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On the sensibility of the organ of hearing

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zero, although it takes up again at each period its initial position. The work is not *nil*, because the forces producing it depend at each instant on the velocity of the electrized body, and not merely on its position. Therefore the magnetized needle furnishes a finite quantity of work, which becomes infinite with the number of the periods. Besides as the system travels along a closed cycle, this work is derived entirely from the forces which maintain the motion of the electrized body. That body is therefore itself submitted to resistant forces, which depend on the velocity of the magnetized needle. It is the existence of these last forces that we wish to demonstrate. If Rowland's effect is the analogue and as it were the complement of the phenomenon discovered by Ørsted, the inverse phenomenon here signalized corresponds in the same manner to induction. It is even found that moving a magnetic field produces, upon a small body charged with a unit of electricity, a mechanical force equal in amount and direction to the electromotive force at the same place; only we have here not an electromotive force without action on the masses, but a force properly so called.

From the preceding a curious consequence may be deduced; it is, that static electricity possesses a proper mechanical inertia, which is simply added to that of the electrized body. If, indeed, an electrized body is in motion in a space where there is no magnet, this motion gives rise to a magnetic field, since a magnetic needle in its vicinity would be deflected. The intensity of the magnetic field is proportional to the velocity; and consequently the variation of that intensity is proportional to the acceleration of the body. Now, from what we have seen above, the variation of a magnetic field produces upon an electrized point a mechanical force equal to the electromotive force of induction, consequently proportional to the velocity of the magnetic variation, and therefore to the acceleration of the body, and with the same direction as the acceleration. But a mechanical force directed thus, and proportional to the acceleration, constitutes what is called a *force of inertia*.

The ratio of the force to the acceleration is a constant quantity for the same electric charge, but not simply proportional to the quantity of electricity.—*Comptes Rendus de l'Académie des Sciences*, July 21, 1879, t. lxxxix. pp. 151–153.

ON THE SENSIBILITY OF THE ORGAN OF HEARING.

BY W. KOHLRAUSCH.

With the aid of a toothed wheel working against a disk of metal or pasteboard, Savart* found that two impulses can make upon the ear the impression of a comparable tone; M. E. Exner† finds by means of tuning-forks vibrating before spherical resonators that 17 impulses, M. Pfäundler‡ again, by experiments on holed sirens and reflection-tones, that only two impulses are required; lastly, M. Auerbach§, nearly in accordance with M. Exner, that about 20 vibra-

* *Ann. de Chim. et Phys.* xliv. p. 348 (1830).

† Pflüger's *Archiv*, xiii. p. 228 (1876).

‡ *Wien. Ber.* lxxvi. p. 572 (1877); cf. A. Seebeck, *Pogg. Ann.* liii. p. 417 (1841).

§ *Wied. Ann.* vi. p. 591 (1879).

tions are necessary for the production of a tone in the physiological sense, the tone being determined to within the interval 100 : 101.

Less sharply defined tones can be produced, in an extremely simple manner, by only two impulses. We have only to put two fingers of the hand together so that the ends of the nails are level, and then strike somewhat obliquely on a table, for instance, whose proper tone is as much deadened as possible by putting books upon it, a closed chest of drawers, &c., eventually moreover by firmly supporting our own body upon it. We shall readily feel, in our hand, that the two fingers but rarely strike it simultaneously; and with a little attention we always hear (best when the stroke is repeated from twice to three times in a second), together with the noise (undetermined as to height) of the knocking, a very hollow tone and of a height which changes *per saltum* according to the position of the fingers, but which by practice we can approximately have at our command. Similar tones are obtained by running the finger-nail over short lengths of ribbed paper.

That real tones are heard on knocking can most easily be perceived from the fact that, on knocking twice with the indicated difference of time, one can almost always state the interval of the tones, and indeed can imitate them (most easily in a whisper), if it approximates to one of the musical intervals to which we are accustomed. I have often heard with certainty differences of height of tone to within about a semitone. The tones from only two impulses are therefore determined with certainty to within the interval 15 : 16.

If we strike with only one finger-nail, these tones are entirely lost; hence we can easily learn to hear by this if the knocking takes place alternately with one and with two fingers. From another side also their presence and the correct determination of the heights and interval of the tones was confirmed to me.

Now the employment of resonators shows indeed that in the noise produced by one knocking on wood, pasteboard, or metal disks whose proper tones are deadened, almost all heights of tone are represented, but so feebly that, in presence of the distinctness of our tones, a resonance in itself unlikely of the objects struck may be unnoticed during the period of the observed tone in question. With a perfectly quiet surrounding, the tones produced by the faintest knocking on stone walls and other heavy solid objects can be heard, in which materials such an aftervibration in consequence of the two feeble shocks, and consequently an objection against the assertion that the tones are rendered perceptible by only two impulses, is certainly excluded.—Wiedemann's *Annalen*, 1879, No. 6, vol. vii. pp. 335, 336.

ON A DIRECT MEASUREMENT OF THE WORK OF INDUCTION,
AND A THENCE-DERIVED DETERMINATION OF THE MECHANICAL EQUIVALENT OF HEAT. BY DR. A. VON WALTENHOFEN,
OF PRAGUE.

The author has made experiments for the purpose of measuring