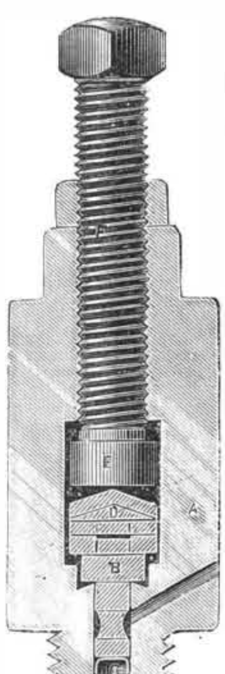
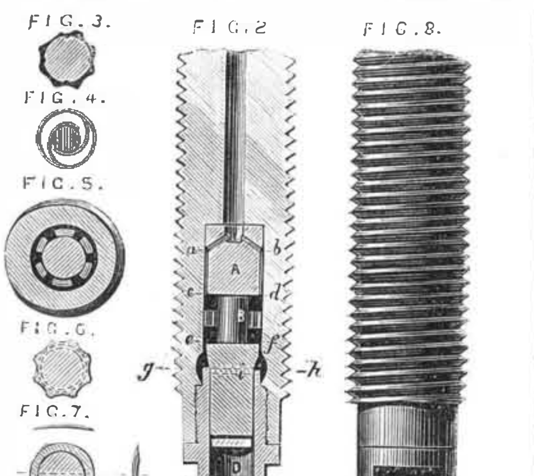
GUNPOWDER PRESSURE GAGES.

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 stee 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?

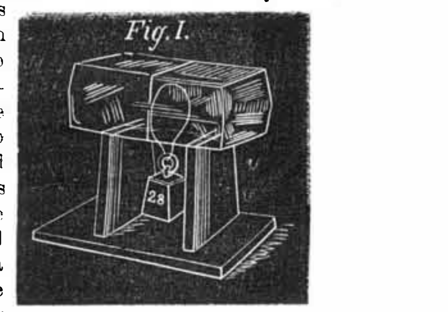
Now I want to make plain to you the possibility of a substance like ice, being squeezed in this way, changing its form but not its volume, and appearing after that change as solid and homogeneous as before. Below the freezing temperature ice is a very hard, brittle substance, but above the freezing point 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.

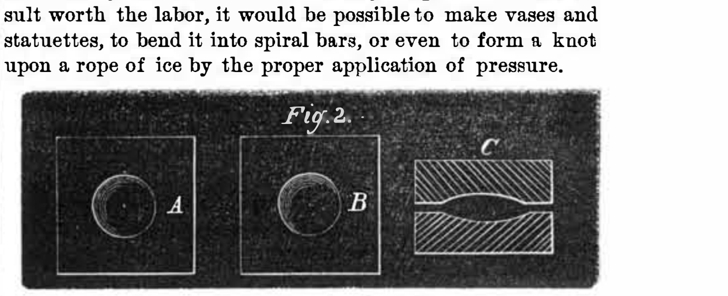
Generalization from these interesting facts led Dr. Tyndall to conclude that a bruised mass of ice, if closely confined, must re-cement itself when its particles are brought into contact by pressure; in fact, the whole of the experiments about to be recorded immediately suggested themselves to his mind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

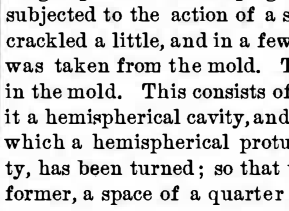


Fig. 3 represents a section of the two pieces of boxwood; the brass pins, *a a*, fixed in the slab, D E, and entering suitable apertures in the mold, F G, being intended to keep the mold concentric. After the ice was subjected to the hydraulic pressure for a few minutes in this mold, it was taken out 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

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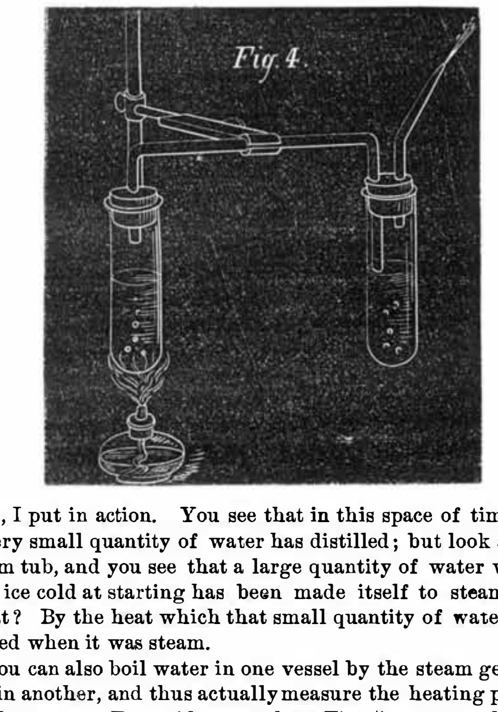
-hearers, that when ice freezes it is larger than the water from whence it comes, and that it cannot freeze without undergoing this change of bulk, which will burst almost anything.

Two cups were next made in the mold above described, and a piece of sealing wax being placed in one, the other was brought down upon it, so that their pieces met, when a momentary squeeze with the lecturer's hand joined them together into a hollow globe. Rings of ice, which had been molded before the lecture, were joined to form a chain; indeed, there is scarcely any limit to these experiments, if time would permit.

The effect of subjecting ice to strain and pressure, when below the melting point, was next demonstrated. This was done by crushing chilled ice in an iron mold; a series of loud cracks announced the rupture of the ice under these circumstances, and at the end it presented itself as a white powder, looking very much like rough salt.

You can now understand how a substance which so readily changes its form under pressure, and so readily re-unites itself when broken, can be forced through narrow gorges, and can accommodate itself to the bendings of the valley through which it moves. But there was another famous theory, which will lead me to say something about another property of ice. If you melt a quantity of ice, the water produced is not quite so big as the ice, and if you freeze water, the ice produced is somewhat bigger than the water; and as you have just now seen, the water swells in freezing, and the force with which it swells is enormous. It was this force that some eminent men thought to be the power which urged the glaciers continually downwards. But the glacier is not continually converting water into ice, as this theory supposes. This experiment leads me to think that you would like to see water frozen and a little bombshell burst in a red hot vessel. But you must first give me your attention while I explain the process.

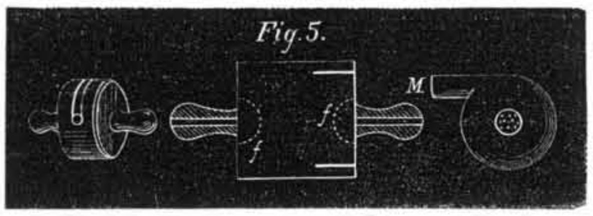
Let us look at the still which, at the beginning of the lecture, I put in action. You see that in this space of time but a very small quantity of water has distilled; but look at the worm tub, and you see that a large quantity of water which was ice cold at starting has been made itself to steam—by what? By the heat which that small quantity of water contained when it was steam.



You can also boil water in one vessel by the steam generated in another, and thus actually measure the heating power of the steam. Two wide test tubes (Fig. 4), connected by a piece of quill tubing which, starting from the neck of one, goes to the bottom of the other, were about half filled with water; and a spirit lamp, placed under the first, in a short time created sufficient steam to pass into the second tube; but, however familiar the result, it was almost startling to see how very much more rapidly the second was made to boil, by the steam which was passed into it, than that had done which had been heated by the lamp, and also the minute increase in bulk of the liquid.

The rule is quite general that, when a liquid passes to the state of gas, heat is consumed, and if heat be not supplied, intense cold is produced. Ether poured on the hand produces an extreme feeling of coldness from the rapidity with which it evaporates. And the rule is just as general that when a solid is dissolved, heat is consumed and cold produced. This explains the coldness of the mixture of salt and pounded ice, or salt and snow—the salt causes the ice to melt, and thus produces great cold. Salts which dissolve with great rapidity produce a correspondingly great degree of cold. This has been taken advantage of by many persons who have invented different kinds of freezing machines. That which we have here is by Mr. Ash, and the ice which I turn out has been produced by the absorption of heat by liquefying certain saline substances, without the use of snow or ice.

We are now prepared for an experiment. There is a gas, which is a very heavy one, often found in brewers' vats, at the bottom of deep wells, etc., a poisonous gas; accidents happen sometimes by the men, who go into these vats to clean them out, not taking sufficient care to see that this gas is first removed. It extinguishes flame, and has many more remarkable qualities. This gas is carbonic acid; now when this gas is subjected to very great pressure, its particles are squeezed closer and closer together, until at length it becomes a liquid. In doing this, the gas gives off a great quantity of heat, the vessels and the pumps becoming very hot. This you understand from what you saw and were told in the earlier lectures. I have some of this liquid gas in this iron bottle. When the cock is turned on, what takes place? Some of the liquid is immediately turned into gas, and takes up, in so doing, exactly the amount of heat it lost in being converted into liquid carbonic acid; but this is done with exceedingly great rapidity. Where is the heat, that it requires, to come from? All the tubes and vessels through which the liberated gas passes become intensely cold, the air in the immediate neighborhood is robbed of all its moisture which falls as snow, but even the heat from these sources is not enough, and it gets the remainder from itself. The total amount of heat, required for part of the liberated gas, is got at the expense of another part, which loses so much heat that it becomes converted, not into the liquid but actually into the solid state.



Dr. Tyndall then allowed some of the gas to blow through a suitable vessel (Fig. 5) for retaining the solidified gas, and in a few minutes exhibited the carbonic acid snow in considerable quantity.

The recipient for the solid carbonic acid is an ingeniously constructed draw out box, the contrivance of M. Thilorier. It consists of a brass cylindrical case, having tubular handles affixed to its ends. Plates of pierced brass are fixed before the outlet of each handle as shown by *f f*; these act as sieves, to keep back the solid acid and allow the gas to pass out. The box has a short tube joined to the side, as in the sectional drawing, so as to form a tangent to the inner circle of the case, and opposite to this tube is placed a bent piece of brass, in order to prevent the violence of the inrushing gas from blowing the solid matter into such fine particles as would enable it to pass through the perforated disks. For the purpose of taking out the solid, the box is made separable, by one end sliding over the other, and retainable together by two obliquely grooved holders placed on opposite sides of the joint. When being used, the tangent tube fits over the nozzle of the gas bottle.

Following out the rule we laid down, if we liquefy this solid, or dissolve it rapidly, the reduction of temperature is now something beyond what can possibly be borne by living creatures. Faraday proved this temperature to be nearly 140° below the freezing point of water, and he made it lower still, by putting it under the receiver of an air pump and exhausting; the temperature thus obtained was 166° below zero, or 198° below the freezing point of water.

If I hold this test tube with the mixture of ether and carbonic acid in it in the electric beam, you can see, not only the hoar frost upon it brilliantly illuminated, but also that the cold in its neighborhood is sufficient to condense and refrigerate the moisture dissolved in the warm air of this room, and in consequence, a miniature fall of snow is produced.

It is plain that a sufficient degree of cold is produced by this mixture to freeze the water in our little glass bomb as we proposed, but how can this be done in a red hot vessel?

Leidenfrost observed that if a sheet of metal, such as this silver basin, is made very hot, and that then a drop of water is allowed to fall upon its surface, the liquid does not boil, but instead of wetting the surface as usual and fizzing off in steam, it rolls about in a lively way in a spheroidal shaped mass (Fig. 6). The reason of this is that the temperature of the basin is so high that it immediately converts any liquid that touches it into vapor, upon which the liquid rests as on a cushion; in fact, the water is lifted up from contact with the hot metal by a spring of its own vapor; so that you see the possibility, at any rate, of a very hot and a very cold substance being very near together, so near as apparently to be touching each other, and that, nevertheless, the distance between them may be sufficient for each to maintain approximately its own temperature.

A mixture of solid carbonic acid and ether was then placed in a red hot platinum crucible, fixed in a circular hole in a large plate, to avoid firing the ether vapor by the flame of the lamp, and a glass tube, having a bulb filled with water at its end, was used to stir about the freezing mixture; in a few minutes a solid lump of ice was produced as it were from the center of a fiery furnace.

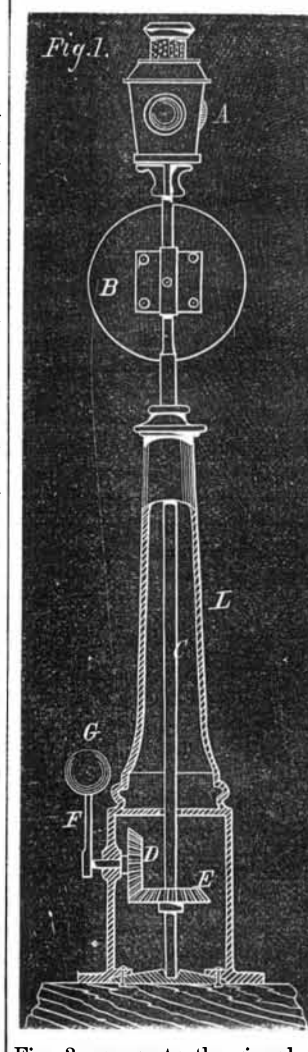
Some of the peculiarities attending cleavage were then touched upon. The little atomic bricks which form crystals often arrange themselves in layers which are perfectly parallel to each other, and which can be separated by mechanical means. Rock salt can thus be cut up into layers, and these layers may again be divided in certain other definite directions. There are, however, other phenomena to which the term cleavage is applied, and in some of these the cleavage only takes place in one direction. Sandstone cleaves in planes parallel to its bedding lines. Among the substances capable of cleavage, slate ranks very high; the blocks in which it is quarried cleave with the utmost facility into thin laminæ, which can be split up again almost indefinitely if the instruments be fine enough. Many theories explaining this peculiarity of slate have been promulgated, but at last it was found that the lamination of the mass was produced by pressure, and that these planes of cleavage were invariably at right angles to the direction of the pressure.

The flattening out of fossils in the slate forms an additional proof of the correctness of the conclusion. Some specimens were exhibited, showing the distortion of trilobites and shells.

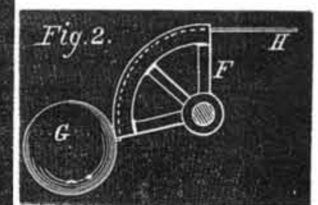
The same cause, which produces the cleavage planes of slate rock, also produces the veined structure of the glaciers. The ice of the higher regions is whitish, through the diffusion of small air bubbles within it. At the sides of the glaciers and at the bottoms of cascades, this ice is sometimes subjected to enormous pressure. It yields laterally as the slate mud has yielded, and a laminated structure is the consequence. On the surface of the glacier, under the medial moraines, and on the sides of the crevasses, the lamination reveals itself as clear blue veins or streaks drawn through the whiter ice.

NEW DEVICE FOR RAILWAY SIGNALS.

Our engraving illustrates a new form of railway signal which is now being introduced along the line of the New York Central and Hudson River Railroad.



In Fig. 1, A—the lamp in which bull's eye lenses of white and red glass are arranged—and B—the target—are attached to the rod, C, which passes through the ornamental iron post, L. The rod is arranged so as to be easily revolved by the action of the miter wheels, D and E. To the wheel, D, by means of a rod passing through the post, the lever, F, is attached, at the end of one arm of which is a solid weight, G. The form and arrangement of the lever and weight are shown in Fig. 2.



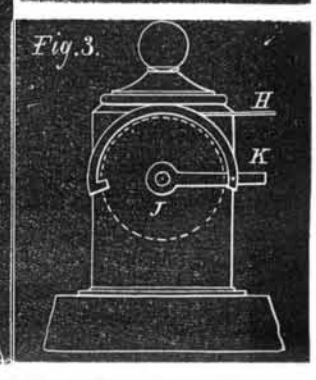


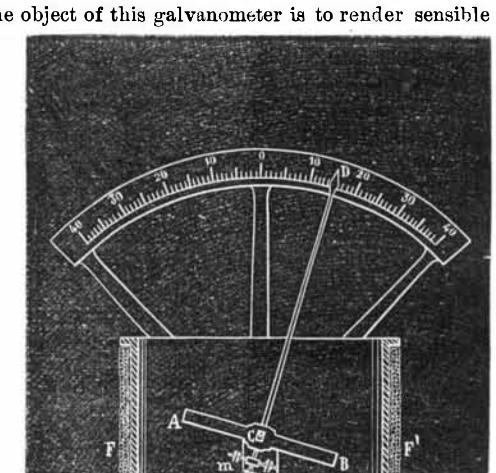
Fig. 3 represents the signal post, on the exterior of which is a hand lever, K, working in a semicircular guide and turning the sheave, J, within the post. To the circumference of this sheave, the wire, H, is fastened, passing therefrom over other sheaves for a distance of from 1,000 to 2,000 feet, until it reaches the lever, described on Fig. 1, to which it is attached, as shown on Fig. 2.

By raising the hand lever, K, the sheave is turned, and the force communicated to the wire raises the lever, F, and weight, G, which, by the action of the miter wheels, revolve the rod, C. By this means, the red or danger side of the target and the red light are displayed. On returning the lever, K, to its former position, the wire is loosened, and the weight, G, falls, turning back the lamp and target.

The apparatus was devised by Mr. J. M. Toucey, the superintendent of the road, and is now in successful operation at many points along the route.

VERTICAL BALANCE GALVANOMETER.

The object of this galvanometer is to render sensible to a



large audience the existence of weak as well as strong currents of electricity, without the necessity of employing any

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