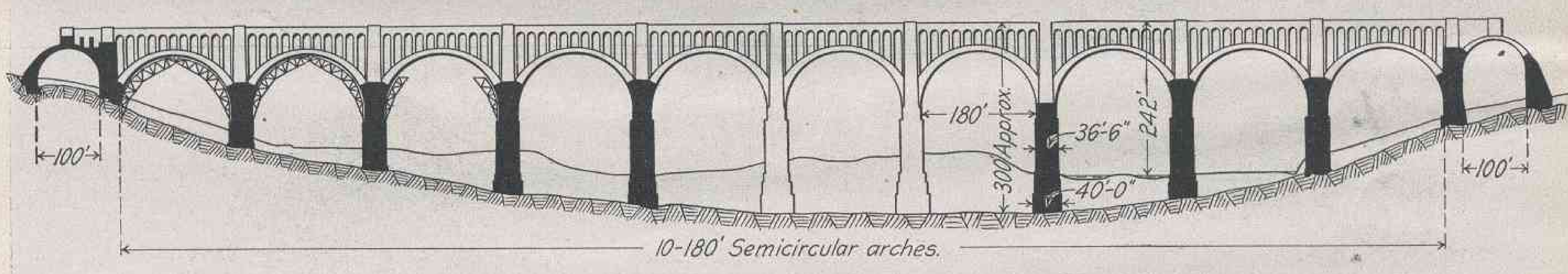
SUMMIT-HALLSTEAD CUT-OFF OF D. L. & W.

Second Article on this Improvement Work Describing the Largest Concrete Arch Bridge in the World and Other Structures.

The unusual operating economies which will be effected on the Delaware, Lackawanna & Western by the expenditure of about $12,000,000 for replacing 40 miles of line between Clark's Summit, Pa., and Hallstead, and the interesting features of the heavy grading and tunnel work now under way on this section, were described in the *Railway Age Gazette* of November 14, 1913. The present article takes up the bridge work that has been done on this line up to the present time, dealing only with the substructures of the two concrete arch viaducts which are exceptionally large and will require a considerable time for their completion. When the superstructures of these bridges have been sufficiently advanced, another description will be presented covering the design of the entire structures and the contractors' methods as developed during the course of the work.



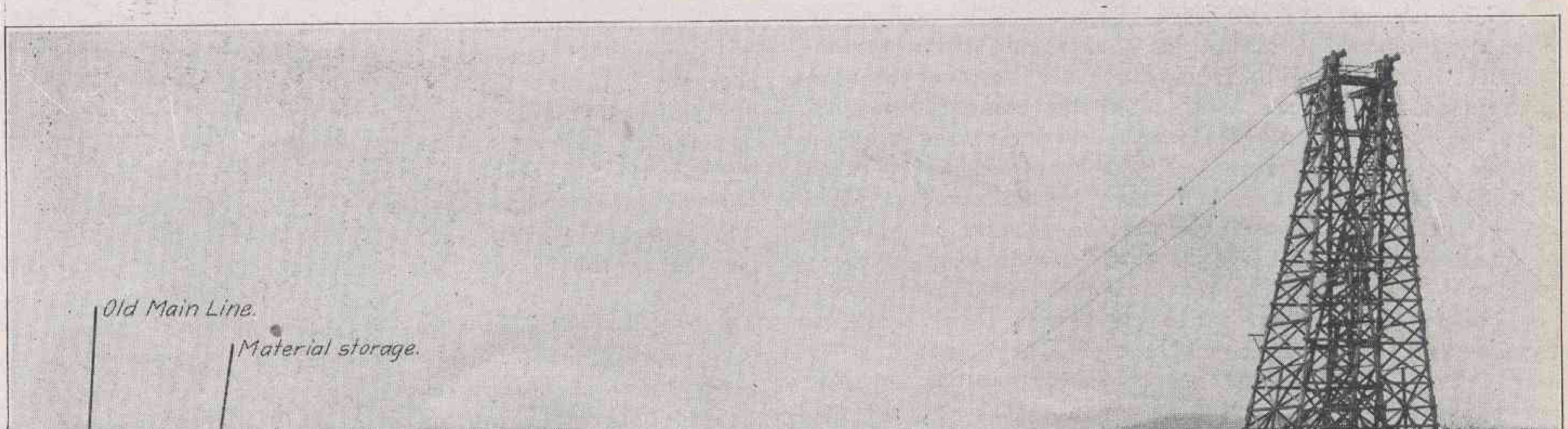
Elevation of Nicholson Viaduct, Showing Progress to November 1.

The two concrete viaducts over Tunkhannock creek and Martin's creek will require about 167,000 and 78,000 yds. respectively, and the minor structures which are about 80 in number, will require 155,000 yds. of concrete, making a grand total of 400,000 yds. exclusive of tunnel lining and other minor quantities. All highways on the new line are carried either over or under the new grade. The elimination of these 22 grade crossings was an important consideration in making the improvement, as all of these would have required elimination in the not very distant future. All structures carrying the roadbed will be of concrete except where the available clearance is not sufficient to permit the use of an arch or reinforced slab, or where the foundation is of such a nature as to make it inadvisable to use a concrete structure.

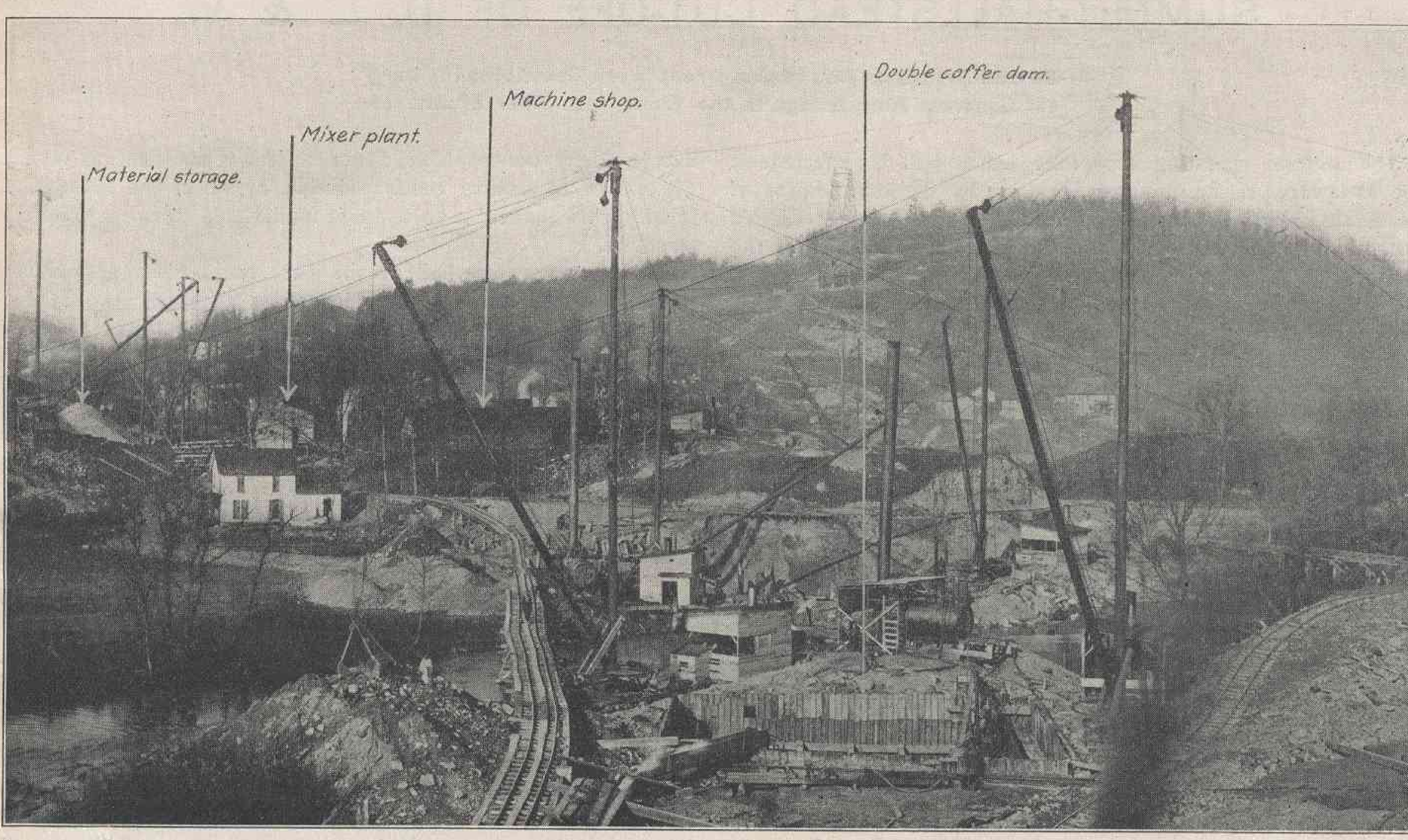
All structures were built to the same standards and specifications that were used on the Hopatcong-Slateford cut-off (see *Railway Age Gazette* of December 6, 1912, and January 3, 1913), except that cement is required to leave not more than 22 per cent. on the 200 sieve and to pass the auto-clave test. This test is carried out as follows: Six neat briquettes are made in the usual manner and placed in a damp closet for 24 hours. They are then removed and three of them broken in the standard tension machine in the usual manner. The other three are placed in an auto-clave, heat applied, and the pressure gradually raised to 295 lbs. in 1 hour. This pressure is maintained for 1 hour and then gradually released. The briquettes are taken out, allowed to cool and then broken in the standard machine. The average of the three briquettes taken from the auto-clave shall show an increase in tensile strength of at least 25 per cent. as compared with the average of the three briquettes tested in the usual manner.

TUNKHANNOCK VIADUCT.

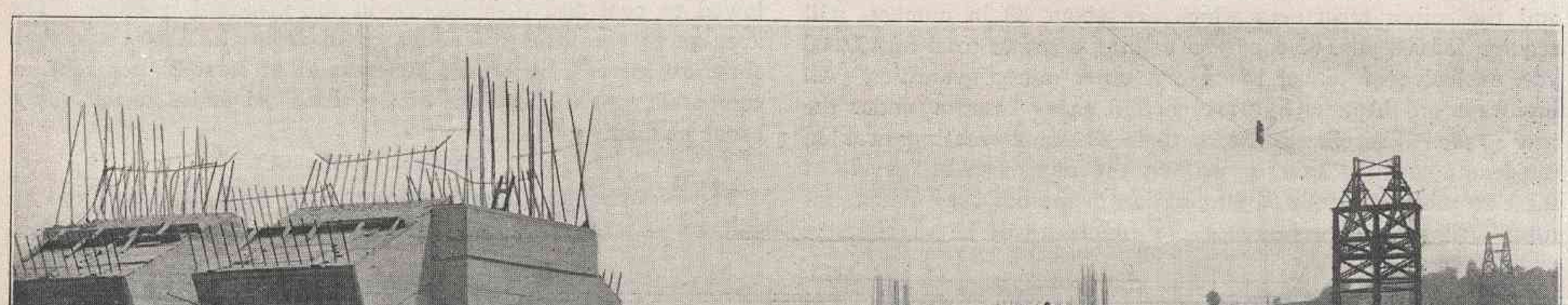
The Tunkhannock creek structure is 2,375 ft. long, end to end, of masonry, and 242 ft. from top of coping to stream bed,



General View of Tunkhannock Viaduct Location, Showing End Tower and Operator's House of Material Cableway in Foreground



Looking Along Center Line of Tunkhannock Viaduct in Early Stages of Construction.

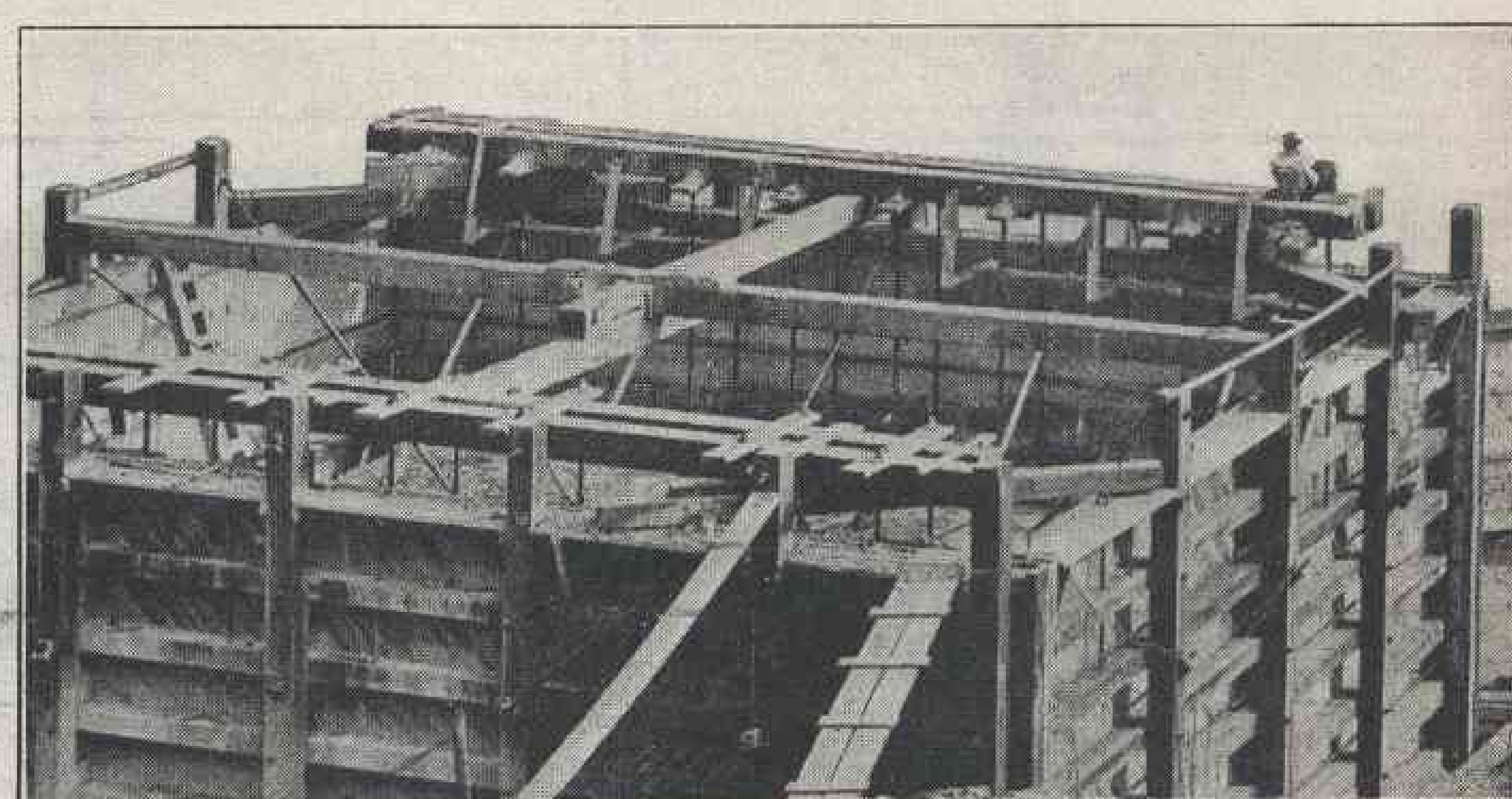


Two of the Tunkhannock Viaduct Piers with Umbrella Sections Completed.

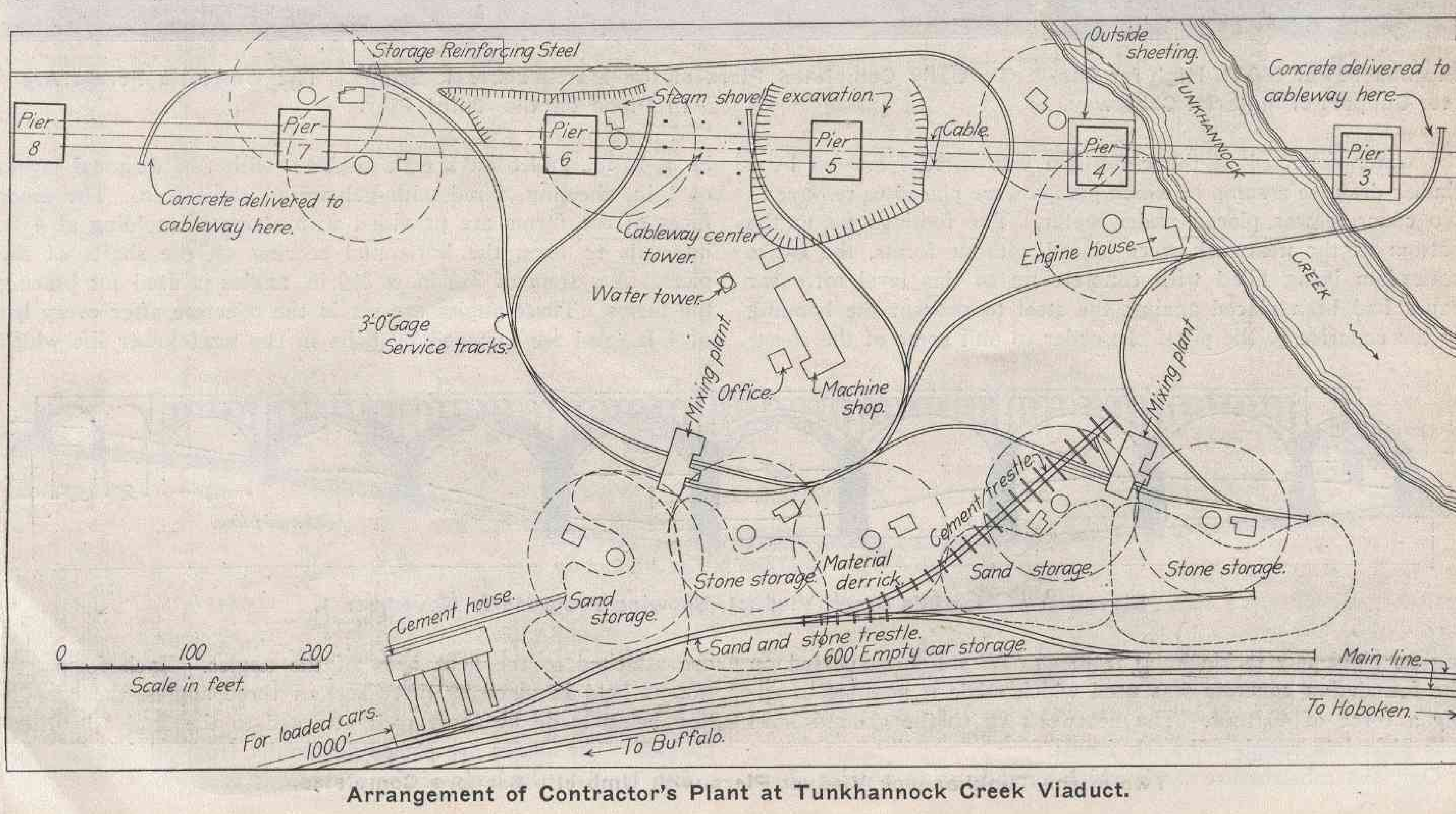
which will be the largest concrete arch bridge in the world. It is composed of ten 180-ft. semi-circular intermediate arch spans and two 100-ft. semi-circular abutment spans, being designed to carry two tracks. The abutment spans will be buried in the end embankments so that they will not be apparent after the work is completed. This viaduct will contain approximately 167,000 cu. yds. of concrete, 2,275,000 lbs. of reinforcing steel and will require the excavation of 43,500 cu. yds. of material for the foundation.

Showing Sectional Pier Forms and Double Cableway.

The piers are 36 ft. 6 in. x 43 ft. 6 in., and are solid below the springing line. The higher piers are 40 ft. x 46 ft. below the ground line, and all piers are carried down to rock, which is reached at a depth of 10 to 95 ft. below the ground surface, making the difference in the elevation between bed rock and top of coping at the deepest piers about 300 ft. With the exception of the abutments, one pier at each end and three other piers, the foundations were excavated down to water level or to rock by a Model 40 Marion steam shovel, using a one-yard dipper. The material encountered was sand and gravel and was allowed to take its natural slope. In most cases the shovel was allowed to cut its way from pier to pier, and the material was used in filling under the temporary material tracks. The abutments and four piers were built in open excavation without sheeting. For the other piers, interlocking steel sheet piling were driven by a steam hammer. The deepest foundations required two lengths of 30 ft. sheeting, the upper set being driven 4 ft. 6 in. outside the lower to give clearance for the hammer and leads. The inner set was driven first and the excavation carried down with the driving. When the outer set was started both were carried



Looking Into One of the Pier Forms, Showing Reinforcement and Form Bracing.

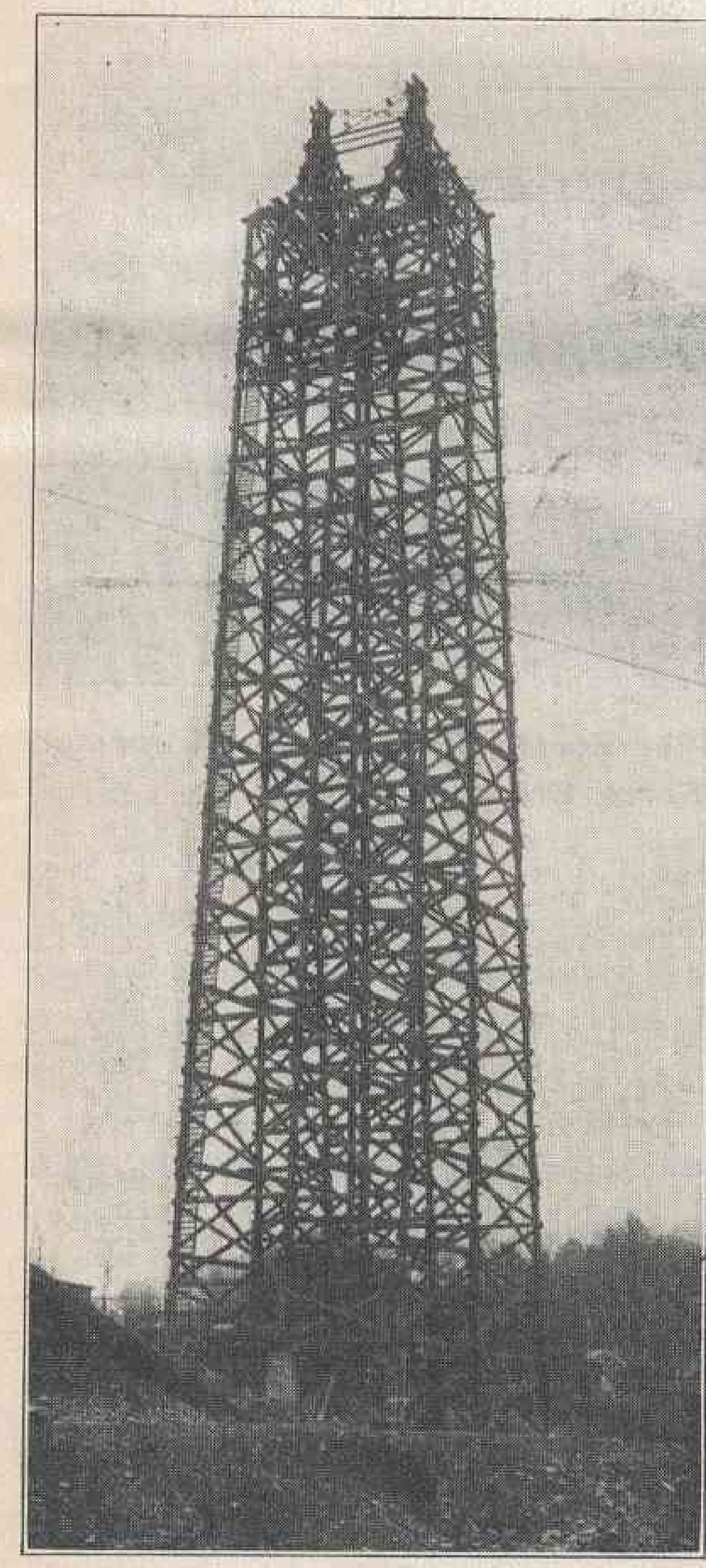


Arrangement of Contractor's Plant at Tunkhannock Creek Viaduct.

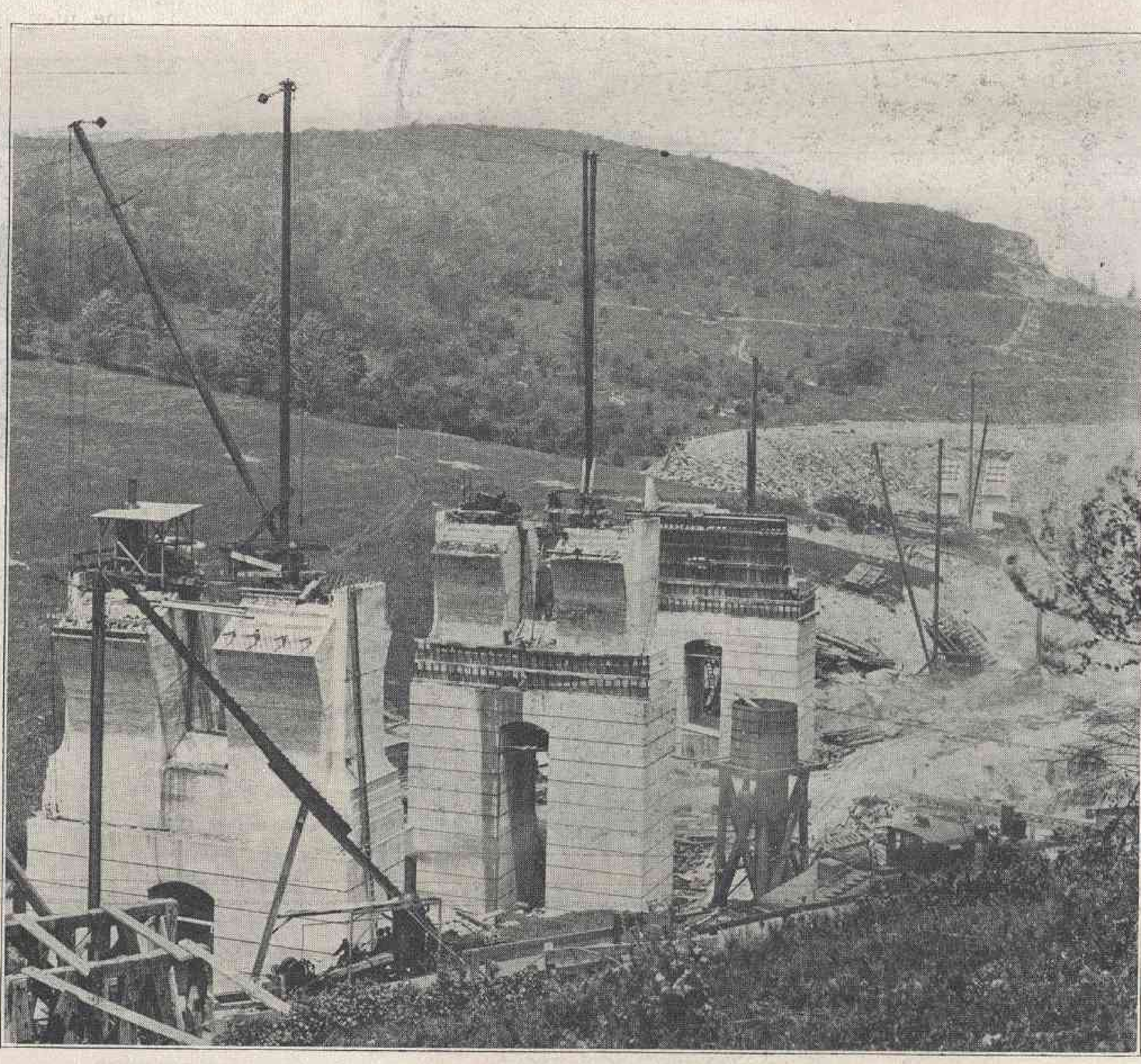
down together, the bracing for the upper set being entirely above the tops of the lower piles so that there was no interference between the two sets of bracing.

The soil through which these cofferdams were driven was largely wet sand, making the pressure unusually high on such deep excavations. Considerable trouble was experienced in one of these deep piers on account of the shifting of this pressure, causing damage to the piles and allowing water to enter. The material was removed by clamshell buckets, some boulders being removed by hand.

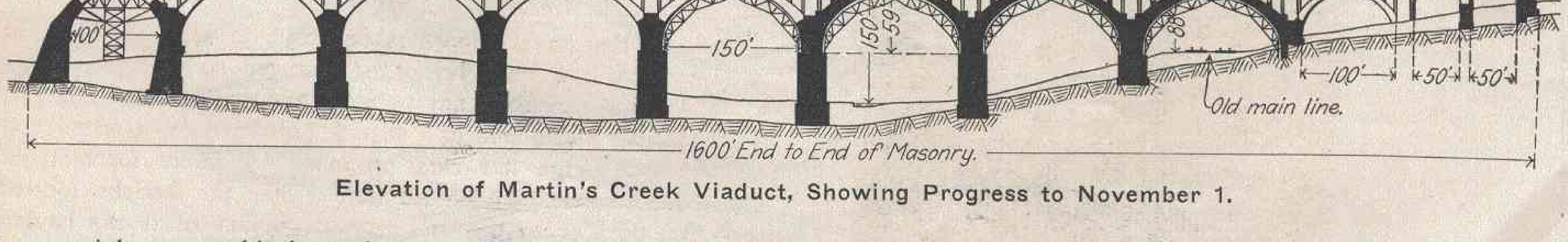
In placing concrete after excavation was completed to rock the water collected in the cofferdam was carried around by a timber drain to a sump in which pumps were placed to remove it. No concrete was placed under water. The footings up to the bottom of the neatwork were placed without forms, the entire cofferdam being filled with concrete up to this level after tar paper had been placed against the steel to prevent the bonding of the concrete to the piles. In order to pull some of the sheeting an eight-part tackle hung from an "A" frame supported on the foundation concrete was used which made it possible to apply a force of 40 tons. The neatwork up to the ground level was placed in rough cribwork forms.



Framed Tower 260 ft. High for Center Support of Material Cableway.

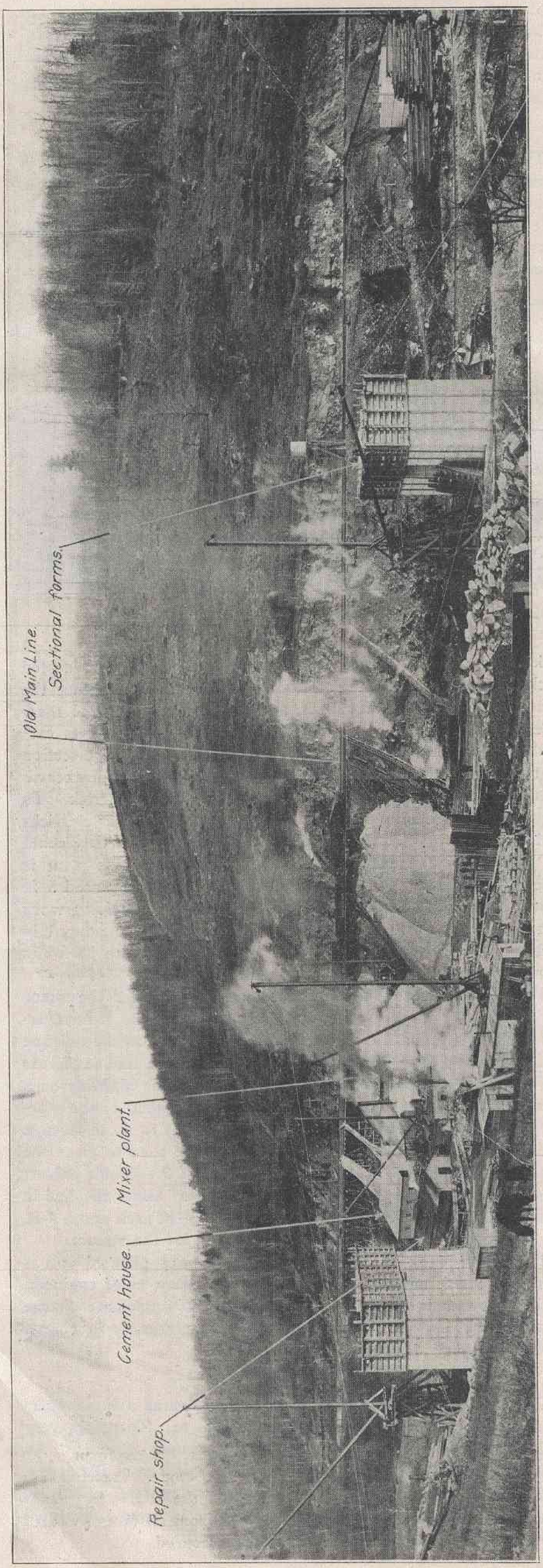


Partially Completed Piers of the Martin's Creek Bridge. The Umbrella Forms Are in Place on the Third Pier.



Elevation of Martin's Creek Viaduct, Showing Progress to November 1.

Only the substructure work which extends up to a point about 37 ft. above the springing line of the arches will be considered at this time. The piers have a 4-ft. offset on each side at an elevation 17 ft. 6 in. below the springing line to support the arch centers, but the 37-ft. section above the springing line is built as a part of the piers, this so-called "umbrella" system being similar to that used on the Delaware river bridge of the Philadelphia & Reading, described in the *Railway Age Gazette* of April 25. The forms used on the bodies of the piers are built up in ten sections 17 ft. 9 in. high in which a 16 ft. lift is made. These sections can readily be handled by the derricks and are used a number of times. The framing of these forms is of 8 in. x 10 in., and 6 in. x 8 in. timbers, with two diagonal layers of 1 in. sheeting, faced with galvanized sheet iron. The inner faces of the forms are provided with strips of molding at 4 ft. intervals to form the horizontal scoring on the shafts of the piers. A system of 3½ in. x 3½ in. angles is used for bracing the forms. These angles are set in the concrete after every lift of 4 ft., and are fastened by bolts in the next lower lift which are attached to the bent ends of the angles. Each form section is held in place by three sets of these angles, the connection being made by short rods attached to the angles by turnbuckles. The angles are placed diagonally from all faces so that a firm bond to the body of the concrete is secured.



General View of Martin's Creek Viaduct Site Showing Contractor's Plant.

The material is being handled by a combination of derricks and a double cableway over the center line of the bridge. The cableway is supported on three framed towers, and is composed of two 2¼-in. cables placed 20 ft. center to center. The end towers are 3,028 ft. apart, and are 150 and 165 ft. high respectively. The center tower is 260 ft. high and 40 ft. x 60 ft. at the bottom, dividing the cableway into four independent operating units. The cables are designed for an average working load of seven tons and a maximum load of 10 tons. An operator's house with two independent hoisting engines is located back of each end tower, one of these being shown in the foreground of the accompanying photograph. The construction of this cableway in itself is an unusual feature of the work. The total length is thought to be the longest ever attempted for cable operation, and the height of the center tower the greatest ever used to support a cable. The complete cable equipment was installed by the Lidgerwood Co. It will be necessary before the completion of the superstructure, to add a section on the top of the center tower, this addition being provided for in the design. On account of the distance between the operator's house and the points of loading and unloading the cables, it was found necessary in order to operate successfully to install a complete telephone system so that the operators could receive all signals from the men at the loading and dumping points by telephone. The operators are provided with head sets, which allow the free use of both hands for operating the engines.

The contractor's plant is complete in every detail and is carefully designed to allow the most economical handling of material. All material is delivered on a 1,600 ft. side track adjacent to the old line, which is about 300 ft. from the new bridge. As an indication of the amount of material handled by this plant, 635 cars of material have been delivered to this siding in a single month. The sand and stone which are brought in bottom dump coal cars are dumped into storage piles from a material trestle about 30 ft. high. A 4,000-bbl. cement house with four covered chutes is provided for the storage of cement for mixing plant No. 1, and a trestle is carried out to plant No. 2, which allows the cement to be handled directly from cars. Derricks operating clamshell buckets are located at convenient points between the storage piles and cement house and the mixing plants to elevate the sand, stone and cement to material bins or the charging floor.

The two mixing plants are duplicates and are housed in frame buildings 40 ft. high, allowing the operation of narrow gage cars carrying concrete buckets directly under the mixers. Each plant has a capacity of about 40 cu. yds. per hour. The charging hoppers over each mixer are bulkheaded vertically to separate the sand and stone, a system which has proved much more effective in the proper proportioning of the materials than the horizontal gage lines frequently used. The cement is distributed evenly over both the sand and the stone. Cube mixers receiving water through the main trunnion are used. The plant is carefully designed as to all its details, the provision for inspection, for instance, being so carefully arranged that one man standing near the charging hopper can watch the proportions in the hopper, the water gage and all the points which should come under his attention. Live steam is piped to the material bins for use in freezing weather.

Each of the mixer plants is designed to serve half of the structure, but the track layout is arranged so that the output of either plant can go to any point on the bridge. The concrete is taken from the plants in 2-cu. yd. bottom dump buckets carried on 3-ft. gage flat cars propelled by dinky locomotives. These locomotives deliver concrete either to derricks located near the piers or to the cableway, a number of tracks having been laid out for the purpose of delivering these buckets to the cableway at convenient points. The general layout of the contractor's plant is shown in the accompanying drawing.

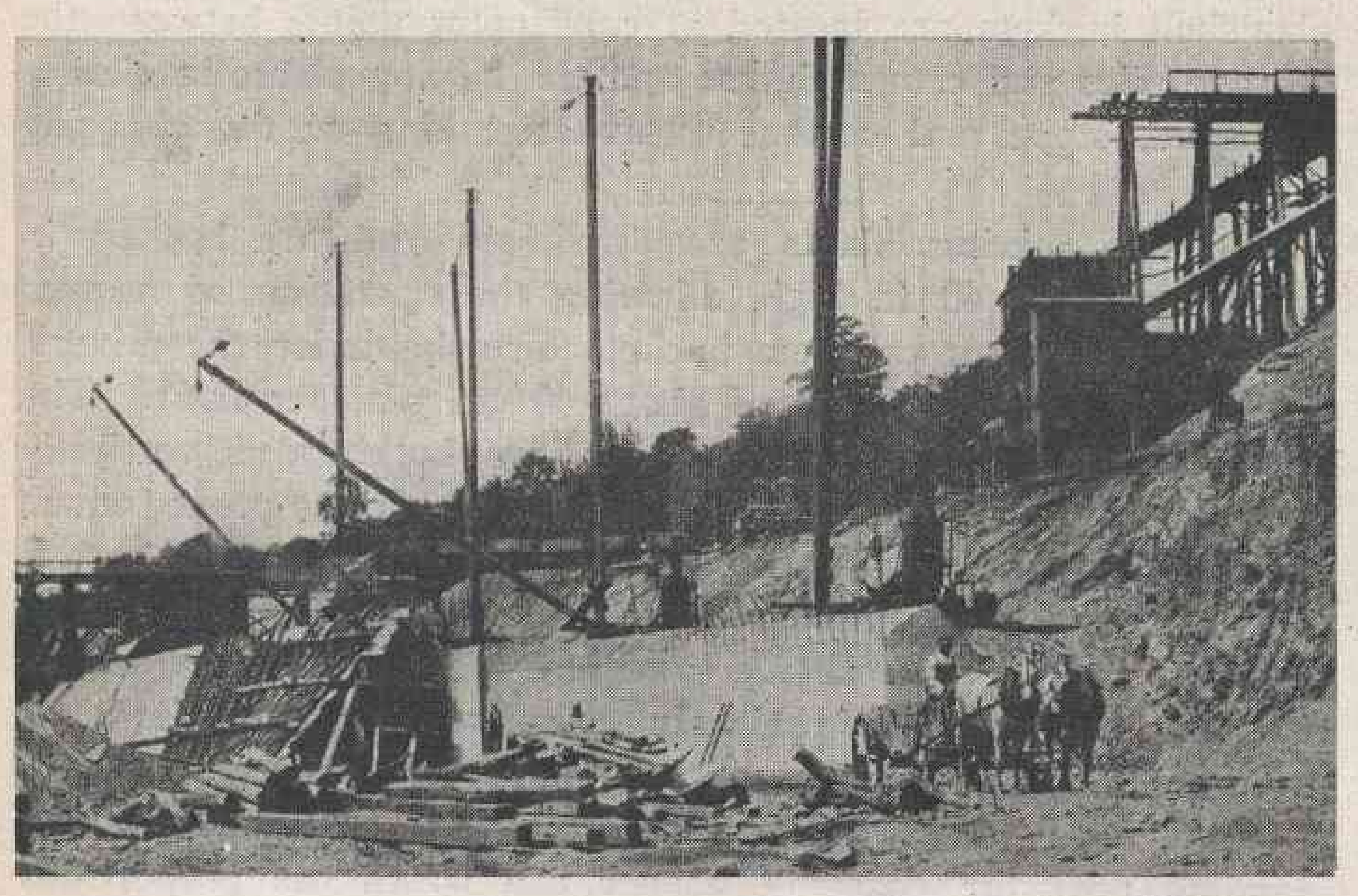
Three grades of concrete known as "A," "B" and "Cyclopean" are used in this structure, class "A" being a 1:2:4 mixture, which is used on very thin heavily reinforced walls; class "B" is a 1:3:5 mixture, which is used for the arch rings, floor system, and all work above the springing line, except where class "A" is specified; "Cyclopean" is the same mixture as "B," with large derrick stone bedded in the concrete, and is used in most of the work below the springing line. This work, which is being handled by Flickwir & Bush, New York, was begun about August, 1912, and more than 85 per cent. of the foundation excavation has been finished, and more than one-third of the total yardage of concrete placed.

MARTIN'S CREEK VIADUCT.

The bridge over Martin's creek is about 1,600 ft. long and is being built for three tracks. The top of rail on the new structure is 150 ft. above the bed of the stream and 88 ft. above the old tracks. It is composed of two 50-ft. and two 100-ft. semicircular arches, and seven 150-ft. by 59-ft. three-centered arches. The structure is similar in general design to the Tunkhannock bridge, and will require about 27,000 cu. yds. of foundation excavation, 78,000 cu. yds. of concrete and 1,600,000 lbs. of reinforcing steel. About 85 per cent. of the foundation excavation is completed and nearly one-third of the concrete is in place.

The main piers are solid for 17 ft. below the springing line and below that elevation they are divided into two legs 23 ft. by 28 ft., separated by a 12-ft. opening. All piers are built on solid rock, which is reached at an elevation varying from 10 to 60 ft. below the ground surface. A steam shovel was used to excavate these foundations down to the water line, and Lackawanna sheet piling were driven by a 6,000-lb. Vulcan hammer below the water line.

The contractor's plant for this structure is almost identical with that in use at the Tunkhannock viaduct, except that no cableway is used, all material being handled by trains and derricks. Two sidings are provided along the old line opposite the new bridge, one over the storage piles and one which is used for holding cars temporarily. A 3,000-bbl. cement house with two chutes is provided near the sand and stone storage piles, as shown in the accompanying photograph. The mixer



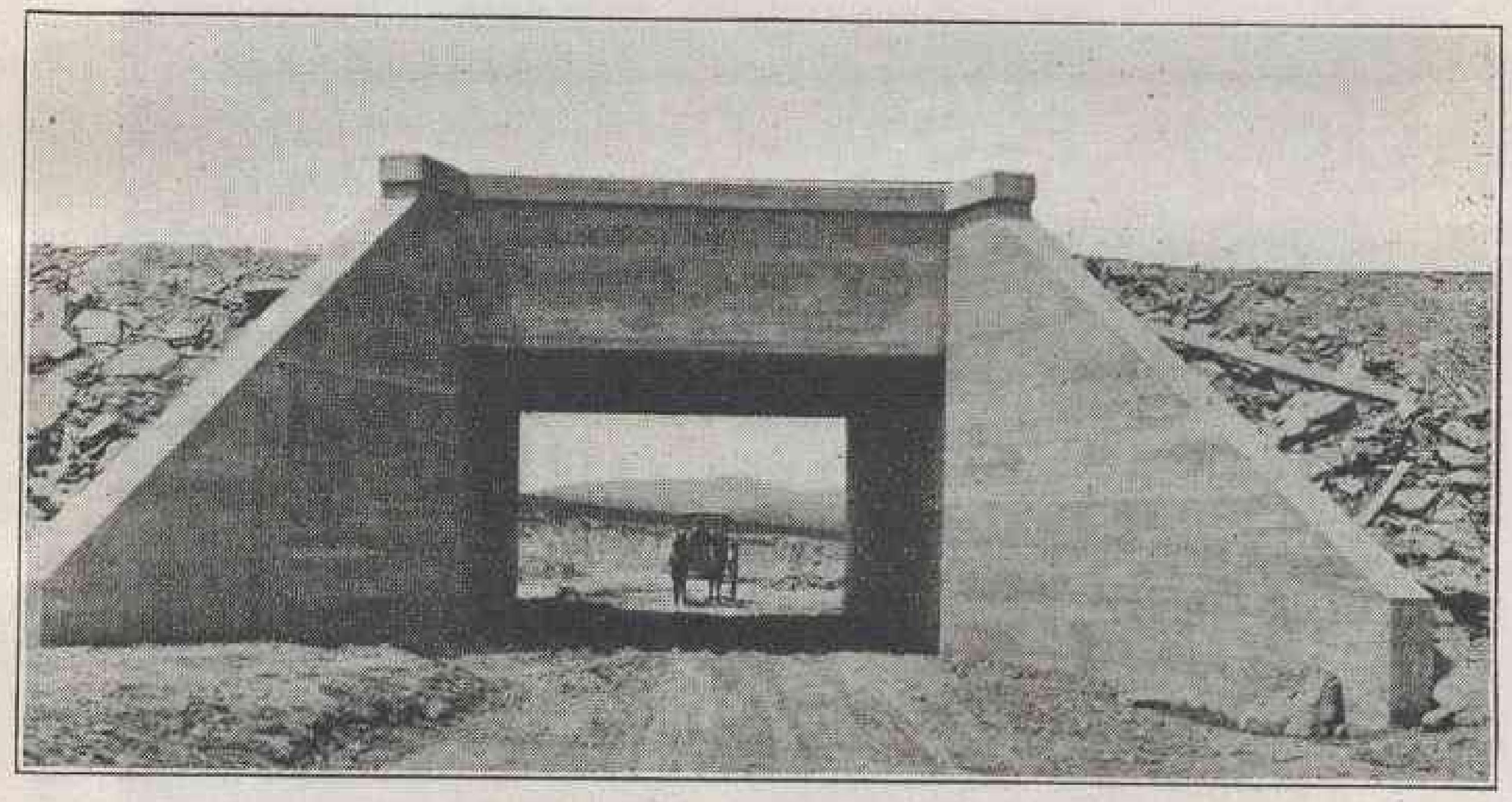
Contractor's Layout for Arch Under Smith Fill.

plant, which is a duplicate of the ones used at Tunkhannock, is located near enough to the storage piles to be served by derricks. On account of the number of narrow gage tracks around the mixer plant the contractor installed an eight-lever interlocking plant to handle all switches in these tracks. One man located on a platform raised slightly above the track level handles all the switches more easily and more rapidly than if they were hand thrown, and on account of the large number of movements that are made over these tracks the machine is an important safety factor.

For the early stages of the piers all material was handled by derricks located in each span. After the completion of the umbrellas on the base of the piers, derricks will be erected on top of this masonry which will be allowed to remain there to handle the concrete for the superstructure. A saw mill, a complete machine shop and a power plant for generating electric light are included in the contractor's layout. This work is being handled by the F. M. Talbot Company, New York.

OTHER STRUCTURES.

The 30-ft. roadway arch under the Smith fill was handled in a manner typical of a large part of the concrete work on the minor structures. The concrete plant was located on the north side of the arch, all materials being brought in by narrow gage cars to the top of the adjacent fill, from which they were chuted down to the storage bins above the mixing plant. Four der-



A Typical Highway Undercrossing.

ricks, two with 78-ft. and two with 68-ft. booms, were located back of the north abutment and were used for handling the concrete from the mixing plant, and also for handling the Blaw steel forms. The ¾-yd. mixer dumped into 1-yd. buckets carried on small flat cars, which were run out on a short section of track from the mixing plant to the edge of the arch excavation, where they could be reached by the nearest derrick. To place the concrete in the ends of the arch the center derricks had to swing these buckets out to a point from which they could be reached by the end derricks. In this manner this plant is able to place about 275 yds. a day. The forms were placed 5 ft. center to center, and 3¼-in. lagging was used. The form work was erected in 50-ft. sections, and the concrete was poured in sections 40 ft. long. In turning the arch, from 10 to 12 hours were required to pour one of these sections.

The concrete arch which carries a highway under the Riker fill was shown in the photograph accompanying the former article. The materials for the arch were brought in on the old line and carried up from the siding on a narrow gage incline, across the new line, and out over the new location of the highway on a trestle, which allowed sand and stone to be dumped to the storage piles. The mixing plant is located adjacent to those storage piles and the derricks shown in the view were used to place the concrete in the arch. At Alford on section No. 9 a double culvert was adopted carrying a roadway and waterway under the line in a single structure. The roadway occupies a 24-ft. arch and a 4-ft. by 6-ft. culvert below the roadway provides for the stream.

The entire work of building this cut-off was planned and is being executed under the direction of G. J. Ray, chief engineer. F. L. Wheaton is engineer of construction in immediate charge of the work, and A. B. Cohen, concrete engineer, is in charge of the masonry designs.

CAR LIGHTING IN JAVA.—In Java railway trains are not operated at night; that is, from 7 p. m. to 5 a. m. Therefore very little provision is made for lighting passenger coaches. An acetylene plant has recently been installed, however, at Bandeong, which has a capacity of 15 tubes per day, compressed to 220 lbs. per sq. in.; and acetylene lighting apparatus is being substituted for oil lamps in the cars of the through trains.