

Galvanism

Nov^r 1803

Whenever a discovery is made by Philosophers, in the great frame of Nature, or any new & popular theory in chemistry, it has ^{always} been observed that physicians instantly endeavour to apply such theories, or popular doctrines to the ~~use~~ explanation of the actions of the human body, and ^{to} of the causes of diseases. This has ever been the case ^{even} in mechanical discoveries.

and it was remarkably so in discoveries in Electricity; and we know that this observation is applicable of oxygen, and ~~is all the rage~~ at present, in that modification of electricity called Galvanism -

The intention of this lecture is with the view of giving you some idea of this recently discovered principle in animal & other bodies - I say, some idea, for I confess that I am by no means full master of the subject.

Philosophers have long since ~~admitted the~~ ^{suspected} opinion that there are two electric fluids, or emanations of two distinct electric powers, essentially differing from each other; and the only arguments to oppose this plausible opinion ^{are} that ~~is~~ ^{is} ~~in~~ ⁱⁿ favour the doctrine of the positive & negative state of the same (sui generis) fluid. If electricity be a fluid sui generis, it certainly appears to us under different modifications, and galvanism

galvanism may be only another modification of it, with which we have hitherto been but little acquainted. Instead ~~however~~, of reasoning on this new subject of conversation, let us have recourse to its history; for that I have ^{always} found to be the best way of conveying a just knowledge of any subject; for in this case you exercise your own judgement, instead of being too much biased by the "ipse dixit" of the teacher.

One day about 9 years ago, when D. Galvani, Prof. of anatomy at Bologna in Italy, was employed in dissecting a frog in a room, where some of his friends were amusing themselves with an electrical machine, one of them happened to draw a spark from the conductor of it, at the same time that the Professor touched one of the nerves of the frog, when the whole body of the animal was instantly affected by a violent convulsion!

Prof. Galvani, at first, imagined that this phenomenon might be owing to his having wounded the nerve of the frog. To assure himself whether or not this was the case, he picked it with the point of his knife, but no motion of the frog's body was produced. He then touched the nerve with the knife, as at first, and directed a spark to be taken at the same moment from the electric machine; on which, to his astonishment, the contractions, or convulsions were renewed!

Upon

Upon the third trial, the animal remained motionless; but luckily, observing that he held his knife by the handle, which was made of ivory, (a non conductor) he changed it for a metallic one, and immediately the contractions took place, as at first, and which was never the case when he used a non conductor.

It is evident that D. Galvani, had no idea of any other principle occasioning this remarkable appearance, than that of atmospherieue electricity; for he directly made many similar experiments with the electrical machine, & with the atmospherieue electricity, which he did by adopting D. Franklin's contrivance of an insulated conductor placed on the top of his house, and brought thence into his study. To this he attached metallic conductors, connected with the nerves of the animals destined to be the subjects of his experiments; and to their legs he fastened wires w^{ch} reached the floor.

These experiments were made on other animals beside frogs; and in all of them considerable movements were made whenever it lightened. These motions preceeded the thunder, & corresponded with its intensity & with its repetition. Even when no lightning was discernible, the movements in these animals took place, whenever a stormy cloud

cloud passed over the house.

One day Prof. Galvani suspended some frogs on the iron palisades, w^{ch} surrounded his garden, by means of iron hooks fixed in the spines of their backs, when he observed that their muscles contracted frequently, and as far as could be judged, involuntarily, as if from the influence of atmospheric electricity.

When this ^{novel} and curious exp^t came to be published, it excited great & universal curiosity. The learned judges of it by the known laws of electricity, and their admiration was in proportion to the degree of variation from these laws; as if gentlemen, they knew all the laws of electricity.

We ought to say now, as that excellent electrician D. Watson of England, said 50 years ago — "notwithstanding the very great progress w^{ch} has been made in our improvements in Electricity, within these few years; posterity will regard us as only in our noviciate!" Whoever lives 50 years hence may say the same of our most learned electricians. New and extraordinary discoveries in this brilliant science have always ^{so} dazzled the eyes of people as to prevent their seeing things ^{at first} distinctly. The dazzling splendour of Galvanism is already somewhat diminished —

Of the

Of the numerous experiments, that have been made we select the following, as the best for illustrating the subject; —

Lay bare abt. an inch of a great nerve of a frog leading to any limb or muscle. Let that end of the bared part of the nerve, w.^c is farthest from the limb be in close contact with a bit of Zinc. [Zinc is one of the semi metals, possessing some remarkable properties, w.^c indicate in my mind, that it contains an extraordinary proportion of what I call "phlo." "giston," or that principle w.^c some suppose has supplanted this ideal word]. — Touch the zinc with a piece of silver, while another part of the silver touches, either the naked nerve, if it be not dry, or whether it be dry or not, the limb or muscle to which it leads, and violent con-tractions will be produced in the limb, or muscle, but not in any muscle on the other side the zinc. —

If you touch the naked nerve with a piece of zinc, & touch with a piece of silver, either the bared nerve or the limb no convulsions will follow; but if you make the zinc & silver touch each other, i. e. complete the circle, then the convulsions will instantly follow.

Frogs & turtles retain their irritability & susceptibility longer w.^c animals of warm blood, they have therefore been selected for these cruel experiments. Frogs

Frogs are susceptible to the Galvanic influence many hours after their ^{spinal marrow} brains have been destroyed, and even after their heads are cut off; - for even then strong convulsions may be excited by application of ~~the~~ metals. A leg of a frog will continue capable of excitement several days after its separation from the body.

Now almost any two metals will produce these movements. The most powerful is Zinc; ~~the~~ Silver. Take now a few experiments on the human body - Put a plate of zinc into one cheek, & a dollar into the other. Then thrust in a rod of zinc between the zinc & the cheek; & a rod of silver between the silver & the other cheek; then bring the outer ends slowly into contact, so as to form the circle, and a smart convulsive twitch will be felt in the parts of the gums, situated between them, accompanied by bright flashes in the eyes. again,

If a piece of zinc be applied to the skin divested of the cuticle, & a piece of silver applied to the tongue, at the moment when they are brought in contact a very smart irritation will be felt in the wound.

These

These facts being established, without attempting the investigation of the cause let us only attend to the manner, in which it is performed.

In attending to this part of the business we at once perceive that these phenomena of convulsions in the animal are effected by the intervention of an Exciting apparatus, which is to galvanism what the Electrical machine is to atmospherical electricity. By the intervention of this exciting apparatus a circle of communication is formed by it, and the nervous or muscular organs of the animal. Now the sphere of this mutual communication may be regarded as a complete circle, divided into two parts; - that part of it which consists of the organs of the animal, under the experiment, is called the animal arch (of the circle) and that part of it, which is formed of the metallic instruments, is called the exciting arch. This is too clear to need illustration.

A committee of the National Institute of France to whom this subject was submitted, have published the result of twenty experiments on the animal arch of the circuit of communication. A few of these we shall select for your information. From these experiments it appears, that the animal arch may consist either of Nerves and
muscles together

muscles together, or of nerves alone, without muscles.
- The Comm^{tee} conceived that the essential part of the animal arch was the nerves, seeing that a muscle is so intersected by nerves that it may be considered, in a great measure, a nervous organ. - It appeared also, that tying up a nerve, or cutting it off interrupts not the galvanic influence & ^{consequent} phenomena, provided the parts bound up & cut off still remain closely touching each other; ~~that~~ ^{It} ^{therefore} ^{appears} that all parts of the animal arch must be contiguous, tho' they need not be whole.

It appears farther, that the animal arc may be composed of different parts of the same animal, or from a diff^t animal, yet the arc so composed shall have the same power to impart its galvanic susceptibility, provided only that these divers parts all touch each other.

Finally, it appears that the covering of the cuticle, or epidermis, in the entire animal body, acts as an obstacle to the decisive display of the effects of galvanism, altho' it affords no obstacle to the action of ~~the~~ atmospheric electricity.

So much for the animal arc, - Let us now turn our attention to the Artificial or Exciting-arch of the circle, or the Galvanic machine, if you please to call it so.

It appears

It appears from the report of the Comm.^{tee} of the National In-
stitute that the exciting arc possesses the greatest power of
excitement when it is composed of at least three distinct
pieces; each of a peculiar nature; the metals, water, and
humid substances, charcoal, and animal substances,
stripped of the cuticle.

It seems that the arc has but a small exciting power
when made of one piece of metal. The slightest alloy, or
friction with extraneous substances, is at any time sufficient
to communicate to the excitatory arc that full power in
which the identity of its composition may have made it
defective.

The energies of ~~the~~ both the excitatory arc, & the animal
arc are alike suspended by the separation of their com-
ponent parts to a certain distance. But the smallest
degree of moisture is sufficient to join the parts of the ex-
citatory arc, and to determine their effects upon the
animal arc.

The committee found that the state of the atmosphere, &
of surrounding bodies greatly influenced the success of the
experiments. They also found that substances fit for the
formation of the exciting arc, were in general, such as are ca-
pable of acting as conductors of electricity.

Now

Anatomists & Physicians seemed highly delighted with these experiments ^{with} of the galvanic influence. They were in hopes that the grand secret, the explanation of muscular motion was about to be revealed. But, in pursuing the experiments, some facts of rather a different nature ^{up} cast & damped in some measure, their ardour. They found, that if the integrity, or completeness of the animal are ^{was} interrupted by a separation of its parts to some distance from one another, still it ^{may} be restored by the interposition of such substances, between the parts divided, as are not of an animal nature; for it was found that a bit of a certain vegetable called Morelle in french, (Hevella mitra. Linn) will absolutely supply the place of a part of a nerve. [The pith of a veg. answers to the brain & nerves of animals].

It moreover appears by experiments made in England since those of the Institute in France, that in constituting the animal arc, the effects are the same if composed of a muscle boiled, are alive; or of blood, or water, or urine, or milk.

The galvanic contractions were equally powerful, when they are excited by a long, or by a short circuit. This was proved in Eng. by an excitatory arc 10/70 long. — These, are some of the leading facts w^{ch} I have been able to collect on the laws of Galvanism.

Its application to medical purposes opens a wide field for the ingenuity & labor of the skillful & industrious practitioner. It has been tried with success in ^{such} some disorders of the eyes, ^{as} producing impaired vision; and in palsies of the extremities; and in chronic rheumatisms. It has produced happy effects in diseases of the ear, ^{or} occasioning difficulty of hearing, and deafness. When applied mechanically, it is said to act

1st as a general exciting remedy, which, when applied in diseases of deficient excitement, (to speak in the Brunonian style) in due time, & in proper degree, is capable of recruiting life, & restoring such a degree of excitement, as to enable the organs to perform their functions in a proper manner.

2^{dly} It is said to operate as a specific exciting remedy, which by its peculiar irritation, or stimulus, is capable of diminishing, & removing morbid stimuli. i. e. a counter stimulus.

3^d It is found to operate most powerfully when the cuticle is removed by a blister.

4th Its operation is supposed to form a just criterion of real & apparent Death; especially in persons strangled by a cord; or who have lain long under water.

It is related in the London Med. Journal, that the corpse of a certain criminal, who was hanged according to law, till he was dead, was made

was made to exhibit very powerful muscular contractions, which continued for seven hours & an half; that on the first application of the process to the face, the jaw of the deceased criminal began to quiver, and the ^{face} ~~jaw~~ horribly convulsed, and that one eye was actually opened. - That in a subsequent application of galvanism, the right hand was raised & the fist clenched, and the legs & thighs set in motion; so that it appeared to the bystanders as if the wretched man was on the eve of being restored to life."

Now ^{we should} make some allowance for all these shocking accounts, especially when ^{we the Legislature and} ~~recollected~~ the printed narratives of ^{the} extraordinary cases, when Animal Magnetism ~~has~~ turned the heads of the people of France, until Lewis XVI. ordered its principles & its facts to be engraven into by a Committee of real philosophers. You may see by this letter which I received from Mr Adams, our late President to what I height this delusion ran. Not, that I would, by any means rank Galvanism with Animal Magnetism

By this time you may be impatient to have some account of the apparatus called from its inventor Volta's pile. Instead of the trivial experiments with small plates & wires of Zinc & Silver, or Zinc & Copper, Signior Volta, an Italian philosopher,

constructed a remarkable apparatus, w^{ch} bears the name of Volta's column, or pile. The construction of this apparatus is founded on certain laws w^{ch} the galvanic agents are found to obey, and which arises from the contact of three, heterogeneous bodies, viz a fluid, or moist one & two solid ones, these last being metals, particularly those which most abound in what the French chemists call oxygen, but which we beg leave to call after Dr Priestley phlogiston.

The column or pile consists of round plates of zinc & copper, & between them pieces of cloth wetted by a solution of common salt, or diluted muriatic acid; a column, or pillar thus constructed constitutes a chain of galvanism. These plates are placed between three or four glass rods or tubes, not merely to secure them, but to insulate them ~~apart~~. The whole apparatus is insulated by glass feet.

In a pile thus constructed we may notice the following series, copper, zinc, wet cloth - The metallic plates that happen to be at the ~~end~~ two ends of the pile ought not to be regarded as active, because it is found that the two heterogeneous plates metals act only upon each other thro' the medium of a moist body. Hence that the phenomena produced by the two ends of the column, w^{ch} are called poles, are not to be

not to be ascribed to the metallic plates ending the pile, but to those which are between them, ^{Thin} rolled plates of zinc, and copper plated with silver is thought an improvement

Theory of the apparatus of Sen. Volta

One of the most intimate of all associations of the human mind is that of cause + effect. In viewing the works of Nature, we necessarily become first acquainted with appearances, or effects, and then we naturally turn our thoughts to trace out other circumstances that gave them birth. In antient days mankind seem to have been restrained by a religious awe from attempting to investigate the cause of thunder and lightning. Instead of tracing the cause their pious minds overwhelmed with awe, sunk into undiscerning amazement! Unable to investigate the essence of light, and of fire, the Deity was called by the name of these inexplicable agents. In our days the bold & active mind no longer acquiesces in unknown principles. We find, or feign a cause for every thing. "Having discovered the cause of any appearance, it is the business of philosophy to trace it in all its effects, and to predict other similar appearances from similar previous situations of things." - Analogy is our best guide in all philosophical investigations.

- vesperis

investigations; and all discoveries, w.^c were not made by mere accident, have been made by the help of it." (Priestley. p. 417. + 18) -

Zinc appears the most important substance in this excitatory apparatus. Let us then enquire whether there be any thing peculiar in the Nat.^e history of this metal -

Zinc is one of the semi-imperfect metals, so called because we can reduce them by fire to ashes or calx, for in a great heat they evaporate, & leave only a powder behind, w.^c is never the case with the three perfect metals. Gold - silver & Platina. When Zinc is exposed to a heat approaching to a white heat, it emits a flame infinitely more lively, more luminous, and more brilliant than the flame of any other inflammable matter whatever. It is so dazzling bright, & so ^{like lightning} vivid as to be insupportable to the sight: ~~like lightning~~. This cannot be owing to sulphur, for it is remarkable that it will not mix with sulphur. To what is this peculiarity owing? It is owing (says Macquiere) to a superabundant proportion of phlogiston. as a farther proof that Zinc abounds with this inflammable principle, call it by what name you chuse, we may remark that it is the most combustible of all known metals, & detonates more violently with nitre, & for that reason is used in fire-works in preference to all substances of that kind. It has a strong affinity with vitriol. acid, & with it forms white vitriol.

Zinc can be mixed, or alloyed, with every metallic substance but Bismuth & Nickel. It has the greatest affinity with Copper, and when mixed with it, forms Brass. [Mixed in different proportions it forms pinchbeck, & Princes metal] — Such are some of the peculiar properties of Zinc.

We can decompose & recompose all metals, excepting Gold — Silver & Platina. They are immutable & ∴ called perfect metals.

Metals are formed out of an earthy basis, & that inflammable principle, hertofore called phlogiston. Do we throw any light on this dark subject when we say that phlogiston is to a metal what life is to an animal body? —

If you expose Zinc, or any other semi-metal to an intense heat, you destroy the metal & reduce it to a mere earth or calx. and if you add the inflammable principle to these earths, or calces, you restore again the original metal. How is this effected? Why, by adding any animal substance, or char coal, which last especially abounds with phlogiston, when a metal ∴ is calcined it parts with its phlogiston, or fiery principle. This calcination, or oxidation, call it w. c. you chuse, is effected by water, as well as by fire, especially if mixed with sea-salt, and then it is vulgarly called rusting. It is in point to observe here, that electricity rusts, or oxydates Iron —

Now the operation of this pile ^{is} in the calcination of the Zinc, which undergoes a diminution of its weight, while the copper is little affected, and we have already seen that all metals lose their phlogiston in calcination, what remains of the Zinc in a metalline form in the pile, and every thing connected with that end of it, is supersaturated with phlogiston; while the calcined part, & every thing connected with that end of the pile, is deprived of it. The former \therefore is in a positive state, and the latter in a negative one, with respect to phlogiston; and it follows from these experiments, that this is the same thing with positive & negative electricity; so that the electric fluid & phlogiston are either the same thing, or have some near relation to each other. The copper, or silver seems to act principally as a conductor of ~~elec-~~ galvanism ~~to~~ ~~it~~; for the surface of it is only blackened in some places in this process, in consequence, probably, of receiving phlo- giston from the Zinc, but the water is most essential to it, because it constitutes ^{the principle part of the weight} in the calc. ~~the~~ ~~principle~~ ~~part~~ ~~of~~ ~~the~~ ~~weight~~ ~~in~~ ~~the~~ ~~calc.~~

D. Priestley says, that these experiments with the galvanic pile favour the hypothesis of two electric fluids, the positive containing the principle of oxygen, & the negative that of phlogiston. These, united to water, constitute the two opposite kinds of air, oxygenous & hydrogen.

These

These experiments tend likewise to confirm the conjecture long since advanced by D. Priestley concerning the similarity of the electric matter & phlogiston; and, together with the proper Galvanic experiments, show that the same matter substance, elaborated from the element, by the Brain, may be the cause of muscular motion, the nerves being the most sensible of all electrometers.

D.^r P. thinks there is no occasion to suppose any circulation of the electric fluid in the Galvanic pile. He thinks that the ~~pile~~ calcination of the zinc supplies phlogiston (as long as the calcination continues, and when that ceases the operation of the pile ceases with it)

Some, who are attached to the new hypothesis of the decomposition of water, imagine that it is shewn to conviction in the column of Volta; But the veteran Priestley denies the inference they would draw from it. He says had this process succeeded without any atmospheric air incumbent upon the water in which it is made, it would have amounted to a full proof of the new theory; one part of the water being deprived of hydrogen, while oxygen abounded in the other, and both of them, with the assistance of caloric, assuming the form of air. But this not being the case, the element of the dephlogisticated air

air evidently coming from the super abundant at-
-mosphere, the element of the inflamm^{le} air, must
necessarily come from the calcined metal, which
is says Priestley a sufficient proof of the doctrine
of phlogiston. And who is there among us but
must pay ^{some} respect to the opinion of the veteran
in Chemistry & Natural Philosophy, J. Priestley.

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