EXPERIMENTS OF M. BJERKNES.

"INVERSE" IMITATION OF ELECTRIC AND MAGNETIC BY HYDRO-DYNAMIC PHENOMENA.

It must be confessed that absolutely nothing is known of the real nature of electricity. The principle of the conservation of energy and that of the unity of physical forces, which tends to simplify the phenomena and embrace them under one common term, for want of a clear and precise definition lead us to consider electricity or rather electric phenomena, as a *mode of movement*. This conception removes the difficulty, simplifies the question, but does not resolve it. The mode of movement, once admitted, forcibly compels the abandonment of the idea of *fluid*, which always accompanied electric phenomena at the outset of their study.

If we are agreed to-day upon the immateriality of electricity, we are, on the other hand, far from understanding the nature of the special mode of movement which characterises electricity, the word being taken in its most general acceptation.

In his *Recherches sur l'électricité*, M. Gaston Planté expresses his ideas on this point in the following words:

"Electricity can be regarded as a movement of *ponderable matter*—movement of *transportation* of a very small mass of matter incited with very great velocity, if the question is of the electric discharge, and a very rapid *vibratory* movement of the molecules of the matter, if the question is of its transmission to a distance under the dynamical form, or of its manifestation under the statical form at the surface of the body."

For some, who are much less precise in their definitions, electricity is produced by *molecular movements*, without otherwise determining its nature, characterised by form, direction, velocity, periodicity, &c.

In the experiments about to be described, M. Bjerknes proposed to throw light upon the question of the nature of molecular movements, by reproducing *mechanically*, but INVERSELY, simple and fundamental electric phenomena

M. Bjerknes designates under the general name of *vibration*, the movements which take, according to their nature, the name of *pulsation*, *oscillation*, etc.

Pulsation has reference to the change in volume. It includes two phases, one, in which the body swells, the other in which it shrinks. Pulsations are *synchronous* when the phases commence simultaneously.

Oscillation has reference to the change in place, it is an alternative displacement to the right and to the left.

M. Bjerknes mechanically obtains pulsations in water by the aid of a very ingenious apparatus.

The *pulsations* are produced by small cylinders stopped at their ends by flexible walls. A small hand pump which is partly shown on the right in fig. 1, is employed to exhaust and compress alternatively the air in the cylinders provided with flexible walls, at a great velocity.

In the simplest pulsator, the two walls dilate and contract at the same time under the action of forcing the air from the pumps, the phrases are synchronous (fig, 2. No. 1). In another arrangement, the two drums are separated by a rigid wall, which forms two chambers each in connection with a separate pipe conducting the air (fig. 2, No. 2). We have thus a most complete system, for by adjusting conveniently the tubes of the air-pump for exhausting and filling, synchronous pulsation can be produced at will, as in the first case, or pulsation in which the phases are alternate.

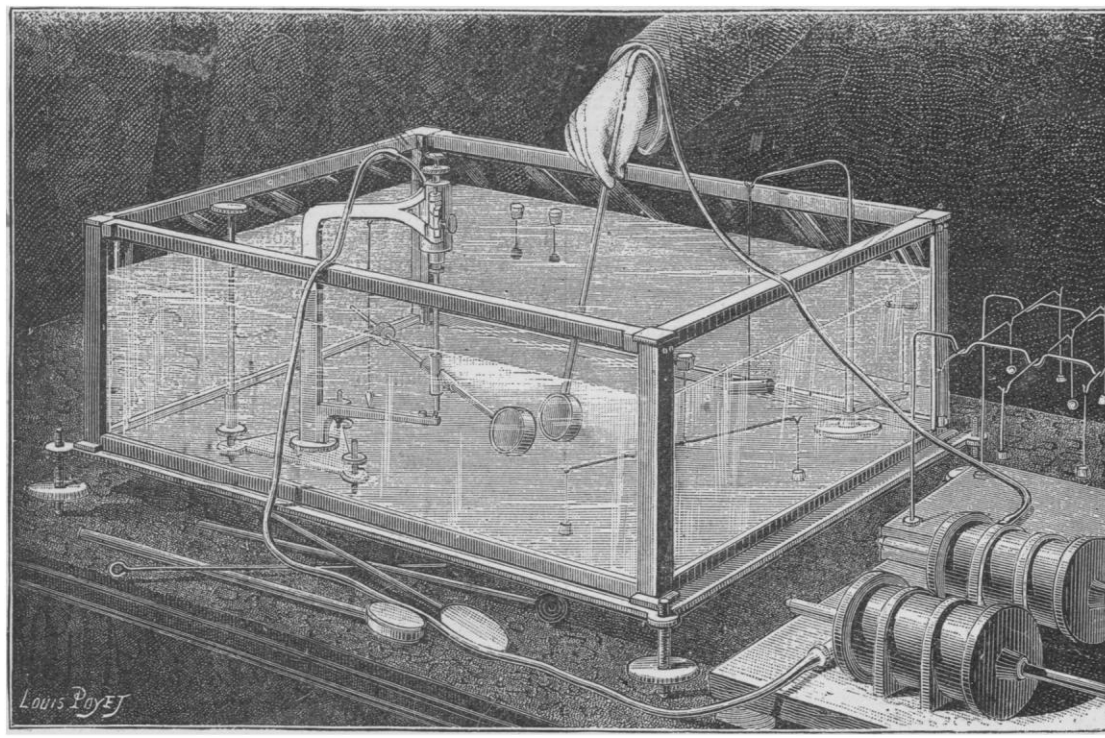

Fig. 1. Apparatus of M. Bjerknes at the Electrical Exposition.

Oscillations are produced by means of small metallic spheres bound to supports, upon which they oscillate, under the action of compressed air, in a plane which varies with the position of the sphere.

Fig. 2 (No. 3) represents two of these oscillators, the sphere on the right oscillating vertically up and down; that on the left, on the other hand, oscillates horizontally from right to left.

This is the very simple and well constructed apparatus which M. Bjerknes employs. Now we come to the phenomena.

First two pulsators are taken and made to vibrate. The phase of dilation, according to M. Bjerknes, correspo ds

to the north pole, the phase of compressing to the south pole. Now bring to one of these pulsators which can turn freely around a vertical axis which acts as its support, while allowing the vibration to continue, a second pulsator held in the hand.

If we put in juxtaposition, in the liquid, the two pulsators whose phases are of the same kind, synchronous, poles of the same name will always be in juxtaposition, there will be *attraction*, the movable pulsator turning on its axis, will tend to approach the pulsator held in the hand by the experimenter, and it will follow it if it is moved. If the phases are changed, so that they are inverse, opposite poles will be together, and there will be *repulsion*. In the one case as in the other, the attractive or repulsive force is proportional to the intensity of the pulsations and inversely proportional to the square of the distances. In both cases, the hydro-dynamic effect is the reverse of the magnetic effect: similar phases attract (poles of the same name repel each other), different phases repel (opposite poles attract).

The same experiment is repeated with the oscillators (Fig, 2, No. 3); by presenting to a vibrating sphere, movable on an axis, a second vibrating sphere, attraction or repulsion is produced according to the synchronism or the discordance of vibration, which the parts of the sphere in juxtaposition present at each instant.

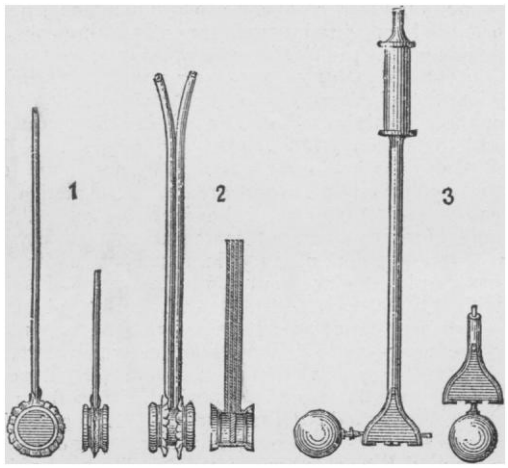

Fig. 2. Apparatus for reproducing pulsations and oscillations in a liquid.
1. Simple drum. 2. Double drum. 3. Spheres.

For these phenomena, the arrangements for which can be varied, M. Bjerknes has a collection of apparatus almost complete, representing inverse analogies to the phenomena of the reciprocal action of two permanent magnets. A result similar to the action of a magnet on a piece of soft iron can be obtained. By presenting, in the water, a small metallic sphere to a pulsator, or to an oscillator, the small sphere will be attracted.

The effects of *diamagnetism* are shown by means of a small sphere lighter than the water, maintained at the middle of the liquid by a thread attached to a weight which ballasts it. By bringing a pulsator or an oscillator near this sphere, the latter will be repulsed.

From these experiments, and from others the details of which cannot be given, M. Bjerknes concludes that the motion in water of a vibrator (pulsator or oscillator) produces in this fluid a real magnetic field with its lines of force, presenting, *but always inversely*, phenomena similar to those of diamagnetism, paramagnetism, magnetic interference, etc.

M. Bjerknes has even succeeded in tracing the directions of the lines of force produced in the liquid, by means of the arrangement shown in fig. 3. For this a light bowl sustained by an elastic rod is placed in the middle of the liquid; this bowl having no motion of its own will take exactly the direction of the oscillation of the ambient medium. If it is surmounted by a small brush, the latter will paint faithfully and automatically on a sheet of glass the lines of force of the field under the influence of which it oscillates.

M. Bjerknes commenced by submitting all these questions to analysis, and the results of his experiments are only the rigorous confirmation of his calculations. In that which concerns the analogy between the electric currents and hydrodynamic action, M. Bjerknes recognized that the question is not as advanced as in magnetic phenomena.

In order to produce more complex movements, the vibrators are no longer suitable. M. Bjerknes attempted to realize them in a viscous liquid, and striking analogies were found between the lines produced by hydro-dynamic phenomena under these conditions and the lines obtained by real currents under corresponding conditions, but the results obtained are not accurate enough to enable one to form an opinion.

What now can be concluded from the experiments of M. Bjerknes? The fact indisputably established is as follows:

Mechanical vibrations produced in a liquid medium cause phenomena analogous, but *inverse*, to the magnetic

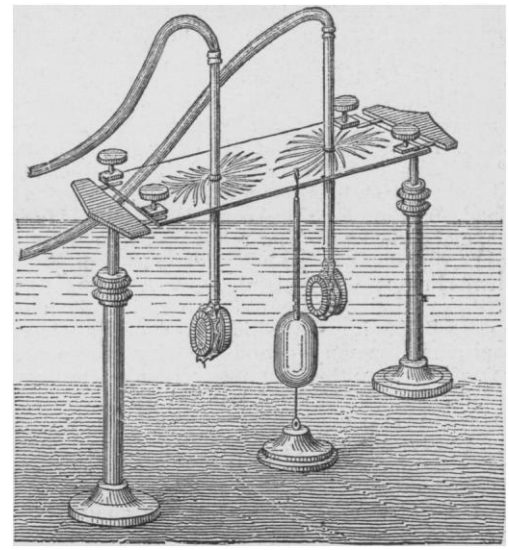

Fig. 3. Apparatus of M. Bjerknes for tracing automatically the lines of hydro-dynamic force.

phenomena produced by magnets. From this can be concluded, by *analogy*, but not *absolutely*, that molecular vibrations of a different nature can produce *direct* phenomena.

If this is not a new *proof*, in the exact meaning of the word, of the *vibratory nature* of magnetic and electric effects, it is at least a powerful argument applied to this view, accepted at the present time by most physicists.—*Translated from La Nature.*

M. PLATEAU describes as "*un petit amusement*" the following experiment:—a flower like a lily, with six petals each about an inch long, was constructed in outline in thin iron wire, the wire being first slightly peroxidised by dipping for an instant into nitric acid. This wire frame was then dipped into a glyceric-soap-solution, which, when it was withdrawn, left soap-films over the petals. The stalk was then set upright in a support, and it was covered by a bell-glass to protect it from air-currents. In a few moments the most beautiful colors made their appearance. If the solution is in good condition the films will last for hours, giving a perpetual play of color over the flower.