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On the Electricity excited by the mere Contact of conducting Substances of different Kinds. In a Letter from Mr. Alexander Volta, *F.R.S. Professor of Natural Philosophy in the University of Pavia, to the Rt. Hon. Sir* Joseph Banks, *Bart. K.B. P.R.S.* Read June 26, 1800. [*Phil. Trans.* 1800, p. 403.]

In prosecuting his experiments on the electricity produced by the mere contact of different metals, or of other conducting bodies, the learned Professor was gradually led to the construction of an apparatus, which in its effects seems to bear a great resemblance to the Leyden phial, or rather to an electric battery weakly charged; but has moreover the singular property of acting without intermission, or rather of re-charging itself continually and spontaneously without any sensible diminution or perceptible intervals in its operations. The object of the present paper is to describe this apparatus, with the variety of constructions it admits of, and to relate the principal effects it is capable of producing on our senses.

It consists of a long series of an alternate succession of three conducting substances, either copper, tin and water; or, what is much preferable, silver, zinc, and a solution of any neutral or alkaline salt. The mode of combining these substances consists in placing horizontally, first, a plate or disk of silver (half-a-crown, for instance,) next a plate of zinc of the same dimensions; and, lastly, a similar piece of a spongy matter, such as pasteboard or leather, fully impregnated with the saline solution. This set of three-fold layers is to be repeated thirty or forty times, forming thus what the author calls his *columnar machine*. It is to be observed, that the metals must always be in the same order, that is, if the silver is the lowermost in the first pair of metallic plates, it is to be so in all the successive ones, but that the effects will be the same if this order be inverted in all the pairs. As the fluid, either water or the saline solution, and not the spongy layer impregnated with it, is the substance that contributes to the effect, it follows that as soon as these layers are dry, no effect will be produced.

This apparatus, when it consists of only twenty pairs of metallic plates, is already capable not only of giving to Cavallo's electrometer, with the aid of a condenser, signs of electricity as high as 10° or 15°, and of charging the condenser by a simple touch to such a degree as to give a spark; but it will also give to two fingers of the same hand, the one touching the foot and the other the top of the column, a succession of small shocks, resembling those occasioned by a Leyden phial, or a battery weakly charged, or by a torpedo in a weak condition. These effects will be increased if the communication be made through water; for which purpose the bottom of the column may be made to communicate, by a thick metallic wire, with water contained in a basin or large cup. A person who now puts one hand into this water, and with a piece of metal held in the other hand touches the summit of the column, will experience shocks and a pricking pain as high as the wrist of the hand plunged in the water, and even some-

times as high as the elbow, while in some cases even the wrist of the other hand will experience a similar sensation.

It has been ascertained by repeated trials, that these effects are stronger in proportion to the greater distance of the metallic pairs, which are made to communicate. Some sensation will be produced when the foot of the column is connected with the third or fourth pair, but it will perceptibly increase as we proceed further towards the summit. This naturally led to an extension of the column much beyond the number of metallic pairs above mentioned; and expedients are here suggested for rendering such extended columns stable and at the same time sufficiently manageable. With a column of about sixty pairs of plates, shocks have been felt as high as the shoulder; such a column may be even divided into two or three distinct cylinders, which being well connected by metallic conductors, will be equally powerful and much more convenient.

Among various other modes of applying the same agents, the author describes an apparatus in which the fluid is interposed between the metals without being absorbed in a spongy substance. This consists of a number of cups or goblets, of any substance except metals, placed in a row either straight or circular, about half filled with a saline solution, and communicating with each other so as to form a kind of chain, by means of a sufficient number of metallic arcs or bows, one arm of which is of silver, or copper plated with silver, and the other of zinc. The ends of these bows are plunged into the liquid in the same successive order, namely, the silver ends being all on one side, and those of zinc on the other,—a condition absolutely necessary to the success of the experiments, it having been observed that if out of sixty bows, for instance, the twenty intermediate ones be turned in the opposite direction from the remainder, the effects produced by the apparatus will be *far less* perceptible.

It was observed, that if a circular communication be completed by means of a bow connecting the first and last of a long series of cups, two hands, or even two fingers plunged into one of these cups will still receive an electric sensation. This is explained by admitting the fact, that warm animal substances, and particularly their fluids, are in general better conductors than water.

The sensible effects of either of these apparatus, composed of forty or fifty links, do not, it seems, consist merely in shocks, contractions, or spasms in the muscles or limbs; but, besides affecting the sense of touch, they are also capable of exciting an imitation in the organs of taste, sight, and even hearing. A particular account is given of these singular effects, from which we learn, that the more sensible the parts are which are exposed to the impressions of this agent, the more quick will be the sensation;—that as to taste, we have only to recollect the experiments formerly described by the author, in which the tongue was sensibly affected by the combination of two metals applied to each side of it;—that with respect to the sense of vision, the sparks yielded by this apparatus are sufficient evidence of the effect, certain expedients only being necessary for facilitating the

perception of these explosions;—and lastly, that the hearing will be strongly affected by introducing into the ears two probes, the opposite extremities of which are connected with the two ends of the apparatus. No effect has as yet been produced upon the sense of smell by this machine, which is ascribed to the circumstance of the electric effluvia not being expanded in and conveyed by the air, which it is thought is the proper vehicle for exciting sensations in the olfactory nerves.

At the close of the paper the author points out the striking analogy there is between this apparatus and the electric organs of the torpedo and electric eel, which are known to consist of membranaceous columns filled from one end to the other with a great number of laminæ or pellicles, floating in some liquid which flows into and fills the cavity. These laminæ cannot be supposed to be excited by friction, nor are they likely to be of an insulating nature; and hence these organs cannot be compared either to the Leyden phial, the electrophore, the condenser, or any other machine capable of being excited by friction. As yet, therefore, they can only be said to bear a resemblance to the apparatus described in this paper. The effects hitherto known of this apparatus, and those which there is every reason to expect will be discovered hereafter, are likely, it is thought, to open a vast field for reflections and inquiries, not only curious but also interesting, particularly to the anatomist, the physiologist, and the physician.

Some Observations on the Head of the Ornithorhynchus paradoxus. *By* Everard Home, *Esq. F.R.S.* Read July 3, 1800. [*Phil. Trans.* 1800, p. 432.]

We learn from this communication that the beak of this singular animal, which on a cursory examination was thought to be exactly similar to that of the Duck, and calculated for the same purposes, is in fact materially different from it; and that, so far from being the mouth of the animal, as had been imagined, it is only a part added to the mouth, and projecting beyond it. This mouth has two grinding teeth on each side, both in the upper and lower jaw; they are without fangs, and may be considered as bony protuberances. Instead of incisor teeth, the nasal and palate bones are continued forwards, so as to support the upper portion of the beak; while the two under jaws are likewise continued forwards in the shape of two thin plates of bone, forming the central part of the under portion of the beak. The tongue is very short, and when extended can be projected into the bill scarcely one quarter of its length.

The organ of smell in this animal differs from that of quadrupeds in general, as well as of birds. The nostrils are nearly at the end of the beak, while the turbinated bones are situated in the skull, as in other quadrupeds; by which means there are two cavities the whole length of the beak superadded to this organ. The nerves which supply this organ are very large in proportion to the size of the animal.