

Account of some Experiments in which an Electric Spark was elicited from a Natural Magnet. By JAMES D. FORBES, Esq. F.R.S.E., F.G.S., &c.

(Read 16th April 1832.)

NOTWITHSTANDING the intimate connexion which has long been known to exist between magnetism and electricity, we may safely say, that, only fifteen years ago, the announcement of the excitation of a luminous spark from a natural magnet would have been received with astonishment and even with incredulity.

After the great discovery of electro-magnetism, in 1819, by Professor OERSTED, the extreme improbability of such a discovery was indeed removed; but, even after that period, until the recent researches of our distinguished countryman Mr FARADAY, every attempt having failed to procure the feeblest trace of electricity from the obdurate magnetic mass, so striking a result, which comes home to the comprehension of those least accustomed to interest themselves in the less palpable results of scientific enquiry, could scarcely have been looked for with any degree of confidence.

The beautiful experiments of Mr FARADAY, the fundamental facts of which I had the honour to lay before the Society at their last meeting, pointed out the path for arriving at this fine result, and enabled us to appreciate the probability of attaining it. Having had the good fortune conclusively to establish so

interesting an experimental truth, though not, if report tells true, until after Signor NOBILI, the ingenious and persevering philosopher of Reggio, I have taken advantage of this last meeting of the Society for the season, to bring the subject before them: and though I regret that, from the nature of the experiment, it can only be shewn to one or two persons at once, I believe that there are several individuals now present, who can bear ocular testimony to the production of the spark.

The discovery of Mr FARADAY has conclusively demonstrated, that in every case where a magnetic current is created (to use the word *current* in its ordinary acceptation, as indicative of a peculiar condition, and without reference to any theory whatever), a momentary electric current is induced at right angles to it. The experiment may be shewn in two ways: either by mechanically causing a magnetic bar to traverse the axis of a helix of copper-wire of considerable length,—or by causing a piece of soft iron, placed in the axis of such a helix, to connect the poles of a horse-shoe magnet, and thus temporarily acquire polarity. In both cases, the current of electricity is most easily shewn by its action on the common Multiplier, the extremities of the wires of which are connected with those of the copper-wire forming the helix, and which, from its rectangular position at every point to the magnetic current caused to traverse its axis, collects the electricity developed in that direction. By both methods, the current is only instantaneous; and in the first case, if the magnet be caused to make a reciprocating motion in the axis of the helix, the currents are of course excited in opposite directions, and, by accommodating these to the alternate vibrations of the needle of the Multiplier, it may, by means of a small bar, be made to oscillate in large arcs.

The second method, however, where the magnetic current is created through a piece of soft iron, by causing it to connect the poles of a large magnet, is that which in my late experiments

I have entirely employed ; and the subject of them has been a very fine natural magnet, capable of supporting 170 lb. presented to the University by Dr HORE. I willingly avail myself of this opportunity to express my obligations to that gentleman for the numerous and important facilities which have been afforded to my researches, in his laboratory, where the magnet still is.

My preliminary experiments demonstrated, by the action upon the multiplier and upon the frog, that a very powerful and instantaneous current of electricity was conveyed through the helix at the moment of making the contact of the connecting iron with the magnet. My attention was then directed to such an arrangement of apparatus as should by means of this current produce a spark. Mr FARADAY had actually accomplished this in the case of an electro-magnet, that is, by the conversion of a soft iron bar into a magnet, by a galvanic current revolving round it. He had, from another portion of the bar, been able to reproduce the electricity, and obtain a spark from it.

In an early stage of my experiments I had, as far back as the 30th of March, obtained a spark from the magnet, which, however, being unable to repeat, from circumstances of which I afterwards became aware, I did not choose to publish at the time. I accordingly proceeded closely to investigate the circumstances under which sparks were to be obtained from feeble galvanic currents of low intensity. I used the common cylindrical electro-magnetic battery, in which, by varying the charge of acid, I could obtain any required power. Thus I adjusted it till I obtained from a momentary current nearly the same action on the Multiplier as I had developed by the magnet. Removing it into a dark place, I found that sparks were obtained at the instant of making and breaking the circuit connecting the cups of the battery. Satisfied that I had a sufficient current of electricity, I proceeded to apply to the magnet the conditions which I had found

most effectual for eliciting the spark. These were, 1st, That the spark is more easily obtained at the instant of interrupting than that of completing the galvanic circuit: 2^d, That of the combinations which I tried, a fine pointed iron-wire suddenly withdrawn from contact with a surface of pure mercury, forming part of the circuit, was the most regular in exciting the spark, and that a good deal depended upon the suddenness of the interruption; and, 3^d, That the spark was easiest obtained from the mercury, not at the horizontal upper surface, but where capillary action attracted it to the sides of the containing vessel; and that this was independent of the material of the vessel, being the same with wood, glass, and metal.

These precautions are all easily resolved into the general one—that the circuit conveying a weak current should be as abruptly divided as possible, in order to the production of a spark; and from the greater power of slender wires formed of imperfect conductors, such as iron, to accumulate the effects of *weak currents**, that part of the apparatus is also explained. The action of the adhesion of mercury to the vessel is probably to render its connection with the wire inserted at that point more perfect.

It will be unnecessary at present to recount the difficulties which still obstructed my progress, though some of them were, I think, of a kind not unimportant to electro-magnetic science. I shall, however, only briefly notice the arrangement of the apparatus with which, on the 13th of April, I succeeded in obtaining the spark at pleasure.

The large natural magnet is represented at A, Fig. 6, Plate IX. A cylindrical connector of soft iron, *ab*, passing through the axis of the helix *c*, was made to connect the poles

* See Mr HARRIS's Paper in this volume.

Fig. 1.

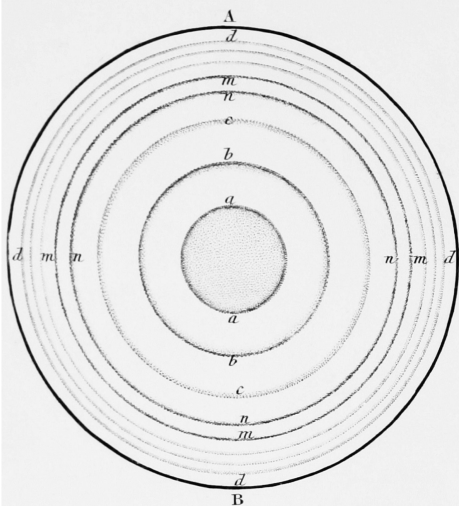


Fig. 2.

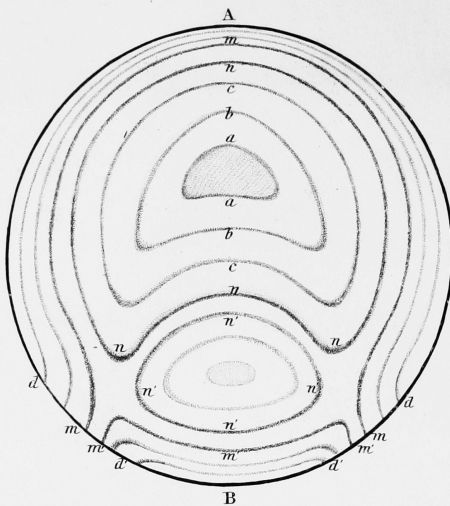


Fig. 3.

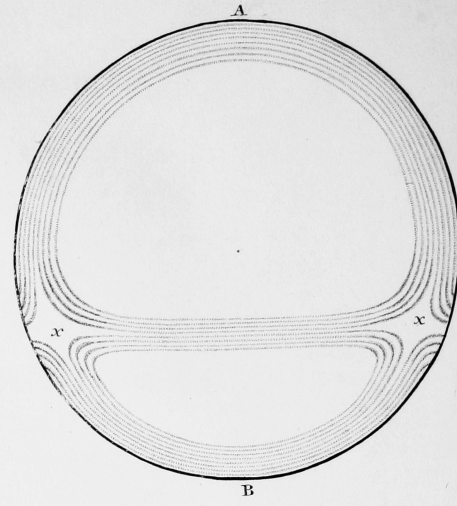


Fig. 4.

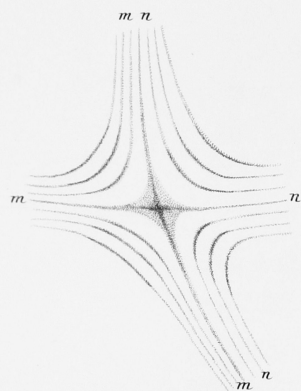


Fig. 5.

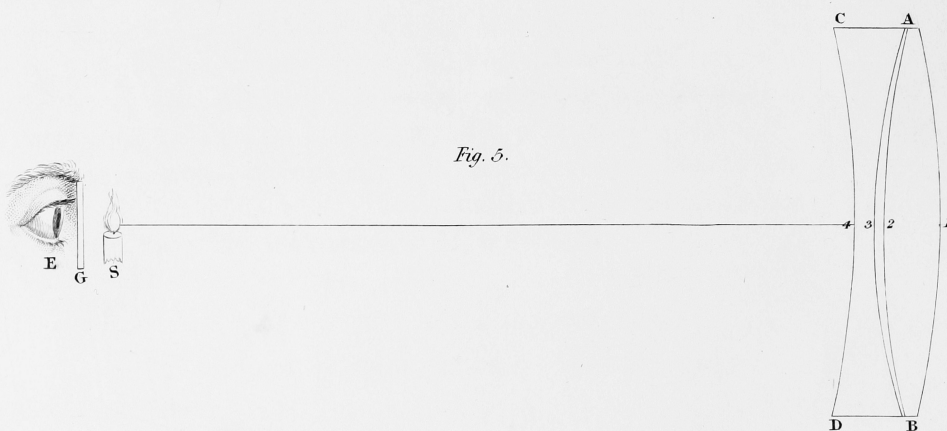
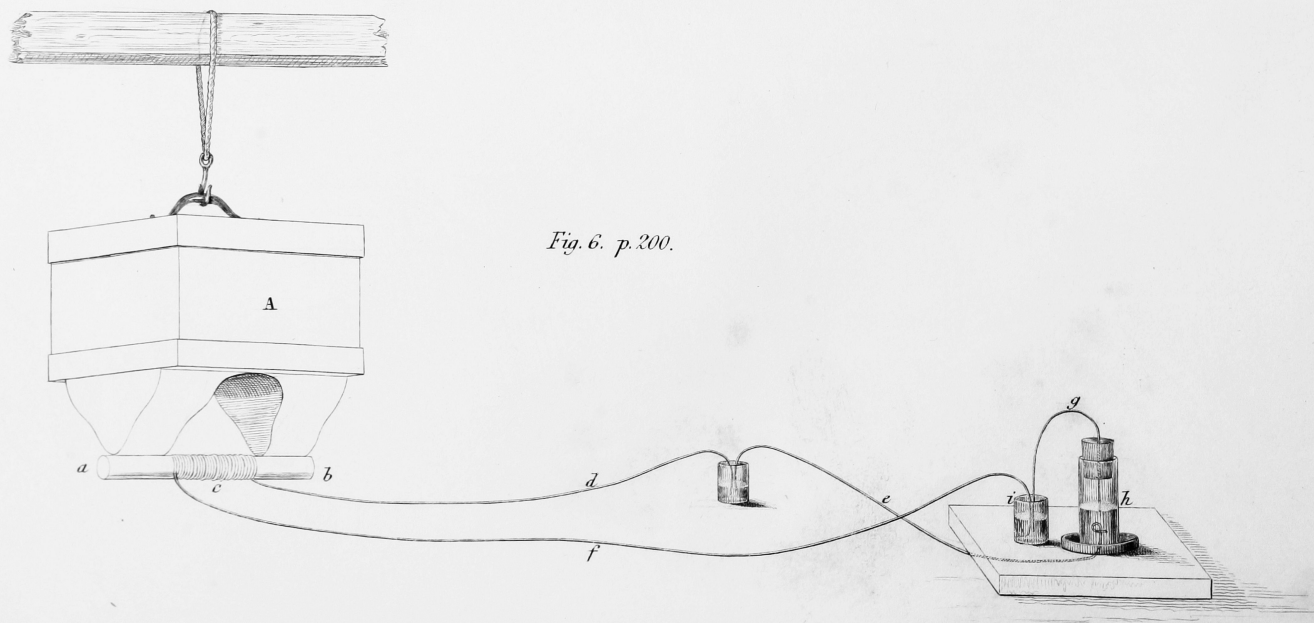


Fig. 6. p. 200.



of the magnet; accuracy of contact was found to be of considerable importance to the success of the experiment, and one side of the cylinder was carefully formed to a curve of about two inches radius for this purpose. I found great advantage from a mechanical guide, not represented in the figure, to enable an assistant to bring up the connector rapidly and accurately to the magnet in the dark. The helix *c* consisted of about 150 feet of copper-wire, nearly one-twentieth of an inch in diameter, $7\frac{1}{2}$ inches long, and containing four layers in thickness, which were carefully separated by insulating partitions of cloth and sealing-wax. The one termination *de* of the wire, passed into the bottom of a glass tube *h*, half filled with mercury, in which the wire terminated, and the purity of the mercurial surface is of great consequence to the experiment. The other extremity *f* of the helical wire communicated by means of the cup of mercury *i*, with the iron-wire *g*, the fine point of which may be brought by the hand into contact with the surface of the mercury in *h*, and separated from it at the instant when the contact of the connector *ab* with the poles of the magnet is effected. The spark is produced in the tube *h*.

The success of the experiment clearly depends on the synchronism of the production of the momentary current by connecting the magnetic poles, and the interruption of the galvanic circuit at the surface of the mercury. This might be pretty nearly ensured by a variety of simple mechanical contrivances which suggest themselves,—but as these would require very considerable nicety in their execution, I have been satisfied with the precision which may be insured by a good ear and an accurate assistant,—as I have thus, with a little practice, been able to produce, for many times in succession, at least two sparks from every three successive contacts.

These sparks have generally a fine green colour; that I obtained on the 30th of March was in every respect similar to those

I afterwards procured. The intensity of light varies considerably, as it depends on the degree of accuracy with which the circuit is broken at the moment of contact. Sometimes it is highly vivid, and has been seen some yards off in a dark place.

As soon as I had the circumstances under my command, I hastened to show the experiment to my brother, who was present, and to Dr GREGORY, acting secretary of this Society. I afterwards had the satisfaction of showing it to Dr HOPE, to Sir JOHN LESLIE, and several other gentlemen.

I have now stated, I hope not with fatiguing minuteness, the mode by which I have arrived at a result of some interest for science—of that striking character, too, which at once seizes the imagination and the attention, and which may even give it a degree of importance superior to what, weighed in the balance of calm philosophy, it may perhaps deserve. The multiplier and the frog are to the eye of science as sure tests of an electric current, as is the spark to the eye of sense.

I beg to repeat, that the success of Signor NOBILI's experiment is only known to me through the medium of the public prints ; I am quite ignorant of the channel by which the report reached this country ; and, at all events, not the slightest clew has been given as to his mode of arriving at the result.

Let the minor circumstances turn out as they may, all who have had any share in this interesting research, must agree in giving to Mr FARADAY the great, almost the sole, merit of a discovery, of which his researches formed the basis, and whose liberality in throwing open to the scientific world an interesting truth, which he might fairly have retained until he had worked it out in its various details, merits as much praise as the originality and fertility of his genius.

POSTSCRIPT.

SINCE the preceding paper was read, and placed in the hands of the printer, I have seen the Account of the experiments of Signori NOBILI and ANTINORI, contained in the number of the *Annales de Chimie et de Physique*, dated December 1831; and I have likewise, by the kindness of Mr FARADAY, received a copy of his paper about to be published in the Philosophical Transactions. From these documents, it is established, 1st, That Mr FARADAY obtained a spark from a temporary or electro-magnet, as far back as November 1831. This I stated to have been the case in the preceding paper, upon Mr FARADAY's authority, who informed me of it about two months ago; and this was the "*cas particulier*," mentioned in the French version of Mr FARADAY's letter to M. HATCHETTE, read to the Academy of Sciences, which gave rise to the experiments of Signori NOBILI and ANTINORI, and who also allude to it in their paper, without knowing the real circumstances of the experiment*. It appears, 2^{dly}, That the first document giving an account of the excitation of a spark by these philosophers, from a *permanent* or *natural* magnet, is dated from the Museum at Florence 31st January 1832, was published in the *Antologia*, bearing the date of November 1831, and afterwards translated into the *Annales de Chimie*, bearing the date of December. "It is evident," says Mr FARADAY, speaking of the former, "the work could not have been then printed, and though Signor NOBILI in his paper has inserted my letter as the text of his experiments, yet the circumstance of the back date has caused many here, who heard of NOBILI's experiments by report only, to imagine his results were anterior to, instead of being dependent upon mine †.

* *Annales de Chimie*, Dec. 1831, pp. 403, 417.

† *Phil. Transactions* for 1832, p. 162, note.

The notice of Signor NOBILI's experiment, to which I have alluded in my paper as having reached me whilst my investigations were in progress, was that contained in the *Literary Gazette* for March 24, stating simply the report of the fact, though without naming any authority. I learn from Mr FARADAY, that it appeared there by a circuitous channel of information, actually derived from Signor NOBILI's communication to himself. The first information I had of NOBILI's method of making the experiment, which was in its simplest form almost the same with my own, and explained in terms nearly identical, was not till the *Annales de Chimie* for December reached my hands, which was on the 30th of April, when the foregoing paper was in the press.

I take this opportunity of adding, that the experiment upon the frog, simply mentioned above, was made at the suggestion and with the assistance of Dr HOPE, on the 3d of April. It appears from Mr FARADAY's paper*, that he was not successful in exciting muscular action by Dr KNIGHT's great compound magnet belonging to the Royal Society, but he afterwards obtained the effect by making a very sudden rupture of contact of the armature of a smaller magnet. The same result was obtained by NOBILI and ANTINORI†, who justly remark the striking proof which it affords of the extreme delicacy of the Frog Galvanometer, since the magneto-electric currents (to use the language of FARADAY) resemble the thermo-electric ones in the very great difficulty with which they pass through moist conductors.

Finally, as far as yet known, no one except Signori NOBILI and ANTINORI and myself have yet obtained the spark from the natural or permanent magnet. This, indeed, must be in a great measure owing to the power of the magnets we have been

* Article 56.

† *Annales de Chimie*, Dec. 1831, p. 425.

able to command, (no notice is given of the size of that at Florence) ; there is little doubt, however, from the constancy and brilliancy of the results I have obtained, that, by following the same method, the experiment may be repeated with smaller apparatus. At least it is in the highest degree probable that it will be obtained with Dr GOWIN KNIGHT's immense artificial battery, consisting of 450 bars, 15 inches long, which was employed by Mr FARADAY and Mr CHRISTIE in the prosecution of the Experiments on Magneto-Electric Induction.

GREENHILL, EDINBURGH,
7th May 1832.