If the last physiological inference is correct, it is highly interesting in a pathological point of view. It enables us to explain how hydrops thoracis, or that species of it called hydrops pleurae, may exist to a certain extent, without being attended with any symptoms indicating the presence of the disease, as related by numerous medical authors. We can also more satisfactorily account how the lung so frequently escapes being wounded when weapons penetrate the cavity of the thorax; and how the extravasation which follows, if not considerable, produces but little derangement. It may also have a practical utility, for it informs the surgeon that the lung descends to a certain point only, so that he need not be afraid wounding it should an operation be required below that position.

Dr. Carson retained open the apertures into the chests of his animals with his fingers; whereas mine were kept open in the manner described, which accounts for the different results of our experiments. Dr. Carson, in his Essays, does not allude to this circumstance, but since my investigations he has mentioned it. When air is admitted into the cavities of the chest, the animal requires the aid of all his respiratory powers.

Article VII.

On M. Schweigger's Electromagnetic Multiplier, with an Account of some Experiments made with it. By Prof. Oersted. (Communicated by the Author.)

Immediately after the discovery of electromagnetism, Prof. Schweigger, of Halle, invented an extremely useful instrument for the purpose of discovering very weak electrical currents by means of the magnetic needle. The effect of this multiplier is founded upon the equal action which every part of a conducting wire when it transmits a current exerts upon the magnetic needle. When a part of this wire is curved as in A B C, fig. 1 (Pl. XX), so that the two branches A B and B C are in a vertical plane, and a magnetic needle D E is properly suspended in the same plane, it will be readily conceived that the needle receives an impulse double that which it would receive from one only of the branches. The impulse given by each branch has also the same direction, since it is in fact the same side of the wire which in both branches is opposite the needle. The effect is still further increased when the conducting wire makes several circumvolutions round the needle, as in fig. 2, and thus an elec-

Fig. 1.

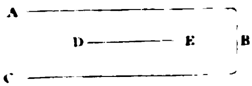


Fig. 2.

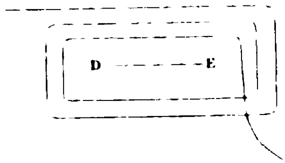


Fig. 3.

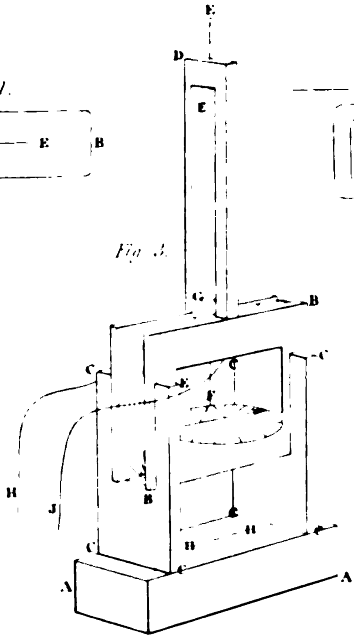


Fig. 4.

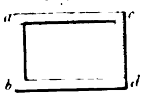


Fig. 5.

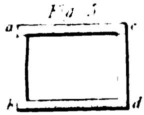


Fig. 8.

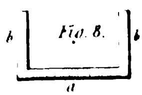


Fig. 6.

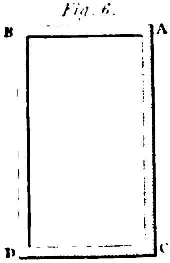


Fig. 7.

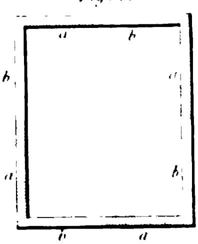


Fig. 10. p. 157.

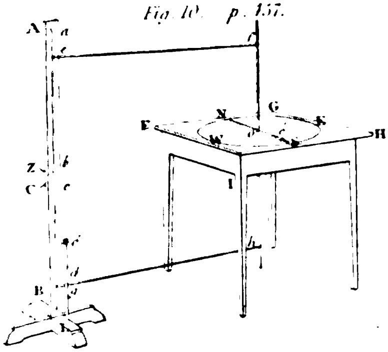
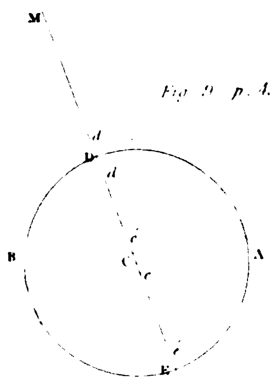


Fig. 9. p. 455.



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tromagnetic multiplier is formed; fig. 3 represents an apparatus according to my construction, which differs, however, from M. Schweigger's in no essential respects. A A, fig. 3, is the foot of the apparatus. C C, C C, are two stands which support a frame B B, which has a groove on the edge to receive the multiplying wire. D D is a stand to support the wire from which the magnetic needle is suspended. E E is a metallic wire passed tightly through a hole made in the upper part of the stand D D. To this metallic wire there is attached by a little wax a thread of raw silk E F, suspending a double triangular loop of paper, in which the magnetic needle is placed. E G is a tube which allows the suspension wire a free passage, and prevents the multiplying wire from touching it. Below the magnetic needle a divided circle is placed to measure the deviations. The multiplying wire is of plated copper, and a quarter of a millimetre, or about $\frac{1}{100}$ of an inch in diameter. It is covered with silk thread, which prevents any communication between the different parts of the multiplying wire; H and J are the two ends of this wire. The use of this apparatus will be understood almost without any explanation. In order to multiply the effect produced by a galvanic arrangement upon the needle, it is requisite only to effect a communication so as to make the multiplying wire a part of the circuit. The effect of a disk of copper and of zinc with pure water as a liquid conductor, was rendered perfectly sensible by this apparatus, and it is even possible by its means to render those galvanic actions sensible, which are too weak to produce a marked effect upon the prepared muscles of a frog. When it is required to discover an action which is so extremely weak as to occasion a scarcely visible deviation, the circuit is interrupted immediately after it has been completed, but it is again effected at each time that the needle is at the point of terminating the preceding oscillation; the apparatus may be rendered still more sensible by putting a small magnetic needle in H H in the situation required to diminish the force with which the suspended needle tends to preserve its direction.

When the multiplier is employed for moderately strong electromagnetic action, thicker conducting wires must be used. If this precaution be neglected, the effect may be diminished instead of increased, owing to the imperfection of the conductor. M. Seebeck has made some very satisfactory researches on this subject, in his memoir on electromagnetism, published two years since in the memoirs of the Berlin Academy.

M. Poggendorf, of Berlin, a distinguished young philosopher, constructed an electromagnetic multiplier very soon after M. Schweigger, and made some striking experiments with it. The experiments of M. Poggendorf having been cited in a work upon electromagnetic phenomena by the celebrated M. Erman, published soon after the discovery of these phenomena, were known to several philosophers before those of M. Schweigger, which circumstance has given rise to different names for the same apparatus. M. Poggendorf has made a very useful application of this apparatus by employing it for the purpose of examining the order of the conductors in the galvanic series. An account of his labours, is contained in the German Journal, the Isis, for the year 1821. M. Avogadro, in Italy, has used the same plan, but without experimenting on so great a number of different bodies, his memoir contains some other observations which are worthy of being known. By the indications of the electromagnetic multiplier, he discovered that some metals at the first moment of their immersion in concentrated nitric acid, produce an effect contrary to that which is observed in a few seconds afterwards; but this alteration does not occur in dilute nitric acid. The metals which have exhibited this property are lead and bismuth, lead and tin, iron and bismuth, cobalt and antimony. M. Avogadro states, that the first effect which occurs in a concentrated acid is similar to that which happens in a diluted acid, and that it is afterwards that the contrary effect is perceived. I have repeated these experiments with lead and bismuth, and I have confirmed them by other means, excepting only that I have always had at the end of the experiment with concentrated acid, the same effect as that constantly produced by the dilute acid. I have also found that the bars of lead and of bismuth which have been acted upon by concentrated acid, gave in repeated experiments constantly the same effects as by dilute acid, unless fresh surfaces were given to them before they were again immersed in the acid; this renewal of the surfaces may be effected not only by mechanical means, but also by diluted nitric acid. It also frequently happened that the bars which had been in diluted acid, and which had been only slightly wiped, gave at first in the concentrated acid a momentary deviation in the same direction as in the diluted acid, very probably on account of the fluid which remained on their surface; they then gave for some seconds the contrary deviation; that is to say, the same as that observed when the experiment is made with bars well cleaned. At length the deviation became such as it would have been, if diluted acid had been employed as a fluid conductor. It is to be remarked that concentrated nitric acid acts much more strongly upon bismuth than upon lead; and, on the contrary, that the diluted acid acts strongly upon the lead, and scarcely at all upon the bismuth. Thus it follows, that the lead acts as the more positive metal in the dilute acid, but as the negative in the concentrated acid.

It remains only to explain why the deviation produced by the concentrated acid does not continue the same during the whole of the experiment. As I am travelling, I have not time to treat of this, or the analogous experiments related by M. Avogadro thoroughly, but I shall content myself with having contributed to call the attention of philosophers to this class of experiments which are equally interesting as regards the theory of solution and that of the excitation of the electric current. M. Avogadro mentions also that arsenic acts with respect to antimony as a positive metal in concentrated nitric acid and as a negative in dilute acid. This phenomenon appears interesting in relation to the chemical effect of this acid upon the two metals in its different degrees of concentration.

Among the experiments to which the electromagnetic multiplier gives rise, it may be stated that by its use, we may show, that when two pieces of the same metal are immersed in an acid capable of acting upon them, that which is first immersed acts towards the other as the most positive metal; this experiment is extremely well performed with two bars of zinc and diluted sulphuric or muriatic acid. It would be extremely interesting to examine the electromagnetic changes which take place during every period of the action of acids and alkalies upon the metals, and nothing affords greater facility for this purpose than the electromagnetic multiplier.

Notice read at the Academy of Sciences of some new Thermoelectric Experiments made by M. Le Baron Fourier and M. Oersted.

I have had the honour of exhibiting to this illustrious Academy the remarkable experiments by which M. Seebeck has shown that an electrical current may be produced in a circuit formed of solid conductors only by disturbing the equilibrium of the caloric. We are therefore in possession of a new kind of electric circuits, which may be called thermoelectric circuits, thus distinguishing them from galvanic circuits, which may in future be denominated hydroelectric. On this subject an interesting question arises respecting electromagnetism, and which relates also to the theory of the motion of heat in solid bodies; the question is to examine whether the thermoelectric effects may be increased by the alternate repetition of bars of different matters, and how it will be necessary to proceed to obtain the sum of these effects. It does not appear that the author of the discovery of the thermoelectric circuit has as yet directed his researches to this point. But M. Le Baron Fourier and I agreed to examine this question together experimentally.

The apparatus with which we performed our first experiments is formed of three bars of bismuth, and three other of antimony, alternately soldered together; so that they form an hexagon, and thus constitute a complex thermoelectric circuit, consisting of three elements. The bars are about 4·7 inches long, 0·6 of an inch wide, and nearly 0·16 of an inch thick. We placed this circuit upon two supports, in an horizontal position, taking care to give to one of the sides of the hexagon the direction of the magnetic needle, and we placed a compass as nearly as possible to and beneath this side. By heating one of the soldered parts with a taper, we produced a very sensible effect upon the needle. By heating two soldered places which were not contiguous, the deviation was considerably increased; lastly, when the temperature was raised at the three alternating solderings, a still greater effect was produced. We also employed an inverse process, reducing by means of melting ice the temperature of one or more of the solderings of the circuit to the freezing point. It will be readily conceived that in this process the solderings which are not cooled are to be considered as heated with respect to those that are. This manner of making the experiment admits of ascertaining by different processes the requisite comparisons for discovering the laws of the power investigated.

Employing the action of ice and that of flame at the same time; that is to say, by heating the three solderings which were not cooled, we produced a very considerable effect; the deviation amounted to 60 degrees.

We afterwards continued these experiments with a stronger apparatus, composed of 22 bars of bismuth and 22 of antimony, much thicker than those of the hexagon, and we satisfied ourselves that each element contributes towards the total effect. In order to make some other experiments, we interrupted the circuit in one place, and soldered at the extremities of the separated bars, small brass cups which we filled with mercury, in order to have a ready mode of forming a perfect communication between these two points by means of metallic wires. A copper wire nearly four inches long, and 0·04 thick, was nearly sufficient to establish an entire communication; and two similar wires, one by the side of the other, effected a most perfect communication; a similar wire, about 40 inches in length, also effected a pretty good communication, but a platina wire, 0·01968 of an inch in diameter, and nearly 16 inches in length, occasioned so imperfect a communication that the variation amounted to only one degree. A slip of paper moistened with a saturated solution of soda, completely interrupted the communication. There was no chemical action; nor did we observe any sensible ignition as might have been expected in an apparatus capable of producing so great an electromagnetic effect. We may also add, that the sum of the effect of all the elements of the complex electromagnetic circuit, is much less than the sum of the isolated effects, which may be produced by employing the same elements to form simple circuits.

I shall now give a detailed account of the experiments referred to in the above communication, accompanied with some further observations.

The bars which were employed in the following experiments were parallelopipeds, the transverse section of which was square, each side being nearly 0·6 of an inch in length.

Exper. 1.—We formed a rectangular circuit *a b c d*, fig. 4, one-half of which was antimony, and the other of bismuth; *a c d* and *a b d* soldered together, so that the two contiguous were of antimony, and the other two of bismuth. One of the sides was nearly four and a half inches long, and the other three inches; the circuit was placed horizontally upon stands, with two of its sides in the direction of the magnetic needle, and the compass was placed upon one of them. Having left the circuit for a time sufficient to regain the equilibrium of temperature, which might have been disturbed during the placing of it, ice was put upon one of the two solderings, *a* or *d*, which unite the two heterogeneous metals. The compass showed a deviation of 22 or 23 degrees; the temperature of the air was 57° of Fahr.; at a temperature of 68°, the deviation was observed to be 30 degrees. We neglected to note the temperature of the atmosphere at the commencement of the experiment. We shall, therefore, only compare the results of experiments made at the same period.

Exper. 2.—Another circuit, fig. 5, was formed of the same length as the former; but having the opposite sides of the same metal, *a b* and *c d* being bismuth, and *a c* and *b d* of antimony so that the circuit was composed of two thermoelectric elements rendered active by ice placed upon two opposite angles. This circuit produced a deviation of 30 to 31 degrees, under the same circumstances in which the simple circuit produced a deviation of 22 to 23 degrees. The temperature in this circuit has its equilibrium soon restored, so that the thermoelectric effect appears weaker than it would do without this circumstance.

Exper. 3.—A circuit A B C D, fig. 6, the circumference of which was double that used in the first experiment, was put in action by ice placed upon one of the solderings. The deviation was only from 13° to 15°, under the same circumstances which, with the circuit, fig. 4, gave 22 or 23 degrees.

Exper. 4.—Another circuit, fig. 7, was formed, of the same length as the preceding, but it had four alternations, or four thermoelectric elements *a b* (*a* being the antimony, and *b* the bismuth). This circuit was put in action by placing ice upon every other soldering. The deviation of the needle amounted to 31¼ degrees, under the same circumstances in which the simple circuit of equal length produced a deviation of only 13 to 15 degrees, but the circuit used in Exper. 2, fig. 5, which had only half its circumference, and half the number of elements, produced nearly the same effect as that obtained in this experiment. Thus it appears, which will be confirmed in the sequel, that the deviations of the needle produced by the thermoelectric circuit increase with the number of the elements when the length of the circuit remains the same, but that they become weaker in proportion as the length is increased. It is also evident, and it will be rendered still more so in the sequel, that these two effects balance each other; so that the effect of a circuit is not altered, when the length of the circumference increases in the same proportion as the number of the elements; or, in other words, elements of equal length form circuits which produce equal deviations, whatever may be the number of the elements. We confirmed these results by comparing the effects of two, three, four, six, thirteen, and twenty-two elements.

In order to form complex circuits capable of producing a great effect upon the magnetic needle, it will be necessary to employ very short elementary bars; and to avoid the inconvenience which follows from the restoration of the equilibrium of temperature which happens too rapidly in such small circuits, the solderings must be placed alternately in contact with continued sources of heat and cold. There is still another increase of effect in the complex thermoelectric circuit, which is not thus limited by the length of the circumference; but before it is mentioned we shall show the relation which exists between the different elements of the complex circuit.

Exper. 5.—We examined the effects of the circuits by cooling first one, then two, afterwards three, &c. of the solderings which were rendered active; and after several experiments, we found the mean numbers to be as follow: In a circuit of three elements, the first gave a deviation of $15\frac{5}{8}°$; the first two $25\frac{7}{8}°$; the three together 31°. In a circuit of four elements, the ice placed upon one soldering gave a deviation of $13\frac{3}{4}°$; upon two 19°; three 25°; four $31\frac{3}{4}°$. In a circuit of six elements, the first gave a deviation of 9°; the first two $13\frac{1}{4}°$; the first three $18\frac{1}{2}°$; the first four 22°; the first five $25\frac{2}{3}°$; the six together $28\frac{2}{3}°$.

It will be observed that the deviation produced by the first cooled soldering, is nearly represented by double the quotient obtained by dividing the total deviations produced by the circuit, when all its elements are put in activity, by the number of elements plus one. It is also evident that the other numbers nearly approach the value of the simple quotient; but still they appear to form a decreasing series. We are now alluding to the deviations measured by the angles, and not of the real extent of the effects. If it were not necessary to regard the different distances of all the points which act upon each other in the different positions of the needle, and even to consider what may be the reciprocal situation more or less oblique of the edges of the conductor and of the needle, the effects might be represented by the tangents of the deviations. It is, however, remarkable, that the experiments which we have made indicate a constant relation between the deviations. If such experiments as we have hitherto had an opportunity of performing were susceptible of greater exactness, consequences interesting to the theory would undoubtedly arise from them.

Exper. 6.—Thermoelectric action may be rendered sensible by means of the electromagnetic multiplier. In order to produce this effect, one of the two pieces of metal, *a*, fig. 8, is combined with two pieces of *b*, the other, so that this arrangement constitutes a broken circuit, the two ends of which are of the same metal. After having put some ice upon one of the solderings, a communication is established between the two pieces *b* by means of the multiplying wire.

The effect of this is sensible upon the needle of the instrument, but yet it is very weak; weaker, for example, than the effect of a piece of copper and silver with water as a fluid conductor. The effect is rendered more evident by communicating a fresh impulse to the needle, at the end of each return after a former impulse.

The extraordinary weakness of this action is very remarkable. We learn from this result that the same thermoelectric elements which produce a great effect upon the magnetic needle of the compass, when their communication is made by a short and thick conductor, act but very little even upon a much more sensible needle, when the communication is made by a thin conductor of considerable length. A hydroelectric current excited by a piece of zinc and silver, with water as a fluid conductor, produces an effect upon the needle perhaps a hundred times greater than that of the thermoelectric current; nevertheless the effect produced by the former upon the needle of the compass, even when the communication is made between the elements by the best conductors is scarcely sensible; while the effect of the latter upon the compass is not only sensible but considerable. All this marks a very important property of the thermoelectric current, which indeed might have been foreseen by theory, but which experience should confirm; that is to say, the thermoelectric circuit contains the electric powers in much greater quantity than the hydroelectric circuit of equal size; but, on the other hand, the intensity of force in the former is much weaker than in the latter. Since the first electromagnetic experiments, it has been clearly seen that the deviation of the needle produced by the electrical current would be regulated according to the quantity of electric power, and not by its intensity. Thus the considerable deviation which the thermoelectric current produces is an indication of the great quantity of power which it contains. As to the intensity, it is universally acknowledged, that an electric current pervades conductors so much the more readily as it is more intense: the hydroelectric current which more easily pervades the wire of the multiplier than the thermoelectric current does, must, therefore, be more intense. The much greater quantity of electric power which must be admitted to exist in the thermoelectric current, will form no objection to this reasoning; for it is perfectly evident that in the case in which a current A, of intensity equal to that of another current B, but greater in quantity, is presented to a conductor sufficient to transmit the quantity of B only; this conductor must be capable of transmitting a part of the current A equal to the current B; and if we suppose A to possess a stronger intensity than B, the transmission of the former will be still greater.

Exper. 7.—We tried the effect of the complex circuit upon the needle of the multiplier, and we found it considerably augmented, by increasing the number of the elements of the circuit, even in cases in which the number did not increase the effect upon the compass. We obtained this result by experiments with 6, 13, and 22 elements. It appears then that the intensity of the power increases in the circuit with the number of the elements, which is perfectly conformable to what happens in Volta's pile. The circuit had no sensible effect upon the compass when the communication was made by the multiplying wire.

Exper. 8.—A platina wire, about 0·004 of an inch in diameter, was not ignited by a thermoelectric circuit composed of 13 elements, but which was nevertheless capable of causing the compass to deviate 28 degrees; yet a hydroelectric circuit producing an equal effect upon the compass, was quite sufficient to ignite the same wire. This difference is derived from the too weak transmission of the thermoelectric current by the platina wire. During the communication effected by this wire, the needle of the compass indicated only 2 or 3 degrees of deviation. An iron wire, about 0·008 of an inch in diameter, was not ignited. The communication effected by this wire produced a greater deviation than the platina wire, but only by 5 degrees. We must wait for the current produced by a thermoelectric apparatus composed of several hundred elements, before we shall be able to ignite a metallic wire.

Exper. 9.—We were unable to produce any sensible chemical action by the thermoelectric circuit; those fluids which have the greatest conducting power resisted its action; for instance, nitric acid, solution of soda, and many metallic solutions. We shall mention only one of these experiments, which, frequently repeated, appeared to produce some chemical effect. We placed a piece of blotting paper moistened with solution of sulphate of copper between two perfectly new five franc pieces; the precaution was taken to put the two pieces in contact with the paper on the sides which had similar impressions, and the thermoelectric current was passed through the two pieces of metal and the moistened paper. In a quarter of an hour some parts of the silver were slightly covered with copper. But as this trace of metallic precipitation did not resist washing accompanied with slight friction, we are disposed to consider this experiment as too questionable. During the time that the two pieces of silver with the paper formed part of the circuit, not the slightest effect was produced upon the compass, so that this small piece of moistened paper may be said to have entirely interrupted the thermoelectric current. In a state of such perfect isolation, no sensible chemical effect could be expected. From the slight intensity indicated by the multiplier, there is reason to think that it would require an electric circuit of many hundred elements to pervade a fluid equally well as a Volta's pile formed of four or five elements; but it is very probable that such an apparatus will produce effects similar to those which may be expected from hydroelectric piles, the metallic elements of which are enormously large.

Exper. 10.—The action of electrical currents upon animal bodies is one of the most remarkable which it exerts. The thermoelectric circuit excited no sensible taste, when it was made to act upon the tongue; but upon a prepared frog, it produced effects of two slightly different metals; this result evinced that the nerves of a frog are excellent conductors.

Exper. 11.—A thermoelectric circuit of 13 elements produced no effect upon the most delicate electrometers; nor did Volta's condenser unequivocally indicate signs of electricity in this circuit. But we acknowledge that we did not repeat this experiment so often as it deserves.

Exper. 12.—The experiments which we have related are sufficient to prove how weak the thermoelectric current is with relation to the conducting power even of the best conductors. Another experiment produced similar results under other forms. The great circuit consisting of a rectangle, the length of which was nearly four times its width, was placed in such a manner that the two short sides were parallel to the needle of the compass; the compass was placed on one of these sides, and the two adjacent elements were rendered active. After having observed the deviation of the needle, a communication was effected between the active parts furthest from the compass by means of a copper wire, so that all the active parts might form a separate circuit. After this diminution of the circumference of the circuit, the needle indicated a stronger action; this effect would not have been very evident, if the transmission of the thermoelectric current were not so difficult even in the metal, that a difference of passage of two or three feet could produce so considerable a change in the effect. It must be observed that the same copper wire employed to effect the communication, when some part of the whole circuit was interrupted, would produce scarcely the same effect as the immediate junction. When the part of the circuit furthest from the compass was rendered active, and a similar communication was effected, the deviation of the needle diminished. However, this difficulty of transmission is unattended with any thing that ought to occasion surprise. For the electricity in a circuit of conductors, in consequence of their contact, must flow in proportion as it acquires the intensity requisite to clear the passage in these conductors; therefore this electricity never acquires sufficient intensity to pervade the conductor with facility, but it will constitute a current as soon as the circuit does not oppose the obstacle of very considerable isolation. It is easy to perceive that the quantity of electricity developed by this continual excitation which exists in the circuit, ought to be so much the greater as the circuit is a more perfect conductor. Thus the thermoelectric circuit supplies an incomparably greater quantity of electricity than any other circuit which has as yet been invented. If by other circuits water, the acids, and the alkalies, have been successively decomposed, it is not beyond the limits of probability, that by means of a new circuit, we shall be able to decompose even the metals, and thus complete that great change in chemistry which commenced with the pile of Volta.

Article VIII.

Analysis of the Native Sulphate of Iron and Alumina. By R. Phillips, FRS. L. and E. &c.

Until after I had completed the analysis of this substance, I was not aware that it had been noticed in any work on mineralogy: I find, however, that it has been described in the 24th number, p. 97, of Mr. Sowerby's Exotic Mineralogy; the specimen mentioned and figured in this work under the name of sulphate of iron and argilla, is stated to be from Bacherstolln, in Schmolnir. Mr. Sowerby mentions that it seems to have been mistaken for native alum, but he justly observes that it differs from alum in containing no alkali, and that the solution yields it upon the addition of potash.

The salt which I subjected to examination originates from the decomposition of iron pyrites in slate-clay. It was presented to me by Charles Macintosh, Esq. and is plentifully met with in the slate clay of the deserted coal mines of Hurlet and Campsie, which as well known is employed for the double purpose of preparing alum and sulphate of iron.

The sulphate of iron and alumina exists in the state of soft delicate fibres, easily separable from each other; it is colourless, and its lustre is silky, and it resembles asbestus in appearance. It is so extremely light that 100 grains of the crystals occupy a space equal to that of an ounce and a quarter of water. By exposure to moist air, the iron is converted into peroxide, and the crystals become yellowish-brown. It is readily soluble in water, and the solution, as above stated, readily yields crystals of alum on the addition of the salts of potash or ammonia. By spontaneous evaporation, crystals of common sulphate of iron are obtained, and the sulphate of alumina remains in solution; this