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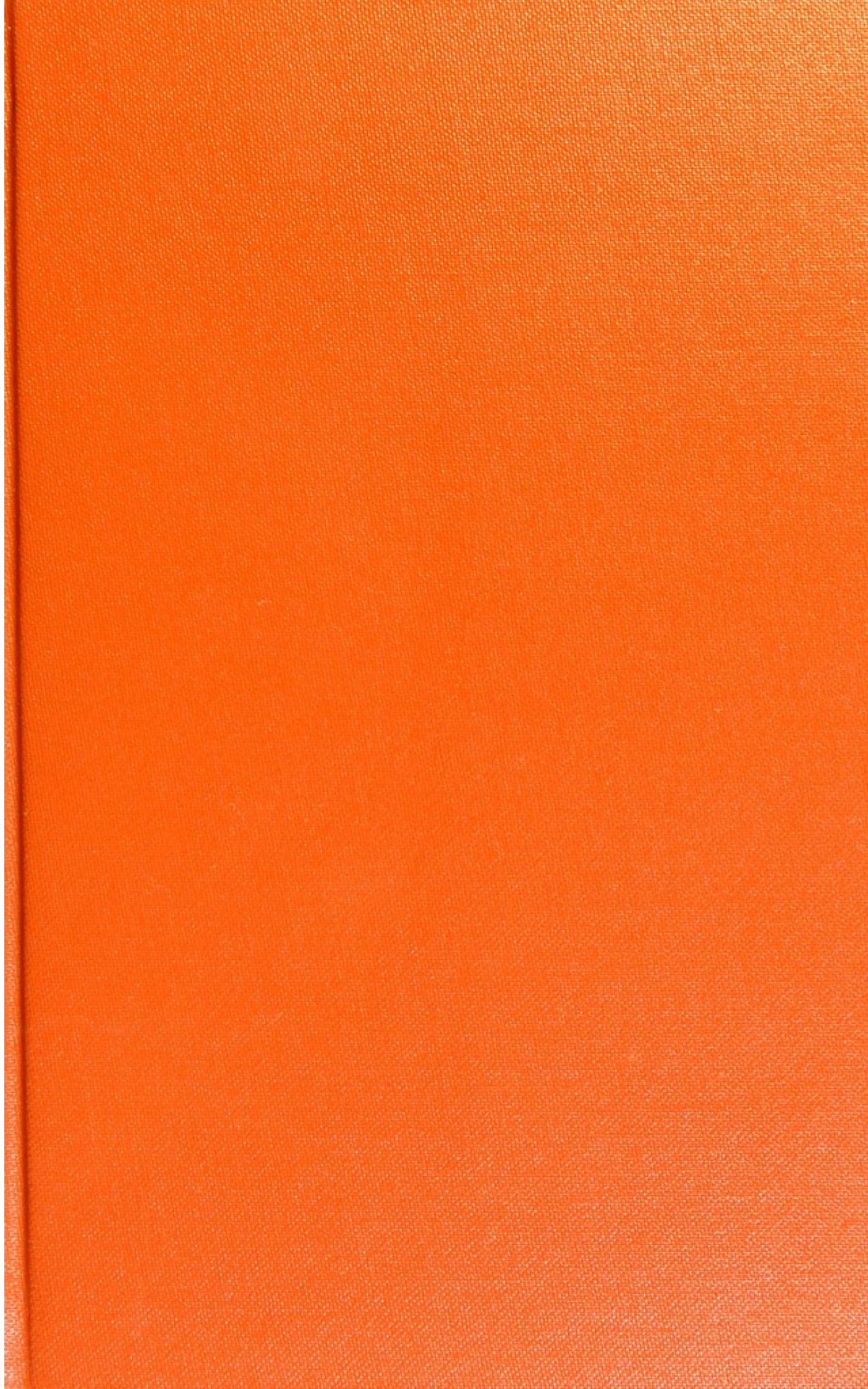
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THE VALUE OF ELECTRICAL TREATMENT.



THE VALUE OF ELECTRICAL TREATMENT.

BY

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Médicale de Paris,
etc., etc., etc.*

Third Edition,

With which is incorporated a chapter on "ELECTRICITY IN GYNÆCOLOGY,"
specially written for it by DR. APOSTOLI, of Paris.

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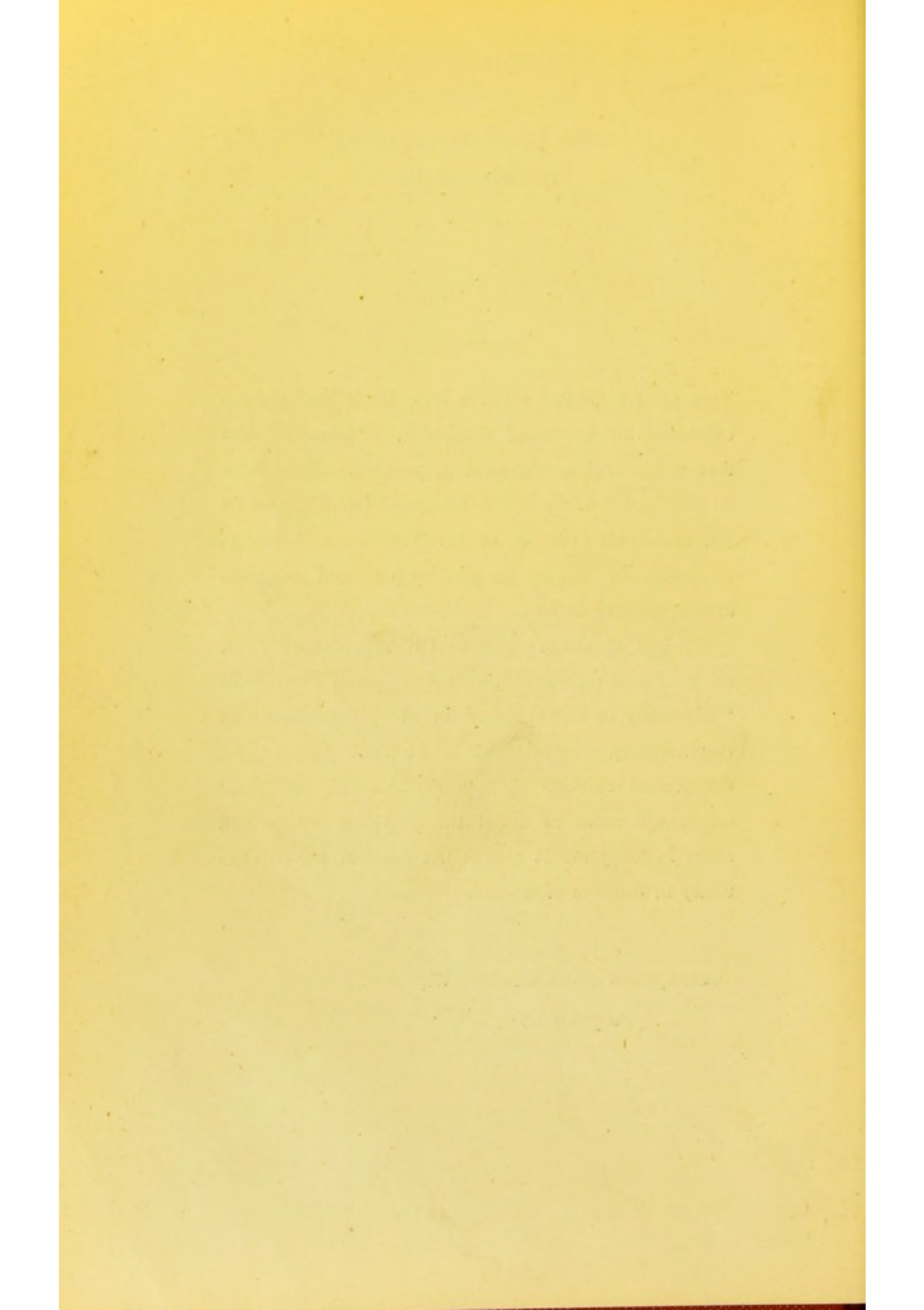
P R E F A C E.

THE second edition of this little book having been exhausted, the continued demand for it seems to show that it has met a real want in practice. Soon after its publication here, it was translated into German by Dr. HERMANN OETKER, of Oeynhausen; and was as favourably received by the medical press and profession in that country as here.

My best thanks are due to Dr. APOSTOLI, of Paris, for having, at my request, written a special chapter on "Electricity in Gynæcology," in which department he is universally acknowledged to be *facile princeps*, for the present edition. I hope that his able and lucid article will serve to dispel the prejudice which still exists in many minds against the habitual use of electricity in diseases of women.

26, QUEEN ANNE STREET, W.,

June, 1899. \



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The Value of Electrical Treatment.

SINCE the appearance of the last edition of my "Treatise on Medical Electricity," in 1873, much quiet and useful work has been done in this department of science, more especially with the object of utilising the more exact physical knowledge which we now possess of the qualities of electricity for the improvement of the methods of its medical application. Electrical measurement is at present far more precise than it was formerly, and the whole apparatus which is now habitually employed in electro-therapeutics is greatly superior to that which was in use twenty years ago. There has been no actual new departure such as was inaugurated by the brilliant researches of Duchenne and Remak about forty years ago, but there is unquestionably more definite knowledge, and more extensive clinical experience than was formerly available. Moreover, there seems good prospect that electro-therapeutics may soon become applicable to even a larger class of cases than hitherto, by the use of the undulating or sinusoïdal current, and of the alternating current of high frequency and potential, which d'Arsonval¹ and the modern French school of electro-therapeutists have introduced into practice, and found beneficial in the treatment of certain nutritional diseases, such as gout, diabetes, chronic rheumatism, and obesity.

In spite of this, it cannot be said that professional opinion about the value of electricity in the treatment of disease is as yet more settled, for a considerable amount of scepticism still prevails with regard to it. That this should be so appears to be owing to several causes. In the first instance the truly outrageous quackery which has been permitted to flourish in connection with medical electricity, without being in the slightest degree interfered with by the Medical Council or any other constituted authority, has cast a somewhat sickly glare on the subject, and created a prejudice against it in many minds. Again, some advanced thinkers in Germany, such as Möbius² and Moll³, have started the peculiar notion that electricity in medicine does not act through its physical and chemical qualities as other remedial agents do, but simply through suggestion—the fad of the day; and the boldness and ingenuity with which such flighty arguments have been brought forward, have recommended them to the favourable notice of many who were not well informed on the subject. Finally, it has often happened that a battery was applied to a patient in a haphazard way, and in ignorance of established rules of practice; and when no result, or an untoward one was obtained, electricity has been debited with the failure. No one would think that the mere purchase of a case of surgical instruments would enable its possessor to perform ovariectomy, or even to remove a simple cyst properly; yet many people seem to imagine that the possession of a battery and electrodes is sufficient for applying electricity to patients, forgetful of the fact that much study and careful training are required for such procedures, if they are to be beneficial, and that success increases in proportion to experience. Several influences have therefore combined to lead to an unfavourable professional estimate of the value of this agent in therapeutics being formed.

On the other hand, there is the indisputable fact that the use of electricity has now become a recognised branch

of study and teaching in most English hospitals, which was not the case twenty years ago ; while in Germany and the United States almost every practitioner makes daily use of both the constant and intermittent current in his treatment of disease. If electricity could not accomplish more than "Perkin's metallic tractors," or other imaginative therapeutical agents, it may be taken for granted that it would long ago have disappeared from practice.

Having been in intimate touch with this subject during a long professional life, it has, under the circumstances just mentioned, appeared to me worth while to submit once more to the profession my views on the uses and the limits of usefulness of electricity in medicine.

* * * *

FORMS OF ELECTRICITY.

The principal forms of electricity which are at present utilised in medical practice, are :—

I.—Electricity in the state of rest, *franklinism*, frictional, or static electricity.

II.—Current electricity, or electricity in the state of motion, which comprehends the following varieties :—

1. *Galvanism*, the continuous or constant galvanic, or voltaic, or battery current.
2. *The constant current from the main*, which is produced by the ordinary constant current dynamo of comparatively low tension, and which, although always flowing in the same direction, is not as uniform in strength or smooth in its action as the battery current.
3. *Faradism*, electro-magnetism, the interrupted intermittent, induced, or faradic current.
4. *d'Arsonval's undulating or sinusoidal current*, which always flows in the same direction, but attains its position and negative maximum gradually, so that, while incessantly varying from one instant to

another, yet shows the utmost regularity in these variations, and is therefore devoid of such sudden changes of potential as the faradic current.

5. d'Arsonval's current of high frequency and potential, which is produced by an oscillating discharge of a condenser consisting of two batteries of Leyden jars, passing through a solenoid, into the interior of which the patient is placed, who may then be traversed by a current of 3,000 Milli-ampères at the rate of 500,000 to a million oscillations per second, without perceiving a shock or any other marked sensation.
6. Morton's⁴ static induced current, which is produced by the aid of condensers or Leyden jars put into the circuit. The part played by the Leyden jars in this arrangement is not simply to intensify the spark, but to act as the source of a continuously interrupted current, which is different from galvanism or faradism, and has been used by Morton chiefly in diseases of the spinal cord, such as tabes, muscular dystrophy, etc.

STATIC ELECTRICITY.

Static or franklinic electricity was known and medically employed long before current electricity had been discovered, but lost favour when the striking phenomena connected with galvanism and faradism began to attract attention. Of recent years static electricity has, however, gradually crept back into practice, and is now considered to be a useful remedy. The induction or influence machines which have been lately constructed, and the best of which are those of Carré, Wimshurst, and Lewandowski, yield a plentiful supply of electricity independently of the weather, which in our damp climate is a very important consideration. They may be put into action either by turning with the hand, by electro-motors, or by gas engines.

Franklinic electricity may be used in the form of a dry bath, the patient being charged while on an insulating couch or stool. In this way many patients in La Salpêtrière, at Paris, are habitually charged with positive electricity for several hours a day. Franklinism is also applied by drawing sparks from round conductors; as the electric wind, or breeze, or douche, when a pointed conductor is approached to those parts which are intended to be acted upon; or a metallic cap, connected with a conductor, is held at a certain distance from the head. A discharge intermediate between the wind and spark is produced by the so-called "electric aigrette," when a blunt metallic point or a piece of wood is approached to the patient's body. Maclure⁵ has found this latter useful in cases where it is intended to act on a particularly sensitive part, such as the face, or as preparatory for stronger treatment in timid patients.

As ozone or electrified oxygen is developed during the action of the franklinic machine, the patient may be made to inhale it by holding an insulated disc with a number of points at some distance from his mouth. This proceeding has been found useful in certain forms of anorexia and spasmodic asthma.

All these different modes of using franklinic electricity produce a mixture of stimulant and sedative effects on the system, which may be utilised in the treatment of certain neuroses, such as hysteria, hystero-epilepsy, encephalasthenia, insomnia, obstinate forms of neuralgia and spasm, anorexia, and constipation of the bowels. Apostoli and Planet⁶ have recently found franklinism of considerable use in certain forms of neurasthenia which occurs in hysterical subjects. The simple static bath produces in such cases refreshing sleep, the ozoniser placed to the mouth causes a better appetite, while static sparks are useful for relieving ovarian pain and habitual constipation. Franklinic electricity often seems to disagree in the beginning of the treatment, more especially in Jewesses, who complain, as soon as they are

placed on the insulating stool, of giddiness, faintness and exhaustion, which may continue for a day or two, during which sleep is more than usually disturbed. The sittings should in such cases be very short, not more than two or three minutes, until the patient is as it were acclimated, after which the application is better borne, and great benefit or a cure is eventually accomplished.

CURRENT ELECTRICITY.

I.—THE CONSTANT OR CONTINUOUS GALVANIC CURRENT.

This is by far the most important form of electricity for medical purposes. Its effects have been much more thoroughly studied than those of franklinism or faradism, and it has been shown to possess greater therapeutical value than all other modifications of the force put together. It may therefore be said to be absolutely indispensable to those who wish to use electricity in therapeutics.

PRESSURE, POTENTIAL, CONDUCTION.

Just as water flowing along pipes meets with a certain resistance, the latter being the less the larger the pipe, thus electricity when flowing through conductors encounters a resistance which varies according to their transverse section.

Electricity is able to overcome obstacles which present themselves in its way, and to do work by its quality of *pressure*, which is also called *electro-motive force*, *potential*, *difference of potential*, or *voltage*, all these terms being synonymous. When equal at two points, the potential will not allow of any electrical interchange; but when different, it will cause electrolysis, that is, a migration of anions to one side and of cations to the opposite side.

Such interchange continues until the difference of potential at the two points has been neutralised. It is this difference which causes the ions to move, and constitutes the electric current. The rate at which the electricity travels is diminished in proportion as there is more friction, that is, more resistance to the passage of the ions.

There are two different kinds of conductors of electricity, viz., 1st, the *metals and sulphurets of metals*, which conduct exceedingly well in the solid condition, better at lower than at higher temperatures, and do not undergo any recognisable chemical change by the transmission of electricity; and, 2nd, the *electrolytes*, which only conduct when dissolved or melted, do so better at higher than at lower temperatures, and are decomposed by the passage of the current through them. The human body, therefore, which does not contain any metals or sulphurets in noteworthy quantities, can only conduct in consequence of being an electrolyte, since it contains about 70 per cent. of water, in which certain salines, more especially sodium chloride, are dissolved. The albuminous matters which are suspended in the blood and the tissues, in the colloid form, do not constitute true solutions in a chemical sense, and do not therefore participate in the electrolytic action. This latter point will be more amply discussed when treating of the mode of action of the current on the living tissues.

OHMS, VOLTS, AMPÈRES, COULOMBS, WATTS AND Joules.

A unit of resistance was first proposed by Werner von Siemens in 1849, and defined as the resistance of a column of mercury one mètre long, and one square millimètre wide. The British Association afterwards proposed their absolute unit (B.A.U.), which was called *Ohm* and adopted by the International Congress of Electricians, which met in Paris in 1881. The Congress, however, modified the

unit in such a way that at present an ohm represents a column of mercury 106 centimètres long and 1 square millimètre wide. At a temperature of 32° an ohm is therefore equivalent to 1.06 Siemens unit. This is called a "legal ohm," in order to distinguish it from the "real ohm," which has not yet been measured with absolute accuracy, but appear to be about 0.3 per cent. less than the legal ohm.

Ohm's law is to the effect that the current-strength is directly proportional to the electro-motive force, and inversely proportional to the resistance encountered in the circuit of the battery; in other words, *the current-strength is equal to the electro-motive force divided by the resistance.*

This may be expressed by the formula $C = \frac{E}{R}$.

The units introduced by the Paris Congress are called "absolute," a term first used by Gauss, who in connection with Wilhelm Weber reduced the magnetic and electric forces to units of length, mass, and time, without reference to arbitrary units. These original units were expressed in millimètres, milligrammes and seconds; but, at Paris, it was decided, on the proposal of Lord Kelvin, that the base of the units should be centimètre, gramme and second; and this is usually designated by the letters C.G.S.

The Congress termed the unit of electro-motive force, or the pressure which forces the electricity over a conductor, a *volt*. Just as we measure the pressure of water in pounds, a pound being the unit of pressure, thus the volt is the unit of pressure, or electromotive force, for electricity. A volt is of nearly the same value as the current given by a single cell of Daniell's battery. The exact value of that cell is 0.9268 volts, and most of the other cells which are in use have similar values.

The unit of current strength, or rate of current flow is called an *ampère*, which is therefore equivalent to $\frac{1 \text{ volt}}{1 \text{ ohm}}$, or

in other words, to the strength of a current produced by the electro-motive force of one volt in a circuit having a resistance of one ohm. A current of one ampère passing for a second is called a *coulomb*. Such a current will precipitate 1.11815 milligrammes of silver from a solution of nitrate of silver in a second. An ampère is however far too large for medical purposes, and the thousandth part of it, or the *Milli-Ampère* (MA.), has therefore been adopted as unit of dosage for medical electricity, just as a grain or a minim is the unit for the dosage of drugs. The strength habitually used in medical applications of electricity varies from $\frac{1}{10}$ th to 15 or 20 MA.'s, while in the hydro-electric bath and in surgical applications, up to 250 MA.'s may be used.

While therefore ampères and coulombs designate the rate of flow, and the quantity which flows in a second, the work done by one volt at the rate of one ampère is called a *watt*; and if this work goes on for a second, the quantity of work done is a *joule*.

INSTRUMENTS REQUIRED.

THE BATTERY.

A good galvanic cell should possess a high electro-motive force, say of 1 or 1.5 volts. It should have a low internal resistance, say of 0.5 to 1.5 ohms. It should be only slightly liable to polarisation, so that the bubbles of hydrogen which are set free on the copper or carbon plate, as soon as the cell is in action, are absorbed as soon as liberated, by being brought into contact with oxygen or chlorine. If the bubbles of gas were allowed to accumulate on the copper plate, as occurs in the original voltaic pile and its modifications, the electro-motive force would be speedily diminished and lost. Not only is hydrogen a bad conductor, so that it weakens the current by introducing additional resistance, but it also sets up an electro-motive force acting in the opposite direction to that of the battery, for hydrogen has

even more affinity to oxygen than zinc, more especially when in the nascent condition. Cells in which polarisation is reduced to a minimum will last a long time if fairly used, and do not require attention for years.

Only two batteries are at present generally used which fulfil the conditions just mentioned, viz. the Leclanché and the chloride of silver cell. In the Leclanché cell (invented in 1868) zinc and carbon are in contact with a concentrated solution of ammonium chloride and pyrolusite, or native peroxide of manganese, which acts as the depolariser. When the cell is in action, the ammonium chloride solution is decomposed, and the nascent hydrogen is absorbed by the oxygen of the pyrolusite, while chlorine combines with zinc, and ammonia is set free. The Leclanché cell is superior to any other where a stationary battery is required for the consulting-room, as it is very constant, provided the cells have a large surface. A battery which Mr. Schall has fitted up for me had lost very little of its electro-motive force after three years' almost daily and often prolonged use. A good dry cell is now made which is even more constant than the old liquid cell. The electro-motive force of the Leclanché is 1.48 volts, while its internal resistance varies according to the size of the cell from 0.4 to 1.5 ohms.

The *chloride of silver cell* consists of zinc, silver, chloride of silver and a diluted solution of ammonium chloride. Chloride of silver is the depolariser and forms chloride of zinc, while metallic silver is deposited in a finely pulverised state. This cell is, on account of its lightness, particularly suited for portable batteries, for depolarisation is very complete in it, and the cell can therefore be made very small without becoming inconstant. The original Warren de la Rue cell (invented in 1868) had an electro-motive force of 1.03 volts, while Scrivanow's modification gives 1.4, and Schall's as much as 1.61 volts. The internal resistance is small and the recent modifications of this battery will remain in good condition for several years.

A battery giving from 40 to 60 volts will generally be found sufficient. It is useful to have it provided with a so-called "double collector," which was invented by Gaiffe, and which permits the successive use of all the cells, while the single collector has the drawback that the first cells of the battery must be always in use, and therefore suffer more than the last. The battery should also have a contrivance by means of which the direction of the current may be reversed in the metallic circuit.

CURRENT FROM THE MAIN.

The electric light having come into general use, there are few places now where the current derived from dynamos may not be utilised for medical purposes. It is claimed for this arrangement that it has the advantage of cheapness, since the original installation at the house of the operator does not cost more than a good battery, and will practically last for ever, while the charge made for the current derived from the main is very small. Such a current is always available, and the trouble and expense connected with the occasional cleaning of the battery and providing of fresh cells may thus be avoided. It seems to me, however, that the mere question of cost is not a decisive one; and with a good Leclanché battery, cleaning and renewal will only be required once in three or four years, and can easily be effected during the annual holiday of the operator. On the other hand there are certain drawbacks connected with deriving the current from the main which have thus far determined me to remain faithful to the battery, as this can be so comfortably arranged that with ordinary care the operator need not have the slightest trouble or anxiety in connection with it.

Two kinds of current are at present used for electric lighting, viz., the continuous current of low tension and the alternating one of high tension. The former has an electro-motive force of between 100 and 250 volts, and may

be used for every kind of medical electrification. The latter constantly changes its direction, and can therefore not be used for galvanisation and electrolysis, but only for cautery, surgical lamps, etc. This current has in the mains a force of from 2,000 to 5,000 volts, and may therefore be distributed very cheaply.

The continuous current from the main may be controlled by interposing resistances, in order to protect the patient from an overdose. The system of the so-called "connection in series" has, however, proved a failure, for while it is true that a resistance of 100,000 ohms may reduce a 100-volt current to one Milli-ampère, yet the current thus arranged acts differently from the battery current, being not absolutely constant but somewhat pulsatory, and therefore produces, even when feeble, very unpleasant sensations, which make it undesirable for practice. Mr. Schall, of Wigmore Street, has therefore introduced the method of "shunting," which is to enable the operator to change both ampères and volts at pleasure. He claims for this system that it allows a finer and more gradual regulation than can be obtained by the best current collector connected with batteries. This is no doubt correct for current collectors, but does not apply to the chain of rheostats which I have used for many years past, and with which any galvanic force from $\frac{1}{20}$ th MA. upwards to any amount may be obtained in the most gradual progression, with the utmost shades of nicety and without producing the slightest shock when increasing or lessening the current-strength.

With regard to the question of safety when using the current from the main, we have to consider that in some towns both the continuous current of low tension, and the alternating one of high tension are employed, and accidents might bring the different wires into contact. Again, in most electric lighting stations the dynamo is suddenly switched off, and a battery of accumulators switched on instead, in the morning and evening, so that there might be a sudden

break in the current at the time of operating, which might have serious consequences for a patient. Finally, there may be leakage of current through imperfect insulation of the conductors in the street from the earth, which might lead to severe shocks being suddenly administered. All these considerations have determined me to discard the current from the main; and I am glad to find that such an excellent operator as Morton⁷, of New York, who has for a considerable time used both the battery-current and that from the main, has in his most recent work pronounced in favour of the former; his reasons for this being that in the latter there are fluctuations, variations in the potential of the lines due to variations in load, that there may be accidental "grounding" of the patient, and danger from lightning, none of which can possibly happen when using the battery current.

THE RHEOSTAT.

In order to procure the finer shades of galvanic power, which are particularly required where the constant current has to be applied to the head or neck, and in sensitive

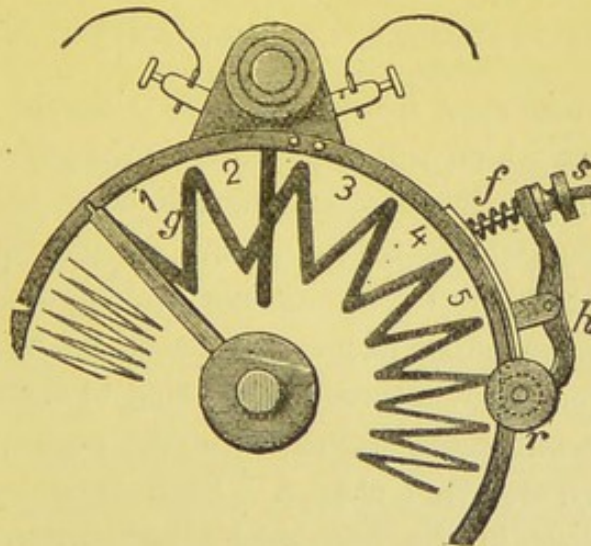


FIG. 1.

Lewandowski's Rheostat.

patients, a well-constructed rheostat, by means of which the amount of resistance in a circuit may be varied *ad*

libitum, is indispensable. With the current-collector we are only able to proceed from one cell to another, while with a rheostat, or, better still, with a chain of two or three rheostats, small fractions of volts are placed at our disposal, and we are thus enabled to apply the current with the utmost delicacy so as to suit the special requirements of each individual case. The most convenient rheostat for the use of the constant current in medicine is that constructed by Lewandowski and Leiter, in which graphite and mercury are used. This instrument has an entire resistance of 100,000 ohms, and allows us to gradually diminish it down to 5 ohms, without the slightest break in the continuity of the current. To work with it is a real pleasure, which can be fully appreciated only by those who have previously employed the crude rheostats which were in fashion even five or ten years ago, and with which "jumps" or "jerks" were apt to disturb the operator as well as the patient. Liquid as well as metal rheostats are not nearly so good as the arrangement just described.

THE GALVANOMETER, OR MILLI-AMPÈRE METER.

Another necessary instrument is an absolute horizontal galvanometer, which will show not only the passage of the current and the direction in which it flows, but also the Milli-ampère which may be passing through the patient's body. The vertical galvanometer which was formerly generally employed, on account of its simple construction, was soon found to be unreliable, owing to changes which are apt to occur in the magnetism of the needle, while the magnet itself does not change. Such one-sided changes do not occur in the horizontal galvanometer, which is therefore now almost exclusively used. The best instruments of this kind are Edelmann's "pocket" and "large" galvanometer.

The latter allows us to read off any current-strength

between $\frac{1}{10}$ th and 800 Milli-ampères, and is particularly useful in the modification suggested by Müller, of Wiesbaden, which is furnished with a vertical scale and index, by which the reading of the instrument is much facilitated. Morton has quaintly remarked that the use of this instrument gives the operator the equivalent of a sixth sense, for he is able to see mentally what is going on beneath the surface. Every variation in the resistance of the patient, or of the electrode contacts, is reflected by the fluctuations of the instrument; and every exclamation of pain or discomfort

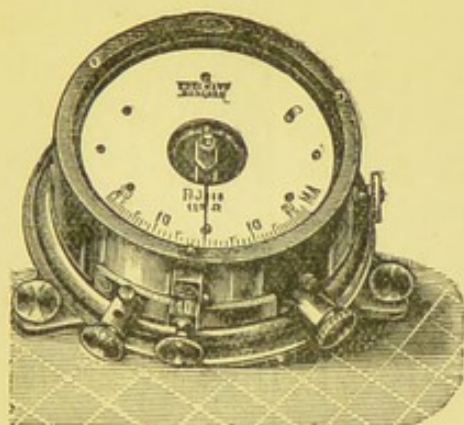


FIG. 2.

Edelmann's Galvanometer.

on the part of the patient finds an easy explanation from the readings of the "Milli-ampère meter." The habitual use of this instrument has indeed a great educational influence on the operator, by showing him whether he is right or wrong; by satisfying him, when during the application the needle remains as firm as a rock at the point desired; by drawing his attention to some otherwise undiscoverable source of error when the needle does not move or makes too rapid oscillations; and last, not least, by showing him, through a fast and furious deflection of the needle, that the current has by some accident or another become short-circuited.

THE COULOMBMETER.

With this instrument we can determine the quantity of hydrogen and oxygen resulting from the electrolytic decomposition of water by the flow of the current within a definite time.

While, therefore, the absolute galvanometer shows the current-strength which may be passing through the patient at a time, the coulombmeter will point out the quantity of

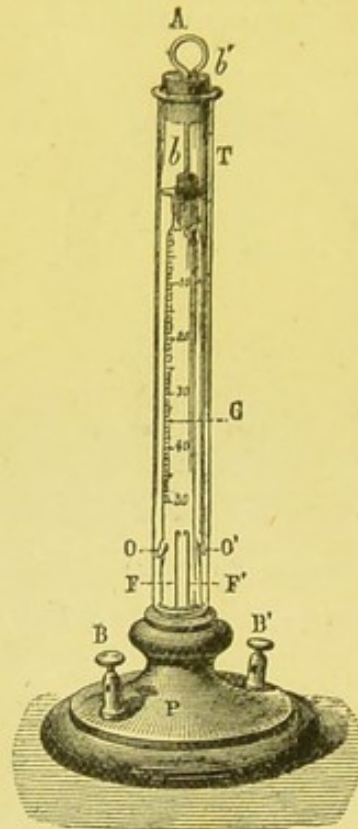


FIG. 3.

The Coulombmeter.

electrolytic work which may have been performed by the current in the tissues during a sitting. A few seconds after the application of electrodes to the skin, that is, after the resistance is overcome, streams of hydrogen and oxygen are seen to issue from the platinum points at the bottom of the tube, and the loss of water which takes place may be read off at the side of the instrument.

A sudden enormous effervescence in the coulombmeter shows the operator that the current has, by some accident, become short-circuited.

RHEOPHORES.

The rheophores or conducting strings should be made of fine flexible brass or copper wire, and thoroughly well insulated. Many years ago I recommended to have the insulating material made of two different colours, so as to be able to distinguish at a glance the positive and negative pole, and this has been pretty generally adopted.

HOW TO FIND THE POLES.

By immersing the free metallic ends of the rheophores into water, we can distinguish at a glance which is the positive and the negative pole; at the former oxygen is evolved, and being in the nascent state, combines at once with the metal; while at the latter hydrogen, which has no affinity to metals, collects in innumerable bubbles, and forms a thick layer of gas on the metal. If a piece of blue litmus paper be immersed into water, and the ends of the rheophores then applied to it, the blue colour will be deepened at the cathode, while it will be changed to red at the anode.

ELECTRODES.

The electrodes or conductors are generally made of tin or lead or carbon plates, which are covered on one side with sponge or chamois leather or flannel or amadou, and on the other side with indiarubber or oilcloth. A large number of differently shaped electrodes is necessary for the electro-therapeutist, and a description of them may be seen in any good instrument-maker's list. For the application of the constant current to the head I am in the habit of using electrodes, the conducting material of which consists of a very fine copper wire gauze, which is more flexible and

lighter than any other conductor. The advantage of such electrodes will be fully appreciated by those who have endeavoured to secure an accurate adaptation of the surface of the electrodes to the head and failed to attain this desideratum through the stiffness of other conducting materials.

DENSITY OF THE CURRENT.

A simple record of the current-strength in MA.'s does not show us the actual electric force which may pass through a tissue at a given time; and it is equally important for us to know the density of the current, that is, the quantity of electricity passing in a unit of time through a unit of transverse section. The density of the current is generally calculated for the "active" or "efficient" electrode, by which we intend to act on a certain organ; while the "indifferent" electrode only serves for establishing the circuit, and is not taken into consideration as far as this point is concerned.

The density of the current is therefore equivalent to the current-strength divided by the surface of the transverse section of the conductor, and is expressed by the formula

$D = \frac{C}{T}$. If, for instance, the current strength is 5 MA.'s, and the surface of the electrode 5 square centimètres, the density of the current is $\frac{5}{5} = 1$; but if the electrode should have a surface of 10 square centimètres, and the current-strength remain the same as before, then the density will be $\frac{5}{10} = \frac{1}{2}$. The density therefore diminishes in proportion as the surface of the electrode increases, and *vice versa*.

It is therefore not sufficient, when describing a medical application of the constant current, to say that so many MA.'s were used, but it is equally necessary to state the superficial area of the electrodes which were employed.

Milli-ampèrage and current density are thus seen to be of the first importance for all therapeutical applications of the current, just as posology is for the use of drugs. It is,

therefore, perhaps to be regretted that, with regard to the dosage of electricity, such widely divergent views should at the present time be held by many of the most prominent workers in this field. On going through the extensive recent literature on medical electricity, and comparing the practice of different observers in this point, one feels indeed tempted to exclaim: *tot homines, tot sententiæ*. I have, on the whole, seen no reason to depart in later years from the principle which I laid down in 1870 (second edition of my "Treatise on Medical Electricity," p. 318), and which was to the effect that "a feeble current used for a short time produces the greatest therapeutical effect. A current which is strong and painful to bear almost always does harm instead of good, and more especially when applied for a considerable time."

Amongst recent writers the two extremes in this matter are represented by Müller⁸, of Wiesbaden, and Morton⁴, of New York. The former has arrived at the result that the best dose for the majority of cases is expressed by the formula $\frac{1}{18}$, *i.e.*, a current-strength of 1 MA. for an electrode surface of 18 square cms.; and this exceedingly low force he administers once daily for a minute or a fraction of a minute only! Morton, on the other hand, recommends for the treatment of spinal diseases a dosage of 65 MA.'s, with an electrode surface of $1\frac{1}{2}$ by 18 inches, which would give the formula of $\frac{65}{54}$, or adapting it to Müller's, of $\frac{21.6}{18}$. In other words, he advises more than twenty times the dose recommended by Müller, and that not for a minute, or a fraction of a minute, but for ten or twenty minutes consecutively. Before ridiculing such differences of opinion, we should, however, remember that much the same thing happens with regard to the posology of drugs. There are many practitioners in this country who consider two grains an ample dose of potassium iodide. The majority of neurologists, when prescribing the same drug, use habitually

doses of from ten to thirty grains. During a recent visit to the United States, I found that a dose of 120 grains is frequently given there to children, and considered as by no means excessive. Professional ideas on posology are therefore seen to vary quite as much as those on electrical dosage.

Just as in prescribing drugs, we must, when applying electricity, be to a great extent guided by our personal experience. For the brain I am in the habit of using a current varying, according to the individual susceptibility of the patient, from $\frac{1}{10}$ th to 2 MA.'s, with a superficial area for the efficient electrode varying from 16 to 130 square centimètres, so that the formula would be from $\frac{1}{32}$ to $\frac{1}{75}$. In treating spinal disease I usually employ, likewise in accordance with individual sensitiveness, a current-strength varying from 2 to 10 MA.'s, and an area of from 40 to 130 square centimètres, which would give a formula varying from $\frac{1}{20}$ to $\frac{1}{13}$. The indifferent electrodes which I am in the habit of employing have an area varying from 40 to 200 square centimètres.

On the whole it will be found advisable to give rather too little electricity than too much, especially in the beginning of the treatment. In cases where there is much torpor a larger current-strength will be required; while where there is irritation, a smaller power will answer better. The conductivity of the different parts of the body has also to be considered, less strength being required for the face and head, and more for the back and limbs, etc.

A further point of great importance in applying the constant current is the *length of time* for which it is to be used. As for current-strength and density, so for time, opinions vary considerably. Müller and Lewandowski are in favour of very short applications, that is, from forty seconds to one minute for the brain, and from one to three minutes to the spinal cord, while American practitioners prolong the application much beyond that. The short

sittings advised by some electro-therapeutists have been severely criticised and ridiculed, and it has been stated that it is impossible to produce a definite effect by an application which lasts only a minute or a fraction of a minute. Such objections are, however, purely theoretical, and not founded on direct observation. In certain forms of asthenia of the brain, for instance, where mental work is distasteful or actually impossible, I have repeatedly seen that the application of a large cathode to the head with 1 MA. for one minute enabled a man to go through a good day's work without trouble or fatigue, or caused the exhaustion induced by a hard day's work to disappear. In persons who are not very impressionable, longer applications are necessary for producing a definite effect; and I have for this reason long made it the rule to begin with short sittings, and to gradually prolong them wherever this should appear expedient. The young electro-therapeutist should remember that long applications to the brain have sometimes brought about the opposite effect of that which was intended, viz., drowsiness, fatigue, and a feeling of discomfort and depression, instead of briskness, exhilaration, buoyancy and desire for physical or mental exertion, which we wish to produce.

Under certain circumstances the length of the application has to be considerably extended if we are to obtain really useful results. Long applications, continued for from ten to fifteen, or even twenty minutes, have appeared to me essential in the treatment of certain psychoses, and of paralysis agitans. This does not appear to have been realised by Lewandowski⁹, the author of the best recent work on the subject, and a most skilful electro-therapeutist, who will not go beyond the traditional forty or sixty seconds for the brain. Experience has shown me that if the patient is very carefully and gradually brought under the influence of the prolonged action of the current, not only is no harm done, but results may be obtained which cannot be achieved in any other manner.

How often should the constant current be applied? In some cases a single application is sufficient to cure a patient. This applies chiefly to cases of neuralgia in the face (not tic douloureux), which I have known to yield permanently to a single application of the anode to the affected part, just as a single application of faradism is frequently sufficient to cure functional aphonia. In the majority of cases, however, a much longer treatment will be required, and its duration will vary according to the nature of the affection. Fresh cases of neuralgia, muscular rheumatism, etc., yield, as a rule, rapidly to this treatment; but where the affection is of long standing, a month or six weeks may be necessary for obtaining a definite and permanent result. In some forms of hemiplegia, and certain spinal affections of very protracted course, such as locomotor ataxy, infantile paralysis, etc., several prolonged courses should be given at intervals, and a continuance of the treatment should be more especially recommended when the first course is shown to have had an influence in improving the most troublesome symptoms, or in arresting the further progress of the complaint.

A further essential rule is to apply the current *to the seat of the disease*. Where debility or paræsthesia in an arm or a leg are owing to central troubles, they will never be vanquished by electricity applied simply to the peripheral part where such morbid symptoms may be perceived. The diagnosis of the localisation of the complaint which may be under notice is, therefore, of cardinal importance for the successful electrical treatment of it; and *no one can be expected to apply electricity with benefit in a given case unless he is well grounded in anatomical and physiological knowledge and in clinical experience*. The electrodes must be placed in such a manner as to insure the passage of the current through the suffering structures. Thus, in a case of paraplegia from myelitis of the lumbar enlargement of the cord, the principal, and often the only, application

will be to the diseased portion of the organ. This rule, however, cannot always be rigidly enforced, partly because it is sometimes difficult to strictly localise the focus of the affection, and partly because a symptomatic treatment is sometimes of considerable assistance, in addition to treatment directed to the actual seat of the complaint. Thus experience has shown that in hemiplegia we should not simply act upon the suffering hemisphere, but on the paralysed limbs as well. Again, it is often useful in peripheral palsies to apply the current, not simply to the suffering nerve, but likewise to its nutritive centre in the bulb or spinal cord.

Müller, of Wiesbaden, has expressed these different rules by the axiom : *leve, breve, sæpe, et in loco morbi.*

MODE OF ACTION OF THE CONSTANT CURRENT.

It has been frequently stated that we know nothing about the way in which electricity acts, and that it is therefore irrational, or grossly empirical and arbitrary, to employ it in therapeutics. I have been much surprised to find that Professor Horsley has lately committed himself to a similar solecism. If such a principle with its logical consequences were adopted, it would imply the abandonment of our most trustworthy drugs, of the mode of action of which in the system we know even less than of that of electricity. No one has yet been able to find out in what way mercury or iodide of potassium produce their effects upon the different tissues of the body; yet, we know that these remedies if properly used have a powerful influence for good, and we therefore utilise them daily in the practice of our profession. In the present state of our knowledge it would be utterly absurd to rely more on physiology than on clinical experience. Of course, when applying electricity to a patient we must be thoroughly acquainted with, and to a great extent guided by, a knowledge of its physiological effects upon the different tissues of the body; yet

clinical experience will always be by far the most important element in any success we may achieve. Just as in operative surgery the mortality is habitually found to diminish in proportion to the increasing experience of the operator, thus success in electro-therapeutics generally becomes more marked as the practical knowledge and skill of the operator are becoming greater. No amount of reading will give such experience ; and as anatomy is only learnt by dissection, thus skill in electro-therapeutics can only be acquired by again and again applying electricity to oneself, and to patients whose cases may be suitable for such treatment.

The mode of action of the constant current is a very complex one, and although much of it is known, there is unquestionably much further knowledge concerning it to be gained. It is, however, a well-established fact that *the structure and function, more especially of nervous and muscular tissue, may be profoundly modified by the passage of the current.*

ELECTROTONUS.

Pflüger's researches on electrotonus which were made on frogs' nerves, but have been shown to be applicable to living men as well, appear to me to supply the key to the large majority of the therapeutical applications of the constant current. The latter when passing through a nerve, causes definite alterations in its condition, viz. a zone of increased excitability in the neighbourhood of the cathode—catelectrotonus—and a zone of diminished excitability in the neighbourhood of the anode—anelectrotonus, there being a "point of indifference" between the two poles, where the excitability is unaltered.

The cathode, therefore, acts as a stimulant, and the anode as a sedative, and the so-called polar method of treatment is based on this fundamental fact. Pflüger also found that the action of the current is not confined to the portion of the nerve which is comprised between the two electrodes, but extends beyond them to some distance.

The conductivity of the nerve is always lessened in the anelectrotonic zone, and may be at last completely annihilated if the current is powerful, and applied for a certain length of time. In such a case anelectrotonus will eventually predominate over catelectrotonus, so that the entire section of the nerve acted upon will show the phenomena of anelectrotonus.

Catelectrotonus originates at once on closing the circuit, while anelectrotonus is established only after the current has been acting for some time. Stimulation, therefore, takes place when the condition of the nerve is changed from normal to catelectrotonus, or from anelectrotonus to normal; in other words, when catelectrotonus appears and anelectrotonus disappears.

Clinical experience shows that the influence of electrotonus cannot be confined to a nerve, but must extend to the *neurone* (Waldeyer). A neurone is a nervous unit, which consists—

1st, Of the *grey nerve cell* ($N C, N' C'$, Fig. 4), in which the nerve-force is generated, and which is invariably multipolar.

2nd, Of the *axis-cylinder, axone* ($a c, a' c'$, Fig. 4) or nervous process, which may be motor, sentient or sensorial, and constitutes a single long nerve-fibre proceeding from the cell, which after passing on for some distance terminates in a number of very fine branches or terminal trees ($t t, t' t'$, Fig. 4), all of which have a free end, and do not anastomose with others.

3rd, Of a more or less considerable number of *proto-plasmic processes* ($p p, p' p'$, Fig. 4) or *dendrites*, which divide almost immediately on leaving the cell into a number of different branches, and terminate with a free end between the dendrites of neighbouring cells. Golgi has rendered it probable that these branches serve for the nutrition of the grey cell. The three different structures just mentioned form therefore the nervous unit or neurone, and the whole

nervous system consists of innumerable multitudes of neurones, which are simply connected with each other by contact, and constantly act and re-act upon each other. The therapeutical effects obtained by proper applications of the

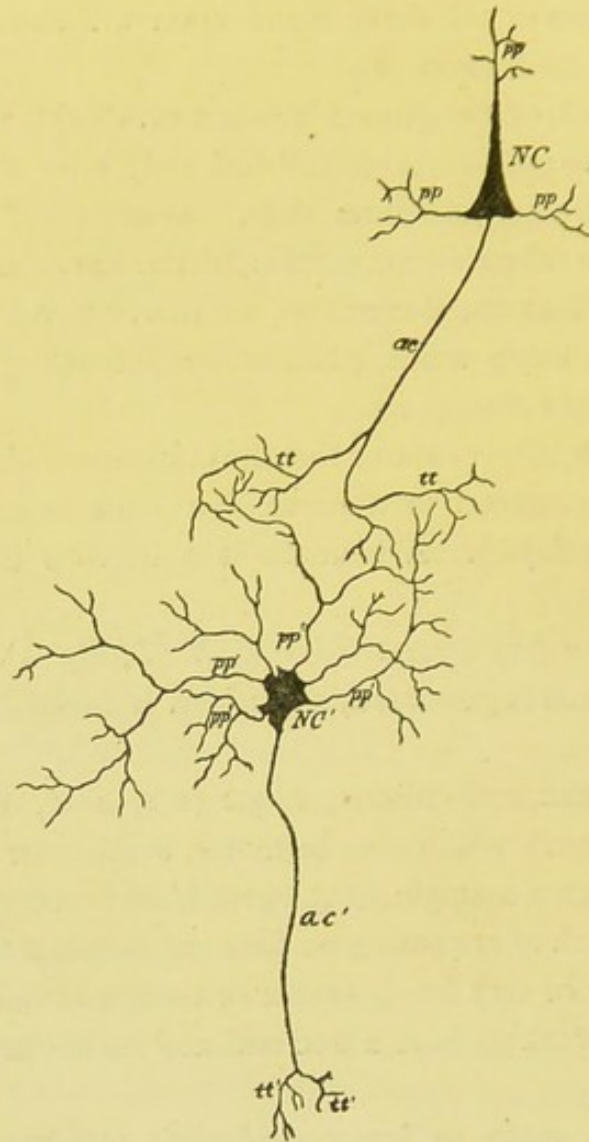


FIG. 4.

constant current can only be explained by assuming that electrotonic effects are not confined to the nerve-fibre, but extend throughout the substance of the neurone.

The electrotonic or modifying effects of the current are produced chiefly by the so-called "*stabile*" application,

which means that the electrodes are kept stationary on certain parts of the body. The polar effects are all-important here, and we have therefore to distinguish between the "active" and the "indifferent" electrode. The active one is that which is placed to the part in which we intend to produce either catelectrotonus or anelectrotonus, while the indifferent conductor, which only serves to close the circuit, may be placed on the sternum, the epigastrium, the hand, the patella, or the feet. It is essential that the electrodes, after being thoroughly well moistened with hot water, should be applied to their different places *before the current is put on*, after which the rheostat is brought into play for effecting a very gradual entrance of the current. The current-strength is then slowly, and without any jerks, increased to that degree of Milli-ampèreage which we intend using. The time of passage should now be carefully noticed, and after the application is over, the rheostat has again to be used, so as to effect a very gradual diminution of current-strength until the needle of the galvanometer points to zero. It is only then that the electrodes should be removed from their places of application. This mode of proceeding, which is very frequently neglected, is more particularly necessary when we apply the current to the head or neck, and want of attention to this rule may jeopardise all the benefit we may otherwise expect from the use of electricity.

The anode will therefore be made the active electrode where we have to do with the various forms of over-action, and where we assume an undue excitability of the affected nerves or neurones. By its sedative effects, it tends to change this condition into the normal one, and may thus prove curative in suitable cases of hyperæsthesia, neuralgia, tinnitus aurium, asthma, muscular spasm, and contractions, vomiting, etc.

The cathode, on the other hand, finds its appropriate sphere of action where the excitability of a nerve or neurone requires to be increased, *i.e.*, in paralysis and

anæsthesia. It must, however, be understood that these differences are not absolute, but that we must in all cases analyse very closely the actual condition of the nervous areas which are affected before proceeding to treatment. Thus it may happen that apparent over-action of certain neurones is owing to sheer debility, and consequent loss of control, and this is often therefore better treated by inducing catelectrotonus in them than anelectrotonus.

STIMULATING EFFECTS.

Electro-physiological researches have shown that the constant current is a powerful stimulant for all the different portions of the nervous system as well as for the muscles. Where these stimulating effects are required, various methods of using the current are at our disposal. We may use: 1st, the *stabile* application of the cathode to the seat of the disease, for producing catelectrotonus; in addition to which we may, 2nd, use the *labile*; 3rd, the intermittent application, and finally, 4th, voltaic alternatives. The *labile* application is that in which one electrode is stationary, while the other (generally the cathode) is slowly passed over certain parts of the body without being removed from the surface. The *intermittent* application is that in which one electrode is stationary while the other is put on, taken off, and put on again. Finally the *voltaic alternative* is produced by effecting a reversal of the poles in the metallic circuit, while both electrodes are stationary on the skin.

ELECTROLYSIS.

Those who wish to gain a thorough insight into this complicated subject, should study the original papers of Faraday,^{9a} in the "Philosophical Transactions," which still form the unshaken foundation of this department of electrology, and the more recent works of Ostwald,¹⁰ Tommasi,¹¹ and Frankenhäuser.¹² The first accurate description of the

effects of electrolysis on animal liquids and tissues was given by myself¹³, in 1869.

Faraday has shown that, when an electrolyte is traversed by the galvanic current, electrolytic decomposition ensues, which is directly proportional to the quantity of electricity which has passed through the electrolyte. The latter is composed of two different constituents with opposite electrical tendencies, viz., the *cation*, which is attracted by the cathode and repelled by the anode; and the *anion*, which is attracted by the anode and repelled by the cathode. Decomposition occurs at the point where the current enters the electrolyte, *i.e.*, the anode, and at the point where it leaves it, *i.e.*, the cathode. The chief electrolytes are salts of metals, such as sodium chloride, cupric sulphate, etc., together with acids and bases, and water, which is the general solvent. The place of the metal may also be taken by hydrogen, ammonia, oxygen and sulphur, and that of the acid radical by hydroxyl, HO. When therefore the galvanic current passes through electrolyte solutions, metals and their substitutes go to the cathode, and acid radicals and hydroxyl to the anode.

The extent to which decomposition takes place in an electrolyte is proportional to its conductivity, and this latter depends not only upon the electrolyte being in a state of solution, but also upon the degree to which it is capable of dissociation, which allows of the separation of the molecules, so that the ions may be parted from each other and prevented from re-uniting by intervening portions of the solvent. As the tendency to dissociation is found to vary considerably in the several electrolytes, their conducting power varies in a corresponding degree. Saline solutions conduct much better than distilled water, because potassium, sodium, and chlorine are more easily dissociated than hydrogen and hydroxyl.

The tension of electrolytic solutions is constant for the same metal, but different for the several metals. If a piece

of zinc be immersed into a solution of table salt, part of it will be dissolved, by zinc-ions being formed ; and zinc becomes negative by parting with its positive electricity to the solution. If now a piece of some other metal which has a lower tension, say copper, be immersed into the same solution, the copper will become charged with positive electricity by attracting the excessive cations of the solution. The copper pole is therefore the anode and the zinc pole the cathode. As soon as the two metals are connected by a conductor, a constant migration of ions must take place, free cations travelling towards the cathode, and free anions towards the anode. This migration is, in fact, the constant current, which does not exist without such constant displacement ; and it would be illogical to assume that the migration takes place in consequence of the current being established.

The rapidity with which the migration of the ions takes place is proportionate to the difference of potential at the two electrodes, and the shortness of their passage through a moistened conductor. This rate decreases, on the other hand, with an increase of resistance, which occurs through friction of the surrounding liquid. Friction is lessened by a high temperature and increased by a low one ; and this is the reason why electrolytes conduct better at higher than at lower temperatures. The frictional resistance also depends upon the chemical constitution and the extent of the surface of the ions being greater in proportion to the number of atoms contained in them.

When living tissue is interposed between the two poles, some parts of it will be found active in an electrical sense, while others are indifferent. It is the active or conducting parts alone which are capable of carrying the electricity ; these are the dissociated parts of the ions, which carry positive or negative electricity towards the anode or cathode. The indifferent parts, on the other hand, consist of non-conductors contained in the solution, and of molecules of the electrolyte which are incapable of dissociation, and which

will therefore act in accordance with their kind and quantity in influencing frictional resistance.

The blood-serum contains about 8 per cent. of solid constituents dissolved in 92 per cent. of water. By far the largest part of the solids consists of albumens, viz., 6·8, which are electrically indifferent, being colloid matters which do not exist in an actual state of solution, but merely in one of suspension, which renders them unfit for ionising. Besides this, there is a mixture of other organic substances, such as sugar, fat, cholesterine, lecithine, urea, uric acid, etc., amounting in all to 0·5 per cent. Of these non-albuminous matters, only urea and uric acid are capable of being electrolysed, but their quantity is so minimal that they may be left out of account.

It is therefore the *mineral constituents* of the serum, amounting to 0·8 per cent., which come chiefly into play, as they are all fond of ionising and travel with great rapidity. Amongst the minerals, sodium chloride stands *facile princeps*, the sodium being 0·43 and chlorine 0·36 per cent., potassium being 0·03, phosphoric acid 0·02, and lime 0·01, together with traces of manganese and oxide of iron. All these salines being capable of easy dissociation, are principally concerned in conducting the galvanic current through the animal tissues.

Frankenhäuser¹² has selected the saliva, as one of the simplest constituents of the body, for showing the manner in which the electric conduction is carried on in the system. The saliva contains per mille 994·4 parts of water, 1·75 parts of organic non-conductors, and 3·86 inorganic salines. The latter consist of sodium 1·001, potassium 0·587, calcium 0·101, chlorine 1·385, sulphuric acid 0·115, carbonic acid 0·600 and phosphoric acid 0·068. Thus sodium, potassium and calcium will migrate towards the cathode, and hydrochloric, sulphuric and phosphoric acids towards the anode, while the remainder continue at rest. As for the rate at which the ions travel, the hydrogen ion is the quickest, and

moves at the rate of 1.0, with a potential of one volt in one second, the distance between the electrodes being one cm. ; hydroxyl travels at 0.5, sodium at 0.12, potassium at 0.2, calcium at 0.1, carbonic dioxide at 0.13, chlorine at 0.2, phosphoric acid at 0.08, and sulphuric acid at 0.2. Thus definite quantities of sodium, potassium and calcium will travel in the saliva during a certain period towards the cathode, while equally definite quantities of chlorine, sulphuric acid, carbonic dioxide and phosphoric acid travel towards the anode ; and the same proceeding takes place in the liquids of the other tissues.

From a therapeutical point of view, that which takes place in the substance of the moist conductor, is far more important than anything which occurs at the points where the electrodes are applied. In order to make the current act with sufficient force on deeply-situated structures, other moistened conductors are interpolated between the body and the electrodes, such as moistened felt, amadou, sponge, etc., which diminish the resistance offered by the skin.

Living tissues are not homogeneous conductors, but contain different solutions which serve to conduct the current from one to another. Differences of this kind exist even in the microscopic elements of the tissues, as it is an essential feature of metabolism that the composition of one particle is never exactly the same as that of neighbouring particles. The current therefore passes in the tissues from one moistened conductor to another, and there will be in two different electrolytic solutions which are placed near each other, a movement in the ions which is called *diffusion*. The faculty of diffusion and electric conductivity are directly proportional to one another.

CATAPHORESIS.

While the thermic effects of the galvanic current, when applied by moistened conductors to the body, are so insignificant that they may be neglected, the mechanical

effects which the continuous current produces, apart from electrolysis, are very important. The tissues of the body contain a great variety of membranes, the intervals between which are filled up with more or less liquid substances, and which are kept in a definite state of equilibrium, partly by the blood-pressure, and partly by osmosis; and the continuous current will, when traversing the tissues, alter this state of equilibrium and conduct liquids through membranes. This process is called *electric endosmosis*, or *cataphoresis* (Du Bois-Reymond). Synonymous terms are "electric diffusion," "anodal diffusion," "anaphoresis," "electric transportation," "electric transfer of particles and fluids," etc.; and the great principle underlying the phenomena in question is the *transformation of electrical into mechanical energy*. This latter causes a motion in watery solutions which proceeds in general in a direction from the anode to the cathode, is totally independent of electrolysis, and affects not only, like the latter, the active substances of the conductor, viz., the saline solutions, but also to some extent the albumens, and other electrically inactive matters. Stewart, of Owen's College, has found that not only water but also pigments and proteids could be transferred from the anode to the cathode. In one of his experiments, 40 per cent. of a hæmoglobin solution were in an hour and a-half conducted from the positive to the negative compartment by a current of five MA.'s. In experimenting on bile it was found that 92 per cent. of the water had, after two hours' action, disappeared from the positive compartment. When a hollow metallic cathode was introduced into the vagina of a rabbit, fluid was forced through it, but when the anode was substituted no fluid appeared. This seems to show that the well-known drying and styptic action of the anode is owing to the removal of fluid, while the liquefying action of the cathode, for instance, in urethral stricture, is owing to the transference of fluid towards it. I long ago directed attention to the

fact that the negative needle in surgical electrolysis is freely movable in the tissues, and taken out with the greatest ease, while a positive needle becomes glued to the tissues, and can often only be removed with a great amount of force. An analogous instance of this will be given when the treatment of impotency comes under consideration. The loss of salts is also of importance, and will by itself cause starvation of tissues in tumours, etc.

Cataphoresis only takes place when there are porous diaphragms between the electrodes, so that a motion in the opposite sense is prevented; and its energy bears a definite proportion to the current-strength and the resistance offered by the diaphragms to the passage of the current. By the process known as osmosis, diluted solutions will pass to saturated ones through membranes even without the aid of electricity; but this natural process is considerably enhanced by the passage of the current through thousands of membranes which it encounters on its way through the tissues. What simple osmosis may do in the space of twenty-four hours, may be done by electricity in as many minutes; and as the skin and other tissues of the body may be looked upon as diaphragms, cataphoresis may be induced through any one of them. The stream of liquids increases in proportion to the number of membranes which the current is traversing. Where the membranes and liquids have the same resistance on either side, as much liquid will go out at the cathode as will pass in at the anode, and there will be under such circumstances no difference of pressure in the cells or other tissue elements. Where, on the other hand, there is more electric resistance at the anode than at the cathode, more fluid will pass in than go out, so that there will be increased pressure in cells and tissues, and *vice versa*.

We have seen that cataphoresis takes place in general from the positive towards the negative pole; but there are substances by which the opposite direction is taken. Thus,

while methylen blue travels in the usual direction, eosin, a saturated alcoholic solution of barium bromide, and solutions of ferro-cyanide of potassium, potassium bichromate, barium, sodium, and potassium chloride, sulphuric acid and iron protochloride travel from the negative to the positive pole. Substances which are not transported at all by cataphoresis, are cobalt and platinum chloride, nitrate of silver, caustic potash, and potassium sulphate.

Morton⁷ has shown that some substances, like ether, chloroform, and alcohol, will only show cataphoric action when mixed with another conducting substance, which he calls the fluid electrode. With a 25 per cent. solution of peroxide of hydrogen in 75 per cent. of ether, for instance, no action will take place unless it is mixed with another conducting fluid, such as water, or a solution of sodium sulphate or chloride. He also claims to have shown that a drug transported by cataphoresis only reaches about half way from the anode to the cathode. This would be in accordance with Lehmann's¹⁴ observations, which show that, with bad conducting fluids, such as solutions of aniline colours, certain changes start from each electrode and meet in the middle, where a precipitate is formed, when a violent agitation takes place in the solution used.

An extraordinary phenomenon, which has been called *galvano-tropism*, but is only one of the effects of cataphoresis, is that which has been shown by Verworn¹⁵ to take place with the Flagellata order of Infusoria when subject to the action of the continuous current. If a few drops of an infusion of hay, which swarms with Paramæcia, be placed between clay electrodes, and traversed by the current, all the infusoria present will turn, as at a word of command, when the current is put on, with the anterior portion of their bodies towards the cathode, and swim in this direction with uniform speed. In a short time the whole population of a drop will be found crowded at the cathode, not one being left behind, so that the anodic side is completely cleared of the Paramæcia.

Matters remain in this condition as long as the circuit remains closed; but as soon as it is opened, the infusoria turn instantly with their anterior side towards the anode. The cathode is now quickly deserted, the majority of the organisms being collected at the anode. The crowding there is, however, not nearly so complete as that which takes place at the cathode on making the circuit, and shortly afterwards the *Paramæcia* disperse, and become again uniformly distributed throughout the drop. The same manœuvre may be repeated over and over again with the same precision, each time the circuit is made or broken.

Munk¹⁶ showed, in 1873, that a liquid contained in an electrode can only be introduced into the body if it conducts the current better than the body, in other words, the external liquid must conduct better than the internal one; within a moist and porous substance that fluid is more rapidly carried off by the current which is the worse conductor. If therefore the liquid of the electrode conducts better than the liquid of the body, the latter will migrate more rapidly under the influence of the current than the former.

It has been found that the cataphoric effects of the current diminish in proportion to the length of time during which the current has been acting; and this appears to be owing to a "secondary internal resistance" being established in the tissues acted upon, by the very fact of the current flowing through them. We have already seen that the cathode renders animal substances more fluid, while the anode dries them up. This is shown by a shrinking of the albumen, or any animal tissue, in contact with the anode, through the water being carried off to the cathode. Du Bois-Reymond and Munk have called this process "choking." The albumen may indeed become so hard at the anode that it is almost impossible to cut it with a knife, and it may be easily understood that this causes a high degree of resistance to the further passage of the current.

Meissner,¹⁷ who has gone more recently into this subject, has shown that if albumen is subjected to the passage of the current, there is at first, for about 30 seconds, an increase of action. This remains at the same level for from 40 to 60 seconds, and then falls, reaching zero after $3\frac{1}{2}$ minutes. At the same time choking is perceived at the anode, while the albumen swells up, and becomes soft and spongy at the cathode, there being an increase in size from 1.3 cm. to 1.5 cm. at the latter point. The secondary internal resistance has therefore become so strong in $3\frac{1}{2}$ minutes that no further effect can take place. If then the direction of the current be reversed, a complete change will be noticed in the albumen. The original choking disappears, while fresh choking is seen to occur at the part which had at first swelled up under the influence of the cathode. It follows from this that, in order to get as much cataphoresis as possible, the direction of the current should be reversed at certain intervals, so that there may not be an eventual cessation of the process through secondary internal resistance; and that therefore both electrodes must be equally saturated with the liquid which we wish to introduce. A similar effect, although in a slighter degree, may be obtained if the current is let out after having fallen to zero, and re-established a few minutes afterwards. This is explained by the fact that, as soon as the current ceases to act, fluid will return from all directions to the dried-up region, whereby conduction is once more re-established. For the human body the duration of effective cataphoresis is, according to the same observer, not $3\frac{1}{2}$ but 5 minutes.

INTRODUCTION OF MEDICINES BY CATAPHORESIS.

Cases not unfrequently occur in practice in which it would appear decidedly advantageous to subject only the suffering part of the body to the action of medicines, without exposing the whole system to their influence, as must be the case when such medicines are swallowed or hypodermically

injected, etc. Thus, for instance, morphine and cocaine, taken in the ordinary way, are apt to relieve the pain of epileptiform neuralgia of the face, but do so frequently at the expense of a disturbed action of the liver and central nervous system, which renders the remedy almost worse than the disease. Again, in cases of optic atrophy we may introduce strychnine locally, through the eyelids by cataphoresis, so as to stimulate the optic nerve, without bringing the whole system under the influence of that drug; while in parasitic skin diseases the entire structure of the corium may be subjected to the local action of antiseptics and parasitocides. Cataphoresis may therefore step in most usefully in such and similar cases, where we have to do either with local affections, or with obstinate local manifestations of constitutional or central diseases.

Although many attempts to effect this purpose had been made in the earlier periods of medical electrology, the whole subject entered a new phase only when Wagner¹⁸ suggested, in 1886, that local anæsthesia might be brought about by the cataphoric introduction of cocaine. Further steps in this direction were taken by Corning, Peterson, Danion, Imbert de la Touche, and Cagney. McGraw was the first who anæsthetised, or, as he called it, obtunded, the sensitive dentine; Westlake first bleached teeth by submitting them to cataphoresis with peroxide of hydrogen; and Morton introduced a more quickly-acting agent than simple cocaine, in his guaiacol-cocaine mixture. The formula for this is:—

R̄. Guaiacol 3j.

Cocain. hydrochlor. anhydr. gr. vi. Misce.

By the use of this mixture the anæsthesia appears to be not only rendered more profound, but also obtained in a shorter time than with an aqueous solution of cocaine. Morton also claims for this proceeding that it lessens the rate of absorption of the cocaine into the system, and therefore prevents general toxic effects, while the guaiacol adds its

own anæsthetic effects to those of the cocaine. A great drawback to the use of Morton's preparation is its unpleasant and persistent odour, which makes the consulting-room smell like a chemist's shop, and requires repeated and plentiful spraying of scent for its removal.

For effecting the diffusion of medicines by cataphoresis Peterson¹⁹ recommended an electrode in the shape of a metallic disc, about $1\frac{1}{4}$ inch in diameter, which is surrounded by a slight rim for receiving a round piece of blotting paper, which has been soaked in the medicinal solution. Morton⁷ prefers for this purpose a disc perforated with a large number of holes, with a reservoir at the back, which holds a supply of the fluid used. In this way the blotting paper cannot become dry. If it were to do so, it would cause considerable resistance at the point where it touches the skin, and might lead to failure of absorption, or cause a burn. Some of Morton's electrodes have a surface of 5 inches, so that a considerable area of the body may be rendered anæsthetic by means of them. Morton's proceeding is as follows:—For introducing an aqueous solution of cocaine, the skin is first carefully washed with soap and water, in order to free it from non-conducting substances. An 8 or 10 per cent. solution is then filled into the perforations of the cataphoric electrode, and dropped upon the blotting paper which is fixed on it. The electrode is connected with the positive pole of the battery, and placed upon the part to be anæsthetised, while the cathode is placed at a distance. The current is then made, and gradually increased to 8 or 10 MA.'s. Ten minutes of such action will be required to effect local anæsthesia. If, on the other hand, the guaiacol mixture be used no washing of the skin is required, and from 1 to 3 MA.'s will in three or four minutes effect a more profound anæsthesia than the aqueous solution produced in ten minutes with 8 or 10 MA.'s. Not only, therefore, is time saved, but the patient is spared the unpleasant feeling produced, at least

in sensitive parts, by the greater current-strength which would be required.

It will be seen at a glance that these statements clash altogether with Meissner's observations that no further absorption takes place after a cataphoric action of five minutes, and that more complete results are arrived at by reversing the direction of the current from time to time. In order to effect this latter purpose easily, Meissner has invented an electrode in which the two poles are very close together, and may both be packed separately with wadding soaked with solutions for cataphoresis. This electrode is applied to a certain point of the surface for five minutes, when the positive pole is supposed to be active; after which the direction of the current should be reversed, so that the negative may work in its turn.

Meissner bases this proceeding on the results of experiments made by him on rabbits with a 4 per cent. solution of sulphate of strychnine, which should give a distinctly acid reaction and would therefore be a good conductor of the current. The back of a rabbit was carefully shaved, so as to avoid injuring the skin, and the electrodes applied at the side of the spinous processes. After the current had acted for four minutes, reflex cramp could be elicited; but the symptoms did not become aggravated by extending the time to fifteen minutes, and the animal eventually recovered. It would therefore appear that the strychnine was eliminated by the urine, and that no further absorption took place. The urine of an animal thus treated, when injected into a smaller animal, produced promptly symptoms of strychnine poisoning, death occurring two minutes after the injection.

In another animal the direction of the current was reversed every five minutes, with the result that, after four minutes reflex excitability was increased, and that after six minutes convulsions appeared, which gradually merged into tetanus. The animal died twenty-four minutes after

the beginning of the experiment. When no current was used, but the electrodes saturated with strychnine were applied to the back of a rabbit, as before, there was not the slightest symptom of poisoning after an hour's trial. Further experiments showed that the current simply drives a drug into the corium, from which it is absorbed by the lymphatic vessels, but not into a viscus, or into an entire extremity. Hydrochlorate of quinine, perchloride of mercury, potassium iodide and cocaine, behaved in a similar manner as strychnine.

Other drugs which have been cataphorically introduced are lithium iodide for syphilitic neoplasms ; lithium bromide and piperazine for rheumatism and gout in joints ; while pilocarpine has been used as a local sweat-producer. It has also been suggested to add a little pilocarpine to solutions intended for cataphoric medication, so as to open up the sweat-glands, and make better pathways for the introduction of the other drugs.

Whether cataphoresis will be effectual in eliminating lead, copper and arsenic from the system in cases of poisoning with these metals, as has been stated by Morton, appears to me doubtful. If it were to enable us one day to eliminate more especially mercury, in workers with this metal, or in medicinal poisoning, an immense step in advance would have been made in practical therapeutics as well as in sanitation.

We shall be safe in stating that most questions connected with cataphoresis are still in a very unsettled condition. While Morton and other American authors speak highly of its effect in "obtunding" or anæsthetising sensitive dentine as well as the gums, so as to permit of painless tooth-extraction and other operations on the teeth, and of bleaching discoloured teeth by the cataphoric introduction of peroxide of hydrogen, many able dentists in this country with whom I have conversed on the subject, consider the proceeding not only tedious, causing unne-

cessary loss of time, but also uncertain in its action, and they therefore employ other more expeditious methods for the purposes just mentioned. The whole subject will therefore require much further strictly methodical experimental research before the unquestionable powers of cataphoresis may be fully utilised in practice.

The recent researches of Karfunkel²⁰ and Hirsch²¹ have added next to nothing to our previous knowledge of this subject.

INTERSTITIAL ELECTROLYSIS.

This term has been proposed by Gautier for a proceeding which partakes both of electrolysis and cataphoresis. We have seen that each pole of the battery is, as it were, "a little chemical workshop by itself," the anode producing acids, and the cathode alkalies, from the tissues which may be directly subjected to the action of the poles. At the anode we find oxygen, chlorine, hydrochloric, phosphoric, and sulphuric acids, developed from the tissues; and if the current be conveyed by oxidisable electrodes, such as iron, zinc, copper, and similar metals, metallic salts will be formed with the acid radicals in proportion as the latter are produced. Platinum is not oxidisable, and Morton (*l. c.*, p. 171) speaks of gold as if it were the same. Such however is not the case, for a gold needle, if submitted to the action of the anode, is speedily rendered black through oxygenation and chlorination, and if introduced into tissues, becomes glued to them, so as to require considerable force for its removal.

In interstitial electrolysis we have therefore not only the usual chemical action produced at the poles, but also secondary effects, by permeation of the tissues with the newly formed metallic salts through cataphoresis. Metallic salts may therefore not only be dissolved but actually driven or forced into the tissues, so that their action will naturally be more profound and thorough than where

metallic solutions are employed in the form of lotions, injections, and sprays, the effects of which must always be more or less superficial. A remarkably low current strength is indeed sufficient to set free a proportionately large quantity of such salts, no doubt in consequence of their acting as electrolytes, and being easily dissociated. Gautier has for gynæcological operations contrasted his method, as one of low strength and long sittings, with Apostoli's method of high current strength and short sittings. During the operation the active electrode loses definitely in weight, the loss being proportional to the Milliampèrage employed, and the length of the application. Morton has used interstitial electrolysis for the treatment of obstinate cases of trachoma, hypertrophic rhinitis, ozæna, keloid, and various other diseases.

EFFECTS ON BACTERIA.

In connection with this it is interesting to find that Krüger²² has observed a considerable difference in the action of polarisable and unpolarisable electrodes on bacteria. When unpolarisable platinum electrodes are used, electrolysis arrests the growth of the microbes, without actually killing them; while with polarisable electrodes the bacteria are completely destroyed, a small current strength being sufficient for this, if used for a certain length of time. He also found that electrolysis of cultures of certain microbes gave to them immunising powers. Two rabbits were injected with diphtheria toxine, one was left to itself, and died two days afterwards; while the other, which received 2 ccm. of electrolytically-prepared antitoxine, remained in perfect health. This anti-toxine was the product of the anode, with 0.19 MA. for 20 hours; it was a clear, colourless liquid, of feebly alkaline reaction, and contained only traces of albumen. These observations point to a new sphere of usefulness of electrolysis, which has already been successfully employed on a large scale for disinfecting sewage. This latter effect is no doubt owing

to the nascent oxygen driven into the mass by cataphoresis, so that electrolysis acts in such a case much in the same manner as permanganate of potash would do.

THE CONSTANT CURRENT AS A GENERAL TONIC.

I now proceed to describe certain methods of applying the constant current in medicine as a general tonic, in conditions characterised by debility and exhaustion, while local applications for local affections will be considered under each separate heading.

CENTRAL GALVANISATION.

This proceeding, which has been chiefly practised by Beard and Rockwell, and other American electro-therapeutists, is carried out in the following manner:—

A large cathode, of from 90 to 300 square cms., is applied to the hypogastrium, while the anode of about 30 square cms. is successively applied to the forehead, the vertex, the occiput, the auriculo-maxillary fossa, the cilio-spinal centre, and the entire length of the spine. A current of 1 or 2 MA.'s or more is used in this way for ten or fifteen minutes.

GENERAL GALVANISATION.

This method consists of the application of a gentle constant current to the nervous centres, plexuses, and large nerve-trunks. The anode of about 30 square cms. surface is first applied to the cilio-spinal centre, stabile; it is then conducted to the side of the neck, the auriculo-maxillary fossa, and the manubrium sterni, the brachial plexus, and the median and ulnar nerves and their terminations, along the extensors of the forearm to the motor point of the radial nerve, and back again to the brachial plexus and the cilio-spinal centre, after which the current is gradually let out. Both upper extremities are treated in this manner, after which the spine, the head, the abdomen, and the lower extremities are similarly submitted to the

galvanic influence. The application to each upper extremity should last from two to three minutes, to the head and spine about half a minute each, and that to the lower segment from two to three minutes each.

A more convenient mode of general galvanisation in certain forms of general debility is the following :—A large cathode of 200 or 300 square cms. is placed to the epigastrium, and a smaller anode of about 40 square cms. to the cervical spine. The current is now turned on, and gradually increased until it reaches from 2 to 5 MA.'s, according to the special susceptibility of the patient. This is allowed to flow for three minutes, and is then gradually turned off. The direction of the current is now reversed, so that the anode is on the spine, and the cathode on the epigastrium, and the proceeding conducted as before. The application is finished by applying a cathode of 130 square cms., with 1 MA. for one minute, to the parietal region of the skull.

THE HYDRO-ELECTRIC BATH.

A further method of general application is the hydro-electric bath, the mode of action and effects of which were first properly studied by Eulenburg²³ (1883). In this country Steavenson²⁴ (1891) and Hedley²⁵ (1892) have strongly recommended its use. The bath is preferably one of porcelain, or where expense is an object, of wood. In the latter case the inside should be painted with white non-metallic enamel. The electricity is introduced by metal plates, which may be fixed at the head and foot, or at the bottom and sides of the bath, and which have a surface of ten or twelve square inches. Where a plate is fixed at the head of the bath, the head, shoulders, and back of the patient should be protected from touching the electrode by a wooden rest, similar to a wicker fire-screen for chair-backs. The head of the bath is generally connected with the cathode. By far the largest portion of the current used

is lost in the water, and only about one-eighth part of it traverses the patient. The bath should be filled with plain water, at a temperature of about 98°. The addition of table salt or acid to the water, which is often done with the idea of increasing the effect, actually serves to diminish it, as the conductivity of the water is thereby improved, and more electricity is lost to the body.

The patient should enter the bath, and remain for a few minutes in it, before the current is turned on. The electricity is then let in very gradually, until the needle shows from 60 to 100 MA.'s. As the treatment proceeds, the strength may be gradually increased to 200, of which the patient would get about 40. After acting for about ten minutes, the current is carefully turned off until the needle is at 0, and only then the patient should be allowed to leave the bath. At the end of the performance he may have an electric douche for about half a minute, which is done by connecting a douche with one of the poles of the battery.

The hydro-electric bath seems to be particularly effective when mineral water baths are used in combination with it. The beneficial effects of a combined electric and mineral water treatment have long been known in Germany, where Voigt, of Oeynhausén, Delhaes, of Teplitz, and Von Renz, of Wildbad, have carried out this plan. In England this treatment appears to be chiefly used at Buxton, where Armstrong is using both galvanic and faradic electricity in conjunction with the Buxton baths, which have long been favourably known for their good effects, more especially in chronic rheumatoid arthritis, even when unassisted by electricity. I had an opportunity of studying the Buxton water in August, 1894, and found that it is not so much allied to Wildbad and Gastein, as is frequently stated, as to Schlangenbad, through its containing silica. This constituent imparts to these two waters the bluish colour and the extraordinary velvety softness, which induced a Frenchman bathing in Schlangenbad to exclaim: "*Ici on devient amoureux de soi-même!*"

Electric hot air or vapour baths are used in the United States for patients who are unable to take the hydro-electric bath.

THE BI-CELLULAR BATH.

Gärtner²⁷ has recommended the use of the so-called "bi-cellular bath," for the purpose of having the body more equably and thoroughly traversed than is possible in the ordinary hydro-electric bath; and also in order to utilise cataphoresis for the introduction of mercury and other drugs into the system. The bath is divided into an upper shorter, and lower longer portion by a wooden frame, which is covered in by a piece of indiarubber, and thus breaks up the metallic connection between the two parts of the bath. At the lower margin of the rubber sheet there is an oval incision for the body of the patient to pass through, and the sheet is made to cover the epigastrium. One pole of the battery is then connected with the upper, and the other with the lower portion of the bath; and each "cell" is thus made to act independently of the other as an extensive metallic electrode, while no part of the current is diverted into the water, and the body receives more electricity than it would in the ordinary hydro-electric bath. The sensation experienced by the patient is, therefore, more equally spread over the whole surface of the body. While in an ordinary mineral water bath there is no absorption of solid constituents by the skin, it has been shown that in the bi-cellular hydro-electric bath a considerable quantity of mercury may be absorbed when perchloride of the metal is added to the water, since mercury subsequently appears in the urine of persons thus treated. Iron, salicylate of soda, and other drugs seem likewise to be absorbed at the anode.

GALVANISATION OF THE BRAIN.

The direct application of the constant current to the different territories of the brain, is far more useful and effective as a nervine tonic than any of the proceedings

which I have just described ; most of the latter being tedious and inconvenient in their application, and of subordinate value in their results. Some of the methods which I am in the habit of using for directly influencing the condition of the brain are old, and others new ; I have however tested them all carefully for many years past ; and they are based on, and have been developed from, clinical experience, while a physiological explanation of their beneficial effects has only been rendered possible much later, in proportion as our doctrines on the histology and physiology of the brain have gradually become more developed. Thus I have practised galvanisation of the occipital lobes years before Flechsig²⁸ described his posterior association centre.

The electrodes which I am in the habit of using for this purpose are made of flexible wire-gauze, so that they can be easily adapted to the various regions of the skull. They are covered with several layers of fine flannel. The "large" electrode is 20 by 6 cm., the "medium" 10 by 4, while the "round," made of ebonite and platinum, and containing fine toilet sponge, is 4 cm. in diameter. A thorough soaking of the surface of the electrodes is of the first importance, as otherwise the skin and subcutaneous cellular tissue would offer a considerable resistance to the passage of the current, and might prevent its reaching the deeply-seated parts. The superfluous water should before use be squeezed out into Turkish towels. Very gradual introduction and cessation of the current are indispensable, as want of care in this respect will lead to the perception of flashes of light, by stimulation of the optic nerve, which is unpleasant and alarming to many persons. For this reason an enormous resistance in the circuit is necessary, so that we may, at least in certain cases, begin and end with no more than $\frac{1}{100}$ Milliampère.

1.—GALVANISATION OF THE ANTERIOR ASSOCIATION CENTRE (PREFRONTAL AREA).

The large active electrode is closely applied to the forehead and temples, while the indifferent electrode rests on the hand of the patient. Current strength from $\frac{2}{10}$ to 2 MA.'s according to individual susceptibility. Only a slight sensation of pricking and heat, with a feeble galvanic taste where the anode is active, should be experienced. In severe cases daily applications are required, lasting from one to five minutes; while in slighter cases we operate every other day. Anelectrotonus of this portion of the cerebral territory is in general more useful than catelectrotonus.

This procedure is chiefly suitable for cases in which there is deficient self-control, diminished initiative, indecision, and difficulty in fixing the attention. Physiological and histological researches have shown that this centre contains the essential constituents of self-consciousness. It directs our actions, enables us to judge our own conduct, and tells us what is right and wrong. It therefore constitutes the *δαίμωνιον* (the divine warning-voice) of which Socrates speaks in Plato's Euthyphron. Disease of this centre changes the perception of the Ego as an active being, and diminishes or annihilates personal initiative. These data will generally enable us to decide whether galvanisation of the zone in question will be useful in a given case or not.

2.—THE MID-BRAIN.

This portion should be galvanised where the action of the emotional centres contained in it is disturbed, and where therefore the mind of the patient is unsettled by feelings of depression, irritability, querulousness, petulance, want of self-confidence, panic, and certain definite forms of fear. I use two different methods in such cases, which are of about equal value, and may in obstinate cases be combined.

a. A round electrode is applied to the right, and another to the left squamoso-temporal region of the skull. Current-strength 1 to 4 MA.'s, duration from two to seven minutes. As the mid-brain also contains centres for the equilibration of the body, it is quite indispensable when operating in this manner to let the current out at an absolutely minimal strength, lest by a sudden interruption severe giddiness should be caused.

b. Another useful method is to send the current through the eyes. These latter are, on account of the large quantity of water contained in the lens and the vitreous body, excellent conductors of electricity. The round active electrode—in general the anode—is placed on the closed eyelid, while the indifferent one rests on the hand of the patient. The current now runs along the optic nerves and tracts to the optic lobes and the pons varolii. As sensitiveness to this method varies very greatly, it is advisable to commence with about $\frac{1}{10}$ MA., which is in many cases sufficient; but, if this should not be perceived, we gradually increase the dose to $\frac{1}{2}$, 1 or 2 MA.'s. This procedure is of considerable use in insomnia.

3.—THE POSTERIOR CENTRE OF ASSOCIATION.

It is difficult to galvanise the whole of this zone in persons with thick hair, as not only the occiput, but also the parietal region should be traversed by the current. In bald people it is, of course, easy enough; but in others the response of the magnetic needle must be most carefully watched from one instant to another, as otherwise either no current, or a too powerful one, might pass. The large flexible electrode is first applied to the parietal region (1 to 2 MA.'s, 2 minutes) and afterwards to the occiput (1 to 3 MA.'s, 3 minutes). The circuit is closed by applying the indifferent electrode to the hand of the patient.

According to Flechsig this centre comprehends in clever persons almost one-half of the whole hemisphere, but is

much less abundantly developed in men of lower intellectual or moral type. It contains the *præcuneus*, the whole of the parietal convolutions, a portion of the *gyrus lingualis*, the second and third temporal convolutions, and the anterior portion of all three occipital convolutions. Focal lesions of this centre impair or destroy the ability of comprehending written or printed words, to correctly name objects which are seen or touched, and to discern the surroundings in which one is placed. It is likewise the principal seat of memory. We galvanise it in cases in which the interpretation of external impressions and logical thinking are difficult or impossible; in flight or sluggishness of ideas, and impaired memory.

4.—THE MEDULLA OBLONGATA.

At the present time widely different ideas are held amongst physiologists about the mode of action of the nervous force in the bulb, some being of opinion that this portion of the brain contains a large number of well-defined and sharply-limited centres for the various automatic functions of the system, while others assume that these various centres have no independent existence, but that reflex functions are brought about by the nerves which control respiration, the heart's action, and other allied performances, requiring the integrity of the bulb in order to be able to act. In a paper published by me²⁹ some years ago, in "*Virchow's Archiv.*," I contended that where physiologists differ, clinical observation may sometimes step in and help us to decide a point; and that in this way the existence of definite centres in the bulb for respiration, cardiac action, the secretion of saliva, sweat and urine, the movements of the pupils, sneezing, coughing, sucking, masticating, vomiting, etc. appeared to me to be incontestably proved.

We therefore galvanise the bulb, chiefly in order to stimulate the vasomotor centre contained in it, with the view of promoting the nutrition of the bloodvessels, and of

retarding the occurrence of arterio-sclerosis as much as possible. It is however found in practice that this proceeding is also most useful in combating nervous palpitations, debility of the cardiac muscular fibre, tachycardia, bradycardia, spasmodic asthma, disturbed secretion of sweat, such as hyperidrosis, etc., irritative or atonic nervous dyspepsia, polyuria, phosphaturia, functional glycosuria, and albuminuria, some otherwise intractable forms of dysmenorrhœa, etc. There are four different methods for acting electrically upon the bulbar centres, viz. :—

a. The anode, five inches by two, is applied to the cervical spine, while a round cathode of two inches in diameter is directed to the region of the superior cervical ganglion at the angle of the lower jaw, 1 to 3 MA.'s, and from one to three minutes to each side of the neck.

b. In cases where there is much irritation, the cathode should be at a distance from the bulbar centres. The anode is thus applied to the cervical spine as before, and the cathode to the hand. From 1 to 5 MA.'s for ten minutes.

c. The positive pole is applied to the back of the head and neck by a large electrode, and the negative, insulated to within a quarter of an inch of the point, passed along the floor of the nostril till it rests on the cervical spine. The current strength may be gradually increased from $\frac{1}{2}$ to 5 MA.'s; length of application from one to five or six minutes (A. Robertson³⁰).

d. The round anode is placed to one and the cathode to the other mastoid process, two to five minutes, 1 to 3 MA.'s.

III.—FARADISM.

Faraday's discovery of induction currents, in 1831, caused a new era in the medical employment of electricity. The use of the voltaic pile had at that time been completely abandoned; constant batteries for medical use were not in existence, and the striking phenomena produced with small

and handy induction machines gave rise to the belief that at last the true medical electricity had been discovered. Duchenne's splendid researches on the physiological effects of localised faradism on the motor nerves and muscles will for ever remain a monument to his genius; but the expectations held out by him that the induced current would be found superior to other forms of electricity as a therapeutical agent have not been fulfilled.

The electro-motive force of the induced current depends, 1st, on the strength of the battery current by which induction is produced; 2nd, on the power of the iron core, which becomes magnetic under the influence of the battery current; 3rd, on the number of convolutions and the more or less perfect insulation of the coils of wire; and, 4th, on the distance between the primary and secondary coil.

The primary current circulates in a comparatively short and thick wire, and the secondary in a long and thin wire, whereby their electro-motive force and resistance are modified; and these circumstances explain to a great extent why these two currents should produce somewhat different physiological effects. More powerful muscular contractions, especially in deeply-situated parts, are produced by the primary current, whereas the sentient nerves of the skin and the superficial muscles are more stimulated by the secondary current.

Many faradic instruments which are manufactured are mere toys, and totally useless for medical purposes. The International Congress of Electricians, which met at Paris in 1881, recommended to the medical profession the use of Du Bois-Reymond's sledge-apparatus, which has been for many years employed in the physiological laboratory of the University of Berlin, as the pattern of what an induction machine should be, and this instrument should therefore be used with preference, more especially in researches where the results obtained by different observers have to be compared. The primary coil of this apparatus contains

300, and the secondary 5,000 convolutions of wire. The diameter of the short and thick wire is 1 millimètre, and that of the long and fine wire 0·25 millimètre. The resistance of the primary coil is 1·5 S.U., and that of the secondary coil 300 S.U. Another good induction machine is that constructed by Stöhrer.


FARADIMETER.

Von Ziemssen and Edelmann have devised a faradimeter for measuring the strength of the induced current, in the same manner as that of the constant current is measured with the rheostat and galvanometer. This is based on the fact that currents of very short duration produce the same effects, whether derived from a galvanic cell or an induction coil, so that the rheostat and galvanometer may be utilised for measuring both forms of current. Lewandowski has introduced another ingenious instrument, in which the same object is obtained by altering the distance of one coil from the other, and by introducing resistances through the rheostat, when the galvanometer may be utilised for measuring the force of the faradic current.

EFFECTS OF FARADISM.

The faradic current produces chiefly stimulating effects, which may be utilised for the skin, the cellular tissue, and the superficial muscles by using dry electrodes, more especially the wire-brush; while moistened conductors, similar to those used for the constant current, are employed when the more deeply situated parts are to be faradised. As this current has no chemical effects, it is on the whole more suitable for directly stimulating the mucous membranes than the constant current, as the latter tends to cauterise such parts by its electrolytic action. The voluntary muscles may be faradically stimulated where they suffer from atony through disuse, as after fracture, dislocation, certain surgical operations, or permanent

bandages, etc.; while the mucous membranes of the stomach and intestines may be faradised for dilatation of the stomach, intestinal palsy, and obstruction of the bowels. In atony of the bladder, nocturnal enuresis, spermatorrhœa, and some forms of impotency, faradisation of the affected parts has also frequently proved useful. Faradisation of the skin by the wire brush may be used in cutaneous anæsthesia, for restoring the sensibility of the surface, and it may also act as an analgesic in different forms of hyperæsthesia, neuralgia, etc. The faradic current has little or no action in paralytic affections; on the other hand, we are able to cause certain effects on the brain and spinal cord by reflex action, through cutaneous faradisation continued for five to six minutes over the chest, back, and arms. It is believed that the bloodvessels of the brain and spinal cord may be contracted by this proceeding, and that revulsion from deeper parts which are congested may thus be produced. The attempt to make use of both currents combined (galvano-faradisation) has on the whole led to insignificant results only.



GENERAL FARADISATION.

Just as the constant current may be applied to the whole surface of the body, Faradisation may be used either by the medium of a bath, or by the proceeding known as "general faradisation." This latter proceeding is very popular in America, and has only one objection, viz., that it is very tedious to carry out. A cathode of large surface is applied to the soles of the feet, or the patient is made to sit upon it. The anode may be either the doctor's hand, or a moistened plate of at least 30 square cms. surface. This is successively applied to the forehead, the closed eyelids, the ears, the sides of the neck, the larynx, the lower portion of the cervical spine corresponding to the cilio-spinal centre, the other portions of the spine, the limbs, and the chest and abdomen. The current should be slight

for the head and neck, and greater for the other parts. Such an application should last from fifteen to thirty minutes, and may be repeated daily or every other day.

IV.—THE SINUSOIDAL CURRENT.

This current has been introduced into practice by d'Arsonval. It may be obtained by means of a small dynamo, which will convert the continuous battery or the dynamo-current of low tension into a sinusoidal current, which attains its minimum and maximum gradually, and is therefore not so abrupt as the faradic current, in which there are very sudden changes of potential. The strength of this current may be regulated by means of a volt regulator or a graphite rheostat. It may give from 4,000 to 12,000 oscillations per minute, and a difference between 32 and 64 volts.

D'Arsonval has shown that if animals are subjected to the action of it, metabolism is increased, as shown by greater consumption of oxygen, and production of carbon dioxide. The current may be passed directly through the tissues, as has been done for instance by Apostoli, in cases of uterine disease, by applying one pole to the uterus in the form of a hysterometer, and the other on the abdomen by a mass of moist sculptor's clay; or it may be applied through a hydro-electric bath, as done by Gautier, Larat and others, in chloro-anæmia, obesity, rickets, gout, rheumatism, eczema, and other cutaneous affections. The exact value of the sinusoidal current in practice has, however, not yet been determined.

V.—THE CURRENT OF HIGH FREQUENCY AND POTENTIAL (D'ARSONVALISM PROPERLY SO-CALLED).

This current is obtained by means of an oscillating Leyden jar discharge passing through a solenoid or cage. Its alternations may amount to many millions in a second, and its effects are entirely different from those of other forms of

electricity. The muscles have no time to respond to such a rapid succession of shocks, nor are the sentient nerves excited, so that neither pain nor muscular contraction are produced. Metabolism, however, is quickened, more oxygen being absorbed and respiration being rendered so much more active that the amount of carbon dioxide which is eliminated by the lungs is more than double that usually excreted, while uric acid is likewise eliminated at a far more rapid ratio. While the temperature of the body remains the same, more heat is developed, this being lost by a proportionate increase of evaporation from the surface. While there is no perceptible influence on the nerves of motion and sensation, the vasomotor nerves are powerfully affected by this current. D'Arsonvalisation will indeed cause dilatation of the vessels in a rabbit's ear, after section of the cervical sympathetic nerve; while in man the blood-pressure falls at first, and afterwards is found to rise permanently.

This current is applied in a variety of ways. D'Arsonval's original recommendation was to place the patient free from all contact with the electrodes, in the interior of a solenoid or cage. The body thus becomes traversed by induction currents of immense power, which will light a series of electrical lamps, yet do not affect the general sensibility or muscular contractility; they only cause a slight feeling of heat at the points of entrance and exit of the current from the body. D'Arsonval has in this way passed a current of 3,000 MA.'s through his own body without suffering any harm, when a current of 300 MA.'s might have killed him, if there had been a hundred instead of a million alternations per second. He considers that currents of extreme frequency have so little apparent effect, because they produce an inhibitory influence on the nervous centres. An analogous fact in chemistry appears to me to be the so-called *spheroidal state of bodies*. If a drop of water be placed in a platinum spoon, and this be held over a spirit

lamp, the water will be seen to evaporate at once; but if the spoon be brought to a white heat first, and then a drop of water put into it, this will not evaporate, but dance about in the spoon for any length of time in the spheroidal condition. Similarly molten metal, when in a state of white heat, will not injure the hands of workmen who may handle it, while the same in a state of red heat would inflict the most fearful injuries.

The discovery of the fact that a current of immense power can thus be sent through the body without causing death or shock to the system, is often ascribed to Tesla, but d'Arsonval may well claim priority, as he demonstrated this fact in 1888, while Tesla's first publications were made in 1891.

Other modes of applying d'Arsonvalism are used by Apostoli and Berlioz³¹, Bergovié³², Bornet and Caillot de Poucy³³. Auto-conduction is practised as before, the patient being enclosed in a cage, but with simultaneous contact of his hands with one of the poles of the battery. The patient may also be placed on a condenser-bed, with permanent contact of both hands with the poles; and lastly Oudin's Resonator is used, into a description of which it seems not necessary to enter. The French electro-therapeutists who are using d'Arsonvalism, consider it to be the best remedy for all chronic diseases owing to deficient metabolism. Their enthusiasm for this exclusively French remedy is pardonable, but will hardly be shared elsewhere before more evidence in favour of this system has been brought forward. Doumer and Oudin have seen good results of it in skin diseases of nervous or parasitic origin, such as acne, seborrhœa, molluscum contagiorum, lupus, etc. Bacteria may also be killed by the prolonged action of d'Arsonvalism, and their toxines, treated by the same agent, may cause immunity. D'Arsonvalism therefore appears to act in this particular similarly to electrolysis (p. 43). Tesla's recent announcement that he has succeeded in killing the tubercle

bacillus in consumptive patients must be taken *cum grano salis*.

* * * * *

I now proceed to consider the principal diseases in which treatment by the various forms of electricity has been shown to be useful. *It may be broadly stated that it is principally two morbid conditions which may be beneficially influenced by proper applications of electricity, viz.: first, the various forms of hyperæsthesia, undue excitability, or over-action; and second, the different varieties of paresis, loss of power, or want of action. Electricity may indeed be made to produce sedative as well as tonic and stimulant effects of uncommon power; and has been proved to be, for many nervous affections bearing the characters just mentioned, far superior to other remedial agents which are at our disposal.*

GENERAL DEBILITY.—PREMATURE OLD AGE.

Cases frequently come under our notice in which, without any actual disease being discoverable, there appears to be a want of tone throughout the system. All our organs are, when in their normal condition, in a state of moderate tonic excitement, enabling them to fulfil their functions in a proper manner, without our being conscious of the processes which are carried on in them. This normal balance of the system which constitutes health, is apt to be permanently lost in consequence of hereditary predisposition, constitutional faults, certain acute infectious diseases, chronic diarrhœa, hæmorrhage, depressing emotions, overwork, and similar causes. Patients of this kind suffer from premature senile involution. Although there is as yet no arteriosclerosis, all functions of the system are slowly and inefficiently performed. The appetite is poor, digestion troublesome, defecation insufficient, the heart's action feeble, and respiration superficial. The habitual occupation of the patient, which had formerly interested and engrossed him, is felt to be burdensome, and he is more or less indifferent

to everything. He has an empty feeling in the head, suffers from indecision, and is inclined to consult others where formerly he had decided on a course of action for himself without difficulty. In the evening there is such weariness that he can hardly stir. Sleep is disturbed, and as soon as he is in bed he begins to brood over the events of the day, which one and all appear to him in the most unfavourable light. He lies awake for hours and is unrefreshed in the morning. The memory is impaired and he is apt to forget the names and addresses of his friends, or things which he ought to do. The sexual power is at a very low ebb, and after an unsatisfactory coition all symptoms are aggravated. The expulsive power of the bladder is enfeebled. The urine is generally normal but often contains an excess of urea and uric acid, while there is no phosphaturia, which is so often met with in encephalasthenia. The walking powers are very bad, and going up stairs is exhausting. The patient often complains of a dull pain in the knees and a feeling of coldness and numbness in the lower extremities. The muscular fibre is flabby and the knee-jerk sluggish. The hair is apt to fall out and to turn grey. Finally, there is a change in the usual temper of the patient, who is apt to become testy, peevish, fretful, and utterly selfish.

I have elsewhere adduced reasons for assuming that in such cases we have to do with certain nutritive changes in the nerve-cell not involving its nucleus, and have found in practice that electricity applied to the different territories of the brain which may be affected (p. 47), is by far the most successful remedy for this condition.

SENIUM PROPRIUM.

Our mean lifetime is at present about fifty years, but the complete cycle of physiological life, to which we ought all to aspire, is a hundred. That so few persons reach this consummation is owing to bad inheritance, mismanagement

of children, neglect of the sick and aged, the large variety of bacterial poisons which make constant war upon us, improper food, unwholesome dwellings and trades, impure air, overcrowding, the habitual abuse of drugs and alcoholic liquors, sexual excesses, over-excitement of the nervous system, excessive brain-work, worry, grief, anxiety, and trouble, and accidents, such as explosions in coal mines, railway and other collisions, drowning, etc. Old age begins, as a rule to which there are exceptions, in men about sixty years of age and in woman after the change of life has been completed, and is the inevitable consequence of arteriosclerosis which sets in about that time of life and causes involution of the central neuron including the nucleus of the cell.

Nuclear wasting appears to occur first in the giant cells of the central convolutions, and extends after a time to the anterior and posterior centres of association, the sensorial centres, the bulb and the spinal cord. The grey cortex thus dies first, and the medulla oblongata last. The effects of the senile involution of the neurons are habitually first seen in the sphere of the voluntary and involuntary muscles. The movements lose their previous strength and precision. The erect position of the body suffers; there is tremor of the head and hands, a tottering gait, and difficulty in standing for any length of time. In sitting the upper portion of the body is inclined to fall forward. The grasp of the dynamometer is diminished and in advanced cases quite absent, and the tendon reflexes are sluggish or lost. These symptoms are in the first instance owing to failure of power in the sensory motor centres in the Rolandic convolutions; but as the anterior cornual grey matter begins to suffer likewise, atrophy of the muscles sets in, causing the emaciation so characteristic of old age, while at a still later period true fatty degeneration of the striped muscular fibres occurs, more especially in the lower extremities, leading often to complete paraplegia. Such

changes in the muscles also cause the peculiar alteration of the countenance in the aged, the features becoming wrinkled, angular, and shrivelled. Up to a certain time the mental faculties of the aged may remain well preserved, and this must be directly proportional to the nutrition of the nerve-cells in the anterior and posterior association-centres (Flechsig). Where this continues satisfactory, elderly people may still have a good memory, a sober and incisive judgment, and readiness in counsel and action. But sooner or later the intellect is likewise impaired, so that there is a difficulty in fixing the attention on a given subject, and sustained mental efforts become impossible. A change in temper is likewise noticed. Self-control is lost and depression is apt to alternate with undue irritability. The aged become petulant, selfish, and indifferent to the usual interests of life and to their family. The memory for recent occurrences becomes a blank. If such persons live long enough senile dementia is the ultimate result, when only the ordinary automatic functions of life are performed, while the intellect and initiative of the individual have perished.

In cases of senium proprium, more especially in its early stage, I have likewise found that we are able by a cautious use of the constant current to the brain, and more especially to the vasomotor centre in the bulb, greatly to retard the progress of the arterio-sclerosis and the involution of the central neuron. A week or two after the commencement of such a treatment the energy of the system is habitually found to have been considerably enhanced. The old man takes fresh interest in the affairs of daily life, he resumes his work with some amount of vigour, he has a more erect attitude, he walks and stands better, and he has a quicker digestion and a healthier sleep. His general aspect is so much changed that he looks five or ten years younger than before the treatment was commenced. His peevish and querulous temper is no longer a source of trouble to his friends. In bald people the growth of the hair is stimulated,

and when grey or white it may resume, at least to some extent, its previous brown or black colour. In about 40 per cent. of such cases treated by me in this manner the results were noted as "very good," in another 30 per cent. as "fair," and in the last 30 as "insignificant." In no case, however, was the treatment entirely useless, and the function which improved in every one of them was that of walking. Quite recently a veteran actor who had delighted the last generation by his magnificent Shakesperian performances, told me, after a few applications: "I no longer *crawl* but *walk*," and a composer of music of advanced age and bowed down by many infirmities volunteered the remark: "I no longer *walk* but *fly*; and young fellows have now a difficulty in keeping up with me." The longer such treatment is continued in a given case the better are in general the results, and I have come to the conclusion that if old people receive about the sixtieth or sixty-fifth year, or indeed at any time when age has begun decidedly to tell upon them, proper and faultlessly carried-out applications of electricity to the brain, either daily or every other day for some time, they may keep their faculties fairly well until the age of eighty or ninety, unless the case should be complicated with serious organic disease of the nervous system or other important organs, such as paralysis agitans, insular sclerosis, cancer, contracted granular kidney, fatty degeneration of the heart, etc. For such complaints we cannot expect much from a galvanic treatment, which finds its principal sphere of action in cases of uncomplicated senile involution.

FAILURE OF BRAIN POWER.

I have so recently³⁸ treated fully of this subject that I can dismiss it here with a few words. This complaint is unquestionably one of the most frequent disorders nowadays met with in practice, and is characterised by an absence of sustained mental and physical vigour, fatigue of body and mind being readily induced by comparatively

slight efforts; while sleeplessness, depression of spirits, exaggerated self-consciousness, and morbid feelings of terror and alarm, as well as various forms of hyperæsthesia, disturb the tenor of life. Although the brain suffers in these cases, there is no organic disease of it to which these troubles could be referred. It will be seen that "general debility" and "failure of brain power" are closely allied; the chief difference between the two conditions being, that in the former there is sluggishness in all the functions of the body, while in the latter there is a peculiar combination of hyperæsthesia and paresis in the different functions of the brain.

Such symptoms occur not only in the intellectual sphere but also in the speech area, the sensory-motor tract, the centres of the special senses, and more especially in the bulb, where the cardiac, respiratory, vasomotor, renal and other centres are apt to suffer. In the various phases of this affection we often gain truly brilliant results from a carefully measured application of electricity to the suffering parts.

It is highly interesting to observe, in well-marked cases of this condition, how completely the various mental functions are dependent upon the physical condition of the hemispheres, and how very automatic is, after all, the mode of action of the cortex. The influence of what we call free will is seen to be frequently ineffective in stimulating the hemispheres to intellectual efforts, while these latter are rendered easy when by the action of the constant current on the vasomotor nerves sufficient arterial blood has been provided for the nutrition of the cortex, and a healthy action of the mental centres is therefore no longer impeded.

A short time ago I was consulted by an author, aged 50, who had for some months past been engaged in the composition of an important work which he intended to bring out. It was not half finished when he was seized with

such utter distaste for literary labour that any attempts to write "made him sick." He found that he had no flow of ideas, and would sit for hours at his desk trying to compose coherent sentences, and then tear the leaves into strips and throw them into the waste-paper basket. The only thing he felt fit for was to read trashy novels, and these very soon wearied him; in fact, he felt so stupid that he thought his literary career was at an end.

I treated him with 1 MA., applied by a flexible cathode of 135 square cms., to both hemispheres for one minute. After two such applications he felt more desire to work, and commenced looking over a portion of his manuscript which he had written some months ago, but felt himself presently and almost unconsciously seized by the real ardour of writing, and finished twelve pages straight off, with a facility which reminded him of his best days. On reading over what he had written, he found the matter excellent, and far superior to anything he had done lately. His *magnum opus* was finished some time ago and has greatly increased his reputation. Thus a slight dilatation of the arterioles of the "mental centres" (Flechsig), and consequently a somewhat more abundant supply of arterial blood to the cineritious matter, which was brought about by the short passage of the constant current, was more effective in restoring the creative powers of the mind than the most determined efforts of his will had been before.

FAILURE OF THE SINGING VOICE.

An interesting fact, which, as far as I know, has not been noticed before, is that in cases where there is want of vigour in intonation and singing, without any local trouble in the laryngeal mucous membrane or other portions of the throat and windpipe, an application of electricity to the laryngeal centre and nerves has a remarkable influence in steadying and strengthening the singing voice. The laryngeal centre has, by Horsley and Semon, been shown to reside in the

lower third of both Rolandic convolutions, close to the speech centre, and appears to suffer not unfrequently from failure of power, usually in consequence of over-exertion or depressing influences in general. Failure of the singing voice is a serious drawback for professionals, whose success in life depends upon their being in perfect possession of their vocal means; and, in the nature of things, no local treatment of the throat itself, which is often in perfect condition in such cases, can have the desired effect. The induction of catelectrotonus of the laryngeal centre and nerves is, in such cases, followed by good results. One to 2 MA.'s should be used to the centre for two or three minutes, with an active electrode of 140 scms., after which the peripheral branches of the laryngeal nerves may receive the galvanic influence for from four to five minutes.

MENTAL AFFECTIONS.

Numerous observations by competent alienists have shown that careful applications of electricity, and more especially of the constant current, may be followed by good results in certain mental disorders. Cases of long standing, and in which organic disease may have become developed, will have only little chance of being benefited; while recent cases and where no structural change has taken place in the brain, are more promising. Where we have to do with mental over-action and excitement, anelectrotonus should be induced, while for depression, melancholia and stupor, catelectrotonus of the mental centres is appropriate.

Flechsig's most recent researches on the development of the myeline sheath of the central nerve-fibre have shown that the mental or thinking centres, as distinguished from the sensorial and sensory-motor spheres in the cortex, occupy four large and well-defined areas in the human brain. These are, 1st, the pre-frontal area, situated immediately above the eyes; 2nd, a large portion of the temporal lobes; 3rd, a considerable area in the posterior parietal

region ; and 4th, the island of Reil. Morbid irritation of these areas leads to confusion of thoughts and insane delusions ; paresis of them causes depression and melancholia ; while their destruction, which takes place in general paralysis, is followed by loss of knowledge, experience, principles, and the higher sentiments, with inability to utilise the past, or to foresee the consequences of actions.

The relative value of these four mental centres is not yet known, but there can be little doubt that in the most complex mental operations they are all acting together. In the electrical treatment of mental affections we must therefore be careful to pass the current through the four areas mentioned above. Particular care is here required, as a strictly stable application, without any break in the steady flow of the current, is absolutely essential for doing good. Flexible, large-sized and thoroughly moistened electrodes should be applied to the fore-brain, and the temporal and parietal lobes, the current passing longitudinally, transversely and diagonally through the parts. This operation is much easier in bald persons, or where the hair is thin, than where the hair is thick and abundant. In the former we generally notice a deflection of the needle of the galvanometer as soon as the current is put on ; while in the latter several minutes may pass before the needle will move. It is therefore of the greatest importance to watch the galvanometer very carefully, as the current is only effective from the instant the needle is seen to move, and the time has therefore to be taken from that point, and not from the moment when the electrodes have been applied. For this reason it is not permissible to attempt to galvanise the hemispheres without an absolute horizontal galvanometer being enclosed in the circuit, as otherwise we should not know what we were doing.

As a current of some strength overcomes the resistance of the hair much more quickly than a feeble current, such as we intend to pass through the cineritious substance, we may

at first put on a stronger power than we intend using, and then watch the galvanometer very carefully, so as to be able to reduce the current-strength at once, as soon as the needle is deflected, taking care that not more than 1 or 2 MA.'s may be passing. If a feeble current is put on, and if the hair should happen to be thick and dry, five or ten minutes may elapse before the first deflection is obtained.

The time during which the current should pass in the cases under consideration is of the greatest importance. The rule I follow is, to begin with a short application, say one or two minutes, and then, as the patient becomes accustomed to, and tolerant of, the current, gradually to prolong the application until twenty minutes are reached. This is much safer than to begin with a long application.

A single lady, aged 44, had suffered from delusional insanity, and had been four months in an asylum. As the delusions left her, she was discharged, but continued in a state approaching dementia. I had some years before treated her with electricity for a severe form of chronic rheumatism, and as the treatment had been rapidly successful, her friends wished to know whether her mental condition might possibly be improved by the same means. When I saw her she appeared very listless, was unable to read or otherwise to occupy herself, and everything had to be done for her as for a child. She appeared to have a difficulty in understanding questions, and the only information which I could at the first interview extract from her was that "her head was very bad." Her physical health appeared to be good. I gave her 1 MA. through the præ-frontal region for one minute with a cathode of 130 cms. surface, and then sent the current transversely through the mid-brain for another minute. Two days afterwards she came again, and was quite talkative. She told me that her head was now a great deal better; the electricity had cleared it at once; she had felt herself again able to think, and on taking up a book, had been delighted to find that she un-

derstood what she was reading. I repeated the application, and next time she told me that she had felt so happy afterwards that "she could have danced all down the street with joy." She began again to take an interest in life, and spent hours in milliners' and drapers' shops, while previously she had evinced the utmost indifference to her dress and general appearance. With all this there was no undue excitability, and she appeared to have herself perfectly in hand. She had altogether seven applications at that time, and came back for another course six months later, when she had felt a slight return of her previous symptoms. She had then three weeks' treatment, at the end of which she appeared to be perfectly well.

The good effects of electricity in mental affections are unfortunately not always so rapidly produced as they were in this case, for in some patients two or three months' treatment is required to produce a favourable result, while in other cases which appear at first sight suitable for it, no benefit is obtained. Continental observers have used this treatment with some degree of success in depression, melancholia, post-epileptic and hysterical insanity, the delirium of persecution, and delusional and confusional insanity; and it is useful to know that Benedict has seen good results from the constant current applied to the spine. I think it is to be regretted that this treatment should be so completely neglected in English asylums as it is at present. I know of only one such institution—and that a private one—where a proper electrical installation is provided.

In taking leave of this subject, I feel that I cannot do better than quote the words of Arndt³⁶, about the necessity of certain qualities for those who undertake the difficult task of treating the insane with electricity. He says that "electricity is an excellent remedy in the treatment of insanity, but in order to be successful with it, great care, patience, and confidence are required—qualities only found in a man convinced of the final efficiency of his treatment.

Mere attendants, nurses, or assistants, who simply do what they are told, and because it is their duty, will never have the success of a medical man convinced of the efficiency of electricity. We have cured patients who have been treated in vain elsewhere. We must likewise not give up treatment too early. Cases are on record in which the effect of the electric treatment became visible only after weeks, and in which it had to be applied again from time to time for months until at last the patient recovered."

PSEUDO-GENERAL PARALYSIS.

This is a not uncommon affection, and often difficult to distinguish from true general paralysis of the insane. I have in several instances accurately diagnosed the condition, as shown by the curative results of electrical treatment, which could not possibly have been obtained had there been true meningo-encephalitis.

A young gentleman, aged 24, was sent to me by Dr. Bantock, in November, 1896. He had two years ago suffered from slight concussion of the brain, through being kicked on the back of the head at football. He was unconscious for a short time, and confined to his bed for three weeks, suffering chiefly from intense pain in the head. In February, 1895, being entirely disabled from attending to his usual occupations, he took a long voyage, but returned rather worse than he had been before. He consulted the heads of the profession, and underwent long courses of treatment subsequently, without any beneficial result. Recently his health had deteriorated so much that he had become a perfect wreck, both mentally and physically, and was also subject to epileptiform seizures, which resisted the routine treatment by bromide.

When I first saw him he was in a state of collapse, had a heavy bromide rash on the face and neck, and was two stone short of his proper weight. His mental power was so feeble that he could not carry on a conversation, read a

book, write a letter, or add a column of figures. When asked a question, he burst out crying; and when writing a letter, he often lost his thread, wrote nonsense, left out words, and made mistakes in spelling. He had had visual, but no auditory hallucinations. There was frequent twitching in the facial muscles. The knee-jerk was exaggerated, and ankle clonus present. The walking-power was extremely feeble, showing loss of co-ordination, and when standing with his eyes closed, the patient swayed like a drunken man. The urine was alkaline, and contained a considerable excess of phosphates.

The complete break up of mental and physical power; the affection of speech and writing; the epileptiform seizures; the visual hallucinations which had taken place; the twitching of the facial muscles, and the marked in-coördination of the lower extremities, pointed to the presence of general paralysis of the insane. But the patient's age, and the fact that he had not had syphilis, made me take a more hopeful view of the case, and I diagnosed pseudo-general paralysis. I treated him chiefly with applications of from 1 to 2 MA.'s to the cortex, for five minutes, and 2 MA.'s to the cervical sympathetic, three minutes each side, every other day. The patient improved from the very beginning of the treatment, and was discharged perfectly well after six weeks. This result was all the more satisfactory as the family history of the patient was strongly neurotic. The patient has since then become an actor, and continues in excellent health.

HYSTERIA.

Hysteria is at present looked upon more as a psychosis than a neurosis, its characteristic feature being a disorder in the lower levels of the mind, that is, in sentiments, moods and impulses, as distinguished from sustained attention, consecutive thinking, and volition. I have in some cases found transverse galvanisation of the mid-brain, with the alternate induction of anelectrotonus and catelectrotonus

in the pre-frontal area exceedingly useful. The faradic brush has long been used for the treatment of hysterical anæsthesia and hyperæsthesia, and is frequently of great service in such cases; and the Franklinic bath and sparks are likewise appropriate.

HEMIPLEGIA.

This most common form of paralysis is generally owing to hæmorrhage in some portion of the motor tract, between the Rolandic convolutions and the bulb; or to embolism of the middle cerebral artery; or to thrombosis of cerebral blood vessels. Some loss of brain substance is the almost invariable consequence of an attack of hemiplegia; and the further progress of the case depends upon the extent to which the motor tract may have been damaged. Late rigidity of the paralysed muscles and exaggerated tendon reflexes are the principal unfavourable symptoms in these cases, showing that secondary sclerosis of the pyramidal tract has followed the original lesion. Where late rigidity is marked, little can be done to improve the patient's condition; yet electricity may even then do a certain amount of good. In some cases there appears to be a great disproportion between the nature and extent of the anatomical lesion, and the degree of the paralysis which may be present. This latter, and where the right side is affected, the concomitant aphasia, may be of a severe kind, and yet yield to a considerable extent to careful electrical treatment. In such cases we must assume that shock to the brain during the attack of apoplexy has had as much, or even more, to do with the paralysis as the actual lesion which has taken place. The best cases for treatment are those where the paralysed muscles are flaccid, and the tendon reflexes only slightly or not at all exaggerated.

I have, in my "Treatise on Medical Electricity" (third edition, p. 508), described the case of a clergyman who had, at the age of 46, suffered from aphasia and right hemi-

plegia, and was quite disabled when he came under my care. A month's treatment restored him to such an extent as to enable him to resume his work in a very large parish. I have seen him since then from time to time, and he has continued in very fair health. When I last saw him, in February, 1894, twenty-six years after the attack, he was able to work all day long, his mental faculties, more especially his memory and power of application, being very good. His speech was fluent, although long conversation was apt to fatigue him. Considering that he was then 72 years of age, his intellectual vigour was remarkable. He squeezed the dynamometer with the right hand, which had been paralysed, up to 108° , and with the left to 120° , showing that some loss of power still existed in the right side, for 120° with the left hand usually corresponds to 140° with the right. There would thus be a deficiency of 32° in the right hand. The deep reflexes of the right upper extremity were only very slightly increased. The hand was fairly useful, as he could button his clothes, carve a joint and write a letter, although not with the same ease as before the attack. He was able to walk well, and did not drag the right foot on the ground. The knee-jerk on the right side was about equal to that on the left, and there was no ankle clonus.

I have treated a very large number of similar cases with both forms of current, and found that perfect recovery is exceptional. Considerable improvement occurred in about 40 per cent. of the cases, and slight improvement in about 30, while in the remaining 30 no beneficial result was obtained.

Independently of the paralysis, patients suffering from hemiplegia often complain of headache, feelings of pressure, coldness, fulness, emptiness and confusion in the head, depression of spirits, and many other unpleasant symptoms, which frequently yield likewise to the treatment. The following modes of application should be used:—First and

foremost the suffering hemisphere has to be treated by strictly stabile galvanisation, care being taken that the focus of the disease should be traversed by the current. Longitudinal galvanisation is here the best method. Where there is much headache and other symptoms of irritation, the influence of the anode should be chiefly utilised; but where there is more depression and torpor, the cathode is more appropriate. In a number of cases I have found it useful to apply successively the anode and the cathode, care being taken to turn the current off before the poles are changed. I begin with thirty seconds in one direction, and after this give the same time to the opposite pole. Then the current is used at the neck, likewise thirty seconds on each side. After this the paralysed extensor muscles of the arm receive a labile application of the cathode, forty passes being made from the shoulder down to the hand. The leg is treated in a similar manner. After a time faradisation may be used for the limbs, the wire-brush being more effective than moistened electrodes. The current-strength should be most carefully considered, anything powerful being injurious.

As the treatment proceeds, the stabile application to the diseased hemisphere, as well as to the neck, should be very gradually prolonged, until five or six minutes are given to each part. Prolonged applications to the paralysed limbs, however, appear to do more harm than good, and the benefit which has been gained is sometimes lost by too frequent or too powerful cathodal passes.

PARALYSIS AGITANS.

This most distressing and disabling affection is generally looked upon as incurable. The only medicine which I have found to do any real good in it is strychnine, but after a time this is apt to lose its effect. A systematic and exceedingly careful use of stabile applications of the constant current to the head and neck, however, does more good

than anything else. I look upon shaking palsy as a neurosis of the Rolandic convolutions, and as the symptoms are more those of debility than of irritation, I am in the habit of inducing catelectrotonus in the motor portion of the cortex in such cases. A cathode of 130 square cms. is applied to the parietal region of the skull, the anode being held on the hand which is most affected. Where both upper extremities suffer, the anode is first placed to one and then to the other hand. I have found it best to pursue the same plan as in hemiplegia, viz., to begin with a short application and gradually to prolong it, so that at last ten or fifteen minutes are given to the central convolutions, and five or six to the structures of the neck. Here, more than in any other affection, the principle of using a feeble current must be most strictly adhered to, and every interruption carefully avoided. I generally use 1 MA., and rarely more than 1.5. I have seen cases where by brutal applications of electricity all symptoms had been aggravated, and the discomfort caused to the patient had been so great as to make him actually dread the word electricity.

The treatment, as described above, should be carried out daily for six weeks. I have often found that long before that time has expired, and, indeed, after four or five applications, the tremor becomes diminished, and the affected parts regain some degree of power. As the treatment proceeds, the statuesque expression of the face and the staring look gradually give way to the former mobility of the features; the speech becomes more natural; the usefulness of the hand is greater, so that a patient who has been unable to open a door, turns the handle without any trouble; the rigidity of the body becomes less, so that it is easier to turn over in bed; and the power of getting up from a chair and of walking in the proper way is re-established. The course of the disease may, indeed, be arrested for years by repeated courses of this treatment.

Such results are, however, as a rule only obtained in

private practice, and where the treatment is carried out by experts possessed of the requisite apparatus, perseverance and skill. In hospitals where electric treatment is often given over to persons who have only little special knowledge and less patience, not much can be expected of electrical applications to patients suffering from this most intractable disorder, unless the head of the department superintends each application himself.

DISEASES OF THE SPINAL CORD.

The remarks which I made when speaking on hemiplegia, viz., that there is sometimes a great disproportion between the nature and extent of the anatomical lesion, and the clinical symptoms which are caused by it, apply equally to certain spinal diseases. It is, of course, understood that any actual destruction of the grey or white matter of the cord can no more be repaired by any form of electricity, than by any other remedial agent, but cases happen in which the structural alteration is comparatively slight, and where a judicious use of electricity may be of the most essential service in improving the impaired function of the organ.

TRANSVERSE MYELITIS.

The principal symptoms of this intractable disease are paraplegia, anæsthesia, paralysis of the sphincters, and bed-sores; while the tendon reflexes are increased where the dorsal portion is affected, and lost where the lumbar enlargement has been inflamed. Atrophy of muscles, and certain vasomotor and secretory symptoms, such as œdema, etc., are likewise often present.

No one would think of applying electricity in the acute stage of this disease, but in its later stages much good may sometimes be done by a careful use of the constant current to the seat of the malady.

The cord may be galvanised either transversely or longitudinally. In the former case one electrode is applied

to the spinal column, and the other to the sternum or abdomen. In the latter case, one electrode is directed to the cervical, and the other to the lumbar portion of the spine, or one is applied immediately beneath the other, when only a certain section of the organ has to be submitted to the galvanic influence. Another way of acting on the whole organ is to apply one electrode to the top of the spine and another immediately below it, and then after a time to move both, or only the lower one, further down the spine, thus making several "stations"; or one electrode, generally the cathode, is placed to the superior cervical ganglion of the sympathetic, and the other, generally the anode, is gradually conducted down the whole length of the opposite side of the spinal column. Otherwise the same rules obtain as those for galvanisation of the brain, viz., that the surface of the electrodes should be large, that they should be applied before the current is turned on, and that the strength of the latter should be gradually increased and again gradually diminished before it is turned off.

If there are points in the spine which are painful, or tender to touch or percussion, or where a moderate current is unpleasantly felt, such points should preferably receive the influence of the anode. The anode should also act more particularly on the seat of the disease. In some cases an alternation of the poles appears to be useful during the same sitting, proper precautions being taken to turn the current off before the change is made.

Short sittings are essential in the beginning of the treatment. For a transverse application one minute is at first sufficient; while when "stations" are made, from one to three minutes are given. The current-strength has to vary according to the peculiar susceptibility of the patient, and according to whether symptoms of irritation or atony are predominant. In the former case from 1 to 2 MA.'s are generally sufficient, while in the latter from 5 to 10 MA.'s may eventually be employed.

In transverse myelitis I have often found that the exclusive treatment of the seat of the disease acts better than peripheral applications to the paralysed limbs or the bladder. The latter may cause unpleasant symptoms, such as pain in the back, twitches in the limbs, restlessness and discomfort, and increased debility in the limbs and the bladder. This is more particularly found where the case is recent. Where the greatest care is taken in applying electricity properly, the effects are frequently satisfactory.

A young lady, aged 21, had an acute attack of inflammation affecting the entire transverse section of the lumbar enlargement of the spinal cord, in February, 1890, during the height of the influenza epidemic which at that time prostrated the majority of the population. Having been quite well in the evening and gone to the play, she was in the night suddenly taken with shivering fits, and severe pain in the head, back and limbs. The temperature speedily ran up to 104° , and she had within twenty-four hours lost all power over the lower limbs, as well as the bladder and rectum. Bedsores soon began to form over the sacrum, and at the heels, and anæsthesia up to the waist was established. I first saw her in April, 1891, when some degree of recovery had taken place in the left half of the spinal cord, this being indicated by some return of motor power in the left thigh and leg, and of sensibility in the right lower extremity. There was muscular wasting on both sides, with complete loss of faradic contractility, and lessened response to the voltaic current (Re. Deg.), but the atrophy was more marked in the right than in the left limb, there being an inch difference in favour of the left thigh, and $\frac{3}{4}$ -inch for the left leg. Sensation and the superficial reflexes were completely lost in the left, while a slight degree of both was perceptible in the right limb. The deep reflexes were lost on both sides, and the bladder and bowels continued paralysed, there being incontinence of the urine with loss of expulsive power of the bladder, while the

bowels could only be moved by means of enemata. The patient underwent successively treatment by electricity, hypodermic injections of strychnine, and baths, and improved more particularly during the time that electricity was systematically used. A transverse application was made to the lumbar portion of the spinal cord, the anode of 130 square cms. being applied to the seat of the disease, and the larger cathode to the hypogastrium. 1 MA. was used in the beginning for one minute, and the current-strength and length of time were gradually increased to 5 MA.'s and five minutes. At a later period, faradisation of the affected limbs by the wire-brush was added to this application. She has now so far recovered that the substance of the affected muscles is much firmer, and responds to both forms of current, while sensation and the superficial reflexes are almost entirely re-established. The knee-jerk is still absent on both sides, but the patient has recovered her motive power to such an extent that she can not only walk for two or three miles without assistance, but can go up and down stairs with ease, and can get on the top of an omnibus. The bladder has not entirely recovered, but she holds her water well during the day, and passes between four and six ounces at a time in the natural way. The action of the bowels is also much easier, and the period, which had become arrested, has returned and is regular. On two several occasions this patient had a long course of massage, by experienced masseuses, but without beneficial results.

PROGRESSIVE LOCOMOTOR ATAXY.

In tabes the effects of a well-directed electric treatment are habitually good. In some of my cases all symptoms have disappeared, excepting the loss of the knee-jerk. A stabile application of the current, with low strength and large electrodes, may be combined with stabile and labile applications to the suffering nerves of the limbs, with the use of the anode for tender points, and galvanisation of the

structures of the neck. Rumpf has used the faradic brush to the spine and limbs, the moistened anode being applied to the sternum, together with mercurial inunction in syphilitic cases, and has seen better results of the combined treatment than of inunction alone. This mode of treatment has however proved disappointing in the hands of other observers, while a combined use of both currents has often been beneficial.

Paralysis of the ocular muscles, optic atrophy, deafness, anæsthesia, paralysis of any of the limbs from neuritis complicated with tabes, paralysis of the bladder and lightning-pains, may be specially treated by local applications of the current to the suffering parts.

When speaking of the beneficial effects of the static induced current in tabes, Morton says that "he does not refer to the paltry administrations of small and toy influence machines. He has yet to see a machine too large for practical work. The smallest machine which in his opinion can be of real use, should at least possess six revolving plates, each being at least 26 inches in diameter. With such a machine thick percussive sparks from 4 to 8 inches in length can be administered over the spine, to nerve-roots and nerve-trunks, to the muscles, to paræsthetic areas. By such means a vigorous and very complete treatment can be carried out in about fifteen minutes. It is a concentrated electric current of enormous electro-motive force, at least 1,000,000 volts localised to the tissue immediately in relation with the disruptive discharge or spark. Electricity of this sort moves, displaces, distorts, and strains matter like living tissue, which suffers a condition of electric stress." No one will dispute the vigorous character of this treatment, from which Morton appears to have seen excellent results.

In acute ataxy after infectious diseases the results of an electric treatment are often particularly good.

A gentleman, aged 57, married, had a severe attack of

typhoid fever in November, 1892. He was three months in bed, and had on several occasions hæmorrhage from the bowels. When he got up, he found that his intellect and memory were not so keen as before, that he had less self-control, was unduly emotional, and had difficulty in walking. When I examined him in July, 1893, I found symptoms of failure of brain power and ataxy in walking and standing. There was no muscular paralysis or anæsthesia, but he walked as if he were slightly intoxicated, could not keep the straight line, swayed in standing, especially with closed eyes, and felt giddy when coming downstairs, or when stooping. The knee-jerk was exaggerated and paradox, the leg, instead of being thrown forwards, making an excursion sideways. There was no ankle-clonus. The urine was slightly alkaline, and contained an excess of phosphates. I treated him with from 1 to 5 MA.'s, with alternation of poles, and large electrodes to the spine for from one to five minutes; and after a time combined with this the faradic wire-brush to the lower extremities. The patient quickly improved, and after about a month's treatment the knee-jerk had lost its paradox and exaggerated character, and the power of walking and standing was fully re-established.

SPASTIC SPINAL PARALYSIS.

In this affection, stable galvanisation of the spine, more especially with the anode, yields good results when carefully practised. Labile applications to the affected limbs are to be avoided, more especially when the tendon reflexes are much exaggerated.

INFANTILE PARALYSIS.

The electric treatment of infantile paralysis is frequently disappointing, because it is not continued sufficiently long. With much perseverance, however, thoroughly good results may be obtained. In this affection the cord should be acted upon in all directions—longitudinally, transversely,

and diagonally, and with alternation of poles, chief attention being directed to the parts which are more particularly suffering, *i.e.*, the cervical enlargement, where the arms are paralysed, and the lumbar enlargement, where one or both lower extremities are affected. In addition to this, the current should be applied to the structures of the neck, and to the wasted muscles with labile and intermittent applications. Faradisation by moistened conductors and the wire-brush, as well as galvano-faradisation are likewise useful. If this treatment is carefully carried out in recent cases for about twelve months, with occasional short pauses, partial or total recovery may take place.

PROGRESSIVE MUSCULAR DYSTROPHY.

In both the spinal and the myopathic forms of this disease the various forms of electricity have been used in every possible manner, and a few cases have been reported in which improvement has followed. Unfortunately, electricity, however administered, seems in the large majority of cases utterly incapable of effecting a cure, or even arresting in any marked manner the further progress of these formidable maladies. Further trials, however, with Morton's static current and d'Arsonval's alternating sinusoïdal current would appear desirable.

SPINAL DEBILITY.

Many persons, especially young women, suffer from such a degree of weakness in the back that they are to a great extent disabled, yet on examining them carefully no objective symptoms can be discovered. The electric tests are normal, there is no anæsthesia, paralysis, or wasting, and the sphincters act well. In such cases a comparatively short galvanic treatment generally proves restorative.

A single lady, aged 43, had always been delicate. Her mother had been very ill previous to her birth, and died

during labour. She was a seven months' child, and was not expected to live. She did not walk until she was three years old, and then only with steel supports, and could never run or romp like other children. As she grew up her walking powers improved, but when 20 years of age she over-walked herself when on a tour in Switzerland, and since then had been more or less of an invalid. Four years before she came to see me, she was ordered to lie on her back, and had done so until now. On examination I did not find any evidence of spinal or other organic disease. There was, however, great pain and tenderness in the spinal column and all the limbs, and any exertion appeared to be too much for her. The constant current applied to the spine, both transversely and longitudinally, had an excellent effect, for after a comparatively short treatment the patient was able to take a good deal of active exercise, had lost all pain and tenderness, and was greatly improved in her general health.

It is, however, in *peripheral nerve diseases*, such as local palsies and neuralgias, that the beneficial effects of electricity are habitually seen in the most striking manner. The principal method of treatment for local palsies is the use of the stable cathode, and for neuralgia that of the stable anode.

NEURITIS.

In most cases of neuritis the prognosis is favourable, except where the inflammation attacks highly specialised structures, such as the expansions of the optic and auditory nerves, which easily succumb to pressure by the effusion. The recuperative power of the ordinary peripheral nerves is very great, and the natural tendency of the disease is therefore towards recovery, so that slight cases often get well without any active treatment at all. In severe cases, on the other hand, the pain and tenderness in the inflamed nerve, together with the anæsthesia, paralysis, and wasting of muscles, may last for months or years without much

improvement, and a judicious electrical treatment is then generally followed by excellent results.

One of the commonest forms of neuritis is *facial palsy*. I have treated a very large number of such cases, and cannot recall one in which considerable improvement or a cure was not effected by the aid of electricity. In the *Lancet* for March, 1891, I have described two cases of that much rarer affection, *bilateral facial paralysis*, in one of which the affection was apparently owing to the sting of a poisonous insect, while in the other, influenza seemed to have caused the trouble. Both were, in fact, cases of multiple neuritis, as other nervous areas were likewise affected, and recovered completely under the influence of the constant current.

It has often been stated that treatment by electricity should be reserved for the later stages of this complaint; but my experience is to the effect that it is most useful when resorted to in the beginning, and by doing so I have habitually seen a much more perfect recovery in the end than where the electricity had only been used some considerable time after the occurrence of the paralysis. The principal thing here is the method of application, in which it is so easy to go astray. A powerful current is sure to do harm by aggravating the existing inflammation, while an exceedingly gentle force appears at once to ease the circulation and to reduce the pressure of the effusion. I am in the habit of using about $\frac{1}{2}$ to 1 MA. with the anode resting on the mastoid process, and the cathode below the stylo-mastoid foramen, so as to embrace the diseased portion of the nerve, for five minutes, after which a few cathodal passes with the same current-strength are made over the paralysed muscles. There can be no question that this is useful, because the patient at once expresses himself as relieved of the unpleasant feeling of stiffness about the face, and because the muscles that have been acted upon are seen to do their work much better after the application. This latter result is more especially seen in the muscles of

the eyelids, where the immediate beneficial effect is often very striking. Perseverance with this treatment for two or three months is, however, generally necessary for securing a permanent result. Occasionally I have found it useful, especially in long-standing and neglected cases, to apply the current not only to the suffering nerve, but also to its nutritive centre in the upper portion of the spinal cord.

PARALYSIS OF THE DELTOID MUSCLE.

This is generally caused by injury to, or inflammation of, the circumflex nerve. I have described an interesting case of neuritis of this nerve in the *Lancet* for March 1, 1890. The patient was a merchant, aged 56, who had, for the last eight years, been subject to diabetes, which did not cause much thirst or polyuria, but was evidently responsible for a great diminution in his walking powers, which had existed all that time. Fourteen months ago he was suddenly, during the night, seized with severe burning pain in the right shoulder and elbow, which in spite of treatment continued for nearly three weeks. When the pain subsided the patient found himself unable to raise the arm, while he could bend the elbow and move the hand and fingers as well as before. He underwent treatment by electricity injudiciously applied, and by massage, for three months, but derived no benefit from either; and considerable wasting about the shoulder-top had been plainly perceptible for some time. On examining the right arm I found that it was hanging down apparently lifeless by the side, and could only be abducted from the body to a very slight extent, in a direction forwards and outwards, but not at all backwards. The patient endeavoured to increase the extent of the abduction by calling into play other groups of muscles, raising the shoulder and stretching the wrist and fingers, but to no purpose. The very slight degree of abduction which could be performed was owing to the action of the supra-spinatus. The patient felt much incon-

venience from this disability, being unable to wash and dress himself without assistance, to eat soup with his right hand, to light a gas-burner, to put his hand into his trousers pocket, etc.

The region of the deltoid appeared flattened, from atrophy of its substance, the skin was flabby, and its sensibility diminished. The electric tests gave the reaction of degeneration, viz., loss of faradic excitability, and lessening of voltaic response, the middle and posterior portions of the muscle being only excitable by a current of 15 MA.'s, while the anterior portion gave a sluggish C.C.C., with 8 MA.'s, the A.O.C. being barely perceptible. All the muscles in the neighbourhood of the deltoid were in their normal condition. The knee-jerk was sluggish, and the urine contained 2 per cent. of sugar. The case was therefore evidently one of acute neuritis of the circumflex nerve, which in the absence of injury, gout, syphilis, alcoholism, etc., had to be ascribed to the saccharine condition of the blood. The paralysis of the deltoid muscle was treated with the faradic brush, and 6 to 8 MA.'s, applied by a stabile cathode of 30 square cms. to the deltoid muscle. After six weeks of this treatment, the patient having attended every other day, he was very much improved, being able to put his hand into his trousers pocket and to eat soup with his right hand. The treatment was continued for another two months and a-half, after which recovery was complete. The electric tests had improved *pari passu*, so that the anterior portion of the muscle responded well to 4 MA.'s, and the faradic current was effective in exciting contraction. The patient died four years afterwards of acute pneumonia, but had had no relapse of the paralysis at any time. A few hypodermic injections of strychnine had been made in addition to the electricity, but definite improvement had already set in before they were used, and as the patient disliked them they were not persevered with.

In the above case the treatment had to be continued for

a considerable time, as the paralysis was complete, and not of recent origin. Where it is incomplete, the improvement under electricity is generally much more rapid. Such was the case of an officer, aged 27, who had dislocated his right shoulder twelve months ago by his horse falling over him. He had been unconscious for some time, but recovered fairly well, and had the dislocation reduced. Ever since, however, he had had difficulty in moving the right arm up to the horizontal line, and suffered much the same inconveniences as the patient whose case I have just described. The paralysis, however, was partial, and the electric tests much better. He recovered the use of his arm after five applications of the stabile cathode.

NEURITIS OF THE BRACHIAL PLEXUS.

This affection is even more disabling than paralysis of the deltoid muscle. I have described a case of total paralysis and anæsthesia of the upper extremity owing to this form of neuritis, and in which I succeeded in completely re-establishing the use of the limb, in the *Transactions of the Royal Medical and Chirurgical Society for 1871*.

Partial paralysis likewise occurs in this plexus in the form described by Duchenne and Erb, in which the deltoid, biceps, brachialis internus, and supinator longus are affected, and in Klumpke's form, in which the lower portion of the plexus suffers, when it is chiefly the small muscles of the hand and the flexors of the fore-arm which become paralysed. The issue of such cases naturally depends upon the cause and extent of the lesion, but electrical treatment is in general indispensable for their cure.

PARALYSIS OF THE MUSCULO-SPIRAL NERVE.

This is a very common form of local palsy, and is generally owing to injury to the nerve where it winds round the humerus, and is therefore particularly exposed to the effects of pressure. In slight cases of this kind recovery ensues

within a few weeks without any special treatment, but in the more severe forms of it, in which there is reaction of degeneration, the aid of the constant current has to be called in for overcoming the affection. E. Remak³⁷, who has studied this subject in a very thorough manner, has found that the best method of treatment is the stabile application of the cathode to the seat of the trouble, the indifferent anode being placed on the sternum. The cathode should have a surface of from 20 to 30 square cms. The current is turned on after both electrodes have been placed in their respective positions, and is then very gradually increased until the patient feels that he is able to extend the hand more easily. This is generally the case when the needle of the galvanometer points to from 6 to 8 MA.'s. This proceeding should be repeated until perfect recovery is obtained.

Paralysis of the ocular muscles is generally owing to some central disease, which itself is mostly due to syphilis, diphtheria, alcoholism, diabetes, etc. Electrical treatment often fails to relieve this palsy, but occasionally proves useful even where it cannot remove the cause. The constant current is more effective than the faradic, a short and slight application being essential. It is important to act as much as possible on the seat of the disease, so that the mode of application has to be carefully considered in each individual case.

Some years ago I treated a case of *external ophthalmoplegia* in this manner, with unquestionable benefit. The patient was a gentleman, aged 26, married, who had always been in bad health, and showed signs of inherited syphilis. He was one day, while at dinner, quite suddenly taken with paralysis of all the external muscles of the right eye, there being complete drooping of the eyelids and inability to move the eye in any direction. The iris and the ciliary muscle were unaffected, so that the disease seemed to be seated in the posterior portion of the nucleus of the third

nerve. I passed the constant current with 1 MA. and 16 square cms. for two minutes transversely through the supposed seat of the trouble, having the cathode on the mastoid process of the affected, and the anode on that of the opposite side ; and afterwards made twenty slight cathodal passes over the closed lid. There was a plainly perceptible improvement immediately after this application, as the patient was able to raise the eyelid to some extent, and could move the eye a little way inwards. After four more applications the ophthalmoplegia had disappeared.

It is but fair to say that in two other similar cases which I have treated in a similar manner, no apparent benefit was obtained.

Direct faradisation of the paralysed muscles by very fine electrodes introduced into the conjunctival sac, which has been much recommended, seems to do more harm than good, and is now almost generally abandoned.

NEURALGIA.

In the various forms of neuralgia, electrical treatment is often successful after a great variety of other therapeutical procedures have failed to do good.

NEURALGIC HEADACHE.

By neuralgic headache I understand that complaint in which the headache constitutes the primary trouble, and is not owing to coarse brain disease, hyperæmia or anæmia, alcoholism, increased arterial pressure, or other habitual causes of headache. The neuralgic headache, which is tolerably common, is generally found in persons with a neurotic inheritance, and comes on after the action of injurious influences, such as acute infectious diseases, mental anxiety, over-exertion, chills, etc. There are habitually no other symptoms excepting such as flow directly from the disturbance induced by the headache. The pain is more or less constant, but is liable to be greatly aggravated from

time to time, so that true neuralgic paroxysms are set up. In such cases there is often no trace of a more general neurosis, such as hysteria, failure of brain power, hemicrania, etc., although similar headache may occur as part and parcel of these conditions.

The neuralgic headache is often benefited by change of air and scene, by hydrotherapeutics, arsenic and some of the modern analgesics; but where it persists after other modes of treatment have had a fair trial, no time should be lost in using the constant current, for many patients lose some of the best years of their lives through this trouble.

A lady, aged 21, had been quite well until she had scarlet fever, at 16 years of age, but had ever since suffered from severe headache, which had never left her for a single day. Both her parents had been highly nervous, and had died of paralysis; and her only sister suffered from great nervous irritability. The headache had, therefore, evidently been produced by a specific poison, in a person having a neurotic inheritance. There was generally a dull feeling in the forehead and vertex, but during the acute attacks, which occurred frequently, the pain was of a shooting, throbbing, and stabbing character, and affected the entire head. The patient was thereby prevented from being in society, and from reading, painting and following other occupations which she had enjoyed before. This had caused a complete alteration in her disposition, which had formerly been bright, while she was now habitually irritable, and often hopeless and depressed. There were no objective symptoms, except tenderness in the forehead and the vertex, slight percussion of which sent a violent thrill through the head. She showed me a bundle of more than fifty prescriptions, from almost as many doctors, and appeared to have taken every medicine and applied every lotion which could reasonably be expected to do her good. I therefore abstained from further

medicinal treatment, and resorted to the use of the constant current, placing a circular anode of 16 square cms. successively to the tender points of the head, a cathode of 40 square cms. being directed to the cervical spine. The current-strength used at first was 1.5 MA.'s, and the length of the application five minutes. The pain and tenderness were lessened by the first application, and after the current had been used twelve times, with somewhat increased strength and time of passage, the patient was quite free from the trouble which had afflicted her so long. Some years afterwards she told me that she had had no relapse, and that I had given her a new lease of life.

In recent cases a single application of the anode is frequently sufficient to cure the affection, as the pain disappears after two or three minutes, and does not return.

TIC DOULOUREUX.

This, the most severe of all forms of neuralgia, likewise occurs habitually on a neurotic base, and may follow malaria, influenza, and other infectious diseases. It is sometimes benefited by the removal of certain causes of irritation in the eye, nose, or mouth; and in the slighter forms of it salicylate of soda, gelseminum, arsenic, and iodide of potassium are useful. Cases of maximum severity have been successfully treated by removal of the suffering nerves, and of the Gasserian ganglion (Rose); but before such operations are resorted to in apparently desperate cases, and also in all other forms which resist the usual treatment, I consider it incumbent upon us to use the constant current first, and to combine it, if necessary, with the cataphoric introduction of cocaine or aconite into the suffering nerve, by means of anodal influence.

A married lady, aged 40, had suffered from strumous opacity on the right cornea, owing to scrofulous keratitis, when 8 years old. She had a neurotic inheritance on both sides, but had on the whole been tolerably well, when one

day, after a long visit to a picture gallery, where she had been standing about in draughts, she was suddenly taken with curious little darts through the right eye and forehead. This went on for about ten minutes, and then subsided, but was the next day followed by more severe attacks, the pain in the eye being of a stabbing character, while the forehead felt as if it were bursting. After a time the attacks became frequent, and every movement of the facial and masticatory muscles gave rise to a paroxysm, so that the patient avoided speaking and eating as much as possible. When the pain was particularly bad, she also felt a kind of spasm in the heart, the action of which became irregular and intermittent, with feelings of anxiety, oppression, and faintness. When I first saw her, two years after the commencement of the affection, the pain although not so overpowering as it is in the worst cases, was sufficiently severe to make her utterly wretched, and to destroy all pleasure in life. During the last six months she had taken unduly large doses of morphine, which was the only thing that gave her temporary relief. There was a tender point corresponding to the supra-orbital nerve, which I treated with a small anode, a cathode of 120 square cms. being directed to the spine. The current-strength was gradually raised, and without shocks, from 0.5 to 6 MA.'s, and continued for fifteen minutes. The current was also sent transversely through the skull, so as to influence the Gasserian ganglion, for five minutes. After two such applications the patient expressed herself as relieved, and the tenderness of the supra-orbital nerve was less; but as there was still much distress, I now added cataphoresis of a 20 per cent. solution of cocaine through the suffering nerve. The effect of the treatment was now more marked, and a satisfactory result was obtained in five weeks, at the end of which the neuralgia appeared to be subdued. The patient then remained free from pain for seven months, after which a relapse took place, which, however, at no time assumed the former

severity. The treatment was at once resumed, and had again a favourable effect, ten applications being sufficient to afford complete relief. Twelve months afterwards I ascertained that the patient had enjoyed good health since the treatment was discontinued.

BRACHIAL NEURALGIA.

The pathology of this form of neuralgia is closely allied to that of others, but different in this, that most cases have an hysterical base. The pain is often of a most violent character, but on the whole the affection is much more manageable than tic, and the prognosis is almost invariably favourable. With the aid of the constant current we succeed habitually in readily overcoming the neuralgia, and I have not found cataphoresis necessary.

A widow, aged 37, with pronounced neurotic inheritance, and who had at various times suffered from definite symptoms of hysteria, consulted me some years ago for severe pain and loss of power in the right arm. She denied having had a chill or an injury to the arm, and attributed the affection to mental anxiety and prolonged nursing of some sick relations. Soon after the last case which she had taken care of had got better, she felt, one evening, about two months ago, a darting and shooting pain in the right arm, and she thought she had broken it. Any movement of the limb increased the pain to such a degree that she felt obliged to keep it perfectly quiet. She had been very ably treated by an experienced practitioner, but did not get any better, and the pain continued so severe, that she had had no sleep during the last two months, and was utterly worn out by pain and insomnia.

On examination I found great tenderness on pressure in the course of the musculo-spiral nerve, more especially where it winds round the humerus, and to a lesser degree over the lower cervical vertebræ. The skin of the arm showed a degree of anæsthesia, and there was loss of the sense of

temperature, for the patient could not distinguish between heat and cold. This showed that there was a degree of neuritis, but there was no trophic disturbance and no paralysis. It is true that loss of power in the hand and fingers was complained of, and that the patient was unable to move the index of the dynamometer with the right hand, while with the left she squeezed it easily up to 90°; yet it seemed to me that this arose more from fear of increasing the pain by movements; and the further course of the case showed that this surmise was correct. The cathode of 64 square cms. was now directed to the lower cervical vertebræ, while the anode of 40 square cms. was placed over the musculo-spiral nerve, for five minutes, with 5 MA.'s, after which cathodal passes were made for three minutes in the course of the suffering nerve. There was no immediate effect after the first application, but four or five hours afterwards the patient felt much easier, and could move her hand and fingers a little without exciting a paroxysm; and she had that night the first real sleep for two months. After this she made further good progress, and had completely recovered after ten applications.

Another case in which the effect of stabile anodal galvanisation was very striking was that of a celebrated actor, aged 52, who, while staying abroad during very hot weather, had sat down in a cool place after a long walk in the sun, and was suddenly taken with most violent pain in the sphere of the brachial plexus. The pain was worst over the collar-bone, in the deltoid, and the terminations of the radial and ulnar nerves. Being then in the company of a most able physician, he was at once properly treated; yet on his return to England nine weeks afterwards he was no better, but continued to suffer "downright intolerable pain." I found the clinical signs of neuritis. A single anodal application over the collar-bone, where there was much tenderness, stilled the pain at once, leaving a very pleasant feeling of a glow all through the limb. The patient recovered completely through a short treatment.

INTERCOSTAL NEURALGIA.

This form of neuralgia is frequently complicated with herpes zoster, and is often very obstinate and severe. The pain is chiefly felt in the front and side of the chest, and there are habitually tender points near the vertebræ, in the axillary line, and close to the sternum. The causes are of a most varied character, and each case therefore requires a very special and careful examination, as the removal of the cause, wherever possible, is of the greatest importance. It is chiefly seen in young men and young women, and I have met with several cases which occurred after influenza. The principal mode of application is the stabile anode to the tender points, after which a few cathodal passes are useful. The affection generally yields to this treatment within a few weeks. In obstinate cases I have seen good effects from the faradic brush, combined with the above proceeding.

IRRITABLE BREAST.

This form of neuralgia occurs chiefly in middle-aged women, and is often connected with pregnancy, the puerperal state, and lactation. It sometimes appears on an anæmic or hysterical base, and may be connected with severe hyperæsthesia, more especially in the region of the nipples. Tender points are habitually found on the spinous processes of the 2nd to 7th dorsal vertebræ, and should be treated by the stabile anode, after which cathodal passes are made over the breast. I have seen several obstinate and tedious cases, which yielded readily to this treatment.

IRRITABLE TESTICLE.

This is generally consequent on gonorrhœa, and the pain is sometimes so severe that it disables the patient from following his occupation. The stabile anode, followed by cathodal passes over the affected testicle, habitually relieves

the distress, but the treatment has occasionally to be followed for a considerable time, on account of the obstinate character of the affection.

SCIATICA.

This is by far the most common form of neuralgia in this country, and occurs frequently in persons of a gouty disposition or in otherwise healthy people after severe chills, more especially from sitting on wet grass after playing lawn-tennis, or after undue exertion in rowing, etc. One of my patients was an officer, aged 28, who had been hunting the elk, moose, and grisly bear in the Rocky Mountains and Nova Scotia, and often got up to his waist into marsh-water, with only moccasins on. This eventually induced severe pain in the right hip and thigh, which assumed a neuralgic character, and darted into the leg and foot. Sciatica also occurs from diabetes, alcoholism, after acute infectious diseases, etc., but neurotic tendencies are far less influential in the production of it than is the case with other forms of neuralgia. In general, the clinical signs of neuritis may be discovered, especially where the affection is of recent origin. In many of my cases the pain had been incessant, and left the patient no peace either by day or night, thus causing insomnia and utter exhaustion of the nervous system; the pain being of a stabbing, boring, throbbing, or burning character, or like incessant pricks by pins and needles, etc. The worst time is often in the early hours of the morning, when the suffering may become so intolerable that the patient is obliged to get out of bed, and walk about the room for hours together.

All experienced electro-therapeutists are agreed that electrical treatment does splendid service in most cases of sciatica, from whatever cause it may spring. Stable galvanisation of the nerve by a large anode has appeared to me the best mode of treatment. Steavenson has advised labile galvanisation of the lower portion of the spine

and the back of the thigh by the cathode, the anode being placed on the abdomen. In several cases which I have treated by this proceeding, the pain instead of being subdued, became more severe, and I have therefore given it up. Faradisation by the wire-brush, and also by moistened conductors, one being placed to the sciatic notch, and the other to the ankle, with a gradually increased current-strength, is likewise useful. The galvanic, faradic, and galvano-faradic bath, and the combined Buxton treatment, also find here an appropriate sphere of action.

I have seen several cases of recently-acquired sciatica in which a single application of the stabile anode permanently relieved the pain. Where the affection is of long standing, however, it is generally more obstinate, but is nevertheless curable by persevering electrical treatment, unless particular complications should be present, such as perimetritis, pelvic tumours, etc., which make against recovery.

A married lady, aged 33, had suffered from left sciatica for about twelve months, having been obliged to be in bed the better part of that time on account of the severity of the pain, which was increased by the slightest movement. She had been most ably treated by Dr. Mackintosh, her usual attendant, as well as by the heads of the profession who had been called into consultation. It seemed occasionally as if the pain was about to yield to the remedies used, but it always returned shortly afterwards in its previous severity; and the patient was almost desperate when I first saw her, in May, 1880. Her health was in other respects good. The pain was chiefly felt on the left side of the sacrum, and in the course of the sciatic nerve from the notch to the knee, where there were several exquisitely tender points. That the pain in this instance was owing to neuritis, was evident from a considerable degree of analgesia which was present in the affected parts. The prick of a pin could not be perceived, and a

current-strength which was plainly felt on the back of the right thigh excited no sensation in the left.

There were from time to time convulsive twitches in the muscles supplied by the left sciatic; but there was no wasting, showing that the neuritis was not very profound. The anode of 30 square cms. was applied successively to the left side of the sacrum, and to the course of the nerve down to the knee. At first a very considerable current-strength had to be used, as owing to the analgesia the patient felt not the least effect from a moderate force. There was, however, an immediate improvement, and after three weeks' treatment she had completely recovered. No relapse has taken place at any time.

MULTIPLE NEURITIS.

The worst form of this disease is that known as *alcoholic paraplegia*, in which electrical treatment often affords great relief, yet rarely proves curative, because the patients, who are mostly middle-aged women, continue their drinking habits to the bitter end, in spite of all advice and supervision. Other forms of polyneuritis appear as so-called "rheumatic" or "diphtheritic paralysis," after influenza, and similar occurrences.

"RHEUMATIC PARALYSIS."

A merchant, aged 56, married, had rheumatic fever ten years ago, and when recovering from it found that he had great difficulty in walking, having lost power, particularly in the left thigh. During the twelve months before I first saw him, the trouble had considerably increased in spite of treatment by strychnine, iodide of potassium and baths. On examination I found slight anæsthesia in the left thigh, with wasting of the rectus, the left thigh being $1\frac{1}{2}$ inches less in circumference than the right. The knee-jerk was very sluggish in the left, but well marked in the right thigh, while the electric tests were fairly satisfactory. The patient had a difficulty in hitting out, and in crossing the left leg

over the right, could not go easily up and down stairs, and was fatigued after a short walk. I made a stabile application of the cathode to the crural nerve in the groin, followed by passes and faradisation of the skin with the wire-brush. After six weeks' treatment all the symptoms above described had greatly lessened; the knee-jerk was very nearly the same in both sides, and the walking power had so much improved that the patient could be on his legs "all day long" without fatigue.

A lady's maid, aged 40, had, after an attack of "acute rheumatism" three years ago, suffered from pain and loss of power in both arms and hands. She had great difficulty in doing her hair, in writing, working, and doing a variety of little things which require easy bending of the elbow. She could not fasten her brooch, or carry a tea-tray. There was rigidity of the biceps, more especially in the right arm, and a degree of numbness in the limbs, with lessened electric responses of the nerves and muscles. Her wrists felt so sore that she could not wear cuffs. There was also numbness, pain, and loss of power in the legs. She was treated with both currents, and it was found that the faradic brush did her most good. After eight applications she was relieved of all her symptoms.

DIPHThERITIC PARALYSIS.

This is the most frequent form of multiple neuritis, which may follow slight as well as severe cases of diphtheria, and is on the whole more frequently seen in adults than children. There is generally paralysis of the soft palate, with nasal twang in speaking, and difficulty of swallowing, paresis of the ocular muscles, and of the laryngeal and cardiac nerves, with paralysis and anæsthesia in the lower extremities, and loss of the knee-jerk. The prognosis is throughout favourable, the only risk which such patients run being syncope from failure of the cardiac centre. Those who escape a "bulbar crisis" (Guthrie) invariably recover from the paralysis with proper treatment.

A merchant, aged 53, had, in December, 1893, a slight attack of diphtheria, which "had been sent to him by post," as he had received a letter shortly before from a correspondent whose whole family was down with it; and the infection could not be traced to any other source. The local trouble continued for sixteen days, after which the throat was well, but two days afterwards he was seized with curious "tickling" sensations in the toes and fingers. The next day he lost power in the legs up to the knees, and in the arms up to the elbows. He consulted me three months afterwards, when there was anæsthesia, paresis, loss of superficial and tendon reflexes, wasting of muscular substance, and lessening of voltaic and faradic responses. There had been no paralysis in the palate, pharynx, larynx, or the ocular muscles at any time. The heart's action was satisfactory, and he had no trouble with the bladder and bowels, but the urine contained a small quantity of sugar. Walking without assistance was impossible, and the character of the walk when the patient was supported on both sides partook of ataxy as well as paralysis. Severe pain in the extremities, with tingling and pins and needles, was likewise complained of. Although the patient was therefore quite disabled I gave a favourable prognosis, more especially as the heart's action was normal, and the general nutrition of the body good. I treated him at first with stabile and labile applications of the constant current to the suffering nerves, to which, after a time, faradisation of the skin and muscles and hypodermic injections of strychnine were added. A decided improvement, however, was noticed before the latter procedure was resorted to, and he eventually made an excellent recovery, as he was quite well about five weeks after the commencement of the treatment.

SPASMODIC DISEASES.

In these affections electrical treatment is as a rule not so much used as in paralysis and neuralgia; yet where

other remedies fail, it will often step in as the right thing in the right place. This applies to cases of vasomotor spasm, facial and masticatory spasm, glosso- and blepharospasm, general tic, writer's cramp, and other professional neuroses, tetany, chorea, and analogous affections. The stabile anode with an exceedingly gentle force ($\frac{1}{2}$ to 1 MA.) should be applied as near as possible to the seat of the disease, the application being gradually prolonged from one or two to twenty minutes.

SPASM OF THE VASOMOTOR CENTRE.

In this form of spasm the pulse is small and thread-like, the skin cold and pale, the face sallow, the hands cold and clammy, and the feet feel like ice. The patient appears anæmic, but is not really so, for the number of red blood-cells is normal. The condition is apt to be worse after meals. As the cortex is equally badly supplied with blood as the peripheral parts, the patient feels low, depressed, lethargic, indifferent to everything, and experiences faint feelings when he is obliged to rouse himself for some mental or physical effort. A preacher is apt to faint away in the pulpit, just when about to commence his sermon; and a barrister feels as if he must faint when beginning a speech in Court. At times an actual fainting fit occurs, while on other occasions the patient just steers clear of it, or may show signs of angina pectoris.

There are few nervous affections in which the beneficial influence of electricity is so quick and remarkable as in the one just described. The principal application is that of the medium-sized anode to the cervical spine, and the circular small cathode to the auriculo-maxillary fossa. In general two MA.'s, for three minutes on each side, is sufficient to raise the pulse, to make the hands dry and warm, and send a pleasant feeling of glow through the whole system. Five or six such applications are frequently sufficient for the cure of an affection which may otherwise

last for years, and spoil the public career of a patient; while purely medicinal remedies in general completely fail to relieve it.

TIC CONVULSIF.

In April, 1885, I treated a case of this kind which occurred in a merchant, aged 40, single, who had been on the whole in good health, with the exception of a bad attack of scarlet fever when he was 21, during which the left membrana tympani was destroyed, entailing complete deafness on that side. The first symptoms of tic supervened two years before he consulted me, in the left side of the face. The eye was spasmodically closed from time to time, and the spasm gradually affected the whole side of the face. The patient had not had syphilis, and was in all other respects in perfect health. The constant current, sent through the mastoid processes, with the anode on the affected side, 16 square cms. and 2 MA.'s, for five minutes, was effectual in relieving the trouble. This form of tic is often treated with electricity applied to the suffering muscles, a proceeding which has appeared to me quite useless.

CARDIAC NEUROSES.

Where the heart's action is irregular and impaired through derangement of the inhibitory or accelerator system of nerves, which occurs so frequently after influenza, electrical treatment may be of great assistance. This applies to *tachycardia*, *bradycardia*, *delirium cordis*, and the vasomotor form of *angina pectoris*.

A married lady, aged 25, had rheumatic fever and endocarditis six years ago, and had since been subject to mitral disease. This did not appear to cause her much trouble until a time when she had great domestic worry and anxiety. Since then she had been subject to distressing attacks, which generally commenced about 4 p.m. She suddenly felt faint and frightened, had swimings in the head, with great pain in the heart and left arm, and such

severe palpitations that she thought she was going to die ; she was covered with clammy sweat, and after a time almost collapsed. Such an attack would last till the next morning, when she gradually became more comfortable. She had been treated with digitalis, strophanthus, and nitroglycerine, but medicines appeared to have no influence on her condition. I directed the stable anode to the pneumogastric nerve at the neck, 16 square cms. and 1 MA., the cathode of 40 square cms. being placed to the cervical spine, and allowed the current to pass for two minutes at each side. This treatment was followed for a month, and had the desired result.

GRAVES'S DISEASE.

In August, 1875, I brought before the Annual Meeting of the British Medical Association, at Edinburgh, a highly interesting case of Graves's disease, in which the three cardinal symptoms of that complaint, viz., tachycardia, exophthalmos, and struma had been present, and in which I had succeeded in saving the life of the patient, which had been in the most imminent danger by a sudden and rapid growth of the tumour in the neck, by electrolysis of the enlarged thyroid body. The case is all the more important, as the subject of it is now (May, 1899) alive and well, that is, more than twenty years after the treatment was discontinued, and has never had any return of the complaint. I therefore subjoin a few particulars of the same, and hope that it may lead to a more frequent recourse to electrolysis in this intractable disease.

J. L., aged 37, single, a native of Yorkshire, and engaged in a mercantile firm in the City, came under my care in April, 1874. He had for the last ten years been subject to a tumour in front of the left side of the neck, involving the thyroid body, which had very gradually increased until it reached an inconvenient size. There had also been a degree of exophthalmus and tachycardia. The patient had

on various occasions consulted the heads of the surgical profession in London, with the view of having the tumour removed. This, however, was not considered expedient by the eminent men whose opinion he had sought, and nothing had been done except painting the skin over the swelling with iodine, which had had no beneficial effect. Things had gone on for a considerable time in this manner, when on April 10th, suddenly, a fresh tumour appeared on the right side of the neck, over the collar bone. This was accompanied by an increase of temperature in the parts, and considerable pulsation. At the same time alarming symptoms of pressure on the pneumogastric nerve became apparent, viz., loss of voice and of the power of swallowing, a sense of choking in the throat, and severe pain at the back of the head, on the right side. There was regurgitation of liquids through the nose, and the patient could not sleep, but was obliged to sit up in bed, propped up by pillows, or to lean forward in a chair.

Under these circumstances he had again consulted Sir William Fergusson, and implored him to operate. Sir William, however, declined to do so, and the patient was then sent to me by his usual medical attendant, Dr. Black, of Islington. I first saw him on April 13th, 1874, and found him in the following state :—Pulse 120, respiration 36 ; anxious expression of countenance ; eyes staring and protruding ; excessive action of the left ventricle. He had not been able to sleep or eat for four days, and could only talk in a whisper. In front of the left side of the neck there was a tumour of the size of an orange, which was very hard, and showed no signs of fluctuation. It was limited interiorly by the thyroid cartilage and the windpipe, which were considerably displaced to the right side ; exteriorly by the strongly pulsating carotid artery, superiorly by the horizontal branch of the lower jaw, and inferiorly by the apex of the trigonum supraclaviculare. On the right side there was a smaller but strongly pulsating

tumour occupying the supraclavicular space. It was much softer and less prominent than the one on the left side. The circumference of the neck on the most prominent point of the left side was $16\frac{1}{4}$ inches, and on the right side $15\frac{1}{2}$ inches.

The patient was in such a state of prostration, and so racked with pain and distress, that I thought it best to commence the treatment with an external application of the constant current, for the purpose of soothing and strengthening the nervous centres, and diminishing the effects of pressure upon the pneumogastric. He recovered his voice almost immediately, had some sleep the night after, and no more regurgitation of liquids. Next morning the expression was less anxious, the pulse had gone down to 90 beats, respiration 28; the voice came and went from time to time. On April 15th he reported that he had had four hours' sleep, eating had become easier, he had drunk off a whole tumblerful of beef-tea without trouble, and the voice was stronger. The tumour on the right side was smaller, and its pulsation diminished. The headache was still intense, and did not seem to be affected by the external application of the current. On April 19th I introduced a needle connected with the cathode of 15 cells of Becker-Muirhead's battery into the tumour on the right side, and allowed the current to pass for 15 minutes. On the 21st the patient reported that he had eaten solid food, and that the headache was nearly gone. The old tumour on the left side was now likewise attacked by electrolysis, to which after a time parenchymatous injections of the tincture of iodine were added. By the middle of May the tumour on the right side had entirely disappeared, and the left was then shrinking visibly under the influence of the treatment, which was continued, with some considerable intervals, until March, 1875. At that time there was only just a trace left to show that there had been once a tumour; and

the circumference of the neck was reduced from $16\frac{1}{4}$ to $13\frac{7}{8}$ inches. Sir William Fergusson had an opportunity of examining him at that time, and expressed to me his gratification at the successful result of my treatment in a case which he had thought beyond surgical interference. Nowadays of course few surgeons would hesitate to operate in such a case.

In cases where the enlargement of the thyroid body is slight, the percutaneous use of the constant current may be sufficient. Various methods have from time to time been used, the principal amongst them being general galvanisation and faradisation; the hydro-electric bath; the constant current to the neck ("cervical sympathetic") with the anode to the cervical spine, and the cathode "in stations" from the stylomastoid fossa down to the clavicle; or the anode to the fifth dorsal vertebra, and the cathode in stations along the whole spinal column; or with the anode on the solar plexus and the sternum. In addition to this the exophthalmus, the thyroid body, the heart, and any vertebræ which may be found tender, may be locally treated. Each particular application should be short and gentle, that is, from a half to one minute, and 1 to 3 MA.'s, according to individual susceptibility, and the anode should as a rule have a larger surface than the cathode. A gradual introduction and cessation of the current are necessary.

Vigouroux and others have recommended faradisation of the neck, putting at first the anode of 7 to 8 square cms. to the nape of the neck, and a small cathode of 1 square cm. on the region of the superior cervical ganglion, leaving them on for one and a-half minutes on each side, with sufficient current-strength for causing contraction of the sternomastoid muscle, then acting on the motor points of the orbicularis palpebrarum muscle, the lids, and neighbourhood of the eyes; this is to be followed by the application of a large cathode to the supraclavicular space, the thyroid

body, and the heart's region. The faradic current should be used in this way from ten to twelve minutes, on alternate days, and the treatment persevered with for months. The different modes of franklinisation have also occasionally proved useful.

Cardew has severely criticised these different methods of electrical treatment, and stated that there is in the works on electro-therapeutics "the most profound confusion, almost amounting to chaos, owing to the enormous number of methods advocated." I cannot see any harm in there being a number of methods of treating such an obstinate complaint, as owing to constitutional differences in patients, which have always to be reckoned with, one method may fail in a given case, while another may prove beneficial. Cardew's criticism would therefore seem to be hardly called for, while the method he has proposed himself is not by any means free from objections. He advises patients who are for some reason unable to be under treatment by experts, to procure a small chloride of silver battery of four or six cells, and to apply the current themselves three times a day, with the anode of $3\frac{1}{2}$ inches in diameter on the nape of the neck, while the cathode of $1\frac{1}{2}$ inches in diameter is moved up and down the side of the neck from the mastoid process along the course of the great nerves, for six minutes at a time. The method may therefore be described as "labile galvanisation of the cervical sympathetic," while almost every experienced electro-therapist uses the stabile method in that region, on account of the feelings of giddiness and other unpleasant sensations in the head, which interruptions of the current are apt to produce. Nor does Cardew say anything about the gradual introduction and cessation of the current, which is so important in such applications. The patient works without a collector, rheostat, or galvanometer, and the method would therefore certainly appear to be a "rough and ready" one, and might be attended with unpleasant results in sensitive

persons. In spite of these drawbacks Cardew's proceeding seems to have done good, which shows that electrical treatment is sometimes of advantage even where the usual rules of application are neglected.

NOISES IN THE HEAD.

Tinnitus aurium, when loud and continuous, is a most distressing affection, and usually depresses the mind and the whole nervous system of the patient in a marked manner. It is exceptional that the sufferers get accustomed to the noise, and are able to follow the advice so freely tendered to them by their doctors and friends, that they should forget all about it, and think of something else; on the contrary, in the large majority of cases no amusement or change of occupation and scene has the slightest influence upon it, and the trouble is felt as keenly after it has lasted for years as it was when it first began. Persons who are otherwise well, are better able to bear up against it than those in delicate health; but even a strongly tempered nervous system may eventually break down under the affliction.

Tinnitus is always produced by irritation of the auditory nerve, and this may be owing to local disease of the ear, or to certain more general conditions which have the tendency to cause modifications in the pressure of the endolymph which surrounds the expansion of the nerve in the labyrinth. It may occur from anything acting unfavourably on the nervous system, such as anxiety, grief, overwork, a sudden fright, or intemperance; and is seen particularly in the anæmic, the hysteric, and the neurotic generally, but also in others in whom it is impossible to discover a constitutional fault.

The fact that we are able, by a careful application of the constant current, to relieve a considerable proportion of cases of tinnitus, is either ignored or doubted in most of the best works on aural diseases. This unfavourable

opinion of the authorities is probably owing to the circumstance that there are few complaints the successful treatment of which by means of electricity requires so much special knowledge of the physiological effects of that agent, such delicate adjustment of apparatus, and such technical skill in manipulating the same as tinnitus of nervous origin; while, on the other hand, a haphazard application of electricity is likely to do more harm than good; and the chance of thereby accomplishing a cure must be considered as exceedingly remote. It is astonishing to find such a distinguished aural surgeon as Politzer stating that the galvanometer and rheostat may be dispensed with in the application of electricity for the relief of aural affections.

I have fully described the proper mode of using the current for tinnitus elsewhere³⁸, and related some striking cases in which benefit resulted from it, so that I would refer the reader to that publication for all further information on these points. Suffice it here to say that in general the stable anode, used with from 1 to 5 MA.'s, for from five to twenty minutes, is the most effective application, and that particular care should be taken in diminishing the current-strength *gradually* at the end of the application, as sudden anode-opening has a prejudicial effect.

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In certain otherwise intractable affections of the *abdominal and pelvic viscera*, electrical treatment is advisable after the failure of other therapeutical procedures.

OBSTINATE VOMITING OF NERVOUS ORIGIN.

During the cholera epidemic of 1849, Duchenne found that an application of the faradic brush relieved the vomiting as well as the cramps from which the patients suffered. The constant current was subsequently used by Tripièr, Onimus and Le Gros, Semmola, and many others, more especially for the vomiting of pregnancy. Apostoli³⁹, who has given an elaborate historical account of these

investigations, advised at first the application of a small anode to the right pneumogastric nerve, at the internal extremity of the collar-bone, with the cathode in the hand of the patient; current strength from 5 to 20 MA.'s. After a few minutes' action the patient should be requested to swallow something, while the current is circulating; and the application should be prolonged for an hour, if necessary. Twenty minutes were in general found sufficient, and two or three such applications were habitually required for producing a decided effect. Apostoli has subsequently recommended the application of both poles direct to the two pneumogastric nerves as the most effective proceeding.

DILATATION OF THE STOMACH.

Where this is owing to obstruction of the pylorus, as is so often the case, no good results can be expected from the use of electricity. In a number of cases, however, its origin is neurotic, and then the constant and faradic current, as well as galvano-faradisation, may be usefully employed.

In November, 1887, Dr. Baumann, of Schlangenbad, sent a young lady, aged 16, to me, who had eighteen months before suffered from jaundice and peritonitis. Two months before I saw her, she was rather suddenly taken with a cutting pain in the region of the stomach, which had never since then left her for a single instant. "She went to bed with it, and she woke up with it." At the same time she had noticed a swelling in the region of the stomach, which had gradually increased, and had now attained the size of about half a Seville orange. This swelling occupied part of the epigastrium, and part of the left hypochondrium, was extremely tender to touch and pressure, and gave on percussion a full tympanitic note. The whole neighbourhood of the tumour was highly sensitive, and touching it made her feel sick. There was loss of appetite and body-weight, and apart from the pain which was always present, she felt very weak and languid. The urine had a

density of 1044, and contained an enormous excess of urea and urates, but no sugar or albumen. I treated the tumour with the stabile anode of 40 square cms. 5 MA.'s for five minutes, and afterwards made cathodal passes over it. The first result of this treatment was relief, and presently complete cessation, of the pain and tenderness; and very soon afterwards the swelling began to subside. After thirty-three sittings every trace of it was gone, and the patient being then perfectly well, the treatment was discontinued. There has been no relapse.

HABITUAL CONSTIPATION.

I have treated a considerable number of cases of atony of the muscular coat of the bowel, leading to obstinate constipation, with both faradism and the constant current. The former is best applied with an insulated metallic cathode in the rectum, while a large anode is gradually conducted along the course of the large bowel. The primary is more useful than the secondary current. The constant current is also very effective, and should be used with a large anode on the lumbar spine, while a cathode of not less than 70 square cms. is well pressed on the region of the cæcum, where it should remain stabile for two minutes, after which it should act on the ascending, transverse and descending colon. It is advisable to reverse the direction of the current from time to time (Voltaic alternatives), and the duration of the sitting should not be less than from fifteen to twenty minutes. It is sometimes useful to follow up galvanisation immediately by faradisation; and the combination of the two currents may likewise be employed.

OBSTRUCTION OF THE BOWELS.

Intestinal obstruction is now generally treated by laparotomy, after purgatives, opium, and belladonna have failed; and in the case of absolute mechanical occlusion, such as strangulation by bands, etc., the knife certainly affords the only chance for the patient's recovery. Nevertheless, the

risks of the operation are known to be great, in spite of recent improvements in its technique ; and for this reason it would appear preferable to resort to electricity rather than to laparotomy in cases where there is reason to believe that the obstruction might be overcome by a powerful contraction of the muscular coat of the bowel, that is, in fæcal accumulation and intestinal palsy, foreign bodies impacted in the intestines, etc.

In January, 1878, Mr. Allingham requested me to see with him a gentleman, aged 54, who had generally been in fair health, but had for the last three months suffered from obstinate constipation, for which purgatives and enemata had been used without effect. Nothing in the shape of a solid or liquid motion had been passed for fully ten days when I saw the patient. The abdomen was very much distended and tender ; there was total loss of appetite, a degree of collapse, with sunken face, and a small and feeble pulse. Mr. Allingham had the day before introduced a long tube, but without bringing any fæces away, and was anxious that the effects of electricity should be tried, as the patient appeared to be in great danger. I introduced an insulated cathode with a free metallic end into the rectum, and applied a moistened conductor to the abdominal parietes, chiefly in the region of the sigmoid flexure. The primary faradic current was now sent through, and its force gradually increased until the patient experienced a decided feeling of vibration throughout the bowel. The application was kept up for twenty minutes. This was done at 10 a.m., and the same evening the patient had a copious motion, with wonderful relief to all symptoms. During the next two days the bowels acted ten times, and in a week he appeared to be quite well.

Another case in which I have used faradism successfully was that of a married lady, aged 57, who had nearly all her life suffered from obstinate constipation, which she thought had been brought on "by living on biscuits at school." She

had often gone for a week or ten days without relief, but did not appear to be much the worse for it until the time I was called in, when there was great distension and tenderness of the abdomen, bilious vomiting, and prostration after eight days' constipation.

I used the same proceeding as in the previous case, at 5.30 p.m. At 1 a.m. she had a good motion, followed presently by two others, when an enormous quantity of fæcal matters was discharged, with complete relief.

I regret to be unable to speak about the further progress of these cases, but in both of them life was evidently saved by the application of electricity.

"ELECTRIC INJECTIONS."

In France the continuous current has recently been somewhat extensively used in similar cases, more especially by MM. Boudet de Pâris and Larat, who have employed it in the form of so-called "electric injections." In order to avoid the escharotic effects of a metallic electrode applied directly to the mucous membrane of the intestines, salt water is injected into the rectum, so as to act as a large liquid electrode, the metallic conductor connected with the positive pole of the battery being enclosed in an elastic sound, and thus conducting the electricity to the salt water. It is claimed that by acting in this manner a considerable current-strength can be safely used. The circuit is closed by placing a large negative electrode on the abdomen. The strength in MA.'s must be regulated according to the susceptibility of the patient. In many cases of pseudo-strangulation and fæcal obstruction, this proceeding continued from five to twenty minutes, has appeared to give relief. In cases in which a real obstacle has to be overcome, it is recommended to use the current as directed for five or six minutes, and then to reverse its direction, care being taken first to reduce its strength, and get*the needle of the galvanometer down to 0, after which the current is gradually put

on again to its former power. As soon as the cathode acts in the rectum, the bowel contracts, and great desire is felt for defæcation, which the patient, however, is requested to resist until he finds it impossible to do so any longer. One, two, or three such applications may be required in the twenty-four hours. M. Boudet states that he has been successful with "electric injections" in thirty-five out of fifty cases (70 per cent.), while M. Larat claims 101 successes in 230 cases (nearly 44 per cent.). The latter recommends recourse to laparotomy at once if the electricity has failed to act in the period just mentioned, and not to lose time by exhibiting purgatives. If electric injections were made soon after the appearance of bad symptoms, and laparotomy followed quickly after failure of electricity, the electro-therapeutist as well as the surgeon would have a better chance of saving the patient's life than now, when they are often called in too late.

PARALYSIS OF THE BLADDER.

In 1871, I brought the treatment of paralysis of the bladder, by means of the constant current, before the Annual Meeting of the British Medical Association, at Plymouth, and related cases in which I had used that treatment with benefit.⁴⁰ One of these was that of a married lady, aged 32, of highly nervous constitution, who had lived much in the tropics, and was sent to me by Dr. Frank, of Cannes, in July, 1870. She had been very delicate as a child, and her mother had died of phthisis. Family troubles thoroughly upset a system naturally predisposed to nervous disturbance, and in which only some powerful exciting cause was required for the full development of hysteria. Early in 1870, when she was under the care of Dr. Siordet, of Mentone, the patient had cataleptiform seizures, and convulsive attacks resembling opisthotonos. She soon after lost her voice, and the power of walking, and of voiding the urine. From March 6th, until the time she came under my

care, the catheter had to be introduced twice daily. This was a cause of great inconvenience, for it became necessary that the patient should, in her travels, merely on account of this symptom, be constantly accompanied by a medical man able to give relief to the bladder, as hospital trained nurses were not to be had then. The urine in this case was quite normal. The labile cathode was used over the region of the bladder. After the first application, the patient passed her urine in a feeble stream, and with a certain amount of pain and straining; after the second application, she could pass it freely, and had fully retained the power of doing so when I last heard from her some years afterwards.

In the paper just mentioned I stated that it was neither necessary nor expedient to apply the current directly to the tissue of the bladder itself, as we might do by means of an insulated sound, with a free metallic end introduced into that organ. Direct galvanisation of the *full* bladder was objectionable, because chemical decomposition of the urine was the consequence of such a proceeding, giving rise to symptoms of fainting, owing to the sudden distension of the viscus by the gases which are set free; while direct galvanisation of the *empty* bladder appeared to produce an irritating effect upon its mucous membrane. External galvanisation produced none of these inconveniences, and was often thoroughly effective, so that it should in all cases be employed in lieu of direct internal galvanisation.

Since then M. Boudet de Pâris has brought forward a new method of directly galvanising the bladder in the same manner in which the "electric injection" of the bowel is performed; that is to say, the electrode is introduced into the viscus protected by an elastic catheter, and then an injection of water or some medicated fluid is made, which serves as the active electrode, and carries the current to all parts of the mucous membrane and muscular coat of the bladder without the risk of cauterising the tissues. Where

a percutaneous application of the constant current, therefore, does not answer, Boudet's "electric injection" may be used.

ENURESIS.

Nocturnal incontinence of the urine in children is a very distressing affection, not only for those who suffer from it, but also for their parents. It is owing either to spasm of the detrusor urinæ, and is then successfully treated by belladonna; or to paresis of the sphincter of the bladder, for which latter electrical treatment is the best. Both forms of the affection probably depend upon disturbed action of the lumbar portion of the spinal cord.

The numerous methods of electrical treatment which have been proposed from time to time for this affection show that the trouble is often very obstinate. A good mode, which has often proved very serviceable to me, is the application of the anode to the lumbar spine, and of the cathode above the os pubis. Large electrodes, three minutes of stable application of from 5 to 8 MA.'s, followed by forty interruptions in the metallic circuit, and twenty voltaic alternatives. In cases where this method fails, we resort to Seeligmüller's proceeding, which is, however, more unpleasant to the patient. The faradic current is used, with the medium-sized anode above the os pubis, while the aseptic end of the negative conducting wire is introduced for a half or a whole inch into the urethra of the child. The current is now made, and gradually increased until the maximum force which we intend using is reached, and this is kept going for two or three minutes. This proceeding is repeated three times at short intervals. In many cases a single such application has been sufficient to eradicate the evil.

IMPOTENCY.

Where loss of virile power is owing to structural disease of the nervous centres, or to exhausting acute or chronic

complaints, such as diabetes, phthisis, kidney disease, etc., or to physical defects in the organs of generation, no one would think of applying electricity for the relief of it. Where, on the other hand, we have to do with functional disturbances, in which inhibition in the brain, or undue excitability or paresis of the different parts of the genital centre in the cord are the cause of the trouble, electrical treatment, if discriminately carried out, is more effective than any other mode of treatment.

1. *Cerebral, mental, imaginary or inhibitory impotency* occurs chiefly in men who suffer from a general lack of confidence in their powers, and who are of a naturally timid or apprehensive cast of mind. It is also seen in those who have during adolescence suffered from unduly frequent nocturnal emissions of sperma, or who have been addicted to excesses. It is very commonly seen in newly-married men who have failed on some particular occasion to accomplish the sexual act satisfactorily, and subsequently are in constant apprehension of failure, with the result that there are further disappointments. In such cases the physiological condition of the sexual organs is usually normal, and the affection is owing to inhibition of the sexual impulses, which are habitually excited by sight, contact or imagination, and which travel from the mid-brain and the occipital lobes to the genital centres in the cord. In such cases encouraging suggestions on the part of the medical attendant, with the assurance that the trouble will shortly yield, and the prescription of a tonic, generally have the desired effect. Occasionally, however, suggestion proves ineffectual, more particularly where there is want of a proper balance of nerve force in other respects. In such cases we must insist upon hygienic conditions of life in their fullest sense being observed, and prescribe the more powerful nervine tonics, such as arsenic, phosphorus, and strychnine. Should such measures, however, fail to lead to the desired result, then a careful application of electricity

may stimulate the reflex centres in the mid-brain and occipital lobes, from which the sexual impulses start, and tend to reduce the undue predominance of inhibition.

The constant current should be applied as follows:—Round electrodes of from 4 to 5 cms. diameter are placed on the mastoid processes, and a current of from 2 to 3 MA.'s is sent through for five minutes, with the usual precaution of gradual introduction and cessation. After this, an oblong anode of 15 by 9 cms. surface is placed on the occiput, while the hand of the patient should rest on the indifferent cathode of about a hundred square cms. The current is then gradually brought up to 2 MA.'s and allowed to act for three minutes, after which it is let out by degrees, and then reversed in the metallic circuit, so that the cathode now acts in its turn on the occiput with the same strength and for the same time as before.

Habitual Frigidity.—In some persons the inhibitory centres of the sexual passion predominate over the reflex centres from the first, subduing all such feelings and impulses. This constitutes congenital or habitual frigidity, which occurs with preference in men of unusual intellectual vigour and self-control, whose mind is constantly fixed on work of an absorbing character. I have seen it in great legal luminaries, and in authors of repute who have written on abstruse subjects. The condition may be accompanied with arrested development of the penis and testicles, but also occurs without any such deficiency.

In such cases the same application as has just been described should be combined with some change in the mode of life adopted by the patient. Incessant application to abstruse intellectual work should be eschewed, and the airier and lighter side of existence cultivated. Where there is deficient development of the penis and testicles, a local application to these organs should be combined with the central application. This is done by placing the anode on the epigastrium and making cathodal passes

along the groin, in the direction of the spermatic nerves, the upper and lower surface of the penis, the perinæum, and the testicles. The current-strength has to be regulated according to the individual susceptibility of the patient, and may vary from 1 to 10 MA.'s. The faradic brush applied to the sexual organs is also useful in these cases.

Cerebral impotence may occur after *injury to the head*, more especially the occiput, and may continue after recovery from all the other symptoms produced by the concussion. Such injury is occasionally followed by wasting of the penis and testicles, and there may be paralysis of the bladder, numbness and loss of power in the limbs, impaired vision and memory, etc. There is usually some amount of meningeal hæmorrhage in such cases, and as the effused blood is gradually absorbed, there is a corresponding improvement in the symptoms. Sometimes the loss of sexual power is the only trouble remaining after such an injury, and where this is the case, recovery under the influence of electrical treatment may be expected. In such cases there appears to be an interruption of conduction between the reflex centres in the occipital lobes and in the lumbar portion of the cord, and I am, therefore, in the habit of conducting the current from one to the other centre, subjecting each part alternately to the influence of the anode and cathode, three minutes each way, with about 5 MA.'s and large electrodes. The application of electricity in this form of impotency was first suggested by the late Mr. Curling⁴¹, with whom I have treated a number of cases of this kind.

2. *Spinal Impotency*.—The sexual power resides in the lumbar enlargement of the spinal cord, which contains two separate, although closely connected, genital centres, one of which presides over erection, and the other over ejaculation. Loss of balance in these centres causes that form of impotency which Gross has called "atonic"—a term which appears to me inappropriate, as in most such cases there is,

more especially in the beginning of the affection, undue excitability rather than atony, or, in other words, over-action, and not want of action. The term "spinal impotency," which includes both undue excitability and paresis, and which draws a distinct line of demarcation between this and the cerebral or inhibitory form, seems to me therefore preferable.

Spinal impotency is frequently owing to excesses, and may be complicated with prostatorrhœa, spermatorrhœa, irritability, and catarrh of the bladder, stricture, gleet, and other allied affections. It occurs, however, likewise without any such complications in persons who have led chaste lives, and have been addicted to studious habits. I have frequently seen it in widowers of a certain age, who had formed new ties after prolonged abstinence.

Paresis and undue excitability require different therapeutical measures for their removal, more especially where electricity is concerned; and a due localisation of the trouble is therefore indispensable for its successful treatment. Where over-action in the ejaculatory centre is treated with faradisation or cathodal passes over the penis and perinæum, we cannot be surprised if the patient should get worse instead of better. By closely analysing the features of each individual case, however, the rules to be acted upon in the electrical treatment follow naturally from general principles; and if closely adhered to, as I shall now describe them, will give satisfactory results in the great majority of cases. Indeed, an extensive clinical experience has shown me that electricity, when used with proper discrimination, is a most effective remedy for spinal impotency.

A. The *ejaculatory centre* is commonly the first to suffer. There is unduly rapid discharge of the seminal fluid, owing to increased excitability of this centre, which responds too quickly to a comparatively slight stimulus. This often occurs at a time when sexual desire and the erectile response to it are still normal. Premature emission renders the act too

short, and, therefore, incomplete and unsatisfactory, for the activity of the ejaculatory centre should only come into play in response to a more powerful and prolonged stimulation.

In cases of undue excitability of the ejaculatory centre, the anode should be applied to the lumbar portion of the spine, by an electrode of 10 by 6 cms., with a cathode of about a hundred square cms. on the epigastrium, or on the patient's hand. According to individual susceptibility, a current of from 5 to 10 MA.'s is then gradually put on, is allowed to flow from five to seven minutes, and slowly let out. In many cases, especially where the affection is of recent origin, this is sufficient for its cure.

In obstinate cases, and where the affection is of long standing, or complicated with urethral or prostatic troubles, an internal application of the anode to the prostatic portion of the urethra by an insulated conductor with a metallic end should be added to this, with 1 or 2 MA.'s for from two to five minutes. Much care and special knowledge are required for the successful use of this proceeding. A metallic anode in contact with the mucous membrane causes free electrolytic decomposition of the urethral mucus, oxygen and acids being developed from it, while cataphoresis renders it dry by removal of water. The metal of the electrode is therefore oxydised and glued to the mucous membrane. This renders the removal of the sound difficult after the application is over; and as no force must be used for pulling it out, I have been led to overcome this obstacle by the simple expedient of reversing the direction of the current in the metallic circuit of the battery, after the anode has done its work and the current has ceased to act. A short cathodal influence is then substituted for the previous anodal action. This leads to the opposite electrolytic effect, hydrogen and alkalies being now developed in place of oxygen and acids, and water flowing towards the cathode by cataphoresis. The congealed mucus is thus fluidified, and the instrument may therefore now be readily removed.

If skilfully performed, this somewhat complicated proceeding is not unpleasant, and highly effectual. The terminations of the spermatic nerves in the vesiculæ, the prostate, and the urethra are soothed by this application; and where chronic discharges, owing to gonorrhœa, etc., are present, a healthy modification of the mucous membrane is brought about. I believe these latter effects to be owing to the germicide action of the anode, as oxygen in the nascent condition has been experimentally shown to be destructive of toxines.

Paresis of the same centre may become developed in the further course of these cases, or may be the initial symptom of spinal impotency. In any case it leads to loss of contractile power in the muscular coat of the vesiculæ seminales, the ejaculatory ducts, the prostate, and the urethra. Erectile power may still be there, but the act is unduly prolonged and the erection generally subsides after a time from exhaustion, without any ejaculation taking place. For this condition I am in the habit of using the opposite arrangement of the poles. Here our object must be to stimulate the centre, which we may do by applying the cathode to the lumbar spine: and where this should not be sufficient to rouse its activity, the ejaculatory ducts and adjacent parts should be stimulated by the application of the insulated cathode to the prostatic portion of the urethra. A stabile cathodal application, with the anode on the epigastrium, for two minutes, with 1 or 2 MA.'s, should be followed by from twenty to forty interruptions in the metallic circuit, whereby the stimulation is considerably increased. There is never any difficulty in removing the cathode from the urethra.

Alternately with this application, faradisation of the prostatic portion of the urethra may be used, the negative pole of the coil being connected with the insulated sound, and the large anode being placed above the os pubis. Length of application, five minutes, and current strength adapted to the peculiar susceptibility of the patient.

B. *The erectile centre* may suffer from loss of power either in the commencement or the further course of spinal impotency, more especially the latter. The erection then becomes imperfect, or is no longer produced at all in response to the ordinary physiological stimulus. In such cases desire may still be present, and even unduly keen. Where this latter state obtains, the erectile centre may still respond to stimulation by abnormal irritants; and it is, therefore, a somewhat fruitful source of sexual aberrations. This constitutes an additional reason why we should use all legitimate means at our disposal for combating the condition, if we are consulted at this stage. If the further progress of the affection is not arrested by treatment, there is eventually complete loss of desire as well as paresis of both spinal centres.

A good deal of confusion has been caused in what has been written on this subject by authors not having traced the symptoms of impotency to affections of the several centres presiding over the sexual act; and this has naturally prevented any definite rules being laid down for treatment.

Paresis and undue excitability necessarily require different therapeutical measures for their removal, more especially where electricity is concerned; and a due localisation of the trouble is, therefore, absolutely necessary for its successful treatment. Where over-action in the ejaculatory centre is treated with Faradisation or cathodal passes over the penis and perinæum, we cannot be surprised if the patient should get worse instead of better. By closely analysing the features of each individual case, however, the rules to be acted upon in the electrical treatment, follow naturally from general principles; and if closely adhered to, as I shall now describe them, will give satisfactory results in the great majority of cases. Indeed, an extensive clinical experience has shown me that electricity, when used with proper discrimination, is our most effective remedy for spinal impotency.

I now proceed to detail the rules which I am in the habit of following in the treatment of these cases. Where we find evidence of undue excitability of the ejaculatory centre, the anode should be applied to the lumbar portion of the spine, by an electrode of ten by six cms., with a cathode of about a hundred square cms. on the epigastrium, or on the patient's hand. According to individual susceptibility, a current of from five to ten milliamperes is then gradually put on, is allowed to flow from five to seven minutes, and slowly let out. In many cases, especially where the affection is of recent origin, this is sufficient for its cure. A single such application makes, sometimes, a decided difference for the better, but in general it will be necessary to apply the current from six to twelve times, either on consecutive or on alternate days.

In obstinate cases, and where the affection is of long standing, or complicated with urethral or prostatic troubles, an internal application of the anode to the prostatic portion of the urethra by an insulated conductor with a metallic end should be added to this, with one or two milliamperes for from two to five minutes. Much care and special knowledge is required for the successful use of this proceeding. A metallic anode in contact with the mucous membrane causes free electrolytic decomposition of the urethral mucus, oxygen and acids being developed from it, while cataphoresis removes the water from the positive to the negative pole. The metal of the electrode is therefore oxydised, and glued to the mucous membrane. This renders the removal of the sound difficult after the application is over; and as no force must be used for pulling it out, I have been led to overcome this obstacle by the simple expedient of reversing the direction of the current in the metallic circuit of the battery, after the anode has done its work and the current has ceased to act. A short cathodal influence is then substituted for the previous anodal action. This leads to the opposite electrolytic and cataphoric effect,

hydrogen and alkalies being now developed in place of oxygen and acids, and water being received instead of given off. The congealed mucus is thus fluidified, and the instrument may, therefore, now be readily removed.

If skilfully performed, this somewhat complicated proceeding is not unpleasant, and highly effectual. The terminations of the spermatic nerves in the vesiculæ, the prostate, and the urethra are soothed by this application; and where chronic discharges, owing to gonorrhœa, etc., are present, a healthy modification of the mucous membrane is brought about. I believe these latter effects to be owing to the germicide action of the anode, as oxygen in the nascent condition has been experimentally shown to be destructive of microbes and their toxines.

For *paresis* of the ejaculatory centre, with loss of tone in the muscular coat of the organs under its influence, I am in the habit of using the opposite arrangement of the poles. Here our object must be to stimulate the centre, which we may do by applying the cathode to the lumbar spine; and where this should not be sufficient to rouse its activity, the ejaculatory ducts and adjacent parts should be stimulated by the application of the insulated cathode to the prostatic portion of the urethra. A stable cathodal application, with the anode on the epigastrium, for two minutes, with one or two milliampères, should be followed by from twenty to forty interruptions in the metallic circuit, whereby the stimulation is considerably increased. There is never any difficulty in removing the cathode from the urethra.

Paresis of the erectile centre is treated by the cathode on the lumbar spine, as before; and as the nervous impulses reaching the sexual organs, and the circulation of blood in them, are generally sluggish, cathodal passes over the external surface of these parts, as described above, should be added. Faradisation of the prostatic portion of the urethra, as described above, may also be useful in these cases.

On the whole, however, the influence of Faradic electricity in this affection is limited. Faradism has no perceptible influence on the nervous centres, but may be used with good results in cases of atony after long-continued gonorrhæa, after caustic injections, etc., and also in place of, or in addition to, cathodal passes over the penis and perinæum in the parietic form of spinal impotency.

Franklinic electricity does not appear to have been employed in such cases of late years, although there has recently been a considerable revival of its use in other affections, more especially in France and the United States. Curiously enough, Bigelow's "International System of Electro-Therapeutics" (Philadelphia, 1894), a bulky and prolix volume of nearly 1,700 closely-printed large 8vo pages, the editor of which modestly mentions in the preface that "each paper in the book is a classic of itself"—does not contain a single line on the use of electricity in impotency, although I have treated of the subject as early as 1870, in the second edition of my "Treatise on Medical Electricity," while Erb (1882) and Lewandowski (1887) have likewise given an encouraging account of their experience in this matter.

ELECTRICITY IN GYNÆCOLOGY.

BY G. APOSTOLI, M.D.

"At the request of my learned colleague, Dr. Julius Althaus, I herewith offer to the medical profession in England a short outline of the present applications of electricity in gynæcology. I must ask for the indulgence of the reader if the subject matter should be occasionally involved, as I have been limited in the space placed at my disposal, so that I have often been prevented from entering fully into certain details and developments which might have made my meaning clearer. The account which I shall now proceed to give is the outcome of my daily practice, and

rests on all the clinical documents which I have collected since 1882. I hope that this very summary survey of facts, all lived through and beyond dispute, may give a new support to the interesting and too much neglected cause of conservative gynæcology.

“1.—ELECTRICAL WORKING TOOLS.

“The gynæcologist who wishes to use electricity in his practice, must have at his disposal :—

“1. The continuous current furnished by a battery or by accumulators. It is better not to use the direct current from the main, because this is subject to slight oscillations, which may cause trouble in its medical application. The current from the main may however be utilised for charging accumulators. There being only slight resistance in such applications, it is best to use a rheostat, and not a collector. Supposing a rheostat could not be obtained, however, and a collector were used, only a single cell should be introduced into the circuit at a time, as if two or three cells were introduced at the same time, the application might become more or less painful for the patient. The principal point is to have sufficient voltage at our command to have a powerful current. This should not be less than from 60 to 80 volts. In my own clinique I am in the habit of using a battery of accumulators charged from the main, and giving 78 volts.

“2. A galvanometer indicating up to 250 MA.'s. I am myself using one with a shunt, and with which we may *ad libitum* reduce the reading from 200 to 20.

“3. An induction coil, preferably that of Tripier's, with rapid interruptions, and primary and secondary current.

“It will be useful to complete this installation by :—

“(a.) A static machine, which can be advantageously employed for a great variety of neurasthenic and hysterical troubles, which so frequently accompany uterine disease.

“(b.) An apparatus furnishing a current of high frequency,

for improving the state of general nutrition, which is so often impaired in female diseases.

“(c.) A galvanic cautery, with a number of differently shaped appliances ; and :—

“(d.) A dynamo for obtaining an alternate sinusoidal and undulating current.

“The following electrodes are likewise required :—

“1. An Apostoli's intra-uterine platinum electrode, which consists of a platinum stem of the shape of an ordinary hystrometer ; this is movable in a sheath of insulating material, so as to allow of increase or diminution of length, and is guarded by a case of celluloid or hardened caoutchouc in order to protect the vagina from any cauterising effect of the current.

“2. A series of intra-uterine carbon electrodes, which are progressively graduated with regard to thickness. Those generally used consist of cylinders of gas carbon, 2 cms. long, supported by an insulated metallic stem, showing graduations perceptible to the eye and finger, and capable of being adapted to the varying capacity of the uterus. These electrodes may also be used for the vagina, for producing electrolytic effects, as for instance on an ulcer in the cervix, etc.

“3. Bi-polar electrodes for faradisation, consisting of hollow tubes of insulating material, carrying two metallic rings which are connected by wires in the tube with the poles of the induction coil. They are made of different sizes for the vagina and the uterus.

“4. A variety of trocars, which are however only rarely used. They are mounted on the stem of an Apostoli's hystrometer, and have an insulating cover for the protection of the vagina. These are either not insulated, and consist then of single metallic stems terminating in a point, which are intended to produce an eschar with more or less considerable loss of substance, according to the nature of the case ; or they are insulated very nearly up to the end,

in order to carry and concentrate the polar action of the current in the interior of the tissues, thus avoiding the formation of eschars on the way.

"5. An indifferent electrode for the skin, which should be as large and as adherent as possible, the best being one made of moist sculptor's clay. It should be prepared in the following manner:—ordinary clay, which must be as free from sand as possible, is carefully moistened, so that it becomes quite sticky, and may be completely adapted to the abdomen, impregnating all the pores of the skin; it is moulded in a frame of wood, $1\frac{1}{2}$ cms. high and 30 cms. long, by 18 or 20. It is then enclosed in a piece of muslin with large meshes, and finally covered at its upper surface with a metallic plate, which is connected with the battery by a wire. This electrode, if well made, is the only one which allows us to obtain a high current-strength without much pain, and without the risk of burning the abdominal parietes.

"II.—MODE OF ACTION OF THE CONTINUOUS CURRENT.

"The constant current has three different effects, viz. 1st, an *inter-polar* action, which soothes the nervous system, equalises circulation, and therefore improves nutrition; 2nd, a *mediate polar* effect on the tissues in the neighbourhood of either of the poles. The positive relieves congestion and soothes functional over-activity, while the negative has the opposite effect, viz. to produce congestion and act as a stimulant. The 3rd, *immediate* polar effect of the platinum electrode is electrolytic, and powerfully modifies the chemical constitution of the tissues. If the action is sufficiently long and intense, there is actual cauterisation and formation of eschars. At the anode acids and some ozone are developed; and the eschar formed there is hard and dry, a hæmostatic effect being produced, while the cicatrix which remains after the separation of the eschar is thick, tough and inclined to shrink. The anode has been shown by my

researches, undertaken with Laquerrière, to be a powerful antiseptic (100 MA.'s, 5 minutes), attenuating or destroying the virulence of cultures of anthrax in its neighbourhood. The cathode, on the other hand, where the alkalies accumulate, produces a soft eschar, which is diffuent and bleeds easily; it has no immediate hæmostatic effect, which is easily understood if we remember that the tissues become congested under the influence of this pole. The cicatrix produced at the cathode has less tendency to shrink, and there is no, or only a very slight, antiseptic influence.*

“III.—OPERATIVE PROCEDURE.

“In most cases the continuous current has to be applied to the interior of the uterus, with most rigid aseptic precautions, for most of the pretended dangers of this method arise simply from neglect of this important point. The operator should brush and soap his hands in a thoroughly business-like manner; the instruments must be cleaned by singeing and boiling; and the patient should have antiseptic vaginal injections immediately before each application, and between the several sittings. After these preliminary measures have been attended to, we introduce the finger into the vagina and ascertain the condition of the cervix. We think it useless and sometimes even hurtful to apply the speculum, which prevents us from making a complete examination of the womb, or at least renders it more difficult. Along the index finger we slip the hysterometer, which penetrates easily into the uterine cavity; we introduce it as deeply as possible and with the greatest gentleness, especially if we are in the presence of some

* Dr. Apostoli, in discussing the effects of the two poles, has apparently neglected to take into account the action of cataphoresis, which is at least equally, if not more, powerful in this respect than that of electrolysis, withdrawing as it does water from the anode, and carrying it mechanically to the cathode. (p. 33.) [*Author.*]

lesion or another. This is the most difficult step of the operation, and must on no account be neglected. The patient should never feel any pain, and a coarse or unskilful manner may neutralize the benefit which would accrue from the treatment, or aggravate a pre-existing inflammatory lesion. Any injury done by a badly-made hystrometer may, for instance, aggravate a hæmorrhage which we may wish to arrest. We afterwards push the insulating cover up to the cervix, in order to protect the whole of the vagina; the electrode of sculptor's clay is then placed on the abdomen, after which the rheophores are fixed. The current is then put on slowly and gradually with the aid of the rheostat. Here also every unnecessary pain should be avoided, and the tolerance of the current by the patient should never be exceeded, any undue boldness in this respect being full of danger. Each sitting should not last longer than five minutes, and may be repeated every other day, in exceptional cases more frequently. The current should be let out as smoothly and slowly as it had been put on. The patient should then rest for $1\frac{1}{2}$ to 2 hours on a couch or bed, before returning to her usual occupation. She should have vaginal injections night and morning, and sexual connexion must be prohibited during the whole course of treatment.

"In large uterine cavities carbon electrodes are more useful than the hystrometer of platinum. These should be slipped into the fundus of the womb, where they will produce cauterisation of a portion of the mucous membrane; they are then drawn forward in order to act on a new surface, the extent of which is measured by notches made on the stem, which guide the operator in his proceeding. The current being here of considerable density, each point should be acted upon for two or three minutes, in order not to fatigue the patient, and the final and total cauterisation of the uterine cavity will be deferred to a future sitting.

“IV.—GALVANO-PUNCTURE: GENERAL INDICATIONS
AND OPERATIVE PROCEEDING.

“I have advised, and frequently practise, the use of an electrode, which, in the form of a trocar, breaks open a certain region, 1st, when there is the necessity of re-establishing an obstructed canal, or where the uterine cavity is entirely inaccessible to the finger; and 2nd, for choice, when it is clinically and therapeutically important to localise the polar electrolytic effect in a limited interstitial point of the uterine substance. The operative proceeding should vary somewhat according to the immediate intention of the surgeon.

“1. If we wish to cause a *loss of substance*, we make use of a naked steel needle, which is introduced into the tissues, while the parts which we do not intend to cauterise are protected by an insulating stem. If the field of operation should be large, two needles may be used, which are introduced pretty close to one another, each being connected with one of the poles of the apparatus.

“2. Where we intend to *open up an obstructed canal*, as for instance where the cervix has undergone cicatrization, a steel needle should be introduced just as before, in the assumed direction of the uterine cavity (*hystérométrie par effraction*) and connected with the negative pole, so that the cicatrix should be made less rigid, and the newly-formed canal have less tendency to become again obstructed.

“3. The current may be introduced into the depth of the tissues where there is obstruction, or the cervix inaccessible, or where we wish to interfere rapidly with the nutrition of the organs. We then take trocars, the ends of which only are naked, so that the mucous membrane pierced by them will not be cauterised or electrolysed except in the immediate neighbourhood of the point of the trocar, while the neighbouring tissues will recover themselves easily and completely after the sitting. There will be nothing but a single aseptic

effraction of the vaginal mucous membrane caused by the penetration of the trocar, and which will become cicatrised by first intention. These galvano-punctures should not penetrate very deeply, not more than $1\frac{1}{2}$ cms.

"They may be made (*a*) in the cervix, (*b*) in the depth of a fibroma. I do not approve, for reasons which want of space prevents me from giving in detail, of any galvano-puncture not made in the following conditions: on fibrous masses plainly perceptible to the finger, and in the space of Douglas. We should avoid any complications, the most serious of which would be the opening of the peritoneum, and the making of a vesico-vaginal fistula.

"For making the puncture, after particularly careful anti-septic precautions, the exploring finger introduced into the vagina recognises the spot where the puncture should be made, and assures itself by prolonged examination that it is really the chosen spot, and that there is no arterial pulsation there. After this the insulating handle, which is to act as a guide to the trocar, is introduced along the exploring finger and kept in place. We then take with the other hand the trocar, the length of which has been previously regulated, so that its end may not go beyond the handle for more than $1\frac{1}{2}$ cms., that is to say, of a length identical with that which we intend using for penetration into the tissues.

"We introduce it in this handle, and let it glide rapidly along, and push it deliberately, with such amount of pressure as we may think desirable, into the region previously fixed upon.

"V.—ELECTRO-DIAGNOSIS IN GYNÆCOLOGY.

"I have laid stress on the necessity of never applying a current in gynæcology which is not easy to bear for the patient. The employment of too great galvanic power may indeed be very risky. In general I use for metritis medium strength, from 80 to 100 MA.'s; and in fibroma a current of 100 to 150 and more, with the express reserve that such

doses must only be administered progressively, as we have always to fear the existence of an unrecognised affection of the adnexa.

"The electric treatment well applied and interpreted allows us to correct a doubtful diagnosis. The galvanic applications will in general be only slightly painful if the indifferent electrode of sculptor's clay is well made and adapted to the entire abdominal parietes, the skin of which should previously be inspected, in order to make sure that it is entirely uninjured, without fret, pimples, or abrasions of any kind. The patients can perfectly differentiate the sensation of burning felt in the skin, from the deep-seated uterine or peri-uterine pain. If therefore a woman does not bear well a medium current-strength, we may, according to my experience, deduce from this one of the following two conclusions: either she is neurotic, with exaggerated sensibility, or she is subject to an inflammatory lesion. There will be no difficulty in arriving at a differential diagnosis of this point. I therefore advise never to use at a first sitting more than 50 MA.'s; and if I have any doubt about the condition of the adnexa, I do not go beyond 25 or 30 MA.'s; even if the patient should appear to be able to bear a stronger dose.

"If immediately after this initial very moderate application the patient feel nothing in particular, we may safely increase the current strength progressively, so as to arrive at the maximum at the fourth or fifth sitting, always provided that no ulterior reaction takes place. If, on the other hand, a more or less marked painful or febrile reaction should occur in the beginning, we shall then be face to face with the differential diagnosis between hysteria and an inflammatory lesion of the adnexa. In both cases we may have post-operative internal reactions, and a purely nervous 'peritonism' may simulate a real inflammatory 'peritonism.' There is however a valuable sign which cannot deceive us, viz. the state of the temperature. Each time that a

woman has, after a galvanic application, a marked and suspicious reaction, the thermometer should be consulted. If there should be the slightest fever, we may suspect that there is a suppurative lesion, or at least a more or less acute peri-uterine inflammatory condition. Where, on the other hand, there is no fever, we would naturally assume a nervous reaction, and this will generally be confirmed by the clinical history and the antecedents of the patient. Should there be any doubt, one could try an application of the secondary faradic current. The fact that this would at once relieve the pain would be in favour of the diagnosis of hysteria.

“VI.—ALTERNATIVE APPLICATIONS: GENERAL INDICATIONS AND OPERATIVE PROCEDURE.

“The effects of faradism vary according to whether we use the current of the thick or the fine wire (primary and secondary). The secondary current influences chiefly the nervous condition, and should be used for relieving pain and other manifestations of hysterical origin. It may be looked upon as certain that every violent abdominal pain which is at once and completely relieved by the secondary current, is a hysterical pain.

“The primary current acts chiefly on the smooth or striped muscular fibre, and may be used for obtaining contractions of the womb, or for modifying the circulation. Tripier has shown that it has a considerable action on the muscular coat of the blood vessels, and that a short application, less than five minutes, causes energetic vaso-constrictor effects; while, if the application be prolonged and fatigue induced, the current acts as a vaso-dilator, by paralysis of the muscular fibres.

“When the faradic current is used, it should be localised as strictly as possible, with bi-polar electrodes. In morbid conditions of the vulva or vagina, we use vaginal electrodes, while internal ovarian or pelvic pain is treated by intra-uterine applications. The electrodes are introduced in the same manner as when the continuous current is used.

“SINUSOIDAL AND UNDULATING CURRENT.

“The sinusoidal current appears to have a similar action on contractility as the primary faradic current, and analgesic effects somewhat superior to those of the secondary current. The undulating current presents the same curve and the same effects as the sinusoidal current, but besides this it has also a polar electrolytic action, and we therefore use it with preference in gynæcology. These two currents are not indispensable to the gynæcologist, yet will, in a number of cases, come in very useful. The operative procedure is the same as with the continuous current.

“VII.—GYNÆCOLOGICAL ELECTRO-THERAPEUTICS.

“This treatment has already rendered great services to conservative medicine, but there is not the slightest intention to substitute it for surgery, the triumphs of which are undeniable. It is only meant for the modest and secondary rank of an auxiliary to surgery, but as such it claims civic rights, marching at the head of conservative medications.

“I. *Metritis*.—In the acute and chiefly in the hyper-acute forms of infectious metritis, electricity can only play a secondary part. Rest, antiseptic washings, opiates, etc., step in here as the principal remedies. But electricity may even here help us. The continuous current may be applied to the vagina, in a feeble dose, to relieve congestion, and the secondary faradic will ease the pain. We may also utilise the undulating current, which has the advantage of relieving congestion, and is an excellent analgesic.

“In the sub-acute form the same proceedings may be used, at least during the first few days, but we may shortly become bolder, and resort to intra-uterine applications for producing the effects of electrolysis. Knowing that the anode is not only a caustic, but also an antiseptic, and tends to relieve congestion, this should be used for equalising circulation and modifying the mucous membrane, and especially for attenu-

ating and destroying the micro-organisms which originate this disease. The current strength should be gradually increased according to the individual aspect of the case, so as to give about 100 MA.'s, with a hystrometer introduced as far as possible into the uterine cavity.

"*Chronic metritis* should also be treated by the intra-uterine anode, cauterising as extensively as possible the mucous membrane; and if the platinum hystrometer should not suffice for this, carbon electrodes may be used. There will thus be destruction of the mucous membrane and antiseptis. In some cases of long-standing parenchymatous metritis, on the other hand, it will be better to use the cathode for stirring up the circulation in the more or less sclerosed uterine muscle. The same pole is also appropriate in certain forms of endometritis, where in consequence of anatomical conditions, such as atresia, flexion, etc., the secretions may have a tendency to stagnate in the uterus. As the negative cicatrix is softer, the cavity may thus be more or less freely drained. Occasionally we may also use the primary faradic current for relieving pain, and the secondary for improving the contractility and vitality of the muscular fibre.

"*Hæmorrhagic metritis* may also be treated by the intra-uterine anode, which is a most powerful hæmostatic. Carbon electrodes have the advantage of acting on the entire surface of the mucous membrane; and it is in general necessary to have a somewhat more powerful current, exceeding 100 MA.'s, for obtaining a thorough effect.

"*Puerperal metritis* should, if there is fever and hyper-acute symptoms, not be treated electrically, but rather with copious intra-uterine irrigations. Where there is retention of products of the placenta, these should be immediately evacuated by curetting or manual extraction. Where subinvolution is at the bottom of the trouble, intra-uterine faradisation, from three to five minutes at most, answers best. If the uterus have become properly contracted, and

there should still be some débris of membranes, or a little infection, intra-uterine electrolysis and the undulating current are indicated.

"*Metritis of the cervix.*—Where the cervix suffers alone, it should be treated with a carbon electrode introduced into it, and ulcerations may require my bi-polar carbon electrode. Finally in cervicitis, where the cervix is thick, hypertrophied and softened, we may, if the intra-uterine electrolysis does not give satisfactory results, make galvano-punctures in the tissue of the uterus itself, using two steel trocars, each of which should be connected with one of the poles. In this way two large losses of substance will be caused, the ulterior cicatrization of which will lead to retraction and atrophy of the diseased tissues.

2. "*Fibroma.*—Independently of surgical operations, with which we have nothing to do here, by far the most rapid and successful conservative treatment is the electrical. If this method be carried out according to the rules which I have laid down since 1884, it gives the following results from an anatomical point of view :—

"(a.) *Arrest of the further growth* of the fibroma in 70 per cent. of the cases treated. It is indeed rare that a fibroma which is regularly treated with sufficient current strength, should subsequently continue to grow.

"(b.) *Diminution in the bulk* of the tumour in from 10 to 20 per cent. Although this decrease is not so frequent as has been affirmed, it nevertheless happens, more especially in interstitial fibroma. In subperitoneal fibroma, on the other hand, next to nothing of this ever occurs. Moreover, the decrease never proceeds to the complete disappearance of the growth.

"(c.) *Greater mobility* of the fibroma in 70 percent., brought about by its decrease in bulk and the diminution of congestion, as well as reduction and absorption of adhesions and peripheral effusions. This greater mobility would facilitate a subsequent surgical operation if such were considered advisable.

“(d.) *Tendency to expulsion* of a portion of the fibrous mass from the uterine muscle. This is an acceleration of a natural process which tends to expel the fibroma either towards the abdomen, by formation of a sub-peritoneal lobe, or towards the uterine cavity, by the appearance of a polypus.

“If we consider secondly the *symptomatic results* of this treatment, they are found to be truly brilliant.

“1. The *hæmorrhage* is most frequently arrested in 80 to 90 per cent. Anodal electrolysis, with sufficient dose, duration and localisation, arrests hæmorrhage often immediately or rapidly, while the tendency to inter-menstrual hæmorrhage is gradually lessened. The catamenia become regular, less copious, and eventually normal.

“2. The *pain*, either menstrual or inter-menstrual, whether due to compression or congestion, is relieved or disappears altogether in 70 per cent. The same is the case with reflex nerve-pain, which may, however, sometimes be treated by the alternate current, whether faradic or undulating.

“3. The general state of health is vastly improved in 70 per cent.

“A SHORT EXPOSITION OF APOSTOLI'S METHOD.

“Anodal intra-uterine electrolysis is the treatment of choice. We introduce the hysterometer as deeply as possible, and resort to the highest current strength, while taking care that the patient is well able to bear it. The sittings are repeated once, twice, or at most thrice per week, according to individual tolerance, until all symptoms have disappeared, which requires on the average a treatment of from 3 to 6 months. A few patients, from 10 to 20 per cent., more especially young women, require a short complementary treatment every year in order to avoid or combat relapses which may occur.

“In some special forms of fibroma in which dysmenorrhœa is an important symptom, with congestion and diminished

or retarded menstruation, cathodal electrolysis will be preferable. This is also better where we have to do with atresia, and a sufficiently deep hystero-metry could not be performed.

"It sometimes happens that patients who have been treated with the anode, come back after some years with symptoms opposite to those which they had had before, *i.e.*, amenorrhœa instead of hæmorrhage, congestion in place of anæmia, etc. If we then desire to resume the treatment, we find that it is impossible to get the electrode into the uterine cavity, as the cicatrix resulting from anodal influence has gradually contracted. The local as well as the general condition indicate then cathodal applications.

"If the atresia should be too considerable, we could use the trocar, and make in the supposed direction of the uterine cavity a cathodal galvano-puncture, in order to open up the orifice of the cavity. For this a naked needle should be used for penetrating the tissues, and a single application will be sufficient to reconstitute the canal. If hystero-metry should be impossible on account of an inaccessible or too highly placed cervix, or if this latter should be hidden by a mass of fibroma, wasted, absorbed, or impossible to recognise, then we should at once make a galvano-puncture in the most prominent lobe of the fibroma, and always in the space of Douglas. An insulated trocar should be used, free only close to its end, in order to oblige the current to pass straight through the parenchyma of the tumour.

"3. *Polypus* falls generally more into the domain of surgery. In exceptional cases, however, especially if the patients desire it, electricity may be applied to the cure of small polypi situated more or less deeply in the uterine cavity. In this case we should use electrolysis in a powerful dose, either with platinum or better with carbon electrodes, but always in such a way as to obtain the maximum of useful effect, that is, density of the current, at the level of the pedicle. In

general the polypus detaches itself after a few sittings. The treatment should however be continued for some time longer, in order to destroy completely anything which may remain of the pedicle, and for modifying the peripheral mucous membrane.

"4. *Cancer of the uterus.* Some authors believe that they have done good in this affection with the continuous current. We have not only never seen any benefit from it, but even noticed that the further growth of the tumour was accelerated. We therefore do not even use it as a palliative in inoperable cases. We may however make an exception for the method of Inglis Parsons, although we have no personal clinical experience of his procedure.

"5. *Uterine displacement, prolapsus, etc.* There are women in whom even considerable malpositions of the uterus do not cause any trouble whatever. In the working classes one meets occasionally old women who walk and work without difficulty, although there is a high degree of prolapsus of the womb. In such cases it is better not to interfere. In a second group are comprised all pathological affections of the womb which are complicated with displacement. The position of the organ is in many such cases only accessory; what is important to relieve is the metritis or the fibroma, which are the first and principal factors of the trouble. Finally we meet with cases where the deviations result from adhesions, retraction or elongation of the ligaments, and are complicated with more or less marked congestion. These cases will be considered further on.

"We do not believe that either electricity or any other non-surgical method can destroy real adhesions which have become fibrous, or give physiological tone to sclerosed ligaments; but we know that in most cases an appropriate reduction of congestion leads to the disappearance of pain, and allows the patients to resume their occupation.

"The anatomical results which are obtained are most

variable. Sometimes, in spite of an amelioration of symptoms, there is no appearance of anatomical change; at other times the organs remain in a bad position, but one feels that they are less thick, less congested, more movable, and that pseudo-adhesions have more or less disappeared; finally they may have returned to a normal or nearly normal position. We believe—and our therapeutical results tend to confirm this theory—that it is chiefly the morbid changes in the circulation which lead to symptoms of distress. Nevertheless electricity may under certain circumstances have a favourable influence on the tone of the ligaments; and it is the primary faradic, or the undulating current, which serves us best for reducing congestion and giving more tone to the muscular fibre.

“6. *Congestive uterine and peri-uterine disorders.* Without entering into any details about the pathogenesis and classification of these functional disorders, we would say that the first duty of the electro-therapist is to make a differential diagnosis between suppurative and non-suppurative inflammatory lesions, and in this the methodical and systematic application of the electric current will be of the greatest possible use, as we have found many times in actual practice.

“Where we have to do with congestion, œdema, effusions, with inflammatory non-suppurating lesions, with adhesions which are not yet organised, etc., the electrical treatment may, at least in the beginning, be expected to have a good effect. It is, however, important not to overdo it, for a current which is unduly powerful, or an unskilful manipulation, may cause a fresh congestion and increase pre-existing inflammatory symptoms. We should commence with vaginal applications of the secondary faradic current, and, as soon as a soothing effect has been produced, we may proceed to intra-uterine applications. These latter must be of moderate strength, gently applied, and should not last longer than five minutes. We may also use

the undulating current with considerable benefit, especially where there is more or less hysterical excitement.

“When a soothing effect has been produced, we may interpolate a few sittings of the primary faradic current, in order to produce a kind of drainage of circulation, and act on the muscular contractility. Later on we must, in certain cases, have recourse to a revulsive and derivative action on the uterus by electrolysis, first vaginal, and afterwards intra-uterine, most frequently positive, in order to reduce congestion. We may also utilise negative electrolysis if the disorder is owing to menstrual irregularity, which will then presently resume the proper physiological type.

“7. *Peri-uterine suppurating lesions, adnexual or peri-adnexual.*—In such cases electricity can only be used in order to correct a doubtful diagnosis ; for the only rational treatment at the present time is a surgical one. For my own part, I do not advise at present the galvano-punctures which I had formerly practised, in order to facilitate the evacuation of a collection of pus, but consider ablation and surgical drainage preferable.

“8. *Non-suppurating lesions of the tube.*—When the study of the electrical reactions has allowed us to make certain that an affection of the tube is non-suppurating, I advise to have recourse to conservative electrical treatment before resorting to extirpation. We should utilise principally the alternate current, faradic or undulating, in applications to the vagina and the uterus. It sometimes happens that under the only influence of the contractions which are produced by these currents, a tumour of the salpinx is evacuated spontaneously in the natural way. On the other hand, it is equally frequent to find that the patients are so much relieved of their different symptoms by the action of these currents in reducing congestion, that they consider themselves cured, although the anatomical condition does not seem to have been sensibly modified. For catarrhal salpingitis we should also use the undulating and faradic current ; they will promote the

evacuation of the products of the cavities by the contractions which they produce, and also reduce congestion to such a degree, that after a few applications the patient will be able, more or less, to resume her previous life.

“9. *Hæmatocele, Hæmatoma, etc.*—In a great hæmatocele, from rupture of extra-uterine pregnancy, surgical proceedings are the only ones allowable; but when we have to do with small hæmatocèles, menstrual hæmatoma, etc., which have a spontaneous tendency to absorption, the patients will be considerably relieved and the natural evolution of the lesion much accelerated by the use of the faradic and undulating current, and their action upon muscular contractility and circulation.

“10. *Ovarian Cysts.*—The only rational treatment for these is extirpation.

“11. *Cystic Ovary, Sclerosed Ovary, etc.*—Electricity is unable to modify anatomically these ovarian lesions. We may, however, try their symptomatic cure, especially if the lesion exist only on one side; for in this case the treatment will cause functional hyper-activity on the healthy side. We shall thus often succeed in improving certain patients so much that they may do without surgical mutilation, which is always serious, and often formidable.

“VIII.—SYMPTOMATIC ELECTRICAL TREATMENT.

“*Pain.*—Pain may be of nervous origin, and is then either primary, without any apparent cause or organic change, or it is secondary, and due to reflex phenomena, starting from a more or less important lesion which may remain unperceived.

“The type of the first is *paroxystic ovaralgia*, which is characterised by crises of intense pain coming on suddenly, and which may sometimes by their violence simulate the gravest disorders (peritonism in all its degrees, etc.). The treatment of choice which I first recommended in 1883, and which sometimes gives immediate and surprising results, is

bi-polar intra-uterine faradisation with the secondary current. It is sometimes necessary to make rather long applications, up to 15 or 20 minutes. We use at once sufficient strength to cause pain, and the application is continued until the patient does not feel anything more of the passage of the current. It happens sometimes during the first sitting that a sort of nervous crisis is induced, characterised by general malaise, spasmodic movements, and a feeling of oppression; the patient then begins to sob or cry, after which a soothing effect takes place, when not only the pain produced by the passage of the current, but also the primary pain will have disappeared. We may continue the same treatment a few days longer, in order to prevent the return of ovarian crises; but we then make the applications much shorter, about 5 minutes.

"In general, we obtain by these means very brilliant results, and, after a few sittings, the women who appeared to be seriously ill, become perfectly well for a longer or shorter time. This treatment has, of course, not the pretension to cure the hysterical diathesis; it is a purely symptomatic one, and nothing more. If the patient should at the same time show other nervous symptoms, we should use static electricity to the painful points; and we have seen intense pelvic neuralgia yield to this simple treatment.

"Another kind of nervous pain consists of *chronic pelvic neuralgia*. This pain is in general owing to a neurasthenic condition, or to a slight chronic affection of the pelvis. It occurs chiefly in women who have undergone operations, and more particularly abdominal mutilations, and is constant but somewhat vague, and variable as far as localisation is concerned. In these generally very obstinate cases a certain amount of success may be achieved by faradisation or static electricity; but we must remember that the affection is often extremely tenacious, and weeks or even months may be required for obtaining a definite improvement. We may have recourse to slight vaginal faradisation, or use the

undulating current, or a gentle continuous current, with daily static baths ; and we must not be surprised if results should be slow, since other modes of treatment generally have no effect whatever. In cases of reflex nervous pain associated with uterine or peri-uterine lesions, these latter should be treated, but, at the same time, inter-current applications of the alternating current, or static electricity with sparks, may be used.

“PAIN FROM COMPRESSION, AND CONGESTIVE PAIN.

“In these cases we generally use the primary faradic current ; this lessens congestion, promotes the absorption of effusions, and equalises circulation by a kind of interstitial drainage, as so well shown by A. Tripier. It also gives tone to the ligaments, and causes diminution and often disappearance of the painful symptoms. Such treatment, however, cannot be applied in all cases ; it could not for instance, markedly relieve the compression caused by a large ovarian-cyst.

“INFLAMMATORY PAIN.

“Wherever there is pus, electricity cannot do any good, and we must rely, in such cases, on surgical interference. It is rather hyperæmia than inflammation which we can cure by electricity, and here it is again the different forms of the alternate current which are so particularly useful.

“VULVAR AND VAGINAL HYPERÆSTHESIA, VAGINISMUS,
ETC.

“In nervous disorders at the level of the vagina or the neck of the womb, which are characterised by pain or spasm, we should use bi-polar vaginal applications of the secondary faradic current ; frequently there is considerable relief after an application of five minutes. It generally does not last very long after the sitting is over, but if we

continue the treatment for a sufficient time the relief is longer and sometimes definite.

“HÆMORRHAGE.

“We have seen that uterine hæmorrhage from metritis or fibroma is generally relieved by positive electrolysis; in cases of sub-involution we use the primary faradic current or the undulating current with benefit. Electricity is useless in hæmorrhage caused by cancer. In profuse menstrual hæmorrhage no special treatment is generally necessary; but if we should think it expedient to interfere in such cases, we might use positive electrolysis, which is unquestionably the proceeding of choice, or faradisation by the primary current in short sittings. With regard to diathetic hæmorrhage, such as hæmophilia, anæmia, the same proceedings may be used; but we should always consider the general condition of the patient, which may be improved by static electricity, and more especially by the application of d'Arsonval's current of high frequency, which we have for the last six years used with considerable success in conditions of impaired nutrition.

“AMENORRHŒA.

“We have to distinguish several causes of amenorrhœa. Where it is owing to an *infantile uterus*, we shall have recourse to intra-uterine electrolysis. Such applications should be made at the presumed time of the catamenia, if there should be such symptoms as general congestion, monthly headaches, epistaxis, etc., which would lead us to suspect a tendency for a certain period. We make then two or three applications close to one another; but if there are no signs pointing to the time when the period would take place, it is better to have long intervals, for instance one sitting each week, for a month or two. Negative electrolysis will produce a temporary congestion and transitory hyperæmia which may produce a normal

discharge, and this may then go on developing progressively; we may also, in order to improve nutrition and to promote drainage, interpolate a few sittings of the primary faradic current of short duration.

"In amenorrhœa, which is owing to a structural fault of the *ovary*, insufficient development, cysts, etc., the same proceedings may be employed, but are as a rule not very successful.

"In *diathetic amenorrhœa*, owing to a general state of bad health, this latter should be treated by static baths, and such of high frequency.

"*Hysterical amenorrhœa* is particularly well suited for electric treatment. The local means already described may be sufficient for a cure, but we may add to them the secondary faradic current which is able powerfully to modify hysterical phenomena. The most successful treatment however of this condition is by static baths, with sparks to the abdomen. This generally produces menstrual congestion, an effect which had been already observed by the old physicians when using Franklinic electricity in the last century.

"DYSMENORRHŒA.

"This may be owing to several causes. There may be a special anatomical condition, such as atresia of the internal os, whether congenital or acquired. In such a case we have recourse to negative electrolysis, which should be localised to the point where the platinum sound reaches the atresic portion of the canal. There will be a slight loss of substance at this place, owing to cauterisation, and the calibre of the canal will be immediately re-established. In order to maintain it, it will be useful from time to time to practise catheterism of the uterus; and as a negative cicatrix has no tendency to contract, the canal will generally remain open. Other forms of dysmenorrhœa are owing to congestive disorders.

"In some women the congestion commences too soon, and

is incomplete. This is the type of pre-menstrual dysmenorrhœa, in which there is only little discharge. In such cases we use again negative electrolysis, in order to promote congestion. In other cases we find the catamenia too abundant, dysmenorrhœa being due to an excess of congestion, or to some particular disorder of the mucous membrane ; we then resort to positive electrolysis. In some instances it will be necessary to associate different modes of application. If we have to do with a uterus which has an enormous cavity and an atresic orifice, we should, between two monthly periods, resort to positive electrolysis, in order to contract the cavity. But while the period is on, we could advantageously combine with this negative electrolysis, so as to insure the passage of the flow through the neck of the womb ; we could also use the primary faradic current, in order to contract the uterus, to give it tone, and to aid it in expelling the clots which may be formed in the cavity. We use at the present time, in such cases, very frequently during the period, daily sittings of the undulating negative current for the cervix. We obtain by this frequently great relief of the pain, which is explained by a slight dilatation of the orifice, produced by the negative polar action ; by the increase of uterine congestion ; by modifying the circulation, and by obtaining uterine contractions.

“There are other dysmenorrhœas which are dependent on the general state of health ; their type is hysterical dysmenorrhœa. In such cases we influence the nerves of the sexual organs by intra-uterine faradisation with the secondary current, and by static baths, with sparks to the abdomen.

“LEUCORRHŒA.

“Leucorrhœa originating from the uterus or salpinx, may be combated by the treatment which has been described for catarrhal metritis and salpingitis. Vaginal leucorrhœa of infectious origin must be treated with antiseptic injections.

There is another frequent form of leucorrhœa, which is diathetic, and is not curable by any purely local treatment.

"When a woman has fluor albus without any appreciable cause, and when a well-directed intra-uterine treatment has not led to sufficient improvement, we must endeavour to modify general nutrition; and here we obtain the best results with static electricity, and above all with the current of high frequency. This may be combined with mineral water treatment, and an appropriate regimen.

"STERILITY.

"Sterility may have many causes, either local or general, which are very often obscure. Treatment may have excellent results where sterility appears to be owing to atresia of the external or internal os. Negative electrolysis, which is more easy to use than laminaria tents, which are generally employed in such cases, gives also more permanent results. In general, we find that when in women, affected by some gynæcological disorder, the lesion is cured, the sexual organs afterwards fulfil their physiological function much better; and it has appeared to me that it is particularly the electrical treatment which promotes ulterior fecundation in a marked manner. I have drawn up favourable statistics of more than a hundred such patients which I have submitted to the International Medical Congress, at Rome, in 1894. Since then several other observers, and quite recently Madame Caplan-Lapina, has brought forward new and convincing facts of this kind. Is this result obtained by a special modification of the mucous membrane, a greater vitality imparted to the sexual organs, or by regularisation of the congestive phenomena? It is impossible to decide this question at the present time. The clinical fact, however, remains certain, whatever may be its explanation; and this is all the more interesting to note, as in the beginning of my electro-therapeutical practice, it was wrongly believed that a novel application which I had made of high intra-uterine intensity, con-

duced eventually to sterility. Facts have completely demolished this quite theoretical conception."

* * *

ELECTROLYSIS OF TUMOURS.

When I first proposed the electrolytic treatment of tumours (1867), operative surgery was not nearly as far advanced as it is at present, and in pre-Listerian times even small operations were not unfrequently followed by septicæmia and fatal results. I well remember a case in which one of the first surgeons of the day excised a small sebaceous tumour from the scalp of a lady of rank, who died three days afterwards from blood-poisoning caused by infection of the wound. Such things are now a matter of history, and as the operative technique has improved *pari passu*, the sphere of electrolysis in general surgery has become greatly limited. Yet there are tumours in which this treatment will have advantage over other surgical procedures; and amongst these I would particularly mention *nævus* and *sebaceous tumours*, in which the effects of electrolysis are truly admirable, and cannot be surpassed by any other means at our disposal. The same applies to

TUMOURS OF THE EYELIDS.

In 1880 I treated a lady, aged 30, who suffered from tarsal tumours, occupying nearly the whole of both upper eyelids, more especially their inner surface, and which had gradually become developed without any apparent cause during the last six months. They looked inflamed, were very disfiguring, and caused great annoyance by interfering with the proper action of the lids. Mr. White Cooper, who was then known as a most skilful operator, preferred electrolysis, of which we had had considerable experience together, to any other proceeding for the removal of the tumours, and sent the lady to me. Reflex action in the lids being very much increased, I operated with anæsthesia,

induced by Mr. Clover, and used my four-pointed electrolytic needle-conductors for the destruction of the tumours, which received the influence of the anode and cathode successively, with a current of about 4 MA.'s. In ten minutes the whole of the tumours, both inside and outside, were completely shrivelled up.

Not a drop of blood was lost at any stage of the operation, which was remarkable, especially when the highly-vascular sub-conjunctival portion of the tumour was treated. The patient recovered quickly from the influence of the anæsthetic, and went the same afternoon to her home in the country. I saw her again about a month afterwards, when I found that the operation had been completely successful. The tumours had vanished, no scar was visible anywhere, and no eversion of the lids had occurred. Both eyelids had indeed a perfectly normal appearance.

Tarsal tumour is a troublesome affection and does not yield to external applications, such as the red precipitate or iodide of potassium ointment, so that if removal becomes necessary, free incisions have to be made, which are generally accompanied by much bleeding. The adhesive inflammation which supervenes upon the operation has sometimes to be increased by touching the interior of the cysts with nitrate of silver; and if the tumour be situated near the margin of the eyelid and the punctum, there may be cicatricial shrinking after the operation, and eversion of the edge of the lid, with displacement of the punctum. All this makes the ordinary operation for tarsal tumour a somewhat formidable one; and electrolysis, which is much simpler and less troublesome, therefore appears preferable. The complete absence of bleeding in the latter procedure is a great advantage, as the operator always sees what he is doing, and can regulate the action of the galvanic force with the greatest nicety. A single application is sufficient for a cure, and there is no danger of subsequent cicatricial shrinking, if the operation be properly performed.

CANCER.

In primary scirrhus electrolysis is useless, and has, indeed, appeared to do more harm than good, as it seems to stimulate the further growth of the tumour. In cases of secondary nodules, however, which crop up after surgical operations, it has done good; and it steps in as a truly admirable palliative in incurable cases, for the relief of the agonising pain which so often renders the last few weeks of the sufferer's life an intolerable agony. Lawson Tait⁴² has used it in a case of encephaloid cancer of the femur, in which the pain was so excessive that the patient had to be kept almost constantly under the influence of hydrate of chloral, morphine, and chloroform. After two electrolytic operations, the tumour was $\frac{3}{4}$ inch less than before, and there was such complete relief of pain that the patient required neither opiate nor chloral, and it was possible to lift her and change the bed-linen without the administration of chloroform, which had not been done for three months previous to the second application of the electricity. After a few days the pain recurred, when electrolysis was again resorted to; and she then continued quite free from pain until her death, which took place from exhaustion and irritative fever about a week afterwards.

EPULIS.

T. W. Nunn⁴³ has successfully treated cases of epulis with electrolysis, and states that the latter replaces with advantage a surgical operation which is more or less complicated, and always attended with considerable hæmorrhage, to say nothing of obviating the concomitants of a wound, which cannot from the circumstances of the case heal by first intention. In one of his cases the late Mr. de Morgan had operated on epulis of the lower jaw, when the hæmorrhage had been, if not alarming, at least considerable, both at the time of the operation, and for many hours afterwards.

When epulis declared itself afterwards in the upper jaw, Nunn electrolysed the tumour with complete success, so that the patient was able to wear artificial teeth with great comfort and advantage.

I have found epulis to yield more quickly to both poles in the growth than to the negative needle simply. The anode connected with one or several steel needles effects much destruction by interstitial electrolysis (p. 42), and also checks hæmorrhage, by the development of ferric chloride. It is difficult to operate in any way on epulis without having some hæmorrhage, but this is infinitely less with electrolysis than when the knife is used.

HYDATID TUMOURS OF THE LIVER.

Hilton Fagge and Durham⁴⁴ have brought before the Royal Medical and Chirurgical Society an account of six cases of hydatid tumours of the liver which were under their care at Guy's Hospital, and in which they carried out my suggestion that these tumours should be treated by electrolysis. Their first case was that of a girl aged 7, who had a hydatid tumour of the size of a cocoanut, occupying the whole thickness of the liver. A single application of the negative needle was sufficient for the cure of the tumour, and this satisfactory result induced Fagge and Durham to use it in five other cases, with equally beneficial effects. Cooper Forster has been successful with the same treatment in two other cases, and Fagge and Durham claim for this method the following advantages: 1, that the operation itself is altogether free from danger, and 2, that it is not liable to set up suppuration within the cyst, and thus indirectly to involve the patient in serious risk.

FACIAL BLEMISHES.

In 1867 I removed by electrolysis a very unsightly hairy mole from the face of a well-known London physician; and in 1868 I used the same proceeding for destroying super-

fluous hair in the face of a lady who was very much disfigured by the growth. This proceeding has subsequently been much taken up in America, where Michel, of St. Louis, has used it for trichiasis, and Hardaway, Fox, and others have extended its employment to other cutaneous affections.

Superfluous hair on the face of ladies, when amounting to moustaches or whiskers or beards, is a great eyesore, and often induces them to retire from society and lead a solitary and miserable life, in which they are apt to brood over their misfortune. There are no really good chemical depilatories by which the hair can be radically removed without leaving a scar on the face, and Erasmus Wilson used to say that the only trustworthy depilatory was the razor. Shaving, however, does not satisfy women who are annoyed by this trouble, and it is therefore fortunate that we possess in electrolysis a useful depilatory. It is better not to use it in the soft silky down on the upper lip of young women, as in consequence of the large number of these fine hairs the proceeding is tedious and protracted, and may, unless done with extreme care, leave a scar more unsightly than the moustache. In elderly women, on the other hand, where the hairs are coarser and generally not so numerous, they are more easily removed.

The electrolytic removal of hair is one of the most delicate operations in electro-surgery, and requires for its proper performance a considerable amount of skill, practical experience, and attention on the part of the operator. The principal rules which have to be observed for this little operation are as follows:—

1st, Each hair should be done singly, except when two or three are in immediate contact.

2nd, Only the negative pole should be employed for destroying the hair-follicle, and the circuit should be closed by a moistened anode held in the patient's hand.

3rd, A fine gold or steel needle should be used for introduction into the follicle.

4th, The current should only begin to act after both electrodes are *in situ*, and must be broken before the needle is removed.

5th, A feeble but absolutely constant current should be used. For fine hairs 1 MA. is the best strength, but where the hair is thick and coarse, 1.2 to 1.4 MA.'s may be employed. The current-strength must be read off from a thoroughly reliable horizontal galvanometer, and this should be carefully watched while the current is acting. If less than 1 MA. be used, a relapse is likely to happen.

6th, Sixty seconds are habitually sufficient for destroying a good-sized follicle; but where the hair is very thick, seventy or eighty seconds may be required. If less time is used, a relapse may occur.

7th, After the follicle has been destroyed, the hair should be extracted by tweezers, and should come out almost by itself. If any resistance be experienced, the current must be put on again for another ten or twenty seconds, and a fresh attempt at extraction made, when the hair will come out with scarcely any pulling.

No dressing, except a little violet powder, is required after the operation.

The sitting should not be prolonged beyond fifteen or at most twenty minutes, as after that the attention of the operator is apt to flag.

If the above rules are strictly followed, the result will, in general, be satisfactory. At first the part of the face which has been operated upon appears red and feels hot, and for a few weeks a slight mark shows the place where the current has acted. This, however, gradually fades away, and becomes imperceptible.

I have had some ladies under my care whose beards were truly startling, and where the face became eventually quite honeycombed with punctures of the electrolytic needle, yet after a time the beard as well as all traces of punctures had disappeared and the face had resumed its

normal appearance. In some few cases, however, the constitutional tendency towards growth is so strong that new hairs will continue to crop up after the old ones are removed; and both patient and doctor may thus be disappointed.

CHILBLAINS.

Although an apparently insignificant affection, chilblains may be a great trouble, as they give rise to an amount of itching, smarting and burning, which may be well nigh unbearable. The first effect of prolonged cold is contraction of the muscular coat of the arterioles, whereby the supply of arterial blood is arrested. There is therefore at first pallor, which is after a time followed by venous congestion, and livid and blue discoloration of the skin, especially when the person comes from outside into a hot room. Sometimes the trouble is speedily relieved, but if not, the chilblain is produced, and often resists all kinds of treatment. Professor Billroth, of Vienna, has mentioned a case where not only ointments, lotions, etc., but ergotine injections and punctures, as for acne rosacea, were used without the desired result. It is therefore useful to know that chilblains readily yield to the application of the labile cathode, which restores the tone of the muscular coat of the arterioles, causing dilatation of the latter, whereby circulation is re-established and venous congestion removed. A large anode should be placed at some distance from the seat of the inflamed surface, after which cathodal passes are made over the erythematous patches. The current-strength has to vary according to the seat of the chilblains and to the susceptibility of the patient. For the fingers, toes, ears, and nose, 1 to 1.5 MA.'s will be generally sufficient, while at the heel as much as 8 or 10 MA.'s may be required. There is generally immediate relief, and after a few applications, entire cessation of the trouble.

RHEUMATISM.

In rheumatism of the muscles, and chronic rheumatism of the joints, electrical treatment is in general very effective. The most frequent forms of muscular rheumatism in this country are *lumbago* and rheumatism in the shoulder. I have treated a very large number of such cases, in which the use of faradic as well as galvanic electricity proved rapidly effectual in relieving the pain and discomfort from which the patients suffered. The stabile anode, followed by cathodal passes, and faradisation of the skin with the wire-brush, are the best proceedings. The same treatment is effectual for *torticollis*.

In stiffness of the joints after rheumatic fever the constant current may be very beneficial in promoting the absorption of effusions, and restoring the mobility and proper use of the joints. It is important in the treatment of such conditions to change the poles from time to time, and to pass the current through the joint in different directions. Thus the knee-joint should be treated first by the stabile anode in front, and the cathode at the back, of the joint, for one minute; then the current is turned off, its direction reversed, and its passage renewed. The anode is then placed to the right, and the cathode to the left side of the joint, the current passed for a minute, and the direction once more reversed. After this it is passed diagonally in two different directions, and the application is finished by stabile and intermittent applications to the neighbouring nerve-trunks and muscles. In obstinate cases the nutritive centre of the knee-joint in the lumbar enlargement of the spinal cord may also be acted upon.

RHEUMATOID ARTHRITIS.

In 1872, I advised, in a paper read before the Annual Meeting of the British Medical Association, at Birmingham,⁴⁶ a systematic treatment of rheumatoid arthritis by the aid of

electricity. In that paper I recommended a modified form of general galvanisation, and concluded by saying that "those who will not shirk the sometimes rather tedious labour involved in carrying out such a treatment perseveringly, will ultimately be amply rewarded for their trouble by an amount of success which, in some forms of the disease, could not have been obtained by any other line of treatment." Subsequently similarly good results have been gained in this disease by Steavenson, who advocated chiefly the employment of the hydro-electric bath; by Armstrong, who combines the use of the hydro-electric bath with treatment by the Buxton waters, and by Lewandowski, who uses a proceeding similar to that first recommended by myself.

Of late years I have chiefly used 1st, the constant current to the bulb (p. 51), which contains an important centre for the nutrition of the joints; 2nd, galvano-faradisation of the extremities affected; and 3rd, the faradic brush, which is very effective for the relief of the more or less fixed pain in the joints which is so common a feature in rheumatoid arthritis.

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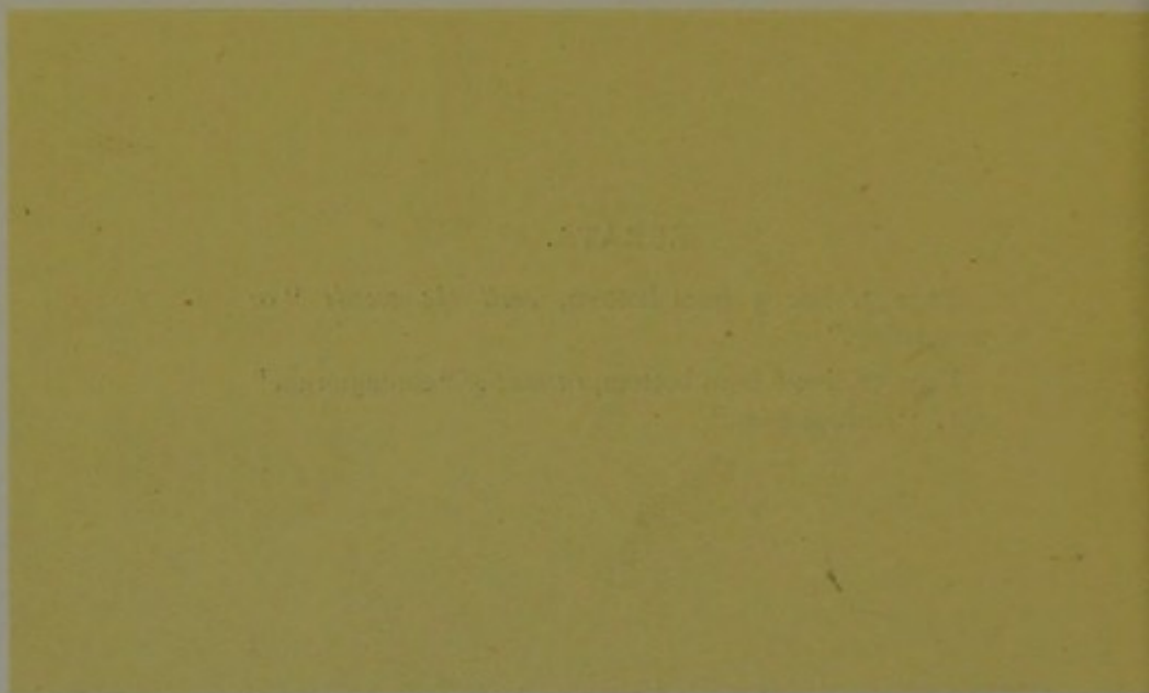
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Page 3, line 4 from bottom, *omit the words* "or undulating."

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