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XLI. Sixth memoir on induction

M. Elie Wartmann

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cultivation of science than mine happens to be. I shall merely add, in conclusion, that in order not to encroach unreasonably on these pages, I have transferred two articles connected with the present paper to the *Mechanics' Magazine*; they probably appear in the numbers for Sept. 16 and Sept. 23; in the latter of which I have given a short and easy investigation of the theorem of Leibnitz for the advanced differential coefficient of the product of two functions.

Belfast, Aug. 26, 1848.

XLI. *Sixth Memoir on Induction*. By M. ELIE WARTMANN, Professor of Natural Philosophy in the Academy of Geneva*.

[Continued from p. 94.]

§ XVIII. *Does Induction affect the acoustic properties of Elastic Bodies?*

165. I PUBLISHED two years ago† some experimental researches on the *causes* of the sounds produced by discontinuous electric currents in metallic wires. This phenomenon may be viewed under other aspects, and it may be asked whether a *permanent* electric induction determines in the molecules of sonorous bodies a change of elasticity which is rendered evident by appreciable modifications in their acoustic properties. The following experiments have been undertaken with a view to solve this question.

166. A disc was selected of 0^m·198 diameter, and 0^m·0018 thickness, forming part of a Marloye's set of plates. This disc was made with the greatest possible care: its texture is remarkably homogeneous, and the acoustic figures, formed of diameters or concentric circumferences, are produced upon it with extreme precision. Its lower surface was covered with a thick layer of gum-lac varnish; and after strongly electrizing this sort of electrophore, the charge was sustained by means of a good machine. It was however impossible to discover the least difference in its sonorous state, whether it was electrified or not.

167. A glass disc, 0^m·135 in diameter and 0^m·002 in thickness, was furnished on both its surfaces with a circular armature of tinfoil, 0^m·117 in diameter. This flat condenser was

* Communicated by the Author.

† *Archives des Sciences Physiques et Naturelles*, vol. i. p. 419. In the sitting of the 8th of May last, M. Wertheim presented to the Academy of Sciences of Paris some further researches on this subject, the conclusions of which are identical with those which I then enunciated with respect to the effects of discontinuous currents. See the *Institut* of the 10th of May, No. 749.

held by its centre between two isolating clamps. Its fundamental tone was then ascertained, and the tones which correspond to different modes of nodal subdivisions. The same experiments were then repeated, after electrifying the lower surface, the other being put in communication with the ground. The fluid distributed over the latter exercised no influence on the musical qualities of the plate. The only effect which indicated its presence was a repulsion of the particles of sand at the fixed point toward the common intersection of the diameters.

168. An iron wire, one metre long, was stretched on a monochord. It occupied the axis of a glass tube, on which was rolled a thick copper wire covered with silk, and forming part of the circuit of a Grove's battery of five pairs (139.). The transversal and longitudinal sounds of the wire remained the same as before the action of the current.

169. A brass wire, arranged on the sonometer parallel to the first, was tuned exactly in unison with it. An electro-magnet excited by the five pairs was placed near the iron wire. Every time the instrument was arranged so that the attraction of its poles could not make the wire bend, the latter comported itself like the brass wire. This was proved by the absence of beats when they were made to sound together.

170. In the preceding experiment the induction was distributed over a great length. It might thence be feared that its effect would be diminished on the nodal or ventral portions of the wire. I therefore repeated these experiments with wires of only 0^m.20 of copper and iron. In order to prevent any temporary or permanent disfigurement resulting from the different tensions to which they were subjected, I employed in stretching them a mechanical artifice used in the suspension of the threads of rheometers. It consists of a moveable nut acting upon a screw terminated by a square prism, which slips into a fixed hollow piece of the same section. The metallic cord was attached at one end to an immoveable pin, and the other to the extremity of the prism opposite to the screw. It coincided with the axis of a bobbin 0^m.1 in length, and 0^m.032 external diameter, and which is perforated by an aperture of 0^m.011, in which were placed eleven concentric tin cylinders, cut according to a generatrice and isolated from one another. Each wire was made to vibrate transversely by means of the bow, first in the natural state and then under the intense induction of Grove's battery, without ever finding a difference in the musical sound. The experiment was repeated with different degrees of tension of the wires, and making them give a numerous series of harmonics. The result never varied.

171. I afterwards operated on metallic plates placed near a magnetic apparatus, the induction of which could make itself felt successively in all their sections. With this view I procured three discs, one of tempered steel, another of untempered steel, and the third of soft iron, 0^m.198 in diameter and 0^m.0018 in thickness: they were fixed in turn on a glass bar, kept vertical by a convenient support. The magnet, which is provided with a vertical steel rod situated in the prolongation of the geometrical axis of the bar, and parallel to the branches of the horseshoe, is arranged above the plate, and at a distance variable at will. This rod is terminated by an endless screw in which a toothed-wheel catches, which is worked by a winch. One of the extremities of the wire of the electro-magnet is fastened to the rod, whilst the other is soldered to a copper ring which surrounds an isolating wooden disc carried by the axis. This simple arrangement permits the current of Grove's battery to pass into this wire without interruption, whatever be the velocity of rotation given to the magnet. It suffices for this to employ as voltaic poles two copper springs, one of which presses against the steel axis, and the other against the ring.

172. The three discs, being of different elasticity, gave a different fundamental sound, notwithstanding the equality of their dimensions. The electro-magnet exerted on them, at a distance of two to six millimetres, so energetic an attraction, that it was necessary to recur to an enormous pressure against their support to overcome it entirely.

173. After having sprinkled the plate under observation with very dry sand, and determined the corresponding sounds by different modes of vibration indicated by acoustic figures, I endeavoured to ascertain whether the magnetic influence is capable of modifying these sounds. Here, again, all the results were negative. The only difference of action of the magnet, according as it was immovable or turned with any rapidity, was limited to a slight irregularity of the nodal lines, solely produced by the currents of air.

174. When iron-filings were substituted for the sand, the sonorous phænomena were still the same, although more suppressed. The filings spread in the vicinity of the poles accumulated against them as soon as the electric current was established, and soon rendered the rotatory motion of the magnet almost impossible.

175. These experiments were repeated, rendering the passage of the electricity discontinuous. The molecular shocks investigated by several physicists were then heard. With a mercurial commutator in the circuit of the battery exciting

the magnet, the plates of soft iron become the seat of sufficiently intense sounds for a great number of persons to be able to hear them simultaneously.

176. Finally, I tried to induce at the same time electricity of tension and magnetism in the steel and iron discs. For this purpose, the bar which supports them was placed in the centre of a glass tube 0^m·02 in diameter, to which was fixed a horizontal circle of wood, 0^m·18 in diameter by 0^m·018 in thickness. This circle, entirely covered with tinfoil, communicates with a good electric machine. Parallel to the surface which is made to vibrate, it is thus brought as near as possible to it without the spark being emitted to it. The acoustic properties of the three discs remained indifferent to this new action. The plate of tempered steel had acquired a permanent magnetism which did not at all interfere with its musical properties.

177. It results from these experiments, that electric or magnetic induction has no *appreciable* action on the elasticity of different sonorous bodies, such as glass, copper, brass, soft iron, and steel tempered or untempered. The number of vibrations executed by them in the unity of time remains the same. But this conclusion must probably not be accepted in too absolute a manner. It might be that extremely energetic and very durable causes of induction determine an action which, in my experiments, has been too weak to be observed*.

Geneva, April 15, 1848.

XLII. *Notes on Quaternions.* By GEORGE BOOLE, Esq.†

Interpretation of Quaternions.

MR. CAYLEY'S ingenious researches, published in the last Number of the Philosophical Magazine, have recalled to my mind some speculations of my own upon the same subject. To the purely mathematical treatment of it I have indeed little to add. What I shall say will rather have reference to its philosophy.

It were much to be desired that the general principles which govern the use of signs, as instruments of reasoning, were re-

* M. G. Wertheim has found that no modification of elasticity is perceptible in an iron or steel wire occupying the centre of an electro-magnetic bobbin, when the current has only traversed it for a short time. According to that ingenious experimentalist, the magnetization does not act directly upon the elasticity, but produces a new molecular arrangement.—*Annales de Chimie et de Physique*, December 1844, vol. xii. p. 623.

† Communicated by the Author.