Outlines of the origin and progress of galvanism : with its application to medicine : in a letter to a friend / by William Meade.

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OUTLINES

OF THE

ORIGIN AND PROGRESS

OF

GALVANISM;

WITH ITS APPLICATION TO

MEDICINE.

IN A LETTER TO A FRIEND.

BY WILLIAM MEADE, M. D.

PRINTED BY J. CONNOR,
FOR A. ARCHER,
DUBLIN.

1805.

For

Mr Russell

with best respects

from the

Author

TO

ROBERT PERCIVAL, M. D.

Professor of Chemistry in the University of Dublin,

WHOSE TALENTS AS A PHILOSOPHER,

AND

JUDGMENT AS A PHYSICIAN,

ARE ONLY EQUALLED

BY THE ZEAL WITH WHICH HE PRACTICES,

AND THE

ARDOR WITH WHICH HE PROMOTES

THE PRINCIPLES

OF

RELIGION AND *VIRTUE,*

THESE OUTLINES

OF THE

SCIENCE OF GALVANISM,

AS CONNECTED WITH MEDICINE,

ARE MOST RESPECTFULLY INSCRIBED

BY

THE AUTHOR.

PREFACE

TO THE SECOND EDITION.

THE *favorable manner which my first attempt has been received, has induced me to comply with the request of my* BOOKSELLER, *and to give to the* PUBLIC *a new and enlarged Edition of the Origin and Progress of* GALVANISM—*when I first ventured to state my ideas on this subject, the Science was only in its infancy,—no systematic Treatise having appeared on it; those who wished to derive information on this interesting subject could only obtain it in detached Essays, published in periodical Papers, particularly in Nicholson's excellent Journal; these, however, fell into the hands of but few persons, and the Public in general, were at that time scarcely acquainted with the name of Galvanism. This will plead my excuse, for attempting so early to diffuse a more general knowledge of it. Since that period, however, others who were engaged with the*

same

same zeal, have published very full and distinct information on it, and the Science, though it has not made the same progress that was to be expected, yet it still has been much improved; and considerable light has been thrown on many of its most important phenomena.

Further observation and experience has also enabled me to make some improvements in the construction of the Galvanic Apparatus; and many new facts have occurred since the publication of the last Edition of this Treatise, which I have now particularly noticed, but in no part of the Science has more information been obtained, than in that which is connected with its application to Medicine; here a new field has been opened for the practical Physician, such as eminently entitle it to the attention of the Profession.

I have, therefore, now collected whatever has been lately noticed with respect to it, and have considerably enlarged that part of this Treatise with the result of my own experience, as well as that of others; hoping, thereby to add in some degree, an encreased confidence in this remedy, for the removal or alleviation of some of the most dangerous Diseases to which the human frame is liable. Should any advantage arise to my Brethren of the Profession, from the observations which I have here collected, I hope it will plead some excuse for thus intruding a second Edition on the Public.

DEAR

DEAR SIR,

WHEN I had lately the honour of ſeeing you, our converſation naturally turned on a ſubject which has for ſome time engroſſed the attention of all philoſophers, and indeed could not but materially intereſt the minds of men of ſcience, who were occupied in the purſuit of uſeful knowledge. You will be at no loſs at preſent to perceive that I allude to the late extraordinary diſcoveries in Galvaniſm, or what is frequently called Animal Electricity. The experiments which have been made on this ſubject have led to concluſions ſo curious and important, that I feel no ſurpriſe at your anxiety to be acquainted with the origin and progreſs of the ſcience of Galvaniſm. To a mind ſo capacious as your's, and ſo intimately acquainted with Chemiſtry, and every other branch of uſeful knowledge, the detail which it will be neceſſary for me to undertake may appear tedious and ſuperfluous; but give me leave, Sir,

here

here to obſerve to you, that the ſciences of Chemiſtry and Natural Philoſophy are but little attended to in this country; men of talents and of education are but ſeldom accuſtomed to ſuch converſation, living, as it were, out of the philoſophical world, they feel unacquainted with thoſe facts, which are not only valuable ſimply as they are connected with the ſciences, but as they relate to the improvement of many of the proceſſes and operations in common life.

Should I, therefore, appear to you either too prolix or diffuſe in theſe obſervations, I beg that you will recollect, that my object is to inform thoſe who have little leiſure to read elaborate treatiſes, and but few opportunities of receiving much information from the works of modern authors.

The numerous and various occupations of your own life, prohibit you from paying that attention to our preſent ſubject, which, otherwiſe, your ardent and philoſophic mind would eagerly embrace.—Some leiſure hours, with the opportunity afforded me of an acquaintance with men of ſcience in England, have induced me to devote much of my attention

attention to the ſubject of the following pages. I claim little merit either in the deſign or compilation; but, ſhould it ſave you the trouble of peruſing the numerous and unintereſting works which are to be found on Galvaniſm; or tend to encourage in others a taſte for the ſtudy of Chemiſtry, with which this ſubject is ſo intimately connected, and to guide inquiſitive minds in their reſearches after curious and inſtructive knowledge, I ſhall eſteem my labour ſufficiently rewarded: at the ſame time I may preſume that a work, which has for its object to give a conciſe and general view of the origin and progreſs of Galvaniſm, may not be totally unacceptable to the generality of readers.

ON THE

ORIGIN OF GALVANISM.

DISCOVERIES in moſt of the ſciences, however improperly named, are generally diſtinguiſhed after the name of the perſon who had the firſt claim to the diſcovery; this, among the reſt, has obtained its preſent title from the celebrated Galvani, Profeſſor at Bologna, who, accidentally amuſing himſelf with ſome electrical experiments, obſerved ſome of thoſe properties of metals which have ſince led to ſo many important diſcoveries. He firſt perceived, while diſſecting a frog, that by touching a nerve of the animal, when ſparks were taken from the conductor of an electrical machine, its whole body was agitated by violent commotions; this led him to make many experiments on the ſubject, and he ſoon found that theſe convulſions could be produced without the aid of electricity, merely by touching the nerves of the animal with two different metals, which at the ſame time touched each other; or communicated by the intervention of any ſubſtance capable of conducting electricity.

This ſimple experiment may be tried to convince any perſon of the fact: lay bare the nerve of an animal, touch it with a piece of zinc, and any part of the limb with a ſilver probe, then bring the

other

other ends of the two metals into contact, when violent contractions will be produced in the muſcle. It has alſo been found, that the limbs or muſcles of many animals continue capable of excitement for ſeveral days after death.

Frogs, unfortunately for them, from their great vitality, have generally become the victim of thoſe experiments; which any perſon may eaſily try, in the following manner: lay bare the ſciatic nerve of a prepared frog, touch this with a ſilver probe, while the muſcles of the lower extremities are touched with a piece of zinc, then bring the ends of theſe metals into contact, when violent convulſions will be produced in the animal; or lay the prepared nerve on a ſhilling, while the feet are placed on a plate of zinc, complete the circuit by any conducting ſubſtance, and the ſame effect will inſtantly be produced, which are repeated as often as the contact is made.

Moſt metals when applied in this manner will ſhew ſome effect, but the moſt powerful certainly are zinc, tin, or lead, when uſed in conjunction with gold, ſilver, or copper. The proceſs is ſimple, nothing more being neceſſary to excite thoſe movements than the formation of a circle, of which part ſhould be the muſcle acted on, and the whole circle completed by the metals. By varying the application of theſe metals, in this way with different parts

of the body, many curious and entertaining experiments may be performed.

For inſtance: If a rod of zinc be applied to the upper, and another to the under ſurface of the tongue, and theſe two metals then brought into contact, a very peculiar ſenſation ſuddenly takes place, reſembling a very ſlight electrical ſhock, and accompanied with ſuch a ſubacid taſte in the mouth as is difficult to deſcribe.

Secondly, If a piece of zinc be placed high up between the upper lip and gum, (or, what frequently ſucceeds better, truſt far up the noſtrils,) and a ſilver rod be introduced under the tongue, as ſoon as the other ends of thoſe rods are brought into contact a very vivid ſenſation is perceived, and a ſenſible flaſh of light appears before the eyes.

Thirdly, Place a plate of ſilver on a table, and over this a plate of zinc, ſomewhat leſs in diameter, ſo as to leave part of the ſilver edge appear all round, then on this plate of zinc lay a leech, or a ſmall worm; when the inſect attempts to move off the zinc, he receives ſuch a ſhock on touching the ſilver, as to induce him to return, and having tried it in different points, with the ſame ſucceſs, he generally gives up the point, and quietly ſubmits to his impriſonment.

Fourthly,

Fourthly, Place a ſilver cup on a plate of zinc, fill this cup with pure water, taſte the water in this ſtate, no perceptible effect is produced, but wet your hand and touch the zinc plate with it, then apply your tongue to the water, and a very ſenſible change occurs, a pungent ſenſation is produced and the water taſtes ſenſibly acid. This ſimple experiment ſerves to explain many curious phenomena: ſuch as the different taſte which is perceived in porter when drank out of a pewter veſſel. Indeed this refinement is carried ſo far, that profeſſor Robinſon aſſerts, that the flavour of ſnuff is much more pungent when taken out of a box, which has been coated with tin foil. However extended this opinion may be, it is certain that the taſte is conſiderably influenced by the combination of metals, and that many circumſtances obſerved in common life are eaſily accounted for on Galvanic principles. So ſenſibly is the taſte affected, either by an alloy, which is a combination of two metals, or by any metal when in contact with another, that a nice obſerver can tell even where a metal has been ſoldered, by examining it with his tongue, the ſenſe of taſte being immediately affected when the tongue paſſes over the ſoldered part, which is otherwiſe not to be perceived.

I ſhall not, Sir, waſte your valuable time by a further detail of thoſe trifling experiments; they were the natural reſults of the firſt diſcovery made

by Galvani, and the ſcience continued for ſeveral years but little improved, till the very extraordinary diſcovery of the vaſt accumulation of the Galvanic influence, which was made by Volta early in the year 1800. Its powers were ſo remarkable, and the effects ſo curious, as to rouſe the attention of all Philoſophers; and from this only may be dated the firſt improvements, which can be conſidered intereſting in Chemiſtry, or uſeful in medicine.

ON THE

PILE OF VOLTA.

For more particular information relative to this part of the ſubject, I muſt refer you to a very elegant paper in Nicolſon's Journal, Vol. i. p. 179. It will be neceſſary, however, for me to ſtate the leading facts, and to deſcribe minutely the apparatus which Volta made uſe of, and alſo the improvements which have ſince been made in it.

Volta's firſt attempt was to encreaſe the Galvanic influence, by adding to the number of pieces of metal; and having firſt placed on a table a flat piece of ſilver, then a piece of zinc of the ſame dimenſions, he found that in order to produce any Galvanic effect, it was neceſſary before the pile was further encreaſed, to interpoſe a fluid, capable of acting in ſome degree on one of the metals; he then added a piece of paper or paſteboard, well ſoaked with a ſolution of common ſalt, or muriat of ammonia, and by continuing to encreaſe the pile, firſt ſilver, then zinc, next moiſtened paper, then ſilver again in the ſame ſucceſſion, he found that a pile conſtructed in this manner afforded a perpetual current of what he called the electric fluid, which was capable of exciting violent muſcular action; by touching it with the hand, or any

conductor,

conductor, at the upper and lower plate, and that theſe ſhocks are repeated as often as the hand is applied. This is what is called a ſimple Galvanic combination, and when two metals are employed, the greateſt effect is produced when one is eaſily oxydated, and the other is not acted on. Thus gold and zinc are the moſt powerful, becauſe gold is a metal of moſt difficult oxydation, and zinc on the contrary, is eaſily acted on by any acid. The pile formed in this manner, may be called a battery, the ſtrength of which is conſiderably encreaſed by the kind of metal employed, and the ſhock which it gives is in proportion to the number of plates employed, more than to their ſize. It reſembles ſo much the effect produced by the Leyden vial, that it is not ſurpriſing that philoſophers ſhould at once call this electrical, and attribute it entirely to the electric fluid; but thoſe who have been accuſtomed to the frequent application of the electric and Galvanic ſhock, perceive a very marked difference in its effects on the whole nervous ſyſtem; it is not ſo inſtantaneous, and gives a much more continued and tremulous ſenſation; and we ſhall hereafter ſee that many philoſophers at preſent, are diſpoſed to attribute it to other cauſes.

In the management of the pile many circumſtances are to be attended to; the intenſity of Galvaniſm is ſo low that it cannot make its way through the dry ſkin; to produce, therefore, the

ſtrongeſt

ſtrongeſt effect, it is neceſſary that the hands ſhould be completely wet, and a large piece of metal graſped in each hand, with the points of which the pile may be touched at each end. Or, place a plate of metal under the firſt plate of ſilver, and another over the upper plate of zinc, let the ends of theſe communicate with two different cups of water, into which the hands may be plunged, and by this means, the circle being complete, the ſhock will be received. However, diſcharging rods, ſuch as I have given in the plate, are more convenient, and can be uſed to receive ſhocks of any intenſity by touching different points of the pile.—But what is ſingularly curious in the pile conſtructed in this manner, is the ſpark which can be procured by touching the points of two conductors communicating with each end of the pile; this ſpark appears to me eſſentially different from the electric, it is much more bright and vivid; it will ſometimes appear three or four times together, but at other times the contact may be frequently made without any ſign of it, though attended with the ſame circumſtances, which is rather unaccountable; and I have frequently obſerved a bright flaſh follow the ſpark and ſhoot along the conductor; it always appears on the wire connected with the ſilver ſide, which would give out hydrogen, and may be exhibited before the eyes at any time in a very ſingular manner. Place a wire in the mouth, which communicates with one end of the pile, and complete

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the circuit by touching with a wet hand the wire which communicates with the other. The flash in this manner appears to encircle the face, and a sharp pungent taste is produced in the mouth.

The spark can be procured much easier and more luminous by connecting a small piece of charcoal to the point of one of the wires, and if the machine is of proper strength the charcoal may even be ignited, or it may be seen under water by connecting the wires in the same manner. It will also be obtained with greater facility, if one of the wires terminate in a fine point while the other is round. This gave rise to a number of attempts to ignite metals with the Galvanic pile, some of which are detailed in a Report to the National Institute at Paris, by Fourcroy, who succeeded completely in igniting different metals; and if this is done in oxygen gas, a real deflagration and decripitation will take place; but for this purpose, he says, that it requires plates of nine or ten inches square, eight or ten of which will be sufficient, while those plates scarcely give any shock, and are by no means powerful in the decomposition of water.

Nothing can be more interesting than the powers of Galvanism in igniting and deflagrating metals; in this as well as in many other points it differs essentially from electricity. I am aware that a powerful charge of an electric battery will deflagrate a consider-

conſiderable portion of any metallic ſubſtance; but this is done in an inſtant, the metal is generally diſſipated, nor can it be kept in a ſtate of ignition. In attempts of this kind on a large ſcale, with a Galvanic apparatus, I have ſeen thirty inches of iron wire, not only fuſed, but exhibited before the eyes for a conſiderable time, in a red heat, as frequent as the communication is made. Its powers alſo in producing light, differ from electricity.—When plates of large dimenſions are made uſe of, an intenſity of light is produced little inferior to ſolar light, and ſuch as that the eye can ſcarcely behold it without pain, greatly ſuperior to what has ever been produced by experimental philoſophy, or chemiſtry. This, unlike the electric ſpark, can be exhibited like a fixed ſtar, by bringing the ends of two wires together which are armed with good charcoal, but it is always neceſſary that the parts ſhould be in actual contact, nor can the ſmalleſt effect be produced in Galvaniſm, unleſs this is the caſe. In this one circumſtance alone, perhaps, does Galvaniſm differ from electricity more than any other; in the latter neither a continued light nor a continued heat can be kept up; while in the former we have both at our command, and can let them gradually looſe, or in a continued ſtream, at pleaſure, but at all times requiring actual contact.

Thus far merely had Volta and other continental philoſophers gone, when Meſſrs. Nicolſon and Car-

liſle undertook to repeat theſe experiments, and to them principally are we indebted for the diſcovery of the powerful effects of Galvaniſm, as a chymical agent, particularly in its action on metals, and in decompoſing water. Accident here, as well as in the firſt experiments of Galvani, led to this curious diſcovery.

While engaged in repeating the experiments of Volta, Meſſrs. Nicolſon and Carliſle obſerved bubbles of air to ariſe from the points of the conductors, whenever they came in contact with water; this ſuggeſted the idea of examining the nature and origin of this aireform fluid.

The reſults of their enquiries are as as follow—that the Galvanic pile has the power of decompoſing water and oxydating metals. Some improvements have been ſince made in the apparatus for this purpoſe, which I ſhall detail, referring you for a more particular account to Nicholſon's * Chemical Journal.

It was neceſſary, in order to collect the gas ariſing from the pile, to contrive a method of receiving it; the firſt attempt was by ſuch a tube as may be ſeen in the plate given by him. Let this tube be filled with water, and each end cloſely ſtopped with a cork, in which a gold wire is introduced, ſo as to meet

* Vol. iv. p. 179.

meet within half an inch of each other, connect then each end of the wire with the pile. ſo as to complete the circuit, immediately gas will be ſeen to ariſe from the points of both wires, ſo as to collect in conſiderable quantity in the tube; which gas, when examined, was found to contain two parts hydrogen, and one part oxygen; theſe, when fired together, either by a taper or the electric ſpark, will explode and form water.

They may alſo be fired by the Galvanic ſpark, as both Meſſrs. Bolton and Crookſhanks have aſcertained; but, in order to collect thoſe gaſes ſeparately, other tubes were conſtructed, as in plate, fig. 1ſt. by which means it was aſcertained, that the gas ariſing from the ſilver ſide was hydrogen, while that from the zinc was oxygen, and as nearly as poſſible in the proportion ſtated to be the component parts of water.

To procure theſe gaſes the points of the wires ſhould not be more than half an inch aſunder, if they are much farther no decompoſition takes place. This is invariably the caſe, which ever way you turn the pile, and has ſuggeſted the trial of different metallic wires, by which means other curious circumſtances have appeared.

For inſtance, connect a gold wire with the zinc end of the pile, and a braſs wire with the ſilver end, the

result will be the same as if both wires were gold, viz. oxygen arising from the zinc side, and hydrogen from the silver; but reverse the pile and a very striking circumstance appears: no gas arises from the brass wire connected with the zinc side, but it immediately changes its colour, blue clouds encircle the point of it, and a very rapid oxydation of the metal immediately takes place, while hydrogen continues to arise as before from the gold wire connected with the silver side. The cause of this is sufficiently obvious; the oxygen fixing itself in combination with this brass wire; but if it had been gold or platina, metals of difficult oxydation, then oxygen, instead of being fixed in it, would have been extricated as in the first experiment. All metals, therefore, which are acted on by acids, or easily combine with oxygen, are unfit to be used for the decomposition of water, when connected, as in this experiment, to the zinc side of the pile.

Salmon has examined those combinations, and made many experiments with different wires, on what he calls the Galvanic Acid, or the power which the pile has in oxydating metals, and reducing them to a saline state; such particularly as zinc, copper, silver, and iron. I have repeated these experiments, but not exactly with the same result.—These metals have invariably been oxydated when connected with the zinc side, the oxydes of which were of different colours, according to the metal employed;

ployed; but I never have obtained thoſe brilliant chryſtals which he deſcribes.

In following up thoſe experiments, it was natural to try the effect of paſſing the Galvanic current by means of wires, through other fluids and different metallic ſolutions. When Ammonia is expoſed to its action inſtead of water, a very rapid decompoſiton of it takes place, its ſtate of aggregation being more weak than other fluids, Hydrogen and Azote are the reſult of the proceſs;—and by paſſing repeated electric ſparks through theſe gaſes, Ammonia may even be reproduced: but if in this caſe we uſe ſilver wires, no decompoſition takes place, fulminating ſilver being formed on the ſilver wire connected with the zinc ſide of the pile, which will detonate violently by even the ſmalleſt friction; this was accidentally diſcovered by Crookſhank, and if the experiment is attempted on a large ſcale the effect of the detonation may be attended with unpleaſant conſequences.

Spirit of Wine has alſo been ſubmitted to the action of Galvaniſm, the ſpirit is in this caſe alſo decompoſed, but not without the wires are armed with good charcoal, and in contact; brilliant ſparks are then produced, and carbonic acid gas, and hydrocarbonate are the reſult of the proceſs. When wires armed with charcoal are introduced into water, the ſame brilliant ſparks appear, but no heat

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is produced though the light is very evident; which ſhews that light is not always the conſequence of heat, and that they may exiſt ſeparately.

It has been aſcertained that oxygen and hydrogen are never obtained but when pure water is uſed. When this water is coloured by Tincture of Litmus, it is changed to a red colour, as far as the point of the oxydating wire, (that is always to be underſtood the wire connected with the zinc ſide) while the other part remained blue. Hence it appears that the oxygen had combined with the Litmus, ſo as to produce the effect of an acid.

If the tube filled with diſtilled water and tinged with tincture of Brazil wood, be ſubmitted to the Galvanic influence in the ſame manner, the fluid which ſurrounds the wire connected with the ſilver ſide, becomes a deep purple. This is as deep a colour as can be procured by Ammonia, and evidently ſhews that an alkali is, in ſome manner produced by the hydrogen ariſing at this ſide.

When the Galvanic influence is paſſed through metallic ſolutions in acids, the conſtant effect appears to be the revival of the metal held in ſolution; this revival is produced by the hydrogen gas, which is known to reduce the oxydes of metals. The ſolutions which have been ſubmitted to this experiment are, acetite of lead, ſulphate of

iron

iron and copper, and nitrate of ſilver, and on thoſe occaſions bright metallic precipitations were always produced by the hydrogen; but particularly from the nitrate of ſilver, ſhoot fine needle-wire like chryſtals, beautifully formed like the Arbor Dianæ. In all thoſe caſes no hydrogen gas is diſengaged, it fixing itſelf in combination with the metallic precipitate.

From thoſe experiments it has been ſuggeſted by Mr. Crookſhank, that Galvaniſm may be employed with ſucceſs in the analyſis of minerals. That it may be a uſeful chemical agent there can be no doubt; we have ſeen that different metals can be diſtinguiſhed by the action of Galvaniſm, when connected with the zinc or oxygen ſide of the trough, and it is evident that the nature of any metallic ſolution may be aſcertained, by ſubmitting it to a current of gas ariſing from the ſilver or hydrogen ſide of it. I have myſelf found it a very uſeful teſt of the preſence of iron in a chalybeate water, and I have no doubt but further experience will enable us to convert this ſcience to the elucidation of many of the important works of Nature.

Theſe are a few of the numerous intereſting experiments, which the pile of Volta has given riſe to, they are not only highly amuſing to the curious obſerver, but they appear to open a new field of inveſtigation to the ſcientific Chemiſt. It is, perhaps, unneceſſary to add a variety of other circumſtances

con-

connected with this ſubject; enough has been ſaid to ſhew to how many uſeful purpoſes this diſcovery may be applied. Philoſophers have occupied much of their attention in endeavouring to illuſtrate the cauſes of theſe phenomena; little, it is true, has yet been done to explain them in a proper manner;—however, I ſhall, in the next chapter, take a ſlight view of the different theories which have been ſuggeſted on this ſubject.

ON THE

THEORY OF GALVANISM.

I SHALL not here enter deeply into the inveſtigation of the different theories which have been ſuggeſted to account for the phenomena of Galvaniſm. Thoſe who were at firſt diſpoſed to attribute all theſe to an electrical cauſe, now ſee ſo many objections to this explanation as to heſitate in their former opinion. That the pile ſhews ſome of the qualities of electricity is evident, from its effects on the electrometer; and it has been ſaid by Mr. Crookſhanks, that he could charge a Leyden vial ſo as to give a ſmall ſhock, by placing the pile between the coatings; many others have, however, attempted this without ſucceſs.

An anonymous correſpondent, in Nicolſon's Journal,* ſays, that after a variety of trials, he has ſucceeded in charging a jar, ſo as to produce a ſlight ſhock, or rather taſte in the mouth, by filling the jar, nearly with ſalt water, and placing it in a veſſel containing the ſame fluid, as nearly as poſſible to the ſame height, he then connected the inſide of the vial with one end of the pile, and the outſide

* Vol. v. p. 174.

with the other; by this means imitating, in ſome degree, the coating of the Leyden vial.

Since this, however, Van Marum,* of Haerlem, has ſucceeded in charging a battery with the pile, and has gone farther than any other perſon to prove the identity of Galvaniſm and the electric fluid. But notwithſtanding this, from a variety of other circumſtances, ſuch as the different ſenſation produced by the ſhock, the neceſſity of the hands being wet to receive it, and its producing no report; the appearance both of the flaſh and the ſpark, and the trifling appearance of other electrical phenomena, it is not ſurpriſing that philoſophers ſhould doubt its being entirely an electric phenomenon; or, ſeeing ſome ſigns of electricity, ſhould attribute it, in part, to a chemical agent, modified by ſome unknown electric circumſtance.

Fabroni was the firſt who attempted to prove, that the phenomena of Galvaniſm proceeded from a mere chemical operation; this opinion firſt aroſe from a variety of obſervations, which he had made on the mutual action which different metals exert on each other; and on the great tendency which one metal has to oxydate when in contact with another. That the ſimple contact of two different metals when expoſed to a fluid, produces a particu-

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* See Journal de Chimie.

lar tendency in one of them to oxydate, may be clearly proved in the following manner:—Place a plate of zinc, and a plate of ſilver in a glaſs, containing a dilute ſolution of ſulphuric acid, no change at firſt ſeems to take place in the metals, but bring the two metals into contact, and bubbles of air will be ſeen to ariſe rapidly from the zinc, a ſpeedy oxydation commencing by a decompoſition of the water, the zinc abſtracting its oxygen, with which it enters into combination, while the hydrogen is let free. This certainly may be called a Galvanic operation, and explains a fact which was not before well underſtood. Ships which were ſheathed with copper, and faſtened with iron bolts, were found to be injured in the ſheathing, by the bolts having become looſe when expoſed for a ſhort time to the ſalt water, while other bolts which were not in contact with copper were but in a ſlight degree injured. The cauſe of this is now ſufficiently obvious, here are two diſſimilar metals and one fluid, a rapid oxydation of the iron therefore takes place by its contact with the copper while expoſed to the ſalt water. Fabroni certainly reaſons very ingeniouſly on theſe facts, and though he does not mean to exclude all electrical influence, it is not ſurpriſing that he ſhould refer many of the phenomena to a chemical proceſs taking place in the metals, he conſiders it to be a ſlow combuſtion and oxydation of the metal, accompanied by an attraction of oxygen, and a diſengage-

ment of light and caloric;—to produce this, it is neceſſary that ſome fluid, ſuch as the Lymph, Saliva, or any other humidity ſhould be preſent, and to theſe changes he thinks the different ſenſations on the animal fibre ſhould be aſcribed.

Creve, obſerving theſe chemical changes which take place in every Galvanic operation, and the neceſſity which there is, that the muſcles ſhould be ſurrounded with humidity in order to produce the ſhock, is inclined to attribute it to the decompoſition of a fluid; that the ſhock is accompanied with the decompoſition of a fluid is very poſſible, and ſo neceſſary is humidity to produce this ſhock, that it is known no ſuch ſenſation can take place even on the tongue by the action of the metals if it has been previouſly wiped dry; that in all Galvanic experiments a fluid is decompoſed, appears highly probable, but that the decompoſition of this fluid explains all the Galvanic phenomena is by no means proved, though many proceſſes in the animal œconomy may be attempted to be explained on the ſame principle, and ſeem to have ſome connection with the Galvanic operation. Reſpiration for inſtance may thus be called a Galvanic proceſs, a decompoſition of the air always taking place during the operation. This, it appears, is the ſtimulus which Nature employs to rouſe into action animated matter, reſpiration being at once ſuſpended when the lungs

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are deprived of this fluid. Modern Surgeons are well acquainted with the pain and inconvenience which arife from too long an expofure of a fore to the atmoftphere; but they could, till lately, have no idea of accounting for it on fuch principles as are here attempted; the theory of Creve, will, however, afford an explanation of it, by fhewing that, while a decompofition of a fluid is taking place, the oxygen entering into a new combination, appears to be that ftimulus which gives pain and irritation.

Thefe attempts to explain Galvanic phenomena, are combated by Volta, who feems difpofed to attribute the whole of them to the electric fluid, and if it is true that the Leyden vial can be charged with the Galvanic pile, it muft be confeffed that it goes nearly to eftablifh the identity of the two fluids; but this has not fucceeded with the moft experienced philofophers in this country. Volta is of opinion that the Galvanic is nothing more than the common electric fluid, excited by the mutual contact of the metals, and that the humid fubftances applied to the plates anfwer no purpofe, but eftablifhing a reciprocal action, or communication between them, fo as to impel the electric fluid in one particular direction, and the reafon why faline fubftances fucceed better than any other, is, he fays, only becaufe they act as better conductors than pure water; the chemical phenomena which are obferved, he thinks are only

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connected with it, as being ſecondary effects of the electricity.

Mr. Davy, to whom this ſcience is indebted for much valuable information, has followed up the experiments of Fabroni and others; and in a very ingenious paper, in the Philoſophical Journal,* has gone farther to explain the theory of Galvaniſm than any other perſon. He firſt found that the zinc of the Galvanic pile does not oxydate in pure water: by pure water is meant, water holding in ſolution no oxygen gas, no nitrous gas, and no acids.

This he proves clearly from a variety of circumſtances; he alſo proves that the power of the pile is greatly increaſed by dipping it into nitrous or marine acids, which enables the zinc to oxydate itſelf more rapidly; and that when pure water is made uſe of, in the conſtruction of the pile, it is capable of but little Galvanic effect. From which it appears that Volta's pile only acts when the fluid between the plates is capable of oxydating the zinc; and that in proportion to the quantity of oxygen which enters into the zinc, ſo is the power of the pile to give the ſhock, or to decompoſe water. He therefore, with great reaſon, concludes that the chemical changes which take place by the oxydation of the zinc, are, ſome how or other, the cauſe of the electrical effect.

* Vol. iv. p. 340.

He alſo has ſince added conſiderably to our ſtore of information on this ſubject, and has found that ſingle metallic plates, connected together by different fluids, were capable of ſtrong Galvanic effects.

It will, perhaps, be never ſatisfactorily explained how this Galvanic influence is cauſed; that chemical changes take place in the metals, there can be no doubt, and that their Galvanic power is much greater while this change is going on, is alſo aſcertained by a variety of experiments: but Mr. Davy has not only taught us that ſtrong Galvanic effects may be produced with one metal, but that the metals are not abſolutely neceſſary; this has been lately confirmed by ſome extraordinary experiments on the animal fibre.

The circumſtances attending this diſcovery were firſt related in Nicolſon's Journal, and are ſo extraordinary that we ſhould be inclined to diſcredit them, were they not verified by the names of men of high literary character. Mr. Aldini, nephew of the celebrated Galvani, has ſince publiſhed his experiments, which prove that the Galvanic matter is generated or collected in the bodies of animals, and has ſucceeded in exciting muſcular contractions in a frog without the aid of a metal. The manner in which, he ſays, he performed theſe experiments, were firſt by laying bare the nerves of a frog;

frog; he took hold of the muſcular part with one hand, while with the other he touched the nerve, and contractions took place as in the former Galvanic experiments.

Secondly, he takes the head of an ox, recently cut off, and touching the ſpinal marrow with a finger wetted with ſalt water, he makes the crural nerves of a frog, which he holds in the other hand, touch the tongue of the ox, and whenever this contact takes place, violent contractions are produced in the frog. Theſe experiments, if correct, ſhew that an animal circle, capable of Galvanic effects, may be formed as well as a metallic one.

Theſe experiments were made in October 1803, by Aldini, who conſiders himſelf the firſt diſcoverer of what he called Animal Galvaniſm, but this was long before ſuſpected by Mr. Davy, and in a paper of his, ſo late as January, 1801, he ſays, "I have lately made ſome experiments, which convince me, that there exiſts in living matter Galvanic action, independent of all influence generated by metallic oxydation. On the whole, no Theory as yet attempted, has explained the different phenomena which are produced by the Galvanic proceſs, and whatever credit we ſhould be inclined to give to the arguments which attribute every thing to the chemical changes which take place in the metals, ſtill we

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muſt heſitate in aſſenting to it, after the diſcoveries which have been made, not only of the ſame effects being produced in ſome inſtances with one metal, but alſo that to produce ſome of the moſt ſtriking Galvanic phenomena, the metals are by no means neceſſary.

To conclude:—though the complete identity of the Galvanic and electric fluids remains to be proved, yet there are ſo many circumſtances to favour this opinion, that it appears to reſt at preſent on ſafer principles than any other; it is only by collecting facts, arranging and comparing them that we can expect to eſtabliſh any rational theory, and it is to be lamented, that neglecting this in Galvaniſm as in other ſciences, ſome philoſophers begin by forming plauſible theories, which are neither ſupported by facts or experience.

Neither the deſign, nor the limits of theſe outlines, will permit me to notice the opinions of a great number of philoſophers who have wrote on the preſent ſubject, ſuch as have appeared either plauſible or conſiſtent, I have given you a ſketch of; while it ſtill continues to excite both intereſt and attention, it ſhould be the province of the Phyſician not to neglect the advantages which may be derived from its application to Medicine; in this way, while his curioſity is excited, and his ardent love of ſcience in-

dulged, by converting his knowledge to so useful a purpose, as the cure of diseases, he may entitle himself to the approbation of his own mind, and to the esteem and gratitude of his fellow-creatures.

ON

ON THE

APPLICATION OF GALVANISM,

TO

MEDICINE.

HAVING traced the connection between electricity and Galvaniſm, and examined with preciſion their reſpective powers on the animal fibre, I ſhould indeed have thought my time very much miſapplied, if I had not beſtowed conſiderable attention on its effects in the cure of a variety of diſeaſes; curious as are many of its moſt important phenomena, yet the ſubject would perhaps appear leſs intereſting, if it were not found capable of being applied to ſome uſeful purpoſe. As ſoon, therefore, as the powers of the pile of Volta became known, it was natural to expect that Phyſicians ſhould attempt to make uſe of its influence as a medical agent, and few I believe who have paid any attention to the ſubject, will deny, that it promiſes to exceed any other ſtimulant in Nature. Having ſo many properties different from electricity, it was natural to expect, that its effect on the nervous ſyſtem would be alſo different, it has accordingly been much uſed of late in Medicine, and ſome late expe-

riments of Aldini, ſhew that its effects are not confined to the living animal, but that it is alſo capable of exciting the vital powers a conſiderable time after death, producing the moſt horrible contortions and grimaces of the muſcles of the head and face in animals, ſome hours deprived of life. When we conſider, therefore, the influence which even a ſmall quantity of this fluid exerts on the muſcles of an animal, even after death, is it not reaſonable to conclude, that the Galvanic current paſſed through a diſeaſed part, may in many inſtances be attended with the beſt effects? It admits of an eaſy application to any part of the body, and may be applied for any length of time, with little labour on the part of the operator, and leſs inconvenience to the patient, its action may be eaſily increaſed or diminiſhed according to the indications of cure, and it muſt be alſo obſerved, that there is this difference between Galvaniſm and electricity, that the Leyden vial, when once diſcharged, exhibits no more effects, without renewing the charge, whereas, Volta's pile continues undiminiſhed in ſtrength, and conſtantly charges itſelf.

Before we take a view of the different diſeaſes to which Galvaniſm is applicable, we ſhould firſt conſider what are its uniform and conſtant effects on the animal frame, and let it be firſt recollected, that the ſenſation produced by it is peculiar, and cannot be

imitated

imitated by electricity; on the intellectual organs in particular its powers differ materially, and when judiciously managed, the ſenſation is deſcribed as by no means diſagreeable.

It is alſo a curious circumſtance that when the powers of the mind are cut off, the effect of Galvaniſm on the animal body is more powerful: Thus, a paralytic limb will be thrown into ſpaſmodic action by a charge, which in a healthy perſon will produce no ſuch effect. That the will is the cauſe of this may be explained by another fact. If a very ſmall Galvanic ſhock is paſſed through the limb of a perſon aſleep, violent ſpaſmodic contractions will take place in the muſcles, but the ſame charge being applied to a perſon whoſe mind is engaged, ſcarcely produces any ſenſible effect. There ſeems therefore, to be a principle exiſting in the living animal which enables it to reſiſt powerful external ſtimuli, and thus it is explained how an inanimate body is more violently affected than an animated one.

Having aſcertained that the immediate effect of Galvaniſm on the ſyſtem, is that of a very powerful and peculiar ſtimulus,—it requires only the diſcernment of a judicious Phyſician, to determine what are the diſeaſes where it may be applied with ſafety or ſucceſs. It will be obvious that it can be only employed with propriety in diſeaſes ariſing either

either from a defective energy of the brain, or a debility in any of the members or functions of the body, arising from a general or partial ceſſation of nervous power, or loſs of tone in any particular part. This, therefore, being laid down as a principle, it will naturally occur that in no diſeaſe can Galvaniſm promiſe more benefit than in paralyſis. It has indeed been propoſed as a remedy in apoplexy, but this is a diſorder that requires much caution, in the application of ſo powerful a ſtimulus, in certain caſes of it unattended with an accumulation of blood in the veſſels of the brain, or a decided determination to the head, perhaps it may be attempted with ſafety; however, in paralyſis, the frequent termination of apoplexy, no ſuch danger is to be apprehended, and where there is total loſs of motion, and but little ſenſibility in the limb, the greateſt advantage may be expected, by a proper application of this ſtimulus, which may be increaſed on ſome occaſions to any proportion.

Should Galvaniſm, applied in the common way to the limb, appear to have but little effect, a much greater ſtate of irritation, or ſtimulus may be produced, by firſt applying ſmall bliſters to each extremity, and while the cuticle is bare paſſing the Galvanic current through the limb, by touching the conductor to thoſe parts where the bliſters had been applied.

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When the tongue is alſo affected with palſy, and the powers of articulation either impeded or deſtroyed, nothing as yet attempted has ſucceeded ſo frequently as Galvaniſm; by paſſing repeated ſhocks between the nape of the neck, and the tongue, I have ſucceeded in reſtoring the organs of ſpeech in a few moments to a perſon who could not expreſs a word ſo diſtinct as to be underſtood. In this caſe the tongue was the only part affected in a man apparently otherwiſe healthy, and it was deſcribed to have occurred after an apoplectic attack with which he was ſeized at night, but ſoon recovered from. I muſt however, confeſs, that the effect of Galvaniſm was little more than temporary, he could immediately after it ſpeak perfectly diſtinct, but in the courſe of the day relapſed again; on the whole, he was greatly relieved, but did not perſevere long enough to give the remedy a fair trial.

In illuſtration of the power of Galvaniſm in paralyſis, I ſhall mention the following caſe which occurred to me.—

I was lately requeſted by a very ſcientific medical friend, to try the effect of Galvaniſm on a patient of his, a lady about fifty years of age, who had been for ſome time in ill-health, the conſequence of Menorrhagia, and was attacked about a year before with apoplexy, from which ſhe recovered at the time, leaving her left ſide in a complete ſtate of paralyſis,

ralyſis, her tongue alſo affected, and the powers of articulation greatly impaired. She was treated for theſe ſymptoms in the uſual manner, and had been electrified for a conſiderable time with little benefit, her general health became more impaired, ſhe had one or two attacks of apoplexy, and became œdematous with other ſymptoms of dropſy: this complaint, however, was nearly removed by the uſe of Digitalis, and, except a conſiderable œdema in the palſied leg and arm, no other ſymptoms of dropſy appeared; on the whole, I did not conſider it a very favourable caſe to attempt the trial of Galvaniſm: however a battery of fifty plates were prepared, and the firſt application was made to the hand and arm of the palſied ſide. The effect was here very ſurpriſing, even on the firſt day, the limb which was pale and enormouſly ſwelled, began to reſume its natural heat and colour, and its powers on the abſorbent ſyſtem, were ſo remarkable, that the ſwelling of the arm totally diſappeared in two days; the limb which before was nearly uſeleſs, gradually began to recover its power of motion, and the fingers which were faſt clinched and contracted, gave way on every Galvanic ſhock; ſmall ſhocks were then paſſed through the tongue, which produced conſiderable irritation, and a copious flow of ſaliva from the ſalivary glands; her ſpeech after each attempt became evidently improved, bliſters were then applied to the hip and foot of the affected

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ſide, and the Galvanic current paſſed through the limb, the œdema here alſo diſappeared and the motion of the leg was ſo far improved, as to enable her to walk, ſhe continued rapidly recovering; the uſe of the hand and arm being nearly reſtored, when on the ninth day ſhe was ſeized with another apoplectic fit, which carried her off in a few hours: but what became ſingularly curious in this caſe, was that the ſide originally affected with paralyſis, did not ſuffer, but during the ſhort time ſhe lived continued well, while the other ſide became paralytic, this is, I apprehend, a very unuſual inſtance, and though Galvaniſm could not be ſaid to be completely ſucceſsful, yet its powers on the ſyſtem ſeem by it perfectly aſcertained, and make it probable that the effect was ſuch as nearly to eſtabliſh a healthy ſtate in the ſide affected, and render it leſs liable to be influenced by the original organic affection of the brain; which neither in this, nor indeed in any caſe can it be expected to remove. It was alſo the firſt inſtance where I had an opportunity of obſerving its powers in ſtimulating the abſorbents to act; this, as far as I am acquainted with, has not been before noticed, and ſo extraordinary was its effect in rapidly cauſing the œdema to ſubſide, that I am perſuaded no application whatever, in ſuch caſes, will be attended with the ſame advantage; here it appears to act as a ſafe and local ſtimulant, reſtoring the natural heat and colour of the limb, and by increaſing

the languid circulation of the part enables the different veſſels to perform their proper functions and recover their loſt tone.

If ſuch are its powers, it will naturally induce us to try its effects in ſome diſeaſes of the Lymphatic ſyſtem, which at preſent, are but imperfectly underſtood; Mr. White has deſcribed a complaint, to which women in the puerperal ſtate are chiefly liable:—This conſiſts in a ſwelling of the lower extremities, unattended with external inflamation, the ſkin being ſmooth, ſhining, and pale; much difference of opinion exiſts, both as to the cauſe and mode of treatment of this diſeaſe: it is allowed on all hands, to be an affection of the Lymphatic ſyſtem, either occaſioned by increaſed exhalation, or diminiſhed abſorption. Doctor Ferrier attributes the diſeaſe to an inflamation of the Lymphatics, while Mr. White aſſerts, that if this ever takes place, it is the effect, not the cauſe of the diſeaſe. Perhaps in this, as in many other inſtances, the difference between active and paſſive inflamation is not well defined; as, if any active inflamation takes place, bliſters and other external ſtimulants would never ſucceed, and thoſe are the remedies allowed even by Doctor Ferrier to be attended with the moſt advantage. It is evident, from the appearance of the limb, that the abſorption is not equal to the effuſion, and from what I have obſerved I know of no remedy ſo capable of

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rouſing the veſſels into action, and promoting abſorption as Galvaniſm, while at the ſame time, its influence is ſo completely under our command, that no danger can be apprehended from its judicious application.

In the caſe which I have juſt detailed, the effect of Galvaniſm was alſo remarkable, for the influence which it had in producing an immediate relaxation of the contracted fingers, and in every ſuch inſtance where I have applied it, I have uniformly found the ſame reſult. In rigidity therefore of the joints, whether the conſequence of the gout, or rheumatiſm, it promiſes much advantage, and the ſame circumſtances that favor its application in thoſe diſeaſes, will alſo encourage us to hope that it may be of equal efficacy in tetanus or locked jaw, a diſeaſe both frequent and fatal in warm climates; none but thoſe who have ſeen the effect of Galvaniſm in producing a relaxation in any muſcle when in a ſtate of contraction or involuntary action, can have an idea of its power on the nervous ſyſtem; locked jaw is one of thoſe complaints, in which the patient is frequently loſt from the inability to take either food or medicine; if, therefore, Galvaniſm anſwers no other purpoſe than the temporary relief of relaxing the ſpaſm and opening the jaw, which I am perſuaded it will generally do, it is ſo far of uſe as counteracting the moſt diſtreſſing ſymptom, and enabling the

patient to take the neceſſary nouriſhment as well as medicine.

There are a number of diſeaſes ſo particularly adapted from their nature and ſituation to the influence of Galvaniſm, that the experienced Phyſician will be at no loſs to decide when it may with propriety be employed. In amauroſis, or loſs of ſight, ſuppoſed moſt frequently to ariſe from a paralyſis of the optic nerve, what remedy ſeems more ſuitable, or can be applied with more convenience? In cataract, which is occaſioned by an opacity of the cryſtaline humour, it can promiſe but little ſucceſs; the complaint ariſing from a local cauſe, and ſeldom removed except by an operation; however, it does not appear improbable but Galvaniſm may afford the Surgeon ſome criterion for judging whether the optic nerve is alſo diſeaſed, or whether impreſſions of light can be received on the retina; if this ſhould appear to be the caſe, the removal of the lens will reſtore the ſight of the eye. This in general may be determined by the patient perceiving the flaſh of light from a proper application of the Galvanic ſtimulus, which I have never ſeen fail in a perfect healthy ſtate of the eye, or when impreſſions of light are felt on the retina.

Galvaniſm has been tried with great ſucceſs in deafneſs, but in no diſeaſe is it more difficult to diſtinguiſh

tinguiſh the cauſe than in this, and on this circumſtance alone ariſe the frequent contradictory reports which we have of it; it is the promiſcuous uſe of this, or any other remedy without a knowledge of the cauſe of diſeaſes, which has brought many of our moſt valuable remedies into diſrepute, and which marks the diſtinction between the Phyſician and the Empiric. The application of a very valuable remedy at an improper time, or in a diſeaſe to which it is not ſuited, may leave unfavourable impreſſions to which in itſelf, it is by no means entitled;—thus, the application of Galvaniſm in apoplexy, ariſing from too great an excitement, whether general or local, will aggravate the morbid ſymptoms, and increaſe the diſeaſe. This cannot be too ſtrongly inculcated, as well as another obvious circumſtance, which is, where the diſeaſe ariſes from mechanical injury, no advantage can be expected till that is firſt removed; thus, for example:—I was lately requeſted to Galvaniſe a very fine boy who had loſt the uſe of the arm and hand, it was much emaciated, had loſt all power of motion, and the circulation even in the limb could ſcarcely be perceived; on making proper enquiry into the cauſe of theſe ſymptoms, I found that they all aroſe from a diſlocation of the arm ſome years before, which was never reduced, the conſequence was, a compreſſion on the nerves and arteries leading to

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the limb; here then was a caſe, where no remedy without the reduction of the limb could be of any ſervice, and where Galvaniſm would be tried in vain, by a careleſs obſerver. Let it therefore be recollected, that before Galvaniſm is attempted in caſes of deafneſs, that one great object is to aſcertain from what cauſe it ariſes; ſhould it be occaſioned by any organic injury of the membrana tympani, which is frequently produced by abſceſſes in the ear, or ſhould it ariſe from mal-conformation in any of the ſemicircular canals which may induce a mechanical obſtruction, then no advantage can be expected from this remedy;—but if it is aſcertained to ariſe from a defective energy of the auditory nerves, or a relaxation or paralyſis of the membrana tympani, then have we every reaſon to expect ſucceſs: in ſome caſes, even when there is a want of ſecretion of wax, hearing is impeded, and the ſtimulus of Galvaniſm may tend to reſtore this ſecretion ſo neceſſary to a healthy ſtate of the ear.

There are few diſeaſes more obſtinate in their nature, or more painful to the patient, than rheumatiſm; however, after what has already been obſerved, it will occur, that it is only in the chronic ſpecies that any advantage can be expected from Galvaniſm, and without entering into the different theories of Galvani and others, aſcribing this diſeaſe to extravaſated humours ſtagnant round the ſurface of the nerves, which

which theories are neither ſupported by facts, or experience, I can have no heſitation in recommending the ſtimulus of Galvaniſm in obſtinate caſes of chronic rheumatiſm, unattended with ſymptoms of general or topical inflamation. It is particularly important, however, to attend to this, I have in one caſe ſeen it aggravate conſiderably the painful ſymptoms, which I look on as a certain proof that the diſorder then partook in ſome degree of the acute ſpecies, though the pulſe, and other circumſtances gave no reaſon to ſuſpect it; indeed it is frequently difficult to diſtinguiſh between theſe two ſtates of rheumatiſm; Galvaniſm, however, ſeems capable of affording a diagnoſtic, and I ſhould be inclined to attribute the diſeaſe to the acute ſpecies, when the application of Galvaniſm ſo far from giving relief, increaſes the painful and other diſtreſſing ſymptoms of the complaint.

The ſame circumſtances that would lead us to employ it in this caſe would alſo recommend it as a moſt uſeful remedy in indolent tumours or ſcrophulous ſwellings, which have long remained ſtationary unattended with pain or inflamation; here ſuch a ſtimulus is peculiarly wanting, and if it does not cauſe the reſolution of the tumour it will tend to bring on a ſuppuration, which in ſuch caſes is frequently an object to be wiſhed. In ſcrophulous habits, buboes ariſing from a venereal cauſe will put

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on ſuch an indolent appearance, as that neither can they be diſperſed by ſuppuration, or reſolution; here Galvaniſm is particularly ſafe and applicable, and Mr. Wilkinſon and others, ſtate, that in ſuch caſes they have employed it with great advantage.

When electricity was firſt employed in the cure of diſeaſes, it did not eſcape the obſervation of Phyſicians; that it may be applied with ſucceſs in obſtinate caſes of Amenorrhœa, it has accordingly been uſed with evident advantage in a variety of inſtances, but with the knowledge which we at preſent poſſeſs of the powers of Galvaniſm, there appears no diſeaſe where it ſhould have a more decided preference over electricity than in this; from the delicacy and timidity of the ſex who are the ſubjects of this diſorder, electricity has never had a fair trial; nor does the electric ſhock ſeem calculated to remove ſuch a complaint, while it becomes an object of fear and alarm, paſſions more calculated to impede than to increaſe the flow of the menſes; if, however, the powers of Galvaniſm are applied with judgment and diſcretion, and with due regard to the feelings of the patient, its peculiar ſtimulus may excite ſuch an action in the veſſels as may reſtore the determination to the uterine ſyſtem.

From the powerful action of Galvaniſm on the ſyſtem, even after life appears extinguiſhed, it has been

been ſuggeſted by Creve that it may be the means of diſtinguiſhing real from apparent death. This is controverted by Humbolt and others, yet it will appear evident, that in ſome caſes conſiderable advantage may be derived from it, though no decided reliance ſhould be placed in it alone; when we are not certain of the length of time that the principle of life has appeared extinguiſhed, and when waiting for the putrefactive proceſs, is attended with inconvenience, the ſimple application of this ſtimulus to the body will determine, whether all irritability in the muſcles is deſtroyed, and of courſe, whether perſevering in any remedy for the reſtoration of the vital principle will hold out any proſpect of ſucceſs. In caſes of ſuſpended animation, whether from drowning or other cauſes, no doubt can be entertained that it may be at leaſt a uſeful aſſiſtant; we have inſtances where life has appeared to return, but ſtill the patient has been loſt for want of ſuch a general ſtimulus as this, capable of rouſing the dormant ſpark of life, and ſtimulating the heart and arteries to action.

I would not have it underſtood that this alone will be ſufficient; on the contrary, the uſual judicious remedies ſhould be tried, but in addition to thoſe on all occaſions, I would recommend the powerful ſtimulus of Galvaniſm, and it only appears ſurpriſing, that ſo little notice has been as yet taken

of it in the inſtructions delivered by the different Humane Societies, or that we ſhould have ſo few well authenticated inſtances of the effects of it in ſuſpended animation.

While we are engaged in attempting the removal of ſome of the moſt dangerous bodily diſeaſes by Galvaniſm, perhaps it may not be altogether ſuperfluous to attend to its action in diſeaſes of the mind; Aldini I believe firſt attempted in ſuch caſes the uſe of it, and ſays, that he has completely ſucceeded in two caſes of mania, attended with melancholia; if it ſhould be found equally uſeful in the hands of others, how valuable a remedy have we for a diſeaſe hitherto ſo little underſtood, for much as we are in the dark with regard to other diſeaſes, there are none with which we are more profoundly ſo than inſanity. It unfortunately happens that Phyſicians engaged in extenſive practice, neglect the ſtudy of mental diſeaſes, forgetting the connection between diſeaſes of the mind and of the body, they leave this part of the profeſſion to men little calculated for it by education, and leſs perhaps from their ignorance of Medicine; while this is the caſe, and ſuch patients are left to the mercy and diſcretion of keepers, diſeaſes of the intellectual organs will continue to be treated with Empiriciſm; remedies by no means adapted will be tried, ſtimulants will be uſed where already there is too great an excitement,

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and evacuants perſevered in where moderate ſtimulants may ſucceed; this only can account for the few who return from inſane aſylums, free from one of the moſt diſtreſſing maladies which falls to the lot of human nature;—to treat this ſubject as it deſerves, I feel myſelf but little qualified; but it muſt be allowed, that the Phyſician who does not in all caſes attend to the influence of the mind on diſeaſes, as well as of diſeaſes on the mind, deſerves but little the confidence of his patient.

To lay down rules for the application of Galvaniſm to the intellectual organs, in every inſtance, would exceed the limits of this eſſay; the ſame cautions before delivered againſt the uſe of ſtimulants, in caſes of great excitement, are here more particularly neceſſary:—therefore, in a high degree of mania, or delirium, I ſhould not conſider Galvaniſm a ſafe remedy, but where there is an evident diminution of the energies of the mind, the propriety of it cannot be doubted; this is a very frequent cauſe of mental derangement, occaſioned by impreſſions made on the ſenſorium by the depreſſing paſſions, producing, in ſome caſes, melancholia, in others, hypochondriaſis; each of theſe ſtates of derangement are accompanied with ſuch a torpor in the Vaſcular ſyſtem, a deficiency of muſcular energy, and a languor of the whole frame, as to promiſe conſiderable ſucceſs from the powerful and peculiar ſtimulus of Galva-

niſm; it ſhould not here be omitted, that in caſe of Hydrophobia, Galvaniſm has been ſaid to have ſucceeded. This is an inſtance of mental derangement ariſing from the abſorption of a peculiar poiſon, attended with ſymptoms ſo fatal and diſtreſſing, that were the powers of this remedy well aſcertained, few improvements, in modern times, would rival the advantages which the world may expect from the diſcoveries of Galvani.

Having taken a ſhort view of the diſeaſes where Galvaniſm may be applied with advantage, it may not, perhaps, appear here unneceſſary, to take ſome notice of Perkin's metallic tractors.

It is probable that when the proprietor firſt thought of applying theſe inſtruments to the cure of diſeaſes, he had ſome idea of the diſcoveries of Galvani, which were made at that period; under impreſſions ariſing from this diſcovery, and ignorant as he muſt have then been of the ſcience of Galvaniſm, it is not ſurpriſing that he ſhould have had erroneous opinions on the ſubject, while at the ſame time the imaginations of the weak and the ignorant were ſo eaſily operated on. Many Perſons of enlightened underſtandings were for a conſiderable time dupes to the faſhionable remedy, called Animal Magnetiſm, now acknowledged to be a deception. But when we read in Perkin's advertiſement,

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a list of the numerous and contradictory diseases for which his Tractors are recommended, and also that they are "equally applicable to all analogous diseases of horses;" should we not hesitate before we assent to such a combination of absurdity?

Sufficient is now known of the mode of exciting the nervous or muscular energy, by the Galvanic or animal circle, to induce the enlightened and judicious Physician to discard those trifling toys, the offspring of ignorance and Empiricism.

It is scarcely necessary to add, that the metals selected by the proprietor of these instruments are not those best calculated to produce Galvanic effects; and that the mode recommended for their use, is inapplicable to any useful purpose, and totally inconsistent with the knowledge which we at present possess of the science of Galvanism.

As it also is evident, from the late experiments of Doctor Hagarth: that they possess no specific power derived from the metals, they should be considered as a popular delusion, and their effects ascribed to impressions of the imagination, which it is well known, have not only particular influence in the removal, but in the formation of diseases.

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I ſhould not have thought it neceſſary to ſay thus much, but that I have heard it gravely aſſerted by perſons both of talents and education, that they can now eaſily explain the operation of the metallic Tractors.

Nearly on the ſame principle, another remedy, called the Galvanic belt, has been recommended, and for which no doubt the proprietor will obtain a patent. Of this, however, I will not ſpeak ſo harſhly, but certainly, neither its conſtruction or mode of application is in any degree reconcileable to the known laws of Galvaniſm. Let us, therefore, at preſent, be ſatisfied with its medical effects, as connected with the pile of Volta. It may not, nor can any remedy always ſucceed; but thus much we know, that its principles are unerring, and that its effects are always obvious, ſuch as a conſtant and powerful excitement of the nervous influence, and a local or general ſtimulus to the ſyſtem.

I have thus, my dear Sir, endeavoured to give you a few of the outlines of the ſcience of Galvaniſm, and its application to the cure of diſeaſes;—many of theſe facts which I have deſcribed muſt have been long ſince familiar to *you*; but few others, however, have either the taſte, or the inclination, to inveſtigate ſubjects ſo unconnected, in appearance, with

with their ordinary purſuits. To ſuch men I cannot addreſs myſelf more forcibly, than in the language of my friend, Mr. Davy, in his Preliminary Lecture on the Study of Chemiſtry.

He calls their attention to this ſcience, by obſerving, that—"To men collected in great cities, who are wearied by the conſtant recurrence of ſimilar artificial purſuits and objects, and who are in need of ſources of permanent attachment, the cultivation of Chemiſtry and the phyſical ſciences may be eminently beneficial; for in all their applications they exhibit almoſt an infinite variety of effects connected with a ſimplicity of deſign. They demonſtrate, that every Being is intended for ſome definite end or purpoſe; they attach feelings of importance even to inanimate objects, and they furniſh to the mind means of obtaining enjoyment unconnected either with the labour or miſery of others."

"To the man of buſineſs, or mechanical employment, the purſuit of experimental reſearch may afford a ſimple pleaſure, unconnected with the gratification of unneceſſary wants, and leading to ſuch an expanſion of the faculties of the mind as muſt give it dignity and power.

"To the refined and faſhionable claſſes of ſociety it may become a ſource of conſolation and

happineſs

happineſs in thoſe moments of ſolitude, when the habits of the world are conſidered with indifference. It may deſtroy diſeaſes of the imagination, owing to too deep a ſenſibility, and it may attach the affections to objects uſeful and permanent."

To theſe inducements I may add, that if in the purſuit of ſo intereſting a ſtudy, the philoſopher ſhould ſucceed in the diſcovery of ſome new remedy for the cure of diſeaſes, or in the application of the ſcience to any of the uſeful arts, he muſt feel a gratification ariſing in his own breaſt, which thoſe only are acquainted with, who devote their leiſure hours to the attainment of uſeful knowledge, and who apply this knowledge to the improvement of the arts, and to the benefit of ſociety.

DIRECTIONS

FOR THE CONSTRUCTION OF THE

GALVANIC APPARATUS,

AND APPLYING IT TO USE.

In order perfectly to underſtand the theory and practice of Galvaniſm as far as we are at preſent acquainted with it: I ſhall firſt repeat, that all Galvanic combinations are either made with two diſſimilar metals, and one fluid, or with two diſſimilar fluids, and one metal, and that in the former caſe the greateſt effect is produced, when one of the metals is eaſily oxydated and the other not acted on.—When only one metal is uſed ſomething ſimilar occurs, one ſide of the plate ſhould be expoſed to a fluid capable of acting on it, while the other ſide is connected with a fluid of a different nature.

To explain thoſe ſimple Galvanic combinations which have led to ſo many important diſcoveries, and gave riſe to the pile of Volta, I have annexed the following figures—

Galvani's firſt diſcovery will be eaſily underſtood by a reference to Plate I. Fig. I A repreſents a prepared frog, that is a frog ſkinned, with part of the vertebre and the ſciatic nerve laid bare, ſuſpended on a rod of zinc, B. In order to produce violent ſpaſmodic action in this frog, nothing more is neceſſary than to touch the zinc rod with a ſilver probe, and then complete the circle by touching the feet of the animal, the whole limb will then be thrown into violent commotions, which will be renewed as often as the contact is made. However, in order to ſhew the ſame experiment in a different way, Fig. II. repreſents a prepared frog, with that part of the ſpine to which the ſciatic nerve is attached, placed on a plate of zinc, Z. while its feet are placed on a plate of ſilver, S. The communication being made by the conductor R. the frog is thrown into violent convulſions, as often as the circle is formed.

Theſe ſhew the influence of two metals in producing Galvanic effects, and frogs are ſelected for this purpoſe, as their muſcular fibres are ſo extremely ſenſible to the electric, or Galvanic influence, that they become the moſt delicate electroſcopes hitherto known. However, in performing theſe experiments, the neceſſity of humidity muſt not be forgot; if the muſcles of the frog ſhould become dry by the animal having been too long killed, no effect is produced, and during each experiment

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the proceſs of oxydation appears on the ſurface of the zinc where it is expoſed to the moiſture of the frog, which farther ſhews that in all Galvanic experiments a decompoſition of a fluid takes place.

In order to ſhew that a Galvanic combination may be formed with two diſſimilar fluids, and one metal, take a glaſs veſſel B. Fig. III. fill this veſſel with water, and place in it a ſmall ſilver cup S. which ſhould be nearly filled with dilute nitrous acid. Thus the two fluids are not in contact, and one ſide of the metal is expoſed to a fluid which is capable of acting on it, while its external ſurface is in contact with another fluid with which it has no affinity;—when, therefore, a frog is made to form the communication as at C. the ſame convulſive motions will take place in the muſcles as in the former experiments.

Having ſeen the effect produced by ſimple Galvanic combinations on the nerves of an animal, as firſt diſcovered by Galvani, it next becomes neceſſary to deſcribe the conſtruction of the pile of Volta, an inſtrument ſimple in itſelf, but capable of producing very powerful effects.

In the former pages detailing the origin of Galvaniſm, I have mentioned that the metals beſt calculated to produce Galvanic phenomena are gold,

ſilver, and copper, when uſed in conjunction with zinc, tin, or lead, and it is alſo obſerved, that the moſt perfect Galvanic combination is formed when one of the metals undergoes the greateſt change, and the other the leaſt.

In the experiments which I have detailed, it is taken for granted that the pile is made of plates of ſilver and zinc, theſe being the metals which experience has taught us produce the moſt powerful effects; ſilver is however too valuable and ſcarce an article to become very generally uſed, and from my own experience, I perceive ſo little difference between this metal and copper when uſed in conjunction with zinc, that I ſee no objection to the general uſe of the latter, the difference being only about eighty-five to one hundred. When the pile as conſtructed by Volta, and ſhewn in Fig. IV is uſed, about twenty pieces of each metal will be ſufficient for performing many intereſting experiments, beginning firſt with a plate of copper, and terminating it with zinc, it may be ſupported in a frame ſuch as is uſed for the common hour-glaſſes, but the uprights which touch the metals ſhould be of glaſs, or a non-conductor, pieces of woollen cloth are much better than card or leather to interpoſe between the plates, they ſhould not be quite ſo large as the plates, and they ſhould be well ſoaked for ſome time in the fluid, and then preſſed, leſt the liquor ſhould run off

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and wet the edges, which would materially injure the operation of the pile. The fluids which are moſt convenient and powerful, are dilute ſolutions of nitrous, or marine acids, about thirty parts of water to one of the acid, ſolutions of common ſalt, or muriate of Ammonia may be alſo uſed for this purpoſe, but they are by no means ſo powerful, and are attended with inconvenience, an effloreſcence forming on the plates, in conſequence of the decompoſition of both ſalts allowing the Alkali, particularly the Ammonia to attack the copper. When it is intended to take the ſhocks with this inſtrument, a flat piece of copper ſhould be placed under the lower plate, one end of which may be bent and turned down into a cup of water, thus, by dipping one hand into the water, and touching the upper plate with the other hand wet, ſhocks of any intenſity may be received in proportion to the number of plates engaged in the circle.

The pile conſtructed in this manner, and conſiſting of á ſeries of ſimple Galvanic combinations may be called a battery, it will not continue capable of action for many hours, as ſoon as the cloths begin to dry, or the plates to oxydate, it loſes its power, and this is accelerated by the unavoidable and unequal preſſure of the plates on the wet cloth, which ſoon forces the liquor out, and by its running down the ſides, and forming a communication between one

plate

plate and another, it not only injures the ſtrength of the pile but is attended with many inconveniencies. To remedy this, it is ſoon neceſſary to take down the pile to wet the cloth and clean the plates. Volta himſelf ſaw the inconvenience of this, and endeavoured to counteract it by applying cement to each plate, and filling theſe cells thus formed with a fluid; however, this was a very ineffectual attempt, which, as far as I have learned, has never been improved on. It required conſiderable ingenuity to prepare a battery which would not be liable to the ſame objections; however, on explaining the advantages attending ſuch an apparatus, formed without the inconvenience attending the pile of Volta.—Mr. Michael Fitzgerald, of this town, undertook to conſtruct one, which would remove the neceſſity of uſing wet cloth in the formation of the pile; and I ſhould do him injuſtice did I not acknowledge, that the inſtrument which he has invented, as deſcribed in Plate I. Fig. V. & VI. is finiſhed with that preciſion and ſkill, which could only be performed by an Artiſt who had talents to conceive, and abilities to execute the moſt difficult pieces of mechaniſm.—Modeſt and unaſſuming merit, the too frequent attendant on real genius, has only kept this ſelf-taught Artiſt in a ſituation where his talents have but few opportunities of being either ſufficiently known, or rewarded.

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The apparatus which I allude to, muſt be acknowledged as the firſt great improvement on the pile of Volta, without altogether deviating from its original conſtruction. For medical purpoſes I have found it a very convenient inſtrument, and have ſhewn it to many gentlemen of ſcience, who highly approve of it;—convenient as it is on a ſmall ſcale for ſuch a purpoſe, it ſtill may be rendered more ſo, when plates of large dimenſions are uſed,; as they may be conſtructed in the ſame manner, of any ſize, and as they can be eaſily taken aſunder and ſeparated, they are not attended with the inconvenience ariſing from large troughs as uſed at preſent. It may, perhaps, be alſo obſerved, that the pile formed in this manner, bears a cloſer analogy to the electric organs of the Torpedo than any other, and very beautifully illuſtrates the conſtruction of the cells in this animal, which appear to be ſo intimately connected with its electrical power. At the ſame time, I am free to confeſs, that even this inſtrument, in ſome reſpects, is not perfect; and that it takes more time and trouble in preparing it than the trough as contrived by the ingenious Mr. Cruickſhank, which has become of general uſe, and which I ſhall now deſcribe—

It had been tried without ſucceſs, to excite a permanent electric current without friction, or any active agent. The pile of Volta, it is true, had this

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effect, but it became neceſſary to conſtruct a machine which would anſwer the ſame purpoſe, and could be applied to many of the experiments in Galvaniſm with more promptneſs and ſucceſs.—This has, in my opinion, been completely done, by the invention of the trough ſuch as I have given in Plate II. Fig. IV. To conſtruct this, it is only neceſſary to get a piece of hard and well ſeaſoned timber, ſuch as oak, or mahogny, and to have it ſcooped in the ſhape of a trough, according to the number and ſize of your plates, which it muſt exactly fit; but grooves in the timber, as directed by Mr. Cruickſhank, are not neceſſary. The inſide of the trough ſhould be coated with a layer of cement about the ſixth of an inch thick, and perfectly uniform and ſmooth. The beſt cement which I have found for this purpoſe is bees-wax and roſin, in the proportion of about four parts of the latter to one of the former; when this is well melted, a ſmall quantity of red lead, or a little fine brick duſt may be added, it is then fit to apply, and ſhould be laid on warm. The plates which were at firſt uſed were ſemicircular, but theſe have no particular advantage, and ſquare ones are now ſubſtituted, as ſo much more ſurface is expoſed to action;—it is not neceſſary that the zinc plate ſhould be thicker than a crown piece, and the copper may be much thinner, they ſhould be made as ſmooth as poſſible, and ſoldered in the common way together, nor is it abſo-

lutely

lutely neceſſary that they ſhould touch at all points, but they ſhould be particularly well done at the edges to prevent the fluid from getting acceſs; having heated theſe plates ſufficiently to melt the cement in paſſing, ſtick them in the trough about a fourth of an inch aſunder, being particularly careful that each plate follows in ſucceſſion;—copper, zinc, and then copper, and alſo that they are ſo accurately fixed that no fluid can paſs from one cell to the other. It is found that metals ſlightly allayed will anſwer perfectly well. The greateſt difficulty which occurs, is forming the plates of zinc, they will not bear the hammer or the roller to ſhape them, and as this metal is ſo volatile that it ſublimes in the open air, it is neceſſary that it ſhould be fuſed in cloſe veſſels, and ſhaped in molds of ſand, or what is much better, in braſs molds, as by this means its ſurface comes out perfectly ſmooth and poliſhed. The braziers underſtand this ſufficiently well, but it is neceſſary to obſerve that few of them know zinc by any other name than ſpelter. Ignorance of this circumſtance put me to much inconvenience in my firſt enquiries. Having conſtructed a trough in this manner, nothing more is neceſſary but to adapt it to uſe: for this purpoſe, the cells ſhould be filled with a fluid capable of exciting it; weak ſolutions of muriate of Soda, or muriate of Ammonia anſwer this purpoſe in ſome degree, but for the reaſons before ſtated, dilute nitrous, or marine acids are much to

be preferred, as the more active the fluid, the more powerful will be the effect; but even this has its limits, as ſhould concentrated acids be uſed, they not only act on the zinc, but alſo at the ſame time on the copper, thereby leſſening the power of the battery;—by the rapidity of its action alſo on the zinc, its ſurface becomes oxydated, and 'till this is removed the Galvanic operation ceaſes. In filling the trough, care ſhould be taken that the cells do not overflow, as it would materially injure its action, if the ſurface of the plates were wet ſo as to make a communication between one cell and the other; as theſe neutral ſalts, or dilute acids are ſufficiently powerful, it may not be unneceſſary to ſtate here, that the uſe of pure alkalies in trying experiments with the trough is liable to great inconvenience; they act powerfully on the cement, and in a ſhort time totally deſtroy the action of the machine. The principal diſadvantage attending the conſtruction of the trough is, that it is not eaſy to come at the plates to clean them, it however ſo happens, that each ſucceſſive operation contributes to do ſo; the firſt effect of the acid, particularly the marine, is to act on the oxyd on the ſurface of the zinc plates, then on the metal itſelf, by which means the action of the battery continues ſo long as the acid remains unſaturated, or 'till a freſh accumulation of oxyd attaches itſelf to the ſurface. The trough muſt be then emptied,

and

and waſhed, which is all that is abſolutely neceſſary till it is again charged for uſe.

The firſt experiment which is generally tried on this machine, is its powers to give the ſhock: to perform this, nothing is neceſſary but to wet the hands with water, and to embrace in each hand ſuch a diſcharging rod as is given in Plate 2d. Fig. V. By touching the firſt cell of the trough with the point of one rod, and any other cell with another, a ſhock may be received through the arms, the ſtrength of which is in proportion to the number of cells engaged in the circle, and alſo in ſome degree to the extent of ſurface of the body which is wet and expoſed to the conductor:—thus touching each end of the trough with the points of the fingers moiſtened, will by no means produce ſuch a ſhock as when a large extent of the ſurface of the ſkin is expoſed to a conducting ſubſtance.

Experiment 2nd. To give a ſhock confined to any circumſcribed part of the body, get two pieces of cloth, about the ſize of a ſhilling, well ſoaked in muriate of Ammonia, and place theſe on each point of the limb, or muſcle through which it is intended that the Galvanic influence ſhould paſs, let each cloth be then touched with rods communicating with each end of the trough, ſo as to complete the circle. But it is as neceſſary here, as in electrical

experiments, that theſe rods ſhould have all communication cut off with the operator's perſon by means of non-conductors; they may, therefore, either paſs through glaſs, or part of them may be covered with cement, as in Plate 2d. Fig. VIII. and in order to apply them with more convenience, they are attached to the trough either by braſs chains or ſpiral wires.

This is the way in which Galvaniſm is applied for medical purpoſes, and it may be given to any ſtrength, according to the part of the trough to which the wires are connected, and renewed as often as is wiſhed, by mere contact, without any inconvenience, and continues of the ſame ſtrength as long as the pile continues in action. I have frequently uſed it myſelf and applied it in this way to others, and nothing can be more ſtriking than the difference between it and electricity.

If it paſſes through any part of the cuticle which is wounded, the operation is intolerably painful, and at all times the effect on the muſcle through which it paſſes is highly powerful, producing a viſible ſpaſm or contraction, and a ſenſation reſembling the puncture of a number of needles. If the ſhocks are of any conſiderable ſtrength, thoſe parts of the limb to which the conductors are applied appear red, and ſhew ſome ſigns of inflammation, which ſuggeſts the neceſſity of ſome caution in the application of Galvaniſm

vaniſm to the more delicate and ſuſceptible organs, to guard againſt the inconvenience which may ariſe from too great an excitement.

Thus in the application of Galvaniſm for the cure of amauroſis, particular care ſhould be taken that the cornea of the eye is guarded from the inſtrument, otherwiſe a dangerous inflammation may be induced. In paſſing the Galvanic ſhock through the ears, care ſhould be taken to commence with a ſmall charge, and alſo that the conductor is properly applied, in ſuch caſes I have armed the conductor with an ivory ball, which only admits a ſufficient part of it to enter the meatus auditorius and prevents the poſſibility of its injuring the tympanum. When only one ear is affected ſuch a conductor may be introduced and faſtened to the head, while ſhocks are taken with the inſtrument, repreſented in Plate 2d. Fig. V. embraced in the hand of the perſon affected, and of ſuch ſtrength as may be found ſafe or proper:—In this way I am engaged at preſent in applying it in a caſe of deafneſs, which if the patient has proper perſeverance promiſes already the moſt complete ſucceſs.

Experiment 3rd. To ſee the flaſh in a very conſpicuous manner, put one of the wires, connected with the copper ſide of the trough into your mouth, or touch it to your forehead, while with a wet hand

you

you touch the other wire connected with the zinc ſide;—as often as this contact is made the flaſh is renewed, accompanied with a very peculiar pungent taſte in the mouth.

Experiment 4th. To procure ſparks and ignite charcoal, fix ſmall pieces of dry and well burnt charcoal to the points of each conductor, bring theſe into contact, by this means bright vivid ſparks will be obtained, and if the machine is ſufficiently ſtrong, the charcoal will not only be ignited, but a continued and brilliant light may be kept up for a conſiderable time.

Metallic wires may be completely fuſed in the ſame manner by connecting them to the conductors, and ſuch an intenſity of heat may be produced, if thoſe experiments are performed in oxygen gas, as cannot be imitated by any other proceſs; however, the common pile will not be ſufficient for this purpoſe, the ſhock, as before obſerved, is in proportion to the number of plates, at leaſt to a certain extent, while to produce the requiſite heat for the fuſion or deflagration of metals requires plates of at leaſt eight inches in diameter, fifty of theſe are ſufficient for this purpoſe, when at the ſame time they poſſeſs no greater degree of power on the animal fibre than the ſame number only three inches in diameter.

No experiments in Galvaniſm are more curious than the effects of it in the decompoſition of water, or the oxydation and revival of metals. Plate 2d. Fig. III. repreſents the apparatus which I have found to anſwer beſt for this purpoſe. The tubes recommended by Meſſrs. Nicholſon and Cruickſhank are attended with many inconveniencies, particularly that for receiving the gaſes ſeparately, as it is a difficult matter to collect them afterwards and ſubmit them to the different teſts requiſite to aſcertain their qualities;—that which I have given Plate 2d. Fig. II. appears to me free from thoſe objections, the gaſes are received with great convenience in ſeparate glaſſes, and may be examined with great accuracy, by which it will appear, that the gas ariſing from the zinc ſide is pure oxygen, and that from the copper ſide of the trough pure hydrogen, in the proportions neceſſary to form water.

In order to confirm this, let the experiment be tried with ſuch a tube as is given in Plate 2d. Fig. I. and when the water in this tube has fallen to the point of the upper wire, let an electric ſpark be paſſed between the two wires A & B. which will ſet fire to theſe two airs, and the water will riſe again in the tube;—now as we know by the former experiments, that the tube contained no airs but hydrogen and oxygen, and as there was nothing to

afford

afford theſe airs but water, we may ſafely infer that the water was decompoſed.

I find this tube more convenient for this experiment than any other; the wire B not being within the Galvanic circle is in no degree connected with the decompoſition of the water;—but when this is finiſhed it anſwers to explode the gaſes by the electric ſpark, without taking the tube from the trough, or running any riſque of the gas either eſcaping or being adulterated by the admixture of common air.

It is now known that the gaſes may be exploded with equal facility by the Galvanic ſpark, and Mr. Davy has deſcribed an apparatus for this purpoſe, in the Journals of the Royal Inſtitution;—but ſuch a one is by no means neceſſary. The tube repreſented Plate 2d. Fig. III. will anſwer perfectly well, but it is neceſſary that the wire C. ſhould be ſomewhat longer than it is repreſented, ſo as to reach about the tenth of an inch above the point of the wire B. as ſoon as the production of gas ceaſes, which it will do when the water falls below this wire, nothing more is neceſſary than to make theſe two wires touch each other when the communication is made with a large battery: as it will be recollected, that Galvaniſm differs from electricity perhaps in nothing more than in this circumſtance,

cumſtance which is the neceſſity of actual contact between the conductors before any ſparks can be drawn.

In order to make experiments on the oxydation of metals, the tube, Fig. III. is uſed; the wire, which ſhould be of gold, is hermetically ſealed to the glaſs, and the lower wire can be changed at pleaſure, by taking off the ring which faſtens it to the wire D. which is much thicker, and has a groove to admit it. Thus experiments may be made on ſilver, copper, or iron wires, all of which are oxydated with different appearances, by connecting them with the zinc ſide of the trough.

When experiments are made on the revival of metals held in ſolution by different acids, the ſame tube will anſwer, but it is better that both wires ſhould be of gold, particularly in that beautiful experiment of forming the Arbor Dianæ; as, if copper wires are uſed, the ſilver is precipitated in a metallic ſtate by the union of the copper with the nitrous acid, to which it has a greater affinity. Thus the formation of the metallic needles by the hydrogen would be fruſtrated, the ſilver being precipitated by the copper before the connexion between the Galvanic trough could be formed.

I have here, Sir, endeavoured to give you as clear and as full a deſcription of the Pile of Volta, the

mode of conſtructing and adapting it to uſe, as was conſiſtent with the deſign of this eſſay;—while engaged in other profeſſional duties and purſuits, it can ſcarcely be expected that theſe outlines ſhould be free from a variety of errors; the whole, however, is the reſult of ſome obſervation and experience. To diffuſe a more general knowledge of a ſcience ſo intereſting in itſelf, and ſo capable of being applied to many uſeful purpoſes, has been my principal object, if it has led me imperceptibly into a fuller inveſtigation of the ſubject than I originally intended, your candour I hope will make allowance for the intention, and your judgment will correct its imperfections.

You, my Dear Sir, have called forth theſe obſervations, ſuch as they are, accept them as a trifling proof of the reſpect and eſteem with which I ſubſcribe myſelf,

Your

Very ſincere Friend,

W. M.

Plate 1st

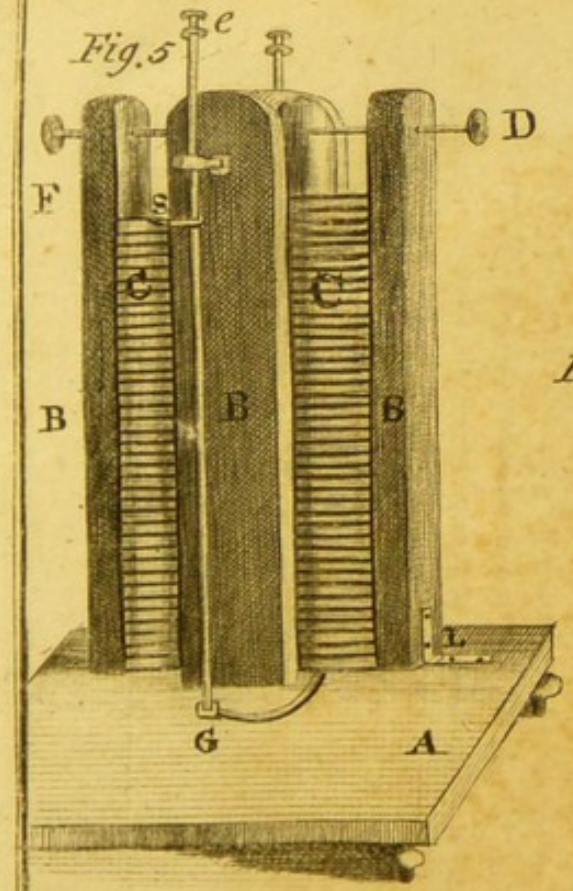
Fig. 5
e
D
F
C
C
B
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B
L
G
A

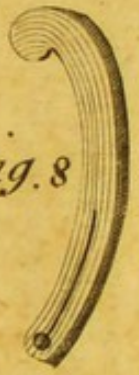


Fig. 8

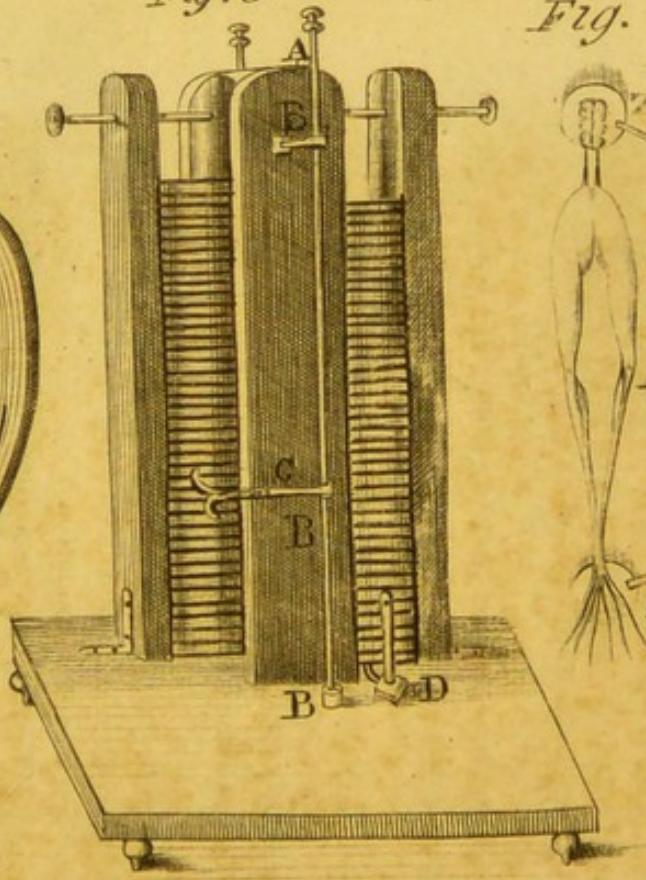


Fig. 6
A
B
C
B
B
D

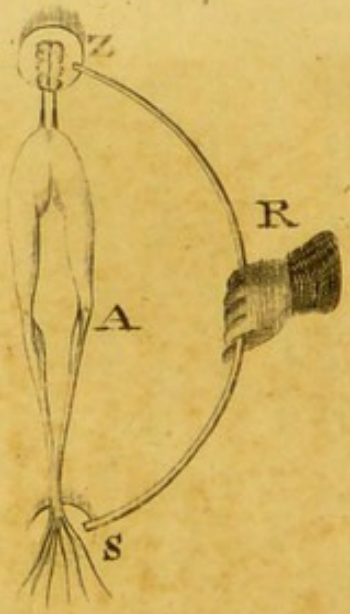
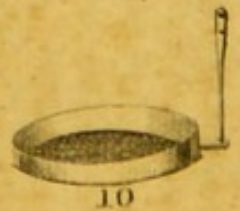


Fig. 2
L
R
A
S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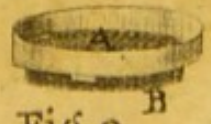
A
B
Fig. 1.


11


A
B
Fig. 9.

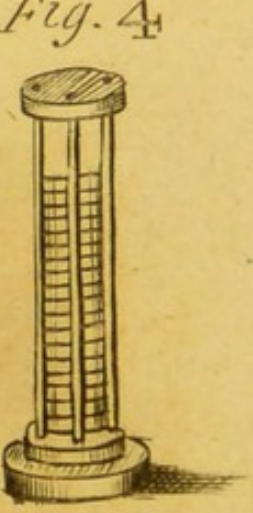
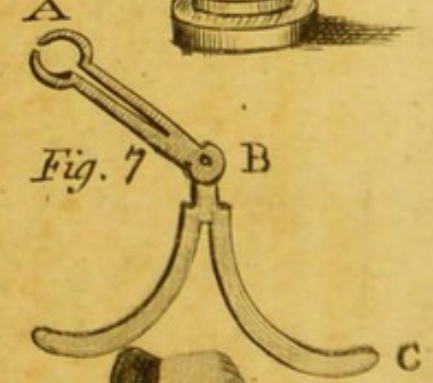


Fig. 4


A
Fig. 7
B
C


C
S
B
Fig. 3.

EXPLANATION OF PLATE I^st.

Fig. 1. Repreſents the lower extremities of a prepared Frog A fixed on a rod of zinc B when a communication is made with a ſilver probe between the legs of the Frog and the rod B the muſcles are thrown into ſpaſmodic action.

Fig. 2. is ſhewn a Frog prepared in the ſame manner, with its feet placed on the ſilver plate S while the ſciatic-nerve attached to part of the vertebre is placed on a plate of zinc Z when a communication is made between theſe two plates with the conductor R the Frog is inſtantly thrown into convulſive action.

Fig 3. Repreſents a Galvanic combination produced by two diſſimilar fluids and one metal. B is a glaſs diſh filled with water, into which is placed a ſmall ſilver cup S filled with dilute nitrous acid—in order to produce the ſame ſpaſmodic action in the muſcles of the Frog, as in the above experiments, nothing more is neceſſary than to complete the circle with the animal as is repreſented at C.

Fig. 4 Repreſents the Galvanic Pile as originally contrived by Volta, ſupported in a frame, and excited into action by diſks of wet cloth interſperſed between the plates.

Fig. 5. Repreſents the back view of Fitzgerald's improvement on the Pile of Volta. A is a ſtand on which the Pile is ſupported, B B B are three pillars made of hard wood, and lined with a coat of cement, they ſerve to ſupport the plates C C in their proper ſituation, and in order to erect the plates on each other, the two ſide pillars turn down by the hinge L. When the Pile is conſtructed, theſe ſide pillars are ſcrewed tight by a rod which paſſes through the centre pillar, and is ſufficiently tightened by a button D which ſcrews on this rod. The communication is made between each Pile by the braſs rod E which is ſcrewed into the conducting wire of the lower plate G and eſtabliſhes the communication with the ſecond pile by a moveable conductor S.

Fig 6. Repreſents the front of the ſame Apparatus, the two tier of plates or cups being connected at the back as before deſcribed in *Fig.* 5 B B is a braſs rod, inſulated at each end by paſſing through Glaſs Tubes cemented to the centre column A. When the Piles are conſtructed and the ſide pillars turned up and ſcrewed tight, the charge is taken with great preciſion by touching the rod B and the braſs pin D which is connected with the lower plate of the pile——The conductor C ſlides on the rod B. and ſerves to regulate the ſtrength of the ſhock by placing the point of it between any given number of plates on either ſide of the pile.

Fig. 7.

Fig. 7. Repreſents this moveable conductor ſeparate, A, the groove which admits it to ſlide on the braſs rod B Fig. 6. and in order to change it to either ſide of the Pile ſo as to include any given number of plates, it moves with a hinge B. The points C are ſhaped ſo as to paſs eaſily between each plate or cup, ſo as to take the ſhock between the pin D Fig 6. and any number required.

Fig. 8. is the braſs conductor which moves on the rod E G Fig. 5. and ſerves to eſtabliſh the communication at S. between the two piles C C.

Figures 9 10 11 Repreſent the zinc and copper plates which are uſed in the formation of the Pile, the conſtruction of them is excluſively the contrivance of Fitzgerald, and in this invention the principal merit of his inſtrument conſiſts.

Fig. 9. repreſents a circular plate of Copper A turned in a lathe and ſcooped, ſo as to repreſent in ſome meaſure the cover of a pill-box.—To the bottom of this cup is ſoldered a plate of zinc, about the thickneſs of a penny piece, but not ſo large as the copper cup.

Fig. 10. Repreſents the ſame ſort of copper cup as at A Fig. 9, but without a plate of zinc attached to it. This is the firſt cup uſed in the formation of the Pile, and is farther repreſented at D Fig. 6. When therefore it is wiſhed to form the Pile, nothing more is neceſſary than to fill this cup with a dilute acid nearly to the top, and then to place on it the cup Fig. 9. with the plate of zinc B. ſoldered to it: by this means the zinc and copper are both in contact with the fluid, and the two copper plates are prevented from touching each other by ſmall bits of whale-bone cemented to each plate; this ſimple contrivance therefore, precludes the neceſſity of uſing diſks of wet cloth between the plates, and by expoſing each metal to a fluid contained in ſeparate cells, it has all the advantages of Cruickſhank's trough, without deviating materially from the conſtruction of the Pile, while at the ſame time it enables us to ſeparate and clean them at pleaſure. Thus, in forming a pile to any extent, nothing more is neceſſary than to conſtruct any number of cups of the form Fig. 9. of any dimenſions and by filling each cell with a fluid, and piling them as deſcribed over each other, a very powerful battery may be formed capable of continuing in action for ſeveral hours.

Fig. 11. Repreſents the firſt cup of the ſecond Pile, as ſhewn at G. Fig. 5. when filled with a fluid, ſuch another cup as is deſcribed in Fig. 9. A is placed on it with its correſponding plate of zinc B ſoldered to it; thus, by adding in ſucceſſion a ſufficient number of theſe cups, the ſecond Pile is formed in the ſame manner as the firſt.

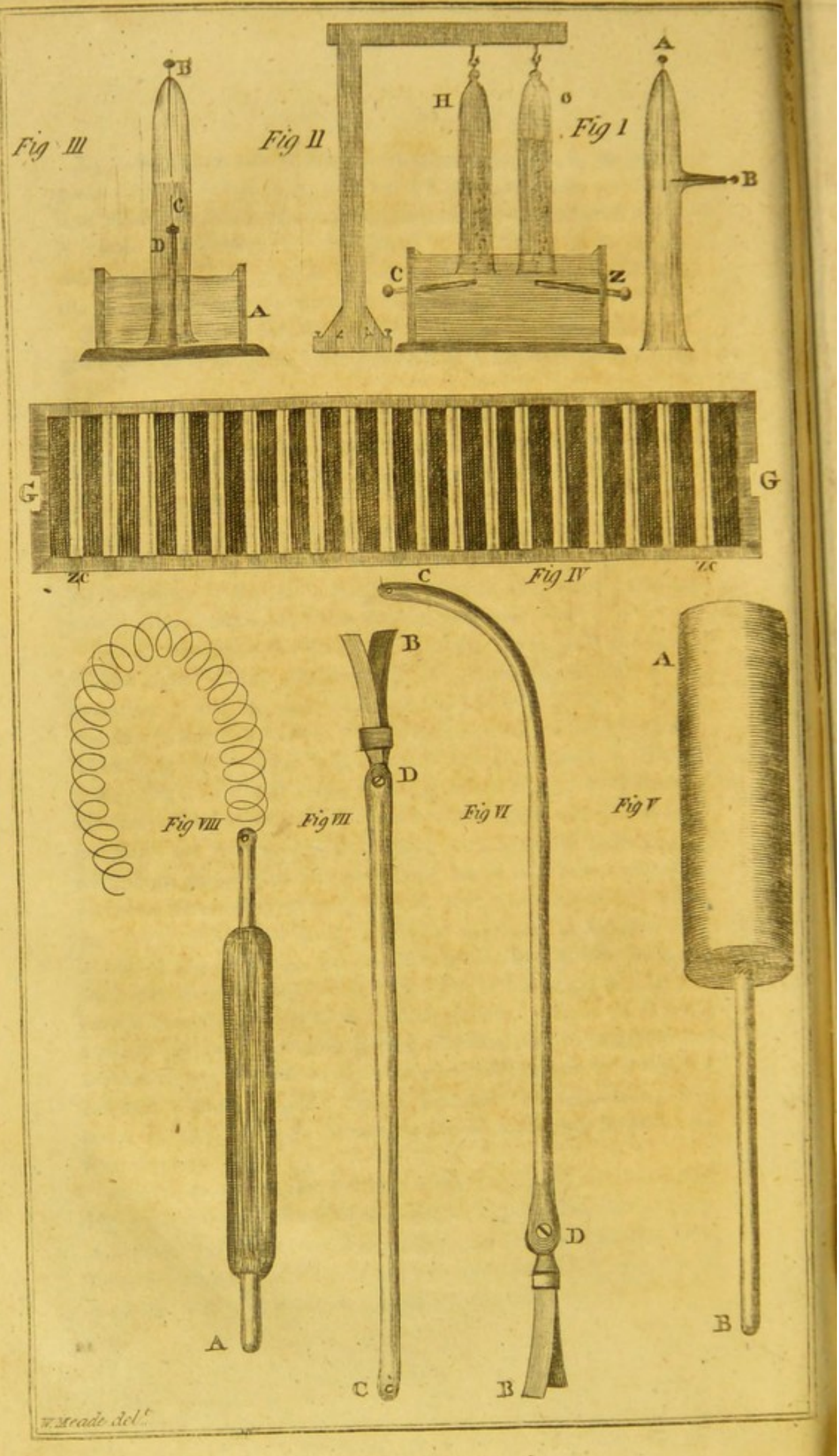


Fig III
B
C
D
A
Fig II
H
G
C
Z
Fig I
A
B
G
G
Zc
Zc
Fig IV
C
Fig VIII
Fig VII
B
D
A
C
Fig VI
D
B
Fig V
A
B
W. Meade del.t

EXPLANATION OF PLATE 2d.

Fig. 1. Repreſents a glaſs tube for receiving oxygen and hydrogen gaſes; this tube, when filled with water, is placed on the diſh A. *Fig.* 3. When theſe gaſes have filled the tube as far as the lower point of the wire A. *Fig.* 1. the electric ſpark paſſed between the wire A. B. will explode them and form water.

Fig. 2. Repreſents two glaſs tubes ſuſpended over two wires Z & C to receive the oxygen and hydrogen ſeparately; the wire Z. is connected with the zinc ſide of the trough, and C. with the copper ſide; thus the tube O. receives oxygen, and the tube H. hydrogen.

Fig. 3. Repreſents a glaſs tube with a gold wire B. hermetically ſealed in it; this tube is filled with water and inverted over the wire C. which is ſcrewed into the diſh A. This wire can be changed, by ſlipping it out of the groove D. where it is held by a ring. By this means experiments on different metals, as well as on different metallic ſolutions may be eaſily tried.

Fig. 4. Repreſents the Galvanic trough containing plates of copper and zinc; the dark ſhades repreſent the cells for holding the fluid; Z. and C. repreſent the zinc and copper plates ſoldered together. G. G. repreſents grooves at each end of the trough into which the two conductors, *Fig.* 6. & 7. ſlide, ſo as to communicate with the cell at each end.

Fig. 5. Repreſents a braſs diſcharging rod, one of which is to be held in each hand to receive the ſhock; A. repreſents the handle, which is much thicker than the point B. in order to expoſe a greater ſurface to the hand.

Fig. 6, & 7. Braſs conductors, the ends B. B. ſlide in the grooves G. of the Galvanic trough; the point C. of *Fig.* 6. is turned down into the diſh A *Fig.* 3. while the ſtraight point C. of *Fig.* 7. is placed on the button B. of *Fig.* 3. the circle between the wires C. & B. is then completed, and gaſes ariſe according to the ſide of the pile to which the conductors are attached; and in order that the conductors ſhould be adapted to any part of the trough, they move on the joints D. in a circular direction.

Fig. 8. Repreſents a braſs rod, partly covered with roſin or glaſs, for medical purpoſes, one of theſe ſhould be connected by the ſpiral wire to each end of the conductors, *Fig.* 6. & 7. which have ſmall holes perforated at the round points to admit them; theſe rods are held by the reſinous part, and the points A. ſhould be applied to that part of the body through which it is wiſhed to paſs the Galvanic current.