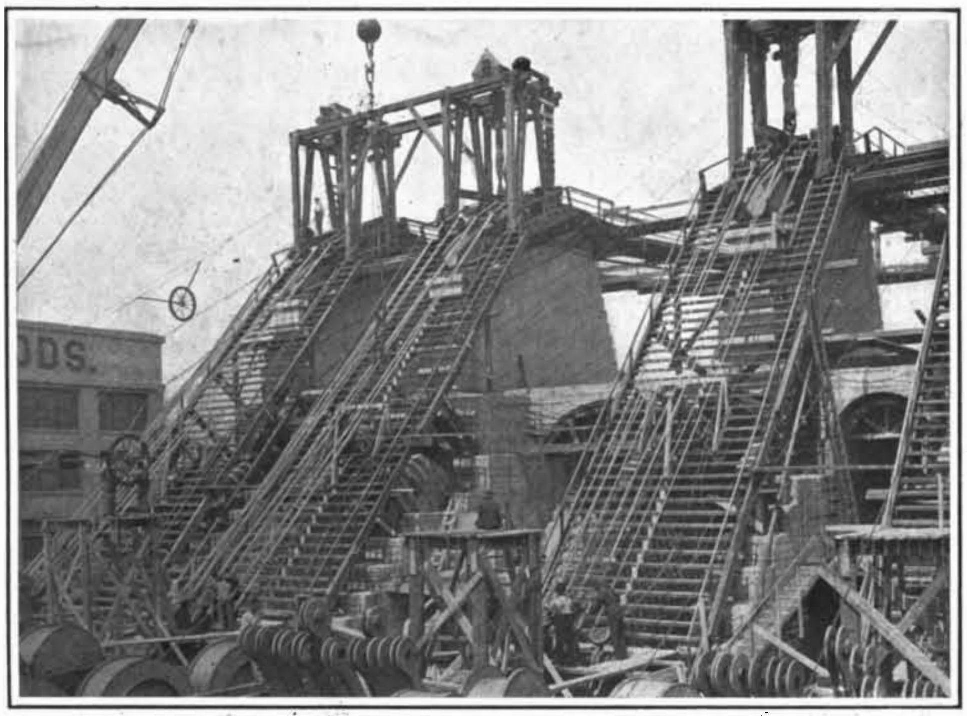
THE CITY'S GIANT BRIDGES

Although the famous Brooklyn suspension bridge was built a quarter of a century ago, and, therefore, cannot legitimately be included in a review of the engineering work of the past decade, we have given it a place among our illustrations, first because of its great historical interest, and secondly because it forms such an important member of the quartette of giant bridges which span the broad waters of the East River, and afford the principal means of communication between New York and Brooklyn.

The wire suspension bridge is essentially an American production; for although chain suspension bridges, in which the main supporting members consisted of flat iron bars linked together by pins, had been built in some numbers in England and on the Continent, the use of wire cables is one of the original and distinguishing characteristics of American long-span bridges. When Col. Roebling first promulgated his plans for spanning the broad expanse of the East River with a wire cable suspension bridge of the enormous span of 1,595 feet, the scheme was regarded with no little apprehension. The longest existing bridges were of less than 1,000 feet span; and it was considered that there were insufficient reliable data available to guarantee an advance to proportions of the unusual magnitude proposed. Great honor, therefore, is due to Mr. Roebling for the courage with which he staked his reputation upon the venture, and the indomitable pluck with which he and his associates carried it through to successful completion. The foundations for the towers were prepared by sinking two huge timber caissons to the rock underlying the river mud and sand. Upon these were erected two massive masonry towers which were carried up to an extreme height of 272 feet above the river. Meanwhile the anchorages, consisting each of a mass of solid masonry, were constructed on either shore, at a distance of 930 feet from the towers, and deep within this masonry were imbedded the huge anchor plates and anchor bars to which the wire cables were attached. Originally it was planned to make these cables of iron wire; but by the time the bridge was ready for their erection, the advance in the manufacture of steel had been such that it was found possible to use steel in place of iron, and thus secure much stronger cables without any increase of weight. It is to the wisdom shown in the adoption of this stronger material that the city is indebted for the ability shown by the bridge, in the later years of its life, to carry loads greatly in excess of those for which it was originally designed. There is no foundation for the popular belief that the bridge is to-day 'greatly overloaded." As a matter of fact, the steel wire cables are perfectly well able to carry their present burden. The so-called weakness of the bridge is due to the comparative weakness of the floor system, and particularly of the stiffening trusses, which on several occasions have been buckled or broken. Of late years, however, the bridge has been subjected to careful and continued scrutiny by competent engineers; and, so long as this is done, no fears need be entertained for the safety of the structure. Plans have been prepared by the Bridge Department, moreover, for the reconstruction and stiffening of the bridge, which include the erection of deeper and stronger stiffening trusses and a complete rebuilding of the floor system. This work will be undertaken as soon as the adjoining Manhattan Bridge has been completed, and when it is completed, the bridge will be good for many centuries of useful service, and will last just as long as it is safeguarded against rusting and decay by frequent painting and careful all-round maintenance.

THE WILLIAMSBURG SUSPENSION BRIDGE.

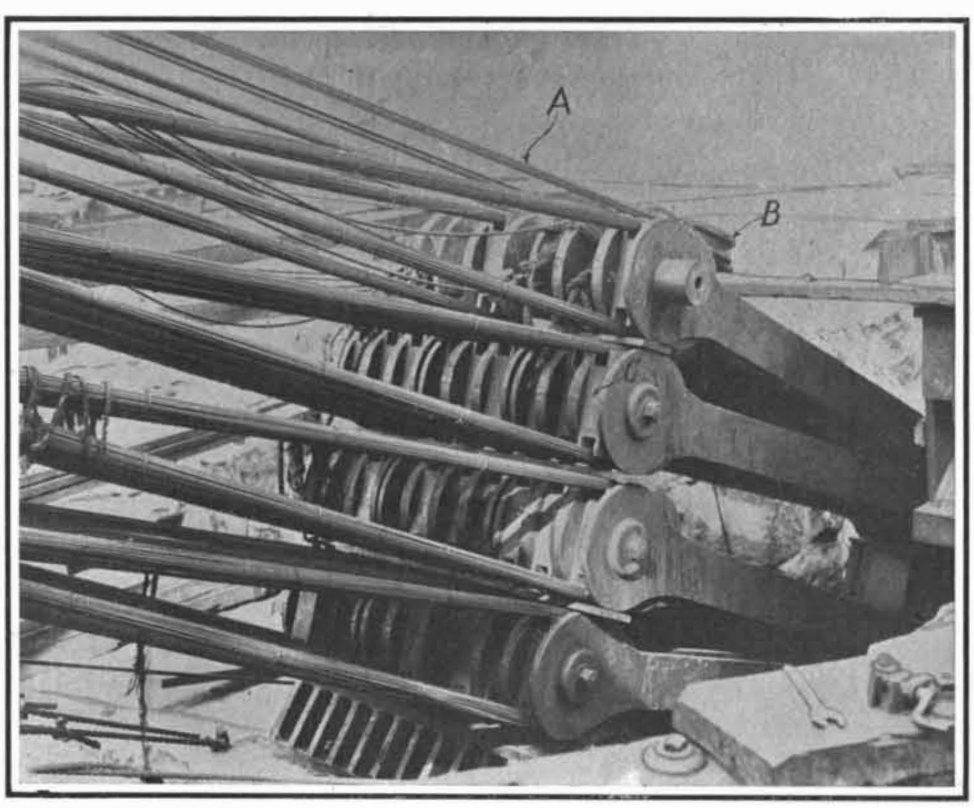
In the closing years of the last century the city undertook the construction of another wire cable suspension bridge. The location of the crossing was laid from Delancey Street, Manhattan, to Broadway, in Brooklyn. The main span is slightly longer than that of the Brooklyn Bridge, the clear width from tower to tower being 1,600 feet. The shore spans, however, are only 596½ feet, as against 930 feet, which is the length of the shore spans of the older structure. In point of weight and carrying capacity, the Williams-



This view shows the cables in course of construction. One end of the wire from a reel is passed around the sheave shown near left-hand corner of engraving, which is drawn across the bridge, thus stringing two lengths of wire at each journey.

ONE OF THE MANHATTAN BRIDGE ANCHORAGES.

burg Bridge, as it is called, is a vastly greater structure; for whereas the floor of the Brooklyn Bridge is only 80 feet wide, with provision for two elevated tracks, two trolley tracks, two 18-foot roadways with two trolley tracks upon them, and a footwalk, the Williamsburg Bridge is 120 feet wide and carries two elevated tracks, four trolley tracks, two 18-foot passenger footwalks between the trusses and two 20-foot roadways on the outside of the trusses, carried on cantilever extensions of the floor beams. The lack of stiffness of the floor of the Brooklyn Bridge is due



Each cable consists of 37 strands in each of which is 250 wires.

THE CONNECTION OF THE WIRE STRANDS TO THE ANCHOR BARS.

to the light construction and shallow depth of the trusses, two of which are 8 feet 9 inches and four 17 feet in depth. This was remedied in the Williamsburg Bridge by the provision of two unusually heavy trusses, each 40 feet in depth, extending continuously from anchorage to anchorage. The steel towers are erected upon heavy masonry piers beneath which are huge caissons which were sunk to the underlying bedrock. The steel towers are carried to a total height of 335 feet above the river. The four cables, each of which is 18¾ inches in diameter, are connected at their ends to heavy cast steel shoes which are pinned to a series of steel anchorage eye-bars imbedded in the masonry of the anchorages. The steel used in constructing these cables is of unusually high tensile strength, the best specimens showing a breaking strength, in some cases, as high as 210,000 pounds to the square inch. The cables for supporting the roadway are attached to the main cables by means of heavy cast-iron saddles, and at their lower ends they are looped around cast-steel shoes, from which the floor beams of the bridge are hung by four heavy steel bolts. It will be noticed from our illustration that there are no suspender cables for the shore spans of the bridge, the main cables serving to carry the weight of the central 1,600-foot spans only. The shore spans consist of extensions of the stiffening trusses; and the load of each of these spans is carried by the tower, the anchorage, and a steel pier located at the center of the truss. The total cost of the bridge, including the approaches and purchase of real estate, was about $22,000,000.

THE MANHATTAN SUSPENSION BRIDGE.

The third of the great crossings of the East River, known as the Manhattan Bridge, which is located about a quarter of a mile to the east of the old Brooklyn Bridge, is now in process of erection, and will probably be opened in 1909-10. Originally designed as a stiffened chain-cable bridge, the plans were subsequently changed by the substitution of wire for chain cables. Upon its completion the bridge, in respect of its carrying capacity, will be the largest suspension bridge in existence, provision having been made for eight railroad and surface tracks, a 35-foot roadway, and two passenger footwalks, each 11 feet in width.

No small part of the cost of building a bridge of this character is due to the difficult nature of the foundations. The caissons for the Williamsburg Bridge were four in number, there being two for each tower; an arrangement which was necessitated by the rather steep slope of the underlying rock at the site of the towers on each side of the river. The borings for the Manhattan Bridge piers showed the surface of the underlying rock to be fairly level, and hence it was decided to construct a single huge caisson for the foundations of each tower. The dimensions of the caissons were necessarily large. They measured 78 feet in the direction of the axis of the bridge by 144 feet transversely to the axis. The caisson proper on the Brooklyn side was 55 feet 6 inches in depth and above this was built a temporary cofferdam, which was erected to prevent the water from flowing into the work during the process of sinking. The total depth of this huge box, when it finally reached bedrock, was about 100 feet. The walls of the caisson were built of two layers of 12 x 12-inch timbers, the outer one laid horizontally, and the inner vertically; while on the outside of this was a double layer of 2-inch planking, the inner one laid diagonally, and the other vertically. Six feet from the bottom cutting edge, which was shod with steel, there was built over the whole caisson a solid roof of timber 2 feet 9 inches in thickness stiffened by heavy trusses. The space beneath this watertight roof, known as the working chamber, was divided into three longitudinal sections, and in this chamber the excavation was done by a large army of "ground hogs," as the men who perform the work of excavation are called. From the working chamber there extended to the surface of the cofferdam nine steel shafts for material, and one elevator shaft. The material at the river bottom was found to be almost pure sand; and it proved possible to blow out the excavated material by means of compressed air which was forced into the working caisson for the workmen. This was done by means of fourteen 4-inch wrought-iron pipes, which extended from the roof of the working chamber to the surface. At the bottom of each of the 4-inch pipes was a length of hose, which reached from the roof of