

as hemorrhages, softening, inflammation, tumors, and atheromatous condition of the arteries, and even in psychoses of all varieties. The methods employed for in-

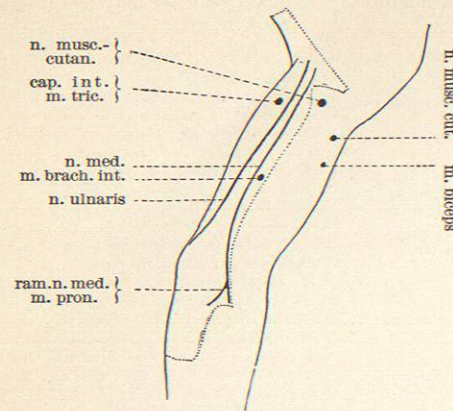


FIG. 1840.—Motor Points of Arm.

fluencing the brain are: 1. Longitudinal brain galvanization, in which the electrodes are applied to the forehead and occiput. The current may be either stable or labile. 2. Transverse brain galvanization, in which the electrodes are applied either to the sides of the frontal bones, to the parietal protuberances, to the temporal bones, or to the mastoid processes.

The electrical applications to the brain are to be made very cautiously, and the rules above mentioned should be observed very strictly (see rules for applying electrical treatment). As a rule, applications to the brain

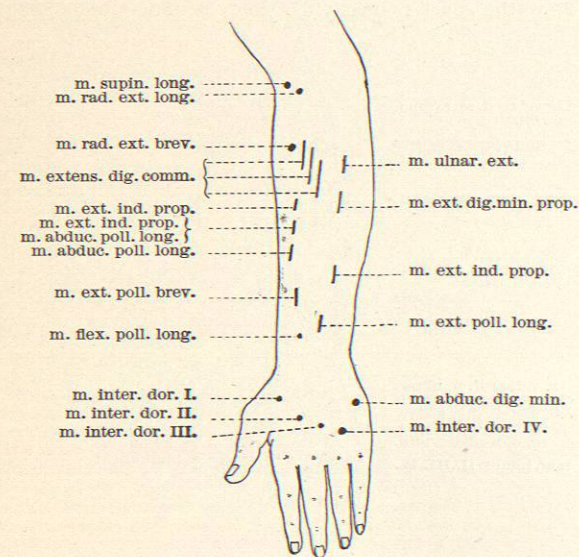


FIG. 1841.—Motor Points of the Extensor Surface of Forearm and Hand.

do not give any permanent result, and if any benefit follows, it is usually by relieving the headache.

The application should be made in the following manner: Place the anode on the forehead and the cath-

ode on the neck or sternum, or place both electrodes on the temples. The séance should not last more than five minutes, and a maximum current of 2 ma. should be used. One should rely rather on the sensations felt by the patient than on the strength of the current. Extreme precautions should be taken in galvanization of the head. Relief from headache can be obtained also by galvanization of the sympathetic system in the neck. The anode should be placed on the neck below the ear, behind the ascending perpendicular portion of the inferior maxilla, and the cathode in the jugular fossa. The cathode may also be placed on the corresponding spot on the opposite side of the neck. Very cautiously the current (from 1 to 3 ma.) is to be turned on for a few minutes.

Headaches can also be relieved by means of static electricity, and the following are the methods: 1. *Static douche*. The positive and negative poles and conductors should be held apart and brought near to the patient's body as in the method of "sharp ends" (see above). By means of a short wire the negative pole is connected with the head-plate and the positive with the earth. With the aid of a screw the head-plate may be brought into more or less close proximity to the patient's head or adapted to special parts of the same. The distance separ-

ating the plate and the head should not be less than 5 cm. The nearer the plate is to the head the more intense will be the action of the current; and by isolating the patient's body by means of a foot-plate this action can be intensified. The séance should last for from five to fifteen minutes. 2. *Static air bath*. The same procedure as that already described on p. 756. The positive pole is

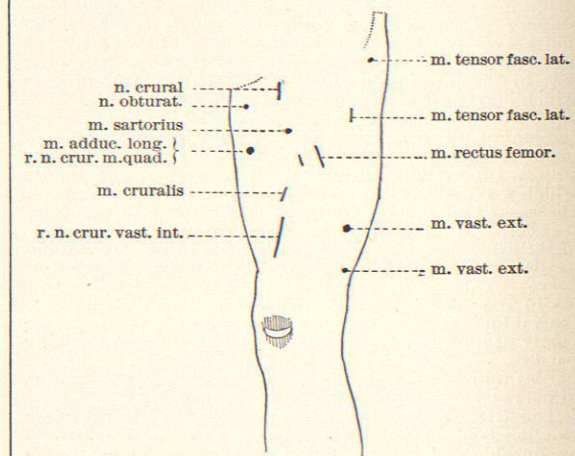


FIG. 1843.—Motor Points of Thigh.

connected with a foot-plate or chair, while the negative is connected with the earth. The séance lasts ten minutes. Patient may remain dressed. 3. *Flashes*. Same procedure as that already described. One pole is to be connected with the foot-plate, while the other (generally the positive one), which is connected with a button electrode, is made to approach the patient's body. Even at a distance of 10-30 cm. flashes and lights are noticed, which can be isolated and directed toward one special muscular part. The procedure causes some irritation.

As regards the treatment of cerebral palsies, good is sometimes obtained from the employment of the faradic current provided contractures have not already developed. In the latter case, however, the current should be applied to those muscles which have a function directly the opposite of that of the contracted muscles. For example, if the contracture puts the arm in flexion, a faradization of the extensors can be tried.

FUNCTIONAL NEUROSES.—Electrical treatment in neuroses like hysteria or neurasthenia may sometimes produce a beneficial effect, not because of any specific in-

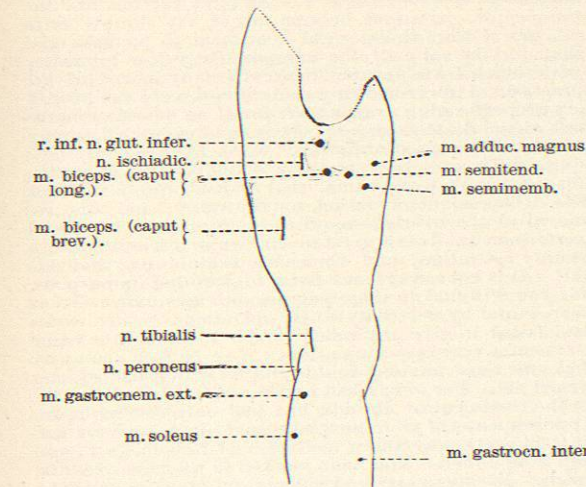


FIG. 1844.—Motor Points of Back of Thigh.

fluence upon the functional disturbances, but rather on account of its suggestive or psychic effect. Any method may be applied in these cases. The tact and ability of the physician in any given case will teach him to what particular method he should have recourse in order to obtain the best suggestive results. On the other hand, there are cases in which electricity, as an adjuvant to massage, will show its really beneficial effect of stimulation. For example, when a general muscular weakness is present, a general faradization will be found very useful. When the circulation is slow, not only in the skin, but also in other organs, a stimulus which will aid the metabolism, respiration, appetite, and general nutrition will be of great importance. The faradic current will produce, in addition to its direct effect on the skin, a reflex action on the central nervous system. The faradic brush or the roller should be applied to the arms, chest, back, and extremities alternately for fifteen or twenty minutes daily, or less often. General galvanization should also be tried. For this purpose the cathode should be placed on an indifferent spot, while the anode, of a smaller size, is to be applied to different parts of the body for about fifteen minutes. A very appropriate electrical treatment in functional neuroses is that by means of the electrical baths (see above).

As to individual symptoms in functional neuroses it is possible to influence them beneficially to some extent by

electricity. Thus, for example, headaches, no matter of what variety, and insomnia can be relieved in some cases. The method of application is described in the paragraph

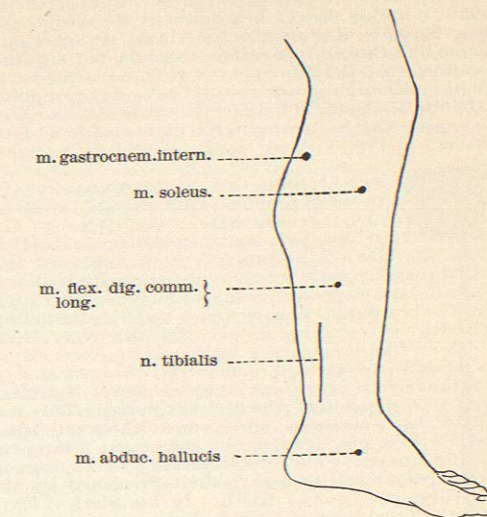


FIG. 1845.—Motor Points of Back of Leg and Inner Border of Foot.

which treats of diseases of the brain. Other functional symptoms, as paræsthesia, hyperæsthesia, or pain in the back, ovarian region, mammary region, etc., should be treated with the faradic brush or the massage roller. The anodal electrode of the galvanic current may also be tried.

Electricity also shows its beneficial effect in *traumatic neuroses*, like writers', pianists', or tailors' cramp. The motor form of these neuroses, if they are not spastic, can

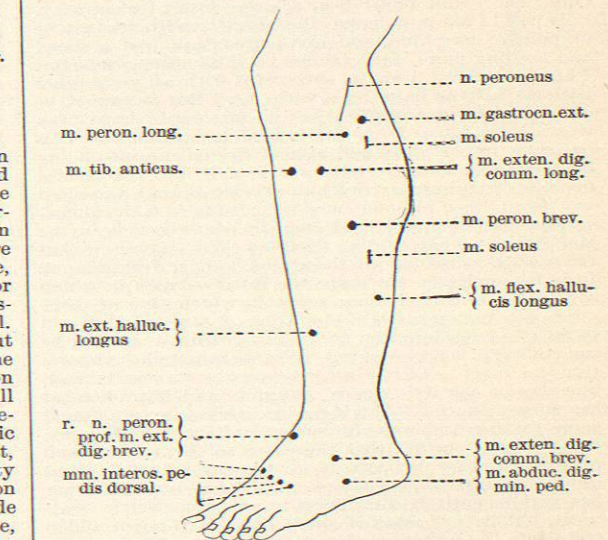


FIG. 1846.—Motor Points of Outer Side of Leg.

be benefited by an appropriate electrical treatment. The principles are the same as those which govern any other parietic condition of muscles. Local faradization of the

muscles, or cathodal galvanization or galvano-faradization, should be applied in the usual manner as described in other parts of this article. In case of *muscular cramps*, if electricity is to be used at all, faradization of the antagonistic muscles should be chosen as the proper procedure. *Tremors* of either a functional or an organic character, like those in multiple disseminated sclerosis, intoxication, etc., should not, as a rule, be treated with electricity, although good results have been reported from the use of electrical baths. The *caso-motor* or *secretory* neuroses may be treated with galvanization of the sympathetic nerve, but not much should be expected from it.

DISEASES OF THE UTERUS AND ITS APPENDAGES.—Fibroid growth is the most prominent affection of the uterus that can be treated by electricity. The object of this treatment is to relieve pain and hemorrhage, as well as to reduce the size of the tumors. It is supposed that currents traversing such growths cause an inhibition of their proliferating power, some degree of absorption through the lymphatic vessels, and a trophic stimulation of the healthy surrounding tissue. The discovery of the treatment of fibroid growths by means of electricity is due to Apostoli of Paris, France. He demonstrated in the '80's that electricity causes an actual arrest of growth and even retrogression of the fibroid tumors. This was verified by many surgeons, and some of them published cases which were characterized by the actual disappearance of the tumors. The best testimony ever given in favor of Apostoli's treatment is that furnished by the eminent surgeon, Thomas Keith. In his work ("Electricity in the Treatment of Uterine Tumors"), which was written in collaboration with Skene, and dedicated to Apostoli, Keith gave the details of one hundred and six cases treated with electricity. In the introduction to this work he says: "For long we had doubts as to the permanency of the treatment in the early cases. The later work has been much more satisfactory. But now more than two years have passed since all operations were given up for this treatment; and our first patient writes—and no one could have had more hemorrhage—that she has been perfectly well all summer, climbing hills and rowing in a boat. Another of the early and doubtful ones, who could never bear a large dose of electricity, tells us: 'I am now in excellent health, without an ache or pain of any kind, and my periods are just a show, and nothing more, and give me no discomfort whatever. I hope you have been as successful with all your other patients as you have been with me. But it cannot be otherwise, for I am sure that no one could have been worse than I was with that awful hemorrhage.' This patient's importunity had almost driven me into doing hysterectomy for her. At first we fell into the natural mistake of trying electricity on every case that presented any symptoms, in some when the tumors were almost certainly sarcomatous, and even in one who was in the last stages of old cardiac disease. We know now that the cases best treated are those which are suffering much from hemorrhage—the more the better,—cases in which something must be done; cases in which two or three years ago the question of operation of some kind would have been considered by us. This treatment, it must be remembered, is a new thing. We began it in comparative ignorance. Electricity is known by its results, and, working on the living body, progress and improvement are slow. In the following cases, therefore, are found some failures and some imperfect and incomplete cases; the marvel is rather that there are so few. Time and experience every day correct our want of knowledge and diminish these imperfections. No large uterine tumor has with us entirely disappeared under the electric treatment, but in four cases of small fibroids, three of which come into the present series, there is not now a trace to be found. The carrying out of this treatment faithfully to the end is not an easy matter, and old tumors that are large, and that have bled for many years, take a long time to improve. The treatment runs away with time, and it requires care and thought. To the surgeon, by

far the simpler plan is hysterectomy and the removal of the ovaries. But Dr. Apostoli's treatment saves our patients from risk of life by operation, and saves them also from a horrid mutilation, the one thing that they all dread. We believe it to be the right treatment, and our patients must get it, however great the inconvenience and monotony it may be to ourselves. Though our results after hysterectomy show the lowest mortality of any yet recorded, and though we have had but a single death after removal of the ovaries for fibroid in almost one hundred operations, we reject even the minor operation in favor of Apostoli's treatment, and we reject hysterectomy altogether on account of the mortality that has hitherto attended it all over the world. The method given us by Apostoli is good, and it will endure. Since we began your treatment, now more than two years ago, we have ceased to perform any operation on the uterus by abdominal section. For myself I have always had grave doubts if I were justified in performing such operations at all, especially hysterectomy, for the mortality attending this operation is out of all proportion to the benefits received by the few. As time went on, and the number of operations became larger, my doubts as to whether I were doing right continued to increase, and that, too, in spite of the comparatively low mortality with which I was favored, more especially in my private practice. I never had any such doubts as to the propriety of performing ovariectomy, for if an ovarian cyst be left alone, death is almost certain, and even that is only reached after great suffering. With hysterectomy it is quite different. Hysterectomy is a hazardous operation for the removal of a tumor that of itself rarely shortens life. The minor operation, on the other hand—the removal of the ovaries—requires no surgical skill for its performance. It is a great mutilation to a woman, being simply castration; and women are beginning to find this out. It is not always successful in attaining its purpose, for you will find in these pages some cases narrated that were cured by electricity where operations on the ovaries had failed to give any relief. Your method thus came to me at a very opportune time. You have taken away from me those anxious doubts and fears that had so long vexed me. For long I had hoped much from electricity in the treatment of fibroids, but had only met with disappointment till your method was made known to me. It is in every way a new method, and it belongs to you and to no other. You have worked in the true scientific spirit. For five years you labored quietly at your clinic, kept up at your own expense, and open to all, before you made your work known. What have those to offer in place of all this who have so bitterly opposed this treatment; who with unlimited material stand aside and will not take the trouble to investigate the matter for themselves, but wait till some one else does it for them; who make only an outcry if by chance they hear of any accident during the progress of the treatment of any case, and who go frantic over the rumor of a death, or worse still, who proclaim they know of deaths that never happen? These men have absolutely nothing whatever to offer in the bad cases, and only hysterectomy in such tumors that will come out more or less easily, so as to be treated by the extraperitoneal method of operating. I have seen not a few cases of bad bleeding fibroids since I came to London; almost every one had consulted one or other surgical authority on the subject of operation. These were invariably told that nothing would do them any good but the removal of the tumor; but in their special case the local difficulties were too great, or they had let their strength go down too far for such an operation. The very feeble and bad cases, with masses of tumor blocking the pelvis, with absence of cervix, and opened-out broad ligaments, would seem to be let alone. Hysterectomy then at best would appear to be a most doubtful remedy for a certain number of cases, and these not of the worst sort. On the other hand, the worse the case, the more feeble the patient, the greater the loss of blood, the more marked is the result of electrical treatment. Given a woman with a large bleeding fibroid,

blanched almost to death from years of hemorrhage, and see her some months after this treatment is completed, you would scarcely recognize her, the improvement is so great. Electricity in any form, when applied to the cure of disease, is set down as pure quackery by many medical men, simply because they know nothing about it, and won't take the trouble to learn for themselves what to many is rather a hard study. Every time that any disease can be cured without resorting to a bloody operation, such as hysterectomy, progress is made in our art, and there is a gain to humanity, while surgery is the better for being purged of a deadly operation. It may seem strange to some that after the results I got in hysterectomy—results that almost made it justifiable—I should now begin to throw stones at the operation instead of trying still further to improve upon it. I would give something to have back again those sixty-four women that I did hysterectomy for, that I might have a trial of Apostoli's treatment upon them. What I now plead for is that, for a time, all bloody operations for the treatment of uterine fibroids should cease and that Apostoli's treatment, as practised by him, should have a fair trial."

Method of Application.—The positive pole is the one generally employed, especially in tumors accompanied by hemorrhages. The indifferent electrode (cathode) should be placed on the abdomen, and the active pole (anode) should be inserted into the uterus. In order to protect the os and cervix, the intra-uterine electrode must be insulated. Apostoli uses a sound covered with a sheath of hard rubber. Of course asepsis and antisepsis should be strictly observed. Currents of from 30 to 50 ma. can be frequently repeated. Each séance should last for about five minutes (Apostoli). Stronger currents are permissible only after weak currents have been tried. The current must be taken off very gradually. After each séance the patient must rest for several hours. If on the following day there is pain or some fever, the electrical treatment should be abandoned. As to the effect of the negative pole, it is diametrically opposite to that of the positive; it produces a temporary congestion which will be very beneficial in non-hemorrhagic fibroids. The negative poles may therefore be expected to render very valuable service in fibroids accompanied with amenorrhœa and dysmenorrhœa. *En résumé* we will say, with Apostoli, that the positive pole should be utilized in cases in which there are hemorrhages, the negative pole in those in which there are no hemorrhages.

N. B. The intra-uterine electrode should never be inserted until an examination has proved conclusively that pregnancy does not exist. An acute metritis or some purulent condition of the pelvis is also a contraindication to the employment of an intra-uterine electrode.

Among the tumors which do not yield to electrical treatment, we may mention the fibro-cystomata and the myomata.

In cases of metritis and perimetritis, the employment of electricity does not, according to the majority of writers, prove of benefit, except to a certain extent in the chronic forms of these diseases. Apostoli believes, however, that even in the acute stage electricity is not contra-indicated. The methods of procedure are the same as for fibroid tumors.

In diseases of the Fallopian tubes and ovaries again only the chronic forms should be treated with electricity. A vagino-abdominal or a combined intra-uterine and abdominal application of a faradic or a galvanic current may be of use. As to the relative value of these two forms of electricity, galvanization, according to Apostoli, is much more powerful than faradization.

In cases of salpingo-ovaritis, not sufficiently ameliorated by intra-uterine galvanism, Apostoli advises galvano-puncture, which treatment is more efficacious although more painful.

Amenorrhœa and dysmenorrhœa can be benefited by the employment of a strong primary faradic current preceded by a stable galvanic current of about 30 ma. In

the latter procedure the patient should be in the recumbent posture, with her body resting upon a large electrode, while the other electrode should rest alternately on the hypogastrium and the epigastrium. Static electricity with sparks drawn from the lumbar region of the cord, hypogastrium, and loins affords the quickest and most reliable method of treatment. General faradization, dorso-abdominal faradization, and the dry brush applied to the abdominal walls or to the soles of the feet, are reliable methods of application. When galvanization is used in these cases it should be applied either near the centre of the body or along the spine; the current can be directed from the lumbar region toward the pubis. As to direct uterine applications, there is a general opinion that electricity applied not directly to the uterus, but to a distant part, exerts a better influence on the menstrual flow, except when the dysmenorrhœic disturbances are due to stenosis of the cervix or to a deviation of the uterus. In the former condition the proper procedure is to introduce a galvanic cathode into the canal of the cervix; for the relief of the latter, Apostoli employs the current of the secondary spiral of a faradic battery, in connection with his bipolar intra-uterine electrode (Fig. 1847), introduced into the uterus.

Subinvolution is treated by intra-uterine faradic currents. Uterine and ovarian pain of a neuralgic character, accompanied by backache, should, according to Apostoli, be relieved by the faradic current. He recommends the employment of a secondary coil, of a long thin wire, so as to obtain as much tension as is convenient. He uses his bipolar electrode, introduced into the uterus, but external applications—one pole over the sacrum and the other on the perineum or in the groin—are often sufficient. Sometimes a better effect is produced by introducing one of the poles into the vagina.

DISEASES OF URINARY ORGANS.—Electrical applications in paralysis and atony of the bladder due to a spinal affection are dwelt upon in the section relating to diseases of the spinal cord. The same method and rules can be applied in diseases of the bladder of a functional character.

In cases of chronic inflammation and stricture of the urethra the negative pole of the galvanic current should be utilized. The patient should be in the recumbent position, on his back. The indifferent electrode is to be placed on either the abdomen or the back. A whalebone bougie à boule, connected with the negative pole, is to be introduced into the urethra and pushed on until it reaches the painful spot or the stricture. The current should not have a strength above 3, 4, or 5 ma. As the current gradually increases in strength, the bougie will glide onward and pass through the previously contracted and painful canal. If after fifteen minutes the bougie does not pass, defer the application. There should be an interval of at least one week between the applications. At each successive attempt a larger bougie should be used. This treatment of stricture depends for its success chiefly upon the action of the electricity, which causes galvano-chemical absorption to take place—a process which is based upon the electrolytic properties of the tissues of the human body (see the paragraph relating to Electrolysis). No treatment will give more satisfactory results, in a case of irritability of the urethra, than this method of employing the galvanic current. Of course

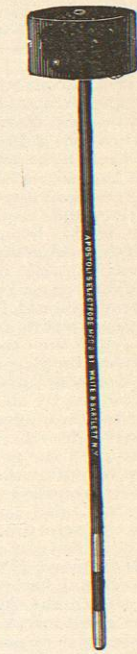


FIG. 1847.—Apostoli's Bipolar Intra-uterine Electrode for Faradic Current.

the gentlest manipulation in a necessary element in this sort of treatment.

Hypertrophy of the prostate may also be treated either by electrolysis or by the galvano-cautery. The electrolytic treatment of this affection is the same as that for stricture of the urethra. An insulated bougie-shaped electrode, connected with the negative pole, should be passed through the urethra and its end allowed to rest against the enlarged gland. A current of 5 ma. is then allowed to pass for twenty minutes. The séance can be repeated every ten days.

The use of galvano-cauterization forms a part of Botini's operation for hypertrophic prostates. The object of this operation is to cauterize and thus divide the prostate. For this purpose Newman's cautery electrode is considered one of the best on the market (Fig. 1848). Tripiet advises faradization for hypertrophy of the prostate. The procedure should be carried out in the following manner: An insulated sound is to be introduced into the urethra and a double bulbous electrode into the rectum, and then, after the current has been turned on, the latter is to be pressed against the prostate.

Nocturnal incontinence of urine is also benefited by electricity, good results being obtained by the use of either faradism or galvanism. One electrode should be introduced into the urethra and placed against the neck of the bladder, while the other is placed over the pubis.

Involuntary seminal emissions, spermatorrhœa, and impotence are also affections which can be ameliorated or removed by the same method of treatment.

Under these circumstances the cathode should be introduced into the urethra and made to rest against the openings of the seminal ducts, while the anode is placed upon the perineum. In impotence it may be well to add, to the procedure just described, galvanization of the spine and also applications of the faradic brush to the penis and scrotum. It seems proper to state here that two electrical instruments, already described in other parts of the HANDBOOK (Figs. 1570 to 1573 inclusive in the present volume), have been devised for the purpose of facilitating both the diagnosis and the treatment of diseases of the genito-urinary tract. I refer to the urethroscope and the cystoscope.

GOUT AND RHEUMATISM.—In these affections, which are associated with chronic inflammatory conditions of the joints and with degenerative changes, electrical baths (see above) are indicated. The baths may be either general, if several joints are affected simultaneously, or local, if only one or two joints of a limb are involved. In the last case the affected member is placed in the bath, one pole of the battery is connected by a wire with a metallic vessel submerged in the water of the bath, and the other pole is placed on an indifferent part of the patient's body.

If with the diseased joint is associated muscular atrophy—which, in fact, often occurs—a local faradization of the muscles should be added to the treatment of the joint. Besides the baths direct faradization or galvanization of the joints is of great utility. Stable unipolar currents, with the anode over the spinal origin of the nerves supplying the joint and the cathode over the joint itself, give good results. Bipolar applications are equally useful. When the faradic current is used, the higher its tension the greater appear to be its analgesic properties. In bipolar treatment the electrodes are placed on both sides of the articulation through which the electrical current passes. At the International Medical Congress of Berlin in 1890 Edison's experiments on the treatment of gout were reported by Bayles; it was demonstrated that the gouty concretions are removed by cataphoresis (electric endosmosis). Good results were obtained by connecting the anti-gouty or the anti-rheumatic drugs with the anode and then directly applying them to the affected joints. The much-desired metabo-

lism, of transforming uric acid into urea, was obtained. The tophi, which in gout are composed of urate of soda, are removed by galvanism, and particularly by the employment of the positive pole; the urates are split at the negative pole.

Muscular rheumatism, lumbago, and rheumatic torticollis may be treated by both galvanic and faradic currents. The method of application is the usual one. Bipolar faradic applications, strong enough to produce vigorous muscular contractions, are the best adapted for the relief of stiffness and spasm. The galvanic current, on the other hand, is more efficacious in relieving pain. The faradic brush also often affords relief in this class of cases. In muscular rheumatism static electricity, as a rule, affords no relief, but the static induction current, with its infinitely rapid succession of sparks, has the character of a faradic current of high tension and, as we mentioned above, it is likely to give relief for a long time.

DISEASES OF THE SKIN.—In the treatment of diseases of the skin electricity may be utilized in two different

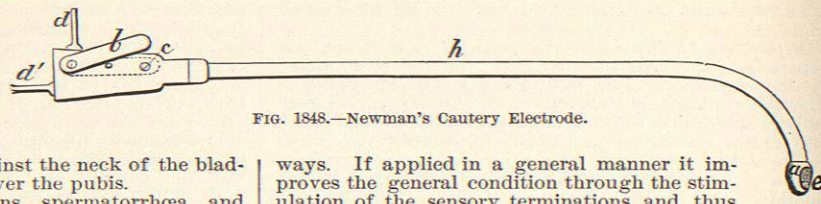


FIG. 1848.—Newman's Cautery Electrode.

ways. If applied in a general manner it improves the general condition through the stimulation of the sensory terminations, and thus improves the trophic condition of the skin; while if applied locally it removes many uncomfortable symptoms, such as pain, pruritus, hyperæsthesia. Electricity may also produce a caustic effect upon the skin, by depositing acids and alkalies on its free surface. For the production of a general effect, all the three varieties of electricity, static, faradic, and galvanic, may be utilized.

Static electricity is recognized as one of the greatest stimulants of metabolism, and at the same time one of the ideal cutaneous stimulants and sedatives. Faradic electricity acts as a stimulant. The galvanic current produces a sedative effect if a mild current (about 3 ma.) is applied continuously for five minutes. Care should be taken that the skin be slightly reddened; otherwise there may be electrolytic action followed by destruction of the skin. During the operation there should be no interruption of the current. The galvanic current, if applied in sufficient strength, can be used as a counter-irritant. The principle of cataphoresis, *i. e.*, the property of the galvanic current to carry drugs under the skin for absorption, can be utilized in diseases of the skin. The anode should be saturated with the desired drug and applied to the spot where the action of the drug is expected. This method is particularly useful in parasitic affections of the skin; the positive electrode being impregnated with the parasiticide solution and placed over the diseased area. That mercury passes through the skin by this procedure was proven by Gärtner (*Rev. d'Electrothérapie*, 1892). Gautier (*Rev. d'Electrothérapie*, 1891) has proved it for copper, and has applied this treatment in lupus, actinomycosis, and sycosis. Copper needles connected with the positive pole are thrust into the diseased spots; during the passage of the current the copper becomes dissolved and forms, with the oxygen and chlorine of the tissues, an oxychloride of copper, which is highly antiseptic and caustic. The galvano-cautery is utilized for the destruction of diseased tissues, and can therefore be applied in pathological conditions of the skin. Electrolysis is of more use. The tissues are destroyed by an alkali or an acid, whether we use the negative or the positive pole. Acids liberated on the positive pole coagulate the albumen, thus protecting the surrounding tissue from the freed acid. The cathode liberates alkali, which does not coagulate albumen, but acts as a destructive agent. The practical application of this principle in diseases of the skin is evident. A point

to be considered is, that the electrode which produces the desired action upon the skin should be a needle and well insulated. The positive pole should be of platinum or gold, because other metals, through undergoing oxidation, leave an indelible stain on the skin. Electrolysis is particularly useful in acne, furuncle, carbuncle, lupus, and epithelioma.

ANEURISMS.—In the treatment of the thoracic and subclavian aneurisms in which medicinal aid fails to effect a cure, electricity has been tried with a fair proportion of good results. The employment of electricity in the treatment of aneurisms is based on the fact that a galvanic current passing through the blood coagulates it, through electrolysis. A clotting occurs around the poles, and then subsequently a further coagulation takes place and fibrin is deposited around the primitive clot. Cinselli treated twenty-three cases, six of which recovered. He operated with needles connected with both poles and introduced into the aneurismal sac; every five minutes he reversed the current. Tripiet and others advocate the insertion only of the positive pole, on account of its power to coagulate albumen. Stewart reports good results with continuous currents; the anode being introduced into the sac, and the cathode placed on the abdomen. The strength of the current may be gradually increased up to as high as 70 ma., but one should commence with 20 ma. Each séance should last about half an hour. Petit ("Dictionnaire Encyclopédique") treated 114 cases of aortic aneurism with electrolysis; 69 were improved.

Aneurisms of the extremities were completely cured. Whether the positive pole should be inserted into the sac, or the negative, or both at the same time, as some authors advise, is a matter which has not been fully determined; but one should always bear in mind that hemorrhagic inflammation of the sac, with suppuration and embolism, may occur. In those cases in which the operation proves successful, the tumor hardens and shrinks. Alfred Gordon.

ELECTROTONUS.—If a constant battery current flows continuously through a muscle or a nerve, it will so alter the chemicophysical condition of the living substance that its physiological properties will be greatly modified. The modifications produced by the flow of the current were first carefully studied by DuBois-Reymond, who gave the name "electrotonus" to the changed condition. The alterations produced are in general of opposite kinds at the anode, the place where the current enters, and the cathode, the place where the current leaves the tissue; therefore we speak of anelectrotonic and catelectrotonic effects of the current. Where the tissue is under the influence of the anode, it is in a state of anelectrotonus, the irritability and conductivity are decreased or even absent; where the tissue is under the influence of the cathode, it is in a state of catelectrotonus, the irritability and conductivity tend to be enhanced. These alterations of physiological activity are accompanied by changes in the electrical condition in the vicinity of the two poles, changes which are revealed by the so-called "electrotonic currents."

In the case of muscle, the alterations produced by the current are chiefly localized at the points to which the electrodes are applied; in the case of nerves the change spreads not only throughout the region between the electrodes, the intrapolar region, but in both directions beyond the part directly exposed to the current, the extrapolar regions. Finally, it must be stated that the current not only influences the condition of the nerve and muscle during the time it is flowing, but leaves behind it important after-effects, these being in general the reverse of those observed at the poles during the flow.

The causes of the physiological changes which result from the passage of the current are to be sought in the chemicophysical changes which it produces in the living substance. The flow of the current causes, through electrolysis, the liberation of ions, which in turn produce

the polarization phenomena observed. These polarization phenomena are without doubt closely related to the changes in irritability and conductivity, and to the excitation effects produced by the polarizing battery current.

The above facts have been ascertained chiefly through the study of isolated nerves and muscles of animals. There is reason to believe, however, that they hold good for the nerves and muscles of man, although necessarily modified by the spread of the current through the fluids which normally surround these structures.

Effects of the Constant Current upon Irritability and Conductivity of Nerves.—Many of the phenomena referred to by the earlier writers under the title of "galvanism" were of electrotonic nature, but most of the accounts are too vague or the data are too incomplete to make the statements of any scientific value. According to Pflüger, the first trustworthy observation which bears directly on the effect of the galvanic current on irritability and conductivity was reported by "that indefatigable experimenter, Ritter" (Gilbert's *Annal. d. Physik*, Bd. vii., S. 477-483). Ritter stated that he remained connected with a battery by his hands for half an hour, and that the hand and arm on the silver side of the battery (negative pole) became stiffened, and gradually the power to move that hand lessened, while his control over the hand connected with the zinc side (positive) increased. Toward the end of the experiment he had ceased to receive any direct sensations of a type to remind him that he was connected with the battery. Ritter's philosophical interpretation of these effects need not be considered, for his results may be explained in the light of the facts which have been ascertained by scientific study of the effects of battery currents on animal tissues.

Pflüger gives the following explanation: On account of the wide spread of the current through the fluids of the tissues of the trunk, we can think of the current ascending one arm, leaving it at the shoulder to spread through the body, then entering the other arm, descending through it, and leaving it at the hand; thus the first arm has an anode at the hand and a cathode at the shoulder, and the other arm has an anode at the shoulder and a cathode at the hand. Experiments on isolated nerves show that exciting a nerve above a descending current excites less than exciting it above an ascending current, and Ritter's observation is in harmony with this result, and is more interesting because in his case the irritant was the normal voluntary impulse. Ritter ("Beiträge zur näheren Kenntniss des Galvanismus," etc., Jena, 1802; Gehlen's *Journal f. d. Chem. Phys.*, u. *Mineral.*, vi., S. 421, 1808) made other interesting observations of fundamental importance. One of these was that the effect of the current on the nerve increases with the time of closure, this being revealed by the modifications of irritability observed when the current is opened. Another observation was that the modifications produced in the nerve by the current may not be limited to the region subjected to the current, but may spread with opposite sign along the nerve toward the muscle, as depression of irritability where there is an ascending, and elevation of irritability where there is a descending current, what we now recognize as the anelectrotonic and catelectrotonic effects.

Twenty years later another discovery having an important bearing upon our question was reported by the physicist Nobili (*Annal. de Chimie et de Physique*, p. 30, 1830). He saw a frog preparation, which had entered into tetanus from some unknown cause, become quiet when a battery current was passed through it. He explained the result as due to a change produced by the current—this change preventing the transmission of the excitation process. He even went so far as to recommend the use of the constant current to the physician as a means of arresting tetanus.

This subject was studied by Matteucci (*Compt. rend.*, vi., 680, 1838) and others, but the first to do really careful work upon it was Valentin ("Lehrbuch d. Physiol. des Menschen," ii., 2, S. 653). He excited a nerve at a dis-