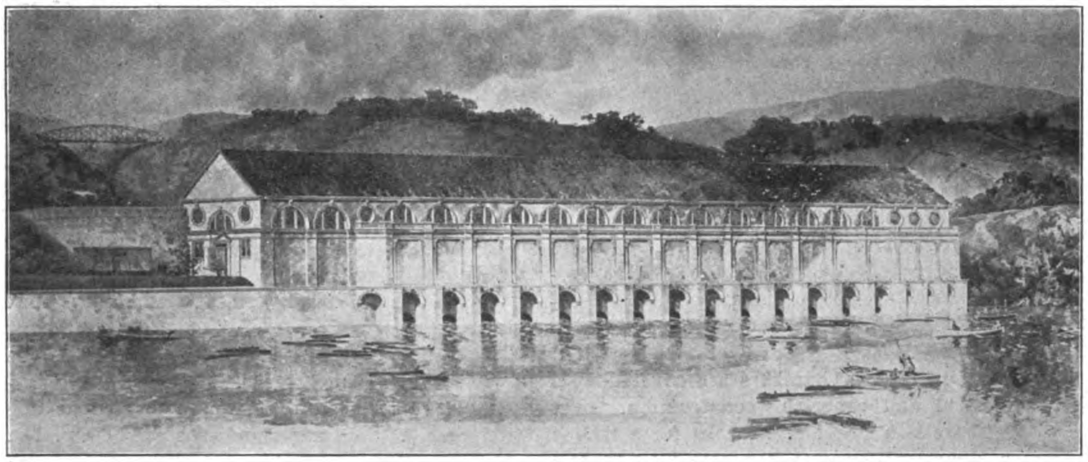
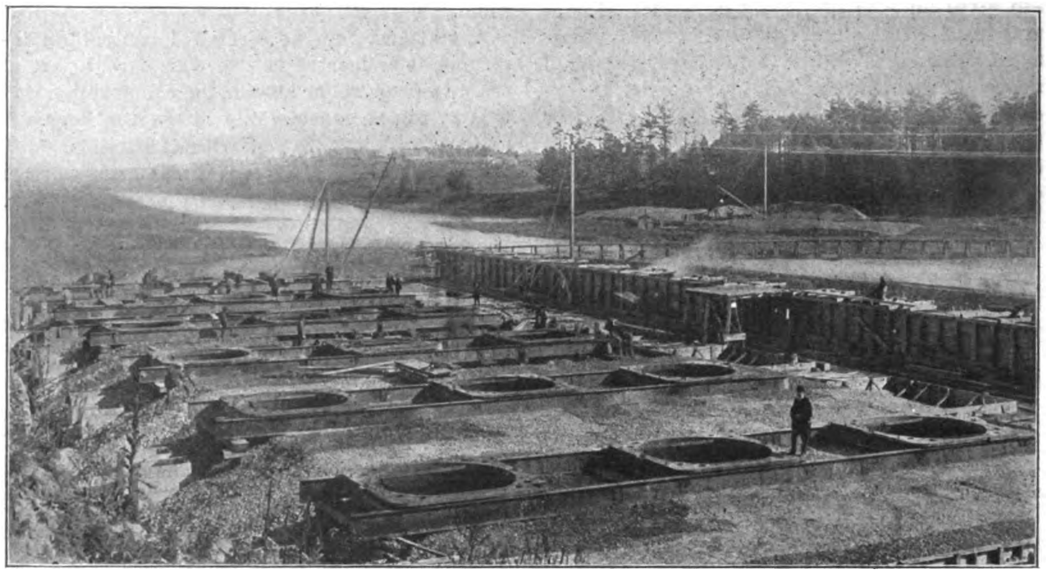
ter and an ammeter for the field current. A switchboard is to be provided for each generator and each is to be erected in the gallery and opposite and close to its machine. The lower part of the board is to contain a three-way double-throw knife switch for connecting the machine to one of two sets of bus bars or entirely disconnecting it. The upper part of the board contains an automatic circuit breaker between the switch and the generator. The circuit breaker may be opened or closed by a crank connected to the piston of an air cylinder and the generator switch can be opened or connected to either bus bar by a similar arrangement. The valve admitting air to the cylinder is to be located close to the cylinder and controlled electrically from the controlling pulpit. It was thought better to so control the air there, than to employ the long air pipes which would be necessary were the air valves placed within reach of the operator at the controlling pulpit. Long pipes would mean a slower moving system and a greater chance of leakage. The ultimate arrangement contemplates the banking of the generators in sets of five so that each of the five can be connected to either one of two sets of bus bars. The bus bars can be connected together if desired. The conductors from the generators to the switchboard are to be copper strips 8 inches deep and ⅛ inch wide, those dimensions being chosen to give ample cooling surface.



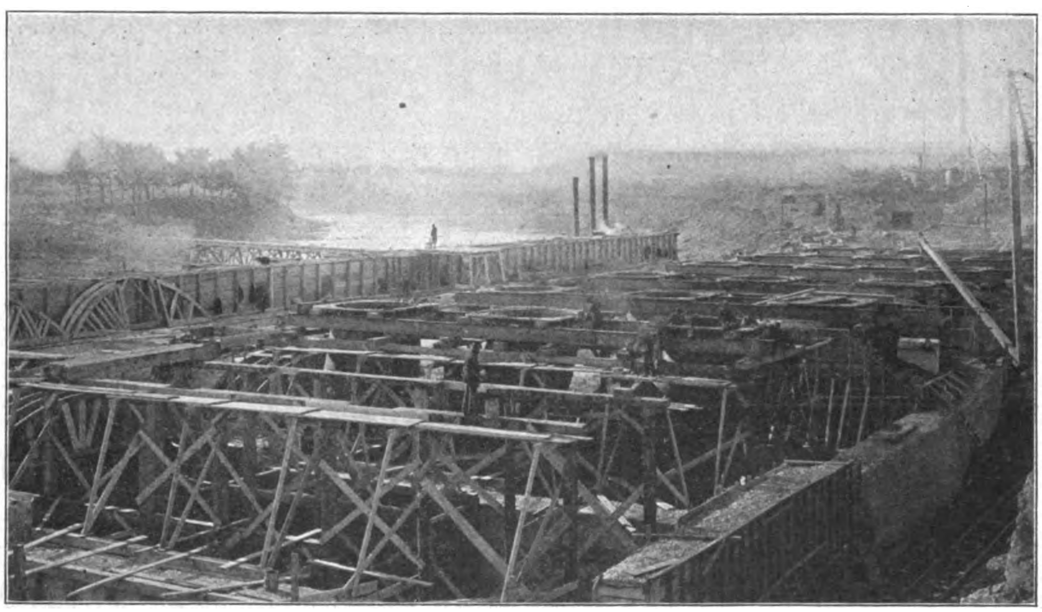
THE MASSENA POWER HOUSE, ST. LAWRENCE POWER COMPANY.

In connection with the automatic circuit breaker mentioned, a time device is to be introduced whereby the circuit is not broken unless a serious overload occurs for a definite period of time. It is also proposed to introduce circuit breakers with this time device set for a shorter period of overload, between the switchboard and the transformers, and also a third circuit breaker without the time device in each power circuit between the transformers and the customer. The objects of this arrangement are to prevent interruptions in the service as much as possible and to protect the plant.

The entire work is being carried out by the St. Lawrence Power Company, of which Mr. C. A. Moreing is president, Mr. William F. Zimmerman vice-president, and Mr. John Bogart of New York, and Messrs. Kincaid, Waller and Manville of London, joint engineers. Mr. W. H. Cushman is resident engineer in charge of construction, and his principal assistant is Mr. S. M. Bishop. The contractor for the canal and power station building is the T. A. Gillespie Company of New York. The Engineering Record is indebted to Mr. Bogart for plans and material from which this description has been prepared.



VIEW LOOKING DOWN THE GRASSE RIVER.



VIEW LOOKING UP THE GRASSE RIVER.

THE LEHIGH VALLEY RAILROAD BRIDGE AT EASTON, PA.

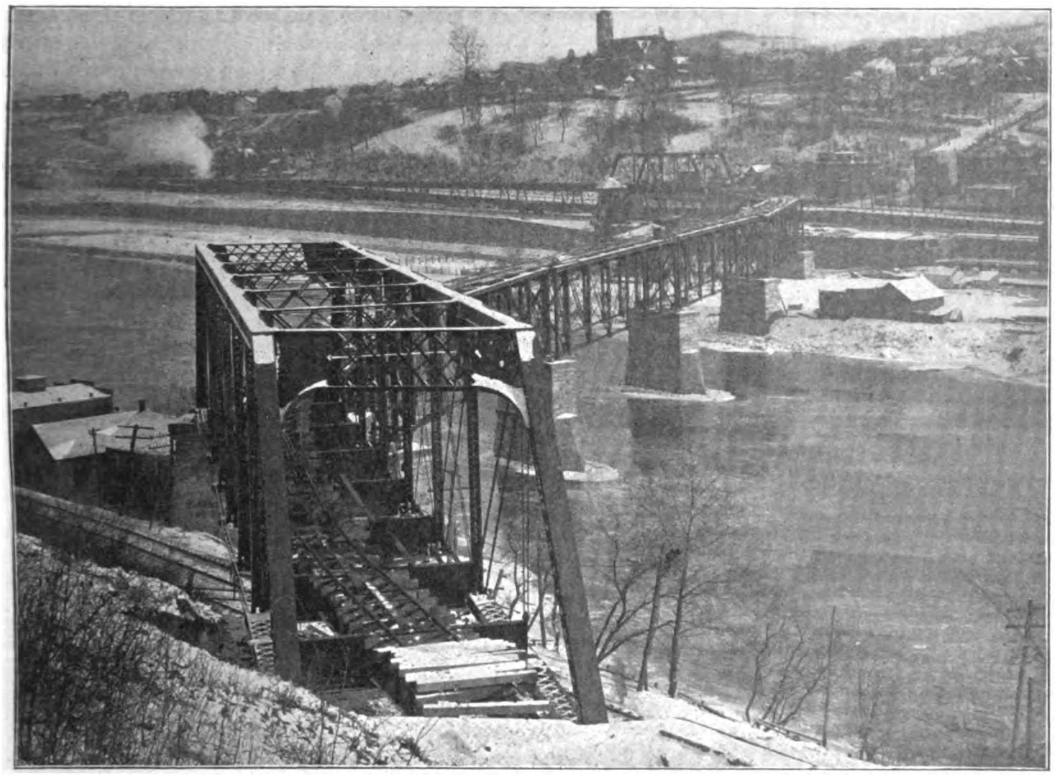
The Easton & Northern Railroad, a branch of the Lehigh Valley Railroad, crosses the Lehigh River at Easton, Pa., on a single-track bridge supported by eight piers and one abutment. These piers and abutments are numbered from 0 at the northwesterly abutment to 8 at the southeasterly pier on the South Easton bank of the river, where a viaduct approach begins. Span 0-1 is a through span 207 feet 5 inches long, center to center of end pins. It crosses the tracks of the Central Railroad of New Jersey and is skewed at both ends. Span 1-2 is a deck span supported at its top chord on pier 1, and at its bottom chord on pier 2. The truss on the inside of the curve is 119 feet 9¾ inches, and on the outside 141 feet 3 inches long. Span 2-3 is a deck span 167 feet 9 inches long with a skew of 15 feet 3 inches. Spans 3-4 and 4-5 are deck spans, each of 167 feet 9 inches, with a skew of 13 feet 3 inches. Span 5-6 is a deck span with an inside truss 197 feet 9 inches long and an outside truss 202 feet 11 inches long. Span 6-7 is a deck span with the truss on the inside of the curve 194 feet 3 inches long, and the outside truss 215 feet 1½ inches; it is supported on pier 6 at its bottom chord and on pier 7 at the top chord. Span 7-8 is a through span crossing the main line tracks of the Lehigh Valley Railroad, and is 187 feet long and skewed 5 feet 11 inches at each end. East of pier 8 is a viaduct approach 690 feet long, composed of alternate 60 and 30-foot spans, beginning at pier 8.

An 8-degree curve to the right begins about 155 feet west of abutment 0 and reaches its point of tangency about 40 feet north of pier 3, the central angle of the curve being 50° 22′ 45″. A tangent then extends across spans 3-4 and 4-5, and a second 8-degree curve to the left begins about 30 feet south of pier 5. This curve extends across spans 5-6, 6-7 and 7-8, and its point of tangency is about 60 feet east of pier 8, on the viaduct, the central angle being 49° 22′ 45″. East of the approach viaduct an earth embankment carries the tracks to their intersection with the main line tracks of the Lehigh Valley Railroad near the Easton Station. The entire structure is on a one per cent. grade downward toward the southeasterly end. The height of the rail above low water is about 75 feet at the northwesterly end of span 0-1, and about 62 feet at the southeasterly end of span 7-8. The least clearance over the Central Railroad of New Jersey tracks under span 0-1 and over the Lehigh Valley Railroad tracks under span 7-8 is 20 feet. The long approach is nearly parallel to the river. The through and deck spans are very much skewed at both ends, and the difficulties of alignment and centrifugal strains due to rapidly moving heavy trains have developed some special features of construction.

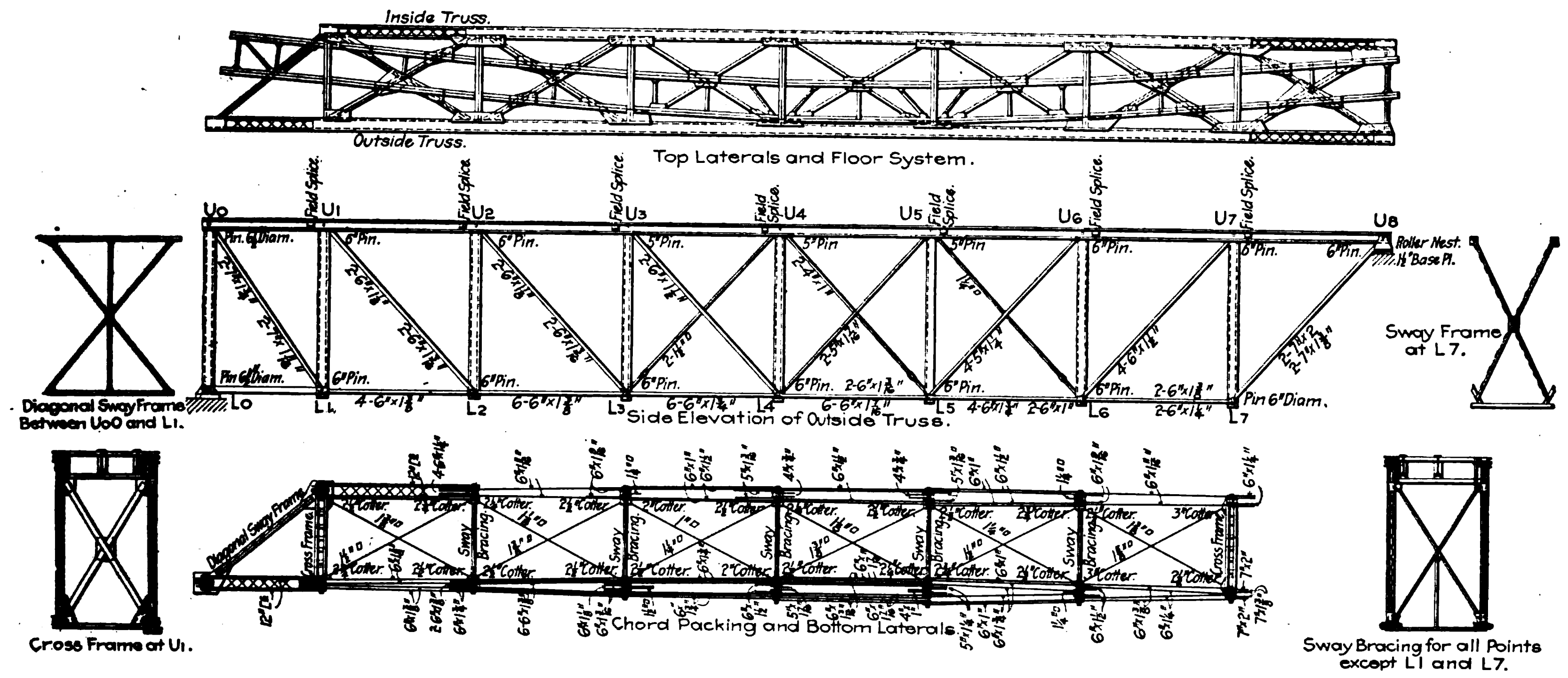
The two through spans are similarly constructed, but the one shown in the foreground of the general view of the bridge has eight panels and is 207 feet 5 inches long, while the one on the opposite bank of the river, which crosses the main line tracks of the Lehigh Valley Railroad, is 187 feet long and has only seven panels. In the 187-foot span the middle ordinate of the curve of the track, 6 feet 4 11/16 inches, is bisected by the longitudinal center line of the span, and all the connections between stringers and floorbeams are made at points on curves parallel to that of the center line of the track. The stringers are braced together with 3 x 3 x ⅜-inch zigzag lateral angles riveted to their top flanges, and by vertical sway-brace frames midway between their ends. Each end of each stringer is seated on a 3½ x 3½ x ½-inch horizontal bracket angle, and is connected to the floorbeam by 28 ⅞-inch rivets through its web and two 13/16-inch reinforcement plates. The end panels of the bottom chords are stiff members, and are so arranged that the end floorbeams and their hangers intersect them at the theoretical center points. To accomplish this, the end hangers are inclined away from the vertical, toward the pier at one end and away from the pier at the other end. Both top and bottom lateral diagonals are pin-connected tension rods. The former are adjustable by right and left clevises, the latter by right and left sleeve nuts. The top lateral connection plates are riveted to the top chords and to the top lateral struts, which are comparatively deep and are riveted to the vertical posts.

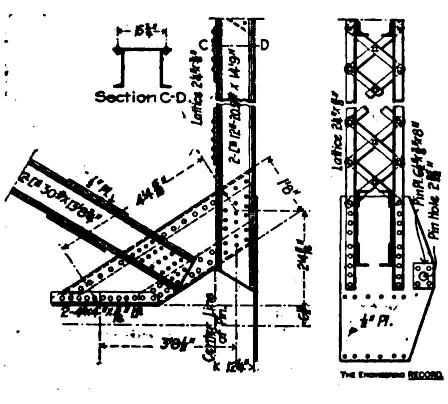
The ends of the floorbeams are cut to clear the heads of the lower-chord eye-bars and are connected to the vertical posts and to the stiff lower-chord sections by lateral connection plates riveted to their lower flanges. There are no pier floorbeams, and the end stringers have separate pedestals on the masonry and the truss shoes are connected by horizontal transverse struts. The portals are deep lattice girders with curved lower chords and solid web plates in the end panels, which are bent to throw the top-chord angles and the end-post connection angles into the required skew with the plane of the portal. The top chords have 24-inch cover plates and 18-inch reinforced web plates. In the outer truss the maximum sections are: top chord, 61.83 square inches; bottom chord, four 7 x 2-inch eye-bars; main diagonals, two 7 x 2-inch eye-bars; top lateral diagonals, one bar 1 inch square; bottom diagonals, two 4 x 1¼-inch bars with a net section of 10 square inches.

The bottom lateral system is made unusually heavy to resist the centrifugal strains from two Lehigh Valley heavy grade locomotives followed by a train and running at a speed of 50 miles an hour. The train load was assumed at 4,000 pounds per lineal foot and the dead load at 950 pounds per lineal foot for the inside truss and at 1,175 pounds for the outside truss. The centrifugal force was estimated to be 900 pounds per lineal foot of bridge, and the dead load at each panel point of the inner and outer trusses

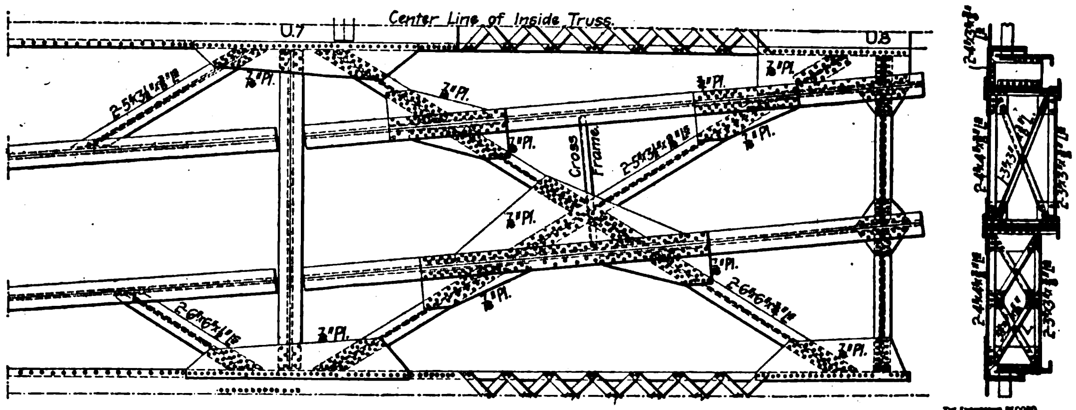


GENERAL VIEW OF THE BRIDGE AND APPROACH.





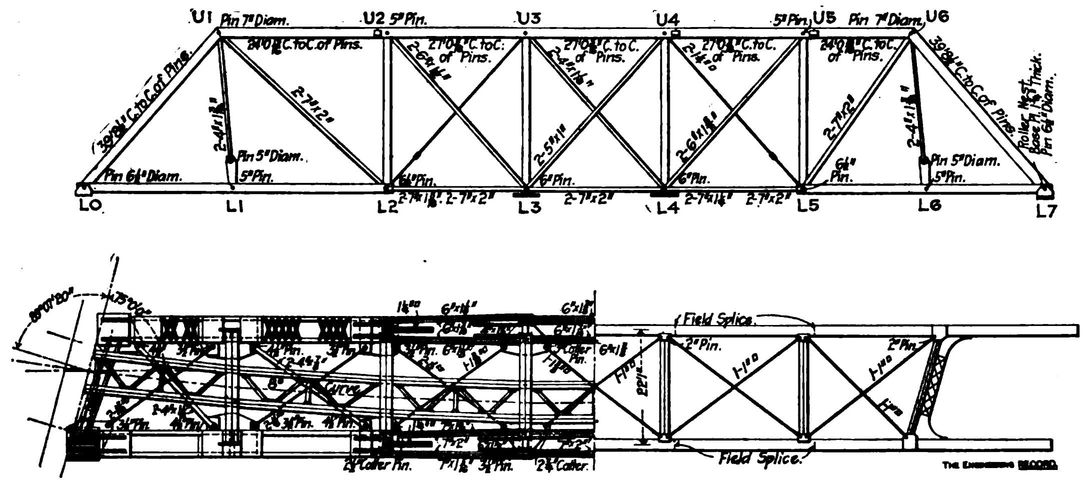
SWAY FRAME DETAILS AT U_1L_1.



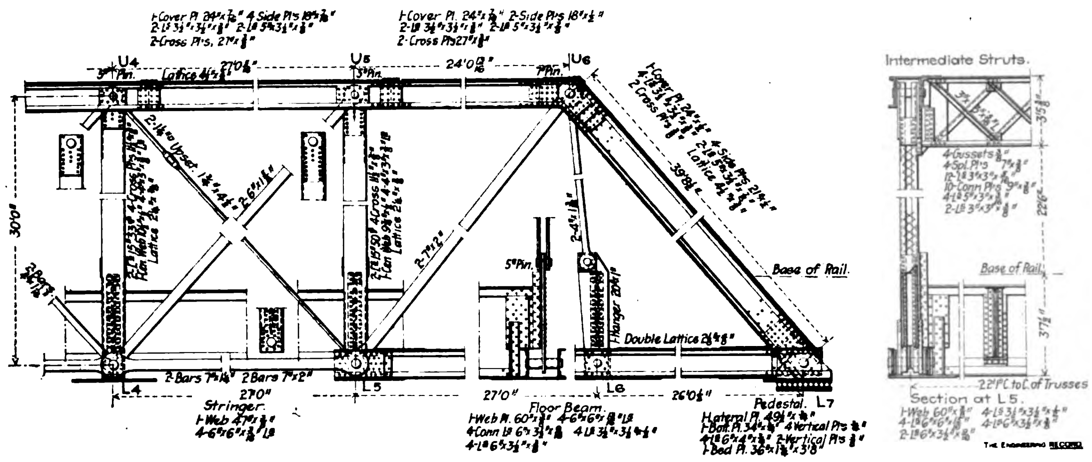
TOP LATERAL SYSTEM.

DETAILS OF SPAN 6-7, EASTON & NORTHERN RAILROAD BRIDGE, EASTON.

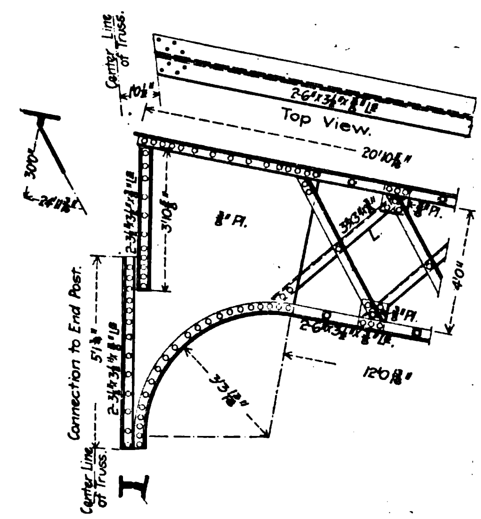
MR. CHARLES E. WEBSTER, CHIEF ENGINEER; MR. F. E. SCHALL, BRIDGE ENGINEER, LEHIGH VALLEY RAILROAD; UNION BRIDGE COMPANY, BUILDERS.



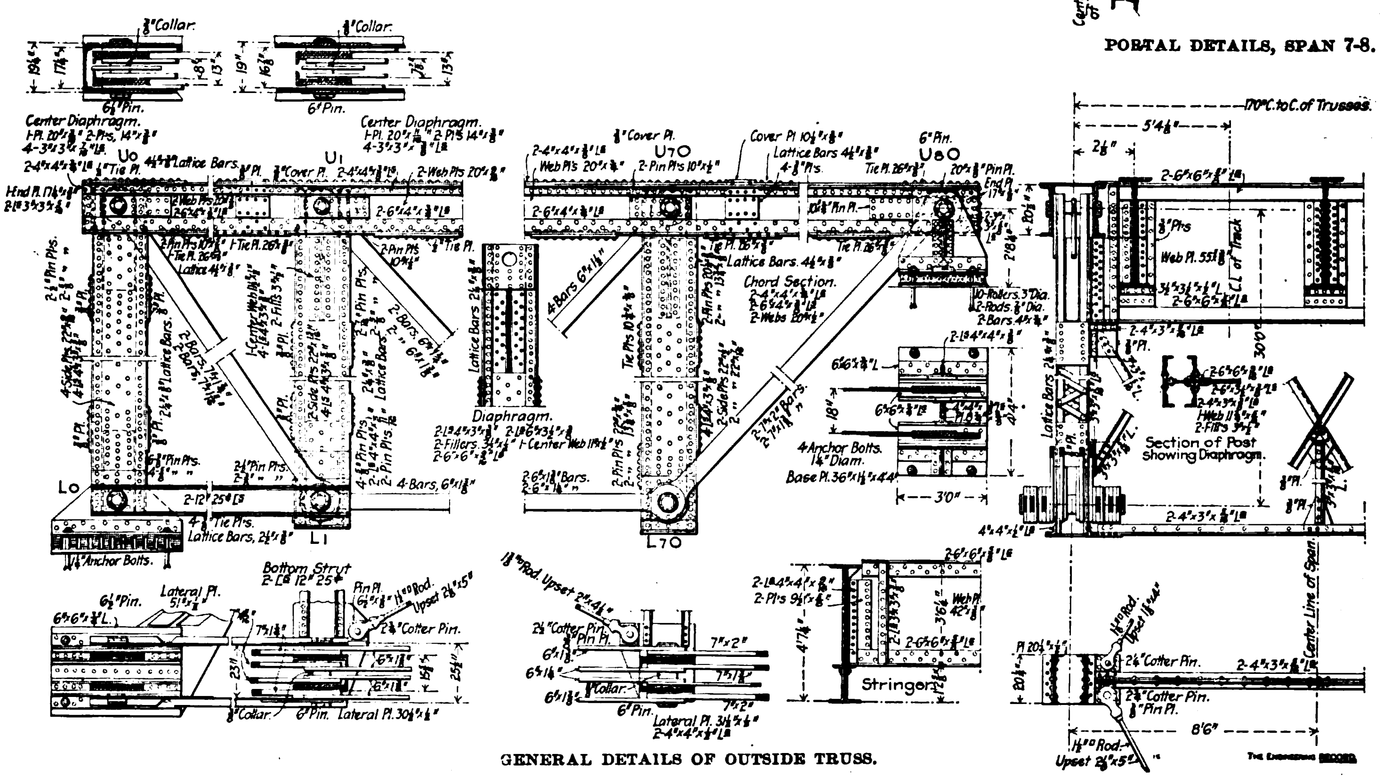
lateral angles have connection plates riveted to the top chords and to the top flanges of the floorbeams and stringers. They are cut off at intersections with the stringers. Where they intersect each other, one is cut to clear the other, and they are spliced by a large connection plate. The connection plates are in general shop riveted to the stringers and field riveted to the other members, except where a splice plate is shop riveted to a short intersecting lateral. In the intermediate panels the sway bracing is an intersecting pair of single diagonal angles, riveted to the vertical posts and having a suspension angle from their intersection to support the middle of the lower transverse strut, which is a pair of small angles back to back.



DETAILS OF OUTER TRUSS OF SPAN 7-8.



PORTAL DETAILS, SPAN 7-8.



GENERAL DETAILS OF OUTSIDE TRUSS.

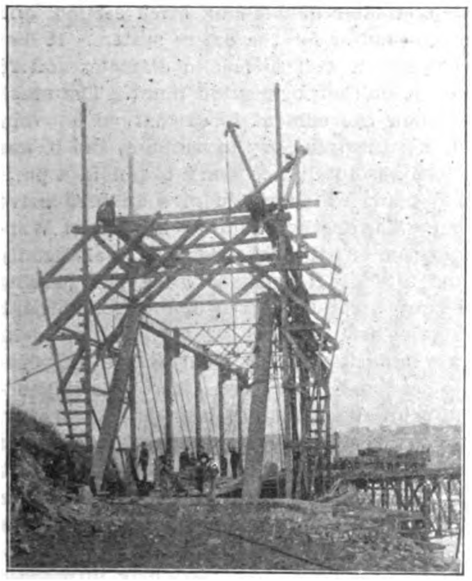
respectively as 25,650 pounds and 31,725 pounds. The maximum floorbeam end shear is 116,000 pounds; the section here is a 60 x ⅜-inch web and four 6 x 6 x 13/16-inch chord angles. The stringers have an end shear of 61,000 pounds, and are made with a 47 x ⅜-inch web, four 6 x 6 x 9/16-inch chord angles and five pairs of vertical web stiffener angles each. The intermediate top lateral struts are each made with four 5 x 3 x 5/16-inch chord angles and single 3 x 3 x 5/16-inch X-brace web lattice angles.

With the exception of spans 3-4 and 4-5, all deck spans are very badly skewed, one result of the location being to make it impossible to construct even two half trusses alike in spans 1-2, 2-3, 5-6 and 6-7. In these spans the arrangement of the stringers with regard to the 8-degree curve of the track and the attachment of floorbeams, laterals and chords to the same connection plate, are substantially the same. One truss of span 6-7 has a length of 194 feet 3 inches and the other 215 feet 1½ inches, as before stated. The dead loads per lineal foot were assumed at 1,129 pounds and 1,480 pounds respectively. The top chord was made throughout with a 26-inch cover, two 20-inch web plates and two 4 x 4-inch and two 6 x 4-inch angles. Its maximum section is 84 square inches in the outside truss. The corresponding maximum bottom chord is six 6 x 1 7/16-inch and two 6 x 1 3/16-inch eye-bars, equal to 66 square inches. The maximum diagonal is two 7 x 1¾-inch and two 7 x 1 11/16-inch bars, equal to 48 square inches.

The maximum bottom lateral diagonal is a bar 1⅝ inches square, and the maximum top lateral is two 6 x 6 x ¾-inch angles. The floorbeams have a 55 x ⅜-inch web and four 6 x 6 x ⅝-inch chord angles. The stringers are 6½ feet apart, and have an end shear of 66,000 pounds; they are made of a 42 x ⅜-inch web and four 6 x 6 x ⅝-inch chord angles. The top

The transverse vertical frame at the end of the trusses, which is supported by the lower chord pedestals, at one end, is exceptionally heavy. The diagonals and the lower strut are each composed of two 12-inch channels, connected at the bottom by diagonal gusset plates, as shown in the detail sketch, and riveted at the top to solid web knee braces, which engage the top of the vertical post and the lower flange of the floorbeam. The lower lateral diagonals are square bars connected by right and left clevises to horizontal plates riveted across the lower ends of the vertical posts, and receiving the field-riveted connections of the lower transverse struts.

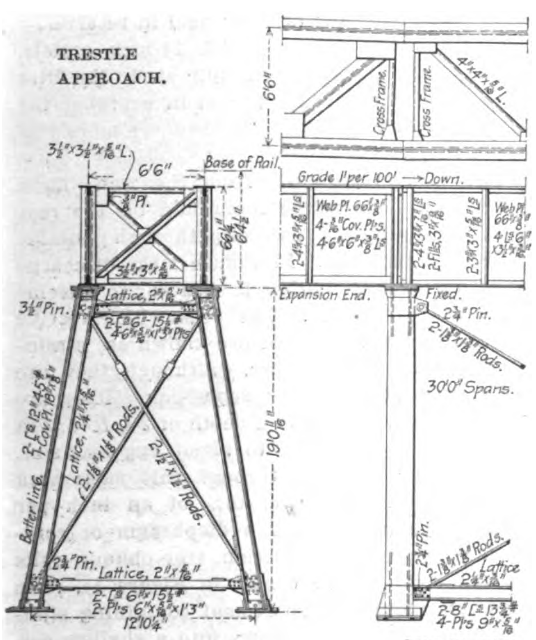
At the drop ends of the trusses the pedestals are unusually high to allow for the clearance of the end diagonal bars and for the expansion displacement. Each pedestal has four webs. The middle ones are connected by a vertical transverse diagonal plate with four stiffening and connection angles. The outside of each outer plate is also stiffened by a pair of vertical angles riveted together back to back. There are vertical diaphragms in the top chords to give center bearings to the pins, and there are vertical transverse diaphragms between the tops of the vertical-post webs to reinforce their floor-beam connections. At the square ends of the



TRAVELER USED ON THE EASTON BRIDGE.

trusses the fixed pedestals are seated on masonry plates made up of a top and bottom plate with piles of flat bars between them. Most of these bars are ¾ inch thick and a few are ½ inch thick. They are 3 inches wide except the end piles, which are 4 inches wide.

The approach viaduct is composed of alternate 30-foot towers and 60-foot spans, all plate girders 66 inches deep. The tower bents are duplicates of the one shown in the detail sketch, except for a variation in posts and bracing caused by the 1 per cent. grade. The long span girders have 6 x 6 x ⅝-inch chord angles, with two 16 x 9/16-inch cover plates. The short spans have 6 x 3½ x 9/16-inch chord angles. At the expansion ends of the long girders, guide strips are riveted at each side of the lower-chord flanges on the caps of the columns, and the girders are bolted to the column caps through slotted holes. The lateral and sway systems throughout were designed in accordance with Cooper's specifications of 1896, and the remainder of the structure conforms to his specifica-



tions of 1890. All material was medium, open-hearth steel. All rivet holes were punched 3/16 inch smaller and reamed 1/16 inch larger than the normal diameters of the rivets, and all sheared edges were planed.

The erection of the bridge began with the approach viaduct, which commenced practically at grade. The tower columns and girder spans were handled by an overhead traveler with an overhang sufficient to set one panel ahead. It was of a simple type used previously by the contractors for the erection of the Brooklyn Elevated Railroad. It consisted of an ordinary standard gauge platform car having a vertical transverse A frame bolted to its deck in front and braced back to the rear by an inclined stiff leg from the top. A boom seat was secured to the middle of the sill of the A frame, and received a 65-foot boom 14 x 16 inches at the lower end, and rigged with six-part 1½-inch manila tackles, its topping lift, being, of course, attached to the top of the A frame. The sill of the A frame was made longer than the width of the car so as to overhang it on both sides, where it was blocked up from the ground or from the completed portion of the viaduct so as to increase the lateral stability. The derrick car was provided with bolts and yokes by which it was clamped to the viaduct girders. Materials were delivered on a surface track alongside the viaduct, and unloaded by the boom swinging 10 or 12 feet from the center line. After the completion of the viaduct, the same traveler was utilized for the erection, on ordinary falsework trestles, of the first through span. The deck spans were erected on falsework supporting the lower chords and floorbeams and having outside tracks for an ordinary striding timber tower traveler. As fast as the bridge panels were built the track was laid on the deck and the material run up to the traveler, which unloaded it and assembled it with tackles suspended from the double longitudinal straining beams on top.

When the last span of the deck structure had been erected, the traveler was stripped and lightened as much as possible. Tackles were attached to its four corners, and it was lifted up about 30 feet to the level of the last span of falsework on which the lower-chord and floor system of the last through span had already been assembled. The traveler had been built to clear the through trusses, and its four plumb posts had been made extra long so as to extend 15 or 20 feet above the upper crossbeams and form derrick masts from which high-level booms could be operated. There booms were rigged on the rear side of the traveler only, and with them the materials were unloaded from the cars and delivered to the tackles suspended from the regular lifting beams. The front plumb posts were not utilized for derrick masts, but were left as long as the others to avoid unnecessary cutting of the long timber. In the engraving, the last span is shown nearly completed. But one boom is in place, and its mast is braced to the top of the traveler by two stiff legs. The erection was accomplished by an average gang of 40 men, who commenced the work on September 10 and finished it on February 25.

Mr. Charles E. Webster was the chief engineer of the railroad company. Mr. F. E. Schall, now bridge engineer of the Lehigh Valley Railroad, inspected all the plans and passed on details submitted. The bridge was designed and constructed by the Union Bridge Company of New York City, and the details of the superstructure were worked out at its shops at Athens under direction of Mr. O. E. Hovey. The Terry & Tench Construction Company was the subcontractor for the erection.

FLORENCE, COLO., WATER-WORKS.

[By R. P. Garrett, Resident Engineer.]

The town of Florence has a population of about 6,000 inhabitants and is situated on the Arkansas River, about 34 miles west of Pueblo. For several years the only source of water supply available was the Arkansas River. The water of this stream was undesirable because during the season of low water, the discharge of sewage from the State Prison, at Canyon City, only 8 miles above, made it unfit for domestic use, and at all times the water is so highly impregnated with alkali as to make it undesirable for nearly all purposes except irrigation. For several years the Denver & Rio Grande Railroad Company has supplied a limited number of people from a plant designed primarily for its own use in furnishing water for its locomotives.

The people were almost unanimously in favor of the town constructing and owning its own plant. The most difficult question to be decided was where to get the supply. Besides the Arkansas River, another source of supply was a mountain stream some 10 miles from the town.

In the fall of 1898 Mr. Hiram Phillips, M. Am. Soc. C. E., was called into consultation. Mr. Phillips decided on a mountain system and designed the plant which is now in successful operation. The chief obstacle which had to be overcome in designing this system was the cost of a pipe line about 10 miles in length. The source of supply being about 2,000 feet above the town, a gravity system was designed, and the cost of the line was materially lessened over the cost of a cast-iron pipe line by the use of sewer pipe for about 7 miles of the distance. The stream flows out of the mountains and down a sandy valley which would lead it to the Arkansas River did it not disappear in the sand about a mile and half from where it leaves the canyon in the mountains.

At a point near the mouth of the canyon where the wall rocks close in, a submerged dam

METHOD OF TRENCHING.

was built resting on solid rock and impervious to water, thus forcing all the water to the surface, where it was allowed to flow through the pipe, through which it was conducted to the storage reservoir about 350 feet above the town.

The reservoir was designed to hold about 50,000,000 gallons. The purpose of the reservoir is to store the water resulting from the melting snow and rains, to be used during the dry seasons of the year. A steel tank holding 450,000 gallons is located about 150 feet above the town. This gives a working pressure in the mains of about 60 pounds per square inch. The system is so constructed that the tank is always filled before any water can enter the reservoir. This was acomplished by placing a basin above the reservoir at such a distance that the water would flow into it at all stages. The 12-inch pipe leading from the basin to the reservoir was placed about 2 feet above the pipe leading around to the steel pressure tank. When the tank is filled a float valve closes the pipe, which in turn is filled up to the basin. The water then runs through the upper pipe leading to the reservoir. Two hydraulic valves are placed at the steel pressure tank, and are operated from the town hall by means of a small pipe connection. By means of these two valves the tank may be cut out of the line and the entire pressure from the reservoir put in the town mains. These valves and connections are constructed so that their operation is slow, in order to avoid excessive, sudden increase of pressure in the mains.

Perhaps the most interesting feature of the