

consist in this, that in our hemisphere, the north pole of the needle moves to the west, during the morning until half-past one p. m., and then returns to the east during the rest of the day, to remain stationary during the night. But this deviation is precisely that which should be occasioned by currents passing along the surface of the globe from the north pole to the equator, augmented, in intensity with the heat of the day and diminishing as it decreases. The diurnal variation is at its maximum (13' to 16') in those months in which the sun is longest above the horizon, May, June, July, August. It is at its minimum (4' to 5') during the winter months. The variation is greater as we pass from the equator towards the pole; but it is evident, that if the currents, proceeding from different points of the earth's surface heated by the sun, rise in the atmosphere to redescend at the polar regions, and thus traversing the globe, reach their points of departure, the nearer the needle to the magnetic pole, the greater the number of currents that will act upon it: near the equator, it will not be subject to any influence from the currents which are formed beyond the region around the needle. In winter these differences are less sensible, because the currents from the equatorial regions are the only ones whose effects will be very decided, on account of the little difference of temperature which exists in this season between the earth's surface and the upper regions of the atmosphere in the temperate and especially the polar zone.

Finally, according to our theory, the same effects should be manifested in the southern hemisphere, only that all is reversed; and this is fully established by the various results of recent observers, including those of Colonel Sabine and a large number of travellers.

I should however acknowledge that there are some anomalies, either in the hours or in the direction of diurnal variation, at certain places, especially at St. Helena and the Cape of Good Hope, anomalies which it is difficult to explain by the theory proposed. But I am convinced that when further examined, they will be found to be due to local and accidental causes, such as the vicinity of the sea, which influences very notably the diurnal variations of temperature and especially their amplitude and the hours of the maximum and minimum of heat. The question whether there are not places of no variation, proposed by Arago, is of little importance in this connection. The points of the earth's surface without diurnal variation, will be those where the two currents originate, and whence they proceed from the right and left towards the two poles: they are situated in the equatorial regions, but they cannot well be laid down, as their position will vary with the sun, the temperature, the winds, and other disturbing causes.

But I do not dwell on this point, as my object is not to treat of the diurnal motions of the needle. My end is simply to prove from the diurnal variations, the existence of the terrestrial currents. In continuation, we may obtain another proof still more direct, although less general, of the presence of these currents, by making use of the telegraph wires for collecting them. This I have done in England, as has also Mr. Barlow; and M. Baumgartner has performed similar experiments in Germany. In these trials, the currents have in all cases been detected by means of the galvanometer. M. Baumgartner, having introduced a very sensitive galvanometer into the circuit formed by the telegraph wire between Vienna and Prague, which has a length of about 61 miles, obtained the following results when the two extremities of the wire were buried in the earth.

1. The magnetic needle never stood at zero, but was more or less deviated.

2. The deviations were of two kinds, some of large extent, even 50°, others small, varying from 1° to 8°,—the former not common, and changing in direction and intensity, so that no law can be discovered; the latter on the contrary subject to a simple law, and being very regular when the air is dry and the sky serene, but with many anomalies when the weather is cold and rainy.

Mr. Barlow has made numerous observations, and obtained results demonstrating the exactness of the principle, which I have laid down. Four main lines starting from Derby, were used in his experiments, two running towards the north and northeast, and two towards the south and southwest. The direction of the currents perceived on the first two lines, was always contrary to that of the currents on the two others, as ought to be the case, on the theory proposed. But the most remarkable fact, is the perfect concordance which these observations have proved to exist between the movement of the needle of the galvanometer placed in the circuit of the telegraph wire and the diurnal variations of the magnetic needle. The diurnal movement of the needle of the galvanometer is subject to disturbances in intensity more or less continued, during storms, and also when the aurora borealis is visible; and so also is this true of the compass needle. There is this difference, that the currents acting on the latter, circulating beneath the earth's surface, should not be subject to disturbances like those which happen to the telegraph wires through the influence of the electrical condition of the atmosphere about them.

The existence then of electric currents circulating beneath the earth's surface appears to us to be well demonstrated, and once proved, it leads necessarily to the conclusion that it is a consequence of the normal and regular reestablishment of the electric equilibrium between the earth and its atmosphere, which is broken essentially in tropical regions, whilst the electric charges, more or less intense, which take place between the earth and the air are the accidental and variable means for the reestablishment of this equilibrium. We may now see how the explanation of the phenomena of the aurora both north and south, flows necessarily from the formation of these electric currents circulating from the equator to the two poles in the upper regions of the atmosphere, and from the two poles to the equator along or beneath the surface of the globe.

As we have said above, the positive electricity with which the atmosphere is charged, especially in the upper regions, is carried towards the two poles either by the greater conductivity of the upper and most rarified strata of the atmosphere, or by the currents of air in the upper regions which move from the equator to the two poles. It is consequently through the vapors which are constantly condensed in the forming mists in the polar regions that the positive electricity should find its passage into the earth, and also therefore its discharge. This discharge when possessing a certain degree of intensity should be luminous, especially if, as is almost always the case near the poles and sometimes in the upper regions of the atmosphere, it encounters in its course icy particles of extreme minuteness, which form the haze as well as the more elevated clouds.

The formation of lunar halos which generally precede the appearance of an aurora, and the fall of rain or snow which also is often a prelude to it, are a proof of the presence in the atmosphere of these fine needles of ice, and of the part they play in the phenomenon before us.