

Holland, who found that he had been making a wrong course from following his needle, there had been no storm, and the compass had not been touched. But on the evening of the same day, there was a brilliant aurora, and to this he attributes the deviation—a conclusion which could not have been dictated by theory, since at the time (in 1818) the relations between electricity and magnetism were not known.

The intimate connection between the aurora and terrestrial magnetism, has led Humboldt to designate as a *magnetic storm* a succession of disturbances of equilibrium in the magnetic forces of the earth. The presence of this storm is indicated by the oscillations of the magnetic needle, and afterwards, by the aurora, of which the oscillations are precursors, and which also put an end to the storm, just as the lightning in an ordinary electric storm announces that the equilibrium, before disturbed, is again established in the normal distribution of the electricity. Humboldt finds proof, amounting to experimental certainty, in the discovery of Faraday, who produced light by the action of magnetic forces alone, that the earth, by virtue of its magnetism, has the property of emitting light quite distinct from that which is afforded by the sun.

While recognizing the truth of the analogy which Humboldt here traces out, we should recollect, that it is not of itself, but because it produces electric currents, that magnetism gives out light; the light is purely electrical in origin. Magnetism produces luminous phenomena only because it can disengage electricity, and it is probably in this point of view that Humboldt says in a general way that it is a source of light.

It is hence in electricity, and in the influence which this agent in a state of motion, and magnetism, mutually exert, that we must look for the cause of the aurora borealis. This is the view which I would sustain, and to the force of my demonstration, I propose to bring some direct experiments, as well as the results of numerous observations through past years.

2. PROPOSED THEORY.

The atmosphere in its normal state is constantly charged with a considerable quantity of positive electricity, which increases as we ascend, starting at the earth's surface where it is zero.

I will not inquire into the origin of this electricity: what is certain is that its production is connected with the action of the sun, since its intensity is subject to diurnal variations. It may be a question whether the sun acts directly, either through its light or its heat, on the constituents of our atmosphere, and so produces the electricity; or whether it is an indirect effect of the solar rays causing evaporation from the waters of the seas, or the vegetation of the land. It is probable that both causes act: yet I am inclined to regard the first as most general and most constant. But this is of little importance here: the fact of the constant charge of positive electricity in the atmosphere and of negative electricity in the earth, is abundantly proved, and this is sufficient for our explanations.

This constant production of the two electricities must necessarily be attended by a recombination or neutralisation, otherwise the contrary electric states would acquire an infinite tension, which is contrary to observation. This recombination or neutralisation takes place in two ways, one irregular and accidental, the other normal and constant.

The first method is exhibited under various forms. Generally it is the simple humidity of the air, or the fall of rain or snow, which causes the neutralisation. At other times, it is

the thunder-bolt, which exhibits in an energetic manner the tendency to union in the two accumulated electricities, one in the air, the other in the ground. The winds in certain cases, by mixing the air from the earth's surface which is negative like the earth, with the positive air of a region more elevated, leads to a neutralisation of the two electricities, causing either storms or an exhibition of heat lightning. In winter, the air being constantly more saturated with moisture, the direct neutralisation is effected through the aqueous vapors and there are therefore fewer great disturbances and consequently fewer storms; and at the same time, as Arago has remarked considering the number of storms, the lightning strikes the earth more frequently in winter than in summer.

In general, the influence of the hygrometric state of the air on the manifestations of atmospheric electricity is almost as great as that of the cause itself which produces this electricity; for this influence makes itself felt both in the production of the accidental phenomena just enumerated, and in the indications of the electrometer by which we ascertain the normal electric state of the air for the hours of the day, and days of the year. Hence it is difficult to deduce from these observations even the intensity of the atmospheric electricity for any given moment, seeing that it is impossible to separate this original intensity from the degree more or less decided which the electric registers may manifest.

Let us now pass to the second mode of neutralisation of the two electricities, which I regard as normal and regular.

The positive electricity, with which the upper beds of the atmosphere are charged, will traverse them freely, because of their high state of rarefaction. But in the polar region, where the intense cold constantly condenses the aqueous vapors, it finds a portion of the atmosphere saturated with humidity, giving rise to mists; and by this means it may easily pass to the earth and combine with the negative electricity with which the earth itself is charged. It consequently results that there are constant currents of positive electricity rising from different points of the earth's surface into the upper regions of the atmosphere, which pass towards the poles, and then return beneath the earth's surface towards each of the points whence they have started. The currents of the northern hemisphere should go to the north pole, and those of the southern, to the south pole. In the equatorial regions, the position of the sun will determine the dividing line between the two systems. We may add that the experiments made with the electric telegraph have demonstrated that the terrestrial globe is an almost perfect conductor of electricity, compensating by its mass, for what it wants in the conductivity of the materials which constitute it. Thus the existence of the currents, whose course I have traced, rests on well established principles, with a foundation of simple experiment.

But more than this: their existence is demonstrated by facts long studied and established,—those pertaining to the diurnal variation of the magnetic needle.

I do not examine here into the origin of the earth's magnetism, a subject to which I shall have occasion to return in another work; for the present, I only say that I do not regard the disturbing causes of the direction of the magnetic needle as of the same nature with those which determine this direction. I content myself now with regarding the earth as a large magnet having its two poles; and I study only the causes that modify the direction which, in this quality of a magnet, it tends to impress on the magnetic needle. These causes are the electric currents, whose existence I have just shown; they well explain the diurnal variations. These variations, in fact,