THE HAVRE DE GRACE BRIDGE OF THE PENNSYLVANIA RAILROAD.

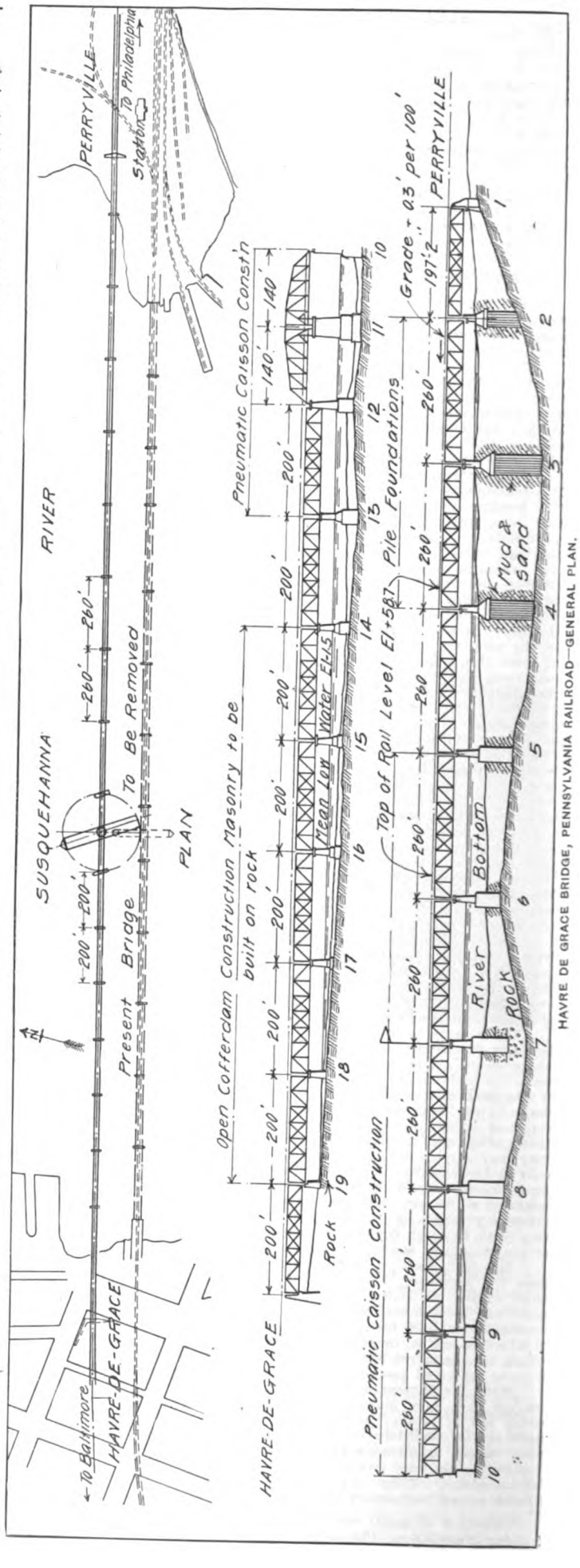
The double track bridge spanning the Susquehanna River, on the Philadelphia Baltimore & Washington division of the Pennsylvania Railroad, now being erected from Havre de Grace to Perryville, is one of the longest structures of the kind on the lines of this company, and is of very great importance, owing to the speed with which it is intended to run the New York-Washington trains over the bridge. It will take the place of an existing bridge which lies about 150 feet south of and parallel to the new location. At the same time that the new bridge is built it is proposed to elevate the tracks through Havre de Grace, removing all grade crossings, for which reason the new structure is 27.70 feet higher than the old one.

In a total length of 4,154 feet the bridge is divided into 18 openings of four different spans, whereof the two end spans are the shortest, about 197 feet in the clear, while seven 200-foot spans compose the southern end. One drawspan of 280 feet provides a double passageway for the river traffic and eight 260-foot spans encompass the northern part of the river. Although there is nothing extraordinary in any of these openings, nevertheless they combine to form an unusually imposing structure.

Inasmuch as they embrace nearly all modern methods, the foundations for this bridge are very interesting. At pier No. 1 the rock was so near the surface that only the simplest kind of cofferdam bracing was required, but pier No. 2 was founded on piles driven to rock from 70 to 80 feet below water by steam pile drivers. Here the piles were cut off about 18 feet below water and very heavy sheeting was driven some distance below the cutoff level, while, as the excavation proceeded, heavy bracing was inserted about every 5 feet, vertically. The moving clay and quicksand was so treacherous at this pier that something like 100,000 feet, board measure, of timber was used in the bracing alone, not counting the sheeting itself. While this might be considered a land pier the foundation work was more troublesome than on some of the river piers, since the mud and silt flowed almost as freely as water.

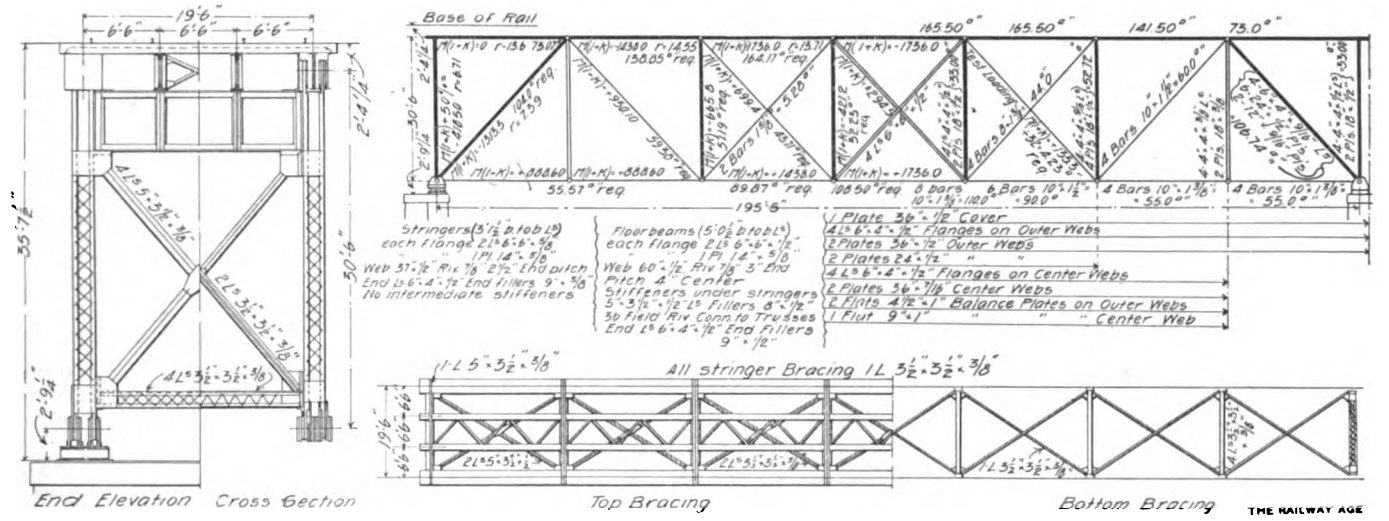
Piers 3 and 4 were very similar to No. 2 except that conditions were even worse, because the piles were cut off from 10 to 12 feet lower than in pier No. 2, and being right in the river, the bracing and pumping were more troublesome. Besides this, many sunken logs and other large objects resting far below the bed of the river seriously interfered with driving the sheeting. After the piles had been cut off in the three foundations for piers 1, 2 and 3, a solid concrete base, about 8 feet thick, was placed around and over the piles. On this base was started the masonry, the bottom courses of which were stepped off as shown on the plans. Piers 5 to 13, inclusive, rest on substantial caissons made of wood and filled with the best Portland cement concrete. Here the contractors had a very elaborate floating derrick plant for facilitating the work at the caissons, and as some fear was expressed that the spring ice going out might force this plant against the old bridge, the contractors at once dismantled the entire plant, but in about a week commenced reerecting it. It is surprising how early and quickly the Susquehanna River freezes over and in 1904 it froze up so as to paralyze navigation of all sorts in the beginning of December, very seriously hampering the caisson work. The Susquehanna seems to be entirely free of salt and the town of Havre de Grace, at the very mouth, takes its drinking water directly from the river. Although this locality is so far south of New York, much more work can be done during a winter in New York than in Havre de Grace.

The caissons were carried to bedrock and some of them 5 or 6 feet in hard rock, with the exception of No. 7,



where the rock is at a much greater depth than could be reached by pneumatic caissons, because men cannot live in much greater air pressure than 45 pounds per square inch, which is equivalent to about 100 feet head of water. But as caisson No. 7 is carried to a good sand foundation about 90 feet under water, on which the total load only

Although at one place the water is from 50 to 60 feet deep, it is not possible for vessels drawing more than 9 or 10 feet to come up to the Havre de Grace bridge, so about 3,500,000 feet of Georgia yellow pine for caisson work had to be taken off the schooners about 20 miles down the bay and brought up on scows. An interesting

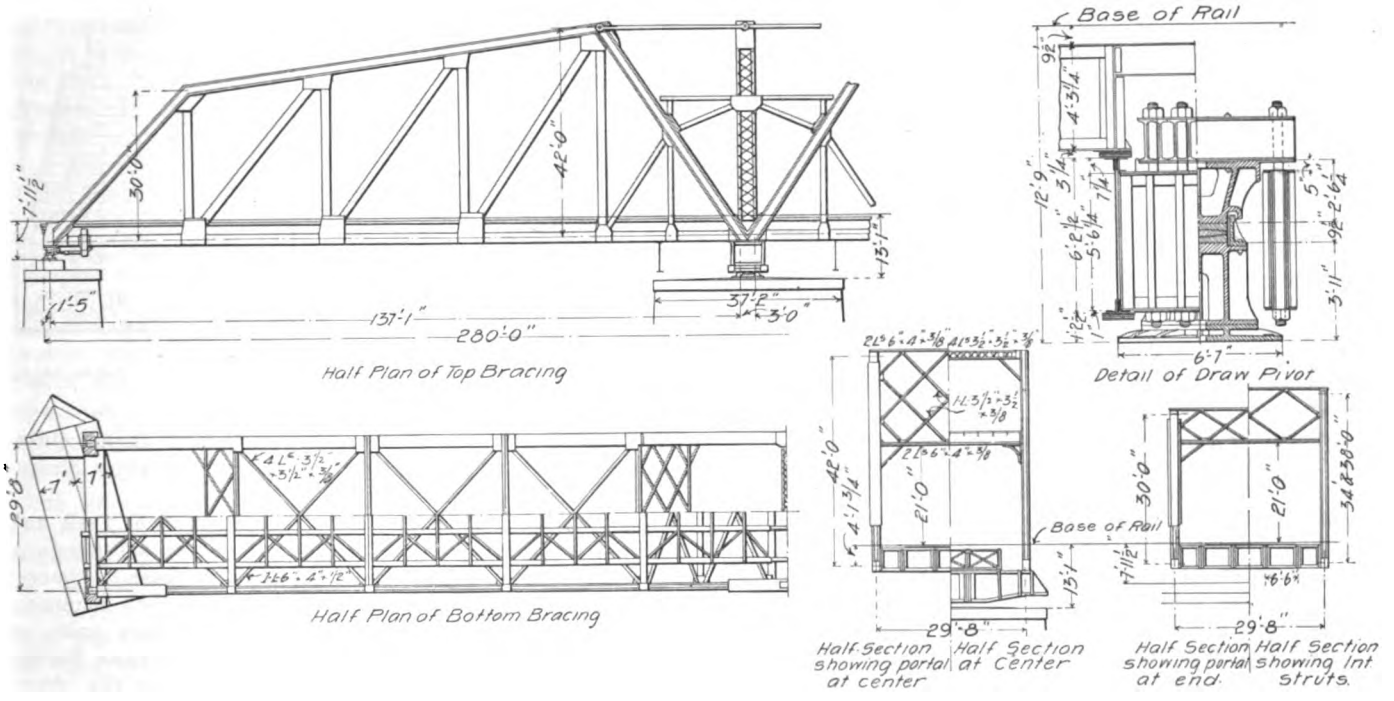


HAVRE DE GRACE BRIDGE, PENNSYLVANIA RAILROAD—DETAILS OF ONE SPAN.

amounts to 2 or 3 tons per square foot, it is absolutely safe.

It was intended originally to carry the foundations for piers Nos. 14, 15 and 16 to rock by means of open cofferdams, but the later explorations showed much greater depths of water than the preliminary borings. There was very little mud on the bottom of the river, but instead a mass of boulders, debris and rotten rock on top of good.

experiment was made by cutting out 4-inch and 6-inch cubes of concrete from the abutment of pier No. 1. This concrete had been mixed and placed in the pier on January 18, 1905, and the cubes were tested at Columbia University on April 22, 1905, with the result that the 4-inch cube broke under a pressure of 34 tons, which is equivalent to 306 tons per square foot, and the 6-inch cube stood the full capacity of the machine, 100,000 pounds, without



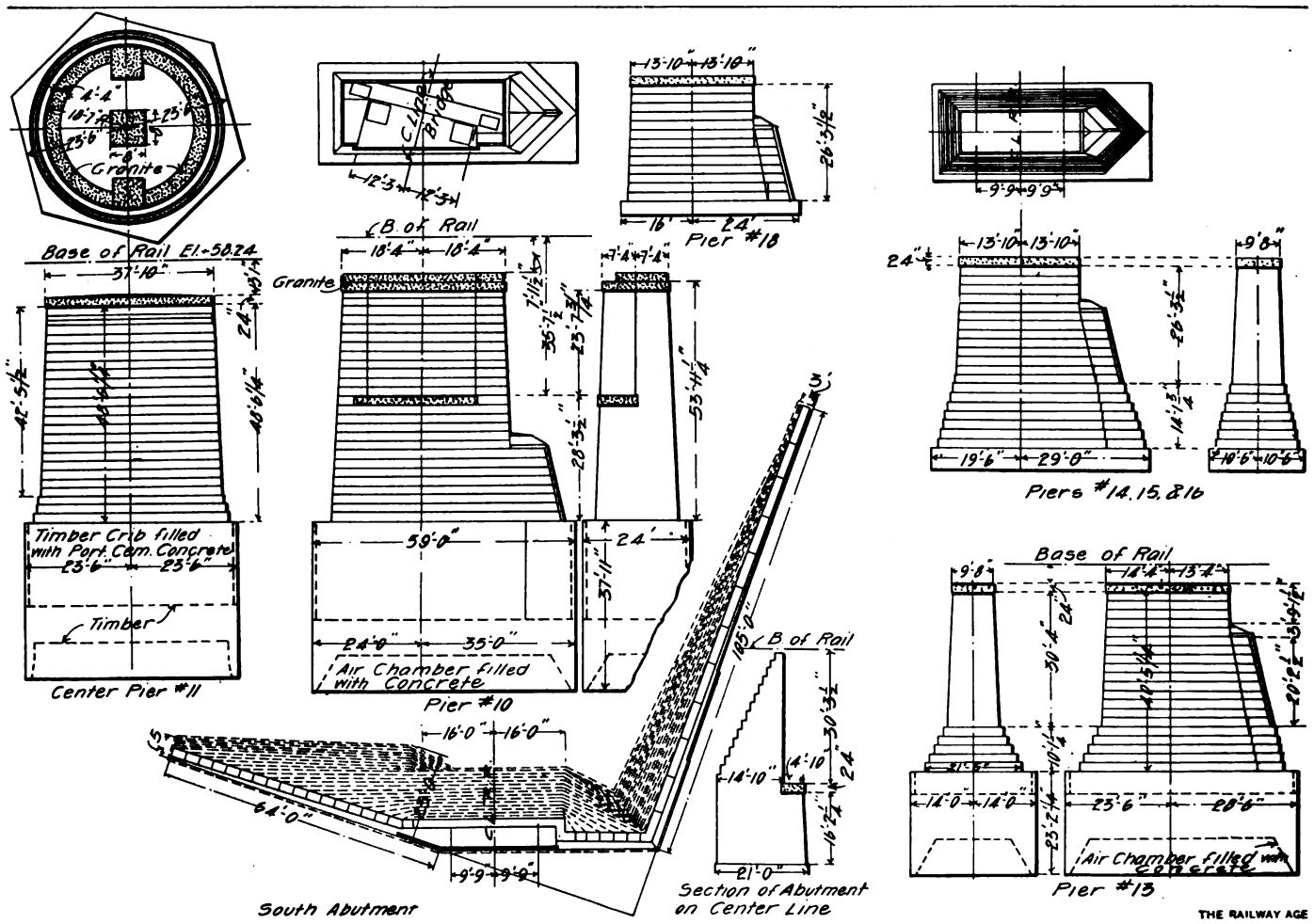
HAVRE DE GRACE BRIDGE, PENNSYLVANIA RAILROAD—DRAW SPAN.

rock; so, as haste was desired greatly by the railroad company, the contractors agreed to put in pneumatic caissons for these three piers also. Piers 17 and 18 were founded on rock by means of open cofferdams, as originally intended, but gave some trouble in pumping, owing to the fineness of the river mud or silt and to the boulders and decayed rock.

the sign of a crack. And yet the cubes were cut at random, next to the sheeting, from what should be the weakest part of the pier, and the concrete was laid and set in very severe weather.

At the drawspan it was necessary to construct piers of a curious form or else have a skew bridge, which is anything but desirable. These piers, therefore, are set in

line with the current, at an angle of 76 degrees, and are built of an unusual width, which permits the skewing of the bridge seats for the drawspans, but in all other cases the piers are normal with the long axis of the bridge. We do not discover any other unusual features, but it may be pointed out that the character of the masonry here follows the general type for such work on the Pennsylvania Railroad. All of the bridge seats and copings are of granite and the walls are of rock face ashlar courses, varying from 20 to 24 inches in depth. From various depths below mean water most of the footings are entirely of concrete and are faced with sandstone or 12 by 12 inch timber sheathing, while above the footings concrete backing is permitted. A rather unusual abutment is provided for the south end of the bridge and is of great massiveness, with one wing wall 105 feet long. This forms a part of our illustrations and is worthy of more than passing attention.



HAVRE DE GRACE BRIDGE, PENNSYLVANIA RAILROAD—MASONRY FEATURES.

Although all face work in general is rock face ashlar, there are considerable differences in the depths to which this type of masonry extends. Pier 19 and both abutments are entirely of ashlar with no concrete footings, while at pier 18, both of the "rest piers" and the pivot pier of the drawspan, the ashlar extends 5.5 feet (approximately) below low water mark. Piers 2, 3 and 4 have ashlar as far as elevation 11, while at piers 5, 6, 7, 8, 9, 13, 14, 15 and 16 the ashlar extends to elevation 20. The concrete used here is entirely of Portland cement and of the proportions 1:2:5. A principal industry along the upper reaches of the Susquehanna is lumbering, and many logs come down as far as Havre de Grace, for which reason, as well as a protection against the heavy flow of ice, it has been necessary to build cutwaters of somewhat unusual strength. These are shown on all river piers except the pivot pier, which latter is protected by a triangular masonry pier on the upstream end and by a heavy pile and sheeting structure downstream. All of the cutwaters are finished with 8 by 8 inch by ⅝-inch angles, bolted to the stonework at every other course.

While there are differences between the 197-foot, the 200-foot and the 260-foot spans, the general appearance is the same. Each structure consists of a pin-connected deck truss of the Pratt type, of which we illustrate a 195-foot 5-inch span. There is nothing remarkable in any of these deck spans, and it is necessary only to call attention to the very rational way in which the details are worked out. Also it is worthy of attention that the only drawings prepared by the Pennsylvania Railroad for any of the superstructure were one sheet each for each of the different lengths, on which are shown all of the necessary dimensions.

McMullen & McDermott, contractors, of New York and Philadelphia, have the contract for all of the substructure, with Mr. T. Kennard Thomson, C. E., as engineer in charge, while the Pennsylvania Steel Company will both manufacture and erect the 200-foot spans and the shore span on the south end; the Pencoyd Works of the American Bridge Company will perform the same functions for the drawspan and all spans north of it. To divide the superstructure of a bridge between two different contractors is rather an unusual arrangement, but it was adopted here because of the great length and in the expectation that a considerable amount of time would be saved by following this plan.

Mr. Wm. H. Brown is chief engineer of this work; Mr. E. B. Temple, assistant to chief engineer, designed the substructure; Mr. H. R. Leonard, engineer of bridges, designed the superstructure, and Mr. J. F. Cullen, assistant engineer, has direct charge of the work.