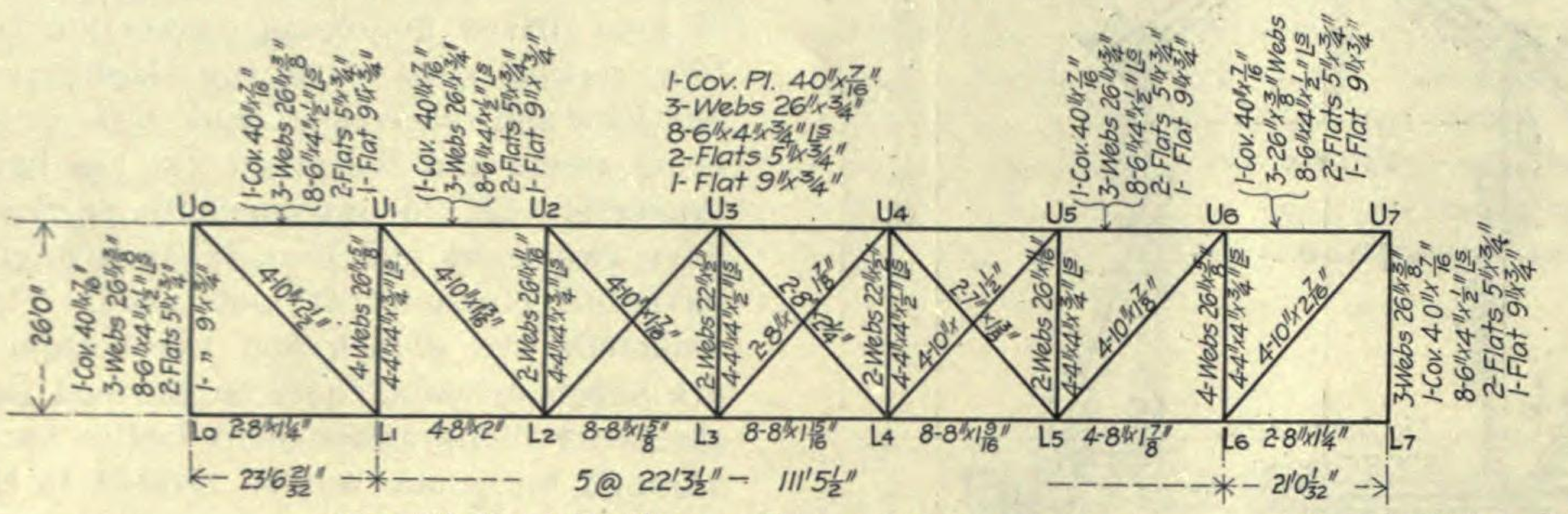
They are stiffened against flexure under their own weight by single 3½x3½x⅜-inch angles riveted to the upper side between stringers and at the ends, and they form three panels of X-bracing between every pair of floorbeams. At the ends of the span they are field riveted to horizontal connection plates shop-riveted to the base-plate of the shoe and field riveted to the floorbeam bottom flange.

As in the previously described 333-foot span of the same bridge the vertical transverse panels between trusses A and B, below the upper floorbeams and between trusses C and D above the upper floorbeams are occupied with sway brace diagonals. In both cases these are pairs of angles riveted together back to back to form Ts which have their wide flanges in the same plane and are riveted together at intersections. In both cases also they form simple X-braces, and above the upper deck their extremities extend to the ends of the transverse struts. Below the upper deck the bracing is modified by connecting the lower ends of the diagonals to the vertical posts at the tops of the kneebraces, about 6 feet above the top flanges of the floorbeams so as to raise the intersection of the diagonals and give clearance under their lower ends for a footwalk in the center of the panel. The footwalk is supplied with deep lattice-girder hand rails which carry its floor between panel points of the main truss, and it has a double pitched roof to protect it from drippings from the railroad track overhead. The top flange of the hand rail girder consists of a small channel, an angle and a 4-inch pipe fastened together as shown in the detail, the oval bottom heads of the bolts being inserted through slotted holes in the pipe and turned 90 degrees before their nuts were screwed up.

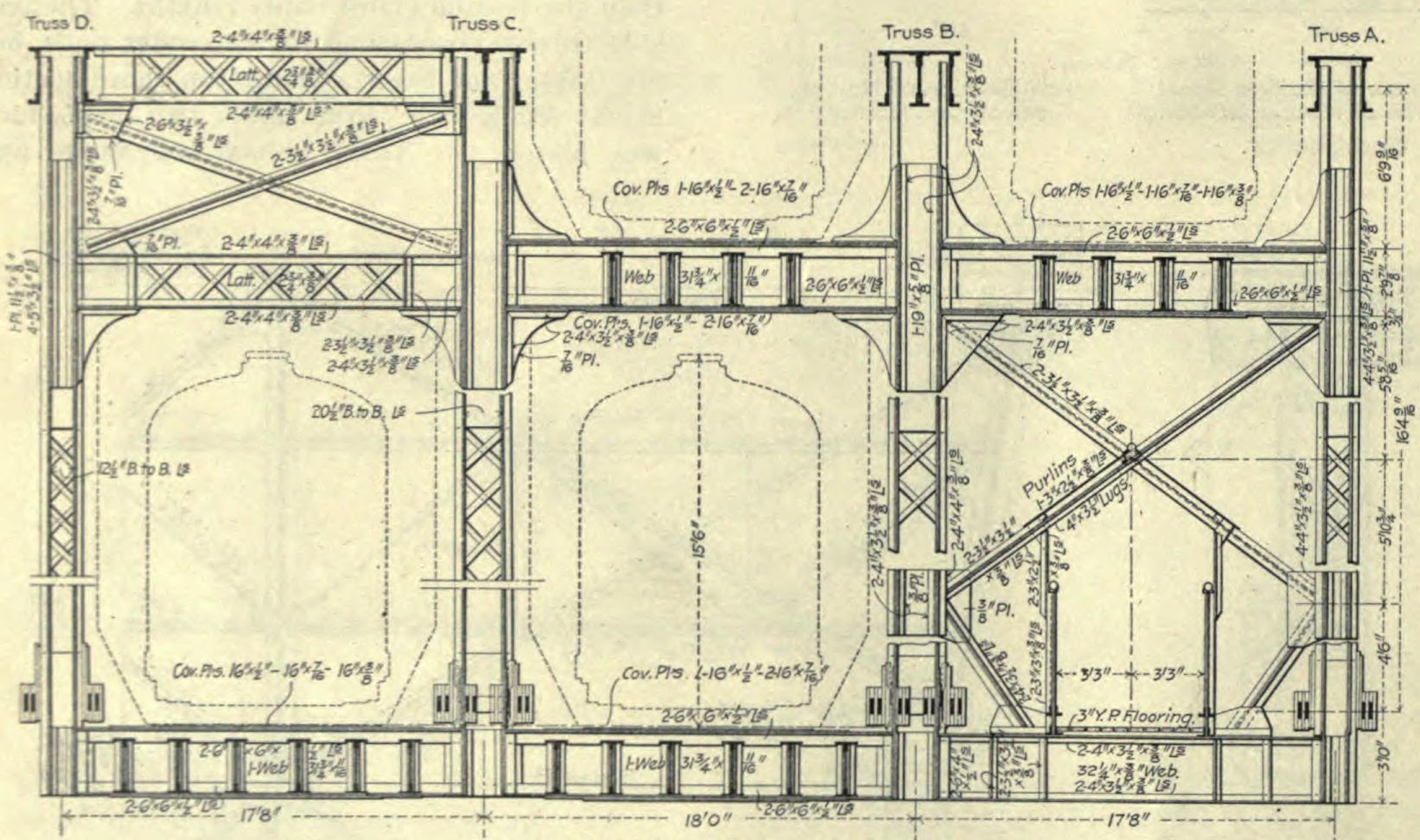
Each span weighs about 650 tons and was designed and constructed under direction of Mr. Thomas Rodd, chief engineer and Mr. J. C. Bland, engineer of bridges for the Pennsylvania Lines West of Pittsburg. The inspection was performed by the railroad company's force under Mr. C. P. Buchanan, inspector of bridges. It was built at the Keystone plant of the American Bridge Co., Mr. Richard Khuen, engineer. It was erected under direction of Mr. S. P. Mitchell, chief engineer, and Mr. H. A. Green, assistant engineer and superintendent of erection for the western district.

The Water-Works of the Louisiana Purchase Exposition, designed by Mr. Richard H. Phillips, will have 15½ miles of cast-iron pipe 4 to 24 inches in diameter, 19¾ miles of ¾ to 6-inch wrought-iron pipe, 375 hydrants and 843 gate valves. The pipes will be run along the roofs of many of the buildings as well as underground. A novel feature will be the deck turret revolving standpipes in the buildings on platforms about 30 feet above the floor. When the ordinary fire streams are insufficient, these turrets will throw 3-inch streams under 150 pounds pressure, the direction being controlled by tiller wheels. Of course these powerful streams will wreck the exhibits they strike, but they will only be employed when the loss of a few exhibitors is needed to ensure the safety of many. Water will be drawn from an 8,000,000-gallon impounding reservoir by nine pumps, and there will be an emergency connection with the city mains.

Gravel Roads in Grand Rapids, Mich., according to City Engineer L. W. Anderson, are constructed so as to reduce the voids to a minimum, by using a mixture of fine gravel when necessary. The clay used in the body of the gravel has been reduced by this means to the smallest permissible amount. When giving the final rolling, an additional sprinkle of clay is added to prevent the gravel from raveling during the dry summer months.



Material Sheet for Heavy Truss, 156 Foot Span.



Cross-Section at Center of 156 Foot Span.

The Use of Wood Pavements Under Heavy Traffic.

Abstract of a paper presented to the American Society of Municipal Improvements by F. A. Kummer.

Attention was drawn in the first part of the paper to a paving block exhibited in connection with it, which was removed from Tremont Street, Boston, after being in use nearly two years. It was taken from near the center of the street where the traffic is very heavy. The surface of this block was almost as hard as stone and the reduction in depth was very slight, being at the most not over ⅛ inch in two years. This reduction in depth was not due to wear, but to the compression of the upper fibers of the block under heavy travel, so that it is considered quite certain no corresponding reduction in depth will be apparent during succeeding years. Under the action of the traffic, the sand spread over the surface of this street was driven into the outer fibers of the wood, so that the whole wearing surface was compacted into a tough and absolutely impervious surface. The edges of the block have not rounded off any, due to the fact that the blocks are laid as close together as they can be driven, thereby leaving no point of attack, as is the case with granite or other block pavements laid with wide joints. When dry, wood pavements are not as slippery as, for instance, asphalt pavements, owing to the fact that the upper surface of the wood always retains a certain elasticity, which is not found with other forms of pavements. When the two pavements are covered with frost, sleet or slime, there is perhaps little to choose between them on the grounds of slipperiness on heavy grades, but for streets of this class a form of pavement has been developed which consists of a block laid with a grooved joint, which proves a perfect foothold for horses upon grades, and as so laid in the City of Boston, has been absolutely non-slippery.

In considering the general question of the paving of streets, several forms of pavement seem open to selection, namely, granite block, wood, asphalt, vitrified brick, asphalt block, bituminous macadam and ordinary macadam. Of these pavements, only the first three named have any place under very heavy traffic and it is questionable whether asphalt, unless laid with much greater care than is usually the case, should be included. For streets of the very heaviest travel, such travel even as is found on the streets in London, such as the Strand, Fleet Street and others too numerous to mention, wood is the most economical and satisfactory pavement that it is possible to lay. Experience has shown abroad that this is true, and streets such as those named have travel which is far heavier than is to be found upon any street in this country, although it is probable that on some of our streets the concentration of the loads is greater owing to the presence of street car tracks in the roadway. If we exclude asphalt as a suitable pavement for streets of this class, we have left only granite block and wood from which to choose.

Granted that it is possible to so prepare wood that it does not absorb moisture and is proof against decay, let us consider how such a block of wood can be destroyed by the action of traffic. If the practice were followed of laying the blocks with one-quarter or one-half inch joints, as is the case abroad, the exposed edges of the blocks would undoubtedly wear with more or less rapidity under the action of the shoes of horses. This wear is not as great in the case of wood as one might at first suppose, as has been demonstrated by the Boylston Street pavement in Boston, to which reference has already been made; but by laying the blocks on streets which are level or nearly level with no

Bridge Raised Thirteen Feet by Jacking

Four-Track, Double-Deck Steel Bridge and Approaches Elevated to Provide Extra Clearance Without Interruption of Traffic

ONE of the most original engineering accomplishments ever carried to successful completion is the lifting of about 7,800 tons of steel bridge truss spans and 7,150 tons of approach viaducts a maximum distance of 13½ ft. with absolutely no interruption of the heaviest railroad traffic. On March 23, 1917, the U.S. War Dept. ordered that the Pittsburgh, Fort Wayne & Chicago Railroad bridge over the Alleghany River at Pittsburgh, Penn., consisting of five main river spans of four-truss, double-deck type and their approaches, be raised from a clearance line at El. 738 to a revised line at El. 750.6, and fixed the time limit for completion at one year from date. It was required that the lifting operation should be carried out between trains and proceed consecutively from pier to pier to prevent excessive grades. All the truss spans on any one pier were raised simultaneously by the use of hydraulic jacks of 100-, 200- or 500-ton capacity. The actual operations of lifting these spans, which were designed for six tracks and are the heaviest for their length in the country, were carried out in less than five months.

A very complete description of this piece of work appears in Engineering News-Record. From this article the following notes are made:

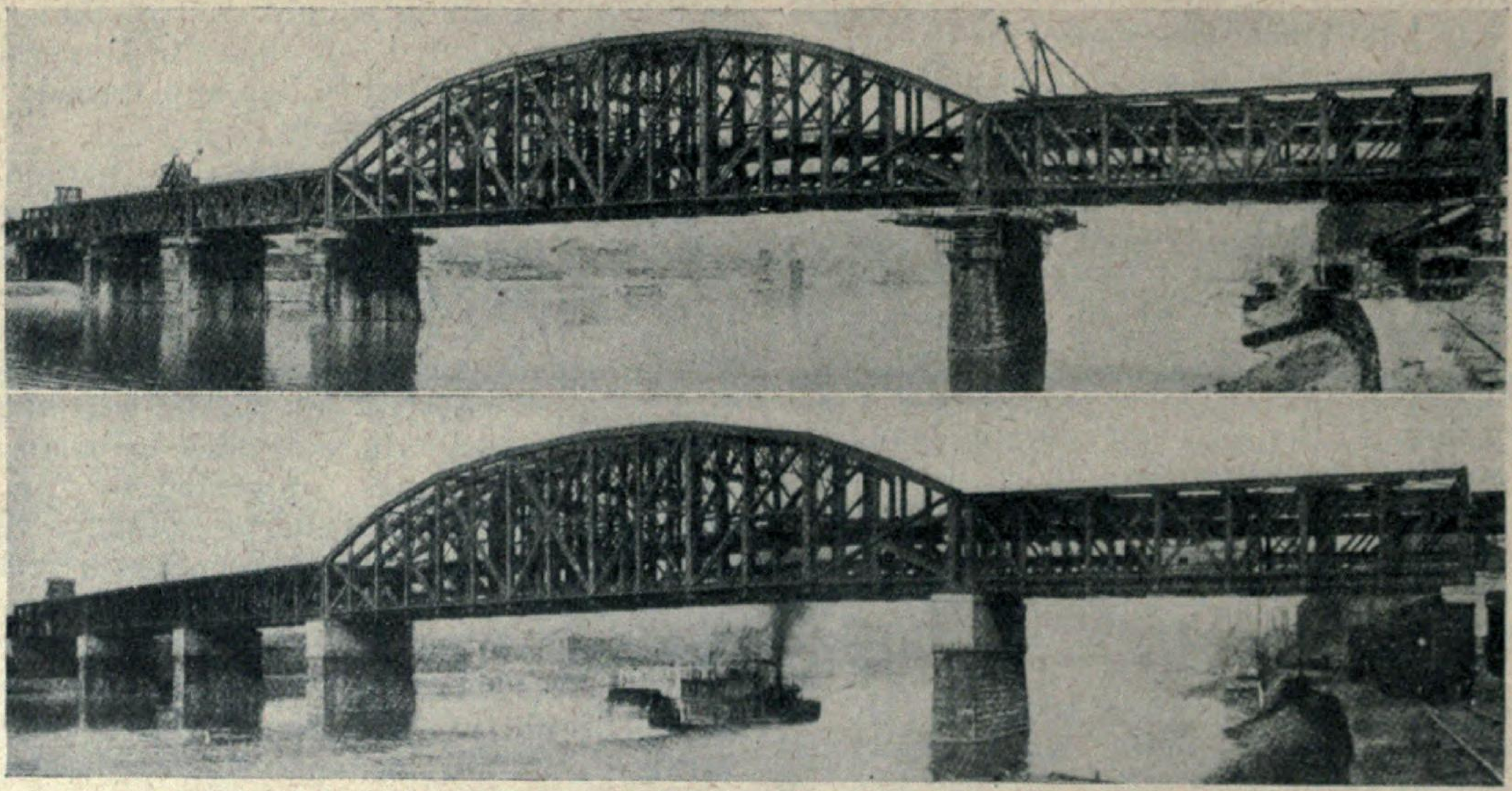
Restricted space and side-clearance limitations complicated the problem of placing new steel grillages on the main piers and providing support for the jacking girders. Furthermore, the approach girder spans and steel bents also had to be raised and the piers supporting these bents rebuilt by the addition of precast concrete blocks. In the Pittsburgh approach, where the side clearances were limited, spliced column extensions were added to the base of the steel column to give the necessary height. A simple device was installed to indicate whether the various spans at one pier were being kept at the same level during the raising operation.

After the completion of the raising, March 15, 1918, much other work had to be done on the bridges, such as the replacing of corroded angles in the upper level struts of the bracing and the placing of cast-iron protection plates above the lower-level tracks, and the introduction of diagonal longitudinal bracing in the approach viaducts on both ends of the bridge.

General Requirements

The Government order required a clear height 12.6 ft. greater than that furnished by the original structure. This involved the raising of the grade of the lower-level tracks at the ends of the longest span a distance of 12.47 ft. and 13.44 ft., respectively, the latter being the maximum lift required in the structure. The various lifts at the end and intermediate piers are given in the accompanying table, which also indicates the jacking loads at the piers, the length of spans and the dead weight of the spans.

The total length raised was 3,283 ft., which was divided into five operations, as follows: (1) Five main

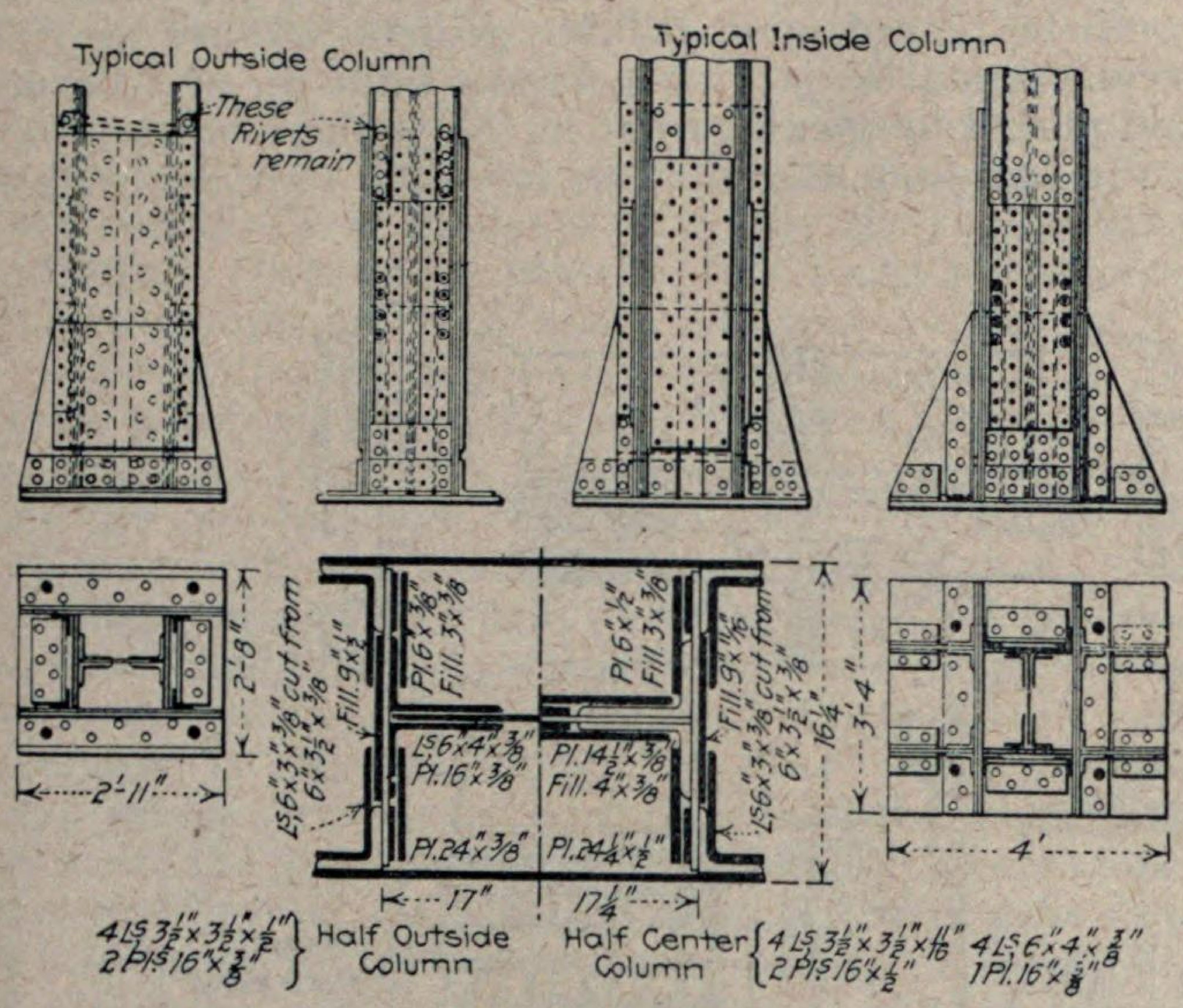


Progress view and final appearance of Allegheny River bridge raised 13 feet to provide greater under clearance.

Main Truss Spans and Weights—Distances Raised

Pier or Span No.	Span Centre to Center of Piers, Feet	Dead Weight of Span Tons	Total Jacking Load at Pier Tons	Distance Raised Feet
1	165.5	1199	602	10.47
2	337.5	3459	2331	12.47
3	160.9	1057	2258	13.44
4	160.9	1048	1048	13.19
5	160.5	1052	1048	12.53
6	.....	....	528	11.26
Total		7815	7815	

river spans supported by six piers, total length 987 ft.; each span is composed of four trusses of double-deck of pin-connected type on a skew, designed for three tracks on each deck, although only two tracks on each deck have been placed; (2) Pittsburgh approach viaduct of 25 half-through plate-girder spans supported on steel column bents, the total length being 823 ft., weight, 4,000 tons; (3) The Duquesne Way viaduct, 24 spans of which were raised, covering a total length of 1,230 ft. weight 2,350 tons. This is a double-track-deck plate-girder viaduct supported on steel columns; (4) Alleghany approach viaduct, composed of five half-through plate-girder spans, double track, on steel columns, length 177 ft., weight, 800 tons; and (5) Penn



Two types of details of typical splices for column extension

Avenue bridge, which is a three-span half-through plate-girder bridge 60 ft. long, with steel columns at intermediate points.

Traffic Not Interfered With

In planning the operation non-interference with traffic was the most important point to be considered, so that all lifting equipment had to be designed to insure the most rapid lifting operations possible. No attempt was made to lift any part of the superstructure under live load. All of the superstructure resting upon any given pier had to be lifted at the same time and kept level during the operation, the distance lifted being limited by the fact that no grade exceeding 1 per cent was to be permitted during the progress of the work. In order to prevent undue strain of the riveted connections in the viaduct approaches, it was planned to raise the girders in consecutive sections of three spans, each lift to be limited to two or three inches.

As the interval between trains was seldom more than 15 minutes, a complete telephone system connecting the train dispatcher's office with those points in the field where the work was being carried on was installed. An elaborate chart was prepared to show when the track was required, how long, and when it would be released. During the work it was found necessary to allow 1.5 per cent. grade at various stages, and the final maximum grade is 1.28 per cent. on the Pittsburg approach. The grade of the upper-level tracks was modified so that they were not lifted the same amount as the lower-level tracks, the difference being made up in depth of ties, some ties as deep as 20 in. being required.

History of the Operations

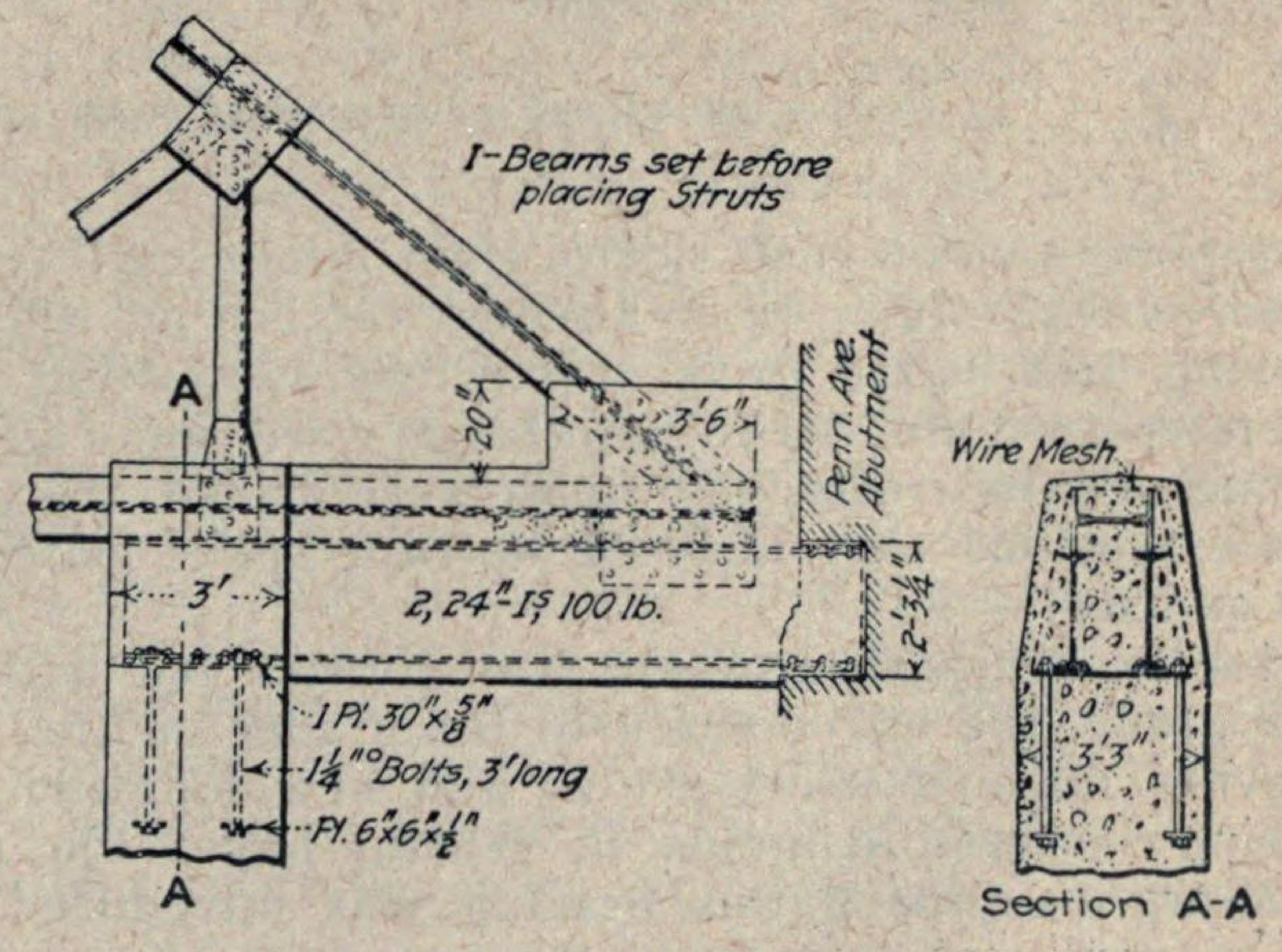
The work was let on a percentage basis, and as many new requirements were discovered the added work extended the time of the final completion of the contract nearly one year longer than that required to raise the bridge to its new level. Preliminary work on the approaches was started June 7, 1917, and all extra work on the main spans and approaches was completed March 15, 1919. The lifting of the main spans and the Alleghany approaches began October 30, 1917, and the last lift was completed March 23. The average lift on the main piers was 3 in. at first, increasing to about 6 in. per day, the maximum, accomplished February 25, 1919, being one foot three inches.

Work on the Pittsburgh approach began Aug. 11, 1917, and was finished March 11, 1918, the work being carried on simultaneously throughout the structure with a force that averaged about 75 men. The addition of splice material and reinforcement for corroded struts and floor-beams, the installation of new longitudinal bracing, and other additional work, kept the contractor on the work for another year.

Approach Columns Raised

The first work was the enlargement of the concrete piers supporting the columns of the approach bents to give sufficient width to support the jacks. Built-up steel brackets were bolted on two sides of the columns to support the dead weight. Beneath these the jacks were placed, the capacity of these jacks varying from 40 to 80 tons. For the heavier brackets eight 1¼-in. bolts were used at the lower end to take the tension, and wood blocks were inserted between the column angles at the top to take the compression.

The first operation was the placing of wood blocks for supporting the jacks, or, in case the precast blocks were finished, outside units were used under the jacks. The jacking up proceeded in 2-



Special longitudinal bracing anchorage at abutment.

inch increments, using timber blocking under the column bases until the structure had been raised about 2 ft., when the centre precast block under the column base was inserted. The second tier of these blocks consisted of five units, the outside oblong blocks running in the opposite direction to those of the first tier. In placing this second tier, the first units placed were those under the jacks, the latter then being used to raise the columns by means of brackets in 3-in. lifts, using timber blocking until the column was high enough for the insertion of the centre section under the column base. The outside sections could then be placed and the work proceed in similar order, tier by tier.

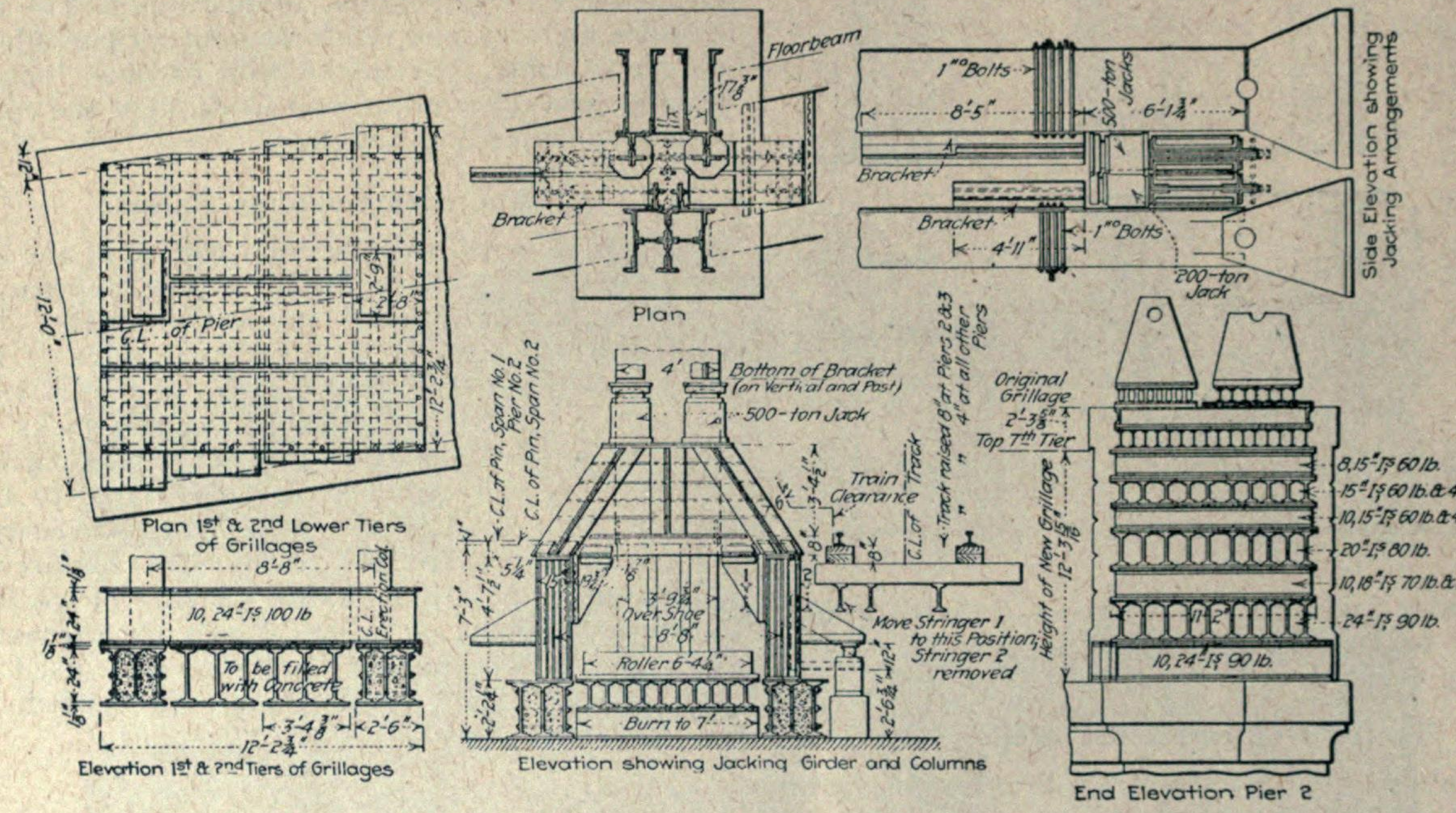
Extensions to Columns

On account of insufficient lateral clearance for trains on the track under the viaduct, the concrete blocks on the Pittsburgh approach were brought up only to the level of the new ground line. The additional height necessary was provided by steel column extensions spliced to the old columns, as indicated on one of the drawings herewith showing the two general types—the inside column with central diaphragm, and an outside column of four angles and two web plates only, using new centre diaphragms at the splices. In placing the new extension, the dead weight and the live load were supported by timber struts from the ground to were used, thus decreasing the number of points of connection between the new diagonals and the columns.

Jacking Up Main Trusses

The eight truss bearings at each intermediate pier were lifted at the same time, keeping all trusses at the same elevation in order to prevent undue strain on the rigidly connected floor-beams and portal bracing. The sceme finally adopted to allow rapid and continuous jacking operations is indicated by the diagram herewith. The problem was to design the jacking girders and steel grillage units to avoid interference and to keep outside of the train-clearance line. New steel brackets were bolted to the vertical end posts of the main trusses, below which the 500-ton hydraulic jacks could be placed upon jacking girders. These girders were carried by jacking columns built up of I-beams and placed in openings left in the grillage units.

It was first necessary to raise the railroad track 8



Jacking girders and columns with I-beam grillages Satisfy clearance requirements—pier No. 2.

the girders, one on each side of the column, each composed of three 12 x 12-in. timbers resting on timber cribbing drift-bolted to fit. After thus supporting the superstructure, the old column bases were removed by cutting out the rivets, new holes were drilled, the column extensions were inserted, and the splice material was added.

As the original structure was constructed with a level grade, the introduction of the grades on the approaches made it necessary to add new longitudinal bracing between columns in certain bays. On the Pittsburgh approach this bracing was introduced in five bays at various parts of the structure, always being placed in a fixed span. Double diagonals were used in all cases except in the end bay, where a special detail was necessary to connect to the abutment because of the presence of an electric-wire conduit running along the abutment. Details of this concrete-covered steel beam construction to span the conduit and connect to the abutment are indicated in one of the accompanying drawings. In the other approaches, single diagonals with a subdiagonal and vertical at the centre to shorten the unsupported length of the strut in. to increase the clearance. The ends of the old I-beam grillages were burned off in order to allow the outside units of I-beams filled with concrete to be placed. These outside units, which had to carry the complete dead load on the jacks, were built up of I-beams bolted together before the concrete filling was placed.

The posts and jacking girders were then erected and the old truss grillages were bolted to the shoes, and jacking proceeded, using 3-in. timber blocking under the old grillages until the trusses were high enough for the insertion of the central unit of the first tier of new grillage. As the 500-ton jacks only had an 8-in. stroke, the clearance between the jacking girders and the truss shoes only permitted an 8-in. raise, and it was necessary to raise these jacking girders every time the bridge was raised 8 in. The dead load of the jacks, jacking girders and supports was about six tons, hence a set of auxiliary jacks was installed to raise the jacking girders by brackets, as indicated on the sketch, to allow rail grillages to be slipped under the jacking columns. These rail grillages were later replaced by I-beam stools. All of these operations, of course, had to be carried on simultaneously at each of the four truss points on a given pier. After the operations had become familar, it was possible to carry through one complete cycle for a 4-in. raise and place the 3-in. plank in four minutes.

Special Device Insured the Constant Level

A simple hydraulic device was designed, on the principle of water seeking its own level, to indicate when the truss bearings were not at the same relative elevation during the operation of lifting. A 3/4-in. pipe was placed below the floor of the span, and risers with glass indicator tubes were placed at each truss. Water with coloring matter was inserted, and the level indicated by placing a rubber band around the glass tube at the beginning of the lift.

All that the men who were operating the inlet valves of the hydraulic jacks had to do was to watch carefully to see that the water in the glass tube was kept constantly at the level shown by the rubber-band indicator. After some practice this could be successfully accomplished wth less than 1/8-in. variation.

The hydraulic jacks were operated from a single steam pump placed on a platform carried by cantilever supports on the north side of span No. 2. The main line of 1½-in. pipe extended the full length of the five bridge spans and connected to 1-in pipes running parallel to each pier, to which copper pipe was attached and connected through the supply valve with each jack on the various piers. These valves were operated by capstans above the floor of the bridge. Stop valves were placed on each side of the connection between the pump and the longitudinal 1½-in. pipe, also just beyond each pier, in order to govern the flow of the water to any set of jacks on any pier desired. A discharge valve was also placed at the connection for the copper supply pipe for each set of jacks, allowing the mixture of water and 50 per cent. alcohol used in the winter to be saved by catching it in buckets and returning to the pump.

Placing Steel Grillages

Timber platforms were hung from the trusses on each side of the main piers at a level just high enough to allow the steel grillages to be rolled into place on pipe rollers. Platforms on both sides of the pier were required because grillage units of alternate tiers had to be made double, each half being placed from opposite sides of the pier to allow space for the jacking columns. In order to avoid delay in obtaining material it was found necessary to use I-beams for these grillages from whatever source was available. For example, 15-in. I-beams from the old Louisville bridge were obtained and many other beams were furnished by the railroad. The height of the last tier was fixed by the required total lift at the given pier. These grillage units were fabricated at the site, using as cover plates the old Quebec bridge hangers which had been utilized in lifting the suspended span. These were 1 1/8 in. thick for those from the old span which was lost in the river, and 1½ in. thick for the hangers last used.

The mortar beds between the grillage tiers made up about 4½ in. of the varying difference between the net height of the steel and the height of the concrete encasement forming new caps for the piers. The concrete encasement was carried up to the top of the seventh tier; the concrete was placed by first filling the I-beam grillages with 1:3:6 gravel concrete, then placing the heart, 10½ ft. wide between the grillages, of the same mix. The outside width of 13 ft. was then made up by 1:2:4 mix, using gravel screened to 3/4 in. and working the mortar against the forms so that no stone would show after the base was rubbed.

Vetrical joints were made to prevent the development of cracks in the concrete at the corner of the steel grillages where it joined the large mass of heart concrete, by using a steel plate nailed to the forms in a narrow V shape, this plate being removed with the forms and the opening pointed up after the concrete had set. The horizontal construction joints were made at any coursing joint, the latter being formed by triangular nailing strips spaced about 2 ft. 6½ in. apart vertically. The care used in the location of the construction joints has resulted in the fact that no crack whatever has appeared, although several months have elapsed since the work was completed.

Repairing Corroded Struts and Floor-Beams

The locomotive gases and blast were found to have caused very severe loss in section of the transverse struts and floor-beams on the upper level above the floor tracks. It was therefore found necessary to replace the 4 x 4-in. angles of the struts by splicing in new sections in both flanges, usually 3 to 4 ft. long, and spliced by 3½ x 3½ x 7/16-in. angles. In some cases plates 10 3/8 x 3/8 in., about 5 ft. long, were riveted to the lower strut angles. Cast-iron protection plates to prevent future corrosion were bolted to the bottom of these struts in the upper deck throughout the length of the bridge. The crowded floor-beams were rebuilt by adding web plates to both sides of the old webs and reinforcing the lower flange angles.

The estimate of the cost (made April, 1917) was $500,000, but owing to the increase in the costs of all kinds of labor and material during the progress of the work, and loss in efficiency due to the unusually severe cold of the winter of 1917-18, the final cost was from $750,000 to $800,000. The exact cost is not known, as accounts are not yet closed.

Professor Charles S. Slichter of Maison, Wis., recently sent a letter to Judge H. A. Robson, congratulating the City of Winnipeg on its new Shoal Lake water supply. Professor Slichter was the man who first officially recommended this source of supply to Judge Robson in a report prepared in 1912. Judge Robson, at that time, was Public Utilities Commissioner. In this letter Prof. Slichter claims that Winnipeg has as magnificent a supply of water as any city on this continent or abroad. He lauds the softness and purity of the supply and questions the rumors that the water is unsanitary. Winnipeg's new water is claimed, in this letter, to be free from contamination and of such quality as to appreciably reduce many diseases attributed to unsanitary supplies. It is Professor Slichter's opinion that mechanical filtration will not have to be resorted to, careful watching of the strainers and a little care at the reservoir being all that is necessary.

The Chicago Bridge & Iron Company has changed its sales office address from 1305 West 105th Street, Chicago, to 2104 Old Colony Bldg. The general sales office has been removed from the works and is now situated in the Old Colony Bldg.

The Montreal Civic Administration have adopted a new schedule of minimum rates to be paid by contractors doing work for the city.