

## On the Electricity excited by the mere Contact of conducting Substances of different Kinds

Alessandro Volta

*Philosophical Magazine* (September 1800)

Reader's Note: This article has been reconstructed from extensive quotes of it in a book on the history of the Galvani-Volta controversy. The author also quoted bits of the article within several of his own paragraphs. I have enclosed those portions in square brackets.

---

[Volta reports some "striking results" associated with the apparatus he has built.]

["The principal of these results, which comprehends nearly all the rest, is the construction of an apparatus . . . which should have an inexhaustible charge, a perpetual action or impulse on the electric field." He used "non-electric" bodies exclusively, "chosen from among those which are the best conductors, and therefore the most remote, as hitherto been believed, from the electric nature."]

[Volta first describes his "column" pile.]

I provide a few dozens of small round plates or disks of copper, brass, or rather silver, an inch in diameter more or less (pieces of coin for example) and an equal number of plates of tin, or, what is better, of zinc nearly of the same size and figure. . . . I prepare also a pretty large number of circular pieces of pasteboard, or any other spongy matter capable of imbibing and retaining a great deal of water or moisture, with which they must be well impregnated in order to ensure success to the experiments. These circular pieces of pasteboard, which I shall call moistened disks, I make a little smaller than the plates of metal, in order that, when interposed between them, as I shall hereafter describe, they may not project beyond them.

I place then horizontally, on a table or any other stand, one of the metallic pieces, for example one of silver, and over the first I adapt one of zinc; on the second I place one of the moistened disks, then another plate of silver followed immediately by another of zinc, over which I place one of the moistened disks. In this manner I continue coupling a plate of silver with one of zinc, and always in the same order, that is to say, the silver below and the zinc above it, or *vice versa*, according as I have begun, and interpose between each of these couples a moistened disk. I continue to form, of several of these stories, a column as high as possible without any danger of its falling.

But, if it contain about twenty of these stories or couples of metal, it will be capable not only of emitting signs of electricity by Cavallo's electrometer, assisted by a condenser, beyond ten or fifteen degrees, and of charging this condenser by mere contact so as to make it emit a spark, &c., but of giving to the fingers with which its extremities (the bottom and top of the column) have been touched several small shocks, more or less frequent, according as the touching has been repeated. Each of these shocks has a perfect resemblance to that slight shock experienced from a Leyden flask weakly charged, or a battery still more weakly charged, or a torpedo in an exceedingly languishing state, which imitates still better the effects of my apparatus by the series of repeated shocks which it can continually communicate.

To obtain such slight shocks from this apparatus which I have described, and which is still too small for great effects, it is necessary that the fingers, with which the two extremities are to be touched at the same time, should be dipped in water, so that the skin, which otherwise is not a good conductor, may be well moistened. To succeed with more certainty, and receive stronger shocks, a

communication must be made, by means of a metallic plate sufficiently large, or a large metallic wire, between the bottom of the column (that is to say, the lower piece of metal,) and water contained in a bason or large cup, in which one, two or three fingers, or the whole hand is to be immersed, while you touch the top or upper extremity (the uppermost or one of the uppermost plates of the column) with the clean extremity of another metallic plate held in the other hand, which must be very moist, and embrace a large surface of the plate held very fast. . . .

I still suppose that all the necessary attention has been employed in the construction of the column, and that each pair or couple of metallic pieces, resulting from a plate of silver applied over one of zinc, is in communication with the following couple by a sufficient stratum of moisture, consisting of salt water rather than common water, or by a piece of pasteboard, skin, or any thing of the same kind well impregnated with this salt water. The disk must not be too small, and its surface must adhere closely to those of the metallic plates between which it is placed.

[Volta describes the *couronne de tasses* ("crown of cups," rendered in the English translation as "chain of cups).]

I dispose, therefore, a row of several basons or cups of any matter whatever, except metal, such as wood, shell, earth or rather glass (small tumblers or drinking glasses are the most convenient), half filled with pure water, or rather salt water or ley: they are made all to communicate by forming them into a sort of chain, by means of so many metallic arcs, one arm of which, [Aa], or only the extremity [A], immersed in one of the tumblers, is of copper or brass, or rather of copper plated with silver; and the other, [Z], immersed into the next tumbler, is of tin, or rather of zinc.

[Volta relates experiments "which are no less instructive than amusing."]

Let three twenties of these tumblers be ranged, and connected with each other by metallic arcs, but in such a manner, that, for the first twenty, these arcs shall be turned in the same direction; for example, the arm of silver turned to the left, and the arm of zinc to the right; and for the second twenty in a contrary direction, that is to say, the zinc to the left, and the silver to the right: in the last place, for the third twenty, the silver to the left, as is the case in regard to the first. When every thing is thus arranged, immerse one finger in the water of the first tumbler, and with the plate grasped in the other hand, as above directed, touch the first metallic arc (that which joins the first tumbler to the second), then the other arc which joins the second and third tumbler, and so on, in succession, till you have touched them all. If the water be very salt and luke-warm, and the skin of the hands well moistened and softened, you will already begin to feel a slight shock in the finger when you have touched the fourth or fifth arc (I have experienced it sometimes very distinctly by touching the third), and by successively proceeding to the sixth and the seventh, &c., the shocks will gradually increase in force to the twentieth arc, that is to say to the last one of those turned in the same direction; but by proceeding onwards to the 21st, 22d, 23d, or 1st, 2d, 3d, of the second twenty, in which they are all turned in a contrary direction, the shocks will each time become weaker, so that at the 36th or 37th, they will be imperceptible, and be entirely null at the 40th, beyond which (and beginning the third twenty, opposed to the second and analogous to the first,) the shocks will be imperceptible to the 44th or 45th arc; but they will begin to become sensible, and to increase gradually, in proportion as you advance to the 60th, where they will have attained the same force as that of the 20th arc.

From these experiments one might believe, that when the torpedo wishes to communicate a shock to the arms of a man or to animals which touch it, or which approach its body under the water (which shock is much weaker than what the fish can give out of the water), it has nothing to do but to bring together some of the parts of its electric organ in that place, where, by some interval, the communication is interrupted, to remove the interruptions from between the columns of which the

said organ is formed, or from between its membranes in the form of thin disks, which lie one above the other from the bottom to the summit of each column? It has, I say, nothing to do but to remove these interruptions in one or more places, and to produce there the requisite contact, either by compressing these columns, or by making some moisture to flow in between the pellicles or diaphragms which have been separated, &c. This is what may be, and what I really conclude to be, the task of the torpedo when it gives a shock; for all the rest, the impulse and movement communicated to the electric fluid, is only a necessary effect of its singular organ, formed, as is seen, of a very numerous series of conductors, which I have every reason to believe sufficiently different from each other to be *exciters* of the electric fluid by their mutual contacts; and to suppose them ranged in a manner proper for impelling that fluid with a sufficient force from top to bottom, or from the bottom to the top, and for determining a current capable of producing the shock, &c. as soon and as often as all the necessary contacts and communications take place.

[There is a section here where Volta discusses the "columnar apparatus," giving instructions on building and efficient running of the pile.]

The current of the electric fluid, impelled and excited by such a number and variety of different conductors, silver, zinc, and water, disposed alternately in the manner above described, excites not only contractions and spasms in the muscles, convulsions more or less violent in the limbs through which it passes in its course; but it irritates also the organs of taste, sight, hearing, and feeling, properly so called, and produces in them sensations peculiar to each.

What proof more evident of the continuation of the electric current as long as the communication of the conductors forming the circle is continued?---and that such a current is only suspended by interrupting that communication? This endless circulation of the electric fluid (this *perpetual motion*) may appear paradoxical and even inexplicable, but it is no less true and real; and you feel it, as I may say, with your hands. Another evident proof may be drawn from this circumstance, that in such experiments you often experience, at the moment when the circle is suddenly interrupted, a shock, a pricking, and agitation, according to circumstances, in the same manner as at the moment when it is completed; with this only difference, that these sensations, occasioned by a kind of reflux of the electric fluid, or by the shock which arises from the sudden suspension of its current are of less strength. But I have no need, and this is not the place to bring forward proofs of such endless circulation of the electric fluid in a circle of conductors, where there are some, which, by being of a different kind, perform, by their mutual contact, the office of *exciters* or *movers*: this proposition, which I advanced in my first researches and discoveries on the subject of galvanism, and always maintained by supporting them with new facts and experiments, will, I hope, meet with no opposers.

To what electricity then, or to what instrument ought the organ of the torpedo or electric eel, &c. to be compared? To that which I have constructed according to the new principle of electricity, discovered by me some years ago, and which my successive experiments, particularly those with which I am at present engaged, have so well confirmed, *viz.* that conductors are also, in certain cases, *exciters* of electricity in the case of the mutual contact of those of different kinds, &c. in that apparatus which I have named the *artificial electric organ*, and which being at the bottom the same as the natural organ of the torpedo, resembles it also in its form, as I have advanced.