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XXXIII. *On the Action of the Voltaic Pile upon the Magnetic Needle.* By M. BOISGERAUD Jun.

(Read in the Academy of Sciences, 9th Nov. 1820.)

I WAS witness in the sitting of the 11th September last, to some experiments relative to the action of the pile on the magnetic needle, which were repeated by M. Arago, and of which M. Ørsted is the inventor. These newly observed phenomena inspired me with a lively interest; I hastened to renew the experiments, and saw my attempt crowned with success. I did not stop at these first attempts; I made new trials, in which I obtained results which appeared to me interesting, and which may perhaps assist in explaining this sort of phenomena. I shall confine myself to reporting those which I conceive to be new.

I made use of a Galvanic trough of twenty pairs of the old construction, and of little power. The conducting wire was composed of two wires of platina of small diameter; they communicated with the poles of the pile, by means of brass wires of a diameter more considerable. I endeavoured to increase the effects of my first pile, by uniting it to a second exactly the same, in such a manner as to form a battery. This arrangement of the apparatus gave me occasion to ascertain that the metallic arc which joined the extreme poles, was not the only one susceptible of making the needle deviate; the intermediary arc, which united one of the piles to the other, produced the same effect, and observed the same laws. I was even able to approximate the effects of the two arcs; and according as they tended, by their respective positions, to produce a deviation in the same or in an opposite direction, the effects were augmented or diminished.

The nature of the conductors in these experiments appeared to me to have a great influence. Thus, a simple leaf of paper dipped in the liquid of the troughs of the pile sufficed to diminish the effect considerably, when it was interposed between the conducting wires of my apparatus; a short piece of charcoal, partly dipped in water, destroyed it entirely*.

The following, is in this respect, a fact remarkable enough. Having placed the magnetic needle under the *intermediary arc* in such a manner that a strong deviation was produced when I made the two extreme poles communicate by a metallic arc, it was not so when I established the communication with my two hands: however, I experienced a shock rendered the more dis-

* Some experiments since made by M. Ampere, with an apparatus of small power, proved that charcoal (especially if incandescent) does not entirely destroy the effects. Water charged with acid produces the same effect.

agreeable, from having a slight wound near that part of the finger which was plunged in one of the troughs of the pile.

I endeavoured, at the desire of M. Poisson, but in vain, to obtain with my apparatus effects at a distance, by terminating my wires of platina with very sharp points; contact was always necessary to produce a sensible deviation.

These facts have led me to conclude that the nullity of action in a Voltaic column of fifty-eight pairs (whether horizontal or vertical) must be attributed at least as much to the imperfect conducting power of the wrappers of wet cloth, as to the small dimension of the discs (that of about a six-franc piece). However, this pile gives a shock strong enough.

I remarked that it is very easy, by means of a battery composed of two piles, to establish the conducting power of liquid or gaseous substances interposed in one of the arcs, by placing the needle at the proximity of the other arc.

Hitherto I made use of a small compass needle suspended horizontally from a vertical pivot of brass. To render the phenomena of inclination more sensible, I took a steel wire of very small diameter, and magnetised it by a single touch*. It was about two centimetres in length, and manifested different degrees of magnetism, branching nearly from its centre point. I suspended this small needle by a very fine silk thread, in such a manner that it was horizontal.

By observing with attention all the circumstances which attended its deviations from the approach of the conducting wire of the pile, I perceived that every time the pole of the needle passed from one side to the other of this wire, though the latter was a little attracted on the passage of the needle, it did not prevent its movement; for the wire of suspension took an oscillatory movement, which approached and receded from the needle of the conducting wire; and when it had sufficiently receded, it took then a movement which could no longer affect that wire; but it avoided encountering the nearest face of the wire to take this new position, and it went, on the contrary, to the face of that side which it had passed.

The oscillations of the wire of suspension being modified by the action of a weight which serves to bring the needle to a point of equilibrium, from which another force would remove it; I thought of placing this small needle slightly coated by a greasy body; because then, the action of the weight being balanced, that of the conducting wire would have all its effect. The experiment succeeded perfectly.

I may observe in passing, that this small needle became sus-

* The effects are more marked, and more easily to be produced, with a wire magnetised to saturation by the method of double touch.

ceptible of decomposing water on the approach of two wires branching from the poles of the pile. This phænomenon, which I believe was already known, is easily to be conceived, and is equally produced with needles of steel not magnetised, of silver, of platina, &c.

Notwithstanding the feeble magnetism of this small needle, when put out of the magnetic meridian it recovered it promptly enough. It presented the same phænomena of declination as the needle to the pivot, and that without sensible oscillations. But I have further observed, that when the conducting wire was horizontal, and in the magnetic meridian of the needle, the latter turned round its middle point, which remained fixed; which supposes a certain symmetry of effects, and appears to me to lead, besides, to the consequence, that, in that case, the existing forces decomposed, according to the plane of the surface of the water, are reduced to two equals, opposite to and equally removed from the middle point of the needle.

It remains to me now to describe the movements of this needle according to the magnetic meridian. I have formed a table of them. For the sake of brevity, I designated the direction of the conducting wire by always commencing at the extremity of that wire by which it approximates to the zinc pole of the pile. The indication of movements applies equally to the two poles of the needle, and they may be indefinitely prolonged on the surface of the water*. The expressions of *attraction* or *repulsion* indicate that the needle approximates or recedes from the conducting wire.

The conducting wire situated	{	Above the surface of the water and directed	From east to west†—repulsion.
			From west to east—attraction.
	{	Under the needle (in the water) and directed	From east to west—attraction.
			From west to east—repulsion.
	{	To the east of the needle and directed	Downwards—attraction.
			Upwards—repulsion.
	{	To the west of the needle and directed	Downwards—repulsion.
			Upwards—attraction.

When the conducting wire is quite perpendicular to the meridian plane, the movement of the needle has constantly taken place according to the magnetic meridian‡, which requires that the forces then existing, decomposed according to the plane of the surface of the water, should give a resulting direction corresponding with the magnetic meridian. If moreover the mid-

* The water was distilled, in order to lessen the decomposing action of the pile.

† These directions are always given according to the needle of the compass.

‡ In the contrary case the movement is involved with that of the declination.

dle point of the needle is in the vertical plane passing by the conducting wire, it remains in a state of repose. This equilibrium is fixed, every time that in this position the conducting wire appears to exercise an attraction on the poles of the needle, and moveable, if it is directed in such a manner as to exercise a repulsion. This remarkable phenomenon seems to prove that the conducting wire acts only the poles of the needle.

The attractions and repulsions above mentioned, succeed in certain cases in a manner which merits observation. The needle of which I made use, was placed on the water in a glass stand, in such a manner that, to observe what passed when the conducting wire was under the needle, I plunged it in the water; and after having plunged it in the water, it came out to the right and left of the needle before touching the edges of the glass. I then drew some parallels to the meridian by the two points where this wire issued from the water. I divided the surface of the water into three parts; the one comprehended between the two wires, and which I called interior; the two others beyond them, or exterior. Thus placed as indicated in the preceding table, every time that there was attraction in the interior part, there was repulsion in the exterior parts, and *vice versa*. For then the needle, after having been repulsed in one of the divisions of water, passed to that where it had attraction by a movement owing in part to a declination, and more or less slow according to the distance of the needle. Once drawn to the attractive side, it takes an accelerated movement, which continues till its middle comes opposite to the conducting wire. This middle point recedes slowly from the wire. I believe that the impossibility of touching it may be ascribed to a capillary effect.

It will be seen by these latter experiments, that there is no equilibrium for the needle subjected to the action of the conducting wire, except when its middle point is of all the points the nearest to the conductor.

I believe that, according as the needle, after being repulsed in one of the divisions of water, enters the other by the north or by the south, it has a greater tendency towards one part of the conducting wire than the other; but this law does not always hold. This tendency of certain faces of the needle, and of the conducting wire, to approximate, in preference to others which seem on the contrary to repel, appears to me to have great influence in these phenomena. It seems to me also, that the results of forces which produce these movements may be regarded as situated in a plane perpendicular to the direction of the conducting wire.

I attempted, lastly, a sort of experiment from which it is difficult to draw conclusions on account of their complexity. [The account of these experiments in our next.]