Progress on Summit Cut-Off of the Lackawanna

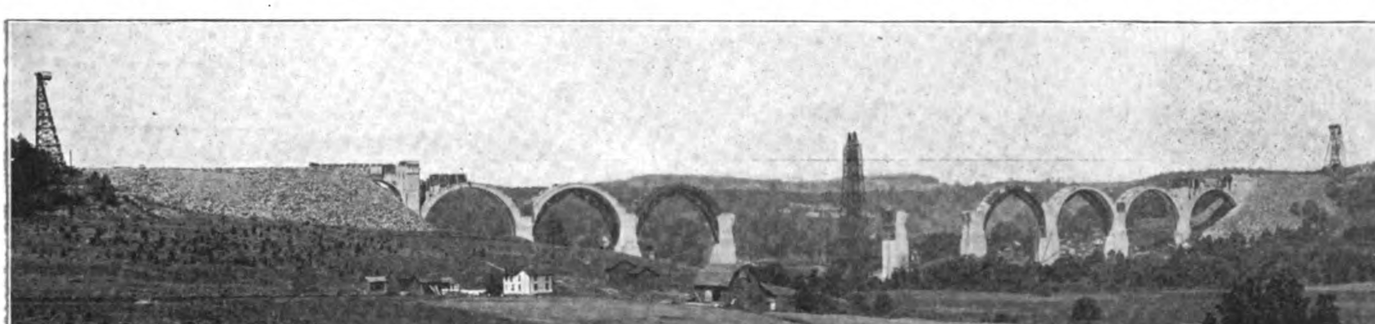
A Description of the Present Stage of Construction of World's Largest Concrete Bridge and a 3,630-ft. Tunnel

It is expected that the new three-track line of the Delaware, Lackawanna & Western between Clark's Summit, Pa., and Hallstead, on which some unusually heavy work has been under way for the last three seasons, will be ready for operation by December 1 of this year. This cut-off of 39.6 miles is being built at a cost of about $12,000,000 to reduce the distance 3.6 miles, the maximum grade eastbound from 1.23 per cent uncompensated to 0.68 per cent compensated and westbound from 0.52 per cent uncompensated to 0.237 per cent compensated; and the maximum degree of curvature from 6 deg. 22 min. to 3 deg., to eliminate 327 ft. of rise and fall and 2,440 deg. of central angle, to add a third track and to abolish all grade crossings. As the maximum train loading is fixed by the grades on the remainder of the engine district, no increased tonnage will be made possible by the improvement, but an important saving in mileage of helper engines and in running time over this portion of the line will be effected. The reasons for this work were fully covered in the *Railway Age Gazette* of April 25, 1913, and November 14, 1913.

A General View of Martin's Creek Viaduct Which Is Now Completed

GENERAL

The construction of this line required the excavation of 13,318,000 cu. yd. of material. The interesting methods of handling this heavy grading work were described in the second article referred to above. The grading is now about 85 per cent completed and about 25 per cent of the track has been laid.



A General View of the Tunkhannock Creek Viaduct Under Construction

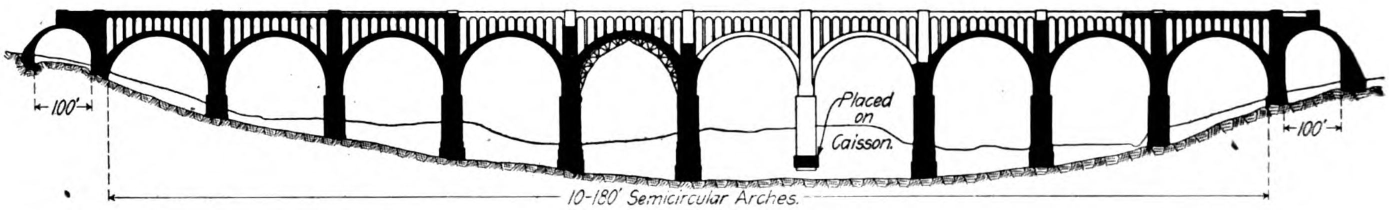
The small bridge work is practically completed, and the last concrete in the Martin's creek viaduct, one of the two large structures, was poured on November 14. The 12-span concrete arch bridge over Tunkhannock creek, which is the largest structure on the line, will probably be the last work completed. This double track viaduct consists of ten 180-ft. and two 100-ft. arches with a total length of 2,375 ft., and a height of 242 ft. from stream bed to top of coping. These dimensions with the concrete yardage of 167,000 make it the largest structure of its type in the world.

The method of sinking the piers to rock at a depth of 10 ft. to 95 ft. below the ground line and the construction of these piers above the ground to the top of the umbrella section 37 ft. above the springing line were described in the *Railway Age Gazette* of December 5, 1913. At present all of the substructure has been finished except pier 5, which has been delayed by serious difficulty with quicksand. A comparatively slight delay was caused by a pocket of quicksand at one corner of pier 4, but as the material at the other end was solid, it was possible to divide the area, finish one end and then brace against the concrete to hold back the pressure of the soft material.

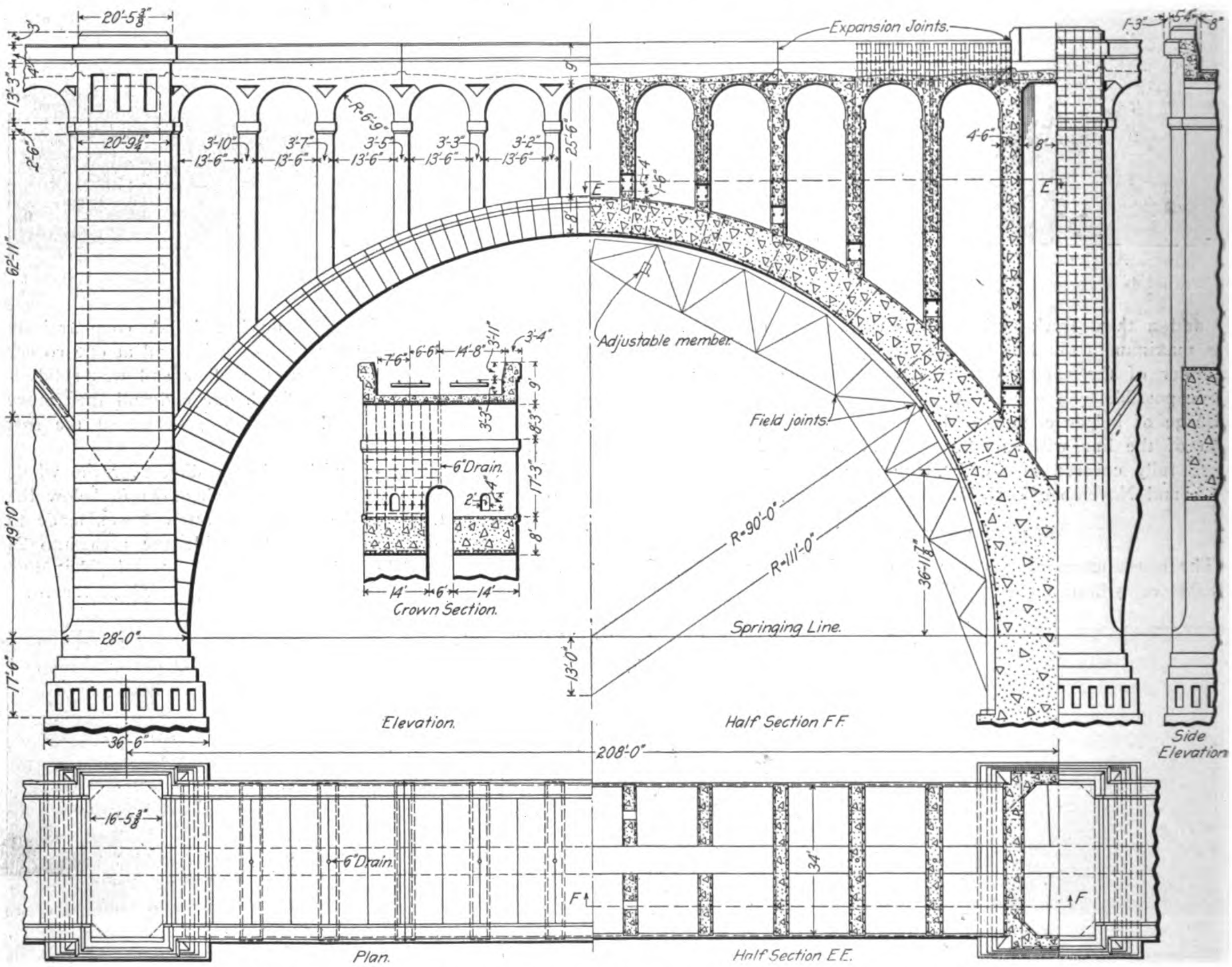
In pier 5, a stratum of quicksand extending over the whole area of the cofferdam was encountered about 75 ft. below the surface and 20 ft. above the rock. An attempt was made to drive sheeting inside the caisson to divide the area into 24 parts, each of which could be finished separately, but this sheeting was bent and displaced by boulders overlying the rock, making this method impracticable. It then became necessary to use a pneumatic caisson which was built in two chambers with two locks in each. The caisson was constructed with the cutting edge 27 ft. above rock; air was turned on December 13, and the caisson had been sunk 10 ft. on December 21.

DESIGN OF CONCRETE ARCH VIADUCTS

As stated in the previous article, the substructure in reality includes the piers and the umbrella tops forming the skewbacks for the arch rings. The superstructure differs somewhat in the 100-ft. and the 180-ft. arches. The former are located at the ends of the structure and are termed abutment spans, as they are completely buried by the approach fill. In these spans the two arch ribs are 5 ft. 6 in. thick at the crown and 12 ft. wide. They are spaced 22 ft. center to center leaving a 10-ft. opening between the ribs and are tied together by four reinforced concrete struts. The ribs support reinforced transverse walls on which is carried a floor slab from 1 ft. 9 in. to 2 ft. 6 in. thick. An 18-in. curtain wall along each outside face closes the opening between the arch ring and the floor slab.



Outline Elevation of Tunkhannock Creek Viaduct Showing Progress up to January 1, 1915



The General Elevation and Cross Section of the Tunkhannock Creek Viaduct

In the 180-ft. spans the arch ribs are 8 ft. thick at the crown and 14 ft. wide, the intrados being semi-circular; the extrados is segmental with a radius of 111 ft. The arch ribs are spaced 20 ft. center to center, leaving a 6 ft. opening between them. They support transverse walls varying in thickness from 3 ft. 2 in. to 4 ft. 6 in., which span the center opening. These walls are connected at the top by spandrel arches of 6 ft. 9 in. radius with a crown thickness of 1 ft. 9 in. Belt courses on the walls 1 ft. 6 in. below the springing line of the spandrel arches provide seats for the centers used in building these arches. The two walls over each pier are connected at the ends by pilasters 3 ft. thick, which stiffen the spandrel system and give the appearance of a solid pier.

The floor is pitched 6 in. to the center of the transverse walls, the drainage being carried down through 6-in. pipes in these walls and discharged in the space between the arch ribs. The minimum depth of ballast is 12 in. over the expansion joints of which there are four on each span, two at the piers and one over the third transverse wall from each pier. These joints consist of a ¼-in. open space covered by a copper plate bent to project down into the joint slightly and with its edges turned down into grooves parallel with the joint, where it is held in place by a mastic filling. The waterproofing is carried continuously over this plate. A parapet wall with an overall width of 3 ft. 4 in. extends 7 ft. 3 in. above the floor at the crown of the spandrel arches and the pilasters extend 3 ft. above the top of the parapet.

The general design of the Martin's creek viaduct is similar to the Tunkhannock creek bridge, except that it will carry three tracks and that seven of the eleven are 150 ft., three-centered arches, consisting of two ribs 17 ft. 6 in. wide with an open space of 12 ft. between ribs. The spandrel arches are flattened to conform with the appearance of the main arches. The total length of this structure is 1,600 ft., the base of rail is 150 ft. above the stream and 78,000 cu. yd. of concrete were required in its construction.

CONSTRUCTION OF CONCRETE ARCH VIADUCTS

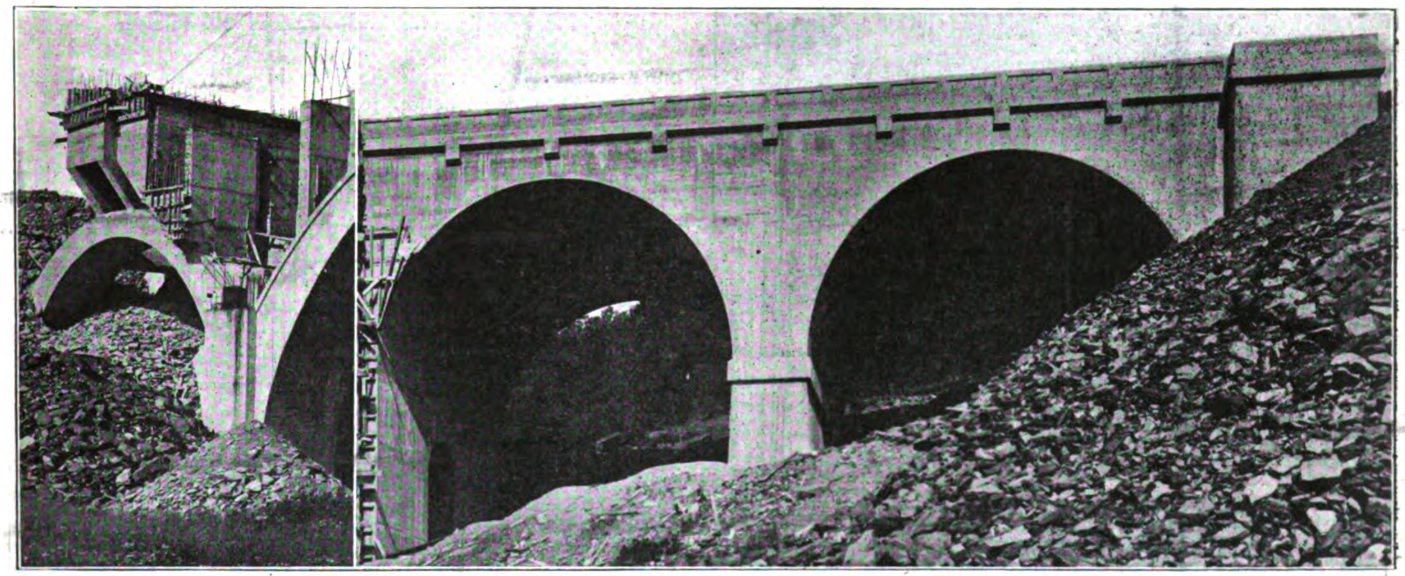
The contractor's methods adopted in building the superstructures of the two large viaducts were practically the same, so that a description of the work on the Tunkhannock bridge will apply in general to the Martin's creek structure as well. As mentioned in the article on the substructures referred to above, all form material and concrete at Martin's creek were handled by derricks, while at Tunkhannock a combination of derricks and a double cableway is being used. The center tower of this cableway was 260 ft. high for the early stages of the work and was later raised by a 40-ft. addition in accordance with its design. Two duplicate concrete mixing plants at Tunkhannock and one at Martin's creek, each with a capacity of about 40 cu. yd. per hour, were provided.

With the exception of the abutment spans in both structures, for which wooden centers supported on wooden towers were used, the arch rings were built on self-supporting steel arch centers. These were seated on benches on the sides of the piers, which in the Tunkhannock bridge are 4 ft. 3 in. wide and 17 ft. 6 in. below the springing line. The spandrel arch centers and all forms are of wood. Five sets of arch centers are used, each of which supports a single main arch rib. After the construction of one rib in a span the centers are moved over under the other rib in the same span and used again without dismantling. In order to utilize both material cables at the same time, the centers are erected on alternate sides in adjacent spans.

Each set of steel centers consists of four three-hinged arches spaced 3 ft. 10 in. center to center and thoroughly braced. The assumed loading on these centers, including the weight of the trusses, lagging and forms, is 1,370,000 lb., which produces a maximum horizontal reaction at the lower skew back pins of 261,100 lb. During the lateral movement of the centers the thrust resulting from the weight of the trusses and lagging is taken by two 1 in. rods connecting these pins. The wind load on the forms is taken by four 1¾-in. anchor bolts extending into the concrete bench on each side of the pedestals. As an added precaution, the contractor used two ¾-in. steel cable guy lines from the crown of the centers.

The four arch trusses in each set are supported by a pedestal 16 ft. 7 in. long. In order to provide for the side movement from one arch rib to the other, the base plate under this pedestal is provided with a guide rib ½ in. by 2½ in. which engages the shoulders of 6-in. rollers running on a bottom grillage. This grillage is 35 ft. 6 in. long, consisting of four 8-in. I-beams with top and bottom cover plates, the former having a guide plate to engage the rollers similar to the one on the pedestal.

The 3½-in. lagging is carried on planks set on edge over each rib with their outer edges curved to conform to the intradosal line. As the top pin is 6 ft. below the crowd of the arch, the lagging for one panel length on each side of the crown is carried on a rigid triangular frame above the top chord sections. The adjacent members of these frames over the pin are about 2 ft. apart at the crown, an oak block being supported in this space by bracket angles to carry the lagging over the joint.



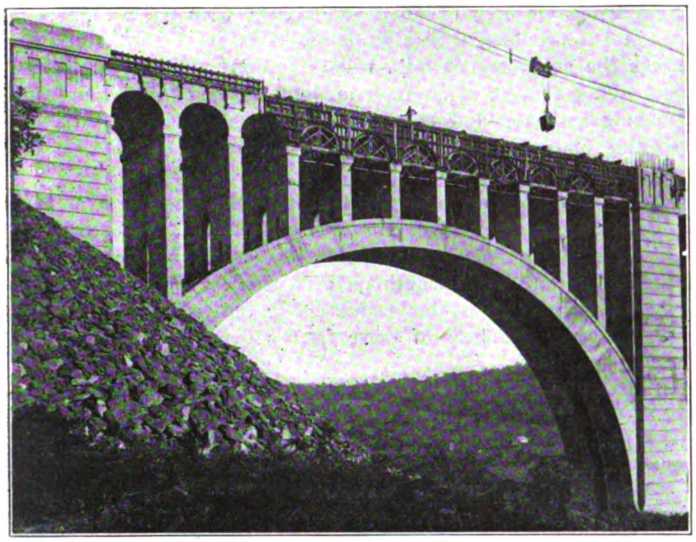
The Abutment Span Before Completion and the Two Short End Spans of the Martin's Creek Bridge

The adjustment of the height of the centers necessary to strike them before removal is accomplished by changing the length of the diagonal members of the two panels adjacent to the crown. Pin connections are used in these panels to make this possible and the diagonals are each made in two pieces connected by bolts with left and right handed threads.

The centers, which have a total weight of about 200 tons, are erected by the cableway, each rib being handled in four pieces. The lower half of each semi-truss is erected first and held in position on the skewback pins by two temporary bolts through gas pipe sleeves in the concrete of the umbrella tops which bear on washer plates at the upper ends of the pipes and support a short I-beam yoke under the upper chords of the trusses. The upper halves are then erected and bolted to the lower sections, the entire semi-trusses being supported as cantilevers from the piers until the crown connections are made, converting them into three-hinged arches.

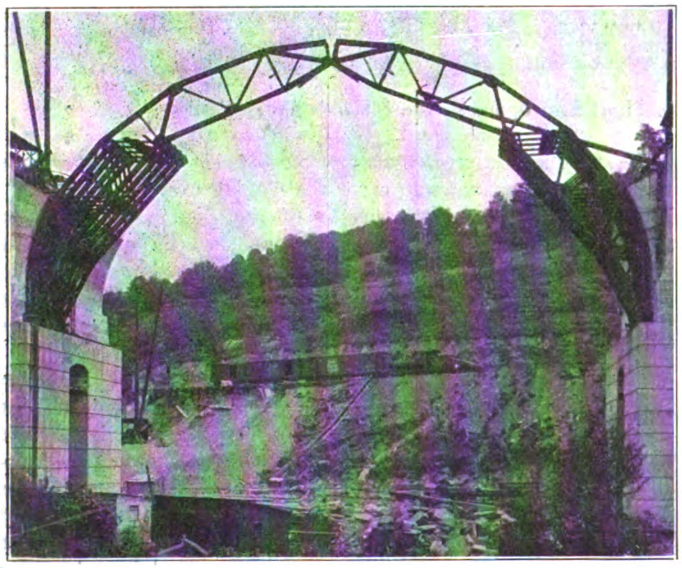
After the completion of the first rib, the centers are struck and are then jacked over on the grillage, a distance of 20 ft., to bring them under the second rib. After this rib is concreted and set, the centers are again struck and rolled into the space between ribs where the segments can be removed one at a time by the cableway for erection in another span.

Each arch rib consists of 11 vouissoirs and the necessary connecting key sections. The corresponding vouissoirs on opposite sides of the arch are concreted simultaneously, and after the last one is placed a set of seven days is allowed before the keys are put in. Separate forms are provided for the vouissoir blocks and the key sections allowing the former to be removed for use on another span while the keys are being placed.



The End Span of the Tunkhannock Viaduct Showing the Pilasters at the Piers and the Spandrel Arches Partially Completed

All the concrete is handled in bottom dump buckets by the cableway from cars pulled by dinkey engines from the mixing plant. In most cases these buckets are dumped directly into the forms, but in the case of the spandrel walls for example, where the width of forms is not great enough to permit this, dumping platforms are used. A stiff-leg derrick was erected on the finished floor as soon as one section was completed and is moved out as the work progresses to handle the spandrel



Erection of the Steel Centers for One Span at Martin's Creek in Progress Showing Details of Crown Connection and Adjustable Members in the Top Panel of Each Semi-Truss

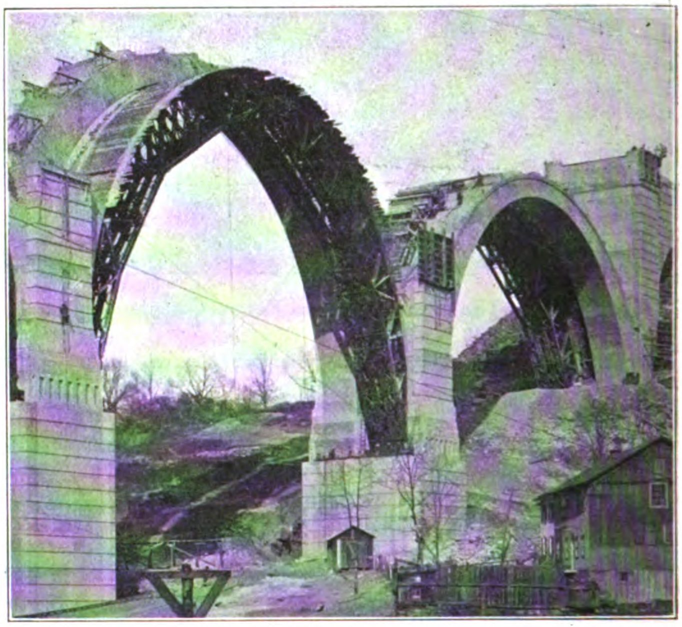
arch forms from under the completed floor at the sides of the bridge, thus obviating the necessity for using the cableway for eccentric loads. In hot weather each floor section is kept flooded until it has set, and in cold weather a tarpaulin cover is provided and a steam pipe run in to heat the surface. The lower section of the parapet walls up to the first offset on the

A Construction View at Tunkhannock Creek Showing Forms in Place for Spandrel Walls, Arches and Pilaster

outer surface is cast with the floor in order to avoid the appearance of a construction joint.

THE NICHOLSON TUNNEL

The excavation in the double track tunnel 3,630 ft. long near Nicholson, amounting to 146,000 cu. yd. was completed about the first of November, and work is now in progress on the lining of this bore, 1,600 lineal ft. of lining having been

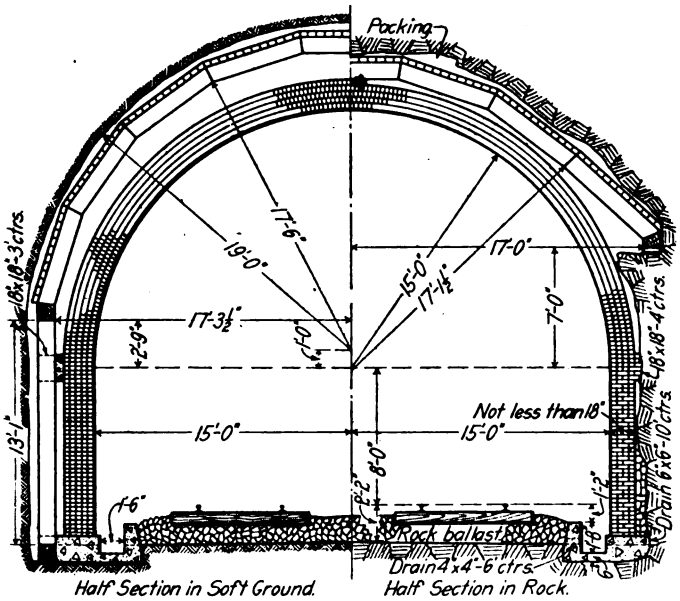


Two Spans of the Tunkhannock Viaduct in Each of Which One Rib Has Been Finished and the Centers Are Now in Place Under the Second Rib

completed. As mentioned in one of the previous articles, two shafts were driven at the third points in order to advance the work before the completion of the portal cuts, which are about 100 ft. deep, and one of which contains over 1,000,000 cu. yd. of material.

Center top headings 9 ft. by 12 ft. were driven in both directions from each shaft and also in from the west portal as soon as the cut at that end had progressed far enough to make this possible. These headings were later widened to allow the placing of the wall plates and the 12 in. by 12 in. roof timbers, which were spaced 4 ft. center to center. The remainder of the section was excavated by a single pass of a 40-ton Marion shovel operated by compressed air. The material was shot down ahead of the shovel in two benches, the upper having a face of about 6 ft. and the lower about 12 ft. The shovel loaded the material into 6-yd. cars operated in trains of 10 by dinkey engines burning hard coal.

Two tracks were provided in the tunnel for this narrow gage equipment with a switch about 200 to 300 ft. from the working face. A train of empty cars would be pushed up to this switch on one of the tracks and the loaded cars collected by another engine on the other track. The first engine would push in two empty cars to the shovel, run back of the switch, the second engine would come up and pull out the two cars as soon as loaded, and the first engine would then set in two more. By the time the loaded train was ready to leave, another train of empty cars would arrive and the process be continued, always having two engines at the shovel to switch the cars. The haul varied from ½ mile to one mile from the portal. The shovel completed the excavation in 350 days elapsed time,



Typical Cross Section in Earth and Rock of the Nicholson Double Track Tunnel

making a progress of about 12 ft. per day of actual working time.

Three compressors located in a plant at the west end supplied air for the shovel and drills, the 10-in. air main being carried for a maximum distance of about one mile. A generator located in the compressor plant furnished electricity for lighting the tunnel during the placing of the lining, although large carbide torches and individual gasolene lights were used until the completion of the excavation.

The tunnel is being lined with vitrified brick which has been shown in extensive tests to have a high compressive strength and resistance to corrosion. The estimates showed that a concrete lining could be placed for about 60 per cent less per cubic yard than the brick, but the yardage is decreased by using the brick so that the comparison of the total costs does not show as great a difference. The proximity of unusually good supplies of brick was a factor considered in this case. The side bricks are obtained in Corning, N. Y., and the arch bricks in Scranton, Pa. The bricks are of two sizes, those in the side walls being 2¼ in. by 4 in. by 8¾ in., and those in the arch 2¾ in. by 4 in. by 8 in. The lining is four courses thick, except in the short section of earth near the east end, where a fifth course is added.

The brick lining is carried on a concrete footing which is extended toward the tracks to form an open drain 18 in. wide and 12 in. deep. The thrust of the arch is taken by 18 in. square thrust blocks of brick at the springing line, spaced 4 ft. center to center. The space above the ring and behind the side walls is back-filled with selected rock, and 6 in. by 6 in. drains through the concrete footings at intervals of 10 ft. afford an outlet for any water collecting behind the lining. In the east approach cut where the grade is descending toward the tunnel, a vitrified pipe line for drainage will be laid with a grade sloping away from the tunnel. So far no difficulty has been encountered with water, and none is anticipated.

The concrete footings are built in 15-ft. form sections, the concrete being mixed at the top of one of the shafts and lowered by a derrick. A crusher was installed here to supply crushed stone for this concrete, using the rock removed from the tunnel. The output of the crusher was also used for the concrete in a small culvert near by.

The brick arch is being built on four 32-ft. sections of centering which are moved forward on wheels. Bricks are laid in 1:2 cement mortar mixed by an electrically operated Ransome mixer in the tunnel. A motor-driven conveyor is also used to elevate the bricks and the mortar to the working platform of the centering. The mason gang employed at present on this work can average 1,500 to 2,000 bricks per man in an eight-hour day.

The plans for this cut-off line and the construction work have been handled under the supervision of G. J. Ray, chief engineer. The designs for the large concrete arch viaducts were made by A. B. Cohen, concrete engineer. All field construction work is directed by F. L. Wheaton, engineer of construction, the residency including the Tunkhannock viaduct, the Nicholson tunnel being in charge of C. W. Simpson, resident engineer.

LAFAYETTE YOUNG ON GOVERNMENT OWNERSHIP

[From the Des Moines Capital]

The railroads are out of politics. In a political sense they are boycotted. Prove that a man is subservient to railroad influence and his defeat is certain. The conditions are much better because these achievements have been had.

Therefore, we cannot agree with Dr. Frank Crane in his desire to put all the corporations into politics. He wants the railroads, tramways, telephone and telegraph lines, and all other systems of transportation; all water-ways, all electricity, gas and the like put under the ownership of the government.

The editor of The Capital has been in nearly every country in the world, and we can say truthfully that the telegraph and telephone lines, also the railway lines, are better managed in the United States, and give better service than in any country in the world where government ownership prevails. The charges in the United States are not excessive.

In a republic where the majority rules, and the majority are in the government employ, what are the other people going to do? We very much fear that under universal government ownership American politics would become so corrupt that the government itself would go down under the weight.

Government ownership is justifiable only when private ownership everlastingly fails. Some arguments could be put up for government slaughter and packing houses; even for flouring mills. But when the transportation business is well managed, why put millions into it?

We venture the statement that very few businesses in America have been destroyed by transportation charges.

Dr. Crane points to higher conditions morally, and anticipates an appreciation of responsibility upon the part of everybody, which is not at present warranted by the facts.