XLVII. On the application of magnetism as a measure of electricity

Rev. J. Cumming M.A. F.R.S. M.G.S

To cite this article: Rev. J. Cumming M.A. F.R.S. M.G.S (1822) XLVII. On the application of magnetism as a measure of electricity , Philosophical Magazine Series 1, 60:294, 253-257, DOI: [10.1080/14786442208652834](https://doi.org/10.1080/14786442208652834)

To link to this article: <http://dx.doi.org/10.1080/14786442208652834>

Published online: 29 Jul 2009.

Submit your article to this journal [↗](#)

View related articles [↗](#)

might accompany it. These masses would be compared with former accidental productions, and the difference observed: at first they would most likely be returned into the bloomery to increase the general produce, but in time become the subject of a separate experiment. It would on trial be found, that they would melt in the common smithy, and by being blown upon in a manner similar to the refining part of the bloomery operation, pass into the state of malleable iron. This would first suggest the idea of a separate furnace and operation for the refinement of iron. The permanent enlargement of the bloomery furnace would ensue. The ores, by a greater descent and longer contact with the fuel, would be more thoroughly cemented. The iron would take up carbon in quantity, fusibility proportionally increase, and cast-iron in all its varieties, from the white conchoidal fracture to the large-grained deep grey, be obtained.

From this period, the making of iron would divide itself into two branches,—the furnace and forge departments; and, like other judicious divisions of labour, would give new spirit and enterprise to the art: in time foot-blasts and hand-blasts, or bellows, would be abandoned, and a more effectual moving power found on the banks of the adjacent streams. Water-wheels, giving motion to bellows and hammers, would succeed the crude and infantine efforts of a ruder age; and these in their turn would give way to other improvements, in a riper age, much more powerful and striking.

XLVII. *On the Application of Magnetism as a Measure of Electricity.* By the Rev. J. CUMMING, M.A. F.R.S. M.G.S. Professor of Chemistry in the University of Cambridge.*

THE methods hitherto in use for ascertaining the quantity and intensity of the electricity produced either by friction or by galvanic action, are (independently of the shock on the animal frame, which obviously affords no definite measure,) derived from its power in decomposing water, or fusing metallic wires. When the electricity is either small in quantity, or of low intensity, there are considerable difficulties in the practical application of either of these methods.

The fusion of platina wire by the elementary battery of Dr. Wollaston, proves that the quantity of electricity developed by very minute metallic surfaces is considerable; yet, exclusively of the difficulty in soldering wires that are barely visible, it is almost impossible to ascertain their length with any pre-

* From the Cambridge Philosophical Transactions for 1822, Part II.
cision.

cision.—The other mode, that of measuring the quantity of water decomposed by a pair of small galvanic plates, is impracticable.—The recent discoveries of Professor CErsted have enabled me to construct two instruments, one for discovering, the other for measuring, galvanic electricity, with a delicacy and precision that seem scarcely to admit of limitation.—The construction of the former instrument I have mentioned in a communication I had the honour to make to this Society some time since;—I shall now describe a few of the experiments I have as yet been enabled to make with it.—A wire of zinc and another of platina, each $\frac{1}{10}$ inch diameter, were coated with sealing-wax, so as to have merely their extremities exposed: on immersing them in a dilute acid, the circuit being at the same time completed through the galvanoscope, the needle deviated so decidedly, as to leave no doubt that a visible effect would have been produced by wires of less than half the dimensions of those I employed.—As the compass, though small, was by no means delicate, we may, I think, conclude from this experiment, that the electricity developed by two metallic surfaces, each $\frac{1}{300}$ of a square inch, may be detected, and their relations to each other ascertained, by this instrument.

The minute surfaces, and consequently small quantities of exciting fluid required for experiments with this instrument, offer the means of examining galvanic effects that have hitherto been unnoticed.

Of the acids whose galvanic effects I believe have not been examined, I have found, with small disks of zinc and copper, that the oxalic and hydriodic have considerable power; the phosphoric and acetic much less.—The action of strong sulphuric acid was inconsiderable, the needle being scarcely affected; but on adding a drop of water it deviated through more than half a right angle.—Were the galvanic action owing solely to the electricity developed by the metallic contact, the fluid acting merely as a conductor, according to a generally received hypothesis, the effect should be greatest when the stronger acid is used, concentrated sulphuric acid being a far better conductor than when diluted: on the other hand, since zinc or iron are readily oxidated by the action of dilute acid, though with difficulty when it is concentrated, this experiment seems to prove, that the galvanic action depends, not on the conducting, but on the oxidating power of the interposed fluid.—Hitherto I have not had the leisure to form that complete series of the electric relations of the metals towards each other, which this instrument affords the means of doing; yet the effects I have observed in two instances, are, I think, so remarkable, that I ought now to mention them.—On using two disks,

one

one of iron, the other of steel, there was produced a decided deviation: since, then, the only difference in the metals arises from an alloy of from a $\frac{1}{60}$ to a $\frac{1}{140}$ part of the whole, it appears that this is sufficient to alter their electric relations.—The powerful affinity of potassium for oxygen, made it highly probable, that, in the galvanic circuit, it would become strongly negative with all the metals. On my first trial with disks of potassium and zinc, the potassium took fire before I could observe the effect; this difficulty I afterwards obviated by alloying it with mercury; on making the contact the needle deviated through nearly a right angle: The same effect was produced with copper; it was needless to try it with the other metals, for being negative with respect to zinc, and zinc being negative with respect to all the other metals, there can be no doubt that in the galvanic circuit, potassium is the most strongly negative metal with which we are acquainted.—It is perhaps scarcely necessary to remark, that, if any proof of the metallic nature of potassium were wanting, this experiment would have afforded it.

In using the magnetic needle as a measure of galvanic effects, we may either observe the deviation at a standard distance of the connecting wire from the needle, or assume a standard angle and measure the distance.—The latter method seems to have the advantage, as enabling us to use a smaller and therefore a more delicate needle, with this additional convenience, that the scale is increased in proportion as the length of the needle is diminished.—I therefore constructed an instrument, having a connecting wire fixed upon a moveable slide divided into inches and tenths, to which a vernier might be added if necessary. My first object was to ascertain the divisions on the scale, corresponding to variations in the angle of deviation;—for this purpose, the moveable wire was placed at different distances from the needle, increasing in arithmetical progression, and the corresponding deviations were observed. As the effects decrease very rapidly during the galvanic actions, the experiments were made as quickly as possible, proceeding from a distance of $\frac{1}{2}$ an inch to $10\frac{1}{2}$ inches, and again returning to the first distance. On taking the mean of several trials, made in this manner, I found that the tangent of the deviation varies inversely as the distance of the connecting wire from the magnetic needle.

It is well known that in a galvanic arrangement, intensity is given by the number, quantity by the magnitude of the plates; but I am not aware that any notice has been taken of the effects produced by varying their distances from each other.—On placing a moveable plate of zinc opposite a fixed copper-

per-plate, I found, that, on diminishing the distance, the deviation of the needle placed under their connecting wire continued to increase, until they were in actual contact. The law of that increase, ascertained by the method I have just mentioned, was such, that the tangent of deviation varied inversely as the square root of the distances of the plates. In the construction of a Voltaic series composed of many plates, the advantages to be obtained by placing them very near each other, would be counterbalanced, by the risk of their intensity becoming sufficient to penetrate through a small distance; but in using large plates, with electricity of low intensity, it is obvious, that provided they are not in actual contact, they cannot be placed too near each other. By availing myself of this observation, I have been enabled to repeat, with a single pair of plates, the experiments of Ampère and Arago, which were originally performed with a battery of twelve pairs.—Of these, one of the most singular is that by which a spiral connecting wire is made to communicate permanent magnetism to a steel wire placed within*. — This experiment I find may be varied, by using a straight connecting wire, and twisting round it a small steel bar; the zinc and copper ends of the bar receiving the northern or southern magnetism respectively, according as its spiral is from right to left, or the contrary. The repetition of this experiment led me to discover the cause of a singular effect, which I had the honour of exhibiting to this Society. The magnet, which was deprived of its attractive power when its north pole was connected with the zinc wire of a pair of galvanic plates, had been placed in the circuit, by twisting the wire round its poles from left to right: on making this spiral from right to left I reversed the effect; and when the spirals round its two poles were in opposite directions, the weights suspended from them were oppositely affected at the same time, the attractive power of one pole being increased when that of the other was destroyed.

The singular effects produced by using a large conducting wire, I have mentioned in my former paper on this subject, and the analogy it forms between the galvanic and the common form of magnetism.—In the further examination of this diffusion of the magnetic influence, I have found it to be far more extensive than I had at first imagined.—On making the connexion between a pair of plates containing about $1\frac{1}{2}$ foot of surface, through a copper globe of more than a foot diameter, and therefore containing full four square feet of surface, every part of it exhibited magnetic effects, either upon a horizontal

* In these, as in the previous experiments, I find that if the spiral be made of large wire it is much more efficacious than if of small.

or a vertical needle.—The same effects were manifested whatever were the forms of the surfaces interposed between the galvanic plates.—On varying the experiment by connecting both extremities of the plates with each other, by means of small wires, so that there was a metallic circuit throughout, (in which case it is generally conceived that all galvanic effect ceases), I found that every part of this circuit affected the magnetic needle.

The magnetism of the connecting wires was examined in the usual mode; that of the plates themselves by immersing in the exciting fluid a small compass in a glass case, made impervious to the water. It is perhaps premature to form any theoretical opinions upon these few facts, which seem to me adverse to the received opinion, that the galvanic effects are produced by the decomposition of an electric fluid circulating between the positive and negative plates; yet, if ever the mysterious agency of galvanism is to be detected, it must be by examining it in its simplest form; and this, the discovery of the connexion between galvanism and magnetism, and the delicacy of the instruments it enables us to apply, seems to promise, more readily than any modes yet tried, the means of accomplishing.

Since this paper was read to the Society, I have had an opportunity, with the assistance of Dr. Clarke and Mr. Lunn, of trying the magnetic effects of atmospherical electricity.—A wire of about 100 yards in length, connected with a kite, readily magnetised a steel needle inclosed in a spiral wire, but caused no deviation in a compass placed beneath it.—I have obtained the same results in repeating Sir H. Davy's experiments both with the Leyden jar and with sparks taken from the conductor of an electrical machine.—It seems that the galvanic magnetism is most readily made sensible by the deviation it causes in the compass needle; but the electrical by its power of communicating permanent magnetism.

The experiment on atmospherical electricity suggests an easy method of ascertaining, from time to time, the prevalent electricity of the air; by inclosing small steel bars in a spiral wire connected with a conducting rod, and examining the magnetism induced in them.

XLVIII. *Report of a Committee of the House of Commons on Steam-Boats.*

[Concluded from p. 132.]

A List of all the Steam-Boats built since 1811: showing their Tonnage, and the Power of their Engines; the Names of the Builders and of the Engine-Makers; the Dates of their being launched, and also the Stations where they ply. [From the Appendix referred to, *supra*, p. 119.]

Vol. 60. No. 294. Oct. 1822.

K k