to strike the glass. To measure the electrical intensity with this instrument, the hook *A* was removed, and its place supplied with a pointed brass rod. The electrometer was first brought in contact with the ground as exhibited in Fig. 13; then held vertically as shown in Fig. 14, and gradually elevated until the leaves began to diverge. He found that the height to which the instrument required to be elevated before the leaves showed signs of electricity, varied at different times, and he estimated the intensity of the electricity of the atmosphere by the inverse ratio of this height.

The explanation of this will be readily seen by a reference to Fig. 15, in which C D represents a portion of the surface of the earth negatively charged, and *a b c* a perpendicular conductor terminated above and below by a bulb. In this condition the unsaturated matter in C D will act upon each atom of the fluid in the conductor, and tend to draw the whole down into the lower bulb; the atom *a* will not only be attracted downward by the action of the earth on itself, but also pressed downward by the attraction of the earth on all the atoms above it, and hence the intensity of the electricity of the lower part of the conductor will be increased by an increase in the perpendicular length of the rod. Now, if we connect the lower bulb of the rod with the earth by means of a good conductor, the redundant electricity of the lower end will be drawn off into the earth and will no longer react by its repulsion on the electricity of the rod to drive it back into the upper bulb, and hence this will become intensely negative; and in this condition it will be a salient point on the surface of the earth. If, while the apparatus is in this condition, we could touch the upper ball with an electrometer, it would exhibit a negative charge.

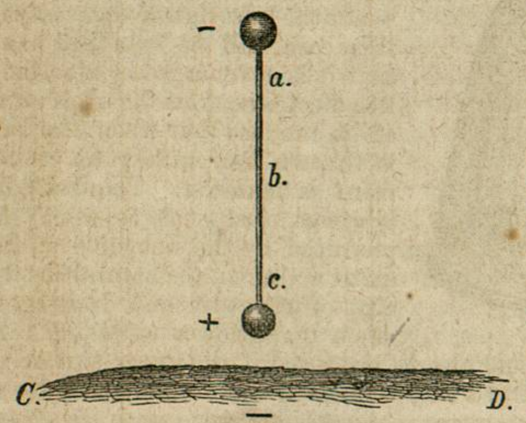

Fig. 15.

If a conductor 20 feet in length were made to revolve on a horizontal axis, passing through the middle of its length so that it could be immediately changed from a horizontal to a vertical position, any change in the apparent condition of the atmosphere would be shown by the greater or less intensity of the balls, as, in succession, they passed the lower point of their circuit; and an apparatus in the form of radiating conductors like the spokes of a wheel, if made to revolve, would furnish a constant source of electricity. An apparatus of this kind was constructed by M. Palmeri, of Italy, and might be used perhaps with success in studying the condition of the atmosphere in ascensions.

The most convenient apparatus, however, for exhibiting electricity

by the induction of the earth, is that invented by M. Dellman, and shown in Fig. 16:

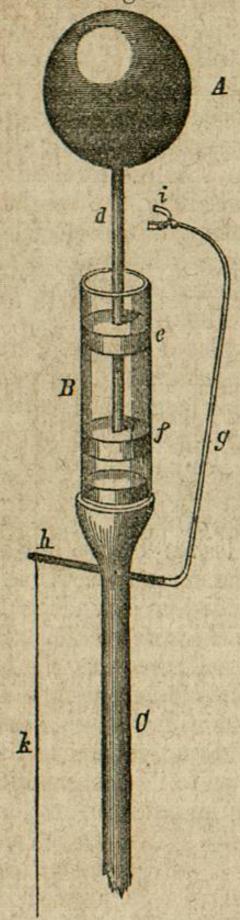

Fig. 16.

A is a brass ball, supported on a thick brass stem, which is insulated inside of a glass tube, by passing through corks of gum shellac. The apparatus is fastened to a pole, which is temporarily elevated, by a windlass or the hand, on the top of a house into the air. When it reaches the height intended, the wire *k*, connected with the earth below, is pulled, the end of the metallic bent lever *g h* is depressed, and the fork *i* brought into contact with the stem of the globe, and thus a perfect metallic connection is formed between the latter and the ground. The wire *k* is then released; the lever falls back; the ball is cut off from the earth, brought down, and applied to an electrometer, and in all cases, when the sky is clear, is found to be negatively electrified. If the wire *k* be insulated through its entire length, and terminated in a bulb at a little distance from the earth, and a pull be given to it by means of a rod of glass, at the instant of contact of the point *i* with the stem *d*, the lower bulb will exhibit a positive charge of electricity.

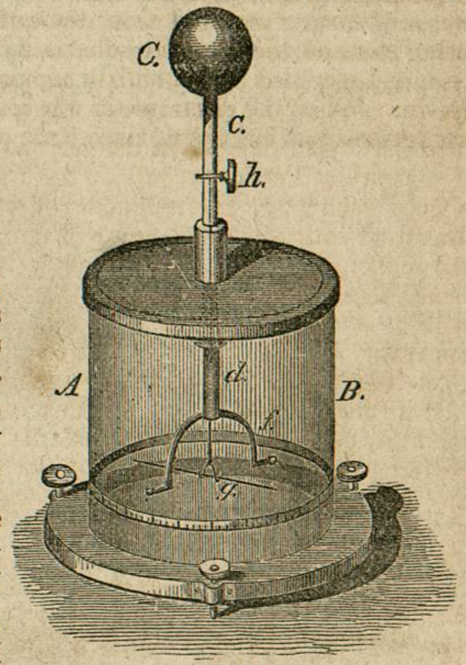

Fig. 17.

The arrangement will, in fact, be precisely the same as that exhibited in the previous figure, [Fig. 15,] namely: a vertical conductor, in which the upper end is rendered *minus*, and the lower end *plus*, by the induction of the earth. This effect is entirely due to induction, and is independent of any free electricity which may exist in the air. The results are exhibited with the greatest intensity during perfectly clear and dry weather, and are not observed when the conductor is placed horizontally, but with increased effect as its upper end is gradually brought nearer the perpendicular.

That these effects are not due to the free electricity of the atmosphere, is conclusively proved by the original experiments of Peltier. For measuring the intensity of the inductive influence of the earth, he made use of an electrometer represented in Fig. 17. In this, *A B* is a glass cylinder, furnished with a wooden foot and a glass cover, in the center of which is cemented a brass tube, carrying a ball *C* at the top, and a bent wire *f* at the bottom. At the level of the bent wire *f* is suspended a fine magnetized needle *g*, the height of which is adjusted by the screw *h*. The intensity of the electricity is measured by the divisions pointed out by the needle on the slip of paper surrounding the cylinder. This instrument, which is very sensitive, has been modified and improved by Dellman.

On the top of the flat roof of his house Peltier placed a flight of steps by which he could ascend with an electrometer in his hand similar to that we have just described, armed with a comparatively large sized polished ball. The ball of the electrometer was held at the height say of four feet above the roof of the house, and in this position it was touched by the end of a wire connected with the earth below. It thus formed the termination of a perpendicular conductor, and was, of course, negatively electrified—the bulb more intensely than the leaves below, but the stratum of air in which it was placed being in the same state, it exhibited no signs of electricity. It was then elevated by ascending the steps to the height of six feet above, and held by the lower plate. The leaves in this case diverged with negative electricity because the ball was still further removed from the earth, and the attraction of which being lessened, the part of the electricity which was in the leaves was set free, and ascended up the bulb by repulsion, leaving a deficiency in the leaves. When the electrometer was brought down to its first position, the leaves again collapsed, since there was again an equilibrium; and when the electrometer was depressed below its normal position, the leaves became positively electrified by the increased attraction of the earth, and in this way the electrometer was made to diverge, to converge, and diverge again, by simply changing its elevation.

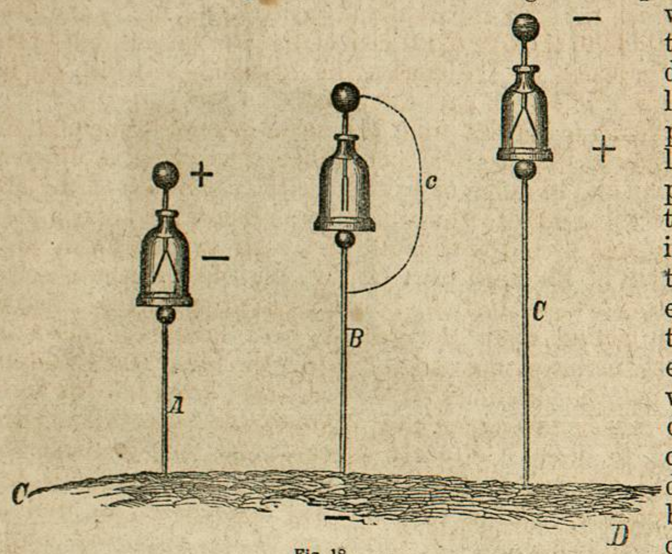

Fig. 18.

Fig. 18 is intended to illustrate the condition of the electrometer in the three positions, in which it is supposed to be supported on three metallic conductors of different heights. The electrometer brought into neutral condition by the ball, is shown in the middle of the figure at *B*, in which the connection of the rod with the ball is indicated by the dotted line. When the electrometer is raised by the hand to a higher elevation, its condition is exhibited by *C*, in which the greater elevation of the rod beneath it causes a greater amount of electricity to be drawn down, and the top of the rod and the bottom of the electrometer in connection with it, to become more intensely negative, and hence to draw down into the leaves a portion of the natural electricity of the ball, and cause the former to diverge with positive excitement relative to the air around.

The condition of the electrometer when brought to a lower level is illustrated by A, in which the shortening of the conductor reduces the number of atoms on which the electricity of the earth acts, and hence those at the top are more pressed upward by their self-repulsion than in the former case, consequently a portion of the natural electricity is driven into the upper ball, and the leaves themselves diverge with a negative charge.

The writer of this article had the pleasure, in 1837, to witness this interesting experiment, as performed on a dry clear day by Peltier himself.

In order that the result may be shown with a slight change of elevation, it is necessary that a large ball be employed, that the effect may be multiplied by all the electricity of the large surface. When the electrometer is terminated with the point of a fine needle, though this is the best means of attracting electricity from the air at a distance, no effect will be exhibited, although the apparatus may be exposed to the atmosphere for several hours, provided the weather is dry and the sky cloudless.

From these experiments it appears conclusive that the positive electricity with which the air is apparently always charged in dry and clear weather is not due to the free electricity of the atmosphere, but to the induction of the earth on the conducting materials of which the instruments are in whole or in part composed.

It is not difficult to deduce from the same general principles the apparent changes in the electrical state of the atmosphere at different times of the day and in different hygrometrical conditions of the air. Vapor of water mingled with the atmosphere renders the latter a positive conductor; and when the moisture of the air extends up as high as the upper part of the apparatus in Fig. 16, a feeble negative electricity will, by slow conduction, be diffused through the adjacent strata, which, acting upon the ball A, will lessen the effect of the more intense action of the earth. While the latter tends to draw the atoms of natural electricity of the conductor down into its lower part, and to render the upper end negative, the vapor around the ball will tend to draw it slightly upward, and thus diminish the effect, and lead the casual observer to suppose that the air is less positively electrified. Peltier in this way has shown, as well as Quetelet and Dellman, that the variations of the electricity of the atmosphere observed from day to day, and at different times in the twenty-four hours, correspond inversely with the variations in the amount of vapor.

The experiments we have thus far described are intended to establish the inductive character of the atmosphere in its condition of dryness and serenity, particularly during clear and cold weather.

We have employed movable conductors terminated by balls, which have been of the most favorable form and relative dimensions to exhibit the effects of induction. The apparatus, however, usually employed before the experiments of Peltier, were principally stationary insulated conductors, terminated by points above, which, as we have seen, act powerfully in discharging electricity from a body, or in absorbing it from the surrounding medium.

If in the experiments with the apparatus, Fig. 16, the rod be terminated by a point instead of a ball, but feeble excitation will be observed during clear cold weather, because the point exhibits so exceedingly small a surface that but very little electricity can be drawn down into the lower end, before the intensity of attraction of unsaturated matter upwards comes into an equilibrium with the attraction of the earth downwards. With this instrument the observer would probably make a record to the effect that the electricity of the atmosphere was very feeble, whereas if the experiment were made with the apparatus previously described, an opposite condition would be noted. The result, however, would be entirely different if the air were damp and the insulated rod elevated to a considerable height, the negative intensity of the upper end would be sufficient to attract a portion of the natural electricity from the surrounding medium, even although this had become slightly negative by the previous induction of the earth. In this case the pointed conductor would indicate a large amount of electricity.

The intensity of the induction may even become so great as to absorb a portion of the natural electricity of the dry atmosphere, as in the case of a very long wire, the upper end of which is furnished with a series of points, and raised to a great height by means of a kite. The points may attract a portion of the natural electricity of the air, and thus produce at the lower end of the wire a series of sparks, following each other, after the lapse of a certain time, at regular intervals.

From the foregoing, it will be evident that in interpreting the indications of the two classes of instruments we have described, which may be denominated those of induction and those of absorption, we must keep constantly in view the principles which have been explained; and it is for want of a clear appreciation of these principles that so much complexity has been introduced in the otherwise comparatively simple effects of induction.

ELECTRICITY OF THE CLOUDS.

The explanation of the thunder-storm and the tornado given by Peltier does not appear to us as satisfactory as could be desired. In common with most of the meteorologists of Europe, he does not take into consideration the real character of the storm, which, as we think, has been fully established by theory and observation in this country.

We have stated in a previous report that this consists in the rushing up of the lighter air to restore the normal equilibrium of the atmosphere, which had been disturbed or rendered unstable by the gradual introduction, next to the ground, of a stratum of warm and moist air. As an illustration of this disturbance, we may mention the fact pointed out to Arago, by Captain Hessard, which he had observed in the Alps, namely, that during great heats there takes place suddenly at the lowest stratum of clouds, upward rushings, extending vertically like rockets.

We shall endeavor to supply the deficiency, in the exposition of Peltier, we have mentioned, and to present, on the principles of the induction of the earth in connection with the upward motion of the air, a logical explanation of the origin and continued supply of the great quantity of electricity developed in the meteors under consideration.

It follows, from the principles of induction, that the upper end of all perpendicular insulated conductors must be electrified negatively, and the lower end positively, since the attraction of the unsaturated matter of the earth below will draw down the natural electricity of the conductor into its lower extremity, leaving a deficiency in the upper part. Now, if we admit, agreeably to the theory of Mr. Espy, that a cloud consists in the upward motion of a mass of moist and heated air, the vapor of which is condensed as it ascends into the colder regions, thus forming a high perpendicular column of partially conducting material, it will be evident that by induction, the upper part of this cloud will become negatively electrified, and the lower part positively, as in the case of the conductor, Figure 15. The intensity of this excitement will depend upon the length of the vertical dimensions of the cloud, which, in many cases, is exceedingly great, and also upon the density, and consequently the conducting power of the vapor. The induction of the earth being very intense, a partial excitement of the atoms of vapor may take place even before the condensation of the whole mass has reached its maximum. If this be the case, a transparent mass of vapor, or that which is merely beginning to condense into cloud, will be electrified throughout its entire mass; and when the condensation of the vapor has gone so far as to render the interior a tolerably good conductor, the electricity of each atom will be repelled to the surface, as in the case of a globular conductor; the intensity

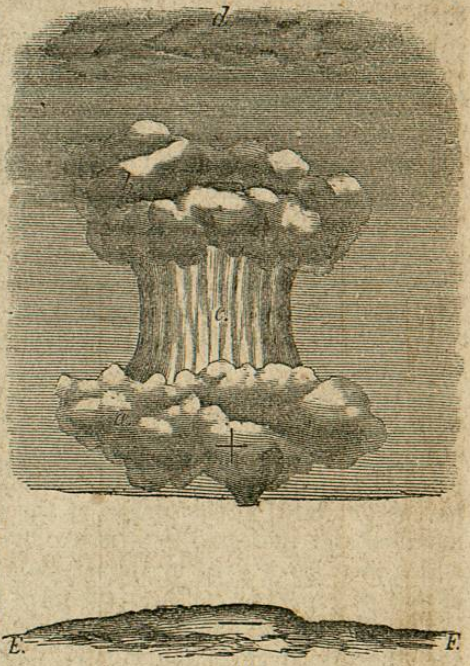

Fig. 19.