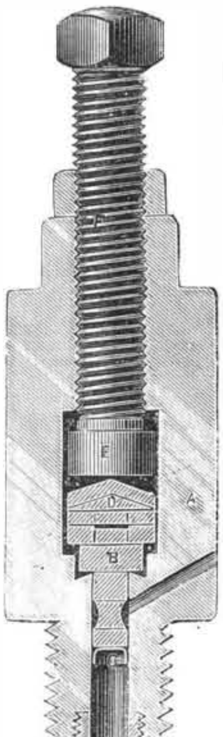
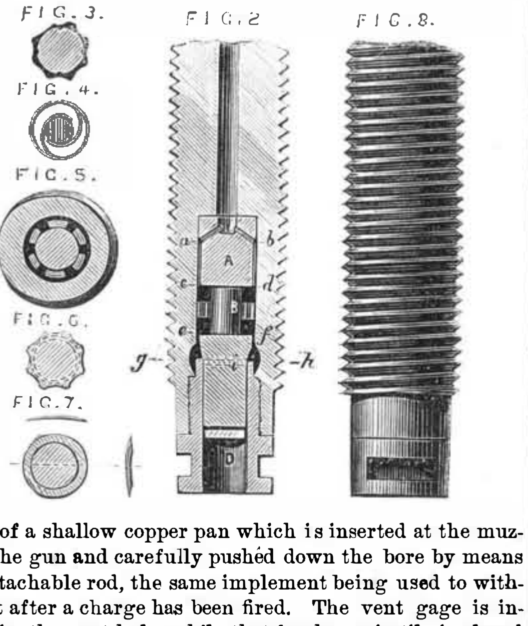
GUNPOWDER PRESSURE GAGES.

Amongst the various investigations, to which the great increase in the dimensions of modern artillery has led, is that relating to the pressure exerted within the bore of the gun by the ignition of the powder charge. The object with which the experiments in this direction were instituted was to determine the kind and quantity of the powder best suited for heavy guns. The Committee on Explosions, having the arrangement of the experiments, used the Rodman pressure gage in the first instance. This gage, we need hardly say, comes to us from the United States, having been devised by Major Rodman, the designer of the cast iron gun bearing his name. This gage is shown at Fig. 1, and in using it a hole is drilled through the gun at any point in the bore where it is desired to ascertain the pressure exerted by the exploding charge. Into this hole the tube, A, is screwed, its lower end, which is open, being flush with the bore. The other end is closed with the piston, B, the joint being rendered tight by means of the gas check, C. The piston carries a knife, D, and upon the knife rests a piece of copper, E, which is held tightly against it by the screw F. When the charge is ignited, the pressure of the gases on the base of the piston forces the knife into the copper, and the indent produced is held to be the measure of the pressure which has acted upon the base of the piston.



The results, however, which were obtained with this apparatus were so exceedingly variable that the committee were led to devise a modified form of pressure gage in which some of the causes of error inherent in the Rodman gage were eliminated. The crusher gage, as it is termed, is shown at Figs. 2 and 8, our illustrations having been prepared from drawings with which we have been favored by the War Department. This apparatus was made in the Royal Gun Factories, and consists of a screw plug of steel provided with a movable base, Fig. 3, which admits of the insertion of a small cylinder or pellet of copper, B, in the chamber, *c, d, e, f*. One end of this cylinder rests against an anvil, A, the other being acted upon by a movable piston, C, which is kept well up to the cylinder by means of a small spring, *i*. The copper cylinder is retained in a truly central position within the chamber by means of a small watch spring seen at Fig. 5. In order to prevent any possible leakage of gas into the chamber, the head of the piston is fluted, as seen at Fig. 7, as is also the body of the anvil, Fig. 4. Four small holes, *a, b*, Fig. 3, communicate with a main vent passing through the upper portion of the plug. Against the lower extremity of the piston a gas check, D, is inserted. The crusher gage is used in exactly the same way as the Rodman gage, being inserted at any required point in the bore of the gun. In the eight inch experimental gun the pressures are taken at intervals along the whole length of the bore, holes being drilled for that purpose. As the gases expand, following up the flight of the projectile, the pressures become weaker, the reduction gradually increasing towards the muzzle as the expansion increases. The forward gages are therefore provided with cylinders made from a softer metal than those used at the immediate point of explosion. In the thirty-five tun gun, the pressures are taken at three points, at the end of the bore, at the vent, and at the base of the projectile. The gage for the end of the bore is placed in the



center of a shallow copper pan which is inserted at the muzzle of the gun and carefully pushed down the bore by means of a detachable rod, the same implement being used to withdraw it after a charge has been fired. The vent gage is inserted in the vent hole, while that for the projectile is placed in a hole made in the base to receive it. The gun is fired by electricity, the wires being inserted in the powder charge before it is placed in the gun. To prevent jamming, they are laid along a groove cast on the outside of the projectile, both powder and shot being rammed carefully home together. The action of the apparatus is very simple. Upon the explosion of a charge, the gas acts on the area of the piston and crushes the copper cylinder against the anvil. The amount of compression which the copper thus sustains becomes an indication of the pressure exerted upon the piston. The area of the copper cylinder found most suitable for the eight inch gun is one twelfth of an inch, the piston area being just double, or one sixth of an inch. In order to obtain data whereon to base the calculations of the pressures, a series of experiments were made, by means of a testing machine, to determine the pressure required to produce a definite amount of compression in copper cylinders, similar to those used in the instrument. The results of these experiments were tabulated, and they furnish a means of comparison whereby the amount of compression produced in the crusher becomes a direct indication of the pressure exerted by the gases at that part of the bore or chamber where the gage is placed.

The results of experiments show that, in the case of R. L. G. (rifle large grain) powder, the indicated pressure was from 22½ tuns to 40 tuns per square inch.

During the year 1870, the Russian Government instituted a series of experiments in this direction with 6, 8, 9, and 11 inch breech loading rifles, and 15 inch muzzle loading smooth bore guns. The object of the experiments was to ascertain the comparative action of grain and prismatic powders in heavy charges, and also to determine the charge suitable for each class of guns. The pressures varied with the charges and projectiles, from 11 tuns to 18 tuns per square inch.

These experiments led to the decided preference of prismatic as against grained powder. With equal velocities, the grained powder developed more than twice the pressure obtained with the prismatic powder. This wide difference, however, was only developed when the velocities were very high; and the higher these ranged, the greater the difference of pressure became between the two powders—always showing in favor of the prismatic. The experiments also indicated the great importance of the size of the diameter of the cartridge in muzzle loading guns, and of the length of the powder chamber in breech loaders. For instance, in the 15 inch gun, the velocities were equal with charges of 75 pounds and 100 pounds, when the diameter of the first was 12 inches, and that of the last 9·7 inch.—*Engineering.*

ON ICE, WATER, VAPOR, AND AIR.

[Report of a recent lecture by Professor John Tyndall, before the Royal Institution.]

Attention was first directed to a large tub in front of the lecture table, containing a freezing mixture of pounded ice and salt, in which were embedded some iron bottles with plugs screwed into their necks, and a large bomb shell, all of which were completely filled with water. Water, when frozen, expands, and these vessels being completely full, it can only do so in their case by rupturing the iron envelope which incloses it, which the speaker hoped would be the case during the following hour.

The great body of the light rays from the sun, and even a portion of the dark ones, pass through ice without losing any of their heating power, and when properly concentrated on combustible bodies, their burning power becomes manifest even after passing through the ice. In an experiment made by Dr. Scoresby, in the polar regions, he succeeded in so concentrating the sun's rays by an ice lens, as to make them burn wood, fire gunpowder, and melt lead; thus showing that the rays of the thing we call radiant heat retain their power even after they have passed through so cold a substance.

Yesterday we succeeded in making a very beautiful ice lens with which we burnt paper, ignited matches, lighted cigars, and exploded gunpowder by the light or by the heat rays—for they are synonymous. I may add, that Mr. Faraday, in summer weather, has been fortunate enough to get a sunbeam through an aperture into this room, and after passing it through an ice lens, to explode gunpowder.

I take this slice from a block of ice and place it in this hot mold, and in a few minutes, as you see, we get it beautifully convex. The lens thus made was held in front of the electric lamp so as to include the whole beam, and a cone of light having its apex a few feet from the lamp was very visible; black paper and matches were ignited almost instantaneously when held at the point, and gunpowder was also exploded; thus verifying and repeating with the electric lamp Scoresby's experiments with the solar rays. We have all these wonderful effects produced by heat which has passed through so cold a body as ice.

I want you to take notice of the small still which is at the corner of the table. The small boiler contains water which is now getting hot, but as yet no steam has been formed; the water surrounding the worm is ice cold, and the glass vessel which will collect the distilled water is now quite empty. In a little while I shall revert to this again.

Now let us mark the wonderful power of ice to mold itself to the valley through which it passes, as exhibited in the glaciers of Switzerland, where the ice can accommodate itself to the flexures of the valley, and the immense masses of ice, which are the tributaries of the Mer de Glace (the Cascade du Taléfre, the Glacier du Géant, the Glacier de Léchaud, and the Glacier des Périades), weld together and squeeze themselves into the extraordinary small space we find at the gorge of Trélaporte. Is not this a wonderful proof of the yielding power of ice?

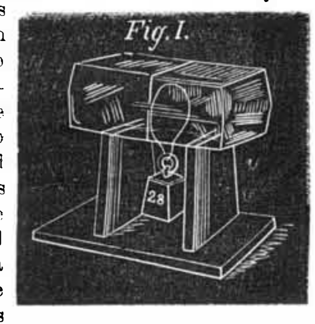
Now I want to make plain to you the possibility of a substance like ice, being squeezed in this way, changing its form but not its volume, and appearing after that change as solid and homogeneous as before. Below the freezing temperature ice is a very hard, brittle substance, but above the freezing point it is much softer and more yielding; it can be readily cut with a knife. But there is something more to be observed; ice not only can be cut with ease when it is melting, but it reunites as readily. This curious phenomenon was first observed by Mr. Faraday who found that, when two pieces of ice with moistened surfaces were placed in contact, they became cemented together by the freezing of the film of water between them, while, when the ice was below 32° Fah. and therefore dry, no effect of the kind could be produced. The freezing was also found to take place under water, and, indeed, it occurs even when the water in which the ice is plunged is as hot as the hand can bear.

Dr. Tyndall then repeated Faraday's experiment. A slice was sawn off a large mass of ice, and then laid on the place from whence it had been cut; a few moments rendered the junction as complete to all appearance as the rest of the block, and the large mass was lifted from the table by the re-united slice. Two smaller pieces of ice were then held closely together in a vessel of warm water, the result being the same as before—one mass of ice in place of two.

It is one of the most valuable features of the science we are studying, that it encourages thinking over facts; by reflecting on these facts, many additions have been made to our knowledge of glaciers and icebergs. This phenomenon is known as regelation. Icebergs are sometimes formed in the open sea by the linking together in this way of separate pieces of ice, and still more frequently icebergs coalesce and form huge chains and islands of ice in mid ocean by the refreezing of the contact surfaces of melting ice.

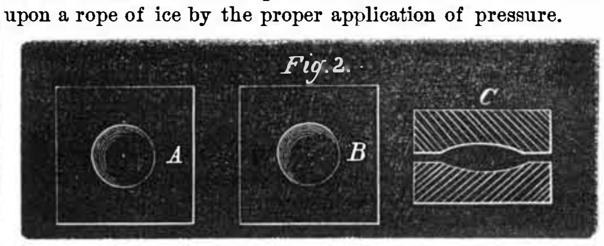
Generalization from these interesting facts led Dr. Tyndall to conclude that a bruised mass of ice, if closely confined, must re-cement itself when its particles are brought into contact by pressure; in fact, the whole of the experiments about to be recorded immediately suggested themselves to his mind as natural deductions from the principle established by Faraday.

Professor Bottomley made an experiment recently, which, as it bears upon this subject, I have set going for you. A block of ice (Fig. 1) was placed on two uprights, with a loop of wire round it, to which was attached a twenty-eight pound weight. The wire immediately began to enter the ice and passed right through it, afterwards dropping down with the weight; but the ice remained undivided, and except for a little opacity along the plane of passage, showed no signs of ever having been divided.



Now let us ask ourselves what must become of the snow granules when they are squeezed together? Every boy knows that they cohere and form a snowball. Salt will not act so. I have no snow, but I can find a substitute for it. Snow is frozen water, and so is ice; if I scrape down this ice into a powder, we shall find it a very good substitute. This was done, and in order to make the snowball firm, the first rough mass was put in a boxwood mold and squeezed in the shape of a sphere, by a hydraulic press. The operation was then repeated, the mold being opened and more ice powder, or rather ice slush, being added, each time, until at length a beautiful solid ball of clear ice was obtained, which, from its containing scarcely any air in its interstices, was rolled before the boys as the firmest snowball they had ever seen.

Dr. Tyndall then made a number of experiments proving how readily ice can be molded to any shape. Were the result worth the labor, it would be possible to make vases and statuettes, to bend it into spiral bars, or even to form a knot upon a rope of ice by the proper application of pressure.



Two pieces of seasoned boxwood, A B (Fig. 2), having corresponding cavities hollowed in them, so that when one was placed on the other a lenticular space, C, was inclosed, had a rough sphere of ice scrapings placed between them, and were subjected to the action of a small hydraulic press. The ice crackled a little, and in a few moments a lens of compact ice was taken from the mold. This lens was in its turn placed in the mold. This consists of a block of boxwood having in it a hemispherical cavity, and covered by a second block, upon which a hemispherical protuberance, smaller than the cavity, has been turned; so that when the latter is placed in the former, a space of a quarter of an inch exists between both.

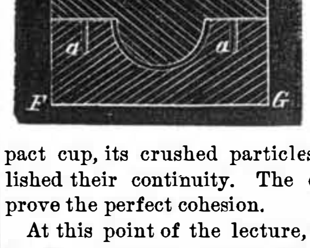


Fig. 3 represents a section of the two pieces of boxwood; the brass pins, *a a*, fixed in the slab, D E, and entering suitable apertures in the mold, F G, being intended to keep the mold concentric. After the ice was subjected to the hydraulic pressure for a few minutes in this mold, it was taken out as a smooth compact cup, its crushed particles having reunited and established their continuity. The cup was filled with wine to prove the perfect cohesion.

At this point of the lecture, the bomb, before mentioned, in some unexplained way exploded; it did not, as was expected, burst, but shot out the screw plug with great violence up into the gallery of the theater; the iron bottles were ruptured with very little noise, but were split from end to end, thus impressing the fact very forcibly on the young