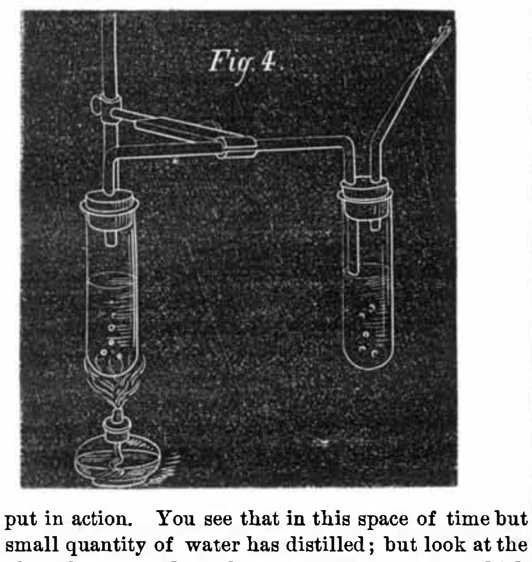
-hearers, that when ice freezes it is larger than the water from whence it comes, and that it cannot freeze without undergoing this change of bulk, which will burst almost anything.

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 lec-

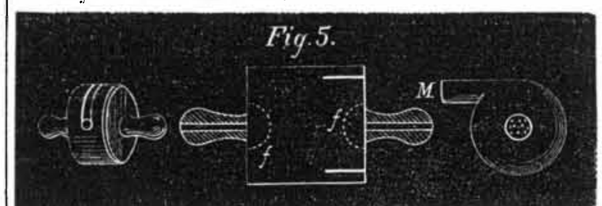


ture, I put in action. You see that in this space of time but a very small quantity of water has distilled; but look at the worm tub, and you see that a large quantity of water which was ice cold at starting has been made itself to steam—by what? By the heat which that small quantity of water contained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

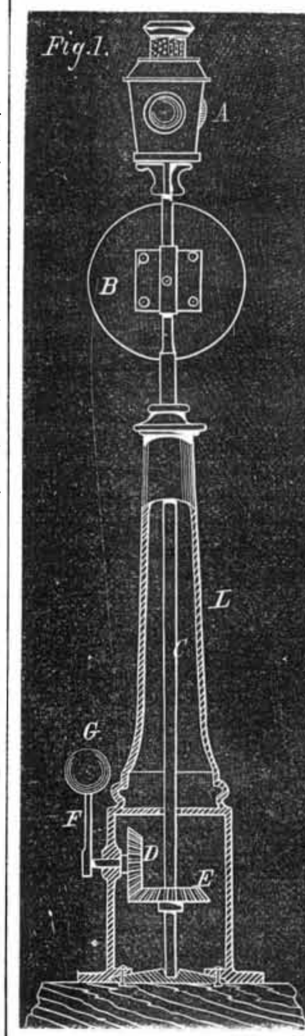
Some of the peculiarities attending cleavage were then touched upon. The little atomic bricks which form crystals often arrange themselves in layers which are perfectly parallel to each other, and which can be separated by mechanical means. Rock salt can thus be cut up into layers, and these layers may 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.

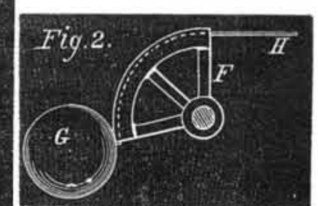
The same cause, which produces the cleavage planes of slate rock, also produces the veined structure of the glaciers. The ice of the higher regions is whitish, through the diffusion of small air bubbles within it. At the sides of the glaciers and at the bottoms of cascades, this ice is sometimes subjected 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.



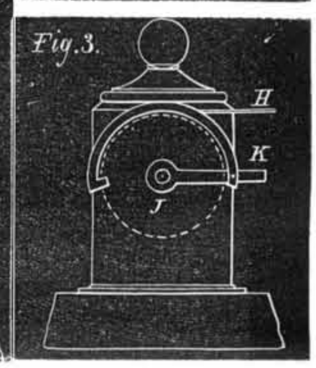


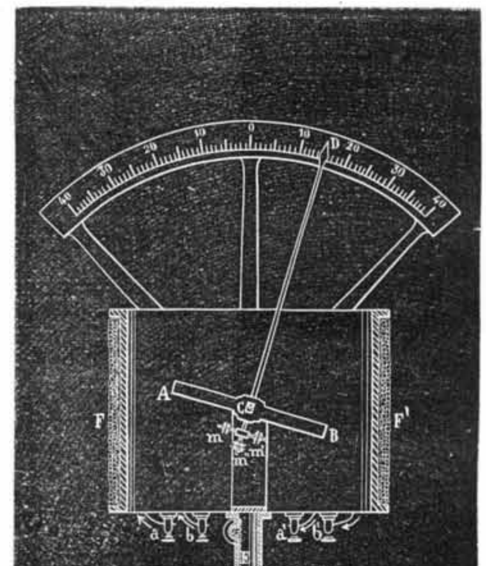
Fig. 3 represents the signal post, on the exterior of which is a hand lever, K, working in a semicircular guide and turning the sheave, J, within the post. To the circumference of this sheave, the wire, H, is fastened, passing therefrom over other sheaves for a distance of from 1,000 to 2,000 feet, until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