RANNEY (A.L.)

STATIC ELECTRICITY

IN

MEDICINE.

An Exposition of the Different Forms of Generators which may be Employed, and the Various

METHODS OF APPLICATION

Of this Therapeutical Agent;

Together with Hints Respecting the Care and Management of Induction-Machines and the Selection of Apparatus.

BY

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HISTORY OF STATIC ELECTRICITY.

We owe to the ingenuity of Otto V. Guericke, the inventor of the air-pump, the first electrical machine where friction was employed as the exciting agent. It consisted of a ball of sulphur which was turned upon its axis by hand-power. An assistant grasped the ball with his hands, and, by so doing, served as a conductor for the escape of the positive electricity to the earth. This primitive affair gave feeble sparks, which could only be seen in total darkness.

Hawksbee substituted later a globe of glass for the ball of sulphur. He obtained more satisfactory sparks with the positive electricity thus generated.

Later still, glass tubes were used, with hand rubbing; and they entirely superseded the globe as generators until the middle of the eighteenth century.

In 1767, Hawksbee's original machine was revived in a modified form by Professor Boze, of Wittemberg; and for a time it came into general use. The accompanying cut of this machine is taken from the *Leçons de Physique* of Abbé Nollet.

The collector was hung from the ceiling by silken cords; and the hands of an assistant were used as rubbers upon the globe of glass.

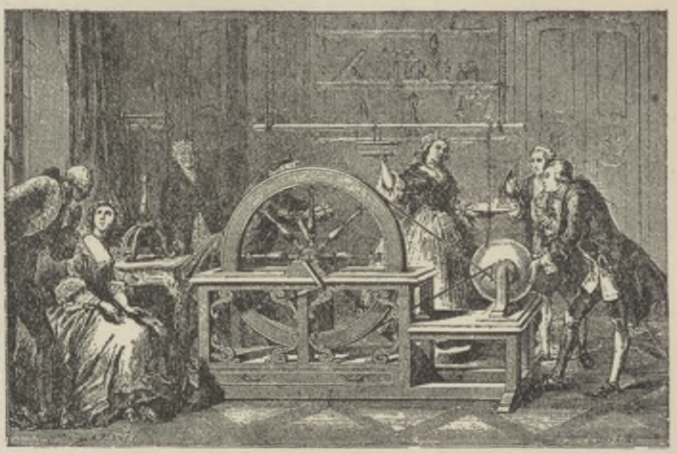


FIGURE 1.—Hawksbee's original electrical machine (from *Leçons de Physique* of the Abbé Nollet, published in 1767). The globe is of glass, and positive electricity is collected upon a conductor suspended by silken cords from the ceiling.

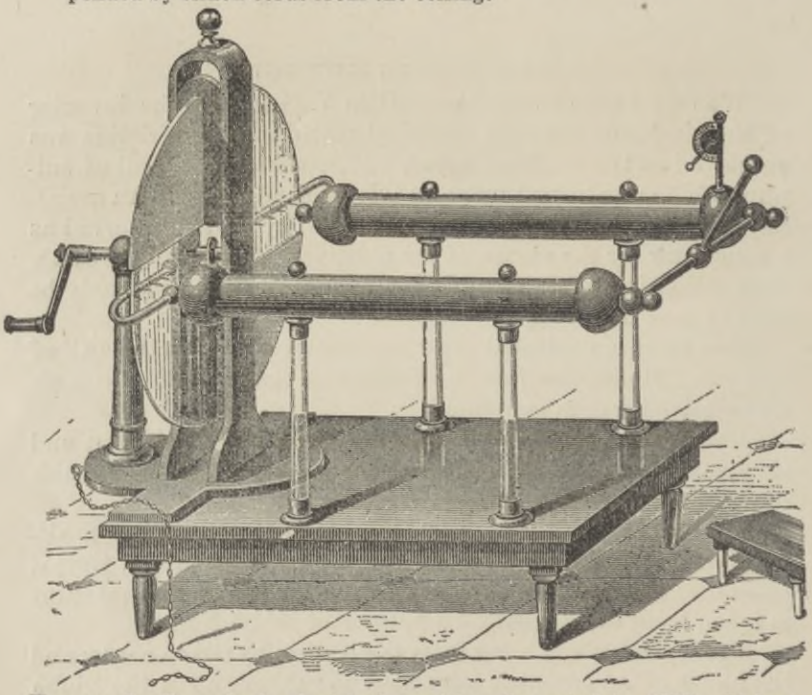


FIGURE 2.—Ramsden's electrical machine (invented in 1768). It has sector-shaped pieces of oiled silk to prevent a loss of electricity from the glass plate while passing from cushion to cushion.

In 1768, Ramsden, of London, invented the so-called "plate-machine." The glass plate was supported by wooden uprights, and the friction was made by means of two cushion-rubbers. The collectors were of metal; and two combs of metal were employed to draw off the electricity from the glass plate. The cushions were "grounded" by means of metal supports, so that the negative electricity which accumulated upon them could escape to the earth. In 1776, Von Marum modified Ramsden's apparatus so as to obviate this loss.

Nairne next modified the machine of Ramsden by substituting a cylinder of glass for a single glass plate and by adding an attachment for collecting the negative electricity by means of

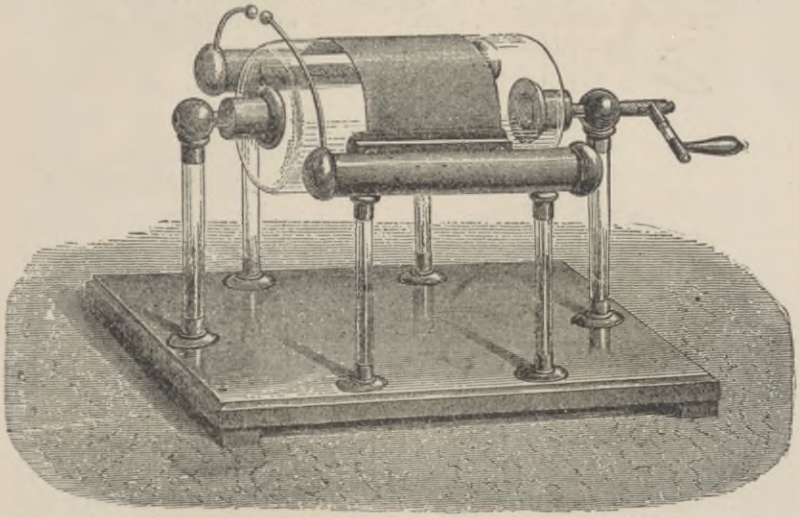


FIGURE 3.—Nairne's electrical machine. The cylinder of glass revolves between two separately insulated conductors—one attached to the rubber and the other to a metal comb.

an insulated conductor placed in communication with the rubbers. This was the first machine that satisfactorily furnished both positive and negative static electricity.

Probably the first electrical apparatus which can properly be said to have been a true "*induction-machine*" was described as early as 1788, by W. Nicholson, before the Royal Society of London. He called it the "*electric-doubler.*" It was built somewhat upon the plan of the machine now known as the Toepler-model. It had three discs, attached to a common hub. These touched upon pins of metal at two points during each revolution, and passed between two pairs of insulated metal

plates without touching them. They deposited their electricity upon a metal ball, which they also passed during each revolution. This ingenious little instrument could to-day be made quite effective by slight modifications. For some unexplainable reason, it was apparently thought to be of little value, and even its existence is not mentioned by any standard author on electrical subjects with which I am familiar. A cut of the machine is published, however, together with the inventor's description of the machine, in an old work entitled the "New Royal Encyclopedia of Arts and Sciences."

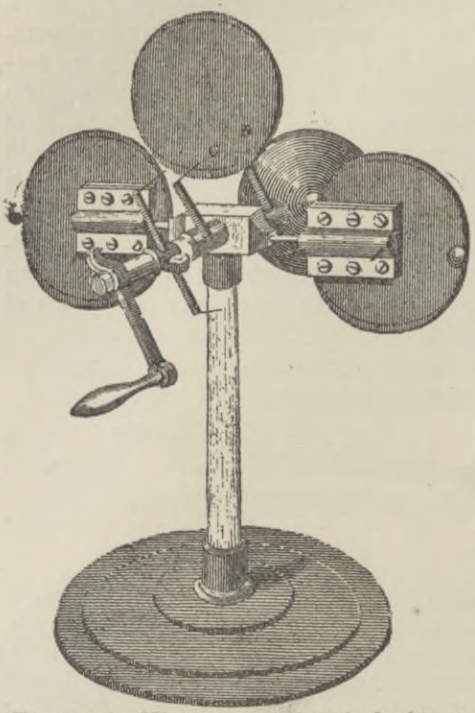


FIGURE 4.—Nicholson's "electric-doubler"—the first induction-machine invented. Reproduced from the original cuts made in the eighteenth century. The lighter portions of the cuts are made of glass.

Lane and Adams both perfected frictional machines during the eighteenth century, in connection with which the Leyden-jar was used for medical purposes. Some of the cures reported by these crude machines are fully as startling as those now obtained by improved apparatus.

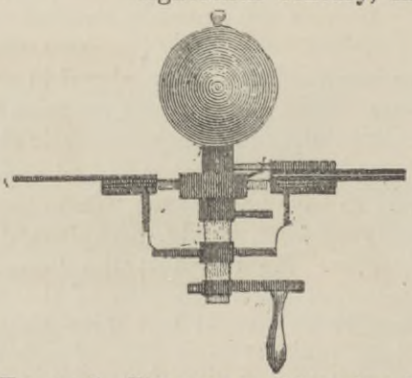


FIGURE 5.—The same machine, viewed from above.

In 1840, Sir W. Armstrong devised a machine by which the friction of cooled steam against the sides of minute orifices,

through which it escaped under a high pressure, became the generator of static electricity. The boiler was insulated by glass legs, and became negatively electrified. The jets of steam conveyed the positive electricity and deposited it upon a metal plate studded with points, upon which the jets were directed. This machine proved very powerful, but difficult to manage, and totally unfit for general use. It made a deafening noise, and saturated everything near it. One of these machines gave a spark of twenty-two inches.

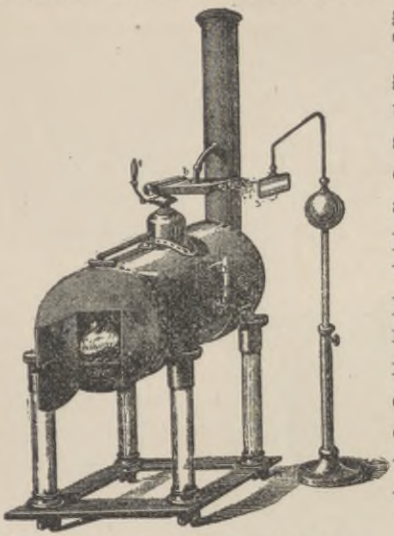


FIGURE 6.—An apparatus for generating frictional electricity by steam, devised by W. Armstrong. The legs upon which the boiler rests are of glass. The negative electricity generated by the machine when in action accumulates upon the boiler, and the positive electricity is collected by the comb upon which the steam-jets are directed.

To Holtz, of Berlin, we do not owe the discovery of the first induction-machine, as many suppose. His apparatus was not perfected until 1865. Although the original model seems crude in comparison with our present instruments, still it cannot be denied that it contained the principle

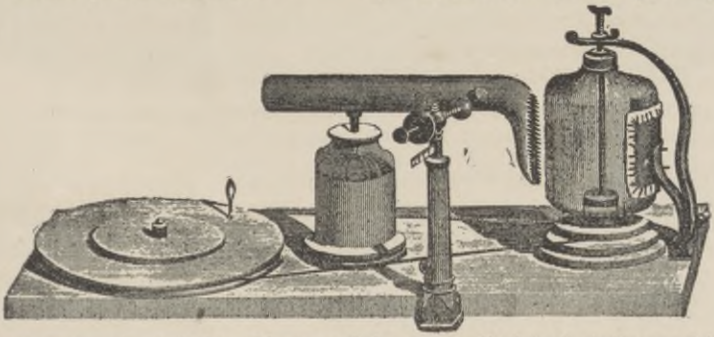


FIGURE 7.—One of the oldest models of a cylindrical static machine. The rubbers are grounded, and a Leyden-jar is connected with the positive electricity stored in the receiver.

which formed the starting-point of all the later improvements;

and many of the mechanical details of the original instrument are to-day generally used.

There is a modified form of an induction-machine which is now sold quite extensively to the medical profession. It is known as the Toepler-machine, or the Voss-machine. It can be made with one or more revolving plates. The fixed plates are larger than the revolving ones, and have usually a central opening. They may, however, be divided or perforated centrally.* They are furnished with paper collectors and discs of

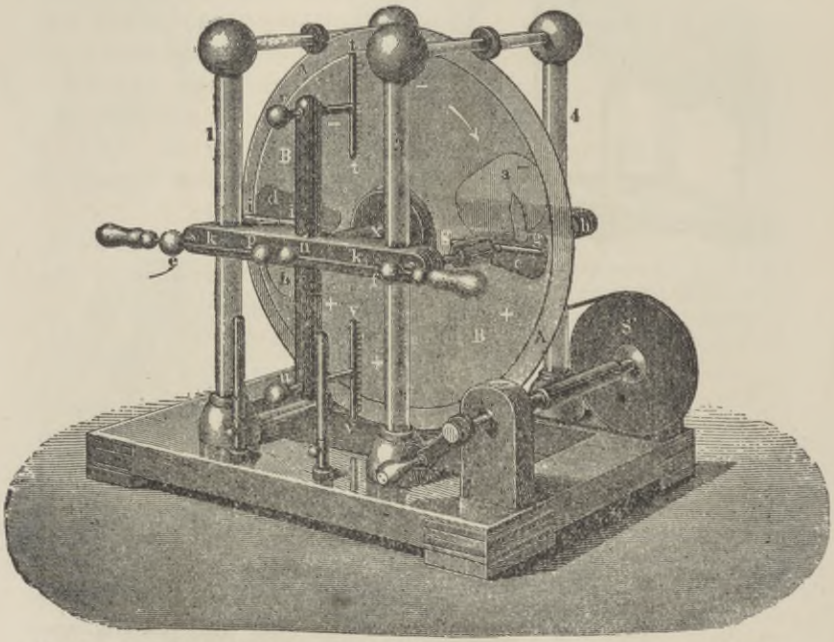


FIGURE 8.—The original model of Holtz's induction-machine with vertical plates. The same inventor also perfected a machine without windows or armatures, in which two horizontal plates revolved in opposite directions. This machine is shown in a subsequent cut.

tin-foil. The revolving plates have metal buttons attached to one of their faces. These buttons impinge upon metal brushes as the plate is revolved. The buttons rest on tin-foil cemented to the glass. The fixed plates are placed as close as possible to the revolving plates.

It is claimed that this machine will work in all weathers. I have not found this to be strictly fact; although it is not as

*I have lately had one so divided, which works admirably.

much affected by dampness as an ordinary plate machine.* This machine is usually not encased—a defect which I have remedied, with satisfactory results. It is lighter and less expensive than the improved patterns of the Holtz-model; but it is far less satisfactory in medicine, because it generates a much smaller quantity of electricity and has less intensity. The spark elicited may be a moderately long one (when compared with the radius of the revolving plates); but it is rather a thin spark at best—thus confirming the view expressed by me respecting the "quantity" generated.

THE PRINCIPLES OF STATIC INDUCTION.

The application of the principles of static induction as demonstrated in the machine devised by Holtz, is difficult to fully explain without devoting more time to the general subject of electrical induction than is deemed wise. It may be roughly summarized, however, as follows:

Any body when electrified has the power, to a greater or less extent, of exerting (even through an intervening substance, which in this instance consists of a plate of glass,) a peculiar effect upon the electrical state of another body closely adjacent to it in position. It tends to draw from the opposed body that variety of electricity which it does not itself possess. Now, if an intervening substance happens to exist between the two bodies, the electricity drawn toward it by induction may be deposited upon the corresponding side of that substance; and a proportionate amount of electricity of the opposite variety is abstracted from the intervening body. Hence, the intervening body becomes either positively or negatively electrified on one side, as the case may be.

In the induction machine, the intervening substance happens to be the revolving glass plate; and the opposed bodies are the two paper collectors and the two metal combs of the machine, which are separated by the revolving plate of glass.

In all induction-machines, the charge is *practically constant when once established*—provided the mechanism be perfect and the plates kept absolutely dry. Under such conditions, it ought never to fail to produce its full effects when the wheels are set in revolution. This is a great desideratum in medicine.

In the original Holtz model only one stationary and one revolving plate were used. Both were circular in shape. The

*This opinion is supported, moreover, by the fact that some manufacturers of these machines give to their purchasers explicit directions respecting the drying of the plates.

stationary plate had openings or "windows" cut in it. Paper collectors were glued to the stationary plate; so made as to project from it and to come in close contact with, and to face the openings in the stationary glass plate. The revolving plate was insulated by legs of glass, while the stationary plate was not. Metal combs were used as terminal attachments to the inner end of the two poles of the machine. They faced the revolving plate and almost touched it.

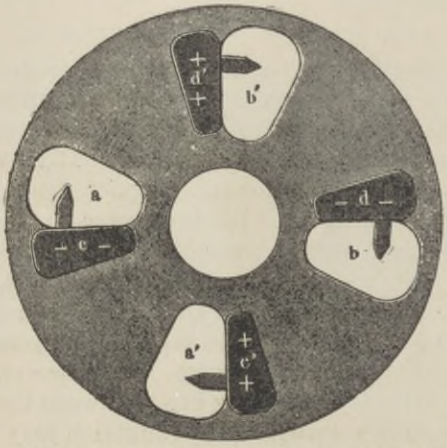


FIGURE 9.—The stationary plate of the original Holtz, showing its armatures and windows, with the projections upon the armatures.

You will find all of these mechanical features practically preserved in the improved models of to-day. The revolving and stationary plates have been increased in number; simply to augment the quantity of electricity generated. The stationary plates are no longer circular; they are made in two pieces, to allow of "windows." Two paper-collectors are glued to each stationary plate. These terminate in points which project into the "windows" made by dividing the plates. The poles of the machine have metal combs on one end, and a brass ball at the other. Extra combs have been added to draw off residual electricity which accumulates in excess; but these are "grounded."

Furthermore, the machine has been encased, simply to protect it from atmospheric changes. Cat-skin rubbers have been added. They are of use only as a means of exciting the plates when, from any cause, induction shall have ceased. We call them the "chargers" of the machine. (See Figure 11).

There have been many mechanical modifications made, from

time to time, of the original model, which have not been here specified by me; but as they do not in any way affect the principle of electrical induction, they are not of importance in this connection.

In the original Holtz machine a charge was primarily effected by rubbing a piece of ebonite briskly with cat-skin until it became highly charged with negative electricity, and then applying it closely to one of the paper collectors on the stationary plate of the machine. By the "law of induction" the comb opposed to this paper collector becomes electrically excited immediately. It at once deposits *positive electricity* on the side

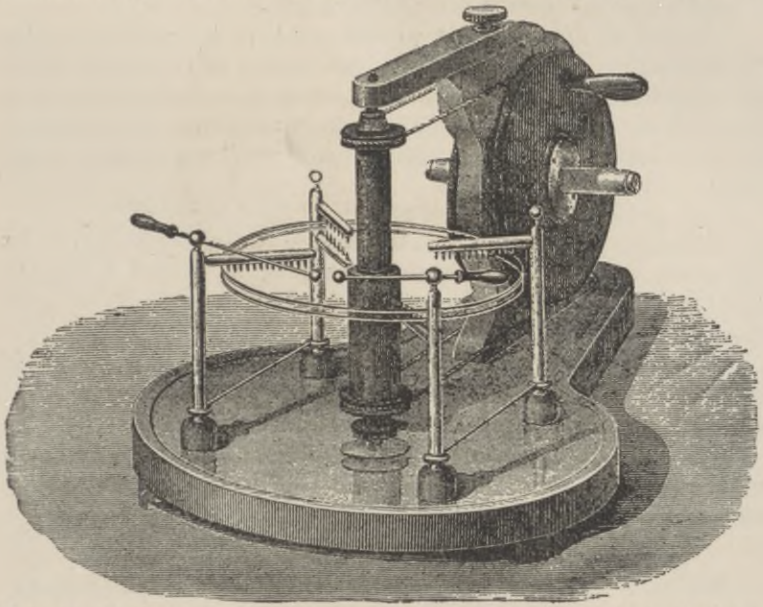


FIGURE 10.—Holtz's static induction machine, with horizontal plates. The plates have neither windows nor armatures, and they revolve in opposite directions.

of the revolving plate nearest to the comb, and takes *negative electricity* away from the revolving plate. Thus the revolving plate becomes *positively electrified* to a very high degree at this point.

Now when the wheel is made to revolve to that point where it meets the other paper collector upon the stationary plate, induction again takes place. Negative electricity is deposited, (1) by the collector on the opposite side of the revolving plate (the side nearest to the paper collector) and (2) by the metal

comb; at the same time positive electricity is taken from the adjacent side of the revolving plate by the collector, and also by the metal comb, from the opposite side of the revolving plate. This interchange of electricities charges the "positive pole" of the machine.

The revolving plate (now excessively charged with *negative electricity*) goes on to the next paper collector. Here a similar exchange of electrical conditions occurs. The negative electricity is taken from the revolving plate by both the paper collector and the metal comb, and positive electricity is given to the plate in exchange from both of these sources. Hence the "negative pole" becomes highly charged.

As long as the revolving wheels are kept in revolution, this interchange of electricities continues at each of the poles; hence the accumulation at each pole soon becomes sufficiently great to allow of an escape from pole to pole in the form of a spark, or into the atmosphere as a "luminous brush" easily seen in the dark.

STATIC ELECTRICITY AS COMPARED WITH GALVANISM.

It has been computed that the *electro-motive force* of a Holtz induction machine is 52,000 times as great as that of a Daniell cell (or 52,000 volts). It is not affected by the velocity of rotation.

The *quantity* generated is proportionate to the velocity of rotation and the number of wheels employed.* It is modified also by the moisture present in the atmosphere.

The *internal resistance* of the machine diminishes rapidly with increased velocity of rotation. It is not influenced by atmospheric conditions.

STATIC ELECTRICITY IN MEDICINE.

The revival of static electricity (or Franklinism) as a therapeutical agent from the oblivion into which, for nearly half a century, it had unaccountably sunk, has been occasioned by several factors. Among these factors the following may be prominently mentioned:

(1) The awakening of the profession at large to the fact that *electrical currents of different kinds have distinct therapeutical actions.*

These are not to be attributed to or confounded with the strength of the current employed, or its method of application. The effects of faradization, galvanization, and franklinization

*On this account I have lately increased the size of the driving-wheel, so as to ensure rapid revolution of the plates of the machine.

upon animal structures differ widely in many respects. The time has come when an intelligent physician cannot justly condemn all forms of electrical treatment of any individual case, because he has failed to obtain satisfactory results with one of the above-mentioned currents alone; even if he has employed that particular form of current with the highest possible skill and judgment.

This is an error into which many are unwittingly led. I could report (if time would permit me to do so) the details of several cases where a failure to employ the proper current has proved most disastrous to patients. One instance of this character (which was happily aborted) impressed me so forcibly at the time, that it is possibly worth narrating:

A patient, who had accidentally severed the musculo-spiral nerve by a pistol bullet, was sent to me some years since for diagnosis, and to confirm or reject an opinion which had been expressed by a physician of prominence, namely, that the only hope of cure lay in a surgical operation for the uniting of the severed ends of the nerve by sutures. This opinion, as I found, was based upon the fact that the *faradaic current* had failed to produce any movement in the paralyzed muscles; and that several months had already elapsed since the accident—during which time the hand was steadily becoming more and more deformed by contracture of the flexor muscles of the hand and forearm.

My examination of the patient showed, however, that a *galvanic current* produced violent contractions of the paralyzed muscles when *passed through the injured nerve* (one pole being placed upon the sternum as a neutral point, and the other upon the musculo-spiral nerve); and the galvanic reactions of the nerve and its muscles furthermore indicated marked "degeneration" as having developed in the nerve below the point where it had been divided. Thus, the question of the advisability of an operation was decided positively in the negative. The nerve had already united.

In about eight months the injured nerve was completely restored by the use of the "static spark"; the contracture had disappeared; and to-day the patient can see no difference in the usefulness of his hands.

(2) The *improvements which have been made in machines for the generation of static currents* for medical purposes have had much to do with the revival of this method of treatment.

Some of the cases reported in the earlier encyclopædias, and

antiquated works on electricity, are fully as startling as those now encountered, when treated with the improved machines; but, on the other hand, many failures to obtain good results must of necessity have occurred in olden times from the imperfect apparatus depicted in the scientific works referred to. Later, I will discuss the various improvements which have been made from time to time since Holtz first devised the present model of an induction machine (1865).

(3) *Improved methods of administration* of static currents have added materially to the effectiveness of this agent as a cure of disease. Some of these methods were unknown in earlier times (as far as my research goes to show).

(4) It is now known that a *considerable quantity*, as well as *length of spark*, is essential to the successful use of a static machine in medicine. Many of the static machines sold to-day are practically worthless, save as a toy; because they do not produce a sufficient quantity of electricity. The requisites of a static machine for medical purposes will be touched upon later.

(5) Experimentation with this agent seems to have confirmed the views of its enthusiastic advocates of the present day, and to support the accuracy of many of the observations reported in old scientific works. The incredulity of the past is rapidly being overthrown in respect to this method of treatment; and the special fields in which it proves of the greatest service are being definitely mapped out by those who are scientifically recording the results of its administration.

For the past few years I have devoted considerable attention to the improvement of the Holtz induction machine. Some of the results of my experimentation have already been published. The machine now described to you is in some respects an improvement upon the one which I originally introduced to the profession through the *Medical Record* of October 17, 1885. I have modified the charger originally used by me, so that it now bears upon the *outer revolving plates above the metal combs*, instead of passing between the central revolving plates. I have found that the application of cat-skin at this point on the outer plates awakens the machine into action (when not charged) with greater rapidity and certainty than at any other part of the machine. Furthermore, there is no longer any difficulty in making the contact between the charger and the glass when the wheels are revolving rapidly;* while, with the old charger, the

* A *slight touch* of the charger of short duration upon revolving wheels, repeated at intervals of a second or two, is more effective than a long continued application to the wheels of an induction machine.

springing of the rubbers often rendered their insertion between the revolving plates (which are in extremely close approximation) a matter of some little annoyance at times. This modifi-

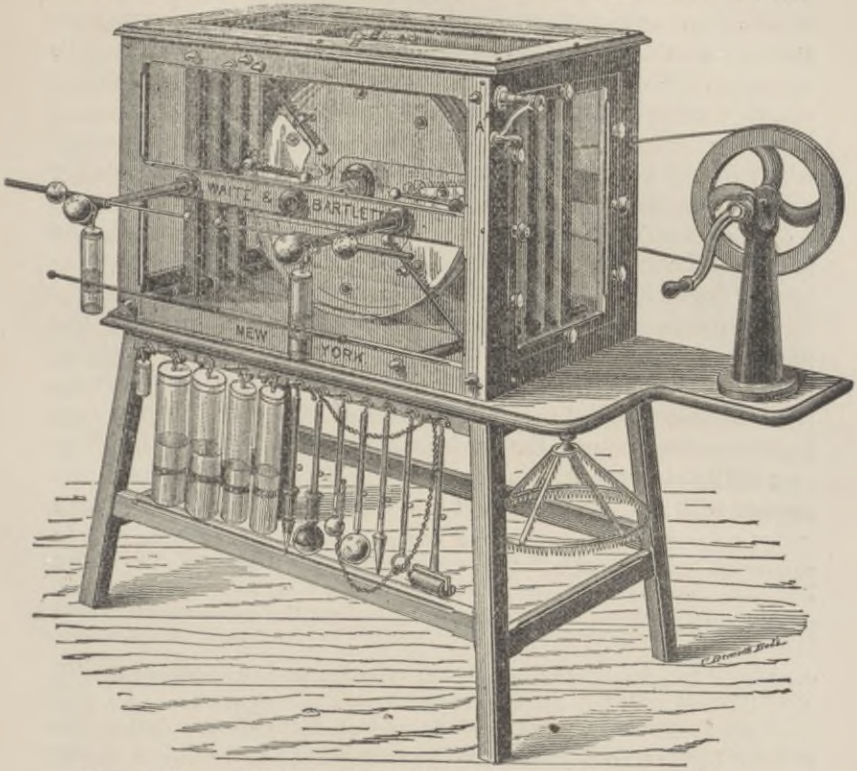


FIGURE 11.—Holtz induction machine, as improved by the Author.

cation in the charger has entailed a slight change in the mechanism by which the rubbers are brought into play when needed.*

Again, although chloride of calcium is not required during the cool months in this particular machine for the purpose of

*In some models of the present day, the charger cannot be raised from between the revolving plates. This is a serious defect.

NOTE.—The following description of this machine is quoted from the author's article in the *Medical Record*, October 17, 1885:

"I would call the attention of the profession to an improved static machine which has been lately devised by me.

"It is the result of many months of experimentation, and is the outgrowth of the dissatisfaction which all other devices for generating electricity by friction have afforded myself, as well as others who have employed them. By those who have had experience with static ma-

drying the air contained within the case (on account of the rubber-packing between all the joints of the case, which almost hermetically seals it), I have found it desirable to use this or some other means of artificially drying the plates *during the summer months*; because the air is then excessively laden with moisture. To allow of the introduction of a tray, containing chloride of calcium, without opening the doors of the case, I have been forced to modify the wood-work of the machine somewhat, and I have also raised the lower level of the stationary glass plates about two inches. By this means I can now slide a tray of nearly the whole width of the case, underneath the plates, and thus expose the air within the case to a large absorbing surface which deprives it of moisture very rapidly.

I hope in time to so perfect my system of packing the joints and the openings in the case (entailed by the parts of the machine which must of necessity perforate it), as to make it absolutely air-tight at all seasons of the year. When this feat is accomplished, the necessity of chloride of calcium* or any artificial dryer within the case will have been entirely dispensed with; but until cabinet-makers can be found who never

*In several instances I have known the *chloride of lime* sold in commerce to be placed within the case of a static machine. The result has been to almost ruin the metal parts of the machine. It took a mechanic nearly a week in one instance to restore the effectiveness of the instrument.

"chines, it is generally conceded that they are frequently charged with difficulty and give but a feeble spark during damp weather; and that they are particularly unsatisfactory and of little service during the summer months, when such conditions are liable to prevail. It is also conceded that some form of motor is generally required to run a machine of large size, because the hand is soon fatigued in overcoming the friction of the plates upon the rubbers in addition to that produced by the by the bearings of the axle, and the belt which connects the driving-wheel with the axle. Furthermore, it is now well recognized that plates of large size (16 to 24 inches in diameter), and several of them, are absolutely essential to a machine which is intended for medical use. Small single-plate machines do not give sufficient quantity or length of spark to be of any practical benefft as a curative agent. Again, it has been found by experience that building a glass case over a static machine does not thoroughly protect the plates of the instrument from dampness. No cabinet-maker can make joints of wood which will not admit of much moisture when the outside air is impregnated with it; and chloride of calcium, if placed within the case, will not absorb all the dampness that enters and collects upon the plates and metal of the machine.

"I found by experience that all the electrodes of a static machine (being insulated by glass) were liable to be easily broken; and that the poles of the instrument, when by accident exposed to outside violence

make mistakes, or a better material than highly finished and shellaced wood† can be obtained from which to construct the frame-work of the machine, I fear this scheme will never be perfectly accomplished. Practically, however, this necessity is not so great as it might at first seem; because during the summer months the diffusion of static electricity into the atmosphere is so great as to seriously interfere with a satisfactory application of this agent to a patient by the methods known as "insulation," the "indirect spark," and the "static wind," in spite of a perfect generator. These methods, as well as other forms of application of static electricity, will be described later.

In other respects than those enumerated, the modified Holtz induction machine introduced to the profession by myself some time since remains practically unaltered. Its effectiveness seems to have been pre-eminently satisfactory to those who have used it, and the quantity and length of spark which can be elicited is as nearly an approach to the maximum of its theoretical quantity and power as could be hoped for.

† It has been computed that fifty coats of shellac-varnish are requisite to prevent the penetration of gases through stone.

"or a blow, were also liable to cause a breakage of the glass windows in the case of the machine (which they perforate in most of the later models).

"In some machines, the case is, moreover, too small for the plates and allows of an escape of more or less of the electricity generated. The first machine which I made upon the present plan had this objection. It would give the operator an occasional shock in consequence of this defect when the hand was used as a motor, and it lost a large percentage of the volume of electricity generated by "grounding" that proportion which jumped to the metal parts of the case.

"Without entering further into numerous difficulties which I have had to encounter and overcome, I may summarize the more important improvements made in the machine shown in the accompanying cut, as follows:

"(1) The case is so constructed that all of its joints are *packed with soft rubber* before its screws are tightened. This prevents the entrance of moisture from without, and makes the machine a useful one at all seasons of the year. Soft rubber now constitutes the best packing for steam apparatus, and is also used in hermetically sealing fruit jars in preference to any known material. All imperfections in the joints of the case are perfectly sealed in this instrument.

"(2) The *doors of the case* are so arranged as to be drawn tightly in contact with a frame covered with soft rubber by means of milled screws.

"(3) The glass in the case is put into the frames with putty, which is impervious to air.

"(4) The poles of the machine perforate the wooden portion of the case, instead of the glass windows. They are insulated with hard rub-

No static machine can give off a spark greater than the radius of the revolving plates. I have frequently demonstrated a spark of eleven and a half inches from a wheel of twelve-inch radius. Furthermore, I think I can justly claim to have so improved all previous models built on the original Holtz-plan, as to ensure a continuance of the charge throughout nine months of the year without recourse to artificial means for drying the plates. When properly cared for and handled, there is little necessity even for a charger during these months.

Before I pass to the consideration of static electricity as a therapeutical agent, it may be well for me to state that the cost of a static induction machine with plates of twenty inches diameter or over must of necessity be large; although the cost has been materially reduced of late by competition and improved methods of manufacture.

Again, it is impossible to transport a static induction machine from house to house without danger of breakage and the employment of a cartman; hence it becomes a part of a physician's office outfit only, and cannot be used in medical practice except by bringing the patient to the machine or going to some expense and risk in transporting it.

Finally, a static machine of the induction model requires a certain amount of care; otherwise the effectiveness of the instrument is liable to deteriorate, and its component parts to become more or less injured.

There is another form of static machine (already described

"ber, and the apertures are protected by soft rubber packing placed between hard rubber buttons and the wood. Thus the danger of breakage of the case by accident is decreased without impairing its impermeability to dampness or allowing of leakage of the electricity generated when the machine is in use, while the strength of the case is materially increased by this modification.

"(5) The axle is so built as to reduce the friction to a minimum and to allow of its being oiled without opening the case.

"(6) The driving-wheel is very large, and rests upon a cast-iron support. This insures both ease of motion and durability.

"(7) The glass plates of the machine are nine in number. Six of these revolve, and three are stationary. The stationary plates are of peculiar shape. The revolving wheels are made of carefully selected glass, so as to be as true as possible and bear evenly upon the rubbers as they revolve.

"(8) The excitants consist of cat-skin rubbers so *arranged as to touch the outer plates* when the machine loses its charge. This charger is a great improvement over all others previously employed by me. Metal buttons are also placed upon the outer plates, which as materially assist in charging.

as the Toepler model), which has been sold extensively to the profession. It has no case to protect it from the atmosphere. It can, therefore, be more readily transported, and it costs much less to manufacture than the induction model; but, on the other hand, it is far less effective, and cannot be favorably compared with the more expensive machine as a part of a physician's office outfit. The *quantity* generated by such a machine is necessarily small; and it is more or less seriously affected by atmospheric changes. In spite of the fact that some of the later authorities on electricity speak in its praise, I cannot give it an unqualified indorsement. It may serve the requirements of scientific institutions admirably; but it is, at best, but a make-shift for the neurologist. I think that I am sustained in this opinion by those who have had experience with the two models, when provided with all their latest improvements. I have been experimenting for some months to devise a cheap static machine, which patients can use at their homes, and I think I have succeeded in producing a tolerably effective instrument; but I should never advise a physician to purchase one for his own use, if he could afford to buy an improved Holtz induction machine.

A STATIC OUTFIT.

The cost of an improved induction machine of the latest pattern varies from $250 to $350, according to the size and number

"(9) The collectors have tinsel attachments which aid in gathering the electricity generated.

"(10) The electrodes are made with handles composed of hard rubber instead of glass. They are therefore less liable to be broken, and are as perfectly insulated.

"(11) Each machine is provided with three pairs of Leyden jars of different sizes. It is arranged also with hooks upon which the electrodes may be hung when not in use.

"In conclusion I would say that I have produced with the machine here described (24 inch plates), and now in my office, a spark of eleven inches in length during a muggy day in August, when most static machines would fail to charge. It runs, after a few turns by the hand, for nearly a minute without any power, and generates without interruption. Any boy of seven years of age can run it without fatigue for half an hour.

"Respecting the uses of static electricity in medicine, I would refer the reader to my lectures, lately published in the *N. Y. Medical Journal*.

"The machine here described is manufactured by Waite & Bartlett, of this city, who have been industriously occupied for several months in perfecting it under my guidance.

"The cost of this machine has been materially reduced from the schedule prices of other makers for similar instruments, rather than increased by the improvements made."

of the plates; hence this is a matter to be carefully considered before purchasing one. It is advisable, in my opinion, to have not less than six revolving and three stationary plates. The revolving plates should not be below twenty inches in diameter. I prefer one with twenty-four inch plates, for medical purposes, over those of less power.

The *attachments* which should be purchased with such an instrument comprise:

(1) An *insulated platform.* These may be made to seat one, two, or more persons at a time. I use for legs the heavy glass insulators employed by telegraph companies upon their poles. They are very strong and cheap, and have another advantage, namely, that they can be screwed up and down upon a wooden pin which perforates their central orifice. This admits of leveling the platform, in case the floor of the room has settled.

(2) A *set of electrodes.* This item comprises a large and small brass ball, a metal point, a wooden point, a roller of metal and of wood, an umbrella-electrode, some sponge-covered electrodes, a pistol-electrode, and a ring to hold the chain away from the patient during the applications. The handles should be long, and made of hard rubber or of glass.

(3) A *set of brass chains* of varying lengths.

(4) A *set of hooks* for attachment to the ends of the chains.

(5) A *set of heavy insulated rheophores* of varying lengths.

(6) *Three pairs of Leyden-jars* of different sizes. I use those of 3 inch, 1½ inch, and 1 inch diameter, respectively.

(7) A *wooden chair* or *stool* which fits the insulated platform.

(8) A *connecting brass rod,* for use when the Leyden-jars are employed.

(9) Some pieces of cat-skin.

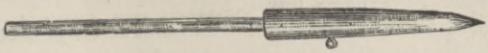
(10) Several bottles of well-selected chloride of calcium.

THE CARE OF AN INDUCTION MACHINE.

A few suggestions of practical value may be made upon this subject.

It is advisable, in the first place, that an induction machine should be placed in a perfectly dry room, *well lighted by the direct rays of the sun*; and, when possible, in close proximity to a window which shall allow the sun's rays to fall directly upon the glass plates of the instrument. By this step we obviate dampness, and thus ensure the greatest effectiveness of the machine.*

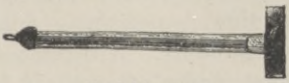
*I have my own in a bay-window where the afternoon's sun has free access to it.



Carbon Electrode, round end.

One and a quarter inch Brass Ball.

Brass Brush.

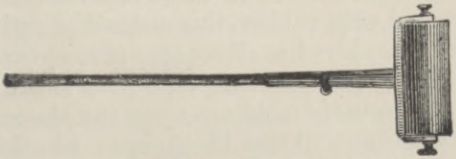


Rubifacient.

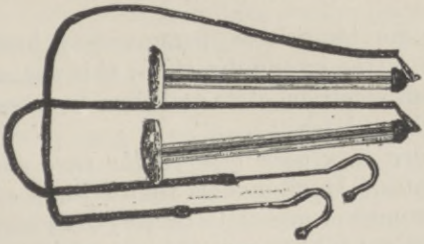
Wood Ball.

Wood Point.

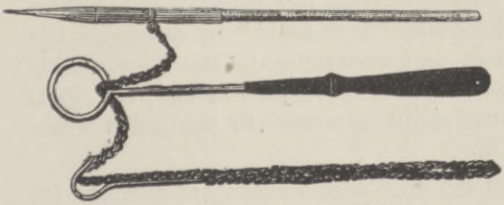
Two and a quarter inch Brass Ball.



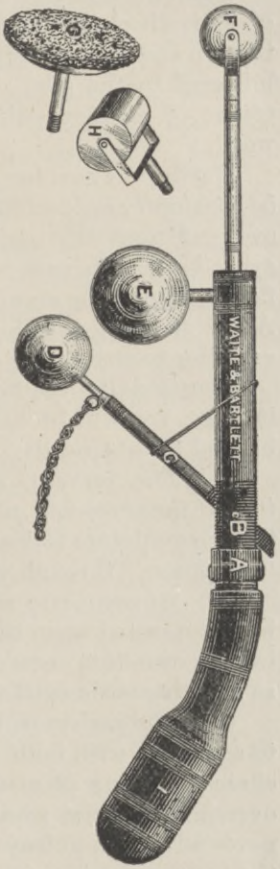
Spinal Roller for Massage.



Handles and Sponges.



Brass Point, and Chain Holder.



Morton's Pistol-Electrode.

FIGURE 12.

In the second place, the *metal parts* of the machine and the metal electrodes should be *rubbed briskly every morning* with dry chamois-skin or silk. Accumulated moisture on the poles or electrodes is a serious drawback to successful static applications.

In the third place, although the *metal parts* of the machine are shellacced when made, they are apt after a lapse of time to require *re-polishing* with emery-paper, powdered emery, or rotten-stone. A light coat of shellac varnish should be given these parts after their brightness has been restored, and all grease or moisture thoroughly removed from them.

Again, it becomes necessary, at intervals, to *oil the bearings* of the wheel-axle and the plate's axle; also to occasionally tighten the leather belt,* and to re-shellac the case if it becomes blistered by the sun. The latter step tends to exclude the entrance of moisture within the case through the pores of the wood.

During the summer months *fresh chloride of calcium should be constantly kept within the case.* It should be renewed whenever sufficient fluid appears in the tray to become evident to the eye. Unless the case is packed with rubber, this method of artificially drying the air must be employed at all seasons of the year. A few drops of petroleum on the floor of the case help to prevent the accumulation of atmospheric moisture upon the plates.

Occasionally, the best machine will lose its charge. Should it do so, you will probably find that one of the following causes has led to this result:

(1) The servant, or some inquisitive person, may have *turned the revolving plates in the wrong direction*; this causes the accumulators to lose their electrical state and thus to arrest "induction" through the glass plates.

(2) *Atmospheric moisture may have entered the case* and been deposited upon the plates. In all models that I know of, but my own, this occurrence must of necessity be very frequent, as no safeguards exist to prevent it.

(3) The instrument may have been left, after an application to a patient, with both the *poles "grounded"* by means of the chains dangling from them and resting upon the floor. This oversight may not prove serious in dry, cold weather; but, it is never advisable to leave the chains attached to the poles when the instrument is not in use.

*Thumb-screws beneath the driving-wheel post are provided for this purpose in my model.

(4) The plates may have loosened from the axle; and, in consequence, some may fail to revolve properly. To obviate this occurrence, double nuts should be used on the plate-axle.

(5) The *combs may have become displaced*, so as to touch the glass or to bear an improper relation to the paper collectors.

(6) The *case may be too small* for the plates; and thus allow of escape of the electricity to the ground. This will be very apparent to the eye when tested in darkness.

THE CHARGING OF A MACHINE.

It is well to know what steps are necessary to start a static induction-machine, in case it loses its charge. I have seen a few instances where the owner of such an instrument has worked himself into a heat of passion as well as of body by fruitless attempts to obtain a spark, while a patient calmly waited with expectancy for the successful termination of his feat. Some of you may have had such an experience. I suggest, therefore, that you follow the directions given, with some regard to their details:

(1) See that the *plates and charger are dry.* If not, you can easily render them so by exposing the machine to strong sunlight, and by putting an abundance of chloride of calcium in trays at the bottom of the case. This may require some hours of delay. Always open the door of the case if the sun's heat be used; and *close them tightly* (by means of the milled-screws which perforate the door) as soon as the machine regains its charge.*

(2) After you have got the plates thoroughly dry, start them in rapid revolution, by turning the driving-wheel *from left to right* as you stand facing it. Now *apply the chargers lightly near to the edge of the revolving wheels for a second or two*, and then sweep them across their face at intervals of a few seconds,

* If you cannot spare the time for these procedures, a large alcohol lamp may be lighted within the case. The air may thus be heated sufficiently to temporarily render the machine useful. I am aware that I have been criticised (in a carping spirit) for offering this suggestion in print; but, as a *temporary expedient*, it oftentimes proves a valuable aid in rapidly regaining a lost charge, and rendering an induction-machine efficient.

I have frequently known the nozzle of a hot-air furnace (such as is used in giving a hot-air bath to a patient beneath the bed-clothes) to be directed into the case of an induction-machine for the purpose of drying the plates when very damp. At one time I tried to build a machine with a tube passing through the case, by means of which the air in the case might be heated indirectly without opening the door; but I found it impracticable, for many reasons.

until the machine starts. The poles should be approximated to within one half-inch, and the chains should not be connected with the poles.

(3) If the machine fails to start, in spite of these directions, you can then *take a piece of cat-skin* and *warm it thoroughly over a gas-jet.* Then set the wheels in rapid revolution and apply the warmed catskin as a rubber (to the plate with the buttons on it) as *close above the metal comb* as it is possible to hold it. This seldom if ever fails; but it requires the opening of the door of the case.

(4) Be sure that the *poles are well dried* with chamois-skin before the machine is put in action; also, that the poles are closely approximated but not in contact.

METHODS OF APPLICATION OF STATIC ELECTRICITY.

Static electricity can be applied in several ways to a patient. Each of these methods has some therapeutic effects which are peculiarly its own. Moreover, the sensations experienced by the patient during the application are greatly modified by the method employed. For these reasons, it is necessary to go into

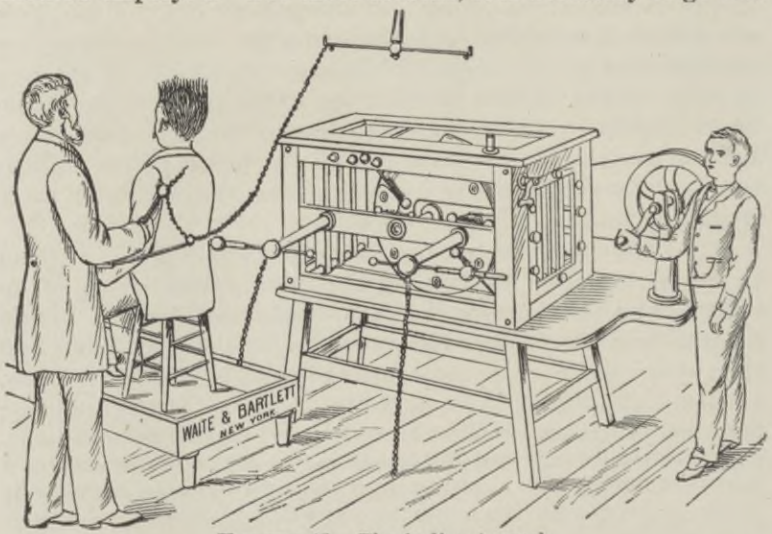


FIGURE 13.—The indirect spark.

greater detail respecting the management of a static machine than that of any other electrical apparatus in medicine with which I am familiar.

We can apply apply the static current to a patient in the following ways:

(1) By the "*indirect spark.*"

(2) By the "*direct spark.*"
(3) By the "*Leyden-jar spark*" or "*static shock.*"
(4) By "*static insulation.*"
(5) By the "*static breeze.*"
(6) By the "*static induced current.*"

THE INDIRECT SPARK.—To administer static electricity by this method, the patient is first placed upon the insulated platform, and sufficiently removed from all surrounding objects to prevent the escape of the charge from the patient to them. The machine is then connected with the patient by a chain, which is either held or simply attached to the stool on which the patient sits. The chain must be sufficiently elevated from the floor to prevent "grounding" of the current. It may be attached to either the positive or negative pole of the machine, according as the operator may desire positive or negative insulation. A chain is then attached to the other pole of the machine, and is "grounded." This can best be effected by attaching it to the gas fixture or a faucet attached to a constant water supply. If this is not convenient, the chain may be thrown upon the floor, when not carpeted, in case the generating power of the machine is ample.

The *poles of the machine are now widely separated* and the wheels put in rapid motion. You will notice that the hair of the patient immediately rises; and, in a dim light or total darkness, you should perceive a peculiar purplish light escaping from the tips of the finger-nails, the hair, and other parts of the body which are more or less pointed. The rapidity of this escape is influenced, (1) by the extent of the charge; (2) by the proximity of a part to some surrounding object; and (3) by the condition of the atmosphere, as regards its moisture. As the patient moves his finger-tips near the door-casing or some article of furniture not insulated, some of you may be able to perceive this escape of electricity, even in this strong light.

Now we have a condition which is known as "static insulation." If the machine is a powerful one, it may be carried to a high point. The patient happens to be charged, in this particular instance, with positive electricity, because he is connected with the positive pole of the machine.

The final step consists in presenting to the part which you wish to influence a brass ball on the end of an insulated handle. This electrode is connected, as you see, with a gas pipe by means of a brass chain. A water pipe makes an equally good connection. When this ball reaches a certain degree of proximity to

the patient,* you notice that a discharge of the accumulated electricity occurs in the form of a "spark." This is known as the "indirect" spark; because the electricity takes an indirect course (through the earth) to form a circuit. It leaps from the patient and escapes to the earth down the gas-pipe or whatever grounding the electrode may chance to have.

The *length* of the "indirect" spark is directly proportionate to the *generating power of the machine*—supposing, of course, that all other factors in the application are equal (such as the humidity of the atmosphere, the completeness of insulation, etc.).

The *volume* of the spark is modified by the *size of the brass ball* on the end of the electrode. A large ball will produce a heavier spark than a small one.

The therapeutical effects of this method of application will be discussed later. I would call your attention, however, to the violent muscular contractions which occur with each spark.

This method is somewhat painful. The withdrawal of a spark leaves a "weal" or lump, which somewhat resembles a recent mosquito-bite. They almost entirely disappear when friction is employed after the application; hence, it is my custom to rub the part with my handkerchief, if exposed, (the face or hands, for example,) after the application.

I would caution you here, in passing, against giving static sparks (by any of the three specified methods) to a patient on his first visit. You are apt to frighten a patient, unless he is well prepared for it. Again, patients grow tolerant of this method of treatment after a while; hence, you can gradually increase the volume and length of spark at successive sittings without endangering the patient's confidence in you or creating alarm. You can regulate the length of the spark by the speed of revolution of the plates of the machine.

For some hours after such an application the patient feels a sense of heat at the spot where the spark occurred. This is not at all unpleasant to many. Some patients even speak of it as agreeable.

By using a *wooden ball* in place of a brass one, a number of very fine sparks are simultaneously elicited—giving to the patient a feeling aptly compared to a "shower of sand." This electrode is admirably adapted for use about the eye or the face, although this is not the limit of its usefulness.

*The length of the spark elicited depends on the power of the machine, the dryness of the atmosphere, and the perfection of the insulation of the patient. I frequently have drawn a spark of eight inches by this method.

Finally, it is not essential to this form of application that the clothing be removed; as the finest silk or woolen fabric is not injured by it. This is a great point in favor of static application, especially in the treatment of females.

Perhaps you have noticed that I use a second electrode with a *ring of brass* attached to the insulated handle, through which the chain is passed before it is attached to the ball-electrode. This is to keep the chain away from the patient, so that sparks will not be caused at points where you do not desire them to occur. A little practice will enable you to handle both with one hand, while you turn the wheels of the machine with the other. Sometimes it may be necessary to have the patient stand rather than sit upon the insulated platform while these applications are being made.

Let us pass now to the second method enunciated.

THE DIRECT SPARK.—By this method, the circuit between the poles of the machine includes the patient only. He sits on the insulated platform, which is connected with one pole of the

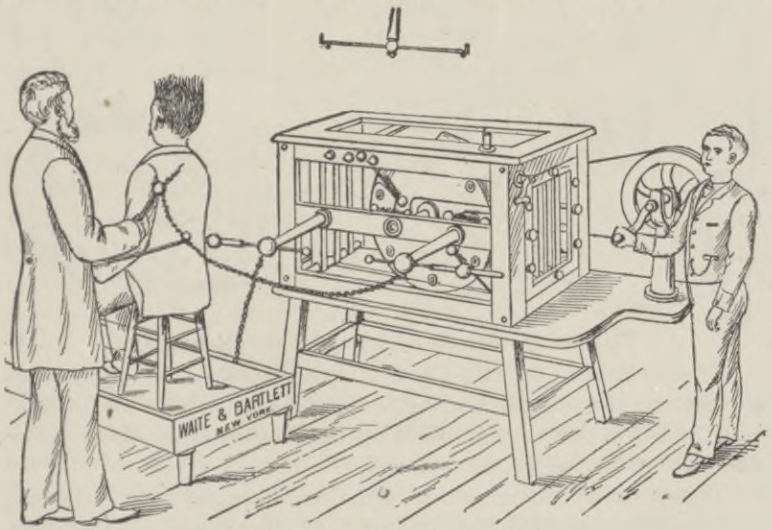


FIGURE 14.—The direct spark.

machine; or one pole may be directly attached to some particular extremity of the patient, when the effects of the current are to be concentrated as much as possible upon that member. The electrode is attached to a chain, which is fastened to the other pole of the machine. The length of spark to be administered is regulated by the *extent of separation of the poles of the ma-*

chine and the speed of revolution of the plates. The further apart the poles, the longer and more severe is the spark.

The ring electrode is employed (as in the former method) to protect the patient from an accidental contact with the chain attached to the electrode.

In neither this nor the method previously described are Leyden-jars employed.

I question, personally, whether the selection of the poles for the attachment of the electrode has much, if any, influence over the therapeutical action of the "direct" spark. If it has, I have not as yet clearly formulated in my own mind any deduction respecting this point.

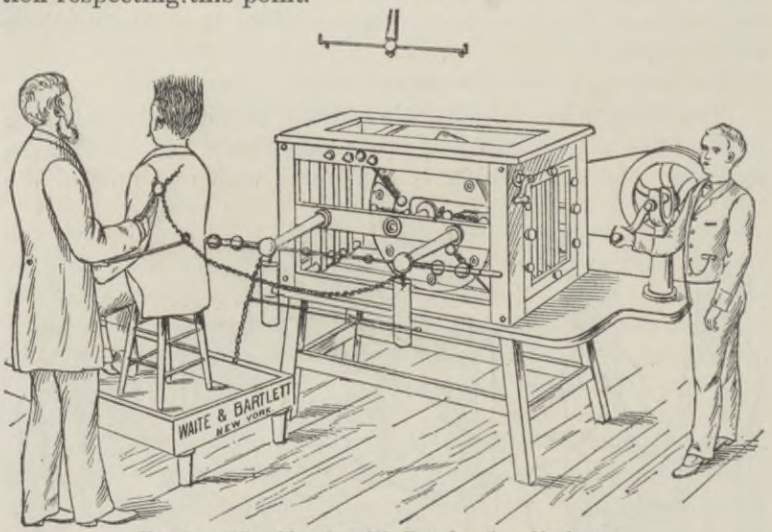


FIGURE 15.—Shock with Leyden-jar discharge.

STATIC SHOCK, OR THE LEYDEN-JAR SPARK.—This method of application is accomplished by first *attaching a pair of Leyden-jars* to the poles of the machine, and *connecting their outer covering of tin-foil by a brass rod.*

The poles of the machine are then brought into close approximation; because the strength of the shock is modified, (1) by the *size of the jars,* and (2) by the *separation of the poles.*

As this method is, at best, a very severe form of application, it is well to begin with very small jars, and to place the poles as nearly in contact as possible (without actually touching each other). They can then be separated at will, as the exigencies of the case seem to demand.

The chains are arranged in a similar manner to that described in the preceding method (direct-spark application).

This method is best applied to the bare skin. The polarity of the electrode is not, to my mind, a matter of much consequence.

I advise you to handle this form of treatment with extreme caution. I have several times accidentally received a moderate static shock, and I can assure you it is not associated with pleasurable sensations.

STATIC INSULATION.—This method has already been described in connection with the administration of the "indirect spark." It is perhaps the most agreeable of all methods of static treatment. The patient is simply charged for a variable space of time (three to twenty minutes) with either positive or negative electricity. The pole of the machine is attached to the insulated platform on which the patient sits or stands. The other pole is "grounded" by a brass chain, running to the floor, a water-pipe, or a gas-fixture.

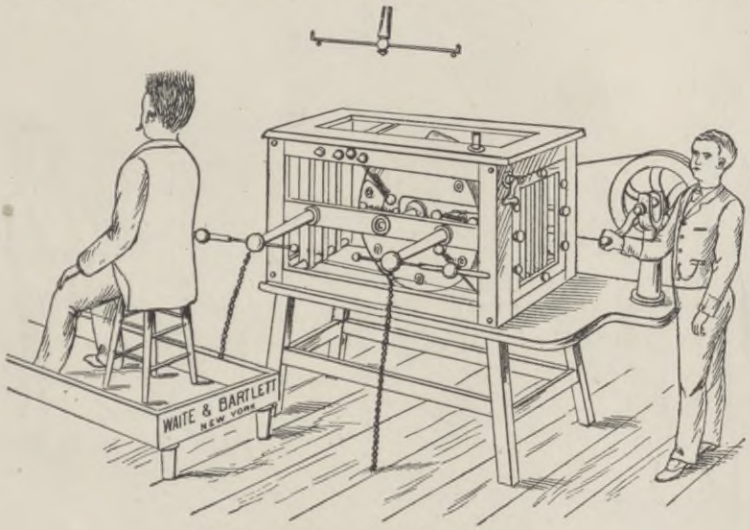


FIGURE 16.—Static insulation.

The *poles of the machine are as widely separated as possible*, before the wheels are set in revolution.

No pain is experienced. The hair becomes erect, unless very much oiled. The patient experiences a peculiar "tingling sensation," with a tendency toward perspiration, if the administration is long-continued. If you approach the patient too

closely, a spark is elicited at the nearest point. This should be avoided, if possible.

Its therapeutical effects will be discussed later.

THE STATIC BREEZE.—This method of administration of static electricity consists in the withdrawal of a static charge from a patient by means of an *electrode of metal or wood, which is pointed.*

If the breeze be *indirectly* induced, this electrode is grounded by a chain attached to a gas-pipe, a water-faucet, or placed in contact with a wood floor when the other connections are not easily accessible. The patient is first insulated (in order to retain a charge), and is then connected with one of the poles

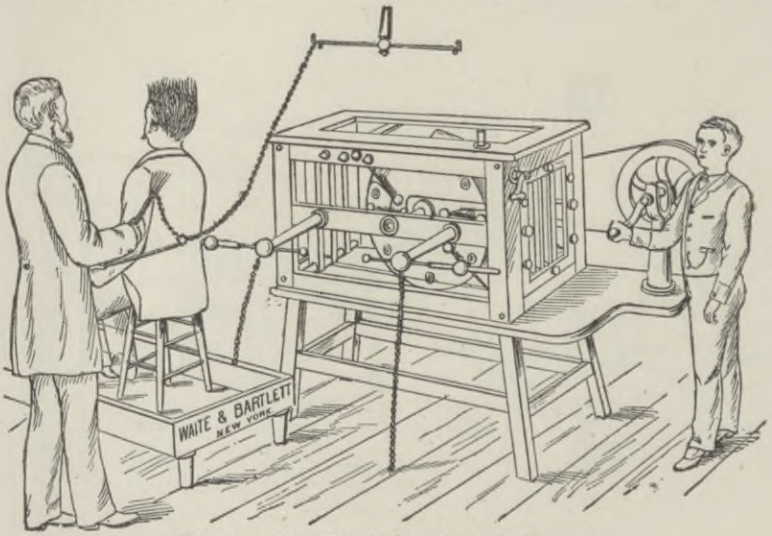


FIGURE 17.—The indirect static breeze.

of the machine by means of a chain, which he either holds or fastens to the platform upon which he sits. The electrode is then employed.

When the breeze is *directly* induced, the insulated stool is connected with one pole of the machine, and the electrode with the other pole.

If the electrode be *a metal one*, the electricity is drawn rapidly from the patient at the point which is nearest to the electrode, and a sensation resembling that of a breeze is experienced at the spot where the electricity escapes. Single or multiple points may be employed on the electrode.

In either of these methods, when the electrode is *composed*

of wood, the sensation is modified, to a certain extent, by the poor conductivity of the wooden point. Most patients compare the effect of such an application to a "shower of sand" concentrated upon the point of withdrawal of the charge.

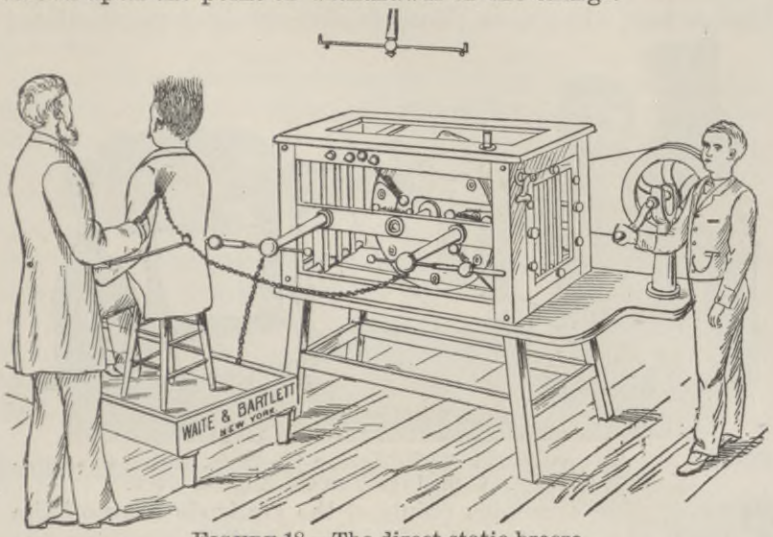


FIGURE 18.—The direct static breeze.

When this method is employed about the eye, the wooden ball or wooden point is usually preferable to one of metal.

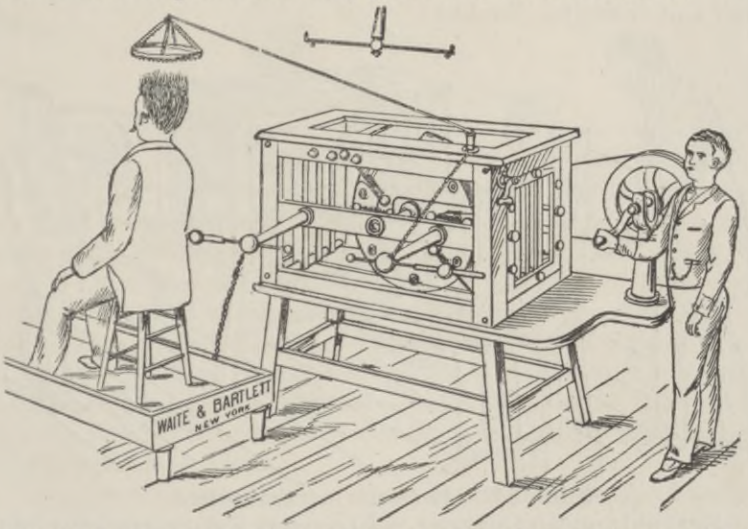


FIGURE 19.—The electrical head-bath, a variety of administration of the static breeze.

When application to the head and scalp are deemed requisite, a metal cap studded with points is hung over the head of the patient by a chain, which is grounded. This cap is known as the "umbrella electrode." It should not touch the patient's head or hair, when he is placed beneath it upon the insulated

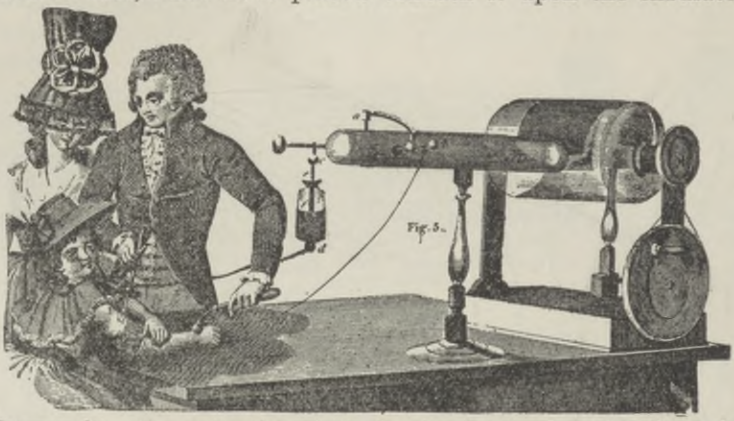


FIGURE 20.—An application of the Leyden-jar shock during the eighteenth century. Copied from an old English work.

platform. The numerous points of the electrode draw off the electricity through the hair and scalp, which passes from the machine to the patient, and produce a sensation which is particularly pleasant. A "strong wind" is felt permeating the hair and encircling the head.

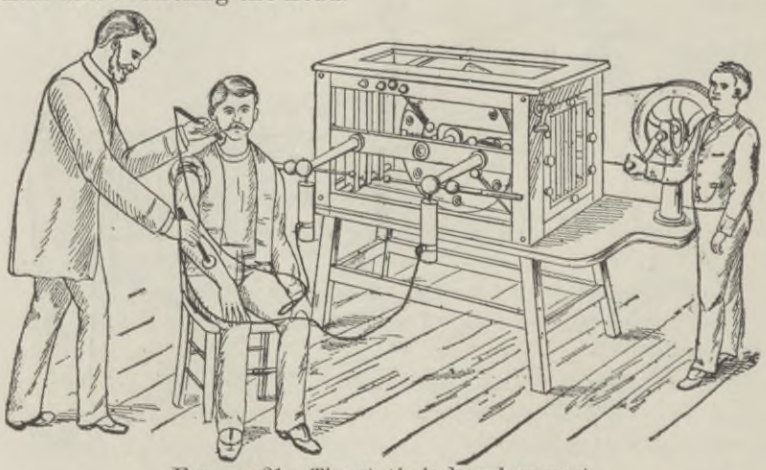


FIGURE 21.—The static induced current.

STATIC INDUCED CURRENT.—To convert a static machine into what, to all practical purposes, may be considered a "Faradaic" instrument, some slight modifications only are required.

The discovery of this method may justly be attributed to the investigations of Professor W. J. Morton, of New York; although Matteucci first devised an instrument which gave shocks by induction simultaneously with the discharge of a Leyden-jar (see Figure 795 of Ganot's work on Physics, by Atkinson).

To produce this form of current, it is necessary to first *hang a pair of Leyden-jars* upon the arms of the machine. The size of the jars employed modifies the strength of the current; hence it is necessary to have jars of different sizes as a part of a static outfit. You now attach the chains or, by preference, insulated wires, which serve to connect the machine with the patient, *upon the hooks that rest upon the outer coating of the jars.* Finally, you attach to the other end of each rheophore an electrode for use upon the body of the patient. The electrodes may be of metal without any covering, or ordinary sponge-covered electrodes may be employed (care being taken that the insulating handles are somewhat longer than usual).

FIGURE 22.—Morton's pistol-electrode.

Before the machine is set in motion, *its poles should be approximated closely.* This step is important; because the separation of the poles intensifies the current, as long as a spark will pass between them. There are two factors, therefore, in determining the strength of the static-induced current:

(1) The size of the jars.

(2) The extent of separation of the poles.

Dr. Morton has devised an ingenious electrode which allows of an application of this form of current to a patient without disturbing the poles of the machine; but it is not an essential part of a static outfit, because an interruption of the current can be accomplished without it.

This electrode represents a simple mechanical means of putting into practice the method discovered by him in 1880, of converting the static electric charge into dynamic electricity or

current. Electric nerve-and-muscle reactions had previously been obtained by means of the interrupted galvanic and the Faradaic currents. It had also been noticeable that the "spark" discharged on a nerve motor point, or over a muscle, produced the characteristic reactions. But the spark was painful, and difficult to direct accurately, particularly about the face and head. To avoid these objections, Dr. Morton arranged this electrode, by means of which the disruptive discharge or spark of static electricity takes place between two brass balls, one of which is in relation with the "ground," while the other is connected to an ordinary moist sponge electrode. This in turn is applied at the point desired of the patient charged on the insulated platform.

As a result, for every static discharge occurring between the two brass balls there is a dynamic discharge or current at the point where the sponge is applied, and nerves and muscles may be stimulated, or rather "irritated," exactly as by the ordinary interruptions of battery currents, direct or induced.

This electrode is another means of converting static into dynamic electricity, based upon the principle described under the name of "static induced current" by Dr. Morton.

This "static induced current," as has been already stated, was obtained by attaching ordinary sponge electrodes by their connecting rods to the outer layer of tin-foil on the Leyden-jars. The patient, in other words, replaced the usual connecting rod between these coatings. On putting the machine in motion and causing a spark between the poles, a "current" was felt by the patient, no insulation of course being required. The advantage of this method is that the ordinary Holtz machine may when required be called upon to perform the work of an an ordinary Faradaic or induction machine.

The greatest event after its discovery, in the history of medical statical electrization or Franklinism, was the invention of the Holtz or induction machine, in 1865. Next in importance, perhaps, is the method discovered and put into practice by Dr. Morton, in 1880, of converting the static discharge into a dynamic discharge or current; and the electrode represented in the above cut is the only novel electrode of any importance not bequeathed to us by the medical electricians previous to 1880.

The difference between the "static induced current" and the Faradaic current is this: The former has a *fixed polarity and direction*, and *greater electro-motive force*. It is far less painful, also, than is the Faradaic current when the electrodes are widely separated.

My attention has lately been drawn by Dr. Morton to another device of his for the preventing of the escape of sparks from a sponge-covered electrode while employing the static induced current. It consists in applying a coil of copper wire closely upon the flat surface of the metal end of the electrode which is covered by the sponge. This is done in order to prevent the concentration of the current at any one point on the surface of the electrode, while in use.

He has also been experimenting of late upon the effects of deriving currents for medical purposes from a helix of insulated wire wound upon each of the Leyden-jars of a Holtz induction-machine.

I have not yet tested the working of either of these later appliances; but I shall do so soon, when I am provided with the necessary apparatus.

STATICAL ELECTRO-THERAPEUTICS.

We have now discussed at some length (1) the physics of this form of electricity; (2) the improvements made from time to time in machines designed to generate it; and (3) the various methods of application of this agent.

We are now prepared to consider more intelligently the various diseased conditions of the human body which static electricity has been shown either to ameliorate or arrest. In this connection I take the liberty of first quoting from an admirable paper of my friend, Dr. Morton, published some years ago upon this subject, a few paragraphs which relate to the rise and fall of static electricity as a therapeutical agent. He says:

"In 1730 Mr. Stephen Gray, of London, first insulated and electrified a human subject, and in 1734 the Abbé Nollet received the first spark drawn from a body thus insulated. From this incident undoubtedly sprung the modern idea of electro-therapeutical science, for Nollet pursued electrical investigations to great lengths, and as early as 1746 was treating paralytics by insulation, sparks, and shocks. About this time, also, Professor Kruger, of Helmstadt, and Kratzenstin, his pupil, cured paralysis by electricity, and Klyn cured by means of sparks a paralyzed arm. These cases were the first strivings of modern electro-therapeutics, but they produced little effect on medical practice.

"It was a publication in 1748 by Jallabert, professor at Geneva, that first drew the earnest attention of the medical world to the real curative power of electricity. Jallabert restored to perfect motion and sensation in two months a locksmith's arm which

had been paralyzed during fifteen years. In the meanwhile the invention and perfecting of the electric machine and Leyden-jar paved the immediate way to the practical use of electricity as a remedial agent, and soon, following the success of Jallabert, the whole medical world was awake on the subject of medical electricity. At Montpelier, under the auspices of Sauvages, president of the Academy of Medicine, the people flocked in multitudes to have their ailments relieved, and so great was the number of successful treatments that the physicians were obliged to appeal to the priests to protect them from the charge of witchcraft. Deshais, in 1749, wrote a dissertation upon the Montpelier experiences. Quelmalz, Linnæus, and Zetzel followed him, and from this period onward up to the year 1800, works* on the subject multiplied in all countries.

"It is interesting to recall that Franklin, in 1752, treated paralytics at Philadelphia by statical electricity.

"It is evident, then, that statical electro-therapeutics was already, at the end of the last century, entering upon a marked career of service to medicine when galvanism and the voltaic pile, in 1800, extinguished it at the very height of its progress. It is not improbable that its abandonment was a loss to medical science.

"Up to comparatively recent times frictional electricity for medical purposes was produced from a single glass wheel. Its *tension was low* and its *quantity small*. But the invention of Holtz, in 1865, marked out for modern statical electricity the possibilities of a new career. In the Holtz machine we have an apparatus simple and durable in construction and capable of furnishing electricity of high tension and in great quantity. And by means of the Leyden-jar condensers, and of the possibility of increasing the number of wheels, both tension and quantity are within the control of the operator. At a given length of spark or tension, every additional wheel adds only to the quantity, and Holtz machines, with as many as twenty revolving wheels, have been constructed, in which the quantity, of course, was very great. This very fact of a greatly increased working quantity of statical electricity justifies the expectation that modern electro-statical therapeutics will take a step greatly in advance of its past.

"Statical electricity, as we have already seen, has never had fair play in modern medicine. The older practitioners (1740 to

* Besides those mentioned, the most important are by De Haen, Watson, Franklin, Priestley, Gardane, Sigaud de la Fond, Bertholon, Cavallo, Wilkinson, and Manduyt; the latter is particularly valuable to the student of medical statical electricity.

1800) have left us glowing records of its value—records embodied in a period of literature still full of fruitful suggestion in other branches of medicine, though in none more advanced than in the treatment by electricity. The physicist of to-day cannot neglect the work of Franklin, of Symmer, of Du Faye, of Cavendish, and the long line of the men of their time who unrolled to view the mysteries of a new science. No more can the physician neglect, from a medical point of view, De Haen, Boze, Bertholon, Nollet, Wilkinson, Cavallo, Manduyt, and a dozen others. True, the mantle of their labors decked in a degree the new galvanism and the newer faradism, while in the act statical electricity dropped from sight. It found conscientious revivers in Sir William Gull, Golding Bird, and Wilks in 1850, and thereabouts, and it is gratifying to note in their writings the highest appreciation of its merits. When at last it fell from their hands again abandoned, it was only and simply because of the inconvenience of administering it. The machine of their day refused to work in the damp of London fogs, and it was necessary in the electrical room of Guy's Hospital to keep a large fire constantly burning to dry the air; and even to-day, in Paris, one may visit the rooms of a practitioner heated summer and winter.

"But these disadvantages have now been removed. Statical electricity was again revived, and with great success, by Professors Clemens in Germany and Scwanda in Austria. In France, its revival has already received a notable impetus emanating from the famous clinic at Salpêtrière, where the presiding care of Professor Charcot and the efficient labors of Dr. Vigouroux have each contributed to place statical electro-therapeutics on a scientific modern basis."

The remarks of Dr. Morton which I have quoted are peculiarly significant in this connection. During the years in which I have personally been engaged in experimenting with various modifications and improvements upon the original model of Holtz's induction machine which have suggested themselves from time to time to my mind, I have had ample opportunities to observe in the daily routine of my practical office work the effects of static electricity upon many patients afflicted with diversified diseases. In preparing this article I have carefully searched through the records of quite a large number of cases where it has been most successfully employed by me. I have been struck in many instances with the rapidity with which it effected an apparent cure; in other cases, with the permanency of its beneficial results; and in all, with the simplicity and ease

of its application. To a lady, for example, it is a matter of no small moment that she is freed from the necessity of divesting herself of any garments worn, and that almost any part of the body can be treated without exposure or annoyance. To the busy practitioner, also, to whom time is valuable, it is not unimportant that several patients can be treated simultaneously; and that no delays are caused by waiting for each one to remove and replace their clothing.

Again, the application of "static insulation" is far more agreeable than "general faradization" or "general galvanization;" and, in my experience, it is fully as efficient in many cases in its remedial action as either of the methods referred to. The inconvenience to the patient of having to disrobe almost completely, and the distaste which many naturally exhibit to having a wet electrode or the operator's wet hand rubbed over the skin for from ten to twenty minutes is entirely obviated. With a sufficiently large insulated platform several patients can, if desired, be given a static bath in the physician's consulting room in the same period of time as would be consumed in administering general faradization to one patient and be spared the annoyances mentioned.

I do not mean to infer that some cases do not require the use of faradaic or galvanic treatment; nor would I be construed as casting any reflection upon the therapeutical value of the methods which were first suggested and employed by Drs. Beard and Rockwell of New York. The question at issue is simply one of convenience to the patient and the physician; provided that the indications of the case justify the trial of the static bath as a substitute for "general faradization" or "general galvanization."

In the second place, I think it has been justly claimed for static electricity that some of its therapeutical effects are more certainly and rapidly obtained than by means of any other form of electrical application.

As examples of such effects, I prominently mention: (1) The *relief of contractured muscles;* (2) the *relief of certain forms of pain;* (3) the *production of muscular contraction and the restoration of muscular power after the "reaction of degeneration"* has shown itself; (4) the *improvement of muscular power and general sensibility in certain organic spinal diseases;* and (5) the *stimulation of the skin in certain trophic neuroses.*

Respecting this statement, I take the liberty of again quoting certain paragraphs from the writings of my friend, Dr. Morton. He says:

"We may now ask the special question, *Why, above and beyond other forms of electricity, does statical electricity cure?* I will offer two explanations, and these are (*a*) first, simple mechanical disturbances, followed by a local alteration of nutrition; and (*b*) secondly, reflex action from irritation of the peripheral distribution of nerves.

"With regard to the first, when the electric discharge in the form of a spark, takes place in a resisting medium like the various parts of the human body which are submitted to it, a very great mechanical disturbance in the tissue at the point of discharge must inevitably result. A piece of paper, for instance, held between the electrode and the skin is perforated by the spark. A parallel to the mechanical action referred to, though in a less localized and less powerful degree, is to be found in ordinary physical exercise or in massage. From this point of view, static electricity by the method of sparks has, in a special degree, owing to its high tension, great advantages. The spark strikes a sharp, incisive, and penetrating, though scarcely painful blow, and often repeated in a given region, creates, by simple disturbance, a great alteration in the nutrition of the part. This, at least, is the only way in which I can account for the almost instantaneous relief and cure, after a few applications, of a large class of pains seated in deep and superficial fasciæ, and due to subacute and chronic rheumatism. Neither blisters, other violent counter-irritation, nor medicine, will dissipate these pains, while, on the other hand, static electricity will subdue them at once.

"The contraction of muscles is also often due to the same mechanical effect of the spark, just as muscles of the thigh may be made to contract by a snap of the finger or sharp blow from a percussion hammer.

"With regard to the second explanation—that by reflex action following a peripheral irritation of the terminal sensory filaments and endings, a very intricate question is opened, which we can no more than glance at here.

"How can simple electrification by insulation and the drawing of sparks, it is asked, produce the decided effects that are claimed for it. Static electricity, it is said, owing to its high tension accumulates merely on the surface of the body, and does not penetrate into the deeper organs, while the spark is merely the briefest kind of current.

"Recent investigations on the irritative action of applications to the skin have thrown a new light upon this question, and show that, though previously unexplained, the effects of the great accu-

mulation of electricity on the surface and the sharp blow of the spark were, in truth, effects based upon a true physiological principle, the principle named by Brown-Séquard, its recent expounder—"the phenomena of inhibition." A few drops of chloroform applied to the neck of a guinea-pig produced, on some occasions, an epileptic attack; on others, the nerves and muscles became highly excitable to stimulation.

"But the most notable effect of irritating applications of chloroform, as well as other substances, was a general anæsthesia; reflex symptoms were inhibited and muscular excitability lost.

"An interesting element has entered into our physiological and therapeutical studies—that of the reflex phenomena of peripheral irritation. And we may at once place under this single heading a large number of facts long familiar.

"External irritant applications, in one form or another, have always formed an important element in medical treatment. And most of these applications have been used to relieve pain, or in some way modify the general sensibility, either in contiguous or remote parts.

"Familiar examples are blisters, sinapisms, cupping, the actual cautery, ammonia, the moxa, aqua and acupuncture, and in latter days the magnet, the tuning-fork, and hypodermic injections of water into the thoracic walls for the purpose of allaying the cough of phthisis. The latest novelty in this direction is the electric percutor of Baudet, consisting of a tuning-fork kept in vibration by electricity, and communicating to any desired nerve or part, by means of a slender rod, the mechanical vibrations originated in the fork.

"Charcot, after cautious experimentation, has given his adherence to the statement that metals (metallotherapy) do produce effects contiguous and remote when applied to the skin—that the magnet also produces similar effects, both upon general sensibility and muscular power. Vigouroux has pointed out that the vibrations of a tuning-fork, either alone or communicated to a sounding-board, provoke similar phenomena.

"Here, then, in this collection of well known facts, and in the broad generalization of Brown-Séquard, drawn from his recent experiments, we have at last, it seems to me, found the law which governs the results produced and to be expected from statical electrification, as well as from some other uses of electricity. This law is the effect produced upon remote parts by affecting the peripheral distribution of the sensory nerves, and the effect produced is most commonly relief of pain or spasm in a remote

part, and in this principle of inhibition from peripheral application may doubtless be found the explanation of many of the definite and hitherto inexplicable effects of static electricity.

"The 'insulation' alone holds the entire sensory peripheral distribution of the skin in its grasp. Every nerve-filament is vibrating, is polarized, or affected, whatever term we choose to use, by the tense layer of electricity or electrical influence collected on the surface, there bound by the natural laws of physics, and only waiting to be drawn off by a spark or diffuse itself gradually into the atmosphere, while in the spark itself is found a still more potent and localized stimulating agent."

I have quoted the preceding paragraphs from the pen of Dr. Morton, because they coincide in the main with my own views; the possible exceptions being a few technical points in which I might not fully agree with that author.

From conversations held with him I am led to infer that his experiences and my own have been generally in accord respecting the therapeutical effects of each of the several methods of statical applications already described by me in preceding pages.

It is extremely difficult to formulate general deductions respecting any therapeutical agent. Such attempts necessarily tend to evoke criticism; because exceptions to every general statement may be brought forward as evidences of their unreliability. I am, however, inclined to offer the following general deductions respecting static electrical applications for the benefit of the reader; with the *proviso* that they may not apply to every case, and that they be not construed too literally:

First.—My experience has not confirmed the view (heretofore advanced by some authors) that the *positive pole* of a static machine has a "tonic" and the *negative pole* a "depressant" action.

I have found, after repeated experimentation, that either pole seems to answer equally well upon most patients. I commonly employ in my office the positive pole, however, because it happens to be the most conveniently connected with the patient.

Second.—As a curative agent, *I regard static electricity as of great value.*

While galvanism must always hold a pre-eminent place in electrical therapeutics, because of the chemical effects so obtained, there are certain diseased conditions in which static electricity is unquestionably superior to faradism and galvanism.

Third.—It has been shown in preceding pages that the *static induced current fulfills all the known indications of faradism.*

It has moreover two great advantages over the faradaic instrument, namely, that a constant polarity is obtained and a much greater electro-motive force. It is also less painful than the faradaic current.

Fourth.—Static electricity possesses a decided advantage in some cases where faradization or galvanization have either given negative results or have apparently lost their remedial power after their use has been too long continued.

It is a common expedient with medical electricians to shift from one form of current to another from time to time whenever the progress of the case seems unsatisfactory. Under such circumstances Franklinism forms another link to the chain; and greatly aids us when faradism and galvanism have both proven inefficient.

Fifth.—I have found *heavy static sparks to surpass any other form of electrical application for the relief of contractured muscles.*

The sparks are withdrawn from the part so affected in rapid succession for about five minutes.

Post-paralytic contracture, old deformities from preternaturally shortened muscles, and the various forms of obstinated and protracted tonic muscular spasm often yield like magic to the influence of heavy sparks.

Sixth.—It is well known that *certain forms of pain often disappear at once after static applications.*

The most marked type of pain so relieved is the so-called "*rheumatic muscular pain*," or that observed in genuine *muscular rheumatism.* I have seen many such cases where one application of heavy sparks to the seat of pain for a few minutes has caused permanent relief.

Again, *neuralgias* of a distressing kind are often dissipated after a few applications of heavy indirect static sparks for from five to ten minutes at a sitting.

Finally, I know of no other agent which exerts so marked an effect of a happy kind upon the "*lightening pain*" observed in locomotor ataxia, as does the heavy static sparks.

Seventh.—The application of the spark, both by the direct and indirect methods (Figures 13 and 14) *excites powerful muscular contractions.*

This effect is often desired in the treatmemt of *hemiplegia* and *other forms of motor paralysis.*

Some authors recommend the employment of "static shock" (Figure 16) for cases of paralysis of long standing; but, person-

ally, I am inclined to regard this form of application as too severe for most patients.

I have often obtained a complete restoration of muscular power in special nerve-trunks by static sparks alone after the "reaction of degeneration" was fully developed and all faradaic excitability had ceased.

Eighth.—Cases which exhibit a marked *impairment of sensation* (whether of touch, pain, or temperature) are generally improved, in my experience, by the use of static sparks over the anæsthetic area more rapidly than by the faradaic or galvanic currents.

I have encountered several very striking cases which illustrate this point admirably, but a lack of space precludes the insertion of their histories.

Ninth.—Remarkable effects of static sparks upon that *form of baldness* known as the so-called "*ivory spots*" or *alopecia arieta*, have been observed by myself through the courtesy of my friend Dr. F. B. Carpenter, of New York. I have seen several of his cases where he has wrought a wonderful change in the appearance of the scalp after several months of treatment of the bald spots by the "direct" spark. The growth of the hair, which had apparently been totally destroyed over the affected regions, is attributable probably to the rekindling of the circulatory and nutritive conditions of the affected area upon the scalp.

Tenth.—As a *general tonic* and also as a *stimulant to depressed nervous functions*, "*static insulation*" (Figure 16) *seems to be particularly of service.*

I employ static electricity constantly by this method in *neurasthenia*, with marked benefit.

I have observed also remarkable improvement in *disturbed visceral functions* (such, for example, as dyspepsia, habitual constipation, diabetes, vertigo, asthma, etc.) after the use of static insulation for from ten to twenty minutes at a sitting.

Many such cases have expressed to me the greatest delight at the beneficial effects which such an application invariably produced. For the past three years, I have used my static machine almost exclusively as a means of *improving the "general nervous tone" of patients*, in preference to my faradaic or galvanic apparatus. It is much more satisfactory to patients because of its ease of application; and as far as I have observed, equally effective as a tonic.

Eleventh.—I am inclined to think that those authors who have written upon static electricity as a therapeutical agent in a luke-

warm spirit, have probably been supplied with an apparatus which has been ineffective because it generated too slowly or imperfectly.

The *size and number of the revolving plates* and their thorough *protection from atmospheric changes* are factors of the greatest importance.

Many of the static machines sold to the profession are hardly more than mere toys. Any machine which gives a thin spark (even if a long one) lacks one essential factor to success as a therapeutical agent, namely, QUANTITY.

Twelfth.—I have used static insulation and sparks with satisfaction in the treatment of *chronic inflammatory and spasmodic diseases*; such, for example, as influenza, phthisis, bronchitis, asthma, laryngitis, neuritis, synovitis, etc.

Three cases of chronic synovitis of the knee-joint of an intractable form recovered completely under my care within a month, under the daily administration of static sparks to the affected joint.

Many cases of bronchitis and asthma have been greatly benefited by insulation and sparks to the chest.

I have used static insulation (followed by the withdrawal of sparks from the spine and abdomen) upon subjects afflicted with dyspepsia, flatulency, and constipation. In many instances this form of electrical treatment gave very marked relief.

The influence of this agent upon visceral derangement is, however, a field for future investigation. It gives promise of happy results. As yet, my personal experience is too limited to justify me in formulating any positive conclusions respecting the method which is best employed in individual cases.

Thirteenth.—Static electricity is of value in the treatment of *hysterical states* and *other allied conditions.*

Charcot has long been an advocate of this therapeutical agent in such cases. My own experience teaches me that it is of great service as an aid to recovery; although I believe that in a very large proportion of these subjects reflex irritation from "eye-strain" has to be combated by the relief of anomalies in the eye or its muscles before a perfect restoration of health can be attained. I have discussed this field elsewhere (see *New York Medical Journal*, February, 1886, and April, 1887).

In closing, I would state that the length of this article (already too prolonged, perhaps) precludes the insertion of the histories of many typical cases, which would be of great interest in this connection. To fairly illustrate the subject in its many

ramifications a very large number of lengthy records would, however, be required.

Medical literature within the past ten years, and antiquated works, also, fairly teem with cases reported by leading men in the profession here and abroad, which illustrate their concurrence and firm belief in the views expressed in preceding pages.

Static electricity is to-day, for the second time, generally recognized by the profession as a valuable therapeutical agent. Most of the leading neurologists have now a Holtz induction-machine as a part of their office equipment. The later editions of recognized works upon electricity as applied to medicine show almost without exception that this variety of electricity is deemed worthy of more attention than it received in the earlier editions. It has passed through its stage of neglect and distrust safely. It is steadily regaining the popularity it so justly achieved in the eighteenth century.

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