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LXXXVIII. On a new galvanic battery

Rev. N.J. Callan

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wards let them be put together, and the process of magnetizing be performed repeatedly upon each by the rest; and it will be found that each magnet possesses nearly, if not quite as much magnetism as the one employed in the first instance, that is, as the prime motor itself. This fact can scarcely be doubted, although it is at variance with the Newtonian law of the perfect equality of action and reaction as applied to mechanical forces, as no force can be supposed capable of generating under the same circumstances a force greater than itself.

Again, suppose we consider caloric as a moving force; what relation is there between that which is required to ignite a quantity of gunpowder and the caloric developed by its combustion? Several similar instances might be adduced of the inapplicability of the Newtonian law to the explanation of obscure physical facts.

LXXXVIII. *On a new Galvanic Battery. By the Rev.* N. J. Callan, *Professor of Natural Philosophy in the College of Maynooth.**

The following paper describes a new galvanic battery, consisting of 20 zinc and as many double copper plates, the whole of which may, by substituting one mercury trough for another, be made to act as a single pair of plates, or as 2, 3, 4, 5, 6, 10, or 20 voltaic circles; and which is capable of producing, by the aid of an electro-magnet, a voltaic current equal in intensity to that of a battery containing 1000 pairs of zinc and copper plates.

UNDER my directions, and on a plan suggested by me, a very large galvanic battery has been lately constructed for the College of Maynooth. This battery consists of 20 zinc plates, each two feet long and two feet broad, and of as many copper cells, each sufficiently large to contain one of the zinc plates. To each zinc plate is soldered a copper wire about half an inch thick and six inches long. The wire projects from the plate in a direction nearly parallel to the sides, and nearly perpendicular to the edge of the plate, which is vertical when the plate is in its copper cell. At two inches from its extremity the wire is bent so as to form nearly a right angle at the bend, and so that these two inches are parallel to the vertical edge of the plate. A wire of the same thickness, and about two inches shorter, is soldered to each of the copper cells: it is bent in the same way as the wires belonging to the zinc plates.

* Communicated by the Author.

Fig. 1.

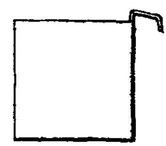
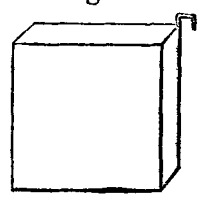
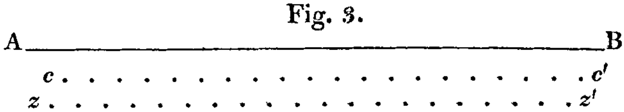


Fig. 2.



Figures 1 and 2 represent a zinc plate and a copper cell along with the wires soldered to them. The 20 copper cells are put into a wooden box about 3½ feet long, 2 feet 2 inches deep, and nearly 3 feet wide, and are separated from each other by partitions of wood. The 20 zinc plates are let down into the copper cells, and are lifted up, at pleasure, by means of a windlass. To prevent the contact of the zinc plates with the copper cells, each zinc plate is covered with a woven net of hemp. When the 20 copper cells are in the wooden box, and the 20 zinc plates in the copper cells, the wires soldered to the copper cells project about ¾ of an inch from one of the sides of the box, and their extremities descend nearly 2 inches below the upper edge of the same side: but the wires soldered to the zinc plates project nearly 2 inches from the same side of the box, and their extremities descend as low as the extremities of the wires belonging to the copper cells. Thus, if A B (fig. 3.) in the exterior surface of one of

Fig. 3.



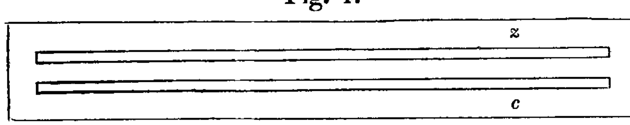
the sides of the box be parallel to the upper edge of the same side, and nearly 2 inches below it, then the row of points $c\,c'$ will represent the extremities of the wires belonging to the copper cells, and the row of points $z\,z'$ will represent the extremities of the wires soldered to the zinc plates.

The acid solution is poured into the copper cells, which are water-tight, and is let out, without lifting the cells, by means of a cock at the bottom of each cell. The cells are barely wide enough to allow the free ascent and descent of the zinc plates. About 30 gallons of fluid are required to charge the whole battery. Both sides of each zinc plate are exposed to the action of the acid mixture, and are within about a quarter of an inch of an equal and parallel surface of copper. Hence the acting surface in each plate is 8 square feet, and the acting surface of zinc as well as of copper in the whole battery is 160 square feet.

By eight mercury troughs, metallic communications may be formed between the 20 zinc plates and the copper cells, so as to make the whole act as a single pair of plates, each containing 160 square feet of surface; or as 2 voltaic circles, in which the zinc of each circle would contain 80 square feet; or as 3 circles, two of which would contain 56 square feet of zinc, and the third of which would contain 48 square feet; or as 4 circles, in each of which there would be 40 square feet of zinc; or as 5, in each of which there would be 32 square feet of zinc; or as 6 circles, four of which would each contain 24 square feet, and two of which would each contain 32 square feet of zinc; or as 10 circles, in each of which there would be 16 square feet of zinc; or as 20 circles, each of which would contain 8 square feet of zinc.

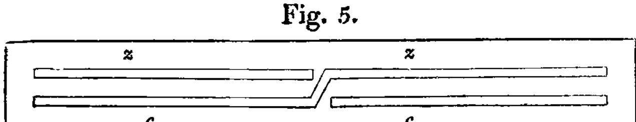
The mercury troughs are made by cutting holes for containing mercury in a piece of wood 3½ feet long, 3½ inches broad, and 2 inches thick. The mercury trough by which all the zinc and copper plates are made to act as a single pair, contains two parallel grooves, each nearly 3½ feet long, ¾ of an inch wide, and an inch deep. One of the grooves receives all the wires of the zinc plates, and the other receives all the wires of the copper cells. Hence when mercury is poured into the two grooves, all the zinc plates are in metallic communication with each other, and act as one plate; and all the coppers likewise act as one copper plate. This trough is represented in fig. 4.; the letter *z* shows the groove for the wires of

Fig. 4.



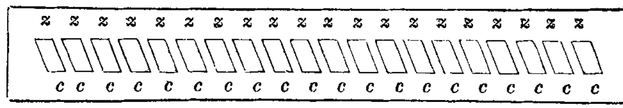
the zinc plates, and *c* the groove for the wires of the copper cells. In the second mercury trough there are four grooves, each of which receives 10 wires. There is a communication between one of the grooves containing the wires of ten copper cells, and that which receives the wires of the zinc plates immersed in the remaining 10 cells. Fig. 5. represents this

Fig. 5.



trough. The third trough contains 6 grooves; the fourth, 8; the fifth, 10; the sixth, 12; and the seventh and eighth each contain 20. Except the trough by which the battery is made to act as 20 voltaic circles, the rest are made like the trough represented in fig. 5. When the battery acts as 20 circles, the wire of each zinc plate, and the wire of the next copper cell, are in the same mercury hole. Fig. 6. represents

Fig. 6.



the upper surface of the trough by which all the zinc and copper plates are made to act as 20 circles.

From the preceding description of our battery, it is evident that the whole 20 zinc plates and copper cells may, by substituting one mercury trough for another, be made to act as a single pair, or as 2, 3, 4, 5, 6, 10, or 20 voltaic circles, and thus be made to supply the place of the calorimotor and of the battery hitherto used for electro-magnetic experiments.

So enormous is the quantity of electricity circulated by this battery when all the zinc and copper plates act as a single circle, that, on one occasion, after having acted without interruption for more than an hour, it rendered powerfully magnetic an electro-magnet on which were coiled 39 thick copper wires, each about 35 feet long, while the mercury in which the wires of the zinc plates were immersed, was connected by 6 copper wires, each $\frac{1}{3}$ of an inch thick and about 6 inches long, with the mercury in communication with the wires of the copper cells. On the fifth day it was tried: after having been in action without interruption for more than two hours, this battery melted very rapidly platina wire $\frac{1}{30}$th of an inch thick, and deflagrated in a most brilliant manner copper and iron wire about $\frac{1}{12}$th of an inch thick.

By this battery, with the aid of an electro-magnet, a current of electricity may be produced which will equal in intensity that of a battery containing 1000 voltaic circles. It is well known that when the connexion between the helix of an electro-magnet and the voltaic battery is broken, a current of electricity is, at the moment of breaking the connexion, made to flow through the helix; and that when the helix is long, that current is capable of giving a shock to any person who holds in each hand a copper cylinder in conducting communication with the ends of the helix. By experiments on the best means of obtaining the shock from the electro-magnet, I have found that the shock increases, within certain limits, with the length and thinness of the bar of soft iron, and with the length of the heliacal coil, as far perhaps as 200 feet, and in proportion, or nearly in proportion, to the number of plates in the voltaic battery from which the current of electricity is passed through the helix. The shock does not increase in proportion to the number of plates unless they are large. The electro-magnet which I first used was a straight bar of soft iron, about 2 feet long, and an inch thick. On this bar were coiled two copper wires, each about 200 feet long. The voltaic battery consisted of 14 pairs of zinc and of as many double copper plates: each plate was about 7 inches square. The end of the first coil and the beginning of the second were immersed into the same cup of mercury, the voltaic current was passed through the first coil only, and the shock was taken by making a communication with the beginning of the first coil and with the end of the second. When the current of electricity was passed through the helix from one pair of plates, the shock received on breaking contact with the battery was equal to that of a battery containing 20 pairs of plates. When two pairs of plates were used, the shock appeared to be doubled; with three voltaic circles, it appeared to be trebled; and with every increase in the number of voltaic circles, there appeared to be a proportional increase of the shock. With the 14 pairs of plates the shock was so strong that a person who took it, from an electro-magnet on which there were four coils of wire, felt the effects of it for several days. With a battery of 4-inch plates the shock increased with the number of plates, but not so rapidly as when large plates were used. I am inclined to think that with a battery of 4-inch plates, the shock increases but little when the number of plates exceeds a hundred. I could not induce any one to take the shock from the electro-magnet when a greater number than 16 of our large plates were used. With 16 of them the shock was exceedingly strong, although the acid mixture employed in charging the battery was very weak; and, from experience, I know that the electro-magnetic effects of a battery depend very much on the strength of the charge.

From all the experiments which I have made on the magneto-electric shock, I think I may fairly conclude, that, if 2000 feet of wire were coiled on a bar of soft iron 6 feet long and an inch thick, a shock might be obtained with the aid of a single pair of plates, which would equal that of a battery of 100 voltaic circles. Hence, since the shock increases in proportion to, or, at least, very rapidly with the number of plates, when they are large, the shock given by such an electro-magnet magnetized by our battery of 20 pairs of plates, should nearly equal, or perhaps exceed that of a battery of 1000 voltaic circles. Hence, by our battery of 20 pairs of plates, an electric current of the highest intensity may be produced. This battery then supplies the place of all the various kinds of galvanic batteries.

The shock given by the electro-magnet may be obtained as often as the connexion of the helix with the battery is broken. Now I have devised a small instrument by which communication with the battery may be broken and renewed 3000 or 4000 times in a minute. Thus 3000 or 4000 shocks may be received, and 3000 or 4000 electric currents of the highest intensity may, in the space of one minute, be passed through water, charcoal, metallic wires, or any other body. It should be remembered that the voltaic current from the battery should not be passed through more than 200 feet of the heliacal coil, and that the shock should be taken from the whole length of the helix.

When a voltaic current passes through a very long wire from a single pair of plates, the wire will give a shock at the moment of breaking contact with the battery. I have found that this as well as the shock from the electro-magnet increases with the number of plates.

I have made a great variety of experiments on electro-magnets. My object in these experiments was to ascertain four things: first, on what the quantity of attraction depends; secondly, on what the distance at which that attraction is exerted depends; thirdly, on what the shock depends; and fourthly, whether by a voltaic current from a large battery, a permanent magnet could be made, which would induce on soft iron magnetism equal to that which is given to an electro-magnet by a battery containing 20 large plates, or 300 four-inch plates. In these experiments I employed three different voltaic batteries, and electro-magnets of various forms. I used the large battery already described; a small battery of 14 pairs of plates, in which each zinc plate was seven inches square; and a Wollaston battery, containing 280 pairs of four-inch plates. Some of my electro-magnets were straight, and others of the horse-shoe form, and one was a square: the iron bars varied in length from 20 inches to six feet, and in thickness from two inches to half an inch. On one of these were coiled 39 copper wires, on another four, on a third three, and on others there was only one wire.

From the results of these experiments, I have deduced the following conclusions: First, that the quantity of attraction increases with the length of the bar of soft iron, at least as far as six feet, and with the thinness till it becomes about an inch; and that it increases nearly in proportion to the number of plates (when they are large) in the battery by which the electro-magnet is magnetized. When the plates are only four inches square the attraction increases, but slowly when the number exceeds 100. Secondly, that the distance at which attraction is exerted, increases also with the length and thickness of the iron bar, and with the number of plates when they are large; but with small plates the increase is very gradual when their number exceeds a hundred. With twenty of our large plates, an iron bar, nearly $3\frac{1}{2}$ lbs. weight, was attracted to a horse-shoe electro-magnet through the distance of an inch, and with ten plates the same bar was attracted to the same magnet, only through the distance of about half an inch. Again, with the twenty plates, the attraction of the same magnet for a sewing-needle was sensible at the distance of 15 inches, and with ten plates the attraction was sensible at the distance of 10 inches. Thirdly, that the shock from the electro-magnet increases within certain limits with the length and thinness of the iron bar, and nearly in proportion to the number of plates when they are large.

When the voltaic current was sent from a battery of 280 four-inch plates, through the heliacal wire coiled round a steel bar about 20 inches long and an inch thick, the steel became almost as strongly magnetic as if it were iron; and when the connexion with the battery was broken, the steel did not retain more than about $\frac{1}{100}$ of its magnetism.

In a paper published in the last (August) number of the Philosophical Magazine, Dr. Ritchie says that the use of the electro-magnet in the apparatus for continued rotation was long since abandoned, because it was incapable of inducing magnetism in an iron bar at a distance. Now he will find that, if instead of a single copper and zinc plate, a battery of 20 pairs of large plates, or of 200 small ones be used, the electro-magnet will have a greater power of inducing magnetism at a distance than any permanent magnet.

The advantages of the battery I have described are, first, that it supplies the place of all the various kinds of voltaic batteries, of the battery for producing a large quantity of electricity of low intensity, of the battery for exciting a large quantity of electricity of the intensity necessary for the rapid fusion and deflagration of metallic wires, and of the battery for producing an electric current of high intensity; and secondly, that it enables a person to compare the power of the very same zinc and copper plates acting as a single pair, with their power when they act as 2, 3, 4, 5, 6, 10, or 20 voltaic circles.

NICHOLAS CALLAN.

Maynooth College, August 23, 1836.