

**General views on the application of galvanism to medical purposes;
principally in cases of suspended animation / By John Aldini.**

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GENERAL VIEWS
ON THE
APPLICATION OF GALVANISM
TO
MEDICAL PURPOSES ;
PRINCIPALLY
IN CASES OF SUSPENDED ANIMATION.

By JOHN ALDINI,
HONORARY MEMBER OF THE ROYAL HUMANE SOCIETY,
Honorary Professor of the Imperial University of Wilna, Corresponding
Member of the Medical Societies of London and Paris, of the
Society for the Encouragement of Arts, Manufactures, &c.,
Member of the Imperial Institute of Milan, and of
the Academies of Turin, Bologna, &c.

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1819.

4

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ORDINARY MEMBER OF THE ROYAL HUMANE SOCIETY.

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LONDON:

ADAM AND CHARLES BLACK, 25, NASSAU ST. AND GREAT
NORTH ST. AND
J. COLEMAN AND CO. LONDON, AND SMITH
AND SON, LONDON.

DEDICATION.

*To the Directors, Governors, &c., of the Royal
Humane Society.*

Your Royal Highnesses,

My Lords and Gentlemen:

THE interest with which you have been pleased to accept my "Observations on Medical Galvanism," the impressive spectacle of individuals who have been restored to life beheld by me at the late Anniversary Festival, the encouragement given to my labours by the august presence of His Royal Highness the Duke of Sussex, the zealous protector of all philanthropic, literary and scientific establishments, induce me to presume to dedicate to you the accompanying little essay.

In a commercial and maritime country like Great Britain, in which so many persons, from their occupations at sea, on canals and rivers, and in mines, are exposed to drowning, suffocation, and other accidents; and it must be added, however painful the remark, where so many unhappy creatures, who, labouring under a temporary privation of reason, form the horrible resolve of self-destruction, the subject of this work is of the utmost importance in a public view.

I cannot but acknowledge, with feelings of the deepest gratitude, the honour you have conferred on me, by electing me an honorary member of your Society. Your views are my views, and they are directed solely to the public good. Anxious to render the application of galvanism to the purposes of medicine generally, and to the cases of suspended animation in particular, more simple, I have endeavoured to unite to the observations herein contained, the relation of some experiments, which appear to me conclusively to demonstrate the power of galvanism over the organs of respiration.

That your benevolent institution may long continue to flourish—that its benefits may be extended to every part of the globe—that this short memoir may be one of the happy instruments to facilitate your laudable endeavours, is my most ardent prayer. If only *one* life be saved by its agency, I shall receive ample recompense for directing my labours to such a research, and partake with you the satisfaction of having added a new means to restore to his friends and to society an apparently lost citizen.

I have the honour to be,

With sentiments of the greatest regard

and esteem,

Your most devoted servant,

JOHN ALDINI.

London, June 15, 1819.

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INTRODUCTION.

It must be admitted that the wonderful discoveries in Galvanism made by Sir Humphry Davy, Dr. Wollaston, and others, have lately conduced much to the knowledge of Chemistry, whilst the same principle has made in general but a small progress in its application to the purposes of Medicine. The effects of galvanism on the animal economy, may be distinguished into two kinds: 1st. That which arises from the mechanical impulse or shock; 2d. That which is produced from the current of the galvanic fluid. The use of galvanism in medicine depends, particularly in cases of *asphyxia*, on the simplicity of the formation of the apparatus, and the facility with which it can be applied.—It is not on the *size* of the plates, which are used in the

galvanic apparatus, that the power of their influence on the animal economy depends ; but on the *number* of them. In chemical operations, the plates belonging to the apparatus require to be of extensive surface, which is not at all necessary when galvanism is only intended to be applied to the animal economy. In short, in my experiments on the passage of the galvanic fluid, made at Calais, across that part of the ocean between the *Jetty of the West* and *Fort Rouge*, I made use of a pile consisting of only eighty plates of zinc of an inch in diameter, together with an equal number of silver plates.

The galvanic influence, considered as mentioned above, forms the subject of the present dissertation, which I commence by describing the apparatus necessary for its application.

SECTION I.

On the Apparatus used in the application of Galvanism to Medical Purposes

1. THE application of medical galvanism must materially depend on the nature of the galvanic apparatus, which should be portable, of little expense, and capable of being put in action by any person, by means of easy and general rules. Some years ago, I was able to employ only a pile, and a trough, constructed in the ordinary manner, to answer the above-mentioned conditions, and this is probably the reason why medical galvanism, which at first promised so much, fell at once nearly into disuse. I have therefore first devoted my thoughts to the construction of an apparatus necessary to be used in cases of suspended animation, which forms the principal object of this dissertation. Afterwards, I have considered those employed in the general

use of medicine ; and, aided by this apparatus, I expect to obtain a prompt and instantaneous galvanic action, by means of a pile, consisting of a series of small plates of copper, with pieces of zinc placed between them, of a less diameter, and separated by small pieces of cloth.

2. The above-mentioned apparatus, made by M. DUMOTIEZ, of *Paris*, when immersed in the usual solution, answered the wished-for end ; but it was much more expensive than the common pile, at the same time that its bulk rendered it cumbersome and inconvenient. By subsequent improvements the action of the pile has been rendered more certain and powerful ; the difficulty and the length of time required to move it, has been avoided, for it is only required to place and displace it whenever it is put into use. I began by placing on a silken thread small pieces of zinc and copper of various forms, either curved or straight, in the same order in which the pile is set, placing between each pair pieces of dry cloth of a smaller surface than that of the pieces of metal. When this kind of pile is once prepared, it has only to be immersed in the usual solution, either of muri-

ate of ammonia, or diluted nitric acid, when wanted for use, and directly the powerful effects of galvanism are produced. After use, it should be dipped in simple water, which, absorbing from the pieces of cloth, the acid which is in a state of solution, stops the oxydation of the pieces of metal, and by this means the pile is always ready to be put in action without setting it again. When composed of from 100 to 150 pieces in the manner mentioned, it will be capable of every impulse and power required in the practice of medicine.

3. Thus have I been enabled to form a pile capable of being brought into action in an instant. For the construction of this instrument, Mr. CUTHBERTSON furnished me with 120 plates of copper and zinc of an inch in diameter, perforated in the middle. Through these spaces I passed two silken threads, one through each of the sixty, placing between each plate a piece of dry cloth as usual. The pieces of cloth should always be less in size than the plates, and therefore I have always made use of pieces of cloth half an inch in diameter. A frame of wood encloses the two piles, and it conse-

quently remains in the power of the person who performs the experiments to make use of the piles separately, or conjointly, by forming a communication between them. The silken thread must be rather longer than the pile formed by the plates, so that when it is necessary to set one or both of the piles in action, we need only dip them in the usual solution, at the same time separating the plates, so that the acid may easily moisten the pieces of cloth. In about a minute's time the plates may be replaced and again approximated to each other, and being suspended to the frame, they will be able to produce a powerful shock. At first the action of one of the piles will be sufficient. In cases where the greatest impulse is requisite, both may be used; this, however, will seldom happen in cases requiring medical galvanism, since the action is so very powerful, that in some cases it might even prove injurious. It must, therefore, be left to the discretion and prudence of the person who employs this agent, to let it act by degrees, so as to ascertain what power is necessary for the relief of the disease, and adapted to the situation of the patient.

4. My object is to shew, not only the strength required, but also the parts to which it ought to be applied in cases of suspended animation. It may be necessary again to repeat the precaution that must be used with regard to the above-mentioned pile, *viz.*, of dipping this galvanic apparatus in water immediately after it has been used. By this means the plates which are a little oxydated by use, may be cleaned without discomposing the pile. It will suffice to withdraw them one by one from the thread to which they are suspended, and place them in a horizontal position, so that they may be conveniently cleaned. By means of this process, and with a little instruction, any one may have the keeping of the said apparatus, and preserve it in a state fit to be used at pleasure. I must observe that in cases of suspended animation, the plates will be but slightly oxydated, the application of galvanism being generally but of short duration; in fact, if the decreasing powers of the animal economy be not quickly restored, they are destroyed altogether; and of course, in that case, the application of an stimulus whatever must prove ineffective

5. By adopting another mode of constructing this apparatus, I have superseded the necessity of making use of pieces of cloth: I place between the plates a solution of ammoniac, availing myself of the principle of attraction, which causes the water to rise in capillary tubes. The following is the apparatus: two vertical columns of wood on a base, sustain horizontally a series of from fifty to seventy plates of copper plated with zinc. They must be placed at small distances from each other, as experience dictates, which renders it easy for the solution to run between the plates when the pile is dipped in it, and by means of the attraction of the surfaces, the solution adheres to them, even when the pile is taken out. By this means a very powerful galvanic shock may be obtained; and, according to the circumstances of the case, use may be made either of one or both of the piles placed vertically on a common base, from which a communication may be made when required. The plates which I use are but an inch square, and therefore the whole apparatus is of a very convenient and portable nature. As I before observed, it is necessary, in order to

prevent the too great oxydation of the plates, and to keep the apparatus in a state fit to be used again, to remove all the solution, by placing the apparatus in pure water, and afterwards carefully wiping it dry. But if, after doing all this, there should chance to remain any oxydation, a fine file may be used, which, being passed over both sides of the plates, will be sure to have the desired effect. Other piles are not so convenient, nor the common trough either, the plates of metal being surrounded by wood on three sides, and not on two only, as in the above-mentioned apparatus.

6. In those diseases which do not require an almost instantaneous application of galvanism, recourse may be had to piles of various constructions, or to troughs as well as to the above-named apparatus, provided the plates be of small dimensions, not exceeding an inch square. Whatever may be the form of the trough, experience has proved to me that the distance between the plates may be less, in order to use a smaller quantity of acid, and to render the apparatus less bulky and more easily to be managed. Attention must also be paid to the choice of the acid

to be used, and to the exact quantity of a ter to be mixed with it, in order to prevent too quick an oxydation, which may cause an instantaneous cessation of the galvanic action, when according to the nature of the disease it might be necessary to keep it in activity for a considerable time. There are many cases in which violent shocks, instead of being of use, would injure the animal economy; whilst repeated slight shocks would prove efficacious, and be equal to a continued action of the apparatus. I remember that being at one time in the vicinity of the sea, I observed that its waters had the power of putting a small trough in action, and I have also remarked the same effects several times, when I made use of an artificial solution of muriate of soda. By these means I have contrived to prolong for many hours the action of galvanism, which would have ceased had I made use of strong solutions, conducing to a too rapid oxydation.

7. When galvanism is applied to medical purposes, it is necessary to have an instrument to measure the extent of its power. When galvanism is employed as a stimulus, the galvanic fluid must be directed to the

diseased part, by means of many successive applications of the arc that conducts it. The number of shocks after the operation are generally unknown ; whereas, by keeping one of the arcs fixed to the column that supports the pile, and to one of the extremities of the diseased part, (instead of applying the other arc with the hands, and withdrawing it continually,) there might be a lever, which rising and falling so as to form a circle between the diseased part and the other column of the pile, a correct account would be kept of the number of shocks, expressed by the number of movements made by the lever. Therefore, by a regular motion of the lever, by means of wheels constructed like those of a watch, I have contrived it so that it should continually rise and fall every second minute, in order to be able, by this alternate motion, to form a communication between the pile and the diseased part. A second dial fixed to this machine, will keep a faithful account of the actions produced, during a stated time, by the application of galvanism.

8. This machine was completed many years ago, in France, under my direction ; I brought it to act with the greatest precision, and it has

often been employed by me with full success. I afterwards presented it to the Museum of Natural Philosophy, in the Lyceum of Brescia, where it is placed in their collection. Mr. Cuthbertson has shewn me a similar instrument which he invented some years ago, and which he has described in his work. Its construction is in some respects different, but it obtains the same results. The utility of a machine like this, for registering the number of shocks given in cases requiring medical galvanism, was universally acknowledged; and yet observing that it has been quite abandoned, I cannot but impute this neglect to the too expensive nature of this apparatus. But I trust that I have succeeded in remedying this inconvenience, by substituting more simple means, in order to produce the same effects, and that without constructing any separate instrument for this object.

9. I think that a common watch may be made to answer every necessary purpose. All that is requisite is to form a communication between the base of the pile, and any metallic part of the watch, by means of different threads; a small metallic cylinder should also be placed at such a distance from

the watch as to be able to come in contact with it at every oscillation. A communication should be formed between the diseased part to which the galvanic operation is to be applied, and the silken thread of the pile, and also with the cylinder ; and thus it will form a part of the circle of the galvanic current, and the patient will feel a shock at each vibration of the pendulum. Consequently, an account being kept of the number of oscillations given in a minute, the number of shocks experienced by the patient in any given time may be correctly ascertained. The alternate striking of the pendulum against the above-mentioned isolated cylinder will be more easy than in the common watches, in which some contrivance is necessary in order to keep up the vibration.

10. When common watches are not used, the movement of a pendulum may be produced for a quarter, or at most half an hour, by means of a spring which may be procured at little expense.

I have found by experience that when galvanism is applied to patients in the aforesaid way, it is necessary to give them a short interval of repose; during which the machine

may be loaded again. Supposing the vibrations to take place every second, the patient may experience in the space of half an hour 1,800 galvanic shocks, which is indicated with precision by the index of the dial annexed to the apparatus. By varying the length of the pendulum, the number of the vibrations may be increased or diminished in a given time, according to the different nature of the case, and the aptitude and strength of the patient to bear the galvanic shock.

11. As the value and importance of galvanism are now universally allowed, every effort should, of course, be made in order to bring the galvanic apparatus to perfection. As Professor ZAMBONI has succeeded by means of two unmoistened piles, in moving a pendulum, so as to make a watch go for months and years, it is perhaps not unreasonable to hope that one day a similar contrivance may be found, adapted to act for a length of time on the animal economy. At all events, the above-mentioned apparatus* suffices to facilitate the medical application of galvanism; and, in devising a method of constructing an

* See the Notes at the end of the Memoir.

apparatus of greater simplicity, I was actuated by the consideration that the materia medica should not be monopolized, to the great injury of the poor, who, owing to the great expense necessary for procuring the assistance of galvanism, are deprived of its advantages, in the same manner as they are in many places of vapour baths and fumigations, although experience has proved them to be a safe and efficacious remedy in various maladies.

SECTION II.

On the Effects of the Galvanic Fluid on the Human Frame, after Death.

12. HAVING many years ago proposed to myself to make an application of galvanism to persons apparently drowned, or in the state of asphyxia, I made a variety of observations on the condition of the human body af-

ter natural death. The method I employ is very simple. I put the hand of a corpse, moistened with salt water, in contact with the base of a Voltaic pile, consisting of from 60 to 80 pair of plates of zinc, coated with copper, and then form a communication to extend from one ear to the top of the pile. The galvanic power by this means has produced, according to the state of irritability of the corpse, various contractions, sometimes of the fingers, sometimes of the hand, and sometimes even of the whole arm. The fingers bend and unbend very visibly, and sometimes the whole fore-arm is carried towards the chest. I have varied and multiplied these experiments on several dead bodies, and I have remarked how much the difference of the diseases, which have proved fatal, contributes to the long or short duration of the muscular contractions. By continuing these researches with more minuteness, we should, I conceive, in time attain a more correct knowledge of the vital principles, and their different degrees of power, as they vary according to the sex, the age, the temperament, the physical constitution, and even the climate, and the changes of the atmosphere.

13. In applying galvanism according to the method I have proposed, no incision is required, and no separation of the nerves, or of the muscles, is necessary. The method is so convenient and simple, that the most scrupulous of the profession, far from opposing it, ought strongly to enforce its being employed, together with the other means, generally used in the cases to which it is adapted. The importance of making such observations, in order to decide, in a probable manner, in what cases it would be necessary to defer interment, and those in which humanity requires all possible means to be employed to re-animate the vital powers, may be easily conceived. Numerous instances could be produced, in which persons have been hurried to the grave before life was entirely extinct. I view with horror and indignation the haste with which a man, who appears to have drawn his last breath, is thus banished from society, and deprived of a chance of recovery. Wise laws, such as those of Athens and Rome, afforded security to prevent persons from being buried alive.

14. With this important object in view, I found it necessary not to confine myself to

observations made on the bodies of men who had sunk under disease ; taking it for granted that the development of the cause which occasions death, destroys all the elasticity of the fibres, the fluids being vitiated or diseased. I did not neglect to avail myself of the first opportunity of applying the galvanic power to a body which preserved, after death, in the highest degree, some of its vital powers.

At Bologna, in the year 1802, the Government granted me permission to make experiments in galvanism on the bodies of two decapitated criminals. The first who was decapitated, was brought to the place which I had selected near the grand Court of Justice. The head first underwent the action of galvanism, by means of a pile of 100 plates of silver and of zinc; two metallic wires, one of which proceeding from the base, the other from the summit of the pile, terminated in the interior of the two ears of the man, which had been previously moistened with a solution of salt in water. All the muscles of the face underwent frightful contractions. The motion of the eye-lids was very strong, though less sensible in the human head, than I had before observed in that of an ox which

I had galvanised. I then placed a metallic wire in the form of a bow from the top of the pile, to the left ear, on one side, and a similar one from the base of the pile to the tip of the tongue, which was protruded about an inch beyond the lip; the face was again contracted, the tongue was drawn in on the first application, and the mouth emitted a little saliva. Strong contractions took place on applying the wire to the nose, to the forehead, to the eyes; and even when I substituted in the place of the first pile, another composed of 50 pieces of copper, and of zinc, which I went on diminishing in order to obtain different degrees of action.

15. I afterwards repeated the same experiments, and with the same results, on the head of the second criminal, who was brought to me half an hour after. Being desirous to examine, according to the principles of Galvani, the power of the arc formed by fluid in animals of warm blood; and wishing to exemplify in man the simultaneous contractions which I had before observed in the heads of two bullocks, by extending the arc in various ways from one to the other, I placed horizontally on a table the heads of the two men who

had been executed, contriving so that the parts of the two heads where the section had been made, should communicate only by means of the animal fluid. All things thus prepared, I made a communication with the pile, from the left ear of one, to the right ear of the other; it was surprising and even frightful to see these two heads making at the same time horrible contortions, as if at each other, so that some of the spectators who were not prepared for such results, were exceedingly terrified. I observed that the convulsions excited in this situation were stronger than those produced when I made the experiments on each head separately. It was also proved that the communication by the animal fluid, had fully made up in this experiment, for the want of the continuation of the nervous and muscular fibres.

16. After these experiments, I went to the body of the second criminal, which I judged better adapted for experiments than the other. The muscles of the fore-arm, and the tendinous parts of the metacarpus were first laid bare, and a communication made between them and the spinal marrow. The galvanic power was then applied, and to the

great surprise of those who assisted at these experiments, the arms were seen to rise. Having uncovered the extending tendons of the fingers, at the back part of the metacarpus, by forming a communication between that part and the spinal marrow, I produced strong contractions in the fingers and in the whole of the hand. I afterwards extended the arc from the biceps muscle of the right arm to the spinal marrow, and directly produced such powerful contractions, that the arm which was placed horizontally was raised in the fore part six inches above the surface of the table, on which the dead body was extended. An hour and a quarter after their execution, I placed in the palm of the hand a pair of iron pincers, weighing half a pound; the hand was raised, and the fingers bent, as if they would clasp them; but when arrived at the greatest height, the contraction ceased, and the pincers fell. Professors Vassalli, Eandi, Giulio, and Rossi, had also observed in several criminals who were decapitated at Turin, that when the uncovered muscle of the biceps as well as its tendon was touched, the contractions succeeded each other so quickly and so violently, that the fore arm was com-

pletely bent against the upper part of the arm, and that the hand raised a weight of several pounds, more than fifty minutes after the decapitation. I think that repeating these experiments, without any interval between them, in order to take advantage of the highest degree of vitality, the hand might be gradually loaded with different weights, until one should be found, which would entirely hinder the motion of the arm, and by which means we should be able to calculate the strength exerted in raising it.

17. Professor Mondini, a celebrated anatomist, of Bologna, assisted at these experiments, and performed himself all the dissections necessary, in order that the galvanic fluid might act in every part of the human body. Consequently, I could apply the metallic arc sometimes from one of the ears to the dura mater, to the other meninges, to the cortical substance of the brain, to the corpus callosum, to the corpora striata, to the thalami nervi optici, and to the cerebellum.

The body of a third decapitated criminal, on which I made these minute applications, was extremely robust, and in him the contractions were most evident. The motion of the

diaphragm was very perceptible; the pectoral and intercostal muscles diminished the spaces between the ribs, and they imitated the motions caused by respiration. The head which had been cut off, being brought near to the neck of the body, I made a communication with the trunk by means of the animal fluid alone, and then extended an arc from the head to the different parts of the trunk; the contractions were visible over the whole of the body, but particularly in the trunk.

18. The above observations seem calculated to prove the communication of galvanic power by the animal fluid, which indeed is essential to the production of muscular contractions, and of more consequence than even animal heat. I have found in my experiments that muscular contractions have taken place after a considerable diminution of the natural heat of the body, even after the body had been cold for many hours, and even after it had been exposed to a temperature below 0; on the contrary, the contractions cease immediately the animal fluid is withdrawn. If a muscle laid bare resists the stimulus of galvanism, owing to the loss of a great deal of moisture, the contractions may imme-

diately be renewed by means of a humid injection, either on the muscles themselves, or on those that surround them. By this means I have been able to prove, that five hours after death there still remained partial motions, whenever the wires were applied to the muscular fibres.

19. In consequence of the former experiments I caused the chest to be opened, in order to apply the galvanic fluid to the heart. The pericardium having been removed, I applied the conductor to this important organ of life, which I had opened to see if, in any of its parts, there existed a fibre capable of oscillation. No contractions took place, which I think must be attributed to the want of a certain degree of heat, and to the absence of animal fluid, which did not exist two hours after death. The before-mentioned Professors of Turin, to whom I communicated these phenomena, dispensed with my proving by new observations this apparent anomaly, produced even in the highest state of vitality. Their experiments are conclusive enough to prove that the galvanic fluid acts on the heart in three different ways :—

1st. By acting on the spinal marrow by

means of a leaden cylinder plunged into the canal of the cervical vertebræ, and by their placing one of the two extremities of a silver arc on the surface of the heart, and the other on the communication of the spinal marrow. The heart which, in the individual on whom galvanism was tried, still possessed a great deal of vitality, was immediately very visibly and strongly contracted.

2d. In forming communication between the par vagum and the sympathetic, without the assistance of the pile.

3d. By means of Volta's apparatus, and by using in general a pile composed of fifty plates of silver and an equal number of zinc. The before-mentioned Professors have by these three procedures, observed on many decapitated persons strong contractions of the heart, and have ascertained that the apex is of all its parts, the most susceptible of motion, and of the galvanic power. They observed also, that next to the intestines, the heart was the first to lose its susceptibility to galvanism, then the diaphragm, and last of all, the muscles at the extremities; which proves, in my opinion, that the heart, which, according to the principles of Haller, is the

first to receive life, and the last to lose it, follows a different law, when it undergoes galvanism.

20. I must in this place refer to the wonderful galvanic experiments made by Professor Ure, at Glasgow, in the month of November, 1818, as also to those made by me before the Royal College of Surgeons, as early as the year 1803, on a criminal executed at Newgate ; that nothing may be omitted on a subject so important, the account, at full length, is subjoined to this essay. From the observations which have been enumerated, it is evident, that the power of galvanism is so satisfactorily shewn, as to render repetition of the experiments unnecessary, unless directed to some new and important view. I should think it a prostitution of galvanism, if it were only employed, to cause sudden gestures, and to convulse the remains of human bodies ; as a mechanic deceives the common people by moving an automaton by the aid of springs and other contrivances. Mr. Ferry, as early as the 20th of April, 1803, shewed me at Paris, a work of his on the following question :
“ Is it allowable, in order to the progress of gal-

vanism, and to throw a greater light on the true theory by which it ought to be regulated, to try experiments on the limbs of individuals who have by their crimes forfeited their lives, and who have been condemned by the law, and to produce on them contractions and convulsive motions?" After many observations, this author, following the rules of rigid justice, condemns as unjust and immoral, such experiments, as the torments of these unfortunate people might probably be prolonged by them. He grants, however, a generous pardon in this work to all those who, up to the time he writes, had tried such experiments, on account of the important truths discovered by their means; and he invited me, and all others who made experiments for this purpose, to promote galvanism in future by trying experiments on that class of quadrupeds whose organization being similar to our own, would conduce to the same end. Very far, however, from regarding the use of galvanism as improper in cases of apparent death, I maintain, that reason and humanity loudly call for its being employed. I, however, agree with the author, in thinking that the experiments already made suffice to recommend its application. (b)

SECTION III.

*On the Application of Galvanism in Cases of
suspended Animation.*

21. THE more we reflect on the condition in which the great springs of life are found in those affected by asphyxia, the more we shall be convinced of the utility of the galvanic stimulus to re-animate them. Their muscular system is relaxed to the greatest degree; their limbs are flexible, and what is more remarkable is, that they continue in this state some time after death; a phenomenon which proves that a man may be dead without his limbs being stiff, which has usually been accounted one of the signs of death. The relaxation of the muscular, is favourable to the inactive state of the vascular powers. The blood-vessels of the brain, and those of the lungs particularly, are gorged with blood. The auricles and the ventricles of the heart are overcharged, the repletion of the venæ cavæ is extreme, and all the venous system is surcharged with blood.

22. Many are the methods which have been proposed to relieve persons in this miserable situation. At the same time that I propose galvanism as the primary means, I consider others as useful and tending to the same end; and principally amongst these, the method of assisting the renovation of action in the lungs, by introducing by artificial means oxygen gas, or air fit for the purposes of respiration. I do not, however, agree with some who are of opinion that recourse is to be had to galvanism, after having for two hours tried unsuccessfully the usual means. But I think that artificial respiration ought to be first attempted, accompanied by the application of the galvanic power externally to the diaphragm, and to the region of the heart, and afterwards to various parts of the muscular system.

23. On applying galvanism to the body of a dog, amongst other experiments that I tried in company with Professors Alibert and Richerand, a certain quantity of air was seen to issue from the trachea whenever the wires were applied. This observation was thought to deserve a particular examination; for which reason I placed the flame of a lighted

candle opposite the *trachea* of another dog, that had been decapitated, and which I galvanised. The candle was twice extinguished, and I might have produced the same effect oftener, as I had the opportunity of convincing myself afterwards. In fact, having repeated these experiments in London, at the Anatomical Theatre formerly belonging to the celebrated Dr. Hunter, now in possession of Mr. Wilson, Professor of Anatomy and Surgery to the Royal College of Surgeons; at Guy's and St. Thomas's Hospitals, in company with Mr. Astley Cooper, who did me the honour of performing himself such dissections as were requisite; I found that, in consequence of applying the arc to the region of the diaphragm, a candle was several times extinguished.

24. This extraordinary effect of galvanism on the lungs, which has lately been confirmed by experiments made by Professor Ure, induced me to try it in the case of drowned animals. I therefore held under water, cats, dogs, and other animals, until respiration and muscular motions seemed to have ceased entirely. After having galvanised them, in a manner similar to that already mentioned, I had

sometimes the satisfaction of restoring them, from apparent death. But what means can be more efficacious in such cases than galvanism? I here invite physicians to repeat and vary these experiments on animals, in a state of asphyxia, produced in different manners, and by different means for establishing these important results.

25. I must not omit to mention here, the interesting observations which M. Gaudin, Professor of the Veterinary School at Alfort, was so good as to communicate to me on this subject. The mayor of the town called in M. Gaudin, in order to galvanise a young man who had just been drawn out of the river *Marne*, into which, whilst leading four horses to water, he had been thrown. Three quarters of an hour had elapsed before the unfortunate young man was taken out of the water. The Professor in vain lavished on him all the resources of art: friction, fumigation, inflation, and even opened several of his veins. Although there were no hopes of recalling him to life, the Professor made the body undergo the action of a galvanic pile of sixty couples of plates of zinc and of copper. From

this weak pile, both from its quality, and the number of the plates, and also by the way in which it was arranged, a conductor was fixed extended to the left arm-pit, and another communication was established from the nostril on the same side, forming an arc to the summit of the pile. The Professor then changed the disposition of the apparatus, and the conductor proceeding from the base of the pile, was placed in the *anus*, and the other introduced into the larynx. At the first touch, not only the muscles of the face were contracted, but two frothy streams also issued from the nostrils, which proved that the diaphragm had participated in this action, and the anus ejected also the *fæces* contained in the *rectum*. From these observations, one may conclude that galvanism is the most powerful of all the means used to recall to life those who have been apparently drowned, and who cannot be re-animated by the usual means. (c)

26. I have lately made a series of experiments to confirm the opinion I entertain of the advantages that I feel confident will be

derived from the employment of galvanism in cases of suspended animation. I have tried its effects upon a dead animal in different modes, and under various circumstances: sometimes from the spinal marrow to the diaphragm, sometimes from one of the ears to the rectum, at others from the origin of the phrenic nerve to the diaphragm, and I succeeded in exciting so powerful an expulsion of air from the lungs, that a lighted candle, held at a little distance from the mouth, was extinguished. This sensible effect of air expired from the lungs, remained constant so long as the conductor was charged with the force of a hundred pieces of copper and zinc of the larger size. I repeated the experiment upon a rabbit, with an apparatus of double power; but although the galvanic shock was thus augmented, I could obtain but one short action, during which I observed, that the candle was extinguished. I am of opinion that this effect may be attributed not only to the greater weakness of the organs of this kind of animal, but also to a certain limit of action which is found in the application of galvanism to animals, and which constitutes

the difference between this and the action of common electricity.

27. During my residence in Paris, I paid a visit to the veterinary school at Charenton, in company with some medical gentlemen of high reputation, and witnessed the galvanic shock applied to various animals, beginning with the rabbit, and finishing with the horse. I observed that the latter animal was capable of sustaining the shock of a battery, formed of various layers of copper and zinc, to the number of 4,000, in various parts of the body, without exhibiting any visible impression on the parts to which it had been applied; whereas an electric battery of equal power, and charged in the usual way, would cause death, and leave behind the traces of its action.

28. But I shall not pursue these speculations any farther, at present. My object is not to lay down any new philosophical theory, but to establish some easy and practicable method of relieving my fellow-creatures when under a state of *asphyxia*. I do not pretend to draw any conclusions as to the manner in which galvanism affects the action

of the heart; for that it does affect it, has, I trust, been sufficiently demonstrated by the experiments detailed in the preceding Section:—all that I maintain is, that it produces an influence, which, acting conjointly with the excitation given to the lungs, concurs in the work of re-animation.

I have also observed, that there are many cases of *asphyxia*, in which it is not necessary to make a direct application to the heart: for we must be careful not to confound *asphyxia* with *syncope*, as many have done. Sauvages divides them into two maladies of distinct natures: for in the case of *syncope*, the motion of the heart does not entirely cease; whereas in *asphyxia*, on the contrary, it no longer perceptibly beats, or performs any other of its functions. A distinction should also be made between *asphyxia* and *apoplexy*; for in the latter, the brain is the first to be affected, while respiration and the pulse continue very strong; whereas, in the case of *asphyxia*, the heart and lungs seem to be the first organs affected.

29. From all this, it may justly be concluded, that the application of galvanism ought not merely to be confined to cases of

drowned persons, but may be employed in any other case whatsoever of a general suspension of sense, whether produced by the effects of pernicious food, or of atmospherical fluids obnoxious to respiration, or proceeding from the fatal consequences of attempted suicide. In many of these cases, it is proper to try the effect of galvanism not only upon the heart, but also on the brain, affected as it invariably is in its functions. In cases of persons falling from lofty buildings, of which but too frequent instances occur, common electricity has been employed with effect: now I conceive, that in such cases galvanism might be much more successfully applied, by having recourse to the simple apparatus which I have before described. Thus, might that loss of time be remedied, which is generally found necessary for preparing and combining the action of an electrifying machine; for my galvanic apparatus might be brought to act immediately.

30. The application of galvanism, in any case, does not exclude the use of those other remedies which have hitherto been beneficially employed by the Royal Humane Society, instituted for the recovery of persons appa-

rently drowned or dead; on the contrary, when prudently associated with the usual remedies, according to the nature of circumstances, it may be rendered doubly efficacious in restoring the vital functions. If animation has been suspended beyond the period of an hour, I fear that this remedy would prove ineffectual; therefore it is necessary to apply it in the very first moment that *asphyxia* takes place. In the case of persons apparently drowned, recourse should immediately be had to an inflation of the lungs, at the same time that the galvanic application is made. This stimulant has the power of exciting the contractions of the heart, and of causing the blood to flow through the lungs. The latter can only be accomplished when the lungs are distended, and when it is assisted by their subsequent subsidence. Every contraction of the heart, excited by too powerful an impulse, and at an improper time, lessens the small remains of vital power. Therefore, moderate shocks, cautiously and gradually increased, and passed through the chest in different directions, are attended with the best effects. These cannot fail, when galvanism is combined in such a manner with the aid

of artificial respiration, that the action of the one keeps in perfect unison with the action of the other, and in no respect interferes with it.

31. I shall not, in this place, enter upon a minute discussion of the new theories respecting *asphyxia*, and of the various applications considered necessary for it; my readers will find all these particulars in the transactions of the Royal Humane Society, and in the works of such illustrious men as Kite, Fothergill, Hunter, Coleman, Goodwyn, Struve, Curry, Portal, Orfila, and Edwards. I confine myself solely to the object I had originally in view, which is to call the attention of the Public to the galvanic apparatus, which I have invented, and which is far preferable to any I ever before offered to their notice. The new plan, here proposed, obviates all the difficulties that heretofore occurred in administering galvanism in cases of *asphyxia*, and I confidently dare all those to the proof, who are inclined to doubt of its efficacy. I had the honour to display its powers in the presence of H. R. H. the Duke of Sussex, who has kindly obtained permission for me to deposit a specimen of my invention in the

archives of the Royal Humane Society^(d), which was done on occasion of His Royal Highness's presence at the various galvanic experiments made relative to this object. I made a promise to his Royal Highness also, whilst sitting as President at the meeting of the Society of Arts on the 14th day of May last, that I would spare no endeavours to present a very simple galvanic apparatus, to be applied to the purposes of medicine, and especially in cases of *asphyxia*; and I publicly called upon the celebrated artists of London, many of whom were then around me, to endeavour to accomplish so desirable and philanthropic an object.

32. I had also the honour, in consequence of the gracious invitation of the learned President*, to display my apparatus before my colleagues at a sitting of the Medical Society of London, in Bolt Court. The only object I had in view in this experimental exhibition, was to avail myself of the authority and favourable opinion of this learned body, in order to ensure attention, and confer publicity, on my invention. I placed various piles in

* Dr. Clutterbuck.

action, some by the interposition of the usual solution, contained within the small intervals between the layers of copper and zinc, by virtue of the attraction of the metallic superficies ; others composed of circular pieces of an inch, down to a quarter of an inch in size, pierced in the centre, and suspended by means of a silken thread, which passed through each piece separately, whilst the interstices were filled with pieces of common cloth of much smaller diameter. I have shewn that these piles are easily constructed, are of a portable nature, and put in action with the utmost facility ; I have shewn, that a few moments after they are immersed in the solution they are capable of galvanic action, and will preserve it in full force for above an hour and a half ; lastly, I have shewn that in applying this power to animal motion, a greater force can be obtained from the process by the metallic superficies than from the former method by the trough.

33. I also exhibited a small pile, composed like the former of a hundred pieces of the above-mentioned metals reduced to nearly the thinness of paper ; its weight was about an ounce and a half, and its height little more

than five inches. The shock was little less in proportion to that obtained from the piles employed above. It is not, however, my intention to employ the last-mentioned pile for the purposes of medicine, on account of its too easy oxydation, but only to impress the Public with the advantages that are to be derived from this newly discovered agent in nature, at a very *trifling expense*. It was also my hope, that this popular manner of displaying its advantages, might tend to diminish that aversion which patients feel towards any new remedy. It is also my desire that, by the medium of public sale, this galvanic apparatus should be placed in the hands of every one, even in those of children; who, though they at first use it merely as a plaything, may be taught its value from their tenderest years, and afterwards learn to apply it in cases of suspended life.

34. To return to the subject which forms the principal object of the present memoir, attention must be paid not only to the best means of curing cases of *asphyxia*, but also to the method of preventing the occurrence of accidents producing them. Those governments merit every praise who have established

schools for swimming, and have formed them into a part of the system for the civil education of youth. By means of this art, not only is the proficient placed in a situation of preserving his own life in cases of danger and shipwreck, but also of having the happiness to save that of his fellow-creatures. A striking instance of this occurred some short time since in Italy. Sir J. Elliot, who acted as Minister Extraordinary from the Court of Great Britain to that of Naples, being one day on his way to his country residence near *Portici*, and passing near the shore, saw a poor fellow who had ventured some distance from the land, and appeared struggling with the waves in a nearly exhausted state. Stripping in an instant, and plunging into the sea, Sir John seized on the man, and dragged him safe to the shore. These cases are, I understand, of frequent occurrence in England, and are annually noticed at the anniversary meetings of the Royal Humane Society. I had the pleasure of being present at the last distribution of prizes at the Society of Arts, and witnessed a gold medal awarded for two models of a life-boat, which was so constructed that it was impossible to sink it. Loca-

telli, the mechanic, constructed a boat of a similar kind at Pavia, which was very ingeniously contrived.

35. The ingenious instrument, called the *Night Life Buoy*, invented and described by Thomas Cook, Lieutenant of the Royal Navy, to give light and be the means of saving persons in cases of danger or shipwreck by night, and exhibited at the last anniversary meeting, justly merited the applause and the premium of the Royal Humane Society. It may not here be misplaced, to give it as my opinion, that the use of gas would be an admirable substitute for the present mode employed in light-houses. Leaving the consideration of the many advantages that might be derived from this mode of lighting vessels at sea, and of guiding them through the dangers of the seas with greater security, I pass on to my subject: at the same time observing, that the Chamber of Commerce at Trieste erected, nearly two years ago, a magnificent light-house furnished with gas, at the point of the *Pirano*; last year I was myself a witness of the gratitude displayed by many seamen, who had been indebted for their lives to this noble and useful establishment. A light-

house, supplied with gas, has been erected about eight months in the neighbourhood of Wells, and it is much to be wished that it should be brought into general use, not only on this, but on every other shore(°).

36. Independently of any of these useful inventions, the Royal Humane Society has given abundant proofs of the utility of the methods it has heretofore adopted. The number of persons restored from apparent death amounted, during the last year alone, to TWO HUNDRED AND FIFTY-EIGHT ; and from the commencement of the institution in 1774, no less a number than FOUR THOUSAND SEVEN HUNDRED AND TWENTY-NINE persons have been restored to their families and to society. There could not be a more glorious and magnificent monument of its success than this ; and it offers a noble example worthy of the imitation of all other nations. The society is impressed with a conviction *that the discovery and subsequent improvements in galvanism* seem calculated to ensure a well-grounded hope that it might be successfully applied in cases of apparent death ; and has expressed an anxious desire that they might be enabled to add a suit-

able galvanic apparatus to the various instruments which they at present employ*. I have, on my part, exerted my utmost zeal to correspond to their wishes ; for I am resolved to bring my apparatus to the highest state of perfection, of which my means will allow me to make it capable : anxious as I feel to render it productive of real and lasting utility, in being made the means of restoring suspended animation.

SECTION IV.

On the Influence of artificial and atmospherical Electricity in medical Purposes.

37. ARTIFICIAL electricity may be administered either by electrical explosion or shock, as is the case when the Leyden jar is employed ; or under the form of the simple electric fluid, by merely placing the animal

* See Annual Report of the Royal Humane Society, for Recovery of Persons apparently Drowned, or Dead, 1819.

body on an isolated stand, in communication with an electrified conductor. Although, at first sight, this second method would not appear to have any great influence on the animal economy, yet it is ascertained, by repeated experiments, that it produces a remarkable evaporation of the fluids, and accelerates their action : hence it follows that in the human body, when it is electrified, a general increase of perspiration, and an acceleration of the course of the animal fluids take place. This double action justifies the confidence which Veratti, Beccaria, Mauduit, Tiberius Cavallo, and others, were led to place in medical electricity, and which they efficaciously applied in a variety of disorders. Still greater is the influence when recourse is had to the electrical shock. In cases of torpor, when the fluids have become stagnant in any particular part, electricity, when cautiously and gradually applied, cannot but produce beneficial effects. The experiments made with artificial electricity, before the extinction of the vital powers, shew that this too, like galvanism, has a remarkable power in restoring animation. In fact, if to an animal recently deprived of life, and not yet cold, an electrical commu-

nication be made, so as to pass from the brain to the extremity of the *sacrum*, the whole body will be observed to be agitated, and the whole muscular system to be so convulsed, that the animal might be thought alive.

38. Hence, I cannot but warmly approve the practice of those physicians who recommend the use of electricity in cases of suspended animation. In the register of the Royal Humane Society for the year 1774, it is reported that a child, three years old, fell from a one pair of stairs window upon the pavement, and was taken up without any signs of life. A medical practitioner being sent for, declared that nothing could be done, and that the child was irrevocably dead; but a gentleman having proposed a trial of electricity, the parents consented. At least twenty minutes elapsed before he could apply the shock, which he gave to various parts of the body without any appearance of success. On directing a few shocks through the *chest*, a small pulsation became perceptible, and soon after the child began to sigh, and to breathe, though with great difficulty: in about ten minutes, it vomited. A kind of stupor remained

for some days; but it was restored to perfect health and spirits in about a week.

39. I have read a similar case in the report for 1787. A lad, in perfect health, fell from a two pair of stairs window into an area, and was taken up to all appearance dead. Upon the strictest examination, no mark of violence could be discovered either upon the head, or any other part. After a variety of means had been tried by a surgeon without effect, the lad was pronounced dead, and sent home. A gentleman (past whose house he was carried) happening to inquire into the circumstances of the case, wished to try the effect of electricity. After four small shocks had been given, the lad shewed some signs of life; and, by continuing them, he gradually recovered, so that in less than two hours, he was able to walk about the house.

40. The success attending the application of electricity, as well as in galvanism, must materially depend upon the mode in which it is employed. According to the strength and direction of the electrical current, it may be made to produce different, or even opposite effects. Dr. Abilgard, in his experiments on fowls, was enabled alternately to suspend

or restore animation. That very ingenious electrician, Mr. Partington, some time ago, repeated the same experiments on a large turkey, and lately on a young quadruped of the canine species, with similar success. When a smart shock or two were passed through the head of this animal, it immediately became motionless, and, to all appearance, dead. In this state, electricity was employed in different degrees, and conveyed in different directions. On being gently transmitted through the region of the heart and lungs, an oscillation of the muscles immediately ensued; it was observed that the vital organs were more excited by slight than by powerful shocks; the latter appearing rather to retard than to promote recovery. When the operation was suspended for a few minutes, or its direction altered to remote parts, the animal always relapsed into its quiescent state, and as constantly revived on its being repeated in the situation above mentioned. By repeating at intervals, sparks, or very slight shocks, it was at length completely revived.

41. Galvani made new discoveries in the mode of employing artificial electricity. The experiments made by him on this subject,

were those that led to his discovery of proper electricity, inherent in the nervous and muscular system. He was the first to observe by means of common electrical machines, that when he had laid open the nerves of an animal, immediately after death, and placed it at a rather greater distance than that which is observed in the common electrical atmosphere, each time a spark was extracted, strong convulsions followed, although the animal was not isolated. An electrometer, capable of easy motion, placed in similar circumstances, was not able to be affected, while the muscular contraction appeared constant; hence it follows, that the animal system offers an electrometer of the greatest energy and sensibility; and this observation made by Galvani, offers a new means of ascertaining the action of atmospherical electricity on the animal economy. According to the various relations between the internal electricity of animals, and atmospherical electricity externally communicated, the influence of this agent varies in their regard.

42. Hence it may be understood, why animals become more lively and active, after heavy rains, and when a storm has cleared the at-

mosphere; and why, on such occasions, many patients experience strange symptoms, and feel a variety of alarming variations in the state of their health. This also shews the justice of Woodward's observation; "*that there were certain persons, who, before a violent thunder-storm, appeared to suffer great depression of spirits, to feel a considerable pressure on the præcordia, and were even forced to relieve their stomach by a vomit.*" Beccaria relates, that he knew a person of the name of Mazeas, who, during violent storms of thunder and lightning, was subject to violent attacks of the epilepsy. "*Hence,*" says Gardinius, "*we may easily account for the drowsiness that is felt on certain days, when artificial electricity is excited only with great difficulty. On these occasions, lassitude, melancholy, lowness of spirits, and hysteric affections, are particularly felt, which makes it evident, that all nervous disorders have a connexion with the atmosphere*.*"

* "*Homines quosdam extitisse, qui ante tonitrua ingentes videbantur angustias pati, sibi que præcordia sentiebant premi, atque etiam ad vomitum cogeantur.*" Narrat Beccaria, se novisse hominem quemdam, Mazeas nuncupatum, qui, fulgurante cœlo atque tonitruis obstrepentibus, molestissimis epilepsiæ ictibus corripiebatur.

" *Hinc*

Yet, we must not suppose that the influence of atmospherical electricity is, at all times, noxious. The more abundant transpiration which takes place by means of electricity thus communicated, and the more free and unobstructed course of the humours, cannot but have a beneficial influence on the animal economy. When the sky is serene, and the electric matter gently and regularly diffused, we enjoy a certain flow of spirits and vigorous tone of mind, which are frequently wanting when we are involved in electrical clouds that hang low and heavy in the atmosphere.

43. Professor Bartholon affirms, that nature employs two modes of transfusing and preserving the electrical agent in the interior of the animal economy. In the first place, a great number of pores are found in the integuments of the human frame, by means of which the electric fluid is communicated equally to the whole system, according as

“Hinc facile percipitur,” inquit Gardinius, *“illa segnities certis quibusdam diebus, in quibus cum magnâ difficultate electricitas artificialis excitatur. Nam lassitudo, tristitia, melancholia, affectiones hystericæ certis quibusdam temporibus præcipuè afficiunt, et aperte demonstrant, omnes nerveos morbos relationem habere cum atmosphærà.”*

the air is in a state of positive, or of negative electricity. In the next place, by means of the organ of respiration, a continual supply of the electric fluid is communicated to the lungs, where there exists a kind of organ of secretion, by virtue of which it is separated from the air with which it was united, and is distributed through the various parts of the system, according to their various capacities. A consideration of this fact led Galvani to establish it as a principle, that, in animal bodies, there are parts which are conductors, and others which are non-conductors of electricity, and on the due action of these the state of health must necessarily depend. He, therefore, examined all the circumstances capable of deranging the natural state of the interior animal electricity; and he thought that *tetanus*, *epilepsia*, convulsions, and in general, nearly all diseases of the nerves, present such phenomena as seem to demonstrate the concurrence of an electric action in producing them. Galvani also felt the necessity of examining the correspondence of the state of the atmosphere with the course of maladies; so that, in the latter years of his life, he established a meteorological journal, in which he

set down his daily observations, not only on barometers and thermometers, but on hygrometers and anemometers, and by means of a Franklin conductor, erected in the upper part of his house, was able to ascertain the quality and quantity of the electricity predominant in the atmosphere. If this plan were pursued by others, accompanied by observations on its correspondence with the effects of various diseases, it could not but produce great advantages in the practice of medicine. I have not treated, in the present section, of the general action of artificial electricity on various diseases of the human body, being of opinion, as I shall hereafter shew, that similar effects may be more easily obtained by means of galvanism.

SECTION V.

On the Application of Galvanism to various Diseases.

44. SEVERAL reasons might be adduced to justify the preference which I here give to the application of galvanism by means of the pile,

to that of electricity taken from an over-charged apparatus. With regard to the action of the common electrical machine, the difficulty found in using it in a wet season, the length of time necessary to produce the action, the form of the apparatus, which renders it difficult to be removed, added to its expense, which precludes many from possessing it, are, no doubt, obstacles which have been the cause of its being so seldom used of late years. The pile, on the contrary, is much cheaper, acts equally well at all times, is not impaired by damp, and may be compared to an apparatus containing in itself a series of Leyden jars, gradually charged by means of the common electric machine. In medical applications I have been accustomed to place a graduated scale which marks the proportionate degrees of action; I also made fixed points, which agreeing with the phenomena of the medical administration, enabled me to determine the different degrees of force, necessary in the different kinds of diseases. I must also observe that if it be required to give a shock to the nervous system by the electric matter in a Leyden jar, a second shock cannot be produced, before the action

of the first is over, and without loading it again. It is quite different in galvanism, by which a strong and continued shock may be obtained without making any change in the apparatus. The common electric machine produces no effect, unless the patient be isolated ; on the contrary, galvanism, when applied by means of a continual current, gradually produces a sensible effect, and soon exhibits remarkable effects on the humours of the body. In short, if the great advantages offered by the pile, in the prompt application of galvanism to a great number of patients be taken into consideration, it must be allowed, that all things considered, this mode of application is far preferable to that of common electricity.

45. The length of time during which I have repeated all the experiments made by Galvani, authorizes me publicly to declare, that he made them all with the view that his important discoveries should be made subservient to the purposes of Medicine. I should think I had forgotten the maxims of prudence and moderation, of which he himself set me the example, if I made a boast of exaggerated cures and wonders pro-

duced by galvanism ; on the contrary, it is my opinion that there is still much to do, in order to decide on the most advisable mode of applying this agent to all diseases, on sure and invariable principles. We are, however, in possession of many very valuable results, founded on observations of the highest importance ; and I think it would be greatly conducive to utility, to repeat and vary a multitude of experiments, which seem to have been forgotten, and to be no longer applied to the relief of the sick, in cases where the application would be highly beneficial.

46. By making an analysis of the direct action of galvanism on the human frame, we should be immediately persuaded of its very powerful effects in exciting the sensations. The sense of smelling is the only one which it has been found impracticable to excite artificially by this means. Galvanism, when communicated to different parts of the countenance, has the power of exciting a radiancy in the eyes, more or less luminous according to the nature of the parts to which it is applied. Delicate as this organ is, this radiancy can be excited by applying a conductor of zinc from the ball of the eye on

one part, and the extremity of the tongue on the other, coated with a plate of tin. The same effect may be produced by the pile itself, when the eyes are closed, whether they be covered with a bandage, or the subject be placed in a darkened room, with the eyes thus bound up. In a room entirely darkened, I tried the effect of galvanism on five blind men, who had been so for above thirty years. I formed an arc between the lips and the extremity of the nose, and by this means succeeded in causing them, for three successive times, to perceive the real sensation of light. In no case is the difference between galvanism and electricity more apparent, than in the application of the former to the sight. Very little benefit had been obtained by means of a metallic point, enclosed in a glass tube, which directed the electrical current to the cornea: and besides the electricity applied directly to so delicate an organ as the eye, could not but be attended with danger. Galvanism, applied to the exterior parts of the eye, in the same place where a current of electricity would have had no influence whatever, has always produced a certain effect on the organ of sight. If,

with one hand you touch the bottom of the pile, and at the same time apply to the summit different parts of the face moistened with salt water, a flash of light will be excited in the eyes. The same result will be obtained, if, instead of touching the bottom of the pile with the hand, you touch it with the sole of your foot. No flash of light is observed when the Leyden jar is employed in the same manner.

47. I excited the sense of hearing by a very slight galvanic action, forming an arc from one of the ears moistened with salt, to one of the sides of the pile; the other hand, which had also been bathed in salt water, being carried to the other side of the same. At every touch, a sensation of sound was excited in the ear, not merely in persons in general, but also in those affected by accidental deafness. I have already observed that the action of the pile should be gentle, otherwise it might make not only a painful, but also a pernicious impression on the brain, through which it passes. Thus too, having placed two metallic coatings, of unequal size, one to the back and the other to the tip of the tongue, a sensation of sometimes an acid, and sometimes an alkaline taste was

excited, which, a long time before the discovery of galvanism, was observed by Sulzer (f). I have witnessed the same sensation obtained by holding one of the hands or feet immersed in water, and making an arc of a piece of silver foil floating on the same, to the tip of the tongue, coated with tin.

48. A powerful proof of the very delicate impression produced by galvanic influence on the touch, is the method already communicated to me by Mr. Fowler, an eminent Dentist in London, for ascertaining the state of the teeth. When the caries is concealed from sight, Mr. Fowler employs the following method to discover the affected tooth. He first insulates the patient, and places in his hand an electric chain ; he then applies a small piece of wire to the *dens sapientiæ*, and draws it gradually over the surface of the tooth ; he then applies it to the next tooth in the same manner, and proceeds in the like method with the rest, until he comes to the diseased tooth, which is discovered by violent pain being produced, and an involuntary commotion in the body. It has always been remarked, when the tooth is extracted, that it exhibited a carious part, which, in its pro-

per situation, was not visible. This method, therefore, is of great importance, as it frequently happens in such cases, that the dentist, not being able to distinguish the diseased from the healthy tooth, is obliged to draw some that are sound before he can discover it.

49. Considering galvanism in this point of view, I cannot follow the opinion of those who imagine that all the hopes of its being rendered advantageous in medicine, will prove ineffectual. On the contrary, I think, that considering the facility afforded by my apparatus, it will be beneficial to apply the galvanic fluid, as a mechanical stimulant in diseases where an excitement of the nervous and muscular system is necessary. If too a change in the humours of the animal economy be found requisite, it will be advantageous to employ galvanism as a chemical agent, and to direct it by means of a current. I have lately repeated the experiments made many years ago by others, as well as by myself, for passing the galvanic current through the bile, the blood, and the urine; and I have been led to form this conclusion, that if galvanism is able to decompose the fluids, separated from the

animal frame, it may probably produce similar effects upon them when connected with the general system of the animal economy in a state of life. I have communicated my method to several eminent professors of Chemistry, who have all agreed as to its beneficial chemical influence on the animal fluids, and acknowledged that it was not possible to obtain the same results by means of the common method of administering galvanism.

50. My method does not require that any incision should be made in the integuments. It is sufficient that the patient should be extended on a sofa, covered with clothes, and in this position he will be able to receive the action of the galvanic current in the affected part, for many hours. Nothing is required but, that by means of two silk ribands, two metallic wires should be attached to the extremities of the parts affected; one of the wires should communicate with the *positive*, and the other with the *negative* pole of the galvanic apparatus. Small pieces of linen cloth, dipped in a strong solution of muriate of soda, should be applied to the place where the extremities of the arcs are conducted, in order to render the course of the galvanic

current through the part affected, more easy and more sure. Professor Ure thinks that the different medical effects produced by the action of the positive and negative poles of the pile, merit particular observation. It is much to be wished that this ingenious Professor may, by his various experiments, throw a light upon the nature of galvanism, as Professor Ermann is now endeavouring to do at Berlin, with a view to establish a new theory on the effects of positive and negative electricity. (g)

51. In order fully to prove the utility of medical galvanism, it will be necessary first, to make comparative experiments with regard to the treatment of every disease ;—secondly, to divide into various classes patients affected by a given malady, and as far as possible, under the same circumstances ;—thirdly, to regulate the treatment of these disorders, sometimes applying galvanism only, sometimes only common remedies, and at other times common remedies and galvanism united ;—fourthly, to observe the state of the patient after he has been restored to health, in order to ascertain the duration of the effects of galvanism, and to observe whether it is more durable in the one method than in the

other ;—fifthly, to carry this plan into effect, it is recommended that professional men in great hospitals should interest themselves in this object, as they are the only persons who have the full means of ascertaining the advantages of medical galvanism, when compared with other remedies.

52. Were I to treat of the application of galvanism to every disorder, it would require a separate treatise ; I reserve for another occasion, my account of the beneficial results obtained from experiments made by me at Florence, in presence of the Professors Mascagni, and Fontana, and of the Count Bardi, at that time Director of the Royal Cabinet of Experimental Philosophy. My only object at present is to offer some observations on diseases proceeding from a derangement of the brain, or of the organ of respiration, as they are immediately connected with the principal purposes of this Essay. *Syncope* and *apoplexy* are almost always accompanied with symptoms prejudicial to the functions of the brain, in consequence of which the senses often remain suspended, or considerably deranged. In this state, galvanism, prudently administered, may produce a beneficial influence on the brain,

and may be distributed from thence to all the nervous and muscular system.

53. Having observed that a mechanical impulse on the fibres of the brain has been beneficial in certain cases, I felt desirous to apply it in cases of torpor in persons affected with melancholy madness ; and repeated observations have persuaded me of the utility of this means. ^(h) These considerations lead me to recommend the administration of galvanism in cases of *syncope*, and sometimes in particular cases of *apoplexy* ; because in these maladies, the brain, being particularly affected, may probably, by this means, be re-established in the regular use of its functions.

54. Galvanism has also been applied to asthmatical complaints, not only in Germany and Italy, but also in England, with singular success. Dr. Philip, Physician, at Worcester*, has employed galvanism in many cases of habitual asthma, and almost uniformly with relief. The time, during which galvanism was applied, till the patient had found his breathing easy, varied from

* Philosophical Transactions of the Royal Society of London, for the year 1817.

five minutes to a quarter of an hour. The galvanic power was applied in the following manner. Two thin plates of metal, about two or three inches in diameter, dipped in water, were directed, one to the nape of the neck, the other to the pit of the stomach, or rather lower. The wires from the different ends of the trough were brought into contact with these plates, and as great a galvanic power maintained, as the patient could bear without complaint. In this way the galvanic fluid was sent through the lungs as much as possible in the direction of their nerves. Dr. Philip observed that the negative wire generally excited the strongest sensation.

55. Many cases of habitual asthma occurred in working people, who had been obliged to abandon their employments in consequence of it, without any hope of returning to their regular engagements. Most of them had tried the usual means in vain. By the use of galvanism they were all restored to their employments. It is remarkable, that in several who had laboured under asthmatic breathing from ten to twenty years, it gave relief quite as readily as in more recent cases; which seems to prove, that the habitual difficulty of

breathing in the most protracted cases of asthma, is not to be ascribed to any permanent change having taken place in the lungs. Mr. Cole, surgeon, says, that no other means have been employed at the Worcester Infirmary equally efficacious, in relieving this disease.

56. Mr. La Beaume, who is well known for his exertions in the cause of galvanism, has particularly directed his attention to cases of asthma, and the public testimonials he has received from his patients prove the happy results of such an application. I have myself been a witness of the precautions used in applying this remedy, and it is my intention to publish separately the interesting observations offered me by him on this subject. It is sufficient at present to remark, that the administration of galvanism in cases of asthma is regulated by small interrupted shocks, repeated at given times; and by this means a galvanic current is brought into action, in order to render the muscular fibres more vigorous in the work of respiration.

57. According to the principles adopted by many physiologists, that the galvanic influence may supply the defect of the nervous

force, there is reason to hope for numerous advantages from the mode of application proposed above. Galvani, in an anonymous work, very little known in England, or even on the Continent, thinks that there is a constant current of animal electricity, passing from the nerves to the muscles, and that sensations are excited in the animal economy, only when some modification takes place in this current. The following is one of the principal experiments made on this subject, of which I was myself a witness. Galvani, applied to the nerves and muscles of a frog, prepared as usual, two different metallic coatings, upon a pane of glass, on which was pasted a piece of tin-foil, which connected these two coatings. He observed, that by either changing the contact of the different metals, placed in the middle of the metallic zone, or producing a chemical alteration, muscular contractions were constantly excited in the frog, as long as the continuity of the arc was not interrupted. Galvani profited of this interesting experiment, and others which he afterwards made analogous to it, for explaining the spasmodic sensations excited in the human body, when, in consequence of

any action, the state of the fluid, which forms a continual arc between the nervous and muscular system, is changed. The influence of atmospherical electricity is sometimes one of the causes of deranging the regular state of the continual electric current, passing through the nerves and muscles, and contributes to produce those phenomena in the animal economy, above described. Galvani, a short time before his death, in the five separate memoirs on animal electricity, addressed to Professor Spallanzani, not only established the existence of currents circulating from the nerves to the muscles, but made and published drawings of their course, and determined the laws of its circulation. (¹)

58. From the facts established in the last mentioned work, Galvani has deduced the following corollaries:—

1st. That the electricity which produces muscular contractions, is resident in the muscles, and is never in a state of equilibrium; and therefore there is always a current, by means of which, the electricity derived from the muscles, has a tendency to return to them.

2d. That the nerves are designed by na-

ture to be the conductors of this electricity, because their extremities are spread over the whole internal substance of the muscular fibres.

3rd. That the nerves perform that function by means of their own medullary substance; and, consequently, when this is interrupted, or separated either by a ligature, or in any other manner, the current of electricity is suspended, although in this state of the nerves, the membranes and the humidity may be able to conduct electricity from the muscles.

59. Galvani, therefore, not only proved the existence of internal electricity, inherent in the animal system: he advanced still farther; he laid down the method of extracting it from the nerves, and of conducting and directing its power at his pleasure. These are his words:—*Nunquam adeo nobis amicam fortunam arbitrati essemus, ut electricitatem in nervis latentem et manibus veluti pertractare, et extra nervos deducere, acpene sub oculos ponere nobis forte primis concederet.** According to their

* Aloysii Galvani de animali electricitate commentarius, cum Joannis Aldini dissertatione, et notis.

principles, it will easily be seen that the application of galvanism by means of a current which I have proposed, is not a capricious hypothesis, but founded on the chemical effects of galvanism, and on the experiments above-mentioned. I think I have already sufficiently demonstrated by facts, that the galvanic action, considered as a stimulant, is so powerful an agent, that it should not be neglected in cases of suspended animation, which forms the principal object of the present dissertation.

APPENDIX.

*An abridged Account of some Galvanic Experiments
made by Professor Ure, at Glasgow, on the Body
of a Criminal immediately after execution, on the
14th of November, 1818.*

THE interesting experiments, lately made by Professor Ure, of Glasgow, have justly called the attention of the whole of these kingdoms to the action of Galvanism on the animal economy, as this branch of science appeared not to have made the progress which might have been expected. As a testimony of my respect for the author, I here insert an abridged account of the above-mentioned experiments, as described by himself, because their important results are immediately connected with the principal object of my inquiries. The subject of these experiments was a middle-sized, athletic, and extremely muscular man, about

thirty years of age. The dissections were skillfully executed by Mr. Marshall, under the superintendence of Doctor Jeffray, the distinguished Professor of Anatomy. Professor Ure had prepared a battery consisting of two hundred and seventy pairs of four-inch plates, with wires of communication, and pointed metallic rods with insulating handles, for the more commodious application of the electric power. By means of this apparatus, he made the following experiments:—

Exp. 1. A large incision was made into the nape of the neck, close below the occiput. The posterior half of the atlas vertebra was then removed, by a bone-forceps, when the spinal marrow was brought into view. A considerable incision was at the same time made in the left hip, through the great glutæal muscle, so as to bring the sciatic nerve into sight; and a small cut was made in the heel. From neither of these did any blood flow. The pointed rod, connected with one end of the battery, was now placed in contact with the spinal marrow, while the other rod was applied to the sciatic nerve. Every muscle of the body was immediately agitated with convulsive movements, resembling a violent shuddering from cold. The left side was most powerfully convulsed at each renewal of the galvanic contact. On moving the second rod from the hip to the heel, the knee being previously bent, the leg

was thrown out with such violence, as nearly to overturn one of the assistants, who in vain attempted to prevent its extension.

Exp. 2. The left phrenic nerve was laid bare at the outer edge of the sterno-thyroideus muscle, from three to four inches above the clavicle; the cutaneous incision having been made by the side of the sterno-cleido-mastoideus. Since this nerve is distributed to the diaphragm, and since it communicates with the heart through the eighth pair, it was expected, by transmitting the galvanic power along it, that the respiratory process would be renewed. Accordingly, a small incision having been made under the cartilage of the seventh rib, the point of the one insulating rod was brought into contact with the great head of the diaphragm, while the other point was applied to the phrenic nerve in the neck. This muscle, the main agent of respiration, was instantly contracted, but with less force than was expected. Satisfied, from ample experience on the living body, that more powerful effects can be produced in galvanic excitation, by leaving the extreme communicating rods in close contact with the parts to be operated on, while the electric chain or circuit is completed, by running the end of the wires along the top of the plates in the last trough of either pole, the other wire being steadily immersed in the last cell of the opposite pole, he had immediate re-

course to this method. The success of it was truly wonderful. Full, nay, laborious breathing instantly commenced. The chest heaved, and fell; the belly was protruded, and again collapsed, with the relaxing and retiring diaphragm. This process was continued without interruption as long as he continued the electric discharges. In the judgment of many scientific gentlemen who witnessed the scene, this respiratory experiment was perhaps the most striking ever made with a philosophical apparatus. Let it be remembered also, that for full half an hour before this period, the body had been well nigh drained of its blood, and the spinal marrow severely lacerated. No pulsation could be perceived meanwhile at the heart or wrist; but he supposes that but for the evacuation of the blood, this phenomenon might also have occurred.

Exp. 3. The supra-orbital nerve was laid bare in the forehead, as it issues through the supra-ciliary foramen, in the eye-brow: the one conducting rod being applied to it, and the other to the heel, most extraordinary grimaces were exhibited every time that the electric discharges were made, by running the wire in his hand along the edges of the last trough, from the 220th to the 227th pair of plates; thus fifty shocks, each greater than the preceding one, were given in two seconds: every muscle in the face was simultane-

ously thrown into fearful action, expressing the united representations of rage, horror, despair, anguish, and ghastly smiles.

Exp. 4. This experiment consisted in transmitting the electric power from the spinal marrow to the ulnar nerve, as it passes by the internal condyle at the elbow; the fingers now moved nimbly, like those of a violin performer; an assistant, who tried to close the fist, found the hand to open forcibly, in spite of his efforts. When the one rod was applied to a slight incision in the tip of the fore finger, the fist being previously clenched, that finger extended instantly; and from the convulsive agitation of the arm, he seemed to point to the different spectators.

An hour having been spent in these galvanic operations, he then prepared to execute an experiment with the view of determining, by a new and simple mode, the quantity of residual air in the lungs. The trachea being cut across below the pomum adami, a short brass tube was introduced into it, and firmly secured; into this tube a stop-cock was screwed, air-tight. A glass globe of 159.3 inches in capacity, with an attached brass cap and stop-cock for weighing gases, being previously exhausted by an air-pump, and nicely poised at a delicate balance, was now connected with the stop-cock in the trachea. A small opening was then carefully made on each side into

the thorax. When the communication between the lungs and the globe was opened by turning the stop-cocks, the air was heard to rush forcibly into the latter with a whizzing sound; when this ceased, the stop-cocks were again shut, the globe unscrewed, and suspended at the balance. Its increase of weight was found to be exactly 31.8 grains. The globe was again attached, in order to ascertain whether the apparatus was air-tight, and upon leaving it some time in connexion with the trachea, it only received an additional increase of 1.6 grains weight. These 33.4 grains of air were found to be equal to 105.2 cubic inches, consisting of about 91 of azote mixed with a little oxygen, and 14.2 of carbonic acid. It is possible, says he, that a larger proportion of carbonic acid would have been found before the galvanic respiration. By this process the air was extracted from the lungs without injuring their texture, and it avoids many chances of fallacy which former experiments were exposed to.—His result agrees very well with Dr. Goodwyn's determination of 109 cubic inches, obtained in a different way;—allowing for variations in the size of the thorax.—Dr. Ure remarks that he is almost willing to imagine, that if, without cutting into and wounding the spinal marrow and blood-vessels of the neck, the pulmonary organs had been set a playing at first, by electrifying the phrenic nerve, there is a

probability that life might have been restored.—Dr. Philip's experiments shew that the action of the diaphragm and lungs is indispensable towards restoring the suspended action of the heart and great blood-vessels, subservient to the circulation of the blood.

It is known, says Dr. Ure, that cases of death-like lethargy, or suspended animation, from disease and accidents have occurred, where life has returned, after longer interruption of its functions, than in the subject of the preceding experiments. It is probable, when apparent death supervenes from suffocation with noxious gases, &c., and when there is no organic læsion, that a judiciously directed galvanic experiment, will, if any thing will, restore the activity of the vital functions.—He thinks, that the plans of administering the galvanic influence as hitherto pursued, are very defective;—that no advantage is likely to accrue from passing electric discharges across the chest, directly through the heart and lungs; but that we should transmit along the channel of the nerves, that substitute for nervous influence, or that power which may perchance awaken its dormant faculties.—Then, indeed, he conceives, fair hopes may be entertained of deriving extensive benefit from galvanism; and of raising this wonderful agent to its expected rank, among the ministers of health and life to man.

An abridged Account of some Galvanic Experiments
made in London, by Professor Aldini, on the
Body of a Criminal, immediately after execution,
January 17th, 1803.*

GALVANISM is every day offering so many new objects to our research, that we have no hesitation in pronouncing it the most curious subject of inquiry that is now engaging the attention of the lovers of natural philosophy. The experiments lately performed in this town by Professor Aldini, must be fresh in the memory of those who were gratified with a sight of these infinitely-interesting phenomena; and by those who were not so fortunate, this short narration will be perused with interest, and may suggest a variety of new and untried objects of inquiry. The subject of the experiments was a malefactor executed at Newgate, on the morning of the 17th of January last. The body was exposed a whole hour, in a temperature of about 30° , after which it was delivered to the College of Surgeons, in pursuance of the usual sen-

* This account is taken from the *Medical and Physical Journal* of Doctors Bradley, Batty, and Noehden. Vol. ix.

tence of the law, and was transferred to Professor Aldini, who with the assistance of Mr. Keate, Mr. Carpue, Mr. Hutchins, Mr. Cuthbertson, and other able men, subjected it to the following experiments, the galvanic power being in all of them supplied by three troughs, combined together, each of which contained forty plates of zinc, and as many of copper; the interposed fluid was diluted muriatic acid.

1. One arc being applied to the mouth and another to the ear (wetted with a solution of common salt) the jaw immediately began to quiver, the adjoining muscles were horribly contorted, and the left eye actually opened.

2. On applying the arc to both ears, a motion of the head was manifested, all the muscles of the face became convulsed, and the lips and eye-lids were evidently affected. The action was increased by making one extremity of the arc to communicate with the nostrils and the other with the ear.

3. On applying the conductors to the ear and to the rectum, such violent muscular contractions were excited, as almost to give the appearance of re-animation.

4. Volatile alkali was first applied to the nostrils and mouth, but without the least sensible effect; but galvanism immediately excited violent action. This, however, was still more increased by

uniting both of these stimuli; and applying them together.

5. The fibres of the biceps flexor cubiti were laid bare, and one arc was applied to them, whilst the other remained in the ear. This produced violent convulsions of all the muscles of the arm.

6. One arc remaining in the ear, and the other being applied to an incision in the wrist, among the small filaments of the nerves and cellular membrane, a very strong action of the muscles of the forearm and hand was perceived. In these two last experiments, the natural moisture of the part was sufficient to conduct the galvanic influence without the intervention of salt water.

7. The short muscles of the thumb were dissected, and on applying the conductor to them, a forcible effort to clench the hand was induced.

8. The effect of other powerful stimulants, caustic ammonia, concentrated sulphuric acid, and the mechanical stimulus of pricking the fibres with the point of the scalpel, were tried by way of comparison with galvanism, but without producing the smallest effect.

9. The thorax and pericardium being opened, and the heart exposed *in situ*, the conducting arc was applied to the ventricles, first upon its surface, then in the substance of its fibres, then upon the carneæ columnæ, and the septum ventriculorum; and, lastly, in the course of the nerves by the

coronary arteries, but without being followed by the slightest contraction or muscular motion.

10. The arc was then conveyed to the right auricle and the appendix auricularis, and considerable contraction was immediately produced, even without the intervention of salt water. In the left auricle, however, scarcely any motion was excited.

11. Conductors being applied from the spinal marrow to the fibres of the biceps flexor cubiti, the glutæus maximus, and the gastrocnemius, separately, no considerable action in the muscles of the arm and leg was produced.

12. One of the conducting arcs being applied to the spinal marrow, and the other to the sciatic nerve, (which was exposed between the great trochanter and the tuberosity of the ischium, and dissected out from its sheath) no contraction whatever ensued in the muscles. But the conductor being removed from the nerve to the adjacent muscular fibres and cellular membrane, as strong an action was manifested as in the former experiments.

13. By making the arc to communicate with the sciatic nerve, and the gastrocnemius muscle, a very great action was produced in the latter.

14. Conductors being applied from the sciatic to the peronæal nerve, scarcely any motion was excited in the muscle.

15. The sciatic nerve being divided about the

middle of the thigh, and conductors being applied from the biceps flexor auris to the gastrocnemius, there ensued a violent contraction of both.

Mr. Carpue, giving account of the appearances on dissection, observes that the blood in the head was not extravasated, but several vessels were prodigiously swelled, and the lungs were entirely deprived of air; he also saw that there was a great inflammation of the intestines, and that the bladder was fully distended with urine.

These are the principal circumstances of the interesting experiments * which are here related; and the reader will readily concur in the leading inference which Professor Aldini deduces from them; namely, that the power of galvanism, as a stimulant, is stronger than any mechanical action whatever, and that hence it affords very powerful means of resuscitation in cases of suspended animation under common circumstances, perhaps superior to any that are usually employed. This consideration may serve to give this study additional interest to those who are not satisfied with any object of philosophical pursuit, without dis-

* During his residence in England, Professor Aldini exhibited many galvanic experiments at Oxford, at Mr. Wilson's Anatomical Theatre in London, and at St. Thomas's and Guy's Hospitals; and we learn with pleasure, that the Lecturers and Pupils of these two Hospitals have presented him with a gold medal in honourable testimony of their approbation.

covering in it an immediate prospect of benefit to mankind. The physiologist, however, will not fail to perceive the variety of curious questions for future inquiry, involved in the singular unsusceptibility of the ventricles of the heart to a stimulus which powerfully affects every other muscle with this influence, compared with that of nerve and medulla spinalis.

From the circumstance of the rapid exhaustion of the power of the troughs, and the extent of active metallic surface requisite to produce the galvanic action in sufficient intensity to exhibit the above phenomena, the author infers the probability that the method of coating nerves with metallic surface, as first practised by Galvani, (on frogs and cold-blooded animals) serves merely to conduct the fluid pre-existent in the animal system; whereas, with Volta's galvanic batteries, the muscles are excited to action by the influence of the apparatus itself.

Observations on the application of Galvanism in Cases of Asphyxia, produced by the noxious Vapours of burning Charcoal. Addressed to Dr. Alibert, Physician to his Majesty the King of France, &c., by Professor Aldini.

HAVING promised to inquire whether galvanism has been employed in England in cases of Asphyxia, and to inform you of the results of this important application, I regret to state that my researches in this respect have been fruitless, with the exception of an account given by Dr. Babington* in which, with the assistance of Mr. Allen, galvanism was had recourse to in conjunction with other remedies, in two cases of asphyxia arising from the noxious vapour of burning charcoal.

In the younger of these subjects, a boy of 13 years of age, the natural process of respiration was imitated by passing a catheter into the trachea, and breathing through it into the lungs; and the galvanic influence was afterwards had recourse to, in order to ascertain whether any remains of life still existed; neither of these means, however, were productive of any visible excitement. In the other case, a man of 38 years of age, finding that the

* Transactions of the Medico-chirurgical Society of London, Vol. I.

vital powers were becoming more enfeebled, and that he also would fall a victim to the accident, the pulse being weak and quick and the respiration very imperfect, the power of voluntary motion suspended, his countenance pale, the eye-lids closed, the eyes rolling in their sockets from side to side; the tongue swollen and projected from the mouth, and locked in this position by the spasmodic action of the muscles of the lower jaw. Having passed a galvanic shock through the chest, he *instantly to our surprise, drew his breath deep*. The muscles of the abdomen were seen to re-act, though feebly, and the eye-lids were raised. *At each successive* application of this powerful agent the respirations were more forcibly performed, and the stroke of the artery at the wrist rose in the same proportion. The inhalation of oxygen gas and the galvanic successions were repeated alternately every half hour, for some hours after, when the powers of life began to be gradually restored, and in the course of a few days the patient progressively recovered.

Dr. Babington concludes this account by some useful reflections on the effects of the remedies usually employed in those cases, and observes, with regard to that of galvanism, that on the present occasion its *effect in promoting a deep and complete* inspiration followed by a more vigorous action of the heart and arteries, *was strongly conspicuous*; and

concludes with remarking on the easy application of the galvanic apparatus and its advantage over the ordinary form of electricity. It may be proper to observe, that the exertions made to recover the poor boy, probably proved ineffectual, from the action of life having been irrevocably suspended by the situation into which he was thrown. In falling out of bed he was immediately exposed to the concentrated stratum of noxious air, which occupied the lower part of the room.

This latter circumstance shows the reason why this boy did not, like the other, feel the beneficial effects of galvanism. The gas which he inhaled from the strata of air near the floor of the room, was much more pernicious, by its almost total separation from atmospherical air. The death of this boy was, therefore, produced by circumstances analogous to those which take place in the *grotta del cane*, where the dog, being obliged to inspire acid carbonic gas, dies, whereas men feel scarcely any ill effects. It may also be added, that the boy, having for a considerable time inspired the pernicious vapours of burning charcoal, the vital forces were extinguished, and therefore the application of galvanism proved ineffectual. These observations are consentaneous to experiments made in company with Dr. Ure. Now, if the beneficial action of galvanism be considered in the other patient, and in persons restored from

syncope by means of artificial electricity, it will afford every ground to hope for success from the application of galvanism. In effect, if it be proved from the acts of the Royal Humane Society, that various individuals have been restored by means of common electricity, with still greater reason may we expect the same effects, in similar circumstances, from the influence of galvanic power, especially since it can be more readily and more expeditiously applied.

I remember with gratitude, that, by your eloquent eulogiums on the life and writings of Galvani, you have been the first to consecrate his memory, and to transmit his discoveries to the latest posterity; and I feel a confidence that your authority will render them beneficial to mankind.

I am, &c.

Your most humble Servant

and Friend,

JOHN ALDINI.

London, 5th June, 1819.

NOTES.

Page 13, Note (a)

I OFFERED, for the examination of the Medical Society, two piles, each composed of sixty plates of copper and zinc, of rectangular form, one inch and a quarter in length, and half an inch in breadth. The plates are supported by two small mahogany pillars, and are separated from each other by interstices ; so that, when the apparatus is immersed in a common solution of muriatic acid, all the interstices remain full. I shewed, that when the apparatus was taken out of the solution, and placed in a vertical situation, the attraction of the metallic surfaces retained the solution so strongly, that it was necessary to employ the action of a pair of bellows, in order to clear it of the solution. This apparatus has the advantage of not requiring pieces of cloth, as was necessary in the common piles. It is of a portable nature, weighing from 24 to 28 ounces ; it is always ready for action, and furnished with such advantages as cannot fail to recommend it. In common troughs, independently of the greater expense of constructing it in the first instance, it requires a more expensive profusion of muriatic acid, which are dispensed with by my method. In my apparatus, even of the largest size, the solution necessary does not weigh more than two or three ounces, and therefore, as it is to be mixed with water, very little expense is incurred for acid employed in my experiments.

My method also affords a great facility in cleaning the plates ; which may be done either by means of a fine file, or by a piece of watch spring, so inclined as to touch both

surfaces. It has besides the convenience of being easily cleaned, either by the one or the other, in either direction, which is not the case with the trough, on account of its having but one side open. As sometimes there will be occasion to take a pile to pieces, for some necessary repair, the only thing requisite is to take out the four screws, when the plates will be at liberty, not being glewed on, but merely inserted in small grooves made in the two stands. This apparatus may also be partially dipt in the solution, first on one side and then on the other, so that a common glass of it will suffice for the purpose. It may also be dropped in with a sponge, when the galvanic power becomes weakened and needs refreshing.

An apparatus of small circular plates, of the diameter of less than half an inch, with small pieces of cloth in the interstices, when compared with the other, possesses a greater activity, and may be employed in every medical application. Two of those are so light, that they do not weigh a pound together, and an ounce of solution in a common glass, is sufficient to put it in action. I shall reserve for a future occasion some preliminary experiments made by me, in order to render the action of the above mentioned apparatus more efficacious, by means of a principle analogous to that by which Mr. Newman lately increased, in a considerable degree, the galvanic power of the trough. Finally, it is necessary to observe, that metallic arcs when used, should have handles of glass, or should be covered with silk fastened by gum, in the place where they are touched by the operator; so that no portion of the galvanic current may be drawn from its object, and thus, by a diminution of its force, escape from the part where it ought to act.

Page 27, Note (b)

In the year 1803, I instituted a series of galvanic ex-

periments upon the bodies of different animals in various anatomical theatres in London, and I had the honour to repeat them before their Royal Highnesses the Prince Regent, and the Dukes of York, Clarence, and Cumberland. On this occasion I selected the head of an ox, and exposed it to the galvanic influence, hoping to obtain the most powerful results; and I observed, that the convulsions were more violent, than those which I had seen take place in Italy and elsewhere in animals of the same species. The size and vigour of the English oxen, generally so well marked, increased the effects of the galvanism. The irritation of the organs was so great, that the whole head was put into most violent agitation. A snorting was perceived from the nostrils, which would have been more strong, if the principal parts of the organs of the voice had not been separated by decapitation. I observed at this time, that upon a person's having caught hold of the skin of the tongue by an iron hook, as it came out from the mouth, there was a strong effort made by this part to contract, as often as the galvanic power was applied to the spinal marrow and muscles of the neck. The force at some times was so great, that the point of the tongue was torn through. Another series of galvanic experiments was instituted by me about the same time at Paris, on different horses, with the assistance of the Professors of the Veterinary School at Alfort.

Page 32, Note (c)

In the case of a decapitated malefactor, I found that when the arc was applied to one ear, and to the lips, a very sensible portion of saliva was discharged from the mouth. This observation was confirmed at Genoa on the head of an ox, and in several other places on the heads of sheep. The phenomenon of the extrusion of the fæcal matters, by means

of galvanism, has been observed by the Brothers Professors Moyon of Geneva in the trunk of an ox, and in the frame of human bodies. That the reader may be perfectly acquainted with these interesting facts, I subjoin the description of Professor Gaudin.

“ Le Maire d’Alfort le 5 Julliet, 1804, me fit appeler pour galvaniser un jeune homme qu’on venait de retirer du courant de la Marne, où quatre chevaux qu’il conduisait à l’abreuvoir l’avaient entraîné.

Les renseignements qui me furent donnés prouvaient que le malheureux jeune homme n’avait été retiré de l’eau qu’une demi-heure et même trois quarts d’heure après son immersion ; depuis une heure on lui prodiguait en vain tous les secours de l’art, les frictions, les fumigations, l’insufflation, même on avait fait l’ouverture de plusieurs vaisseaux veineux. Des contusions profondes, des échimoses étendues sur la tête, et dans les autres régions du corps, semblaient annoncer que le malheureux était mort plutôt des coups qu’il avait reçus des quatre chevaux fixés les uns aux autres, que des suites de l’immersion : tout annonçait enfin qu’il ne restait plus d’espoir de le rappeler à la vie.

“ Je soumis à l’action galvanique ce cadavre deux heures après sa submersion, plutôt pour expérimenter, que dans l’espoir de produire un effet avantageux. Une pile composée de soixante paires de disques de zinc et de cuivre, fut disposée avec la précipitation que la foule et les circonstances d’un tel accident ne manquent pas d’occasionner : faible par le nombre de disques et par son mode d’arrangement, elle fut placée sur un isoloir près de la tête du cadavre étendu sur un matelas ; un conducteur métallique partant de la base de la pile, fut fixé sous l’aisselle gauche ; un autre fil placé dans la narine du même côté, venait former l’arc à la partie supérieure de la pile. A chaque attouche-

ment les muscles des paupières, des lèvres, de la face, éprouvèrent des contractions sensibles, le bras gauche opéra des mouvements de rétraction faciles à distinguer; cependant le reste du corps parut ne point partager cette action contractile : je changeai alors la disposition de l'appareil; le conducteur partant de la base de la pile, fut placé dans l'anus, et l'autre introduit dans le larynx : au premier attouchement tous les muscles de la face se contractèrent et deux jets d'un liquide écumeux sorti des narines, me prouvèrent que le diaphragme avait participé à cette action; l'anus permit également la sortie des matières fécales contenues dans le rectum. Je répétais ces attouchements, toujours accompagnés des mêmes phénomènes; mais l'action décroissante de la pile, et l'inutilité de ces essais pour ranimer un cadavre, me déterminèrent à ne pas pousser plus loin cette expérience.

“ Appuyé de l'opinion du professeur Aldini, ne m'est-il pas permis de croire que l'agent galvanique serait le moyen le plus puissant pour rendre à la vie les noyés retirés de l'eau à temps, et que les soins ordinaires ne peuvent ranimer? Ne peut-on pas le considérer dans ce cas comme le *maximum* des efforts de l'art? Cette question est importante à résoudre; elle ne peut manquer de fixer l'attention d'un gouvernement éclairé.”

Page 39, Note (d).

Mr. Pettigrew, Secretary of the Royal Humane Society, afforded me every opportunity of performing my experiments in his house, and has been my zealous co-operator in forwarding this object. He inserted in the register of the Society the observations I had made, and rendered me his friendly assistance in order to enable me to publish my dissertation in English. In his hands I have deposited the galvanic apparatus above described, in order to place it in

the Society's archives, that it may be rendered beneficial in promoting the views of that Institution. He has also kindly communicated to me all particulars respecting the laws and regulations of the Royal Humane Society, that I might be in a capacity of encouraging the erection of similar establishments on the Continent.

Page 44, Note (e)

One of the principal objects of my journey has been to learn the state of illumination by gas, not only in London, but also in the principal towns of the kingdom. While at Edinburgh I had an interview with Mr. Stevenson the engineer, to whom I feel indebted for a variety of information respecting the light-house of Scotland. And by his assistance I formed a general plan for substituting gas in place of the methods generally used in these establishments. The experiments recently made at Philadelphia, by means of the instrument called the *American water-burner*, encourages me to support the opinion, I have already published; viz., to render the flame of gas more brilliant by means of an aëriform fluid extracted from steam. I am also desirous that the magnificent display of gas by which this great capital is illuminated, should be assisted by reflectors, which are employed with much advantage in Paris, and some of the greater cities of the Continent. It has also struck me that ladders should be dispensed with, by substituting a simple rod for opening the valves, and lighting the gas, a plan that is common in Vienna. On my return to Italy, I propose publishing my political and economical views on these subjects, according to the memoir which I read before the Royal Society of London, on the 28th of last January, under the title, "*Experimental Inquiries on the use of Gas Light on the Continent, with some observations on the present state of the illumination of London.*"

Page 60, Note (f)

Sulzer, before Galvani's discovery, had found methods of exciting the sense of taste:—

“ Si l'on joint deux pièces, l'une de plomb, et l'autre d'argent, de sorte que les deux bords fassent un même plan, et qu'on les approche sur la langue, on en sentira quelque goût assez approchant au goût de vitriol de fer, au lieu que chaque pièce à part ne donne aucune trace de ce goût. N'est-il pas probable que par cette jonction des deux métaux il arrive quelque solution de l'un, ou de l'autre, et que les particules dissoutes s'insinuent dans la langue? *Sulzer. Nouvelle theorie des plaisirs, 1767.*”

Page 63, Note (e).

I have lately been to Glasgow, to pay a visit to Professor Ure, to profit of his superior knowledge on this subject; and I performed various experiments with him on this occasion, for the purpose of establishing a more useful method for applying galvanism in cases of suspended animation. I perfectly agree with him on the utility of passing the galvanic action through the phrenic nerve, for restoring respiration. Professor Rossi, according to experiments made on drowned animals, thought it indispensable to open an artificial passage in the trachea for introducing air, because the *glottis* remains shut in cases of asphyxia of this kind. I think that any incision may be dispensed with, a precaution being used to raise up the *epiglottis* with an instrument before the application of galvanism.

Page 65, Note (h)

I observed with the greatest satisfaction, in the hospitals of Germany, and principally in that of Berlin, the many beneficial advantages derived from the moral treatment employed for the cure of madness; I could not,

however, equally approve their physical treatment, with respect to employing a centrifugal apparatus whose violent motion is supposed to have the power of curing the disorders of the brain. Instead of this method, I should rather prefer for this purpose, the action of galvanism, particularly in cases of melancholy madness. Dr. Tuthill has actually employed it on two subjects, on one of whom it produced beneficial effects. This took place at Bethlehem Hospital, an establishment not only remarkable for the magnificence of its structure, but for the wisdom of its regulations; and, as far as I have seen, would be the first institution of this kind in the world, if it possessed the advantages of moral treatment.

Page 69, Note (1)

Galvani not only published this commentary containing his first discoveries in animal electricity, which are well known, but also the two works mentioned above, where he treats of a new general plan of Physiology, according to principles established by his experiments. For this purpose he instituted a chemical analysis of the different parts of the human body, in order to ascertain those that were most adapted either to retain or to conduct animal electricity in the state of life.

The Galvanic apparatus of Professor Aldini, described in this work, with Plates of, and directions for their use, may be had of Messrs. Newman, Optician, 8, Lisle Street, Leicester Square; Bate, Optician, 17, Poultry;—Also of Mr. Ruthven, Edinburgh.

FINIS.

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