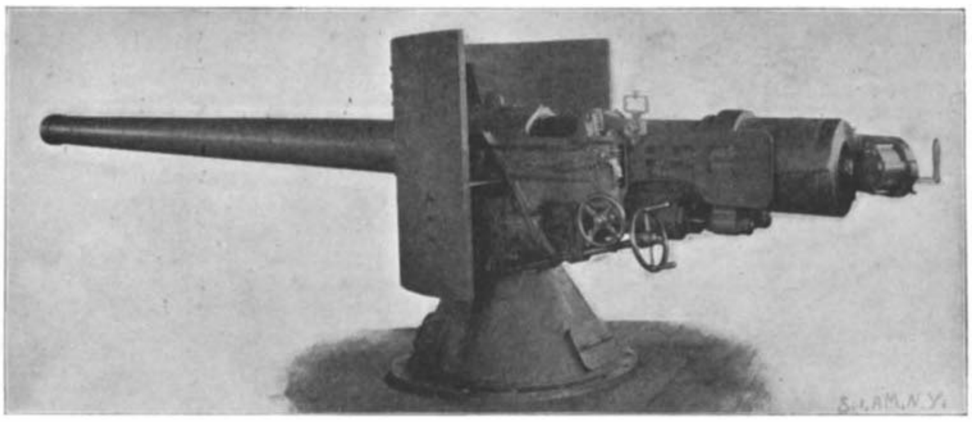
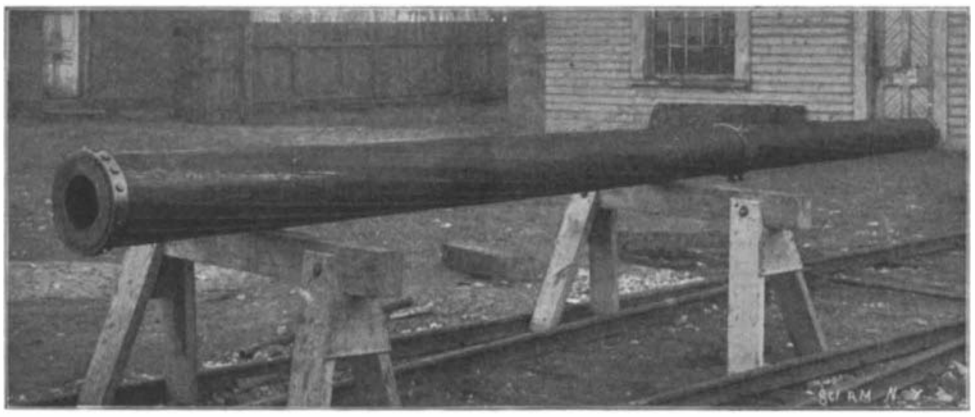
NEW 5-INCH SEGMENTAL WIRE-WOUND GUN FOR THE UNITED STATES ARMY.

If one were asked to name the particular implement of war which is called upon to do the hardest work and endure the heaviest and most destructive stresses, he would not be very far wrong if he selected the modern breech-loading rifle. There is certainly no product of the forge and the machine-shop that is subjected to such extreme care, both in the selection of the raw materials and in the various details of its fabrication, as is bestowed on the high-powered rifle of to-day. Broadly speaking, the problem in gun manufacture is to secure the highest qualities of strength and endurance for a minimum weight of material. It is a well-known fact that the strength and lasting qualities of steel are directly proportional—other things being equal—to the amount of working to which it is subjected during manufacture; and, since the work that can be put into the steel is inversely proportional to its bulk, it follows that, in the manufacture of ordnance, the smaller the section of the elements of which the gun is built up, the greater will be the tensile and elastic qualities of the finished piece.

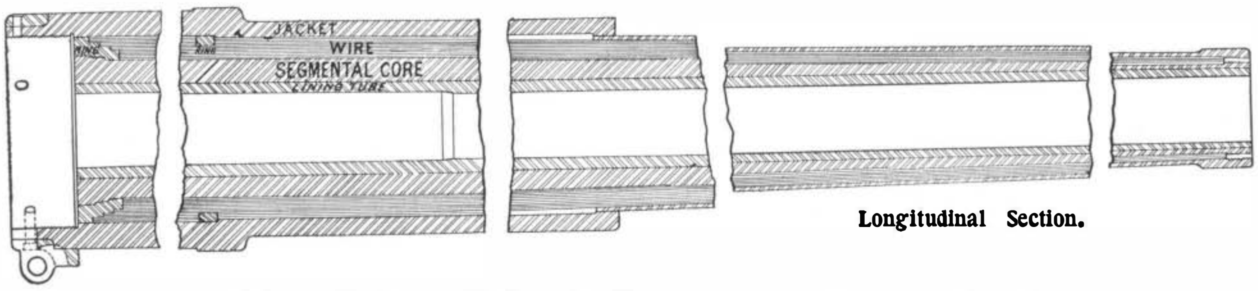
If the above proposition be true, it will be substantiated by the history of modern ordnance; and a brief review of the subject shows that with the increase in the strength of guns there has been an increase in the number of parts of which they were built up, and a decrease in the sectional area of these parts themselves. The cast-iron gun of the era of the Civil War was formed in one piece, and the best that it could do was to show a muzzle velocity of 1,500 feet per second. A single reinforcing hoop was then shrunk over the breech of the gun, and its effect was seen in an increase in the ratio of power to weight. This improvement opened up the way for the "built-up" guns which consist of a large number of separate elements, each of which is carefully worked, annealed and oil-tempered, in the effort to produce the highest possible results in elasticity and ultimate strength. Coupled with these qualities is the advantage that, in a gun consisting of many separate sections, the possibility of unseen flaws in the metal is reduced and the reliability of the piece is also proportionately increased.

In addition to these advantages, the metal in the finished built-up gun is thrown into a condition of initial strain which eminently prepares it for meeting the enormous stresses imposed at the moment of firing. The built-up gun consists of an inner tube, containing the bore with its rifling, and a number of superimposed hoops, which are turned to a carefully calculated diameter, less than that of the tube, and then enlarged by heating and shrunk on. The great tensile strain resulting from the shrinkage of the hoops throws the metal of the inner tube into a state of initial compression. The result of this is that the shock of discharge is felt throughout the whole body of the gun from bore to circumference, and every particle of the metal does its share of useful work. The system of built-up construction has undoubtedly been brought to a high stage of excellence, as shown by the fact that modern built-up guns secure a muzzle velocity of 3,000 feet per second with a maximum chamber pressure of 17 tons to the square inch.


The Finished Gun on a Rapid-Fire-Pedestal Mount.


The Core of Involuted Sheets Assembled Ready for Winding.

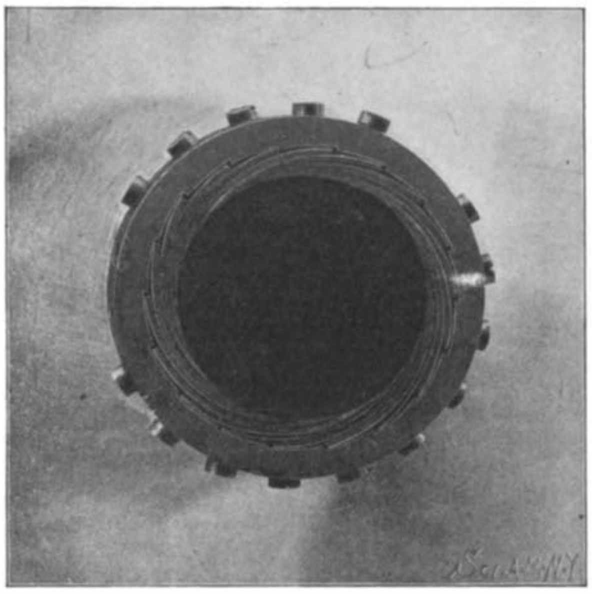
The method of securing the desired initial compression of the metal at the bore of the gun by shrinking on steel hoops is open to the objections that it is exceedingly expensive, the best guns costing a thousand dollars per ton weight of gun, and that it is not possible to determine with absolute certainty just how much initial strain exists in the gun after shrinkage. Moreover, in spite of the great care exercised in manufacturing the tube and hoops, these parts are sufficiently large to contain unsuspected defects which cannot be detected even by the most careful examination.



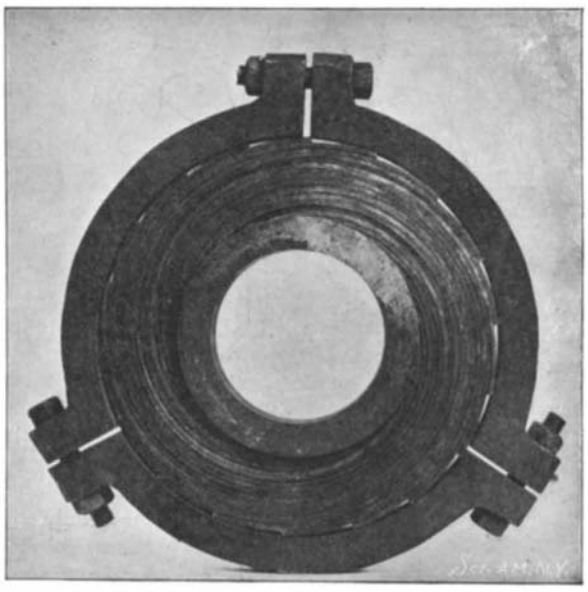
Longitudinal Section.

With a view to remedying these defects, the system of wire-wound gun construction was introduced, the credit for its inception being due to Mr. Longridge, in England, and the credit for its development and commercial introduction being due to the well-known Armstrong firm. In this system the gun consists of an inner tube about which is wound a ribbon of steel, the accumulated tension of the winding being calculated to produce the desired initial compression at the bore. Over the wire-winding is shrunk on a series of jackets as in the hooped gun. The system may be described as a compromise between the hooped gun and the fully developed wire-tube gun, which is represented by the piece which forms the subject of our accompanying illustrations.

In the Brown segmental wire-tube gun we have the highest possible development of the wire-wound system. Judged by the ballistic results achieved at the Government proving grounds, it is—weight for weight—by far the most efficient weapon in the world, and there is now under construction a 4½-inch gun, which, if it passes satisfactorily its proving test, will be so far in advance of any existing ordnance as to be positively in a class by itself. In the Scientific American for November 28, 1896, we published a description of the Brown system as applied in the 10-inch rifle which has lately been completed for the United States Government. The piece consists of a thin liner which forms the bore, a segmental tube wound with wire, and a jacket. The segmental tube consists of a large number of thin, tapered plates of steel which are assembled and clamped together, and are then wound with wire under a constant tension. The assembled segments form a kind of arch to sustain the accumulated compressive effect of the winding; and, owing to the fact that they are cold-rolled to their finished size, it is possible to secure in them a far higher quality, both as to homogeneity and compressive strength, than is possible in the inner or A-tube of an ordinary built-up gun. The cheapness of manufacture, furthermore, enables them to be produced at a cost below that of the tube. This 10-inch gun was planned in the early days of smokeless powder, and was designed for powder containing 66 2-3 per cent per cent of nitroglycerine. In its recent Government test, when it was fired with a 35 per cent nitroglycerine powder, it was found that the chamber was not large enough to contain as much of the new explosive as was necessary to give a muzzle velocity of 2,800 feet per second. The chamber has now been en-


View at Muzzle Showing Curved Sheets in Assembling Ring Before Liner is Inserted.


Group of Involuted Steel Sheets.

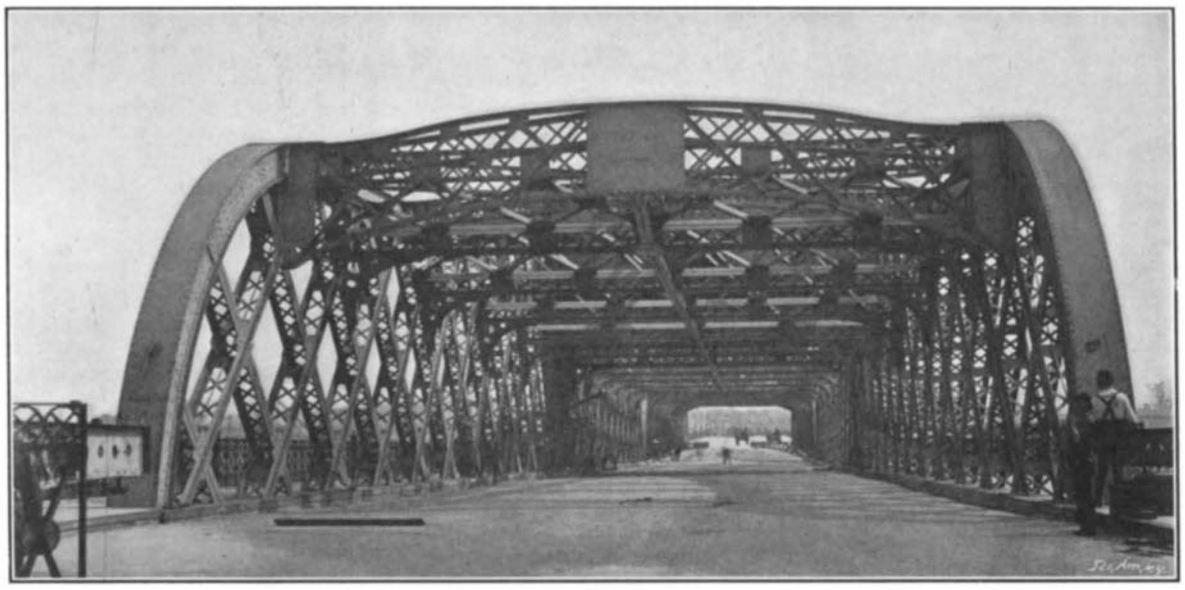

Section Through Sheet-Steel Tube, Showing Liner and Assembling Clamp.

NEW 5-INCH, SEGMENTAL, WIRE-TUBE GUN FOR THE UNITED STATES ARMY.

larged to the required dimensions, and, judging from the results already achieved, when the gun gave its 575-pound shell a velocity of 2,503 feet per second, it is fully expected that the desired velocity of 2,800 feet per second will be obtained. The piece will then equal in velocity the navy 10-inch gun; but, as the shell fired from the Brown gun is 75 pounds heavier than the navy shell, and of the two guns the Brown is 7.4 tons lighter, the resultant muzzle energy and the foot tons of muzzle energy per ton weight of gun will be considerably greater, as is evident from the table below:

	Length in Feet.	Weight in Tons.	Weight of Shell in Pounds.	Muzzle Energy in Foot Tons.	Foot Tons of Energy per Ton Weight of Gun.
Brown Segmental Wire-Tube Gun.............	37½	26.0	575	31,298	1,204
Navy Gun................	37½	33.4	500	27,216	815

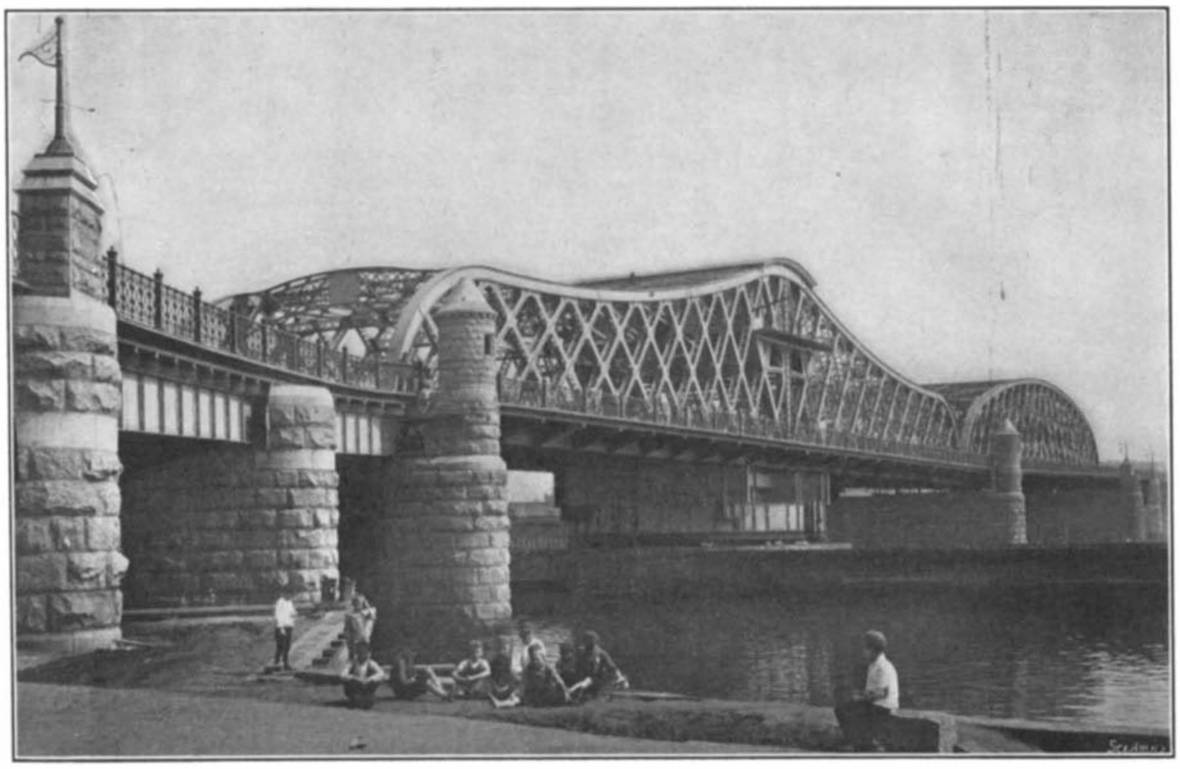
The above table tells its own story, and to anyone who has followed the development of modern ordnance and is familiar with the best that has been done, it will be seen that the development of 1,204 foot tons of energy per ton weight of gun has never been approached, the nearest to it being that of the Krupp 50-caliber 12-inch gun which develops 946 foot tons per ton weight of gun.


LOOKING NORTH THROUGH THE SWING-SPAN OF THE NEW BRIDGE.

Clear width of roadway, 42 feet.

Since the design of the first 5-inch gun was brought out, Mr. Brown has developed an important improvement by substituting for the straight segments as used in that gun a series of overlaid curved steel plates, as shown in our illustrations. The plates are formed from sheet steel, varying in thickness from 1.7 to 0.4 inches, which is cut to the desired taper, and rolled in a special mill to the involute form shown in one of the accompanying illustrations. The substitution of these involutes for the longitudinal segments is a logical step along the line of development which is being carried out so successfully in this gun. The substitution of straight segments for the inner tube of the accepted type of gun was made, as we have seen, with a view to securing more thorough working and higher quality in the steel. The thinness of the curved sheets, and the thorough working and subsequent inspection to which they are subjected, insure a yet more perfect condition of the core.

The following description of the process of manufacture applies to a 5-inch gun which was built as a type piece and subjected to trials at Sandy Hook. The report of these firing trials, as made by the officer in charge, certainly does not betray any partiality for the gun, and therefore, particular value attaches to the fact that the results of the trials, as gathered from the report, prove that the gun has not merely achieved, but has considerably exceeded, the contract requirements. Unfortunately, it was mounted upon a carriage designed for guns of far less power, and it was impossible to carry the velocity to as high a figure as the gun was capable of securing, owing to the risk of injuring the carriage. The insufficiency of the carriage was foreseen and inevitable, and it in no way reflects upon the capabilities of the piece. In the construction of the segmental core, sheets of steel one-seventh of an inch thick, 30 inches wide and 19 feet long are cut into two pieces along a diagonal line, the resulting halves being each 24 inches wide on one end, 6 inches on the other, and 19 feet in length. One edge of the plates is planed to a curved bevel fitting the curvature of the outside of the lining tube, and each piece is bent in special rollers to the involute form shown in the accompanying illustration. Eighteen of these curved plates are superimposed on each other and assembled into the annular circular form shown in the illustration. They then are fastened by screw-bolts to two rings, one at the breech, and the other at the muzzle. Then more clamps are applied to the assembled segments, and a tapered lining-tube, rough-bored to 4 inches internal diameter, is forced by hydraulic pressure into the segments. More clamps are then added, one at every 4 inches of length. The lining-tube is then pressed home to its final position under a hydraulic pressure of about 50,000 tons. The structure is placed in a lathe and the outside of the segments is turned to a cylinder stepped with shallow shoulders at eight different points. The structure is then placed in another lathe, fitted with a gear for winding on the wire at a specified tension of 2,600 pounds per wire, or about 128,000 pounds per square inch. The end of the first wire is fastened by a plug into a hole in the first shoulder and is wound from there to the breech and back again to the shoulder, where it is fastened by plugging. The same process is repeated at each shoulder, the winding being carried to the breech ring and back to the shoulder from which it started. After the desired number of windings have been put on, the chase jacket is forced on with hydraulic pressure and a threaded muzzle cap is screwed into place. The trunnion jacket is then shrunk on, the liner is bored and rifled, and the breech mechanism fitted, leaving the gun ready for mounting.


THE NEW WILLIS AVENUE BRIDGE OVER THE HARLEM RIVER.

Swing-span, 310 feet; fixed span, 250 feet; total length, including approaches, 2,507 feet.

We have before us a report by Prof. J. B. Denton, of Stevens Institute of Technology, of a mathematical analysis of the stresses of the 5-inch gun. From the summarized conclusions we quote the following:

"I. By means of the tension due to the wire windings all parts of the segmental core or tube will be bound together with sufficient pressure to cause the frictional adhesion between its curved lines of division to exceed the shearing forces which would be transmitted along these lines in a forged tube of the same thickness, when fired with powder developing the highest current pressures.

"II. The metal of the segmental core, by virtue of the magnitude of its frictional adhesion, is as available as a source of longitudinal strength and transverse stiffness as the same thickness of solid steel.

"III. The division of the core into parts gives it an advantage over the same thickness of solid metal, in that a crack or incipient rupture at any point will not depreciate its usefulness; whereas a flaw in the solid metal may induce rupture.

"IV. The distribution of the wire windings secures a practically uniform compressive resistance in the firing tube, throughout its length, and without exceeding 90 per cent of the elastic strength of the tightest wire, the lining tube was probably compressed so that, with 50,000 pounds per square inch of powder pressure, it was not required to exert a tensile resistance."

With this testimony of Prof. Denton to the longitudinal and tangential strength of the assembled "segmental core" before us, it is interesting to note that the cost of the segmental tube would be materially reduced. Moreover, to the above undoubted advantages is to be added another of scarcely less importance, namely, that whereas the manufacture of hooped guns can be carried out at only four establishments in this country, the manufacture of this type of gun is so simple that it could be carried on in any machine-shop where there is a crane to handle it and a lathe of sufficient length to turn it; which means that there are at least a half-hundred shops in the United States that could safely contract for the construction of a number of these weapons.

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THE WILLIS AVENUE BRIDGE OVER THE HARLEM RIVER.

The opening of the handsome bridge which has just been completed across the Harlem River at Willis Avenue forms another important link between Manhattan Island and the suburban districts to the north of it. The new structure was commenced about three years ago, but its completion has been delayed beyond the time originally intended.

Although the length of the river-crossing is inconsiderable compared with the great structures which are being built across the East River, the overall length of the Willis Avenue Bridge entitles it to rank among the notable city bridges of the world. Its total length overall is 2,507 feet, and its total width overall, from railing to railing of the sidewalks, is 70 feet; while 6,200 tons of steel was used in its construction.

Commencing at the southern entrance at 125th Street, the bridge consists first of a masonry approach 345 feet in length. This is followed by 259 feet of short, plate-girder spans, carried on masonry piers, the last of these spans resting upon the fixed pier of the central swing-span. The latter is 310 feet in length between end pins, and provides two clear channel openings each of 108 feet width. To the north of the swing-span is a bowstring truss, 250 feet in length between end pins. To the north of this truss are six plate-girder spans, of a total length of 113 feet, followed by nine similar spans covering a length of 479 feet. The street grade is finally reached by means of a 200-foot masonry approach.

The most notable feature of the bridge is the swing-span and the adjacent bowstring truss. Both are constructed on the riveted system, the top and bottom chords consisting of built-up box sections, the web members being built-up latticed struts and ties. The swing-span is similar in contour to the swing-span of the Third Avenue Bridge over the same river, which was opened a few years ago. An endeavor has been made to secure gracefulness of out-