

Reference.	Circumstances.	Current.	Symptoms.	Result.	Post-mortem findings.	Treatment.
19. London Electrical Review, January 27th, 1889.	Accidental contact with wires of arc-lamp circuit.	4,000 to 5,000 volts.	Fell immediately but rose, took three or four steps, and sank unconscious.	Death.		Artificial respiration. Died on removal to place of shelter. Time not stated.
20. London Electrical Review, September 24th, 1888. (Paris: <i>Revue Electrique</i> .)	A beam fell upon wires carrying current upon which a man who was killed. The other workmen who went to his assistance were killed.	2,400 volts, alternating current.	Instantaneous death in the three cases.	Death.		
21. <i>Revue Scientifique</i> , May 18th, 1901. (Paris: <i>Revue Electrique</i> .)	Grasped two large electrodes; current passed two or three seconds before turned off.	Secondary current from a Ruhmkorff coil, excited by alternating current, 110 volts, 25 periods, about 30 ma. primary current 50 amperes.	No burn. Thrown to the ground by removal muscular tetanus; limbs and trunk; perturbation of vital and color sense; unconsciousness a few seconds; no pain. On trying to move arms and hands found them paralyzed. Hyperaesthesia to cold; loss of tactile sensibility and muscular sense; hyperaemia of hands and forearms. In three to four minutes arms recovered mobility; fifteen minutes hands the same; some hours to fifteen minutes recovered. Same and muscular sense recovered. Heat sense returned to normal half an hour later. At this time on trying to walk, out of breath. One hour and a half after, tachycardia, arrhythmia, continuing until next day; stopped suddenly. Lassitude lasted thirty-six hours.	Recovery.		

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ELECTROTHERAPEUTICS.—The knowledge of the therapeutic applications of electricity presupposes a thorough familiarity with the main principles of electrical effects upon tissues and organs, and also with the proper dosage of every form of electricity in every given case; it also presupposes a familiarity with the different forms of batteries used for therapeutic purposes. A series of observations shows that the blood-vessels contract and dilate when they are under the influence of an electrical current and that the normal irritability of nerves is changed when a current passes through them. This last phenomenon is called electrotonus. It has been observed that the anode of the galvanic current applied to a nerve diminishes its irritability, while the cathode increases it. The law of electrotonus is equally true of sensory and of motor nerves. Electrical stimulation of a motor nerve produces a contraction of the muscle innervated by the nerve and its branches. A current passing through a sensory nerve will produce both effects—motor and sensory. Electricity causes muscles not only to contract but also to undergo changes of a trophic character.

Apart from the purely physiological influence upon blood-vessels, nerves, and muscles, electricity shows its chemical effects by means of cataphoresis and electrolysis. By cataphoresis we understand a phenomenon which partakes of the nature of osmosis and which is brought into existence by the action of a galvanic current upon organic tissues. Thus, for example, medicinal substances, as mercury, cocaine, chloroform, etc., can be transferred into the tissues when an electrical current passes through the skin to which the drugs are applied. By electrolysis we understand a splitting up of chemical compounds into their component elements, the acid element being set free at the positive, the alkaline element at the negative pole. In living tissues an acid, dry eschar is formed under the positive pole, an alkaline, moist slough under the negative pole.

FORMS OF ELECTRICITY FOR THERAPEUTIC PURPOSES.—The forms of electricity used in therapeutics are: static, galvanic, and faradic.

The application of *Static Electricity* to the body for therapeutic purposes is known as Franklinization. This is the form of electricity which is developed by rubbing certain bodies, and which has the property of spreading over the electrical conductors (for example, metals) and of remaining there. The terminal portions of these bodies have more tension than the middle portions; at the sharp ends the tension is greatest. One distinguishes two sorts of this electricity—positive and negative. By contact with electrical bodies the non-electrical bodies become electrified. Also at a distance the electrical bodies have an influence over the non-electrical bodies (induction). If a non-electrical body is brought into close proximity with the negative pole, the body in question will be found to have assumed the character of a positive

pole. For therapeutic purposes one can use direct contact with either the positive or the negative pole. Several methods are employed in Franklinization: (a) *Insulation*. The patient is placed upon an insulator and is connected with one pole of the static machine by a chain. The free end of the other pole (also a chain) rests upon the floor. The machine is put in rapid motion. The patient is charged with static electricity. (b) *Sparks*. When a piece of metal attached to the free end of the chain is brought close to the patient's body, insulated as before, sparks will be obtained from it. Sparks are powerful means of exciting deep organs, as well as the skin, and the procedure is attended with pain. (c) *Breeze*. If instead of a ball electrode a pointed electrode is used, a sensation as of a spray will be experienced; this is called a breeze. (d) *Induced static current*. In this case a pair of sponge electrodes are attached to two Leyden jars, which are suspended from the poles of the machine. Before applying the sponge electrodes to the body, the poles should be approached to each other. An induced static current is thus obtained. One of the best electrodes for this purpose was devised by W. J. Morton, who named it a pistol electrode. Ranney's device (Fig. 1834) is a decided improvement for use in applying induced static electricity. Other electrodes used with static machines are: a plate for the head, in the form of a crown, and a button-shaped electrode.

Galvanic currents are used in therapeutics for general and for local applications. The different methods of employing galvanic currents are termed *central galvanization*, *local galvanization*, *general galvanization*, and that by means of the *galvanic bath*. In central galvanization one large negative electrode is placed over the epigastrium and the positive electrode over the head, along the spine, or against the trunk. Each *séance* should last not more than fifteen minutes. In local galvanization the rules of application are the same; the cathode should be placed on some indifferent spot, as the sternum or the neck, and the anode on the diseased spot. In general galvanization the patient is seated on a large negative electrode, well moistened, and the other electrode is applied first to the head, then to the neck, face, upper extremities, trunk, and lower extremities. As to galvanic baths we distinguish two varieties: *monopolar* and *bipolar*. In monopolar galvanic baths the cathode is connected with the water, while the anode is either connected with a tube lying over the bathtub, which the patient will hold in his hands, or with a large plate which is put on the patient's back or on some indifferent part of the body (sternum, neck). The bath is called cathodal, when the water is connected with the cathode, and vice versa. A bipolar galvanic bath consists of a bathtub, where both electrodes are connected with the water, and the patient is not in contact with either. The currents will pass through the body from one electrode to another. Each *séance* should last at the beginning about ten minutes. As to the strength of the current it may be permitted to reach 100 ma.

Faradic Electricity.—This form of electricity is used in therapeutics both in a general manner and as a local application. The utilization of general faradization is governed by the same rules as those given for general galvanization. The only point to be mentioned is that on account of our inability to measure exactly the strength of the current in a faradic battery we must guide ourselves by the sensory or motor effects. Local faradization which is used for stimulation of the skin, muscles, and deep structures, is obtained by using large sponge electrodes or dry brush electrodes. The method of application is exactly the same as that already mentioned. Special mention should be made of the combination of galvanic and faradic currents in one machine, but we do not as yet possess positive data as to the real value of farado-galvanization.

THERAPEUTIC EFFECTS OF THE VARIOUS FORMS OF ELECTRICITY.—*Static electricity* increases the blood pressure, accelerates the circulation, stimulates the function of secretory organs, and restores disturbed functions. Sparks and induced static electricity are indicated when

a strong action is sought for. The advantage of Franklinization is that it can be applied through the clothing. *Faradic currents* have their effect upon muscular contractility and vaso-motor phenomena; this form of electricity is therefore indicated in effusions, which will be absorbed through the stimulation of the vascular system. In disorders of deep-seated organs faradism, by producing hyperaemia of the skin, will relieve congestion. *Galvanism* shows its effect in various ways. The vaso-motor effect will be manifested in the variation of the calibre of the blood-vessels. As to the trophic effect of galvanism, there is no doubt that atrophies are favorably influenced by this form of electricity. The chemical effects of galvanism are manifested in cataphoresis and electrolysis (see above). A special practical application

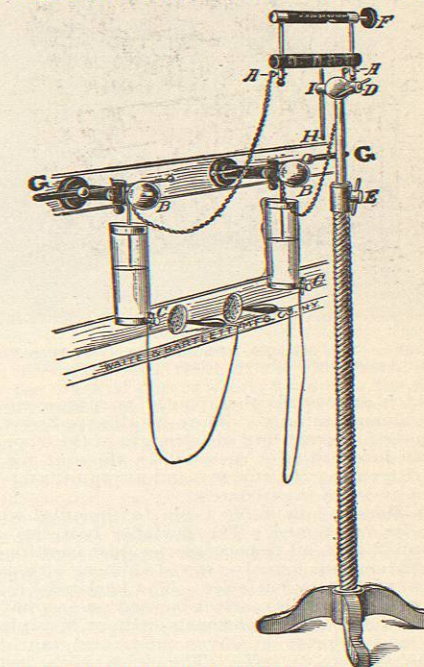


FIG. 1834.—Ranney's Device for Induced Current. To use this device, connect with short chains the poles of the static to binding posts A A on device. Use the current through well-moistened sponge-covered discs, the cord tips being connected to the binding posts attached to the Leyden jar supports. Press sponges firmly on part to be treated, and regulate strength by turning F.

of galvanic currents is furnished in galvano-cauterization. This surgical procedure has an important advantage over other methods of accomplishing the same results. First, hemorrhage is a rare occurrence, and next, the cauterized surface presents a clean aseptic appearance. In operations in the nose, throat, or other cavities, it has a decided advantage over the thermo-cautery in the fact that it is applied cold and heated while applied to the diseased spot. This form of electrical application is indicated in ulcers, in angiomata, in fistulae, where a stimulation of healthy granulations is desirable, in growths which are to be removed from the nose, pharynx, etc.

BATTERIES USED IN ELECTROTHERAPEUTICS.

The number of various batteries devised for electrotherapeutic purposes is considerable. They are made stationary and portable. The stationary *galvanic batteries* are the most satisfactory. The cells are put in a closet or cellar and connected with the switchboard by insulated wires. The cells present usually some modification

of a Leclanché element. Otto Flemming of Philadelphia, Waite & Bartlett of New York, and the McIntosh Galvanic and Faradic Battery Company of Chicago make



FIG. 1835.—Wagner Static Machine, with Four Revolving Mica Plates (diam. 28 in.) and Four Stationary Glass Plates (diam. 31 in.).

batteries which answer all therapeutic purposes except that of the galvano-cautery. They are all supplied with a galvanometer for measuring the strength of the current, an automatic interrupter or rheotome, a rheostat for increasing or decreasing the current, and a commutator for changing the poles of the currents.

G. Betton Massey's movable table for hospital work should also be mentioned. The portable batteries, although supplied with all the accessories just mentioned, lack one desideratum, namely, the steadiness of action of the cells of stationary batteries. The Leclanché cells, or sulphate of copper cells, cannot be used on account of their size and weight, and bichromate cells, or bisulphate of mercury and chloride of silver cells, must take the place of the stationary cells. The writer has tested Flemming's bichromate portable battery, and, although it presents some inconvenience, it is at present the best form of portable battery. The Waite & Bartlett bat-

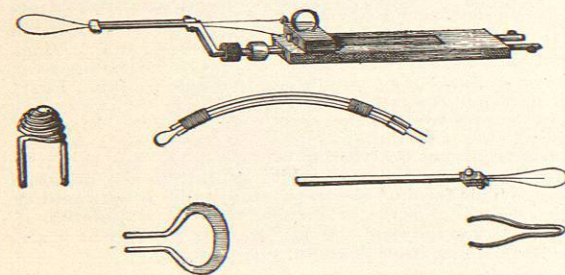


FIG. 1836.—Small Galvano-caustic Operating Set.

teries are worthy of commendation. There are now on the market dry chloride of silver batteries which are very convenient.

Faradic batteries are portable. The DuBois-Reymond's coil is taken as a type, and different variations of it have

been introduced by different makers. Flemming, for example, has improved DuBois-Reymond's coil in a very advantageous way. Dry chloride of silver batteries in the hands of the writer have proven to be extremely satisfactory. *Static machines:* All the static machines devised for electrotherapeutic purposes have for basis Holtz's original machine. The McIntosh Battery Company of Chicago, Waite & Bartlett of New York, Queen & Co. of Philadelphia, make these machines with a high electromotive force. R. V. Wagner & Co., of Chicago, have lately devised a powerful static machine in which the use of mica plates (instead of glass) constitutes the principal feature. This new arrangement promises a very high speed. A machine constructed with mica plates 28 inches in diameter can be run at a speed of more than 2,000 revolutions per minute, whereas a machine with glass plates of corresponding size cannot be run faster than at a rate of 400 revolutions per minute; and, furthermore, as the generating capacity of the machine is in direct proportion to the speed at

which it is run, a machine having two revolving mica plates has a much greater capacity than one having many times this number of glass plates (Fig. 1835).

As to a galvano-cautery outfit the following requirements are necessary: the elements must be of a large surface, and the battery itself of a small internal resistance; the current must produce a sufficient degree of heat in the cautery ends. While the cautery batteries are stationary, they are, as a rule, portable. Fig. 1836 presents an outfit sufficient for ordinary work. For laryngeal operations Schrötter's laryngeal cautery instruments are very satisfactory (Fig. 1837). For general cauterization purposes Dawson's cautery battery and Bruns' cautery battery, as made by the McIntosh Co., are to be commended.

RULES FOR APPLYING ELECTRICAL TREATMENT.—The rules which the writer has here formulated are general in character, and the therapist should adapt them to each individual case, using his own judgment as to the necessity for changing them. Before any application is made it is very important to localize the disease; but sometimes difficulties arise. For example, in palsies of ocular muscles, or in functional neuroses in which the exact place of the disease is unknown, or, finally, in progressive pathological processes of the central nervous system, in which the direct application of a current is an impossibility, we must content ourselves with symptomatic treatment—*i. e.*, we must apply the current to a place where, although it may be remote from the diseased focus, the most pronounced symptoms have been observed.

The next important consideration in electrotherapeutics is the dosage of currents. A strong galvanic current produces on the skin, and especially on the mucous membranes, painful, burning sensations, and is apt to injure the integument, so that sometimes after a single application an ulcer forms. The beginning of pain serves as a warning in regard to the strength of the current. Only

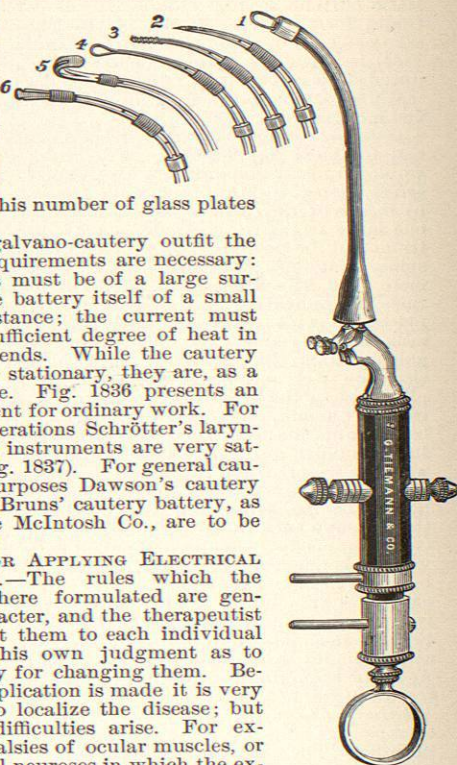


FIG. 1837.—Schrötter's Laryngeal Cautery Instruments.

a slight burning sensation is permissible. Faradic currents of stronger power produce only pain and redness of the skin; nevertheless, one should not use at the beginning a strong faradic current, because it is likely to frighten the patient and so to call forth resistance on his part. Galvanic currents of average strength, when applied to the head and neck, cause dizziness, flashes before the eyes, a peculiar taste in the tongue, nausea, tinnitus aurium, and in hysterical patients cramps and spells of all sorts. The same symptoms are sometimes observed even with milder currents when applied to the head and neck. They occur at each closure and opening of the current, especially when the increase or decrease of the strength of the current is produced abruptly, and not gradually. It is therefore necessary in applying electricity to that part of the body to use a rheostat and cautiously to move it forward or backward. The needle of the galvanometer will indicate whether the increase or decrease is rapid or not. The needle should not make abrupt movements, but slow and regular ones in the desired direction. It is advisable to put in as few elements as possible and to use up the whole rheostat or at least a large part of it. By this means it will be easier to avoid sudden changes in the strength of the current than if we employ many elements, as in the latter case the changes are more marked and sudden ones are more difficult to avoid in spite of the rheostat. In the employment of the latter, for either increasing or diminishing the strength of the current, it is strictly necessary to effect the change in a gradual manner, especially when we are making a polar application, *i. e.*, when we wish to obtain an anodal or a cathodal result. For example, in neuralgias we use the anode of the galvanic current in order to diminish or allay pain. In this case we must be particularly careful to increase the strength of the current, by means of the rheostat, very gradually. It is equally important not to reverse the current while it is closed, neither must we close or open it suddenly. It is therefore a good plan to instruct the patient not to remove the electrodes before the séance of treatment is terminated. In such cases one electrode should be provided with an interrupter, by means of which the closure and opening of the current can be effected in a gradual manner. For therapeutic purposes the electrodes should be first applied to the desired places, and only afterward should the current be turned on very gradually. In terminating a séance it is well first to remove the current (by a slow turning back of the handle of the rheostat), then next to disconnect the elements, and last of all to remove the electrodes.

If direct effects on muscles and nerve trunks are desired, one must moisten the electrodes thoroughly, because the resistance of the skin will thereby be diminished. Dry, especially metallic electrodes (brushes, etc.) exert a direct effect on the skin, and only an indirect one (through reflex action) on the central nervous system and the circulatory apparatus. They are especially used for faradic applications. For galvanic currents metallic electrodes are not advisable because of their injurious effect upon the skin. It is desirable, therefore, when galvanic currents are used, that the electrodes should be well covered in order that the patient's skin may not come in contact with their metallic parts.

In recent cases electrical applications should be made daily; in old cases every other day. When the applications are made less frequently they produce a suggestive rather than a therapeutic effect.

ELECTROTHERAPEUTIC APPLICATIONS IN DISEASES.

The question of the real value of electrical applications in various diseases is even at the present time under discussion. Some authors do not believe at all in the curative effect of electricity. Opposed to this absolutely sceptical view there is another which is held by men who believe in the curative value of this agency, but only through its influence upon the patient's mind. This latter influence, it must be admitted, is sometimes com-

petent to remove or allay certain unpleasant symptoms, especially those of a nervous character, which accompany certain diseases. The third view is that which is held by the majority of writers, *viz.*, that the various electric currents do actually exert a curative effect upon certain pathological conditions of the living body. They base their views on: (a) exact clinical experiments; (b) experiments on animals, in which the psychic effect is out of the question, and in which artificially produced diseases are cured by means of electrotherapeutic methods; and (c) the fact that electrical currents show their effect especially on the nervous system. The study of the clinical data concerning the applications of electricity in diseases of various organs permits us to arrive at the following conclusion: the electrical current produces, in addition to the psychical influence already mentioned, the following well-established effects: a chemical effect upon the fluids and solids of the body, an effect upon the smooth muscle cells of the blood-vessels, a stimulating effect upon the nerves, an effect upon striated muscular tissue (contraction), and finally changes in the molecular life of the tissues in general.

DISEASES OF PERIPHERAL NERVES.—(a) *Neuralgia.* The irritability of the sensory nerves is diminished by the application of the galvanic anode. The application is made in the following way: one electrode of larger size is thoroughly moistened and applied to some indifferent spot (sternum, back); the smaller electrode is placed on the spot which is considered to be diseased. The number of elements to be used is always determined in advance (on the head and neck they should be fewer than on any other part of the body). With the rheostat we can slowly and gradually regulate the strength of the current, and the galvanometer will show the desired strength. The number of milliamperes shown on the galvanometer will depend upon (1) the localization of the nerve (for the fifth nerve the maximum will be 2 ma., for the brachial plexus about 4 ma., for the sciatic nerve about 8 ma.); (2) upon the length of time during which the disease has existed (in recent cases use weaker currents); (3) upon the sensibility of the individual. Each séance devoted to such an application of the electrical current should not last more than five or six minutes.

Descending galvanic currents are also found to be of value in allaying pain. When we use such a current we should apply both electrodes to the nerve trunk at a certain distance from each other; the anode being placed centrally and the cathode peripherally. Of course this is possible only in cases in which the nerve trunks are not far from the surface. Thus, for example, in cases of sciatica the anode should be placed in the middle of the gluteal fold and the cathode in the popliteal space at the point where the nerve divides into two branches.

In old neuralgias the voltaic alternative currents are used. They are produced by abrupt or rapid movements of the rheostat after both electrodes have been placed according to the general rule.

As to the faradic current it can be used with a faradic brush electrode, which should then be the anode and with which a massage should be exercised over the painful area, while the cathode is kept immovable on an indifferent spot. This procedure will often allay pain.

Cataphoresis with various drugs has been practised by many authors, and comparatively good results have been obtained. According to this method the remedy for relieving pain is applied to the anode which is in contact with the neuralgic area. The cathode is placed on an indifferent spot. By employing cataphoresis with cocaine and with aconitine Peterson and Séguin were successful in relieving patients who were suffering from supra-orbital neuralgia.

Treatment by high intensities has been recommended in tic douloureux. An electrode attached to the positive pole is placed on the diseased side, while the indifferent electrode is placed on the back. The current is gradually increased to 30-50 ma. and is allowed to remain at this strength for from half an hour to an hour. Static electricity in the form of sparks is of great utility in neural-

gias. One of the methods of Franklinization for allaying neuralgia and various forms of paræsthesia is that of "sharp ends": the positive pole is connected with electrodes which have sharp ends, while the negative is connected with the earth or with an isolated plate for the feet. The electrodes should not be brought nearer the patient's body than at the distance of 2 cm. The conductors must be separated from each other by a distance of from 5 to 8 cm. When everything is in readiness we shall find that light emanates from the ends of the electrodes and that ozone is given forth. The skin, when under the influence of the current, appears to give out a pleasant odor. This form of electricity is used chiefly in the treatment of neuralgias and paræsthesias of all kinds.

(b) *Local Cramps, so-called Tics.*—In these affections the mode of employing the current is similar to that already described previously. A *labile application*, however, is the one most likely to prove beneficial. This is effected by applying one electrode at some indifferent point, while the other is moved slowly up and down over the region affected, without interrupting the current.

It is important to bear in mind that while the electrodes are *in situ* and the patient is beginning to feel burning sensations, they should not be removed, because by so doing the sensations in question would simply be intensified.

(c) *Paralysis of Peripheral Nerves.*—In the case of peripheral palsies therapeutic effects may be obtained by stimulating the muscles innervated by palsied nerves. The faradic current should be employed. The rules laid down for guidance in electrical examinations should be observed here. The negative electrode is to be placed on an indifferent point, while the positive electrode, supplied with an interrupting handle, should be applied to the affected muscles; the contractions obtained with each closure should be well marked. Both electrodes can also be placed simultaneously on the affected muscle, but if this is done a larger number of closures will be found necessary. The faradic current should not be used in cases in which there are spasms of the affected muscles. The galvanic current is to be used only when there is no response to the faradic. The cathode should be placed upon the affected muscles, while the anode is applied at some indifferent spot. During the passage of the current the cathode is kept moving to and fro over the diseased area without once being removed altogether. After each séance the current should be shut off before the electrodes are removed, especially when the face and neck are under treatment. Both currents, faradic and galvanic, can be utilized at the same sitting if a combination apparatus is employed. When there is no response to the galvanic or the faradic current, it is useless to attempt electrical treatment, and massage should be substituted. When the paralysis or atrophy is followed by contracture of the muscles, electrical applications to the affected muscles should never be attempted. Instead, the attempt may be made to produce a compensatory or counteracting effect by stimulating the muscles which have a function opposite to that of the diseased ones. Thus, for example, if the flexors of the forearm are permanently contracted, the extensors of the limb might advantageously be stimulated, and vice versa.

DISEASES OF THE SPINAL CORD.—In the treatment of diseases of the spinal cord electricity affords a better outlook for improvement, if not for recovery, than does any other method of therapeutics. It can be applied to the cord itself or directly to the different organs dependent upon the parts of the spinal cord that are affected. As to the cord itself two kinds of galvanization are to be used: *stabile* and *labile*. In the first, the positive electrode is to be placed on the neck, while the negative one should be applied to the lumbar region of the spinal column. A current of from 4 to 8 ma. is then to be turned on for about ten minutes. In the second method the anode is to be applied, as before, on the neck, and the cathode is to be moved up and down along the spine without once being removed. This galvanization can be used only in systemic diseases of the cord, in tabes, or in chronic inflammatory conditions (posterior and lateral

sclerosis, multiple sclerosis), but not in acute processes like myelitis or hæmatomyelia. In systemic diseases a longitudinal galvanization, in the form of stable and labile applications, is indicated. By adopting this plan the current will be made to pass through the entire cord. In case a segment of the cord is diseased, as in transverse myelitis of a chronic character, a transverse galvanization is indicated. This may be carried out by placing one electrode over the spine, while the other is applied to the median line in front.

The effect of galvanization of the cord is expressed by a betterment of its circulation and nutrition. Better results, however, will be obtained if the electrical current is applied directly to the organs affected by the disease of the cord. This is true, for example, of the palsies accompanying poliomyelitis or myelitis. In old palsies due to diseases of the cord the faradic current should be used. In cases of spasticity the anodal labile application of the galvanic current should be utilized. In mild palsies the galvanic cathode should be put in use. Paræsthetic disturbances accompanying palsies can be relieved by the application of the galvanic anodal electrode or by using the faradic brush; the latter being especially indicated in cases of sharp pain.

In diseases of the spinal cord the sphincters of the bladder and rectum are often involved, and there are apt to be sexual disturbances. Cases have been reported in which good results were obtained by introducing into the urethra, as far as the bladder, an insulated electrode having the form of a bougie. Before turning on the electrical current (one of 10 ma.) the bladder should be half filled with warm salt water, and after a few minutes the current should be reversed. The faradic current is to be employed, and the external electrode is to be placed against the perineum, the lumbar part of the spine, or over the pubis. The galvanic current may also be utilized, but in that case the bougie-like electrode should be made the cathode. Good results have also been obtained from external electrization; the cathode of the galvanic current having been placed in these cases on the lumbar region and the anode on the perineum or the pubis. The most careful asepsis must be observed.

Impotence due to spinal diseases can be treated with the faradic brush, to be applied over the lumbar region, or with a labile galvanic current.

The question of electrotherapeutics in progressive muscular atrophies is intimately associated with that of *reactions of degeneration*. In each case a thorough investigation concerning the electrical reactions of atrophied and paralyzed muscles is absolutely indispensable, for the reactions of the diseased muscles to electrical currents will determine the nature and seat of the lesion. Also the prognosis of certain forms of paralysis depends almost exclusively upon the electrical reactions. It is therefore essential to say a few words in regard to the electrical reactions in muscular wastings and paralyses.

In diseases which involve the region of the peripheral neurones and which lead to degeneration of muscles one finds abnormalities in the electrical irritability of the affected nerves and muscles. These abnormalities present the following characteristic points:

1. *Quantitative* changes, namely: (a) diminution and entire loss of irritability (faradic and galvanic) of the nerves and of faradic irritability of the muscles; (b) increase and soon diminution of galvanic irritability of muscles. 2. *Qualitative* changes, especially: (a) slowness of galvanic muscular contractions, and eventually (b) deviation from the normal formula. If Ca represents the cathode (negative pole), An the anode (positive pole), c the closure, and o the opening, we shall have as the formula for normal nerve reactions to galvanism: $CaC > AnC > AnC > AnC > AnC > AnC$; and as that for normal muscle reactions: $CaC > AnC > AnC > AnC$. In disease the formulae will be reversed.

The complicated anomalies of irritability, which accompany muscular degeneration and which disappear when the degeneration is followed by regeneration, were studied first by Erb (1868), Ziemssen, and Weiss; and finally Erb

proposed that the corresponding symbol should be RD (reaction of degeneration).

The reaction of degeneration takes place in the following cases: 1. Diseases of the medulla with involvement

one or more muscles located in a region where previously the current had elicited no response, or if such contractility can be excited in these very muscles by a direct application of the faradic current, we may feel warranted

in giving a favorable prognosis—*i.e.*, the case in hand belongs to the curable variety. The more muscles respond to direct or indirect stimulation, the better is the prognosis. It is also important to watch the form of galvanic muscular contraction. If the galvano-muscular irritability is low, but the formerly slow contraction becomes rapid, the prognosis as a rule is good; but if it remains slow and becomes even slower, the prognosis is bad; it is probably a completely incurable form of paralysis.

It is important to examine all the muscles of the diseased area by direct stimulation and indirectly (by application of the current to the nerves) in order to ascertain whether all the muscles innervated by the nerves in question contract or not.

We said before that progressive muscular atrophies should be treated with electricity. In progressive muscular dystrophies, in which the palsy and atrophy are not due to involvement of the spinal cord, the faradic contractility is preserved for a very long time, and it is the last to disappear. The galvanic current should therefore be used in these cases, and a labile cathodal application should be made at the beginning and should soon be followed by the faradic current, or a combination of galvanism and faradism may be tried.

The accompanying figures (Figs. 1838 to 1846) will show the exact points where the electrodes should be

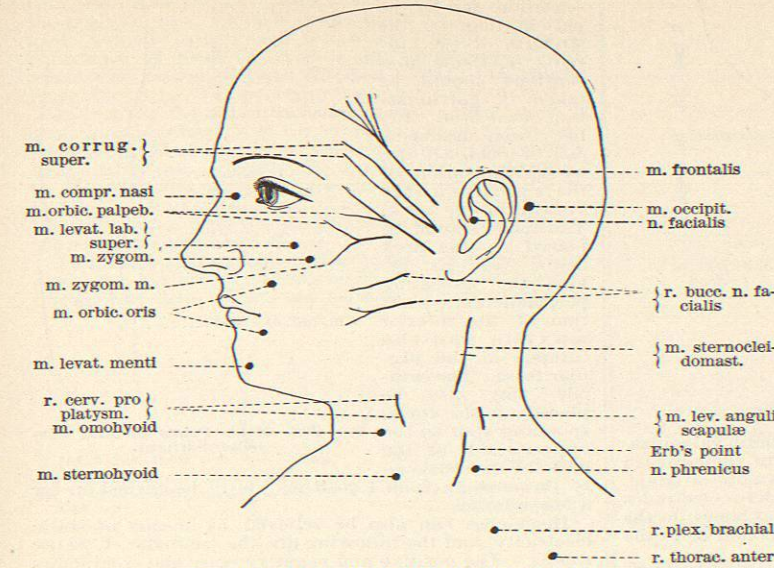


FIG. 1838.—Motor Points of Head, Face, and Neck.

of the nuclei of cranial nerves (such, for example, as the different forms of bulbar paralysis). 2. Diseases in which the cells of the anterior horns are involved (such, for example, as acute anterior poliomyelitis; so-called infantile palsy; progressive muscular atrophy; hemorrhage and softening in the anterior horns; tumors, including gliomata; syringomyelia; transverse myelitis; and amyotrophic lateral sclerosis). In diffused foci of an inflammatory or a sclerotic nature, which have their seat in the anterior horns, we find RD in the muscles which derive their nervous supply from the corresponding parts of the cord. 3. Diseases affecting the roots of cerebral or spinal nerves. Among these may be included meningeal processes of various kinds involving also the trunks, tuberculous disease of the columns, and tumors which have their origin in the roots or meninges. 4. Diseases of peripheral nerves: (a) Affections due to compression of the nerve (as, for example, the pressure palsies of the arms, peroneal palsy, and palsies of the ulnar and median nerves); rheumatic facial palsies; injuries of nerves in surgical operations. (b) Inflammation of nerves (as in the facial palsies which are caused by disease of the middle ear, and in the idiopathic palsies which are partly of a toxic nature—*e.g.*, lead, arsenic, and alcoholic palsies—and partly the result of infection—*e.g.*, the palsies following diphtheria, influenza, etc. (c) Tumors of nerves.

The RD may be complete or partial. The complete reaction is observed in two classes of cases: those which are curable and those which are incurable. The curable cases may again be subdivided into the light and the more serious forms. A differential diagnosis between the incurable and the clearly curable cases can be made only after the lapse of eight, ten, or even fifteen weeks after the commencement of the disease. If by that time we notice a return of contractility (under the use of a strong current applied indirectly through the nerves) in

* In infantile palsies of cerebral origin the electrical reactions show either a simple diminution or else no change whatever, but no RD.

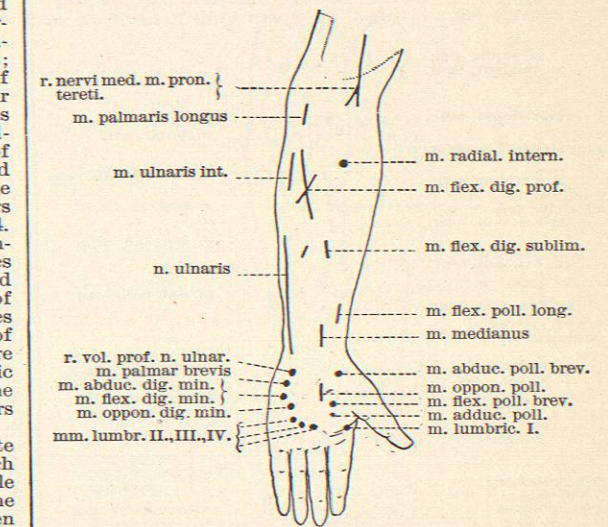


FIG. 1839.—Motor Points of Forearm.

applied in order to influence certain muscles and nerves of the face and four extremities in cases of paralysis and atrophy.

DISEASES OF THE BRAIN.—Galvanization of the head has been resorted to in various diseases of the brain, such