<table>
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<th>Title</th>
<th>Voltaic electricity</th>
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<tr>
<td>Author</td>
<td>Wright, Thomas</td>
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- p61, p77 missing.
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Remarks on Voltaic Electricity
and electro-magnetism and their
applications to the cure of disease.

The present century has, in every branch
of science, unfolded most important
relations to the enquirer; and amongst
the most remarkable of these may be
reckoned the various facts which have
been elucidated, with regard to the science,
in which I have undertaken to make the
following observations. It is not a little
extraordinary that the application of
electricity to the cure of disease has been
so limited, especially as the experiments
and theories of many eminent physicists
tend to prove, that its agency is most
similar, if not identical with that of the
influence of the animal body. The
only reason I can assign for this neglect,
is the general want of practical familiarity
with the science amongst medical men, and
the great complexity, cost, and liability to
damage, which characterizes the instruments
now generally in use, for this
By using the terms "electricity," "current," "magnetic atmosphere," etc., in the following pages, I do not mean them to be understood as any thing more than convenient designations of certain changes of force in matter.

It will be convenient to consider dilute sulphuric acid as \( \text{H}_2\text{SO}_4 \) and gypsum, or Hydrargyrum, a compound of \( \text{SO}_3 \) (the gas sulphur of Gauthier) with water, instead of \( \text{SO}_3 \cdot \text{H}_2\text{O} \) (sulphate of water.) The solution should consist of 1 acid with 60 water.
administration of the electric influence.

Having for some years past endeavoured
to apply the information which I have
collected in that branch of science to the
construction of portable and economical instruments,
and it being the opinion of several of my
medical friends that I have been successful,
I shall devote part of the following pages
to a description of the construction, and
general theory of the mode of action, of
Voltaic and electro-magnetic apparatus.

The first and not least important
part of my task will be, the description
of the Voltaic Battery with its more useful
modifications. This instrument in its
most simple and uncomplicated form
consists of a plate of metal readily oxidizable,
(lime), a liquid capable of acting chemically
upon it, (dilute sulphuric acid), and a
plate of a less readily oxidizable metal,
(copper) to conduct the electricity* set in
motion by the union of the Lime and
acids,* such an arrangement is shown
by Fig. (1) in this case the union of one
equivalent 30,* with an equivalent of Lime in
The circuit closed, and active.
attended with the passage of a proportionate quantity of electricity from the zinc, throu the liquid to the copper and throu the latter to the zinc again.

Theoretically no chemical action can take place, indeed the copper is in contact with the zinc and the conducting wire complete, but we know that it is to the contrary practically. (Why, it is needless to discuss here) We must therefore substitute for the zinc an amalgam of that metal which is not acted on by dilute sulphuric acid, this is easily effected by dipping the zinc plate in the solution and afterwards rubbing it with mercury: The arrangement Fig. 2 is thus formed in which as long as the Zn and copper are ununited, all chemicals and electric action are quiescent. Join them by a wire or allow them to touch each other and in an instant a torrent of bubbles of Hydrogen will be given off from the copper plate - but the copper plate is not chemically acted on, show there are we to explain the elimination of hydrogen from it and not from the Zn which
Fig. 3

Polarized conduction wires:

\[ \times \quad + \quad + \quad + \quad - \quad - \quad - \quad + \quad + \quad + \quad \times \]

Thus:

\[ \text{M}^+ , \text{SO}_4^2-, \text{SO}_4^2+, \text{SO}_4^2+, \text{Cu}^+ \]

<table>
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<th>Polarized</th>
<th>Solution</th>
<th>Plate</th>
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I have used \( M \) as a symbol for mercury metal. I hope there was no confusion between it and the \( H \).
is the seat of action? Of this there has been several modes of explanation, I shall venture to give that which seems most feasible to myself. Let us suppose the battery to consist of three elements, two compound and combining, ZM and HSO₄, and one simple and uncombining, copper; on uniting the ZM and copper, or "closing the circuit" the whole arrangement becomes polarized i.e. the Z of the ZM positive its M negative, the SO₄ of the HSO₄ negative its H positive, the face of the copper in opposition with the liquid negative and the alternate faces of the atoms of it and the conducting wire negative and positive in the same direction (Fig 3 shows the arrangement). This state of polarization rises in intensity until the Z unites with the SO₄ rest in series, carrying its charge with it, the released H unites with the next succeeding SO₄ with the same connection of charge until the H is in opposition to the copper, unable to unite with it, flies off in a gaseous state, after giving up its charge to be conducted from atom to atom of the conducting wire to the ZM again. The arrangement is thus restored.
to its original state, and ready for renewed polarization and discharge, which instantly took place.

There are three principal causes of resistance to chemical action and passage of current in the above arrangement: 1st. the resistance offered by the conducting wire, which may be either from its extension, its density or from its consisting of a metal less capable of conducting electricity. 2d. the greater or less resistance to conduction in the fluid element, in proportion to the greater or less distance between the plates. 3d. the resistance offered by the fluid element to decomposition.

The first of these causes of resistance is reduced to a minimum, by the employment of a short thick wire of metal having great forces of conduction as copper. The second, by approximating the plates closely to each other. And the third, by adding some other electrical compound to facilitate the decomposition of the SO₂H, or employing an element of more easy decomposition.

The following experiment will illustrate the mode in which this last may be effected:

Exp. Increase the length of the conducting wire.
* We have an analogous mode of inducing decomposition employed during the formation of phosphates of hydrogen and phosphate of potash from water, phosphorus and carbon dioxide.
until it is observed, by the galvanometer hereafter to be described, that a much less quantity of electricity is passing thru the arrangement on account of the increasing resistance to conduction. Now add to the fluid element a quantity of pounded sulphate of copper; the hydrogen will instantly disappear from the copper plate, precipitated metallic copper will appear instead of it, and the galvanometer will indicate an increased passage of current. In this experiment, the hydrogen uniting with the $SO_4^{-}$ of the $CuSO_4$ is more readily induced* to render its own $SO_4^{-}$ to the Zinc, and the current thus so far freed from the 3rd cause of resistance, is better enabled to encounter the resistance of the conduction wires.

If we divide the copper wire, conducting the current thus disimpeded, and immerse the divided ends into a solution of a salt we shall find that the current will pass thru it, enforcing a state of polarization, decomposition and dischage—similar to that taken place in the battery. The separated components of the fluid appearing at the immersed ends of the wires. The chemical action on the liquid conductor substituted, will be exactly in for—
portion to the quantity of electricity passing, and this again in proportion to the facility offered by the liquids to decomposition. This may be shown by Exp. (Fig. 1)

Let the substitute liquids be dilute $\text{SO}_3 \cdot \text{H}_2$ mixed with $\text{SO}_4 \cdot \text{Cu}$, i.e., the transmission of the current through the copper wire in connection with the copper of the battery and the positive pole will be dissolved, that in connection with the zinc, "the negative pole" covered with precipitated copper; the $\text{SO}_4$ of the $\text{SO}_4 \cdot \text{H}_2$ enters into forced combination with the copper of the positive pole, and it combines with the $\text{SO}_4$ of the $\text{SO}_4 \cdot \text{Cu}$ in the decomposition of the liquid being facilitated by combination at each pole.

Substitute for the acelculated sulphate of copper in the last exp. dilute acel. sulph. ($\text{SO}_3 \cdot \text{H}_2$). The positive pole will be dissolved as before, but at the negative pole hydrogen will be given off, in a gaseous state; we have combination at one pole only, and the current will be retarded in proportion.

Allow the fluid conductor to remain as in the last experiments, but let the part of the positive pole immersed consist,
of platinum, here, inasmuch as the SO₄ cannot combine with the platinum, there will be a further retardation of the current, indeed, to a point an extent, as entirely to stop its progress. In order therefore, to the overcome this resistance, we must seek some means of augmenting the force of the battery.

In the explanation of this I endeavor to show that it was the affinity of zinc for, and its combination with SO₄ which causes the polymerization in, and impulsion of current through the circle of zinc, liquid and conducting wire, it will then, be readily understood, that by introducing other similar forces in the circle, we shall, in a proportionate degree, increase the impulsive power of the battery. Fig. (5) shews an arrangement in which this result is so obtained. The current from pair No. 1 instead of being conducted from the copper to its own zinc again is carried to the zinc of the next pair (No. 2) and from that in like manner that pair No. 3 receiving a fresh impulse as it passes through the zinc of each pair, if now, the poles of this compounded battery, when charged with SO₄, Cu be immersed in dilute acid sulphuric— we shall find
that a sufficient power has been obtained to decompose it, even when the positive pole consist of platinum. Hydrogen will be given off as before, and the SO₄ eliminated at the positive pole will three combine with the R. of the water of the solution, setting free its oxygen in the form of gas. As the quantity of gas evolved is one third of the quantity of electricity flowing through the circuit, it is often necessary to collect it for this, as well as for other purposes. Fig. (6) shows an instrument for this end, the "Voltaimeter" of Faraday. The platinum terminals are enclosed in an inverted glass bell, resting on a well cemented wooden sloe, from the top of the glass proceeds a tube, to conduct the mixed gases into a graduate glass jar inverted over the shelf of a pneumatic trough. A wire proceeds from each terminal, thru' the sloe, and terminates in a binding screw for convenience of connection with the battery.

By increasing the number of pairs in series, the impulsive power or "tension" of the battery may be increased to any extent, in the large battery of the Royal Society consisting of upwards of 2000 alternations, it has driven the current, in the form of a stream of fire, between the poles gradually
separated to the distance of four inches. Platinum neither, the most infusible, metals, when introduced into this stream of most intense heat, melted like wax, the diamonds entered into combustion, other infusible gums were dissipated.

A battery of such tension as this is seldom required, indeed it is not necessary for any common purposes. The tension should be apportioned to the resistance to be overcome in the circuit. Thus solutions of the more readily decomposable salts, as nitrate of silver, sulphate of copper, require not more than one or two parts. Sulphuric acid or salts of hydrogen ten parts. Twenty parts will give a slight shock, twice the human body, a hundred, a pretty strong one. Water requires a great number of alternations for decomposition; indeed I doubt if perfectly pure water can be decomposed at all. It seems rather to conduct the current in the same manner as metals do, i.e., by polarization and discharge from atom to atom.

The quantity of electricity, set in motion, is in proportion to quantity of gum dissolved in each alternation, its increase may, therefore, be effected by augmenting the strength of the fluid, current or the sign of the plates. The interposition
According to a mere poetical theory, a certain amount of emotion is produced in the mind capable of producing the same physical effects.
of a pair, having smaller plates or weaker unity fluid, will, of course, decrease the quantity of electricity as it requires to be forced into the same degree of resistance as the rest.

During the passage of the current, through the conducting wire, a certain quantity of the latent heat of the latter is rendered sensible and this in proportion to the resistance offered by the conductor.

Thus if we unite the poles of an active arrangement (three disconnected pairs of 6 such plates) with a fine platinum wire, both bad conductors of heat and electricity, it will instantly become white hot and fuse. wires of greater conducting power, as of copper, silver, or gold, if extended until they offer the same degree of resistance, will evolve the same quantity of heat, but not so perceptibly, on account of its being diffused thru a large quantity of metal. A very interesting experiment has been devised for showing the relative productions of heat by resistance in different metals. The poles of a battery are joined by a small chain of fine wires, platinum silver alternately, on the passage of the current the platinum links will become white hot, while the silver remain cold.

And I shall now mention some of the more important batteries in use. The fact is, the original
Pile of Volta. It is formed in the following manner. Take equal squares of zinc, copper, and wooden cloth, equal in size and number, and having soaked the zinc in dilute sulphuric acid, or salt and water, pile them as shown in Fig (7). The Pile of Volta is shown at Fig (5) and is the first arrangement described in those observations. Mr. Crichton soldered the zinc and copper plates, back to back, and cemented them in a wooden trough as in Fig (8). Dr. Mellaston divided an earthenware trough with partitions, and immersed a pair of zinc and copper in each division, the copper plate being folded round the zinc brought to the sides of the latter into action, the plates were all fastened to a wooden box and could be immersed into the exciting fluid at once; Fig (9) illustrates this arrangement. Mr. Troup introduced an arrangement of concentric cylinders of copper with a cylinder of zinc between them. All these arrangements were excited with dilute sulphuric, nitric or muriatic acids or ovens, mixtures of them, and they had this great disadvantage, that, the very energetic, when first put in action, their power quickly declined, and soon almost ceased. This singular phenomenon
had been ascribed to the reduction of gaseous hydrogen to the salt of gaseous formed in the battery, by the hydrogen and its deposit on the copper plate, thus converting the latter into a second gaseous element, and renewing the action; it has also been referred to the adhesion of hydrogen in a solid form to the copper plate, and this view is supported not by the fact that the action of the battery will quickly decline, even the fixed element is divided spontaneously by a porous partition, rendering difficult if not impossible for the gaseous to pass to the copper, and 2nd that the action of the plates is renewed by exposure to the air and reimmersion. I think that the decline of action may probably be referred to both of these causes, first to the adhesion of the hydrogen and secondly to the reduction by it of the salt of gaseous.

The inconvenience thus occasioned had, of late years been obviated in two modes, chemical and mechanical.

The chemical mode, generally, consists of the employment of a salt of copper instead of or combined with the dilute acid, this arrangement was first used by Mr. Maurice de la Pique and published by him in the London Edinburgh.
Copper is precipitated on the zinc plate but its effects on the action of the battery are slight.
Phil. May, when it underwent the unfavourable
criticism of the Editor who laboured under the
erroneous impression that he was capable of
judging of such matters. It is a most convenient
mode of charging a Benjamini soaked
brough, a battery of this kind from its current
being insubscript, increases double the tension to
an charged with dilute acid alone. Its mode
of action will be understood from the remarks
at top 81. Mr. Daniel and Mr. Mullins, preceded
by the elder Dejuncel divided the fluid between
the cylinders of a jar battery (the one) by a
porous partition; Mr. Daniel charging with an
acidulous solution of sulphate of copper in the
division next to the copper, and with dilute
sulphuric acid next to the zinc; Mr. Mullins will
the unacidulated solution of sulphate of copper in
the first compartment & rum our of ammonia in
the last. Mr. Daniel's zinc was amalgamated, not
so Mr. Mullins. Mr. Daniel has insisted on
the advantage of incurring the copper over
the zinc that, in his Work on Chemical Philosophy
adduced much curious matter in support of his
position, it is however for economy of space con-
venient to have the plates of an equal sign.
for, unless more than an equivalent of electricity can be obtained from the solution of an equivalent of zinc, I do not perceive what advantage can be obtained, in altering the size of the metals proportionately to each other, especially as every difference in the diameter of the cylinders, will increase their distance from each other. The experiments of Mr. Drake, published in the Phil. Mag. go to prove that there is an increase of current when either copper or zinc is augmented.

Mr. Page of Philadelphia has introduced the use of lead in place of the copper.

The two following are modifications generally used by myself; their cost is a mere trifle, and their arrangement easy. An earthenware jar is lined with the thinnest sheet lead or lead foil, which is turned over its rim and secured with a bright copper wire twisted round it, to serve as the positive pole; a piece of the strongest brown paper is then formed into an open cylinder, an inch less in diameter than the jar, its edges closed with sealing-wax; a piece of gum is bent into a rude cylinder, an inch less than the last 1/2 cm. soldered to it, and a quantity of pitch having been melted at the bottom...
Fig 10
the paper and zinc cylinder are fixed into it and
the whole is then allowed to cool. Fig. (10) shows
three alternated, the connecting wires of each pair
placed in opposite and bound together with fine copper
wire. The pitch should be sufficiently thick to hold
the cylinder firmly. The apparatus is charged with
disulfate of zinc and water, inside the paper cylinder
and disulfate of copper outside it. By adding dilute
acid to the disulfate of copper, so the proportions of
1 to 3 parts by measure, the action may be doubled, it
will be advisable in this case to add a little course
"cork" in the inner compartment or to amalgamate the
give. All batteries excited by disulfate of copper should
be filled with water when not in action, as the freshly
precipitated copper is very apt to combine with the
carbonic acid of the atmosphere, forming an insoluble
carbonate, which is most difficult to get rid of. Hence
the advantage of using lead, which being inexpensive
and pliable can be renewed at pleasure.

The second battery used by me is of still simpler
construction. A flat piece of zinc, to which a copper
wire has been soldered, having been covered on each
side, with two folds of filtering paper soaked in
disulfate of copper solution, is completely wrapped up
in lead foil, an aperture being left from which the
same may protrude, another coil is inserted round the
lead, and the apparatus (Fig. 11) is complete; it has
the advantage of being readily put together, portable
(it can be wrapped in paper and slipped in the pocket
for use with electromagnets machines) and will continue
active 6 hours, if occasionally pressed to keep the solution
of copper being prevented by the lead; a
Voltaic pile, zinc, lead foil & filtering paper contains in
the copper solution from a good arrangement for common
purposes.

Mr. Grove has invented an exceedingly
powerful arrangement, in which he uses pure nitric
acid in the compartment of the negative plate, which
is of platinum foil and dilute sulphuric acid (1 part
to 4 water by volume) or a solution of potassa in opposition
to the zinc, which last is amalgamated. The fluids are
separated by a partition of carbon paper in the "tissue" state.

When living in Manchester a few years ago I
was associated with some other gentlemen for the purpose
of experimentalising in this and other sciences, and
amongst other apparatus we had a Grove's battery of
50 pairs, each pair having an active surface of 32 sq.

It is difficult to describe the splendid effects of
this battery, whilst the poles were unconnected there
was not the slightest chemical action, but on their
union, the consisting of copper wire, flesh, flesh, they became too hot to be touched, and the nitric acid in each cell, suffering decomposition by the hydrogen boiled and gave off clouds of nitric oxide gas; a piece of platinum wire, more than a yard long, became white hot when forming part of the circle... the light from the combustion of charcoal, the current passing between the pieces fastened to the poles was too intense for the eye to bear... a steel file, fastened to one pole, when dipped into a cup of mercury in connection with the contrary pole entered into violent combustion and finally exploding exploded and covered the gentleman manipulating with a shower of sparks; when the elements were connected so as to form a battery of five alternations it decomposed SO, if at the rate of 130 circles of mixed gases per minute. The general mode of setting up Grove's battery is in the Williston form except that the wire is folded around the platinums.

The second mode of preventing the deposition of zinc on the negative plate is mechanical... Since, having observed that the hydrogen was given off more rapidly from the sharp edges and staples of the negative copper plate, considered that he could convert the whole surface into a complete array of points, the gas would be driven off before it could
reduce the zinc, he then formed the plate of covering the negative plate (of silver foil) with finely divided platinum (platinum black), this experiment was crowned with success and his elegant arrangement is now employed by every electrician in the kingdom. Bellott's form is adopted for this battery, the zinc (amalgamated) surrounding the platinaed plate.

Mr. Roberts and Mr. Sturgeon, finding that surfaces of iron had the same property of eliminating hydrogen rapidly, substituted iron for the platinaed silver of zinc and with equal results. Mr. Roberts uses sheet iron, Mr. Sturgeon, cast iron; the latter is the best. Twelve of the sixpenny three-legged pots in common use among the poor with included cylinders of amalgamated zinc form a battery of great power and convenient construction. The charge for Amos Y. Sturgeon's batteries is sulphuric acid with from 8 to 14 parts by measure of water; the mixture must be allowed to cool before use, otherwise it will dissolve the amalgamated zinc.

From experiments I have made, I am led to believe that, with some exceptions arising from this cause, the hydrogen adheres to metals in proportion to their capability to form alloys; for instance, from mercury it will not rise at all, from lead scarcely, from copper in large
The induction I can now to describe throughly was 1843 for my friend Prof. Allan Thomson who ordered it thus: having the mode of induction I wished measured in the class I ordered it to that the Society may understand the principle on which it is constructed. I shall give a brief sketch of the proposed action of electric currents through each other situated from any gradient. Thus 1845 in which their original observation can extend. I the document of motion by the central form of a single cell the primary and the secondary each containing forms of the center of an electric magnet. I think therefore if the Thomson of the secondary cell contains from it an in the machine certain induction coils.
bubbles, but from iron in an exceedingly fine mist.

The relative degree of intensity of different kinds of batteries is as follows:— The most efficient number of alternations for decomposing $SO_4^-$

of Grove's 5 alternations

10 of batteries charged with $SO_4^-$, $C_2^-$

20 — — — with $SO_4^-$

varying a little with the strengths of the charge on all
these, and in favour of the fast charge of Potassa (in Grove's)

Charcoal and coke have been recommended instead of platinum in Grove's battery, and, in compliance with the recommendation of a German writer, I have tried black lead crucibles but found that they would not conduct.

I shall now, after glancing at the phenomena of magnetism, proceed to glance at the phenomena of the reciprocal action of electricity and magnetism when in motion, on each other.

A magnet is a mass of some metal or metallic compound, the atoms of which exist in a peculiar forced state of polarity.

Iron and nickel are the metals employed in the production of the phenomena of magnetism, the latter rarely so, I shall not therefore allude to it further. Magnets are of two kinds, temporary and
permanent. Temporary magnets are those, which, made of the softest and finest iron, instantly lose their forced polarity on the cause compelling it being removed. Permanent magnets, on the contrary, made of iron of the hardest texture, or of some combination of iron with oxygen, carbon, sulphur, or phosphorus, retain their polarity after the removal of the compelling cause, and acquire the property of enforcing a like polarity in other ferocious bodies. Thus: A piece of soft iron binding wire, will, on being applied to the poles of a horse-cline magnet, become strongly polarized and attracted, returning to its natural state on being withdrawn; if, however, we twist this same wire until it becomes perfectly hard or substitute for it one of steel, it will be found that both will afterwards retain their polarity and attract filips of iron.

Iron is capable of taking a definite degree of polarity only, and this capacity decreases in proportion to the hardness or impurity of the metal. Its retentive power is in inverse proportion to its capacity. A bar is said to be "saturated" when its polarity is carried to the highest degree.

Ferocious bodies acquire an increased tendency both to the receipt and loss of polarity by
conduction or vibration taking place amongst the
particles of their mass. Thus, by hammering steel bars
placed vertically on the ground, or still better on masses
of soft iron, they will become considerably magnetic by
induction from the magnetism of the earth, and may
be readily demagnetized again by further hammering
after inversion.

If a small bar magnet be rolled in iron filings
it will be found on withdrawal from them, covered
at each end with a cluster of adhering particles, while
the centre will be quite clean; the extremities of
which are denominated the magnetic poles and are
the seats from whence the opposites and divided form
of the magnet emit their influence on animal bodies;
but we are not to suppose that the centre is the seat of
magnetism, it is on the contrary the very part in
which the polarization is most complete; but is unable
to exercise any influence on foreign bodies, from being
employed in antagonizing equal and opposite forces.

For instance: - if Pp 12 represent the polarized
atoms of a bar magnet, + the positive pole of the
negative pole, it will be seen that the faces of atom
4 (affixed 13) are acting and reacting on by equal
forces, while, the negative face of atom 1 and positive
face of atom 7 being respectively engaged in antagonizing
owing to the reciprocal attraction between the particles of the nucleus exerted by each atom on the others
5. positive or negative force, these two atoms will act on surrounding matter with their discharged positive or negative force similarly. The lower line of figures will represent the proportionate attractive force of different atoms according to their proximity to the center.

A magnetized ring of steel, enclosed magnetic circuit, will have all its forces balanced, antagonizing each other, imparting no action on other bodies. But if to be divided at any part, will instantly establish opposite forces on poles at such parts. A 'shoe-shoe' magnet, having its poles united by an accurately fitting piece of iron in the same condition as the steel ring, and the forces in such a circuit by their reaction on each other develop an incased degree of magnetism; so a horseshoe magnet having its "keeper" made partly of iron and every as in Fig. (13) will have very inferior lifting power to one, the keeper of which is entirely of iron, and polarized therein, completing the circuit.

As a general rule, the attractive power of magnet is in proportion to the length of the lines or series of polarized atoms of which they consist, their cohesive power to the number of such lines or series. A long magnet being the best adapted for acting on distant objects, polarizing long bars of iron, and forming magnets in bars of hard steel and other refractory substances. A short and thick
one for lifting weights. This rule is more particularly applicable to soft iron electro magnets than to permanent steel rods.

When dissimilar poles of magnets are brought into apposition with each other, they are reciprocally attracted, forming a closed circuit, each other's polarity, similar poles exercise repulsion and deteriorate each other's polarity; hence the attractive power of magnets is very superior to their repulsive power, and the united force of several magnets combined falls far short of the aggregate of their individual forces before combination — unless a high retractive power is given to them, by making them of exceedingly hard steel.

A magnet, when freely suspended, will arrange itself in a direction parallel or nearly so, to the axis of the earth's rotation, the experiment being made at the equator; in proportion however as it approaches one of the earth's poles, the end directed to that pole will "dip" towards it under the preponderance of attraction caused by its vicinity. Fig. (14) shows the direction taken by the needle at different distances from the poles.

The poles of the magnet are named after the poles of the earth to which they point.
As to the reciprocal action of electricity and magnetism in motion on each other

If a ring of steel be made to surround a wire, conducting a voltaic current, it will become magnetic or polarized in a direction dependent on that of the current. For instance, let $A$ represent the sectional area of the conducting wire, $B$ the steel ring surrounding it; if the voltaic current be supposed to pass in the wire from the observer thro' the paper, it will polarize the atoms of the steel in the direction shown in the Figure, and if the ring be broken at $B$ (Fig. 16) the divided ends will become true magnetic poles ($A$ positive and $B$ negative). Needles already magnetized will, if brought near the conducting wire, arrange themselves at right angles to it with their poles in the same direction (Fig. 17). If the direction of the current is reversed, that of the needles and the polarization of the ring will be reversed also.

These effects have been attributed to a magnetic atmosphere exerted around the conducting wire, a mode of explanation which, if not correct, is very convenient.

From this supposed atmosphere, a conducting wire, having the property of attracting iron filings along its whole length, and of arranging itself, under favourable circumstances, at right angles to the earth's axis, and parallel to another...
* From the property, possessed by the conducting wire, of deflecting the needle at right angles to it, we devise a method of ascertaining the quantity of electricity passing along the wire in a given time; the galvanometer. This instrument is formed by bending a wire into a rectangular coil, and suspending in it a magnetic needle. The needle is then allowed to arrange itself in its polar position with regard to the earth, and the plane of the rectangle is brought parallel with it; on the commencement of a current tho' the apparatus a deflection of the needle takes place from which the amount of current electricity may be calculated.

* The wire being covered with cotton for insulation.
A wire carrying a current in a opposite direction to the
magnet, there rests, are described in works on electricity.
Professor Davy, in the 1820-21 vol. of his 'Chemical
Philosophy,' entered into an elaborate explanation of
them illustrated by an imposing cheval de face of
arrows, with a little attention, however, they will be
seen to arise from a constant tendency of the two to
render themselves at right angles to each other.

The magnetism, produced in the steel ring, is
in proportion to the quantity of electricity passing
right angles to it, in a given time; if therefore
instead of carrying the ring to surround the wire, the former
is coiled round the latter, each turn of the coil will
give a proportionate degree of force, until the saturation
of the metal interferes with the result.

Soft iron, in account of its greater capacity
for magnetism, is always used for electro-magnets which
have, by this means, been made of astonishing power.
Many investigations have been undertaken with
the view of determining the mode of coiling the con-
sducting wire best adapted for exciting magnetism
in bars of iron; those of Professor Henry of America,
and Professor Stoff of Hiel, are most to the use.
I shall describe the most conducted experiments.
In the *Encyclopædia Britannica*

In the same work he says: "We shall give an account in this section of the method of making bar magnets of soft iron by the influence of electric currents. This process consists in winding spirally round a bar of iron ABC a copper wire covered with silk threads. A galvanic current is then made to pass through the bar ABC, by two wires WW, communicating with two wooden vessels DE containing mercury. Then
of the form of these gentlemen: "A bar of
soft iron two inches square and twenty inches
long was bent into the form of a dense shoe, nine
inches and a half high. A piece of iron, from the
same bar, weighing seven pounds, was filed per-
fectly flat on one surface, for an armature in lieu
of the extremity of the leg of the shoe. These
armatures of the legs of the shoe, were also
truly ground to the surface of the armatures. Around
this horse-shoe 540 feet of copper bell wire, were
wound, in nine coils of 60 feet each. These coils
were not continued along the whole length of the
bar, but each strand of the wire, occupied about
two inches and was coiled several times backward
and forward over itself; the several ends of the
wires were left projecting "&c. [I am compelled to
copy this experiment from Bichat's Treatise on
Magnetism, as I cannot have access to the Journal
in which it was published &c. I cannot from this
loose way in which that book is written. That it
may not be deemed perfectly unsatisfactory. The
flammable gas in the cylinder, a small single battery was used
consisting of two concave cylinders, in the gap
between them, the whole of the inner surface
in actions involving both sides of the two rods &c.}
"the voltaic apparatus consists of a single element
big one plate of zinc placed in a copper vessel,
and having an area of five sq. ft, the agency
when armed as shown at men, may suspend by
the hook H 100 killogrammes."

[No matter, I
suppose, what may be the strength of the spirit
liquid, the size, of the iron, or the length, or thickness
of the copper wire, forming the spiral, indeed this
last is of no moment as the element is made
to pass not thru it, but the iron has]
two fifths of a square foot, and the quantity of dilute acid only half a pint. The following are the results.

1. Each solders to the battery in succession 7 1/4
2. One on each side of the arch 2 00
3. One from each of the legs 3 00
4. One from each end of legs the other from middle of arch
5. Two from each end 5 07
6. Wires attached 5 70
7. All the wires attached 6 50
8. A plate of iron, twelve long and six wide, and surrounded with copper as substitute for preceding battery 7 50

From many experiments I have made, I am led to believe, that to obtain attractive power, the circuit being enclosed, the coil wire should be chiefly arranged at the ends of the bar but when adhesive and lifting power is the object, the circuit being closed, the most advantageous plan is to distribute it equally over the whole length. The magnetic circuit cannot be called closed in
Mr. Joule made a still more powerful magnet. He took a rod of iron about two feet long, and on each end a half in diameter, hollow along its whole length. He then cut a groove along the flat surfaces of each half. The flat surfaces were accurately ground together and a copper rod inserted through the long hole, cylinder in shape, formed. The magnets of iron were fastened to the iron rod and a magnet was made. It consists partly of a thick diagram.

Charged with 1 part of sulphur and 3 of water by measure.
clear, by the most careful grinding and polishing, the surfaces of the poles of a magnet and its keeper, are brought into accurate contact in every part. Mr. Watkin found, that a magnet having a lifting power of 100 lbs., was only capable of sustaining 80 lbs., when a piece of writing paper was interposed between its poles and the keeper.

I state that magnets for adhesive lifting should be short and thick. The following description of an electric magnet by Mr. Jule of Manchester well illustrates this position. The magnet (As pictured) with its keeper (blue), both of soft iron, form together a hollow cylinder 3 inches long, 3 1/2 inches in its exterior and 1 inch in its interior diameter. It was coiled in the direction of the dotted lines with 91 copper wires; each 1/2-inch in diameter and 25 feet long, all bound together with tape.

The weight of the magnet was 19 lbs. and with a powerful cast iron and zinc battery [16 carbon cells each having a surface of 20 sq. ft. arranged in a series of four], it sustained the enormous weight of 277 5 lbs. or nearly a ton and a quarter, and yet this powerful instrument would little attract iron.

I have endeavored to show that the
Volatile current, or electricity in motion, determines magnetics in steel or iron, in a line at right angles to its course. In the same way, block magnets in motion, or iron in the act of becoming or ceasing to be polarized, determine to a current of electricity in a conducting wire, at right angles to the line of its polarity. The direction of this current produced by the accession of magnetism being in an opposite, that produced by its recession, being in a similar direction, to the course, a voltaic current would take, when producing a similar direction of polarization in the iron employed.

For instance: Let \( A \) (Fig. 19) be the area of a wire, which is passing thro' a divided iron ring \( B C D \). We know that a voltaic current passing in the wire from the observer thro' the paper will magnetize it, in the direction shown by the arrow. Let the voltaic current cease, and produce a similar direction of polarity in the iron by induction, from a horse-shoe magnet as in Fig. 20. At the instant of its acquiring polarization by these means, a current will be determined in the wire, in a direction thro' the paper towards the observer and, on removing the magnet suddenly and the ring ceasing to be magnetic, a current will pass in an
opposite direction to the last, and in a similar one to that taken by the voltaic current in Fig. 19.

The same effects, increased in degree, take place when the wire is coiled round the wire, and if a short electric shock be coiled with a hundred yards of wire, the ends of which are allowed to vibrate gently against each other and suddenly applied together, from a powerful horseshoe magnet, a spark will be seen between the slightly touching ends of the wire, both on contact removal of the soft wire.

But it is not necessary to have wire at all for demonstrating the production of an electric current by magnetism in motion inasmuch as the magnetic atmosphere of a wire conducting an electric current is alone capable of effecting it.

Thus we know that a single pair of plates has not tension sufficient to drive the current either through the air or through the human body, and on making and breaking contact between them with a short wire we shall not have either spark or shock; on employing, however, a wire of 100 yards long there will still be no effects on closing the circuit, but no opening it a bright spark will pass between the
divided ends of the wires and a shock will be felt in the fingers holding them. In this experiment, the voltaic current passes and excites a magnetic atmosphere around itself, it is interrupted and the atmosphere discharges, and by its discharge induces the electric current, which produces the sparks and shocks; the longer the conducting wire is, the greater will be the length of the series of shocks acted on, and the higher will be the intensity of the current set in motion.

By rolling the conducting wire round a glass tube, as in Fig (21), the atmosphere of different parts of the wire is collected together, and acts on the whole coil, and the sparks and shocks are proportionately increased.

The current produced by the accession of the magnetic atmosphere is not perceptible in this experiment on account of the circuit being closed, it does exist however, and the experiments of Arago prove, that it exerts a retarding effect on the current from the battery by passing in a direction contrary to it. (The late Mr. Kemp has shown, by experiment, that currents of different tension may pass in opposite directions in the same wire.)

If a second coil of wire be superimposed on
By (22) we the one already coiled on the place taken, a current will also be excited in it in the direction of magnetoism in the inner end, still in the same direction as the battery current, but not on the occasion of the motion for a reason to be thereafter described. At 35 this is a mistake.

By introducing a bar of iron within the place taken the arrangement will receive a most powerful auxiliary in the magnetism excited by the battery current in the iron, and if contact be made and broken into the battery quickly, as by drawing one end of the discharged conducting wire along a file connected with it to the end, a constant stream of sparks and succession of shocks may be produced.

With this aid of the apparatus so may also produce very efficient decompositions with a single pair of platina points. If we fasten two wires tipped with platina to the projecting ends of the inner coil at A and B, before they reach the battery, and dip their platina points in a fluid of dilute acid, no sparks will appear on breaking contact at the usual place (C), in consequence of the induced current being diverted thus the needle, decomposing its contained fluid in the usual way. In this case it will...
be seen that the current from the battery is exposed from the vessel, as the two wires, leading into the latter, are attached only to different parts of the same pole, elongated into a coil; on removing, however, the wires, leading to the ends to D and E, the induced current will pass thro' the battery, and, forcing the current that generated along with it thru the fluid to be decomposed, will produce a correspondingly greater quantity of the eliminated gases.

It is not a little curious to observe, that while the inner coil is employed in decomposition, no spark or shock can be obtained from the superimposed coil; and again, if this last lead its ends joined, the decomposition set up by the former coil will at once cease, and on further examination it will appear, that of the two coils, that, the ends of which are connected by the best conducting medium, will present or diminish the current in the other.

The explanation of this phenomenon is difficult, but, I think, as follows: The accession of magnetism produced around the inner perfect conductor, by the passage of this induced current, tends to induce in the less perfect circuit.
To the passage of current (on making contact with the battery) in opposition to the battery current, must be attributed the phenomenon of their being no current in the absence of magnetic flux in the superposed coil, for by increasing the impulsion power of the battery and then preventing the passage of the current a new initial current is immediately perceived, increasing in intensity in the aforementioned coil. Professor Henry found that with ten pairs of plates it was more powerful than the current in uncoiled magnetism; by this means therefore we obtain two currents from this coil one on making and the other on breaking contact with the battery.

It has been found by the experiments of Sturgeon and Page that iron in a divided state as soon as plates is much more effective for electromagnets than solid bars, probably from the much greater density of iron after suffering compression in rolling and wire-drawing, and from the prevention by this means of the induction of currents in it, which might interfere with the currents in its coils. Prof. Pfaff suggested that in this case of wires it may be owing to the filiform arrangement of the fibers of this metal.
a current in a contrary direction, to that endured
in it by the creation of magnetism, caused by
the interruption of the battery currents, and that
retains or stops its according to the degree of diffusion
in conducting power, produced by the two currents.

By the aid of the electro-magnetic coil
above described, we are enabled to obtain, with
from one to six pairs of plates, all the effects
of a battery of extended series, but the construction
and use of the apparatus is a matter of some
necessity. The following points should be carefully
attended to:

1st. The core, inside the coil, of the finest and
most accurately annealed metal, should be of
a shape best adapted to induce polarization, and
should have every facility given to the rapid removal
of magnetism in it. We know that
the intensity of polarization in a magnet is
in proportion to the excess of its length over its
diameter, and the higher its intensity (or the more forced the polarization) the more rapid
will its recoil to the natural state. Again, a
given length of wire, conducting a given quantity
of electricity, will induce an equal amount of
magnetism in whatever way it is coiled.
over a small bar of iron, the magnetism will be condensed and the intensity high; if over a large bar, the former will be diffused and the latter low. The intensity of the induced current depends on the rapidity of rise and fall of magnetism. It will, therefore, require a powerful battery be used, to make advantage of the small length of wire used for the electro-magnet.

Besides the excitement and cessation of magnetism being facilitated by the softness and purity of the iron, we know that reduction of the metal has a similar effect. Dr. Page magnetized a soft iron wire, and, having carefully suspended it within a coil, tapped it smartly, it was instantly demagnetized and a current passed through the coil.

2. As the inner coil carries the voltage current, care must be taken to appportion the resistance offered by it and the inductive power of the battery current to each other, so as to obtain the greatest amount of magnetism from a given arrangement. Professor Clerk having coiled a copper wire (3000) five miles long, round a bar of iron, found, on breaking contact between it and a single pair of plates, that the could
not obtain any shocks from it, but, on substituting for the last a battery of small pieces of zinc and copper wire arranged in series, it gave a shock capable of passing through 26 percent.

The battery current, heated the mechanical substance it suffers from the inner coil, meets with further, the only momentary check, from the occasion of magnetism around its column; therefore, a rapid succession of shocks is required. This impediment must be overcome by increase of the impulsive power of the battery. Increase the number of banks or cells.

2. As the superimposed coil is employed for obtaining currents of tension rather than quantity, its wire should be of considerable length and twisty.

To determine which part of the quadrant most the most efficient in induction, I wound a bundle of thin wire wire, 12 inches long, with 14 yards of copper wire (No. 18), and over that slipped a bottle, wound with 40 yards of very fine copper wire, capable of motion to different parts of the electro-magnet. I was at first not a little surprised to find that the whole was nearly twice as powerful when the bottle was situated in the center of the coil (Fig 23), as when at the end; on adding 9 other such bottles, so that the whole length of the magnets was equal to the them.
the effects on each were found to be proportionate to its proximity to the centre. The whole of this wire, joined in a coil of 800 yards, gave a constant stream of sparks between its ends, disposed to the distance of a quarter of an inch, and fully 3/4 of an inch from the flame of a spirit lamp interposed between them. The shock from the whole length was similar to that from a large electrical jar weakly charged, and was felt chiefly in the shoulders and chest, causing a peculiar sensation of anxiety and dread, but little contraction of the muscles, while that from the three centimetre bobbin (1/20 yard) caused the most violent cramp of the muscles of the arm and forearm, rendering it perfectly impossible to free oneself from the apparatus, the centimetre bobbin (the hands being unrestrained) produced nearly as violent effects as the last three, but chiefly confined to the muscles of the hand, and flexor of the forearm.

I consider the results obtained in this last experiment very curious, and tending to prove a position at p. 22, that magnetic polarity is most perfectly developed at the middle of a bar, and further that it is in the polarizer and not the attraction force which is effective in induction.
for the centre of the bar has no attracting power at all. In order to examine the last point further, I coiled 20 yards of copper wire, wound a bundle of iron wires 8 inches long, the middle third being covered with only one layer of wire, the two outer thirds with five layers. I then bent the electromagnet thus formed into an U form (Fig. 24). This arrangement ought to be the most efficient form were the attractive power the induction agent as the wire is cold directly over the rest of that power, but on its being neutralized, a certain engaged, by joining the two poles with a piece of iron (in doubtful case the state of polarization would be altered, the choke instead of being decreased, was considerably augmented.

I now thought that by filling up the interspace with coils of fine wire I should have the most efficient form of exciting for induction of any substance with the same for induction of current. 80 yards of fine wire were accordingly coiled in the central space, but I was surprised to find that the choke was not nearly so efficient as I expected; it was apparently less distinct, a succession of them giving the sensation of a continued current.
The size of the coil must of course be proportioned to the effects desired to be produced. A bundle of five iron wires 3 inches long by half an inch diameter, being an inner coil of No. 16 copper wire 30 yards long to prevent rapid soil of 80 yards will give most powerful shocks from each coil, which may be increased by joining the two coils end to end in a length of 110 yards.
and causing an agreeable feeling of warmth in
the arms, with little muscular contraction, which,
may be attributed to a decomposition in quantity of the
current. No sooner developed,

From experiments with a great number of coils,
I found that long thin electro magnets of soft iron
"binding" wires gave the highest electro effects,
one of two feet by 1/8" of an inch diameter being
the best, but that magnets composed of carefully
reheated loop wire gave the most beautiful
quantity effects, as the deflagration of acetone.
A compound bar of loop iron 20 inches long
2 square wound with 8 copper wires (3/16) each
20 yards long all covered together with tape, when
connected with a core of four pairs, each having
an effective surface, of two square feet, charged
in Mr. D's. mode as deflagrating an iron wire,
throwing the sparks to the distances of two feet
but barely you any appreciable shock...

From

I am proud to describe, my medical
electro magnetic machine. It consists of an electro
magnet with inner and superimposed coils,* and,
a deflecting electro tone or apparatus for breaking
contact. The latter part of the apparatus I invented
in May 1840, and published in the March of that
year at Dr. Ingenman's request, in the 5th volume of his "Annals of Electricity," during which month I drew a small plan of it for Mr. A. Kemp of Edinburgh, which he has modified in his "Improved Electric Magneto Machine." Fig. 25 (26) shows the machine, the first from above, the other from the side in which the electric term is fixed. The coil (coloured crimson, its enclosed iron blue), rests on and is loosely embedded in its foot-board (num. 1, 2, 3, 4). The brass rod and Finally fixed in the foot-board -- to 2 is soldered a brass ring or a spring which, passing 3 and gently pressing against it, is continued to the end of the coil and terminates in a piece of iron (blue). The beginning of the inner coil is soldered to 2, the end to 12, the beginning of the superimposed coil to 4, the end to 1, so that both coils are reunited into one, having its terminations at 2 and 1. On the poles of the battery being united into the aperture in 3 and the current will pass from 3 thru the spring 2, thru the inner coil, and back again to the battery thru 4, magnetizing the bundle of iron, this immediately attracts the arm at the end of the spring and, by separating the latter from 3, breaks contact with the battery; the attraction of the arm
The instrument thus described is so small that it may be carried, with a Americas battery, conductor, and all the apparatus necessary for administering its influence, in a japanned tin box, nine inches by four, and can be easily carried under the arm.

The different parts of the apparatus may be covered in sheet India-rubber, and the bottle containing the requisite quantity of acid sulphuric, for exciting the apparatus, will pass inside the hollow conductor. Its stopper must be carefully wound with the sheet carbonum.
immediately ceased, and the spring falls back into its place to be again immediately attracted. The points of contact between the spring and 2 are furnished with platinum, as any other metal would become oxidized and be displaced by the current. The sparks present a beautiful appearance under the microscope, consisting of a long, slender, white, thread-like body on the side corresponding to positive pole of the battery it can to leave the platinum in the form of a thread from every little inequality of the metal and to enter the opposite pole causing a myriad of small spots on its surface. Thrashes are obtained from the inner coil by the application of the conductors to 9 and 10, from the upper expanded coil at 4 and 1, from the two coils combined at 1 and 2.

The conductors are pieces of bread soaked, slipping over each other from one end to the other, and the wires connecting them with the machine are very fine and long and merely inserted into slits in the pollard. The cause of the very efficient action of these electric tubes is the rapid vibration into which it throws the whole apparatus, and it is not a little singular to observe the immediate change in the working of the apparatus when there is prevented by placing the machine in several folds of flannel. The threads often cease entirely, it should, then, be admitted, if possible, to rest on some substance which will vibrate synchronously with it. *
I must apologize for the seemingly careless way in which the following pages are transcribed; the reason is that during the time of editing these papers my nervous system got into such an excited state that I had considerable difficulty in applying my mind to the task.
As to the identity of the electric influence with that of the nervous influence of animal life.

Perhaps there is not in all the whole science of Physiology, a subject on which philosophy are more divided in their opinions, than on the identity of the nervous influence with electricity. Upon a first glance at this subject the identity of these forces seems complete, and the same is the case in many animals, where nature, circumstances, and habit, distorted the laws of electricity and magnetism so as to render them no theories which suppose these to be the action agents in the production of muscular force. On a full investigation of the subject, there are many links wanting in the chain of analytical details, which cannot be readily supplied, of the great similarity in the phenomena of simultaneous electrical action and motion quoted by the first (if they are) influence is not a little striking, I shall endeavor, as shortly as possible, to collate the preceding pages a few of the
facts which seem to me to bear the strongest evidence in favour of that opinion.

And we have an attendant effect

In the nervous system and this. In the potato butter and

its spinal cord, its influence.

1. Transmission of current.
2. Destruction of nerve.
3. Formation of new nerve.
4. Contraction of muscular fibres.
5. Slack generation of current.

Of the exact mode of the transmission
of nervous influence, and indeed of the very
fact of such transmission at all, we can but
form conjecture. As far as observation has
yet gone, I believe, we are warranted in
considering each nervous fibre as an endless tube, containing
a transparent fluid, and having a part of its
length. Distributed in the brains or spinal cords.
Granting this to be the case, we can easily perceive how the phenomena of disturbance, in the nervous function from excessive depletion and from effusion in the brain should be so similar to each other. Pressure on the nervous fluid would take place in both cases, in the first, from atmospheric pressure, forcing the nervous fluid along its tubules into the brain in the 2nd, from the pressure exerted by the blood forcing it out. In both cases there would be pressure of the nervous tissue against its neurilemma along the whole course of the nerve. Paralysis would be caused by the pressure of a clot of blood in the brain that:
where it received motor power or deposits intellect. A place of changes, taking place at its own instigation, and the another part, in the molecule or atom where its deposits such motor power or receive such intelligence, according to the function of the nerve. Be that motor or sensory. Of course, moreover, that the sensory and motor tubes are perfectly distinct from each other, and not consisting of a fluid proceeding from the central nervous system with motor and returning to the sensory functions, for we know that the liquids form obtained in the distribution of the nerve thereby which is completely sensory, and besides, the sensory nerve generally has a finer diameter than that of motor nerves. We have a strong analogy in the bloodless tube, with the closed electric circuit and, could be by any possibility demonstrated the principle of electric currents into the nervous system, the explanation of the "after" influence obtained by the sensory in the motor nervous. By comparing it with currents passing in the closed circuit, inducing a current in a similar closed circuit, would, I think, immediately suggest itself to the mind. There is some
reason to believe, that this fluid contained in the nerve tubes is a much better conductor not only of current, but also of electric influence than the surrounding tissue, for if the poles of a single pair of plates are applied at each side of the cut extremities of a nerve, contraction results in the muscle to which it is distributed, leading us to suppose that part, at least, of the electric current had chosen to traverse the better conducting medium of the nervous fluid rather than the nerve itself. I, again, the nerve be treated, the contractile of the jalousie is as completely prevented as that of the nervous influence would be by the same means; and this view is not submitted upon by the fact that contractions are produced when one of the poles are inserted below the ligation, and the other above it, or in the muscle itself. Its capability of passing must be seen, as its nervous being no reason why it should not pass the supposed better conductor after passing the obstruction offered to it. I think this view of the case will receive confirmation on considering the conducting apparatus of the Palpae, from which all the atom effects may be attributed.
Diagram showing the transmission of attraction or magnetic force and chemical action by a closed circuit. (See Professor Lamy's paper in Phil. Mag.)

Let A be an inner coil.  
B a battery inducing current as its  
C a super-imposed coil  
D the inner coil of another electro-magnet its  
ends connected with the last-posed circuit  
E its super-imposed coil its ends dipping  
in a solution of sulphate of copper.  
The current from C passing thru D will magnetize E' inducing a  
ecurrent in E2 which will decompose the sulphate of copper.
to galvanic stimulation of the nerves indicates an opinion which is entitled to much consideration from being entertained by the supple sagacious mind of Müller. I have frequently observed that currents of low tension when passed into the arms, caused much more painful sensations and muscular contractions than those of high tension, which I always attributed to their acting more powerfully on the nerves and by better conduction. But it may be asked, if the motor and sensory nerves are excursions from whence is derived the "batteries or inducers" current to set in motion the currents supposed to be circulating within them? I believe my reply fairly answer from the sympathetic, exteroceptive, it scarcely necessary to go further than to assert that these phenomena excitation of matter produce all the changes in the organism of the body, and it will be therefore attempted to prove that muscular power and nervous influence varies in proportion to the amount of such changes. Its intimate distribution with this other system of nerves whenever they may be supposed to receive impulse of influence need only be alluded to.

Mr. Reast of Genovesa have obtained some
curious results arising on the doctrine that electric currents passed in the nervous system.

This experiment consisted in shearing, that when a living needle had been inserted into the cranial muscle of a frog, and parallel to the longitudinal direction of the muscular fibrils, and thereafter (?) at right angles to the capillary termination of the nerve distributed to the muscles, it became sufficiently magnetic to attract light particles of iron, whenever contraction was excited in the muscle by stimulating the cerebral spinal origin of the motor nerve. By reading the above paragraph, in Dr. Gravez's work on clinical medicine, I commenced a series of experiments to determine whether any magnetic effect could be obtained from the passage of the nervous influence through muscles in a state of contraction:—Having cut some soft iron wire into lengths of about 2 inches, I marked one end of each wire, sealing a glass on presenting them marked ends to the south pole of a magnetic needle, delicately suspended by a filament, they all proved slightly magnetic, some reacting strongly others repelling towards it. I then pressed each wire consecutively on the cranial muscle in a state of strong con-
Having thus arranged and being directed towards the shoulder, and found on a pair presenting them to the needle, that they all repelled it, I again having taken one of them, I applied it to the contracted muscle with its marked end towards the forearm; its polarity was immediately changed, and it attracted the south pole of the needle. In this way, I could reverse the poles of the wire at pleasure without the slightest uncertainty in the results. In the foregoing experiments, the elbow was directed towards the ground and the lower end of the wire took north polar attraction, in the same direction as in them, except a small bar, when examined critically, on the ground. It became necessary therefore to determine whether a change of direction in the arm would be attended by a change of direction in the attraction of the wire, on lying down the arm and pointing the elbow upward. I found that this was the case, the lower end of the wire still took the polar attraction as the direction of the inducing force was changed. I was at first disappointed with this result as it promised to negative those already obtained.
And to refer the produced dispersions to the induction influence of the earth. Still, there was no doubt that this polarity that was only momentarily after application of the air to the contracted muscle, for then removed, it could be placed in any position without suffering change, and that it was not due to increase of temperature, was proved by increasing the iron to warm water in the direction of the disk, without any effect being produced.

The following seems to be the explanation of the contradictory results obtained in the last experiment: We know that magnetic forces, when exerting attraction towards each other, recede, increase, from reciprocal augmentations of polarity, but when exerting repulsion, their central relation being reversed, have, their polarity increased. The adrenoe fibres in the arm (muscle) cross under the vein in all directions of which it will only be necessary to consider those passing at right angles to it, some of these will endure more the south polarity downwards in the arm, so that the two forces are equally balanced, but the state of polarity, having the north pole downwards, is augmented by the induction.
March 22nd

I am now quite convinced that the experiments are entirely fallacious and that the magnetism was produced in the wire by the slightly heating its burning movement amongst its particles sufficient to enable them to arrange themselves in the desired direction of polarity. You m. producing the arm to the arm with their heads of compasses the iron caused magnetic
of the earth, while the average state of polarity is increased, therefore, we have the effect of the current inducing earth. Polarity downwards alone developed. There is also another cause, to be assigned for the production of magnifications in these experiments viz., the state of vibration into which a muscle is thrown during contraction, which completely electrifies the same state of vibration in the wire and disperses it to receive polarity by the inductive influence of the earth, but by placing a piece of the bisected I could not feel any vibrating sensation, in addition to which the effect was produced with any coat and shirt interposed which would, I think, prevent any influence of this kind. I should not omit to state that a similar change of polarity was produced in the wire by tapping it steadily against any hard substance when inclined in the direction of the dip. The endeavor to detect electric currents in the aor, of animals had before employed the genius of M. Prevost, assisted by M. Baviere. The Italian philosopher Fauro and Santulastic have also been engaged in this field of inquiry.
I think it but right to mention the case in which electrical current arrived at me described to the Royal Academy of Science, vol. 13, p. 162, by Mr. Contraini... they are summed up in five propositions.

1. In any brother animal there is an electric current which passes through the body, which we call the electric current, which passes in the outer nerve tissues, and which is constantly present from the constitution to the electrical organs. By means of the sphincter. The quantity of this current, according to the experiments which have been made, is increased in proportion to the state of mind than in another state of mind.

2. In any brother animal there is an electric current which passes from the outer nerve to the outer nerve of the mind, and which is in this sense a current of the electric current. By means of the sphincter, we are that it is constantly directed from the outer nerve to the outer nerve, if you will, from the outer nerve to the outer nerve. The quantity of the electric current in general presents with the same state than in another state of mind.

3. The electric current in any brother animal, from observer to observer, in proportion as it comes from a life, which having taken place, it passes in an opposite direction to that in which it was directed before.

4. If the outer nerve is suspended, the electric current is exchanged in the direction of the other parts. The voluntary part of the electric current is in general present with the same state than in another state of mind.

5. The electric current, which enters to be received or measured in the same sense, it is very small, and perhaps it is even not felt when received. In these propositions we must note that the variables of currents, whose own states of mind are such, would take place in the constitution of a similar current, by a similar action, and again, the peculiar effects to which minds are known in this world, at times.

The following description of the electrical organs and a consensual body of the facts cited in this is best described from the various articles of Osmund, electricity, contained in the Encyclopaedia of Anatomy and Physiology by Mr. Credman. The electric organs occupy a large part of the body, especially of the body, and again, the peculiar effects to which minds are known in this world, at times.
by galvanometers of the most delicate construction. Procure Dumas was unable to perceive any deflection of the needle, unless when one of the two platinum wires, in connection with different parts of the nerve, were red hot, a result which Müller justly attributes to the production of thermo-electric currents. Pavlov and Santodiochi, having sunk the stump of a dog's nerve into the muscles, the other into the nerve supplying them, observed a deflection of the needle on exciting the animal to move the member. There is much room, however, for suspicion of fallacy in this experiment, for, independent of the seeming impossibility to insert a statuette into the nerves, Sturm has found that pieces of metal of the same kind, but having a slight difference in surface, are capable of generating a voltaic current. It is proper, that the same effect is produced by the same metal excited at each end by different fluids, so that it is just possible the effects obtained by the Italian philosophers, may have arisen from one of these causes.

In the Torpedo and Gymnastics we have instances of animals operating a true electrical influence, capable of giving shocks and sparkers, magnetizing iron and effecting chemical demands.
contrastingly to the muscular and nervous of the great part of the cavity, which exhibits the thorax from the abdominal area. Their base and direction towards the backbone of those circumference and distinguished thus the third part of the dozen dorsal flanks. The common intercostal being removed, the thorax formed an accustomed, the electrical organs. The outer one has longitudinal fleshy, which are anterior deeply attached, and provided off, margins of the organs, seemed to resemble, with the thin. The common flanks of considerable density, forms the immediate under of the electric columns, and sends projections down between them to form their palisades. These form their walls. Of course, the essential parts of the electrical organs is formed by a solution of the pastern, combined into a certain amount. The paras intercostal, parallel with another, and perpendicular between them and central, circumference of the hole, so that their extremities are expanded through their company only of their fascials and the common extreme parts. The chest of these columns can either central or posterior, a long spring; a few small, later, poll. They are connected to the columns by short, flexible, and by a certain expansiveness of tendon, attached upon them. This center contains each column as being divided into numerous distinct compartments, by delicate mucous membranes, placed horizontally, at very short distance from each other. The excitations between them appeared to have the entire effect. The found the partitions in several places adhering to one another, if not entirely, and all, through to their whole extent, attached to the colon to the extremity. The partitions are covered with a fine network of tendon, veins, and nerves. The electrical organs, thus formed, are subdivided by these partitions. The third, the thoracic, the third. The third, the thoracic, the third, the thoracic, the third. The last, the thoracic, the third. The last, the thoracic, the third. The last, the thoracic, the third. The last, the thoracic, the third.

**Distribution of electrical organs in Robin's seconds**

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Drs. Dary has also observed a large number of fleshy, formed by the union of the anterior posterior current nerves and供应, the muscles and skin of the under surface of the thorax.
ection, in all respects similar to that obtained from the voltaic battery, the power is, too, as completely under the influence of the will, as the transmission of the nervous influence is, and an exertion of each is attended with a similar degree of modification. The gymnast, having employed its electrical power, excessively, on animals, driven into the water for that purpose, becomes so completely exhausted that it is easily captured, and according to Humboldt, is scarcely able to give shocks for two days afterwards. It is also remarked in the Encyclopaedia of Anatomy and Physiology that "all electrical powers become exhausted and die, even in sea-water, when allowed to give a continued succession of shocks."

Muller denies that the electrical influence of the Papada is identical with the nervous influence, and remarks that the fish is furnished with a distinct apparatus for exhibiting this power similar to the galvanic battery. I confess, however, that I cannot, from what I have read of the electric organs of these animals, see any analogy between them. The structure of these organs seems to be rather adapted to the accumulation of electricity,
in the Gymnura the electrical organs are also found a little by longitudinal transverse sections. The nerve is shown from the spinal to the cerebral alike, but further than this being related to the organs nothing seems to be known of their distribution.
conducted into them by the immense current supplying them, prior to the generation of each fluid. Mr. Sturgeon has shown that galvanic electricity may be thus accumulated in this method. On May 15, 1826, he remarks: "It is well known that a frictional battery of about a hundred pairs will, by confining water alone in the cells, charge to a certain degree of intensity almost any extent of coated surface, of glass that we please, and that the same degree of charge is given to it by a single contact of the conductors however short its duration. This being understood, and also understanding that the force, produced by any discharge from a given intensity, would be proportionate to the quantity of fluid used, and that a series of shocks in rapid succession might be produced by mere mechanical contrivances, and that the degree of force might be regulated by varying the extent of coated surface, and that proceeds to describe an instrument which having a coated surface of seven square feet only, gave considerable shocks. Nor immense, thin, if the mode of action in the tree is the same.
must be the quantity of electricity set in motion by the discharging organs of the figure, of which, in a file four feet long, has been estimated at 823 feet. If the spasm and the following process, either in the fish and the Völtaic pile, be exactly reenacted, the current employed for the same purpose in any known electrical apparatus. Nature no less. The nervous nerves are distributed in the cells of the electrical organs, and as it is this the agency of these nerves, that the organs act, it is not impossible that the nervous influence itself is accumulated in these cells as in condensers, and that it is discharged at will. Piedemont on the contrary supposes the organs to resemble the Voltaic pile "inasmuch as they are formed of alternate layers of moistened conductors of different natures, to wit, of membranous partitions and of gelatinous albumenoid fluid", such a combination however would not generate electricity at all, for an apparatus for generating electricity cannot consist of two fluids of different characters.
The whole organ seems to be built up on the type of annelid and nemine. Mr. Malpighi found that the albumenous substance which surrounds the brain differs only from the substance of the electric organs only by its greater quantity of water. I remark it would be impracticable for one not to connect the analogy which exists between the composition of the electric matter and that of the electric organs of the tadpoles we have analysed to the observations in the 12th Volume of the Phil. Mag.
with one conducting medium, on which, one of the
fluids may act, or of two conducting media,
with one fluid capable of combining with one of
such media, the arrangement must consist of
two different elements: were it not so the force
would be equally balanced; a cumulative apparatus
on the contrary consists of only a conducting and
an insulating medium which, if we consider
the membranous divisions of the cells in electrical
fields to have the power of conducting and then
include fluid or pulp that of conductors, in the
structure of the organs in electrical fields I
think we may reason that the cellular divisions
have the property abode ascribed to them, from
the fact, that the apparatus is insulated from
the water, and the field itself, only by a strong ap-
neurosis, of which (in the Torpedo) they are pro-
ing atoms, the skin. The smooth thick hair of
these animals seems to have this property
of preventing the passage of currents, for Humboldt
saw the Symnostee receive the discharge of
another, without giving any evidence of feeling
it. Dr. Davy, also, thinks that the electricity
of the torpedo does not pass through the skin,
but through numerous groups of glands arranged,
chiefly around the electrical organs, and
spreading on the surface of the skin by tubes
having strong saline coats, secreting a thick
ammonia. These fluids, which are peculiar to
the present species of Ray, are supplied by
the largest branch of the electrical nerves, its
distribution being confined to them alone—a fact
which strongly leads to the suspicion that
it acts as a conductor. Dr. Bany found also
that by cutting the nerves supplying these
organs, their electrical power was destroyed;
but, when a small portion of brain was accidentally
left contiguous to the electrical nerves of one side,
and with which they were connected, the pole, on
being irritated, gave a shock to an assistant who
grasped the corresponding electric organ. Here
the organ an independent generating apparatus,
the atom acted as would I think, cleanly be obtained.
But, even supposing it to be a generating apparatus,
we know that it would require a certain amount
of chemical action to take place within it, to produce
a certain electrical effect, and, as far as investigations
inform us, there is no evidence of its receiving any
excitatory fluid, but the blood, and no evidence of
its having any conducting or porter, but the nerves.
The distribution of the electrical current to the apparatus, for carrying into effect the destruction and separation of tissue, is another strong indication of the vital action of these organs. Mr. Vertheeri from experiments on the aspiration of this animal, during the exercise of its spinal function, came to the conclusion that the intensity of the electric function was in proportion to the force of circulation and respiration. He observed that, hydrochlorate of etherolysis, a remedy which was known to be powerful in exciting the action of the second influence on the muscular fibres, immediately produced violent contractions in the animal, accompanied by formaldehyde, terminating in death by convulsions. Under the influence of hydrochlorate of morphia, the organs were rendered inactive, giving no more than sixty discharges in ten minutes.
The exciting and conducting apparatus of the
second influence.

On February, during a course of experiments
with a garnet, wheels and living in the Adelaide
Galleria, obtained from its all phenomena exhibited
by the water battery. I endeavored to inaugurate
the results I obtained with an artificial
garnet, the electrical form of which was
furnished by an electro-magnetic coil, and after
several trials with different varieties of coils
succeeded with one consisting of a bundle of five
wires, 12 inches by 12 inches in diameter,
rounded with an inner coil of 50 yards (20000 wrap
per) and a superfine guard coil of 60 yards (2000);
the two joined in a continuous coil of 90 yards,
from the ends of which, five copper wires insulated
with sealing wax varnish, passed to pieces of
tinfoil fastened around the head and tail of
any garnet, or immersing it in water, a short
and felt no introducing the hand into any part
of the vessel, which made much more evident when
the plane of the hand was parallel with the vessel,
than when it was at right angles to it; it
increased as the hand was approached to it and
in its proximity to the pieces of tinfoil; when, however,
Dry hands were insensible. The shock was intolerable when they were each placed about an inch from the opposite extremities and decreased as they were removed towards the center; altogether the effects produced were very striking.

Dr. Faraday in his experiments has observed, that the current of the Gymnoglossus flows from the anterior to the postauric parts, and remarks that on comparing the middle parts of the fish with those behind before and behind it, he found the conductor, when applied to the middle was negative to the conductor if applied to the anterior parts but positive to it when it was applied to places near the tail, from which he infers "that within certain limits the condition of the fish externally at the time of the shock appears to be such, that at a given part is negative to other parts anterior to it and positive to such as are behind it"; an inference which he was scarcely warranted in drawing for, I obtained the very same results with the model, which was in no electric condition at all, except where the tongue was attached, being made of a piece of varnished wood; the current in each case was evidently carried thro' the water.
There are several other instances of electricity being
developed by animals as in the dolphin and a variety
of mantis. See also in Captain Brown's edition of
White's Natural History of Selborne a curious account
of shocks received from the jaws with
from the head and tail, until it reached the
conduction, and then this trouble; she is not
entitled to suppose either that "the shock which
is felt when the hands are in the most favour-
able position, is the effect of a very small
portion of electricity only, while the animal
discharges at this moment, by far the largest
portion passing thru' the surrounding water." 
for it is very evident, that the human body,
from the saline nature of its fluids, is a
much better conducting medium than the "sur-
rounding water", and would, as such, direct
by far the greater, if not nearly, all the current
from it; such was found to be the case in
experimenting with the model.

There is no difficulty in understanding
the proportion, existing between the exertion
of muscular force, and the distinction and
separation of the tissues. Professor Liebig,
in his work on Animal Chemistry, has set forth
his doctrine in a most distinct and beautiful
manner. "As an intermediate effect" says he,
of the manifestation of vital mechanical force,
we see, that a part of the muscular substance,
dissolves with its properties, its character of life, and this process separates from the living part, and loses its capacity of growth and its power of assistance. We find that this change of properties is accompanied by the entrance of a foreign body (oxygen) into the composition of muscular fibre (just as the acid lost its chemical character by combining with the 'gas'). And all experience proves, that this embrittlement of living muscular fibre, into compound or Achilles, of vitality, is accelerated or retarded according to the amount of force employed to produce motion. Now, it may safely be affirmed, that they are mutually proportional, that a rapid transformation of muscular fibre, or, as it may be called, a rapid change of matter, determines a greater amount of mechanical force, and conversely, that a greater amount of mechanical motion (of mechanical force, speed, or motion) determines a more rapid change of matter. For carrying on the molecular motion in the animal body, a certain amount of vital force is expended, at every moment of existence, and consequently, an incessant change of matter goes on, but the amount of living tissue, which,
* "There is, in my opinion," writes Dr. Marshall Hall, "an
ultimate law of animal existence, which seems to
regulate the different forms in which the different classes
of animals present themselves. The quantity of respiration
is inversely as the degree of conductivity to the muscles
in use, the former being marked by the quantity of oxygen
consumed in a given time, ascertained by the pneumotachy
meter, by the force of palomannium necessary to demonstrate
its existence. The bird verifies this a high respiring and
low conductivity; the reptile, being a high degree of
in consequence of this form of consumption of vital force, loses its condition of life, and its capacity of growth, is confined within narrow limits, it is directly proportional to the force required for these involuntary movements.

In maintaining the proportion of the species of muscular force to be equivalent to the amount of destruction of tissue, we must be guided to refer to forces operating in the same animal in the same physical state; for the same degree of stimulus (or nervous influence, the result of transformation of tissue) applied to the muscular fibre of the reptile would produce a much greater contractile effect in it, than in that of a mammal and still more so than in that of a bird; the irritability of the former so greatly exceeding that of the latter class of animals. Just as the same electric current, passing round a bar of soft iron, would produce a far greater amount of fluidity in its tissue in one of lead, still under the same circumstances. If, therefore, the quantity of heat, generated during muscular motion, be proportionate to the quantity of nervous influence exerted, those animals, having the greatest irritability of fibre, will generate the least degree
of heat, during the production of a given amount of force. And this we find to be the case, the mean temperature of the reptile being about 82.5 of the mammal 101.90 of the bird, 104.86 according to the observations of Dr. Ray.

This applies, also, not only to the force exerted in muscular contraction, but for the exercise of the other animal functions.

A physical change of state in the same animal, is attended by a similar change in the proportion between vital of tissue and heat generated on the one hand to the amount of animal function exercised. Thus: Dr. Marshall shall found that in the bat during a state of hibernation, the respiration, and consequently the distillation of tissue, had almost entirely ceased, and the internal heat not more than three degrees above that of the air, varying with changes in the latter; yet, in consequence of the extreme degree of irritability which the systems of these animals possessed, when in that peculiar state, the vessels and their functions, necessary for maintaining its existence, were still carried on, by the exceedingly small quantity of nervous influence, which could have been transmitted to them.
Dr. Jell found, that the slightest movement of the
animals was sufficient to cause it to respire, an
act which was followed by an immediate rise of their
temperature. It seemed indeed to be in a state very analo-
gous to hyposthenurina, the temperature of which according to
Mr. Prosper, is, during their sleep, from about, equal-
ly on a level with that of the atmosphere. The exten-
sive muscular form or which these insects employing during
locomotion is attended with a very high degree of
respiration, and the production of an amount of heat
which, were it all its evolution facilitated by a correct
circulation from their whole cutaneous surface, would
probably destroy the animal. Does not the fact of these
insects possessing the Drachmans with regard to
change of temperature, common to laboratory animals,
lead to the suspicion that they may also have the
same irritability of muscular fibre, and that thus,
under the influence of their high annual energy, as
indicated by respiration, renders them capable of producing
their usual rate of muscular force, which they seek.

It is well known also that persons who have
been accustomed to much exercise, or have passed for
a course of training of only a few weeks even, can
undergo temporary and severe emotion with a less excited
state of the respiratory and circulatory systems than
Those leading a sedentary life, and can sustain continued fatigue for a longer time, which may be 
referred to the firm of the former having required greater irritability and consequently demanding a 
less amount of destruction of tissues to produce the 
required force. Hence the peculiar effect of toisons; 
I have frequently seen in two or three days a re-
amarkable change of this kind under the exhibition of 
large doses of sulphate of quinine.

I have before mentioned that according to 
the experiments of Mr. Joule, the degree of heat, 
generated in the voltaic circuit, is in proportion 
to the resistance offered to the passage of current 
and not to the quantity of zinc discharged, and 
the experiments of Mr. Galvani confirmed by those of 
Mr. Deprazry have decided that the heat discharged 
by the fixation of oxygen in the act of respiration is 
not equal to the whole of that which is produced by 
the animals. May I suspect this as an index to 
the fact (supposed) that the animal heat is the 
result of the passage of warm or electric influences 
in the nerves?

Of the similarity of process between the 
induction of magnetism in iron and the experiment.
Dr. Milen Philip's experiments on well-known. He found that division of the forepaws was followed by difficult respiration, nausea, and feeble attempts to vomit. Spermaceti, previously introduced into the stomach, was not digested; on application, however, of a galvanic current along the course of the arm, the disturbed functions were restored; these results have been confirmed by the experiments of Mr. W. Benham, Dr. M. Edward, and Mr. Tocqueville. Dr. Benjamin Brodie, and called in question by Dr. Reid, who found that in dogs the division of the pneumogastric only caused temporal suspension of function; but in Dr. Philip's experiments, the removal of this suspension was decided, and general analogy would lead us to infer their truth.
of contraction in muscle, by the nerves influence, we have not, I think, any evidence. "M. Prevost,
Demart have compared the "pneum of muscular" fibre to the magnetic needle of a galvanometer, which,
like the muscular fibre, being subject to the action of opposite electric currents, is thrown into motion". But
the needle of a galvanometer, "subject to the action of opposite electric currents", is not "thrown into motion at
all, so that this theory is not tenable. Nor can the other theory, promulgated by them, that the muscular
fibre is thrown into zig-zag lines by the attraction of the nervous current, passing round it, and thus shortened,
be at all maintained. For, in the first place, it has never been proved that the nervous current does pass
round the muscular fibre, and, in the second place, it has been shown that the zig-zag lines are fibres which
are not, thrown into that form by fibres which are, in a state of contraction.

Mr. T. Wharton, Jnr. has with much
ingenuity advanced the opinion, that the disk
of which, with interposing substance, according to Mr. Brown,
the muscular fibre is compassed) are similar to electric
magnets and promises to call them neurmagnets. "The
neuro-magneticnodes, then, consisting of muscular
fibre, of microscopic minuteness, are arranged as so
The involuntary members are little or not at all entitled to 
contraction by patrimonies, probably from the absence of 
mixed circuits, or proportions to their removal from the influence 
of the bill, and the necessity of these agents for the preservation 
of some decisions.
to operate on each other at short distances only, and therefore with great force—a force which, as in other cases of attraction, goes on to augment in a rapidly increasing rate, as the fibers approach each other. By the multiplication of the nerve-magnets in linear series constituting a muscular fiber, one, this limited extent of motion is obtained; and according to the number of linear series arranged side by side in a muscle, so is the power of that muscle. The primitive fibrils of the muscles are disposed in loose crosses the muscular fibers, not coincide round the nerve-magnets, as the conducting current is around electric magnets, when much electric magnetic force. But this is not a difference in principle, it is merely one of arrangement;” I fear, however, that this is a most essential difference in principle, since much of the nerve's influence, returning over the fiber in a contrary direction to that in which it passed before, would undo its own work, as in Fig. 6. The distribution of the nerve, too, with respect to the muscular fiber becomes most important. Dr. Schwann examined with the microscope the distribution of nerves in the lateral abdominal muscles of the Frog, and found the anastomosis of the fascicles as frequent that the muscle aponeurosis interwoven with a network not unlike, many of the veins running parallel
with the muscular fibre; this lack also appears to be the case from a drawing given of nerves distributed in Dr. Carpenter's Physiology of Blood and this theory (Carpenter) apply to the muscles of strictly organic life, which "consist of a series of mucus which do not possess transverse strie" (Carpenter); here we have certainly no analogy with the electro-magnet for Mr. Joule has shown (Analogy of Electricity, Vol. vii.) that an iron bar receives longitude and increments by the transmission of an electro-current round it.

There seems, at present, not to be any place in the explanation of the process, by which muscle undergoes contraction, from the influence of the nerve. Contractility, by the influence of agents, which, in inorganic matter, produced expansion, etc., until getting a tendency to be one of the characteristics of matter, when existing in that peculiar state, which we designate life, and it is in the tissue which possesses it alone that the phenomena of animal life can be perceived; we cannot, for instance, say that the brain and spinal cord of the Frog, when removed from the body can convey any signs by which we may judge that they live, whereas if the operation is performed carefully, and at distant intervals, the ability of these may be gradually destroyed, and yet this.
It has been argued as a part of the attrition of the
\[\text{Illegible text}\]

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\[\text{Illegible text}\]
heat will not then cease to beat, and this even after it shall have been removed from the body.*

At least, also, completely isolated from the nerve centres, will continue to afford evidence of life, as long as it is furnished with a sufficient supply of blood (arterial) and induced to supply it to its emanation by the stimulus of certain electricity. I think, therefore, we must still believe with Helvetius, that animal irritability resides in the contractile tissues; the Humboldt, Müller, valentine & others, have attempted to transpor it to the nerves, and further that these last are merely conductors of a force, formerly developed in the paralytic system, and transmitted along them, at the instance of emotion or emotion or, as in tetanus, independently of both.

I have now endeavored to bring together the most imposing facts, which would seem to tend toward the proof of identity between the voltage current, or electricity, with the nervous influence, we have seen (in electrical physics) the phenomena of each arising from a force produced by the action of the same matter (animal tissue) acted on by the the same fluid (arterial blood) and presented to the senses by the same conducting media (nervous); yet, does all this prove them to be identical? For, no
A. E. Hunts, Photographing B 213 on Cal. May 7th, 1870

for the production of light by electricity - and the application of the Physical Science for the production of magnetism by the same agents.
From that, by physical appliances, we can convert the natural and artificial forces of matter into each other. Thus: as by the union of oxygen with matter in the body, in the galvanic battery, or in the tides of the ocean engine, or by the attraction or repulsion of one body towards another, as in the fall of a stream, or therein of a column of water, we can produce a retardation impetus of motion, and can convert that by the cranks or wheels into a rotary one, so can we by this rotary motion (in the plane electrical machine) which again the manifestations of divided or polarized forces, the union of which (as by joining the lower end of a large electrical battery) will produce, in the circuit, the play of other forces, or it may be only different modifications of the same disturbance of force: at A. magnetism (when passing current)

at B. light (when passing through)

at C. heat (when passing through platinum wire)

at D. chemical decomposition (when passing through solid potassium)

Again by the action of the magnets, heat, or light, we can by the aid of different instruments, obtain electricity from it the other, hence three forces are converted into each other, or in modifications of the same force.

Now he has in the animal body an instrument (the nervous system) by which impulses of matter (sensations)
Humboldt found on dissecting the nerve from Muscles that the latter were sensitive to stimuli, even though he from want of proper mechanism or modification of force.

Consider the curious effects with regard to chemical action, and enhancement and determination of phosphorescence by the division of this force at the opposite end of the spectrum (in Mr. Hunt's Book on Photography) and consider especially the wonderful results obtained by Mr. Moser with regard to "invisible lights." The book of Mr. Hunt is worthy of great attention. From it may be gleaned facts which entirely prove that all the different modifications of force are capable by proper direction of producing the same effects. He proved that "If a person has been touched at a particular part by any body, it acquires the property of precipitating all vapors which adhere to it, or which combine chemically with it on those parts, different to what it does in their untouched parts. Moreover absolute contact with the foregoing body in not necessary, more particular points producing similar effects. Consider these together with the articles on incineration in a late number of "Microscopist." The testimony of Mr. Byng, Harris continued.
electricity, heat, light & chemical action on all capable of producing the same effect. Muscular contraction, it is, then, probable that these act, not directly, but by the mediation of another modification of force peculiar to life, the second influence.

A host of electrical devices, it will be advisable to consider, shortly the effect which the galvanic battery and electro-magnetic machine have upon the human body. On making and completing the circuit between the poles, a shock takes place in the muscles through which the current passes at each of the two crossings and during the interval between them is felt a peculiar thrilling sensation. The fact of the sensation is forcibly caused by a much rapid succession of gentle shocks or contractions in the muscle consequent upon the repeated polarization and discharge in the battery versus conducting the current. The shock (muscular contraction) from the sudden impulse and creation of such currents, causing induced currents of electricity or nervous influence in the ending tides of the heart (as in diagram p. 46) heat is also developed. The current through which the currents passed and the organs are stimulated, to an increase of activity, as when the current is passed through the eye.
a living soul"

"Ment, modifications and enlargements," says
the author of the "Human Organism." This, of themselves
slender, and unequal to the work, yet, when
properly and regularly used and employed, are capable
of bringing such things before the subject
into operation of physical science, it will be advisable
to augment, whereby their effect, unlike the galvanic battery
and electric magnetic machines have upon the human
body. On making and completing the circuits between
the poles, a shock takes place in the muscles
through which the current passess at equal of the two
processes and during the interval between them is
felt a peculiar thrilling sensation. The fact of the
sensation is forcibly caused by a most rapid
production of gentle shocks or contractions in the muscles,
consisting upon the repeated polarization and discharges,
in the battery processes conducting the current. The
shock (convulsion contraction motion) from the sudden suspension
and creation of such currents, causing induced current
of electricity in several influence, in the earliest times of
the world (as in diagram p. 46) that is also observed
by it entering through which the current produces and
organ is stimulated to an increase of action
when the current is passed through the eye.
On the application of solar
electricity and electro-magnetism
to the cure of disease.

On entering upon a summary of the numerous
observations which have been, of late years, made in
this department of electrical science, it will be advisable
to mention, firstly, the effect which the galvanic battery
and electric magnetic machine have upon the human
body. On making and completing the circuits between
the poles, a shock takes place in the muscles
through which the current passes at each of the two
processes and during the interval between them is
felt a peculiar thrilling sensation. The fact of this
sensation is promptly caused by a much rapid
succession of partial shocks or contractions in the muscle,
consisting from the repeated polarization and discharge,
in the battery, nerve, conducting the current. The
shock (sudden contraction or shock) from the sudden impulsion
and vibration of suchcurrents, causing induced currents
of electricity in nervous influence in the earliest tacks of
the nerves (as in diagram No. 46) that is also developed
in this manner through which the current passes, and
the organs are stimulated to an increase of action.
Thus when the current is passed through the eye.
This result is a flaw of taste, indicating the use of gelatin in these cases was parasitic of the taste. Pain suspends this contention. The heat produced is most delicate at the surface when the poles are applied, on employing a battery of 50 pairs to a patient for the cure of chronic diseases. He complained loudly that I was burning his hand. On removing the poles after the lapse of a portion of an hour, I found considerable redness and under the piece of flannel which served as the appliqué conductor.

The electro-magnetic machine affords only simple unfeeling of current, but there may be repeated so frequently as to simulate the effects of a continuous one, and their intensity or quantity can be regulated with such precision and novelty that this instrument is most capable of general application.

Besides the shock, strong counter-voltage may be produced by this machine, by placing a piece of thin muslin on the skin over it a piece of lead foil to which one end of the coil wire is attached, the other end of the coil wire is held by its conductor in the hand, in crossing the leads a torrent of sparks forced to between it and the skin producing a sensation like that of strong sensitive sentient.

Other modes of applying it will appear in
the detail of cases hereafter.

The chances in which electricity has been employed, as a remedial agent, are very various in character. Dr. Philip employed it in asthma, and in consumption and epilepsy. Mr. Goudre has found it serviceable in restoring the function when suspended by concussion. Mr. Majendie has repeatedly restored rabbits after submersion in water for more than a quarter of an hour. Mr. Bland of Leeds near Addison, an ingenious experimenter, has also restored dogs (whelpes) after submersion for fifteen minutes duration in cold water, after forty minutes in warm water. (Bennett's Stuttering Vol. IV.)

Mr. Clarke of Dublin has been successful in an anaestheia in which I am convinced from my own observation great benefit may be expected. Dr. Goldenby Bird has successfully treated Chorea by drawing spinae from the spine, and before the remedial effect to the counter-vibration they produced, hence my plan of counter-vibration by the electro-magnetic machine might have the same effect. He has also been successful by the same form of application, in the treatment of 'dropped hands'. He remarks that paralysis is but a symptom of education or motion, or both, dependent on exposure to cold or inflammation, upon some functional affection.
afford a local character, or upon the impression produced by effusion in some part of the central nervous system, which had become absorbed under the influence of previous treatment, was successfully treated by the application of electricity; whilst those dependent upon some structural lesion, whether produced by accident or otherwise, he never saw the slightest effect. He also obtained very satisfactory results in the treatment of phthisic cerebration by electric shocks, not so in epilepsy, better results obtained. M. Violle recommends the use of the continued currents in tetanus. M. Garret Mauthner has placed it to the test of experiment, and, this the patient died, the symptoms abated... M. Perrot & Dumot have proposed to decompose calculi in the bladder by a battery of 180 points. M. Provois has applied it with success in incontinence of urine, and M. Clarke, midwife, in both these cases the current was transmitted from a catheter passed into the bladder to a conductor applied to the perineum...

I shall now join a detail of cases in which phthisis has been of some

Suspended animation

Case related by Dr. Desplancq of Naintré, in which, by holding from a bladder leading to hand a needle, could
Suspended animation

Case related by Dr. Page Halpern - poisoning by
a dose of 3/8 "Pulv. cubeb" - face red and swollen: the dark purple: mouth containing a vicious pungent saline: tongue had a dry and chapped appearance in the centre: some forhead temples tender: pupils contracted to a point: pulse cold: pulse very slow: moderately full and stopped by the least pressure, respiration very slow, short and gasping.

Treatment: "Sulfate of arsenic was administered as an emetic and hot mustard and water to arouse the sensibility of the stomach, to its impermeability, large draughts of the and titillation of the fauces produced vomiting and a small quantity of the poison was apparently brought up. The stomach found was at hand and the vomiting was readily forced out. As soon as this was done the patient was made to sit on the edge of the bed with his feet dangling in a tub of almost boiling water strongly charged with mustard; the cup was applied to each temple and about two ounces of blood abstracted. Large pieces were drawn over the chest, stomach and inner parts of the thighs, a very strong application, of ammonium carbonate and tempivine was applied to the whole length of the spinal column until the skin became very red and inflamed, when the stomach seemed to be cleared of all traces of the poison. the stomach's draught was suspended and a large quantity down with castor oil administered, but
only a partial remission, the patient soon appeared to be sinking.
the surface was cold and covered with a bluish tinge, the
face was flushed with a protracted time; the jaw and eyes are
pallid, in which the patient by principal stimulation and
sweat time on the face and shoulders with the open hands
was with slightly moist and raised, conscious andbrands
and water were now given with light stroke and an injection
composed of turpentine and ammonia. This produced a slight
discharge from the eyes. The stimulating luminaent already
mentioned was repeated to the urine and over the region
of the body, the pulse was hardly perceptible at the wrists
of, at times, it was at all to be felt, the stimulants were
continued." After attempting the restorations of the patient,
by walking him into the cool air, between two curtains,
without effect, electro-magnetism was applied. The balls
were applied at first to each side of the neck and passed
down behind the clavicles, the arms and body were more com-
pletely but the patient lay as unconscious as before. We
next went over the shoulder and the thorax to a corresponding point on the right side; in an
instant his eyes opened widely, and with a pleasant expression
of remittrence. His head and body were thrown convulsively forward
and the patient the arm sunk back into this reclining position
and was again asleep; the balls were reapplied in the same
situation with similar results, a third and fourth time, and
he cried "come". Reaction was nor positively established. The
heart had received a strong impulse, the pulse was becoming rapidly
developed and the whole face was warm. The employment of
luminous was now omitted and the patient in poor
condition recovered. Sept. 7, 1843

Case related by Dr. Rush at the Friendly Hospital.
Patient, Mary Jones, age 2 months,
possessed by 12 degrees of lancetanum. "When admitted the
infant was quite unconscious and motionless. The surface
was cold and expressed. The pulse of the heart could
not be felt. Breathing was very difficult and was performed
with intervals of half a minute. At least between each
inspiration, the pupils were very small and she had lost
the form of distinction." The usual remedies were used in their
full extent with partial success but this child soon adapted to its
former state. Electro magnets were now applied to the
chest and spine for an hour and a half. Deep boxes and
a half after the lancetanum had been taken aspiration
became established. This art was regular and the further
use of electricity was not required; but in half an hour a
new train of symptoms set in, the pupils dilated widely, and
the child fell into a state of apoplexy; without any of the
symptoms of coma, the breathing was performed by sighs,
the surface was again cold, and she became quite conscious
from this state it was found impossible to reunite her. She died.

Dr. Gaspett, March 24, 1843
Prunella, a young woman of 26 years, in a state of complete coma, the patient was contracted the face pale, the lips, the pulse, the face, and the respirations cease, the stomach pumped, was immediately used, warm water, frictions and afterwards strong coffee being injected and again drawn out and the electric shocks were passed across the shoulders by the electric magnets opposition, with the effect of instantly entering the patient to consciousness, she was then made to walk about the ward, supported by one of the nurses and the electric shocks were removed at intervals as she became stronger. The burns were freely opened by calomel and arsenic oil and the was discharged cured. Dated 31st July 1841

Maurice L. Cartier

Case under the treatment of Mr. Clarke of Dublin.

Miss Cummins admitted May 17th 1842 discharged cured on 1st July. "Necrose of right eye, amputation which had deprived right eye of power and as regard the left that she could hardly see the dimmest point of her ward when distant from it. The lights of the room also awakened of ten months duration it proved aconite " electricity was applied to the region of the eyes and on that evening the inflammation ceased to the eye afterwards, when on 14 days the amnousness ceased.
The more which tendency of diminishing the strengths of the currents is by passing it thro' a channels of water in a long flat dish these

the quantity of electre of passing being in proportion to the quantity of metals immersed, the thickness of the plates of fluids, and the approach of the those to each other in the liquid
completely cured, the stitches removed, and her recovery was complete.

The following case was under my own care—Mrs. A., of the Rev. John Smith's, applied to me for advice; she had paralysis of the left arm, caused by a severe accident in the right arm, was quite unable to hold a pen for more than a few seconds, and told me that her arm was so cold in bed, at night, that it prevented her from sleeping. There was hemiplegia of the right eye, and almost complete loss of vision in the right; the pupil not contracting when a candle was held close to it; in this eye there was too considerable "placoid." I commenced by passing a gentle electric current through the electric magnet with the arm for five or six hours every day, on the fourth application the deadly coldness of the right arm was removed, and the electric current at night. I continued this treatment for a month by which time the sensation and motion of the arm were as far restored that she could write with ease (when her arm was restored). I also found that the arm was considerably increased in bulk. The electric influence was now applied to the eye by placing a roll of flannel on the white of each eye successively, and passing a gentle current from time to time to the hand. Upon this fresh experiment she told me that she could move her right eye, which was before extremely immobile and useless; I did not honour them with any
It is doubtful whether this eye will ever be fully restored as the disease of pharosia still continues the same and if, caused by alteration in shape of the parts, I am afraid is likely to do so.
differences, but on visiting her the next day, found that the vision of the two eyes was much more consistent, and from that time the process of cure has progressed gradually, and she is now able to read writing of this size, and can print her places in a prayer book with large print with the left eye, and can distinguish distinctly thin lines, drawn on paper, with the right eye. During the process of treatment, she has improved greatly in bulk and appearance, the conspicuous nature of the two eyes, having restored the appearance of confidence to her countenance, which was before greatly marred.

The treatment before I saw her had consisted of a period lasting for 'pains which she had felt in the head,' probably neurotic, and afterwards of some readjustment of the painful moan. All these symptoms had seemed to be intermittent for some time before I saw her. In my first visit I ordered her to take a few quarts of water, and to have a small dose of Bect. Levey's at bed-time, as the complaint of being very nervous and these were the states omitted before. The electricity was commenced with...

I had another case of amnesia in the Prison at Newmarket, (charity), which continued to improve while under treatment of a similar nature to the last, but, unfortunately for the patient and myself, the period of treatment terminated before a cure was completed.
I have given the remarks of Dr. Golding Bird on the subject, which seem to me to include all that it is necessary to know on the subject; I will however mention the case of — Lawler 609 High Street four weeks under my care by my friend Dr. Lee; the man had for some years suffered under paralytic of the lower extremities, bladder and ejaculatory urine, mutter; his treatment had for some time consisted of the injection of strychnia, during which the physiological effects of that drug had been very well marked, and when I first saw him, the slightest touch of the sole of his foot against any substance was sufficient to cause contraction of the muscles; under this treatment a certain degree of improvement had been produced, but as it had been for some time stationary, we determined to give electricity a trial; in three weeks after commencement of its, he was able to go down three flights of stairs and to walk on the street with the aid of a stick, but, much to our disappointment he soon began to recur to the state of intermission to which he had been accustomed, and once in a short time returned back to his former state. After no little perseverance, we were obliged to give up the case, and lost the opportunity of trying the electric influence the bladder and the affected joints adjacent to it.
Dr. Rutherford of Manchester has suggested that use of electricity in utero, transmission, and to elicit the contraction of the uterus during parturition. He has found, however, that this uterus is not excited by electricity and relates a very amusing case of the effects of magnetism, in a woman who passed the shock after the conductor was grounded, but before the current was completed; it is not improbable, therefore, that the contractions observed by Dr. Rutherford were the effects of excitement in the mind; it would be interesting, I think, to ascertain if the stimulating of the muscles would have any effect on the uterine by sympathy, or the mode of contraction, applied to the spine or abdomen, acting as a stimulus from the sudden change, sensation it would produce.

I must now conclude these observations, having stated many of the facts in favor of the application of this current with the thought that enthusiastic or overzealous; the cases I have described and the reports of many eminent physicians, will I hope, tend to convince more persons of sound observation, to employ it and investigate its effects.