CAUSE OF THE RECENT EXPLOSION OF THE TEN-INCH GUN AT SANDY HOOK EXPLAINED.

BY HUDSON MAXIM.

At the Sandy Hook proving grounds, on Wednesday, March 29, a ten-inch gun burst, killing one man and wounding several others, the gun being literally blown to fragments.

According to newspaper accounts of the disaster, a full charge of 141 pounds of smokeless powder had already been fired, registering a pressure of only 33,000 pounds to the square inch. A small addition to the charge was made for the next round, about enough, it was intended, to bring the pressure up to 35,000 pounds.

The pressure gage found after the explosion indicated a pressure up to its full capacity of 79,000 pounds to the square inch. How much the pressure was which burst the gun there is of course no means of knowing, but it is probable that it exceeded 100,000 pounds.

This is not the first time that smokeless powder has shown itself to be very erratic. The reason for such tremendous mounting of pressure on the addition of but a small quantity to a charge which had previously given only 33,000 pounds to the square inch is a problem which requires careful consideration. The writer believes he can explain the curious phenomenon and the cause of the erratic action. He also believes that the remedy here suggested, if and when adopted, will avert further disaster.

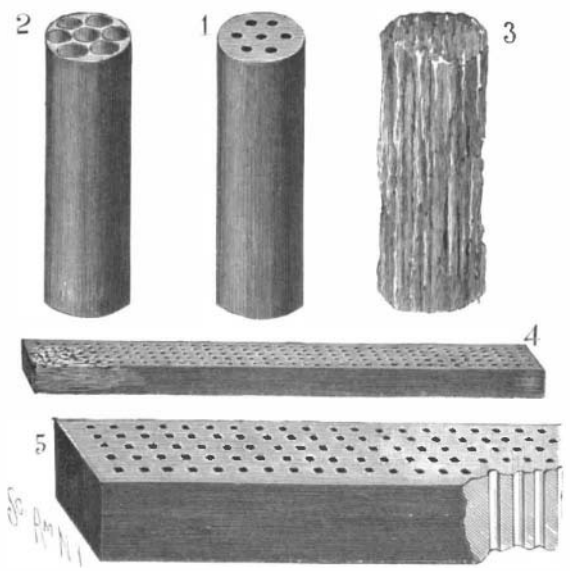
The writer understands that the smokeless powder grains which were used in the above test were in the form of cylinders about three diameters long, and longitudinally perforated with seven holes (see Fig. 1). In loading the gun these grains are filled into bags, which are placed in the powder chamber, the bags approximating in diameter the size of the powder chamber. On firing, the powder charge is ignited by a small flash charge of black rifle powder. When all goes well, the combustion of the grains progresses regularly from all the exposed areas, both outside and inside of the grains, as explained and illustrated on page 31 of the Army and Coast Defense number of the SCIENTIFIC AMERICAN SUPPLEMENT, July 9, 1898.

As smokeless powder burns with a rapidity increasing with the pressure, the combustion within the perforations is somewhat more rapid than upon the exterior surfaces of the grains, owing to the work required to displace the products of the combustion as formed. Fig. 1 shows the grain before being fired, having equal burning thicknesses between the perforations and between the outer circle of perforations and the circumferential surface of the grain. Fig. 2 shows the same grain partially consumed by firing in a gun too small and under too low a pressure to effect complete consumption. This grain was recovered in front of the gun after firing, having been ejected from the gun end on with great velocity, so that the rush of cold air through the perforations extinguished the flame. It will be observed that the remaining unconsumed walls between the perforations are much thinner than the outer and circumferential wall of the grain. This evidences considerably more rapid combustion within the perforations than upon the outer surfaces.

If we were to take a longitudinally perforated cylinder of smokeless powder, say eighteen inches in length, and ignite one end of it, and allow it to be burned in the open under atmospheric pressure, the flame would run along through the perforations and jets of flame would be thrown out at both ends with great violence, until the pressure mounted sufficiently high to explode the grain, blowing it into fragments at its central portion. If we take a similar rod or grain about 8 inches long and ignite it in a similar manner, we shall find that it will not explode as in the other instance. If, however, instead of burning this shorter grain in the open, we should place it in a gun and fire it under considerable pressure, it would burst, owing to the increased rapidity of interior combustion, with proportionate increase of internal pressure in excess of external pressure. Fig. 3 illustrates a grain which has been shattered by internal pressure.

As the external pressure upon the grains is increased, the internal pressure rises in due proportion, so that a length of grain and size of perforation which will not burst under atmospheric pressure will burst in a gun when the conditions of confinement become such that the internal pressure becomes so much in excess of external pressure as to exceed the bursting strength of the grain. Similarly, a length of grain and size of perforation which will stand without bursting when fired in a gun under a given pressure may not stand if the pressure be increased. In other words, the length and size of perforation must be in keeping with the degree of pressure to which the grain is to be subjected in the gun.

The grain used in the above disastrous test, while it would probably stand without disruption a pressure,



1, 2, perforated powder before and after partial combustion; 3, powder after being shattered; 4, 5, new powder with transverse perforations.

6.—SKETCH SHOWING POWDER JAMMED IN THE COMPRESSION SLOPE OR NECK OF POWDER CHAMBER.

say, of 50,000 pounds to the square inch, or even somewhat more, would yet be disrupted under a sufficiently high pressure, say of 75,000 pounds. Consequently, it is not likely that the bursting of the grain in the above test was due simply to the sudden mounting of the pressure occasioned by the slight addition to the charge. It is probable that another cause operated to mount the pressure abnormally high and beyond the bursting limit of the grains, and which, coacting with their disruption, raised the pressure to a tremendous height and destroyed the weapon.

Let us consider what probably took place. The flash charge set the whole charge forward against the projectile, and rammed it into the contracted neck of the powder chamber, where it narrows down to the rifled portion. The products of combustion set free at the rear of the charge, finding vent only by passing through the charge to follow the projectile along down the bore, produced a considerable excess of pressure at the rear of the charge, which tended to jam the forward portion still harder into the narrow neck (see illustration, Fig. 6). As a result of the excess of pressure at the rear of the charge and the impeded escape of the gases through the jam, the grains constituting the jam were more or less crushed, presenting a greatly increased burning area, with corresponding increase of pressure, which was sufficient to blow up all of the uncrushed grains, increasing still more, and to an enormous degree, the burning areas, and resulting in a pressure sufficient to burst the gun.

The substance of the powder grains under consideration is a very hard and vitreous colloid, and although it possesses considerable tensile strength, being by no means fragile, yet it is capable of being readily crushed or blown into fragments.

Explosive compounds are burned in two ways, one from surfaces, the other by what is called detonation, where the explosive is consumed nearly simultaneously throughout its mass by a wave action.

If a grain of smokeless powder be cut up into a fine sawdust and confined, and fired with a strong exploder, it will detonate like dynamite. Fibrous guncotton consists, in reality, of fine tubes, whose walls consist of a vitreous colloid, and the difference between guncotton in a fibrous state and that of the hard colloid used for smokeless powder is one of difference in the amount of surface presented—a difference in physical condition.

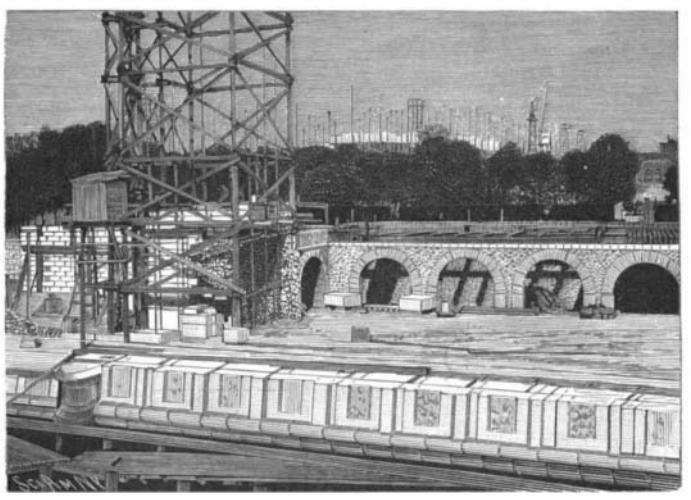
If a piece of smokeless powder be dissolved in acetone, and poured in a fine stream into water, the water will absorb the acetone and precipitate the smokeless powder compound in a fine state of division, with a fibrous texture resembling very closely the original guncotton. This substance will detonate with the same ease and violence as fibrous guncotton; and, if the smokeless powder contains a percentage of nitroglycerine, the artificial fiber thus produced will detonate with even greater violence than guncotton.

The foregoing considerations make it easy to understand how the disruption or crushing into fine fragments of powder grains in a gun can cause the pressure to mount to a degree approaching that which would be produced by detonation.

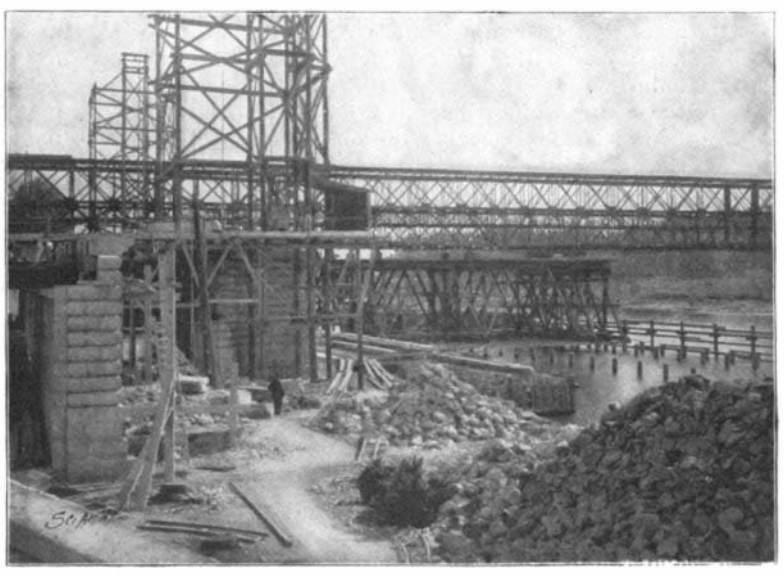
The writer believes that the higher and higher ballistics which are constantly being sought, and the higher and higher pressures that are being employed to attain the highest possible velocities, will require a modification in the present form of powder granulation now adopted by this government. Although the writer is himself one of the inventors of this grain, he does not believe that the longitudinally perforated grain is the ideal form for the attainment of the highest ballistics. If the grains be shortened so that higher pressures may be had without danger of disruption, we still have the same danger of jamming into the forward end of the powder chamber. Furthermore, as the grains are cut shorter, the amount of initial burning area is increased, with consequent lowering of the ballistic qualities of the powder.

The writer believes that the grain shown in Figs. 4 and 5, made in lengths of, say, eighteen inches, and having a thickness of from three-quarters of an inch to one inch, and a width of from one inch to one inch and one-half, and multiperforated in the manner shown, is a much preferable form. The burning thicknesses between the perforations should be adapted to the caliber of the gun in which the grains are to be employed. Such a grain packed into the powder chamber in a longitudinal direction to the bore would be incapable of jamming, while the initial area per unit of weight of material would be even less than that now presented to the flame of ignition by longitudinally perforated grains. The perforations could also be made smaller without danger of disruption from internal pressure, and a greater increase of burning area secured.

While finely granulated smokeless powder, or a smokeless powder sawdust above described, may be made to detonate like dynamite, yet it must be borne in mind that the pressure necessary to produce the detonative wave in such material is very high indeed, and much higher than ever could be attained in guns under normal service conditions. It is probable that the hard colloid of which



ABUTMENT OF THE ALEXANDER III. BRIDGE.



THE 1900 PARIS EXPOSITION—FOOT BRIDGE FOR USE IN CONSTRUCTION OF THE ALEXANDER III. BRIDGE.

the grains were composed which blew up the 10-inch gun would not detonate under 100,000 pounds to the square inch, although the rapidity of combustion under that pressure would be very great. To detonate the compound, it must be subjected to a sudden pressure sufficient to force upon the constituent molecules a rearrangement. It is probable that the powder did not detonate in the 10-inch gun in the true sense of the word.

It is probable that had there been placed in the gun, with the charge which exploded it, a piece of powder material of the same size and character as the grains fired, but without any perforations, it would not have been all consumed.

A GLIMPSE OF THE PARIS EXPOSITION OF 1900.

BY CHARLES RICHARDS DODGE.

The grounds of the Paris Exposition of 1900, lying within the city, comprise four plots or tracts, two of which, the Champ de Mars and the Esplanade des Invalides, are situated south of the Seine, with two lesser tracts, the Trocadero grounds and the site of the Art Palaces, situated on the north side of the Seine. The main tract, the Champ de Mars, and the Trocadero grounds just across the Seine, are connected by the Pont d'Iéna, and thus form one section. A second section is formed by uniting the Esplanade with the plot taken from the city park system, the two being united by the beautiful Alexander III. bridge, in process of construction. These two sections are connected along the Seine by considerable spaces on either side of the river, formed by the Seine embankments, and, on the south side, by taking in Quai d'Orsay, one of the city streets. While the several sections are almost in the heart of Paris, with blocks of buildings and systems of streets between, it will be possible to fence the grounds into one inclosure, with gates at different points, so that one ticket will admit to all parts of the grounds. It should be mentioned that another section of the Exposition will be located in Parc Vincennes, eight miles distant, though directly connected with the Exposition grounds by rail, with rapid trains running at short intervals.

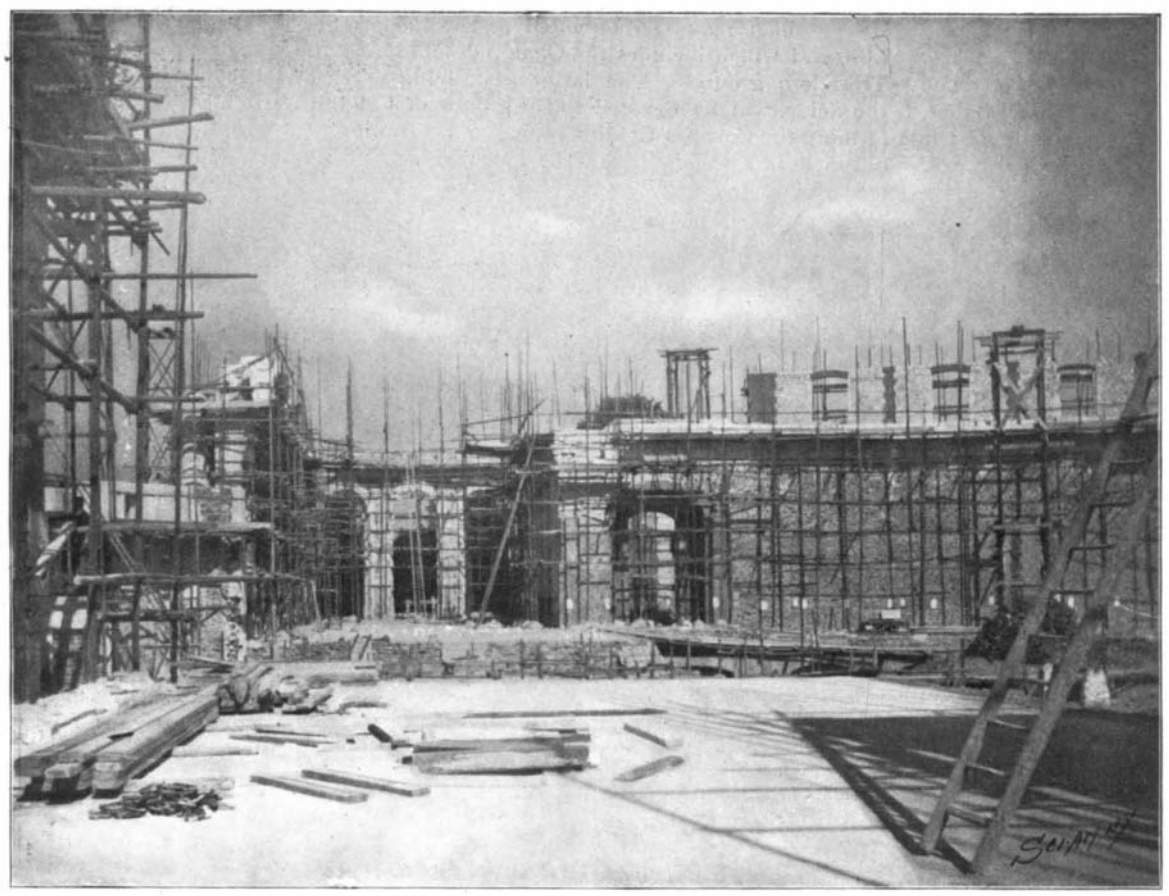
The main entrance to the Exposition proper will be near the Place de la Concorde, and, therefore, only a short distance from the garden of the Tuileries. The eastern sections of the grounds nearest to this point are to be connected by a magnificent piece of permanent engineering work over the Seine, to be known as the Alexander III. bridge. Upon the large tract extending along the north bank of the river, which was acquired by using a portion of the park system between Cours de Reine and the Avenue des Champs Elysées, and including the site of the now demolished Palais l'Industrie, two superb palaces of art are in process of construction, which are to be permanent. To make room for these immense structures it was necessary to sacrifice the old Palais l'Industrie, and, to make the buildings themselves more imposing, a new thoroughfare is to be established, the Avenue Nicholas II. Starting from the Avenue des Champs Elysées, this thoroughfare will pass between the two Art Palaces, upon which they will front vis-a-vis, and, crossing the Seine by means of the new Alexander III. bridge, will extend the entire length of the Esplanade des Invalides in a straight line, ending at the Exposition building that forms the boundary of the grounds in this direction.

In the effort to secure all available space, even the Seine has been encroached upon, and the embankments extended further out into the stream on either side at large outlay, the surface of the new embankments being at a lower level than those at present existing.

When in Paris recently it was my good fortune to be permitted to go through the ateliers of the Exposition, for the present located in that portion of the old Palais l'Industrie still standing, where are to be seen the plaster models, in exquisite detail, of two palaces of art, models of portions of the bridge structure and its approaches, besides many beautiful models and designs of art work to be used upon the bridge and to enrich façades of Exposition buildings now in process of construction.

The Grand Palace of Fine Arts, which will house the treasures of sculpture and painting of all nations at the Exposition, is on the west side of the Avenue Nicholas II. and quite near the famous Avenue des Champs Elysées. Prizes to the value of 45,000 francs were offered for designs for this building. The design of M. Louvet was selected from sixty competitors, and the first prize of 15,000 francs was awarded to this architect. The accompanying illustration shows the fine massive proportions of the Grand Palace, which is constructed of cut stone, the same that is used so largely for building purposes in the city of Paris. The palace is provided with two grand staircases, and will have an imposing entrance hall. The first floor will be devoted to a series of superb exhibition rooms for paintings, and an enormous salon is provided for sculpture. There will also be suites of smaller exhibition rooms, besides a café and other rooms for entertainment or comfort of the Exposition visitors. Ample arrangements have been made for lighting all of these exhibition rooms, the upper ones, of course, being lighted from the roof.

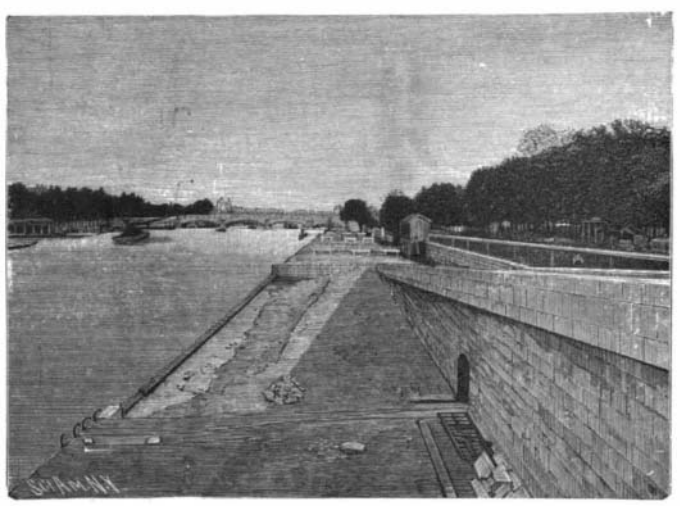
The lesser Palace of Art, an interior view of which is shown, known as the Girault Palace, from the name of the architect whose design was accepted, occupies a position on the east side of the Avenue Nicholas II. It will be a permanent structure, similar to the Grand Palace in materials and general style, and I understand will be devoted to historical treasures, a part of the



THE 1900 PARIS EXPOSITION—INTERIOR OF THE SMALLER ART PALACE.

THE 1900 PARIS EXPOSITION—EXTERIOR OF THE GRAND ART PALACE.

THE SEINE EMBANKMENT COFFER DAM.



ENLARGED AND COMPLETED SEINE EMBANKMENT.