Treatment of Neuralgia.

The Faradic current will very frequently cure a neuralgia at one sitting of from twenty to thirty minutes. Not that every one, however roughly or carelessly he may apply it, can secure such favorable results. In our own experience the following method has been uniformly successful:

First. Place the so-called positive pole over the painful spot, sponge-covered electrode, sponge moistened with warm salt water.

Second. Place the other pole at some adjacent healthy part, a little below the positive and opposite to it, preferably at some point along the spinal column. Thus, if the neuralgia is in the head and the face, place the negative over the lower cervical vertebræ; if of the abdominal viscera, over the lower dorsal vertebræ, or down towards the coccyx; suit the strength of the current to the location, that it may not be painful; very light over the head and face, and sufficiently strong over the viscera. Give stationary application to the painful spot, and manipulate all around from that as a centre towards the other pole. Some practitioners claim that for this application the negative electrode should be attached to a cord twice the length of the other.

The galvanic current is also used to treat neuralgias; positive pole to the affected parts, and negative on some opposite healthy part.

A person who is subject to recurring neuralgias should receive the general tonic treatment until the system is sufficiently toned up to resist the neuralgic tendency.

In our next we shall speak of the treatment of rheumatic affections.

Dr. A. Lapthorn Smith, of Montreal, has recently given an interesting account of his experiences with Apostoli's method (*American Journal of Obstetrics*). Dr. Smith has abandoned punctures, and relies upon the intra-uterine applications, using not very strong currents, apparently not much over one hundred milliampères. He reports cases of endometritis, perimetritis, and fibroids cured or greatly relieved. No exact rules can be given as to the frequency and number of applications, or the strength of the current. The use of the positive pole in hemorrhagic conditions is approved by him, as by all others. It seems, indeed, that a relief of menorrhagia is one of the things which it is agreed electricity can accomplish. Ovarian pains also are often cured. The exact effect of the currents upon fibroids is yet an unsettled point. They certainly often decrease in size under treatment, but whether there is a true electrolytic action is yet hardly demonstrated.

The action of the two poles upon the living tissues is directly antagonistic, the one relieving pain and congestion, and the other rather tending to produce it.

The alkalies are attracted to the negative pole, and the acids go to the positive; fluids are attracted to the negative pole. Its effect is like a blister, but its influence greater and the penetration deeper.

The acids which accumulate at the positive pole produce coagulation of the elements capable of undergoing that change; this effect also extends some distance from the electrode. The positive pole relieves pain and congestion, and favors coagulation, while the negative promotes absorption.

ELEMENTARY PRINCIPLES

OF

ELECTRO-THERAPEUTICS

FOR THE USE OF

PHYSICIANS AND STUDENTS.

WITH 135 ILLUSTRATIONS.

PREPARED BY

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ERRATA.

Page	11	Line	42	Read	Coulomb, for Conlomb.
"	28	"	5	"	a pair, for the pair.
"	39	"	22	"	neutral point, for central point.
"	106	"	15	"	milli-ampere, for mille-ampere.
"	220	"	17	"	with the skin, for with skin.
"	224	"	16	"	currents, for current.
"	280	"	23	"	other causes, for other will causes.
"	321	"	14	"	of the heart, for of heart.
"	345	"	8	"	symphysis, for symphisis.

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VOCABULARY.

ACCUMULATOR. An apparatus to accumulate or store electricity. This name is applied both to the Leyden jar and the storage battery.

Action, Local. Chemical action that takes place in battery cells, consuming zinc without producing a working current.

Active Electricity. Electricity in a state to exert attractive and repulsive powers or produce heat, light, shocks or decomposition. Free electricity.

Agonic Line. Line of no variation. An irregular curved line drawn so as to connect all the points on the earth's surface where the needle points due north and south.

Alternate Currents. Those currents in which the direction is changed every half revolution. They are produced by revolving an armature before a magnet, or a magnet before an armature, in magneto-electric machines.

Amalgamation. Covering the surface of zinc with mercury to prevent waste.

Ampere. The unit of current strength formerly called a Weber. It is the current carried in one second by an electro-motive force of one volt through a circuit whose resistance is one ohm.

Anelectrotonos. The condition of lessened irritability which exists in that portion of a nerve nearest the positive pole after a current of electricity has been carried through it for some time.

Animal Electricity. Free electricity existing in the body. It may exhibit magnetic, static or dynamic properties, according to the circumstances attending its presence.

Anions. Those atoms which collect about the anode or positive pole when a chemical compound is decomposed by electricity.

Anode. The "way" by which electricity enters. This name is used alike for the positive pole of the battery and the electrode connected with it.

Antozone. Oxygen in a positively polar condition.

Appliances, Electrical. This term is generally understood to refer to various belts, soles, jackets, etc., inclosing magnets, small cells or coils, to be worn on the person for various complaints.

Armature or Keeper. Soft iron bar attached to the poles of magnets to preserve their magnetism.

Artificial Magnet. A bar of metal, originally without magnetic properties, to which magnetism has been imparted by another magnet.

Ascending Currents. The current applied by placing the positive electrode upon the periphery of a nerve, and the negative to the nerve center.

Axial Line. See *Magnetic Axis.*

BASE. The part of a battery upon which is fastened the coil and binding posts, switches, etc.

Battery. This name is applied to (1) The apparatus complete, for production of electricity. (2) To the cells.

Binding Posts. Clamps for connecting conducting wires with the electrical apparatus.

Bound Electricity. Electricity which does not manifest its presence by any of the usual phenomena. This term is also applied to electricity "accumulated" or "condensed" in the Leyden jar.

Break. An opening in the circuit preventing the passage of electricity.

CALLAUD BATTERY. Another name for the Gravity Battery.

Capacity. The capacity of a condenser (accumulator) is measured by the quantity of electricity of unit potential which it can contain.

Carbon. A substance which collects in the neck of retorts in gas manufacture.

Catalectrotonus. The condition of increased irritability in that portion of a nerve nearest the negative pole resulting from carrying a current of electricity through it for some time.

Cathode. The "way" by which electricity leaves. This name is given both to the negative pole of the battery and the electrode attached to it.

Cations. Those products of chemical decomposition which appear at the negative pole are called cations.

Cautery. See *Galvano-Cautery.*

Cell. The jar, cup, or other container, which holds the elements and agent which produces a difference of potential between them.

Centimetre. The unit of length. For its value see *units.*

C. G. S. The centimetre-gramme-second system of measurements. See *Units.*

Central Galvanization. The method of applying a galvanic current to the nerve centres. Fully described in text.

Centrifugal Current. The descending current.

Centripetal Current. The ascending current.

Charge of Electricity. The quantity of electricity in a body.

Circle, Galvanic. This includes fluid, elements, and connections between the elements outside the fluid.

Circuit. The path traversed by the current. It includes the elements, battery fluid, conducting cords, electrodes, and any intervening substance or body.

Circuit Breaker. An apparatus for interrupting the circuit, also called a rheotome or current breaker.

Clamps. Devices for completing the connection between electrodes and conducting cords.

Closed Circuit. When the elements are united outside the fluid, either by direct contact or through a good conductor.

Closing Contractions. Muscular contractions produced at the instant the circuit is closed.

Coil Induction. Rolls of wire in which a current is induced by the alternate opening and closing of a circuit. The coil is also called the helix.

Collecting Plate. The electro-negative element of the pair from which the positive current comes. Called the collecting plate because the hydrogen and other products of decomposition collect about it.

Commutator. A pole changer or device for changing the direction of the current.

Compound Magnet. Several single magnets united, with similar poles adjacent.

Condenser. An apparatus for accumulating or storing a large amount of electricity on a small surface. A Leyden jar is an example. See *Micro-Farad.*

Conductors. All materials which readily permit electricity to pass over them. This term is also applied to the electrodes, and cords by which they are joined to battery.

Conjunctive Wire or Arch. The metal wire joining the two elements of a galvanic pair, outside the fluid.

Connections. The wires, metallic cords, binding posts, and all metals used to complete the circuit are included under this term.

Constant Battery. A galvanic battery with two fluid or gravity cells.

Constant Current. A galvanic current from a Constant Battery.

Contact Breaker. See *Circuit Breaker.*

Continued Current. The uninterrupted galvanic current.

Continuous Electrization. The protracted applications made by belts, chains, etc., worn on the body.

Convection. The discharge of electricity attended by alternate attraction and repulsion of particles of air, and the materials floating in it.

Core. A bundle of soft iron wires used as a magnet in the center of the coil.

Coulomb. The unit of quantity formerly called the Weber.

Current Breaker. A device for alternately opening and closing the circuit. A rheotome.

Current, Electric. The transfer of electrical energy along a conductor. It is commonly spoken of as flowing from the positive to the negative points in the circuit.

Current Reverser. A pole changer.

Current Selector. This name is applied to two separate devices for altering the strength of current. (*a*) Galvanic Current Selector brings any number of cells into circuit. (*b*) Faradic Current Selector brings the primary or secondary current into circuit.

Cylinder Machine. A form of static machine.

DANIELLS CELL. Invented by Prof. Daniells, of London. It consists of a porous cup containing dilute sulphuric acid immersed in a jar containing a solution of sulphate of copper. The elements are copper and zinc.

Declination. The dip of the needle. The angle it makes with a horizontal plane.

Deflection. The turning aside of the marked end of needle from O or N of the scale over which it is suspended when the scale is so arranged that O or N points due north.

Demagnetize. To take away magnetic properties.

Density. The amount of electricity accumulated on a unit of surface is called "density." The term is also applied to a large quantity passing over a small conductor. Sometimes erroneously used as equivalent to tension or intensity.

Derivation Wire. If two points in a closed circuit be connected by an additional conductor, this conductor is called a derivation wire.

Derived Current. That portion of the current drawn off, or "derived," by a derivation wire. Its potential is much less than the original or primitive current.

Descending Current. The negative electrode upon the periphery, and the positive on the nerve center, gives a descending current.

Diamagnetic Bodies. Those which are repelled by a magnet.

Dielectric. Insulators across which electric action takes place are called *dielectrics*. The glass of the Leyden jar across which electricity is propagated from the inner to the outer coating is a dielectric.

Difference of Potential. When electricity moves or tends to move from one point to another, there is said to be a difference of potential between them.

Diffusion of Current. The power of a galvanic current to extend its influence in all directions, that power never being limited to the two electrodes.

Dip. See *Inclination.*

Dipping Needle. A magnetic needle. The compass needle.

Direct Current. This term is used in two senses. (1) The descending current. (2) The galvanic current.

Discharge. A sudden equalization of potentials.

Discharger. An instrument through which the difference of potential between two surfaces is equalized. This name is also given to the instrument which directs the charge from a condenser through an object.

Disruptive Discharge. A restoration of the equilibrium of potentials accompanied by light and sound.

Downward Current. The term applied to the electric current from the center to the periphery. See *Descending Current.*

Dynamic Electricity. Electricity in motion, *i. e.* propagated as a current.

Dynamo-Electric Machine. Also called magneto-electric, are machines in which a powerful electric current is produced by revolving coils of wire between the poles of a horseshoe magnet.

Dyne. The unit of force — *i. e.* the force which, if it acted for one second on a mass of one gramme, would, if the mass was previously at rest, give it a velocity of one centimetre per second ; or, if it was previously in motion in the direction of the force, would in that time alter its velocity by that amount.

EBONITE. Black rubber rendered hard by vulcanizing; also known as vulcanite.

Electric. Any substance, such as glass, amber, etc., in which electricity can be excited.

Electrical Machine. See *Machine.*

Electric Aura. A current of electrified air, also called "Electric Wind."

Electric Bath. This term is applied to two methods of electrization. 1. Allowing an electric charge to be slowly drawn off or dissipated from an insulated patient by the surrounding air. 2. Electrizing a patient while in a water, vapor or hot-air bath.

Electric Brush. A wire brush used as an electrode. It is connected with one pole of the battery.

Electric Disks. See *Electrizers.*

Electric Endosmosis. When a porous diaphragm is placed in a liquid traversed by a continuous current, the liquid will pass through the diaphragm in the direction of the positive current. This process is electric endosmosis.

Electric Fish. Certain fishes that give electrical shocks when touched. The best known are the *Torpedo* or *Electric Ray* of the Mediterranean, the Gymnotus or electric eel found in certain ponds in Surinam, and the Malapterurus or electric shad of the Nile.

Electric Fluid. This name was formerly given to electricity, in accordance with the theory that it is a subtle and imponderable fluid which permeates all bodies.

Electric Force. The power of electricity to move matter.

Electric Hand. The hand of the operator used as an electrode.

Electrician. One versed in the science of electricity in its relation to the arts. A term that is often incorrectly used instead of electro-therapeutist.

Electricity. A mode of motion of the atoms of matter.

Electric Machine. This term is usually applied to the apparatus for producing static electricity. See *Machine.*

Electric Moxa. A burn made by the galvanic current on the skin, as a counter-irritant.

Electric Potential. See *Potential.*

Electric Residue. See *Residual Charge.*

Electric Tension. Free electricity struggles to escape from the surface upon which it is accumulated, and this effort is termed electric tension; it may be considered a kind of pressure or strain acting from the center of a body outward.

Electrify. To communicate electricity to a body not previously exhibiting its presence. To charge with electricity.

Electrine. Belonging to amber.

Electrization. The act of applying electricity.

Electrizers. Discs of different metals, as copper and zinc or silver and zinc, which are sometimes applied to the surface of the body and connected with copper wire; the perspiration excites a feeble galvanic current that may be kept up for an indefinite time.

Electro-Biology. Electrical currents developed in living animal tissues, by friction, chemical decomposition, etc. This term is also applied to the phenomena supposed to be developed by mesmerism.

Electro-Bioscopy. Testing the muscles by electricity to see if life is extinct.

Electro-Cautery. See Galvano-Cautery.

Electro-Chemical Bath. The introduction and withdrawal of metals from the living body by means of a galvanic current applied through a bath.

Electro-Chemistry. See *Electrolysis.*

Electrodes. The name originally given to the points at which electricity enters and leaves a substance. The name is now generally given to the instruments fastened to the conducting cords that are used in applying electricity to the human body.

Electro-Diagnosis. The discrimination of disease by means of electricity. Electro-Pathology.

Electro-Dynamics. The phenomena of electricity in motion.

Electro-lithotrity. The disintegration of calculi in the bladder by electricity.

Electrologist. One who makes a specialty of electro-therapeutics.

Electrolysis. Separation of a chemical substance into its elements, by electricity.

Electrolyte. The body acted upon by electrolysis.

Electrolytic. Relating to chemical decomposition produced by electricity.

Electro-magnet. A mass of soft iron surrounded by a coil of wire, which is rendered temporarily magnetic by passing a current of electricity through the coil.

Electro-magnetism. 1. Magnetism developed by electricity. 2. A current from a magneto-electric machine.

Electrometer. Instrument for measuring the strength of the attractions and repulsions between electrified bodies. Also see *Electroscope.*

Electro-Motive Force. The force which tends to move electricity from one point to another.

Electron. Amber.

Electro-Negative Bath. Electrifying a patient from negative jar of a static machine.

Electro-Otiatria. Electricity applied to treatment of diseases of the ear. It also includes the electro-physiology of the ear.

Electro-Pathology. See Electro-diagnosis.

Electrophorus. This consists of (*a*) a lower disc or generating plate of resin or hard rubber; (*b*) an upper disc or collecting-plate of metal two inches less in diameter than the lower plate. Its use is to generate small quantities of static electricity.

Electro-Physiology. The effect produced on the healthy tissues of the living body by electricity.

Electro-Positive Bath. Electrifying a patient from the positive jar of the static machine.

Electro-Puncture. The application of any form of electricity by means of needles thrust into the tissues.

Electroscope. Apparatus for detecting the presence of static electricity, and determining whether it is positive or negative. Also see *Electrometer*.

Electro-Statics. That science which treats of static or franklinic electricity.

Electrostixis. Electro-puncture.

Electro-Surgery. The use of any form of electricity in surgical diseases. Electrolysis and galvano-cautery are the principal forms in which it is employed.

Electro-Therapeutics—Electro-Therapy. Treatment of disease by electricity.

Electro-Therapeutist. One who is versed in the use of electricity in disease; incorrectly called an electrician.

Electro-Tonic. The name Faraday gave to the changing state of the conducting wires while the current is forming or ceasing.

Electrotonos. The peculiar condition of a motor-nerve when a continuous galvanic current is passed along it.

Electrum. Amber. This name is also given to an alloy of gold and silver.

Elements. The metals, or carbon and metals, immersed in battery fluid to generate a current of electricity.

Endosmose. See *Electric Endosmosis*.

Equator. See *Magnetic Equator*.

Erg. The unit of work; *i. e.*, it is equal to the work required to move a body through one centimetre against a force of one dyne.

Essential Resistance. The resistance within a battery cell (internal resistance.)

External Resistance. Resistance in the circuit outside the cell (non-essential resistance).

Extra Current. This name refers to (*a*) the appreciable current in the primary coil which is due entirely to induction, and is partly galvanic and partly magnetic. (*b*) It is also given to currents taken from different layers of the secondary coil. (*c*) The transient currents in a coil, produced by the induction of each portion of the current on the neighboring wires, on which it acts as if they were portions of another circuit.

Extra Polar. Electricity is believed to be propagated within the tissues in every direction from the electrodes. Its effect upon those not between the two poles is called extra-polar.

FARAD. A million micro-farads. 1. The capacity of a condenser which holds one coulomb at a potential of one volt. 2. A coulomb in a farad condenser is capable of causing a difference of potential between the poles of a circuit that it will require an electro-motive force of one volt to overcome.

Faradic Current. The current generated in a coil of wire by induction. Also called induced, interrupted or extra current.

Faradic Induction. A current of electricity passing through a wire excites a wave of electricity in a second wire placed near and parallel with it at the instant of opening and closing the circuit. This is faradic induction.

Faradism. The application of induction currents to the treatment of disease.

Faradization. Application of the faradic current.

Ferro-Magnetic. Iron and similar bodies that are attracted by iron. Also called paramagnetic bodies.

Field, Magnetic. See *Magnetic Field*.

Franklinism. Static electricity employed as a remedial agent. Named from Benjamin Franklin.

Frictional Electricity. Electricity set free by friction. Static or Franklinic electricity.

Free Electricity. Unbound electricity. That state in which it exhibits attraction and repulsion.

Fustigation, Electric. The application of electricity through a metallic brush.

GALVANIC APPARATUS. Apparatus for generating and furnishing the galvanic current.

Galvanic Battery. See *Batteries*.

Galvanic Belt. An appliance for the continuous application of galvanism. It consists of a series of small cells containing elements which are fastened to a belt to be worn around the body.

Galvanic Chain. A series of links usually composed alternately of zinc and copper, to be worn around the body. The current is generated by dipping them in vinegar or water, or simply by the moisture supplied by the perspiration.

Galvanic Circle. This usually refers to a pair of elements immersed in battery fluid and connected outside the fluid. A single circle is one galvanic cell in action. A compound circle is two or more connected together.

Galvanic Current. The current direct from the battery cells. It is frequently called a voltaic current. When carried through a coil of wire it becomes a faradic current.

Galvanic Disks. Disks of two dissimilar metals arranged alternately on a band, jacket, sole, etc., between which a communication is established when moistened and placed on the skin, and a feeble galvanic current is set up.

Galvanic Elements. Two dissimilar metals, or two pieces of the same metal, which are of unequal hardness, that are used in generating a current of electricity.

Galvanic Pair. See *Galvanic Elements.*

Galvanic Pessary. An instrument for retaining the uterus in position and at the same time conducting to it a galvanic current. It may be composed of alternate pieces of two dissimilar metals which generate the current when moistened with the secretions of the surface to which the instrument is applied, or it may be connected with a belt or pocket battery which generates the current.

Galvanic Poultice. Minute pieces of zinc and copper wrapped in cotton wool, each pair separated by flannel, all inclosed in a bag, one side of which is made of rubber cloth, the other of cotton. The cotton surface is applied next the skin, and the accumulated perspiration excites galvanic action.

Galvanism. The science which treats of that form of electricity which is generated by chemical action.

Galvanization. The medical application of the galvanic current.

Galvanization Localized. An application of the galvanic current limited to a particular muscle, nerve or organ.

Galvanize. To affect by the galvanic current.

Galvano-Cautery. Also written Galvano-Causty. Burning or cauterization of the tissues by an electric current sent through a wire or plate of great resistance (usually platinum).

Galvano-Cauterization. To burn with a galvanic current.

Galvano-Contractility. Usually refers to muscular contraction produced by the galvanic current.

Calvano-Faradization. Name given by Beard and Rockwell to the simultaneous application of the galvanic and faradic current.

Galvanometer. An instrument for measuring the total quantity of electricity which passes through it in one second.

Galvano-Plasty. (*a*) The art of separating chemical elements from their compounds by electricity. (*b*) The art of depositing metals by electricity, as in electrotyping.

Galvano-Puncture. See *Electro-Puncture.*

Galvanoscope. An instrument for detecting the direction and presence of a galvanic current.

Galvano-Surgery. The application of the galvanic current to surgery. It includes (*a*) Electrolysis, (*b*) Galvano-Cautery.

Galvano-Therapeutics. The application of the galvanic current to the treatment of disease.

General Electrization. The application of electricity to all parts of the surface of the body during a treatment.

General Faradization. General Electrization with the faradic current.

General Galvanization. General Electrization with the galvanic current.

Gramme. Theoretically, this is the mass of one cubic centimetre of distilled water at 4° C.

Gravity Batteries. Galvanic cells in which the elements are placed horizontally, and the two fluids are kept separate by difference in density.

HELIX. See *Coil.*

Horseshoe Magnets. Magnets in the form of the letter U.

Horticulture, Electrical. The process of exposing fruit, flowers, etc., to electric light during the night and the sun during the day. Dr. Siemens having tested this during late years, announced that the growth is twice as rapid as under other conditions.

Hydro-Electrization. A term coined by Beard and Rockwell to indicate that electricity is applied by means of water as an electrode.

Hydrostat. A device for preventing the spilling of fluid out of battery cells. Designed to render a battery portable without the necessity of removing the fluid from the cells.

IONS. Elements into which a substance is divided by electrolysis.

Inclination or Dip. The angle which a freely suspended magnetic needle, when parallel with the magnetic meridian, makes with the horizon.

Induced Charge. When a charged body is brought near another, but not in contact with it, the latter becomes electrified or posesses an induced charge.

Induced Currents. See *Faradic Current.*

Inducing Current. See *Primary Current.*

Induction. The process of exciting electricity in any object by bringing it near to but not in contact with a circuit through which a current of electricity is passing, or an electrified body.

Induction Coil. This refers to the coarse wire coil through which the primary current passes. It is also used to include the entire coil and its core which are necessary to the production of a faradic current.

Initial Charge. A charge excited on glass or rubber and conveyed to the plates of a static machine by contact.

Insulators. Substances such as glass, rubber, shellac, etc., which hinder the passage of electricity over or through them.

Insulation. Supporting or surrounding a body by an insulator.

Insulating Stool or Platform. A stool or platform which has glass or rubber legs. Any stool, platform, or chair, may be insulated by glass tumblers or saltcellars.

Intensity. The energy or effectiveness with which electricity acts, as estimated by the results produced.

Intensity, Magnetic. The amount of force with which a magnetic needle is brought back to its natural position when moved out of it. The same term is applied to the power with which a magnet retains its hold upon attracted objects.

Interrupted Current. A current from a circuit that is alternately opened and closed.

Inverse Current. Ascending or centripetal current.

JARS. See *Leyden Jar.*

KEEPER. See *Armature.*

LABILE CURRENT. Moving or gliding one or both electrodes over the surface treated.

Latent Electricity. Passive, bound, or natural electricity. That form of electricity which does not manifest any of the properties peculiar to it.

Leyden Jar. The ordinary form consists of (*a*) a glass jar or bottle. (*b*) An outside and inside coating of metal reaching within two to four inches of the top. (*c*) An insulating cap fitting into the neck of the jar which supports a brass rod terminating above in a knob, and below in a strip of foil or chain, that lies upon the inner metallic coating on the bottom of the jar.

Local Action. Decomposition of zinc in the battery fluid when the elements are not connected.

Local Electrization. The application of electricity to a single organ, muscle, or nerve, with a stationary electrode.

Lodestone. An ore found in iron-mines which possesses the property of attracting iron or steel, and when freely suspended, the direction of the magnetic meridian.

Line of Force at any Point. The direction in which a charged body placed at that point tends to move.

Lines of Magnetic Force. The curved lines through which the force emanating from a magnet acts. They may be illustrated by holding the poles of a magnet against a sheet of stiff paper upon which iron filings are sprinkled.

Lines of Flow. The direction of a current passing through a conductor have been demonstrated to be in curves similar to the lines of magnetic force.

MACHINE, ELECTRIC. According to common usage this term refers to the apparatus for generating static or franklinic electricity, and also the magneto-electric or dynamo-electric apparatus. Strictly speaking, this term applies to all batteries or devices for generating electricity.

Magnet. 1. The lodestone. 2. A bar of steel or iron to which the peculiar properties of the lodestone have been imparted.

Magnetic Axis. The line joining the poles of a magnet.

Magnetic Equator. The line of no dip. An imaginary curved line connecting those points on the earth's surface where the dipping needle remains parallel with the horizon.

Magnetic Field. 1. Any region where magnetic force acts. 2. Within the influence of a magnet.

Magnetic Induction. The influence of magnets through space either to produce other magnets, or to induce electric currents in metallic circuits.

Magnetic Meridian. A great circle parallel with the direction of the magnetic needle, and passing through its poles.

Magnetic Poles. Points in the northern and southern hemispheres at which the magnetic needle stands exactly vertical.

Magnetic Potential. The potential of a magnetic pole is of precisely the same nature as that due to an electrified body at that place. See *Potential.*

Magnetic Substances. Iron, nickel, cobalt and all other substances to which the properties of the lodestone may be imparted.

Magnetism. That force which causes the lodestone and other magnetic bodies to exhibit the phenomena of attraction, repulsion, polarity, etc.

Magnetize. To communicate magnetic properties to substances that do not naturally exhibit them.

Magneto-Electricity. Electricity generated or set free by the action of a magnet.

Magneto-Electric Machine. See *Dynamo-Electric Machine.*

Micro-Farad. Practical unit of capacity. A condenser of one micro-farad capacity would contain about 300 circular sheets of tinfoil separated by mica plates, and would be contained in a box 3¼ inches deep and 6½ inches in diameter.

Molecule. The minute particles of which matter is supposed to be composed.

Motor-Points. The points on the surface of the body where the various branches of the motor nerves supplying the muscles may be affected by electricity.

Multiplier. A coil of wire through which a galvanic current is passed to increase or multiply its effect upon a magnetic needle placed above it.

Mutual Action of Two Currents. Two currents moving in the same direction repel each other; moving in opposite directions they attract each other.

NATURAL ELECTRICITY. When electricity exists in such a form that its equilibrium must be disturbed before its presence is manifest, it is called natural electricity.

Negative Electricity. Also marked. Originally referred to that form of electricity developed by rubbing sealing-wax. Electricity from any plate, condenser or element which affects the electroscope in the same way as sealing-wax is called negative.

Negative Element. That portion of the carbon, copper or platinum element immersed in the fluid is electro-negative. The zinc, from which negative electricity is obtained, is, however, usually spoken of as the *negative* element.

Neutral Line. A point midway between the poles of a magnet to which iron filings will not adhere, and which exerts no signs of magnetic force.

Non-Conductor. Any substance that does not freely transmit electricity, such as glass, paraffine, rubber, etc. An Insulator.

Non-Electric. Those substances which permit electricity excited on them by friction to escape as fast as formed, in consequence of which it was formerly supposed that they were incapable of being electrified, hence the name.

Non-Essential. External resistance. The resistance in the circuit outside the cell.

OHM. The unit of resistance. It is very nearly equal to the resistance of a cylindrical wire of pure copper 250 feet in length, having a diameter of 1-20 of an inch.

Ohm's Law. The law devised by Ohm for determining the current generated and the amount of work it can do under given conditions, when the force of the battery and the resistance of the circuit are known. His formulæ (E standing for electro-motive force; R, resistance; C, current) are:

$$C=\frac{E}{R} \qquad R=\frac{E}{R} \qquad E=C+R$$

Ohm Meter. An instrument for measuring ohms.

Opening Contractions. Muscular contractions produced by opening or breaking the circuit.

Oxidation. This term here relates to rust collected upon the metal parts of a battery. Rust is a poor conductor, and impedes the passage of electricity. It must be scraped off.

Ozone. Oxygen rendered electro-negative by passing through it a positive charge of static electricity.

PARAFFINE. A carbo-hydrogen obtained from petroleum and other sources. It is a white, waxy solid, not acted upon by acids or alkalies. It is an excellent insulating substance, unequalled for its resistance to moisture. It is used to insulate wires, and a thin layer of it on the upper end of the battery elements and their metal connections, prevents an accumulation of salts on them. Whenever applied for insulating purposes it should be melted and the objects to which it is applied should be hot.

Para-Magnetic Bodies. Iron and similar substances which are attracted by the magnet.

Passive Electricity. Electricity in a state of equilibrium. See *Natural Electricity.*

Peripheral Electrization. Electricity applied to the periphery, or external surface of the body.

Permanent Magnet. Those which retain magnetic properties when removed from the source from whence they acquired it.

Phreno-Magnetism. Excitement of the organs of the brain by mesmeric passes of magnetic influence.

Pile. Originally the name given to a pile composed of disks of zinc and copper separated by a moist, porous material, constructed by Prof. Volta, hence called the Voltaic pile. It is now frequently applied to the combination of elements in battery cells.

Plantinode. Name given by Daniells to the collecting plate, platinum, carbon, copper, etc.

Platinum. A metal first discovered in the mines of Choco, Peru. It is nearly of the color of silver but less bright, and is the heaviest of metals. It is much used for the collecting plate in battery cells, because it is not acted upon by the fluid.

Polar. Relating to the poles.

Polar Force. That force with which similar ends of magnets attract, and dissimilar repel each other.

Polarity of Electricity. That property of electricity which causes it to exhibit attraction and repulsion.

Polarity of Magnets. That property which causes them when freely suspended to assume a northerly and southerly direction; also to attract dissimilar, and repel similar, poles of other magnets.

Polarity of Nerves. That condition of a nerve in which the part nearest the negative pole is in a state of increased, and that nearest the positive is in a state of diminished, irritability.

Polarizable. The property of exhibiting polarity under certain conditions.

Polarization. The act of arranging the substances which form an electric circuit in polar order, that is the positive atoms collected together in one part of the circuit, and the negative in another, so arranged that they react on each other.

Polarization of Elements. When the hydrogen set free in a cell is permitted to collect about the carbon, platinum or copper plate in the fluid, there is a counter-current set up between the gaseous envelope and the zinc within the fluid, which tends to counteract or destroy the current passing through the external circuit, and the elements are said to be polarized.

Polarizing. Giving polarity to.

Polarizing Current. A current which produces the electrotonic condition.

Polar Method. This is accomplished by placing the pole whose distinctive effect is wanted, over the part to be treated, and the other pole over some indifferent part.

Pole Changer. A rheotrope or current reverser. A device for changing the direction of the current without removing the electrodes. A useful instrument for employing a galvanic current to produce contractions.

Poles, Electric. Points where electricity passes in and out.

Poles, Magnetic. Points where magnetism is concentrated.

Poles, Consecutive or Consequent. When a magnet is irregularly magnetized, it frequently contains three or more poles, and the term *consequent* is applied to the extra poles.

Portative Force. The power of a magnet to sustain weights fastened to its armature.

Positive Electricity. That which is set free by rubbing glass with silk.

Positive Pole. The binding post, conducting cord and electrode connected with the carbon, copper or platinum (electro-negative) element of the battery are respectively called the positive pole.

Potential. This term holds the same relation to electricity that the term level does to gravity. Just as water at a higher level tends to flow to a lower one, so electricity at a higher potential tends to move to a point of lower potential. It is often used synonymously with tension; but since the latter term is used to express very diverse conditions, electricians now make use of the term potential in referring to "electric level," whether static, dynamic or magnetic.

Potential (Dynamic). Difference of "electric level" between two elements, when both are immersed in the same fluid, which acts chemically upon one of them. The same term applies to difference in electric level produced by revolving coils of wire between the poles of horseshoe magnets.

Potential (Magnetic). The potential or "electric level" due to a given magnetic pole is of precisely the same nature as that of an electrified body at that place.

Potential (Static). This is the difference in "electric level" between an electrified body and the earth, the latter being the standard and regarded as zero.

Potential at a Point. An abbreviation for difference of potential between the point and the earth.

Primary Coil. The layers of coarse wire which form the inner coil of the helix.

Primary Current. The inducing current from the primary coil. Sometimes the galvanic current direct from the cells is incorrectly called primary, to distinguish it from that obtained indirectly by induction.

Primitive Current. When two points in a closed circuit are connected by an additional conductor, a portion of the current is drawn off. The current, as it existed before a part is drawn off, is the primitive current.

Protracted Applications. The continued application of electricity by means of belts disks, etc., for a long time.

QUALITY OF A CURRENT. This refers to its strength as determined by its electromotive force and resistance, and also to the rapidity of its interruptions, and whether it is smooth or harsh.

Quantity. The amount of electricity generated in a given time. For purposes of calculation, electricity is regarded as if it were a material, incompressible fluid; *e. g.*, if two bodies contain equal quantities of one kind of electricity, and it all be transferred to one, the latter will contain twice the quantity it did before; on the contrary, if the electricity in one body is divided with another not previously electrified, the former will have only one-half the quantity it had before.

RADICALS. The *ions* or elementary atoms into which a chemical compound is divided by electrolysis.

Reaction Electrical. The phenomena developed in any part of the body under the influence of electricity.

Regulator (Current). See *Shield*.

Residual charge. A feeble charge of electricity which can be obtained from a Leyden jar a few minutes after it has been thoroughly discharged. Literally "the charge left over."

Residual Magnetism. Moderately hard iron when magnetized retains some magnetic polarity, this is residual magnetism.

Resinous Electricity. Negative electricity. That which is excited by rubbing wax or resin with flannel.

Resistance. Opposition to the transfer of electricity, or to its development as a current.

Reverse Current. See *Ascending Current.*

Reverser (Current). Pole changer.

Rheochord. A metallic wire introduced into a circuit to measure the resistance or vary the strength of the current.

Rheometer. (Gr. *rheos*, a current, and *metron*, a measure.) An instrument for measuring a galvanic current. Galvanometer.

Rheomotor. (L. *motor*, a mover, from *moveo*, I move.) An apparatus by which an electrical current is originated.

Rheophore. (Gr. *phoreo*, I bear along.) An electrode.

Rheoscope. (Gr. *shope*, I view.) An apparatus for ascertaining the existence of a galvanic current. A galvanoscope.

Rheostat. (Gr. *statos*, that stands.) An instrument for bringing a definite amount of resistance into the circuit. It receives its name from its power to keep the galvanometer needle standing at the same point during an experiment. Two forms are commonly used for medical batteries, the *hydro-rheostat* and *resistance* coil. The resistance coil differs from the rheochord in that the wire composing the former is in a coil, in the latter it is straight.

Rheotome. (Gr. *temno*, I cut.) A current breaker.

Rheotrope. (Gr. *trepo*, I turn.) A pole changer, or current reverser.

Rotary Machine. Magnetic-Electric Machines in which electricity is generated by turning a crank.

Ruhmkoff Coil. A very powerful induction coil invented by Ruhmkoff, a celebrated electrician of Paris.

SECONDARY ACTION. See *Secondary Electrolysis.*

Secondary Battery. A storage battery. An apparatus for accumulating electric energy.

Secondary Coil. A coil of fine wire wound in many layers around the primary coil from which it is separated by insulation.

Secondary Current. The induced or "to and fro" current from the secondary coil of the helix. The faradic current.

Secondary Electrolysis. Decomposition supposed to be accomplished by the chemical action of the elements set free by electricity. It is secondary action that causes the hydrogen to be used up by the chromic acid set free in the battery fluid, and the consequent formation of chrome alum.

Sensibility, Electro-Muscular. The peculiar sensation produced when a muscle contracts under the stimulus of an electric current.

Shield. The tube or sheath which answers the purpose of a current regulator. When it is moved entirely within the coil, the strength of the current is diminished; when withdrawn, it is increased.

Shock. 1. A sudden discharge of electricity from a Leyden jar or the conductor of a static machine. 2. The unpleasant or painful impression made on the nerves by opening or closing the circuit or suddenly increasing the strength of the current.

Short Circuit. Name given to the circuit when it is completed before reaching the conductors or electrodes. Polarization depends upon the establishment of a short circuit within the cell.

Stabile Current. A current applied with both electrodes in a fixed position. Labile and stabile were terms selected by Remak to describe the method of applying a current.

Statical Electricity. Electricity at rest. It is set free by friction, pressure, cleavage, etc.

Static Machines. Apparatus for generating frictional or Franklinic electricity.

Storage Batteries. See *Secondary Batteries.* They have been used for supplying a current for galvano-cautery purposes, and also for illuminating internal cavities of the body.

Switch. Metallic bars revolving on a pivot, used to connect sections of cells, as current reversers, and current selectors. They form a part of the battery accessories that are attached to the base.

TANGENT GALVANOMETER. An instrument for the accurate measurement of the strength of the galvanic current.

Tension. Potential. This term is applied by various authors to (1) the tendency of electricity to overcome resistance; (2) the strain put upon the circuit by the electromotive force; (3) the difference of potential of any two points joined by a conductor.

Tetanization. The production of a tetanic or contracted state in a nerve by passing an electric current through it.

Thermo-Electricity. Electricity that is generated when two metals are soldered together so as to form a closed circuit, and one of the junctions is heated more than the other.

To and fro Current. Faradic Current.

Torpedo. The electric ray, a species of fish found in the Mediterranean.

Tray Cell. One form of gravity cell which is named from its shape.

Trembler. The vibrator or rheotome.

Two-Fluid Cell. A cell in which a different fluid is used with each element.

UNIFORM CURRENT. A current that is kept at the same strength during the application. (B & R.)

Unipolar Application. See *Polar Method.*

Uninterrupted Current. The galvanic current.

Units, Absolute. They are based upon units of mass (gramme), length (meter), and time (second).

Unit of Current. An ampere. It is the current through a circuit with electro-motive force of one volt, resistance one ohm.

Unit of Electro-Motive Force. One volt represented by the current from one Daniells cell.

Unit of Resistance. The ohm.

Unpolarizable Electrodes. Those made of pure amalgamated zinc or zinc that has been immersed in a syrupy solution of sulphate of zinc. Used in delicate physiological experiments.

Unpolarized. Not possessing polarity.

Upward Current. Term applied to the current when it passes from the branches toward the trunk or root of a nerve. The negative pole is placed on the trunk, the positive on the branches.

VITREOUS ELECTRICITY. Electricity excited by friction of glass.

Volt. The unit of electro-motive force.

Voltameter. An apparatus for measuring the strength of a galvanic current by decomposing water.

Voltaic Alternatives. Galvanism acts as a stimulus to nerves and muscles most energetically when the circuit is frequently opened and closed. When a pole changer is introduced into the circuit so as to not only break the circuit, but change the direction of the current at every break, the method has been named *voltaic alternatives.* This reversal is a much more powerful stimulant than simple interruption of current.

Voltaic Pile. The compound galvanic circle invented by Volta in 1800. Described in text.

INTRODUCTION.

There is no branch of science which received earlier attention or has been the subject of more persistent research than Electricity in its various forms. To those whose attention has not been called to the subject specially, it is a matter of surprise that so much has been accomplished in the various departments of this science without its having sooner obtained a recognized place in the armentarium of the medical profession. It may not be out of place to give a brief résumé of its history, and the various practical applications made of it in the past, before undertaking to show the position it at present occupies and its promises for the future.

It was fully six centuries before the Christian era that Thales, one of the seven sages of Greece, discovered that amber, when rubbed with a dry cloth, developed a peculiar force capable of attracting light bodies such as chaff, bits of paper, pith, etc., and in consequence he believed it to be possessed of a soul which was nourished by the attracted objects.

The luminous appearance attending friction of certain substances was noticed by Roman historians. They also record the appearance of flame, on various occasions, at the points of soldiers' javelins, and on the top of ships' masts. One ancient philosopher relates of himself that, when changing his clothing, sudden sparks were emitted from his person, and at the same time his servant received slight shocks on touching him.

The electric fish, of the Mediterranean, were known to have the power of sending shocks through the water some distance away, of sufficient power to benumb their prey and to disagreeably affect the fishermen, whose spears conveyed the shock from the water to their hands.

The loadstone, also named magnet, from Magnesia, a country in Thessaly, where it was first noticed, is referred to in the Talmud under a Hebrew name, meaning "the stone that attracts." Lucretius, in a poem written sixty years before the Christian era, mentions the power of a loadstone to suspend a series of rings hanging in a chain, one to another. These references show that the power of attraction possessed by the magnet, and its capability of communicating this property to pieces of iron, were known at the very dawn of our history. It is equally certain that the peculiar property which causes a magnet, when freely suspended, to point toward the poles of the earth, was not only known, but made of practical use. More than one thousand years before our era, at the obscurely known Epoch of Codrus, and the return of the Heraclidæ to the Peloponnesus, these people employed magnetic cars on which was the figure of a man whose movable outstretched arm, always pointing to the *south*, guided them on their way across the vast and grassy plains of Tartary. During the third century of our era, at least seven hundred years before the introduction of the compass in European seas, Chinese vessels navigated the Indian ocean with needles pointing to the south. The magnetic needle was brought from China to Italy in 1260, and one traveler asserts that he saw a pilot in the East Indies direct his course by a compass, like those now in use, in the year 1500.

With the exception of the application of the loadstone to the use of the mariner, the various phenomena of electricity and magnetism awakened only vacant wonder, and, while many centuries rolled away, remained but barren facts on the surface of human knowledge.

Gilbert, physician to Queen Elizabeth, in the year 1600 wrote a book in which he gave a classified account of all the electrical phenomena known to his time, and added the results of his personal investigations. He first gave the name *poles* to the ends of the magnet, because they point toward the poles of the earth. He also gave the name electricity (from *elektron*, amber) to the force developed from amber by friction.

The needle does not, however, point directly to the north and south poles of the earth, except in certain localities (for the magnetic and geographical poles do not coincide), neither does it preserve an undeviating direction. Since its use rendered possible voyages of discovery by land and by sea, and it early became a commercial necessity to the merchant who traded with distant people, whether across the trackless water or the equally trackless desert, the fluctuations to which it is subject seriously impaired its value.

The observation of this variation or declination is usually credited to Columbus, who is stated to have discovered it in September, 1492, during his first memorable voyage of discovery; yet one Peter Adziger, in a Latin letter to a friend, written in 1269, describes the process by which he has reckoned the amount of the variation of the needle, showing that this subject had commanded attention long before the period generally named.

The *commercial* necessity for some method of accurately computing the variations of the needle, whereby its deviations could be corrected, has led to the construction of costly apparatus for recording its changes. Observations upon its behavior have been carried on over the entire globe during every season and under all conditions of stormy or clear weather, and the phenomena of magnetism (which gives to the needle its value) have been classified under their appropriate laws, and these laws arranged to form a systematic whole until the science of magnetism is as well established as any of the physical sciences.

The earth is now regarded as a magnetic mass, acting on a magnetic needle, as one needle acts upon another. To the variations of this magnetic influence of the earth is due in part the variations of the needle. The result of various observations may be summed up as follows:

1. *There is a daily variation* which consists of a slight easterly movement of the north end of the needle that reaches its maximum about 7 A.M. It then recedes till its westerly maximum is reached, about 1 P.M. It again returns easterly more slowly, reaching its maximum about 10 P.M. The range of variation is greater during the day than during the night, which is believed to be due to the magnetic influence of the sun.

2. *There is a variation of the earth's magnetism* accompanying the change of seasons. This is indicated by a movement of the magnetic pole from east to west. During the months between the vernal equinox and summer solstice the needle retrogrades to the east, and during the following nine months its general motion is to the west. The magnetic influence of the earth is strongest during December, January and February, when it is nearest the sun, and least during May, June and July, when it is farthest from the sun.

3. Irregular or fitful agitations of the needle were first observed in 1750, by Worgenthin, and later, in 1806, by Humboldt, who gave the accompanying phenomena the name of "magnetic storms."

4. There is still another variation of the magnetic pole of the earth for which no theory has fully accounted. The pole of the magnetic needle now points more than one thousand miles away from the geographical pole of the earth. The needle pointed due north in 1660 (in London, where the observation

was made). It then moved westward until 1818, when it was directed to a point 24° 27′ from the pole, then it began to move back again, and will point due north again in 1976, making a complete cycle in three hundred and twenty years.

Self-recording apparatus, now used in magnetic observatories, give daily and hourly reports of all magnetic variations, and when sufficient time has elapsed to secure enough observations from different parts of the world, much light will undoubtedly be thrown on the cause of the earth's magnetism and its changes.

The earth, atmosphere and clouds form a Leyden jar on an extensive scale, the earth and clouds representing the coatings of the jar, and the air fulfilling the part of the glass through which the electricity passes by induction or discharge.

It is found that in fine weather the atmosphere is almost invariably charged positively; before rain it often assumes a negative state. The rain that first falls is usually negative, although the atmosphere before and after the fall may be positive. Fogs, snow and hail, if unattended by rain, are nearly always positively charged. Clouds are always positive. Electricity, like magnetism, has a period of maximum and minimum intensity during the day, that may be traced to the influence of the sun, and another during the night, dependent on the moon. There is also a yearly variation, dependent upon the relative position of the earth and sun, atmospheric electricity having thirteen times as great intensity when the earth is in that part of its orbit nearest the sun, as when it has receded to that part of its orbit most remote from the sun.

There are also irregular or fitful disturbances of the electrical conditions of the atmosphere accompanying the agitation of the needle during magnetic storms. "These perturbations manifest themselves often simultaneously over land and sea, over hundreds and thousands of miles, or propagating themselves gradually, in a short space of time, in every direction, over the surface of the earth." At these times occur brilliant displays of the aurora borealis, which are believed to be neither the cause nor effect, but simply an accompanying phenomenon, of the electrical disturbances, and due to the same cause.

To the German astronomer Schwabe is due the honor of recording daily observations during more than thirty years, by means of which he established the periodicity of these phenomena. He finds they increase in number and frequency during a little more than five years, then decrease for the same period, occupying, to complete a cycle, about eleven years. He also discovered that they coincide with the appearance of dark spots on the sun; although, from any evidence yet adduced, no one can say that the storms are caused by the sun-spots, or that the sun-spots are caused by the magnetic storms. Whether the sun is the source of electricity, or whether the magnetism of both earth and sun is derived from some common central reservoir of this force, still remains an unsolved problem.

The influence of terrestrial magnetism and atmospheric electricity over health and disease is a subject of practical interest to every physician. That electricity is at all times present in the human body, and that under certain circumstances it becomes manifest through sparks emitted from the person, as well as by other means, has long been known to all who have given any attention to the natural sciences. Cecil relates an instance of a gentleman whose sensitiveness to atmospheric electrical conditions was so great that he was advised to insulate himself by wearing silk underclothing. So successful was this measure that he declared, "it made life another thing."

Dr. Hosford, of New Hampshire, reported in 1837 the following, which is interesting as describing a condition due to disturbed electrical conditions of the human body. On January 25 of that year, during a brilliant display of aurora borealis (magnetic storm), a cheerful, intelligent lady, about thirty years of age, became suddenly and unconsciously charged with electricity, which she first discovered on attempting to pass her hand over her brother's face, when all the family were astonished to see a display of sparks pass from her fingers to his face. This peculiar condition continued without diminution until the last of February, when it began to decline, and disappeared permanently in May. During its continuance, being greatly annoyed by disagreeable shocks on touching any conducting substances,— such as kitchen utensils, needles, springs of chairs,— every effort was made to relieve her, but neither the change of clothing from flannel and silk to cotton, nor any other device, gave her relief. She was not conscious, from any internal sensations, of her peculiar power, but sparks continued to pass from her fingers at the rate of three or four per minute when brought near a conductor, and she could charge others when insulated. She had never been confined to her bed by a day's illness, but had suffered for some months during the previous year with neuralgia, which permanently disappeared with the return of her normal electrical condition in May.

Dr. C. Woodman, of Paw Paw, Michigan,* reports the following curious case: A patient, aged twenty-seven years, can generate light through the medium of his breath, assisted by manipulations with his hands. He will take anybody's handkerchief and hold it to his mouth, rub it vigorously with his hands while breathing on it, and immediately it bursts into flames and burns until consumed. He will strip, and rinse out his mouth thoroughly, wash his hands, and submit to the most rigid examination to preclude the possibility of any humbug, and then by his breath, blown upon any paper or cloth, envelop it in flame. He will, when out

* *Medical News.* [We do not vouch for this.—C. M. H.]

gunning and without matches, desirous of a fire, lie down after collecting dry leaves, and by breathing on them, start the fire, and then coolly take off his wet stockings and dry them. It is impossible to persuade him to do it more than twice a day, and the effort is attended with the most extreme exhaustion. He will sink into a chair after doing it, and on one occasion, after he had a newspaper on fire as narrated, I placed my hand on his head, and discovered his scalp to be violently twitching, as if under intense excitement. He will do it any time, no matter where he is, under any circumstances; and Dr. Woodman has repeatedly known of his sitting back from the dinner-table, taking a swallow of water, and by blowing on his napkin at once set it on fire. He says that he first discovered his strange power by inhaling and exhaling on a perfumed handkerchief, that suddenly burned while in his hands.

The following case has been reported by Dr. C. A. Leale:* A strong man was able to light the gas with ease after a few frictions with his finger. He was recommended to rub his wife, who was suffering from neurasthenia. She recovered, but he became morose, restless, and complained of a disagreeable feeling when his wife touched him. He finally recovered, but was not able to engage in his former business.

There are occasionally reports through the newspapers of the effect of magnetic storms upon invalids, and nervous people, faintings, spasms, palpitations, etc., having occurred when the subjects were not at the time aware that there were any electrical disturbances. Many invalids are enabled to foretell changes in the weather by the aggravation or amelioration of their disease, and their change of symptoms will be found to correspond to the change in atmospheric electricity from positive to negative, or vice versa, which immediately pre-

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cedes or follows storms. The daily and nightly rise and fall of the grave symptoms attendant upon many acute diseases correspond very nearly with the variations in terrestrial electricity, and are recognized as occurring with such regularity that the experienced practitioner can often readily predict the condition of the patient for hours in advance.

Certain groups of diseases are influenced by the seasons. The greater prevalence of lung diseases during the winter months, and of bowel complaints during the summer, cannot be fully explained by the differences in temperature and diet; while of the epidemics, small-pox is recognized as a winter disease, and cholera as a summer disease, although no feasible theory for this has hitherto been advanced, so far as known to the writer. The variation in atmospheric pressure undoubtedly exerts considerable influence over the state of the health; but this very variation of pressure would, of itself, greatly influence the electrical conditions of the human body.

From the days when the Greek slave of Anthero was subjected to the shocks of the torpedo, or electric fish, to cure him of his infirmity, and the Grecian women and children wore amber beads under the belief that its mysterious soul would exert a healing influence over their diseases, mankind has, from time to time, sought in electricity a "panacea for all human ills." At times its champions have made the most impossible promises for it, which, failing to be fulfilled, have thrown disfavor upon its power, and it would pass into obscurity, forgotten by the public, until an opportunity presented to again call attention to it as possessing almost miraculous properties. During the period it has been undergoing these alternations in *popular* favor, a few ardent lovers of science have quietly pursued its investigation with such a wealth of reward in knowledge of its properties and its possibilities, that it has been recently remarked by one writer that probably "the age of *discovery*, so far as electricity is concerned, is past, and we have actively entered upon the age of the practical application of principles long ago demonstrated."

The discovery of the Leyden jar, in 1746, was followed by important results to science. The following year a present of the pair to the Literary Society at Philadelphia, awakened Franklin's attention to physical science, to which he does not appear to have previously given any special attention, but he now took up experiments with avidity, and in 1749 made the discovery of the identity of lightning and electricity, which, although long suspected, had never, previously to his celebrated experiment of drawing lightning from a cloud with a kite attached to a silk cord, been actually demonstrated. The same year he wrote as follows to Mr. Collinsen, the donor of the jars:

"We are not a little chagrined that we have hitherto been able to produce nothing in the way of use to mankind, and the hot weather coming on, when electrical experiments are not so agreeable, it is proposed to put an end to them for the season in a party of pleasure on the banks of the Schuylkill. Among other experiments which we shall exhibit for our diversion, will be the firing of spirits by means of a spark sent from side to side through the river without any other conductor than the water — an experiment which we have some time since performed to the amazement of many. A turkey is to be killed for dinner by an *electrical shock*, and roasted by the "electrical jack" (a little moving power he had invented) before a fire kindled by the electrified bottle, when the health of all the famous electricians of England, Holland, France and Germany is to be drank in "*electrified bumpers*," under the discharge of guns by the *electrical battery*."

In 1730 Dufaye transmitted electricity along a cord of moist packthread for 1300 feet. In 1774 Le Sage, a Frenchman at Geneva, transmitted a message over wires. He used twenty-four, one for each letter of the French alphabet, insulating them in glass tubes buried in the earth. These wires were connected with an electrical machine at one end, and electroscopes at the other, their divergence marking the letters.

Three years afterward, near London, a current was passed through wires for a distance of two miles, the wires being insulated by and supported upon logs of baked wood. But one discovery must wait upon another, and it was not until the discovery of the electro-magnet that transmission of messages over wires could be rendered practical. In 1840 Prof. B. Silliman took daguerreotypes by an electric light obtained from a zinc and copper battery in the laboratory of Yale College, and in 1854 an electric light was used in Paris during four months to enable eight hundred men to continue the work of excavation of a hill that had to be removed for some public purpose.

Nearly all these earlier investigators made numerous experiments in treating disease both with electricity and the magnet. Many points of resemblance between the nervous force and electricity were noted, which, taken together with the evident influence of electrical variations over disease led to the belief that nervous force was but electricity modified to adapt it to the animal system. In 1848, Matteuci, who had devoted much time to this subject, conclusively proved that electricity and nervous force are not identical, but bear the same analogy to each other as exists between heat, light and electricity. In addition to this, it has been claimed that there are electrical currents generated in the muscles and secretory organs, the result of the chemical changes going on within the tissues, and that these currents may be modified by artificial currents from without the body. For many years the influence of electricity in all its forms over the tissues of the body has been diligently investigated, and the application of electricity to treatment of disease is now claiming the attention of the medical world more universally than at any previous period of its history.

It is to be regretted that the early observers, who, with meager materials at their command and no preceding records to guide them, made those brilliant discoveries which now form the bases of all the practical electrical inventions that so delight and astonish the public of the present day, have left us no fuller account of their experience with disease. Frequent mention is made by them of remarkable cures of nervous disorders, paralysis, epilepsy, neuralgia and rheumatism. Those disorders, well known to be influenced by changes in external circumstances of weather, season and climate, seemed to receive the most benefit. These reports of marvelous cures are not confined to a single observer, nor any one land. Records from almost every country on the globe, and from many experimenters, are found throughout our literature of the past two hundred years, confirming the valuable properties possessed by electricity as a remedial agent, but in regard to the particular condition of the patient with which successes or failures occurred, the strength of current used, and frequently the kind of electricity employed, we are left in the dark. Its use, until very recent years, has been entirely empirical.

The large class of neuroses, including hysteria, epilepsy, paralytic, neuralgic and spasmodic affections which so frequently baffle us when other therapeutic agents are employed, and tax professional skill to the utmost, should invite our investigation to this field, which, the experience of the past encourages us to believe, offers greater inducements to the original investigator than any other branch of our art. Since the specialist, who has used galvanism only, reports gratifying success in the same class of cases as those who employ exclusively either franklinism or faradism, we conclude that at present success depends more upon the care with which the details of treatment are carried out than upon the form of electricity employed.

There is reason to believe that the time is not far distant when the differential indications for selection of the particular current best suited to various diseased conditions shall be clearly defined, and to Dr. Rockwell is due the honor of first directing the profession in our own country to this path of investigation. We need a series of carefully recorded observations, no less accurate and extensive than those which established the cycle of magnetic storms, to determine how much diseases are actually influenced by electrical disturbances, and what relation the cycles of magnetic and electric phenomena bear to the appearance of epidemics. We also need full and complete clinical reports from conservative and observant practitioners before a satisfactory knowledge can be acquired of the true place electricity should occupy in our armentarium.

Many reports of cases as now made are worthless, in not being sufficiently explicit. In reporting cases these points should be distinctly brought out, after describing the diseased condition in the usual manner:

1. The method of applying the current; whether general or local, labile or stabile, continuous or interrupted.

2. The kind of current used.

3. The direction of the current and location of electrodes.

4. The length of sitting.

5. The number of sittings.

6. The interval between sittings.

7. The power of battery current employed. Batteries of different makes, and of the same make under varying conditions, as described in chapter on batteries, differ so much in the force of current sent between the electrodes that it is important to settle upon some standard of comparison for medical batteries, as has been done for those employed in the arts, that the actual current strength may be indicated in reports of clinical cases.

Evaporation and condensation of vapor are constantly setting free vast amounts of electricity, which cannot but exert an influence over the electrical conditions of the human body. The lightning flashes transform oxygen of the atmosphere into ozone, which purifies noxious vapors and destroys poisonous exhalations. There is some ground for believing that the prevalence of certain epidemics may bear some relation to electrical conditions of the earth and air. When cholera prevailed in 1849 with great fatality, it was observed that in localities in England where the pestilence raged most severely the magnetic attraction was diminished one half.

Dr. Henry Stone has proposed a novel theory, which he terms the Electro-Galvanic Theory of Yellow Fever, in which he attributes the presence of the disease as an epidemic to disturbed electrical conditions. Among other indications pointing to this origin, he cites what he terms the popular belief, that telegraph operators, other things being equal, are especially liable to violence of attack. Those interested in learning his views, and the arguments by which he supports them, will find the article referred to in the New Orleans *Med. and Surg. Journal*, July, 1881.

G. A. Sprechor* also advances the theory that malarial diseases depend upon the same cause. He cites the statement of Audrand that during the great cholera epidemic in Paris, an electrical machine, which he was in the habit of using, gave, during April and May, sparks not more than half as long as those which it usually emitted. During June 4th, 5th and 6th, only a slight crackling could be obtained, and on the 7th of that month no electrical phenomena could be excited. The days of the greatest mortality corresponded with the absence of electrical manifestations, and the rapid abatement of the epidemic coincided with a return of electrical phenomena in the atmosphere.

Dr. Sprechor suggests that the extension of our telegraph and railroad systems through the country may have some influence in modifying and directing malarial troubles, by the

* *Pacific Med. and Surg. Jour.*, Feb. 1883.

formation of extensive conductors of electricity, and notes the effect these have upon the manifestation of electrical phenomena by the fact, which he asserts, that our great hurricanes and tornadoes follow the lines of railroads. He further suggests that an explanation of the fact that animals and negroes are not at all, or very little, affected by malarial disease may be found in the fact that the hairy coat of the one and the dense oily skin of the other are a more or less perfect means of electrically insulating them.

It may seem chimerical to suggest at the present time the possibility that at some future time the relation of epidemics to electrical disturbances, and dependence upon them, may become established, and that some method can be devised by which the electrical currents of the human system can be modified so as to render it less susceptible to contagious influence, and thereby prove as efficient a protector against certain of our most fatal epidemics as vaccination is against smallpox or antisepsis against zymotic poisons. This certainly offers a most attractive field for study and experiment.

CHAPTER I.

MAGNETISM.

THE THEORY CONCERNING THE NATURE OF ELECTRICITY.

Electricity is now very generally regarded as a form of motion akin to light, heat and sound, which pervades the earth itself, all objects upon its surface, the atmosphere surrounding it, and the heavenly bodies. We know that from electricity we can obtain heat and light, while from heat, and the action of the sun's rays, we can obtain electricity, but although we have tolerably correct ideas in regard to the character of motion of heat and light, our ideas as to the precise nature of the change which motion must undergo to appear as electricity, are still very defective.

ACTIVE AND PASSIVE ELECTRICITY.

So long as its distribution is uniform throughout any object, its presence cannot be detected; it is then said to exist in a *passive* or *bound state*, or in a *state of equilibrium*. When the electric equilibrium between any two points of an object, or between two objects, is disturbed, electricity is said to be *free* or *unbound*. It is with electricity in a *free* state that we have to do in its application to electro-therapeutics.

OBSCURITY OF ELECTRICAL LANGUAGE.

Formerly it was believed to consist of a fluid or fluids, which flowed through bodies as a stream of water flows through its channel, and many of the terms used by the earlier writers on the subject are still retained, and convey an incorrect idea of the real nature of electricity. At the meeting of the electrical congress at Paris, in 1881, a revision of electrical language was suggested, which should make it conform to the present theories concerning this force. Some important changes were made, although much remains to be done, and there is still some confusion, even in the works of recent writers, in the use of terms. For the convenience of the reader, a full vocabulary of electrical terms is arranged on page 7, to which reference should be made when the meaning of the text is not clear.

FORMS OF ELECTRICITY.

The manifestations of electricity may be arranged under three heads: 1, magnetic; 2, static; 3, dynamic. Its magnetic properties as existing originally in the loadstone will be considered under the head of *Magnetism.* The phenomena attending static electricity set free by friction belong to *Franklinism.* Free electricity, moving as a current, is termed *Dynamic.* Dynamic electricity includes *Galvanism* and *Faradism.*

MAGNETISM.

The fact that the earth is a vast magnet, exerting magnetic influence over all objects upon its surface, was long since proven.

It is the magnetic power of the earth which gives to the loadstone its peculiar properties, and Sir Wm. Thomson holds the belief that man possesses a seventh sense, which he terms the "magnetic sense," that enables its possessor to detect, by peculiar sensations, marked variations in terrestrial magnetism.

The notion that the magnet exerts a peculiar influence upon health is a very old one. In ancient times, the mineral ore, or natural magnet, either alone or mixed with other materials, was used as medicine externally or internally for the cure or relief of certain disorders of mind or body. Before reviewing the experiments that have been made with this agent, it is necessary to define the properties it possesses and the laws which govern its manifestation.

The presence of magnetism in any object is shown:

1. By its power of attracting iron filings, needles, etc.

2. By attracting or repelling other magnets.

3. By arranging itself, when freely suspended, so as to point toward the poles of the earth.

4. By its power to impart its own magnetic properties to iron or steel.

NATURAL AND ARTIFICIAL MAGNETS.

A natural magnet consists of a reddish brown or gray ore found in iron mines throughout the world.

Artificial magnets are those in which the peculiar properties of magnetism are induced artificially.

Artificial magnets are of two kinds: 1. *Temporary*, made of soft iron, which acquires magnetism readily, but loses it as readily as acquired. 2. *Permanent*, made of hardened cast steel, which cannot be so highly magnetized as soft iron.

MAGNETIC POLARITY.

When a small magnetic bar or needle is freely suspended it will be found that it will arrange itself so that one end will point toward the north pole of the earth; and if the needle be turned in any other direction, as soon as it is free to move it will return to its original position, the same end always pointing in a northerly direction.

Manufacturers mark one end of the needle in various ways to distinguish it; sometimes by a notch, paint, or letters N or S. It is important to know which end of the magnet is pointing in a given direction when it is used as a compass-needle, and also when it is used in making or testing other magnets.

THE MAGNETIC POLES OF THE EARTH.

The earth's magnetic poles do not correspond with the geographical poles. They are located at points in the northern and southern hemispheres, where the magnetic needle becomes vertical or perpendicular to the horizon when so hung that it may revolve perpendicularly to the earth's surface. Midway between these points is a place where the needle stands parallel with the horizon, and when passing northward from this, the north end of the needle begins to dip more and more until its pole is reached. Passing southward, the south end of the needle dips in the same way.

ATTRACTION AND REPULSION.

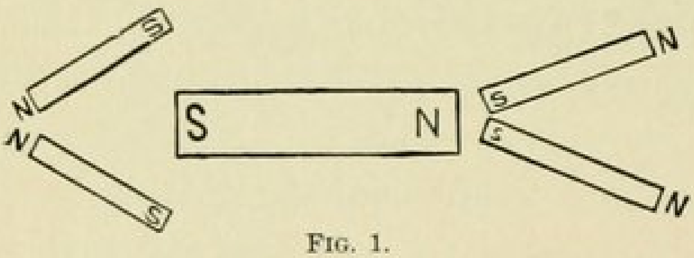

FIG. 1.

When a magnet is brought near a magnetic needle, or a small magnet that is free to move, it will be found that the north pole of one magnet repels the north pole of the other, and the south pole of the one repels the south pole of the other. When, however, the north pole of the first magnet is brought near the south pole of the movable magnet, the latter will be attracted and will approach nearer. Fig. 1 represents a large magnet with two small movable magnets at each end. The latter were at first parallel, but the *attractive* power of the large magnet has been exerted at the north end to draw toward itself the south ends of the small magnets, the repulsive force of its south end has driven off the south ends of the small parallel magnets near it.

THE LAW OF MAGNETIC ATTRACTION AND REPULSION.

Like poles repel, unlike poles attract each other.

The power of attraction is not equal throughout the entire length of the magnet. Dip a magnet in iron filings, and it will be noticed that the greatest cluster will be attracted to the poles or ends, while toward the middle will be found a space where none adhere.

LINES OF MAGNETIC FORCE.

If iron filings be spread on a stiff sheet of paper with a strong magnet held near to the paper, and underneath it, when the paper is slightly jarred the filings will arrange themselves in curved lines, as shown in Fig. 2.

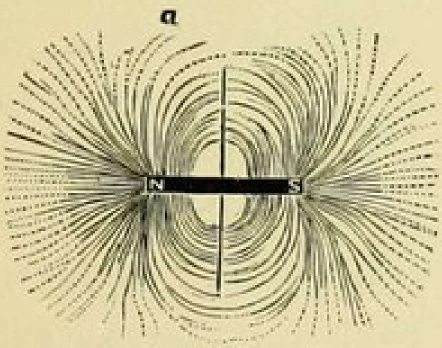

FIG. 2.

These curved lines are called *lines of magnetic force*, and the space through which the magnet exercises its force (the space covered by the curved lines) Faraday named the *Magnetic Field*.

The lines of force diminish in number and length the further they are from the poles, until they entirely disappear, as represented by the white space at the center of *a*. The line across the center marks the *central point*, or point of no attraction.

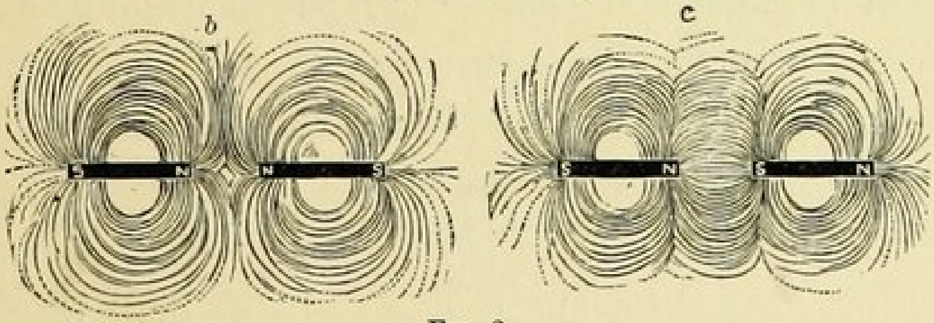

FIG. 3.

In Fig. 3 we have two equal magnets brought near, but not in contact with, each other. *b* represents what takes place when their north poles are adjacent. The particles, repelled by one, after a little distance fall within the lines of repulsion of the other, and are repelled alike by both. *c* shows the same magnets with unlike poles adjacent. Particles repelled by N are attracted by S, and *vice versa*, illustrating why *like poles repel and unlike poles attract each other.*

TRUE POLARITY OF THE COMPASS NEEDLE.

Since like poles repel and unlike attract each other, it follows that if two magnets be freely suspended within the sphere of their attraction (their magnetic field), the marked end of one will arrange itself parallel to the opposite or unmarked end of the other magnet; therefore, that end of the compass-needle that points toward the north magnetic pole of the earth must be in an opposite or unlike magnetic state; or, in other words, that end of the needle pointing north possesses south magnetism, and that end pointing south possesses north magnetism.

Some authors call the magnetism of the north pole of the earth *boreal*, and that of the south pole *austral;* while the magnetism of the end of the needle pointing north is called *austral*, and its opposite end *boreal.*

Unfortunately there is no uniformity in the marking of magnets among manufacturers. In England and Germany the end of the needle that, when freely suspended, points toward the north is marked N, while in France this same end of the needle is marked S. In determining the polarity of unmarked magnets, this discrepancy should not be lost sight of.

EFFECT OF DIVIDING A MAGNET.

If a magnet is divided, since there is in the bar a neutral point where no magnetic properties are exhibited, it might be supposed that one half would exhibit only boreal and the other only austral magnetism, but such is not the fact; each half has two poles exactly like the original magnet, and no division can be made so small but that the resulting portions will exhibit both kinds of magnetism. *No magnet was ever seen that had but one pole.*

MAGNETIC INDUCTION.

When a soft piece of iron is brought near a magnet it immediately assumes the magnetic state. This influence of a magnet operating at a distance is called *magnetic induction.* It is through induction that iron filings, tacks, etc., are attracted, and that magnetic properties are transferred from one bar to another when charging magnets.

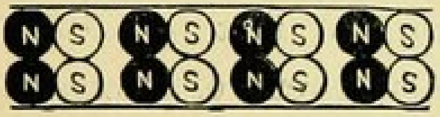

FIG. 4.
Arrangement of molecules in a bar that exhibits no magnetic attraction.

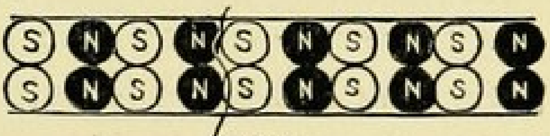

FIG. 5.
Arrangement of molecules in a magnet. The irregular line across the bar marks a line of fracture which always occurs at a point which sets free a north and south atom.

Magnetizing a bar of iron or steel consists in breaking up the magnetic affinity of the atoms and rearranging them so that the layer at each end is left without a mate.

This explanation of the process has been suggested:

1. Each molecule of iron, steel, or other magnetic substance, is a separate and independent magnet, having a north and a south pole exactly the same as that shown by a steel bar magnet.

2. The inherent polarity or magnetism of each molecule is a constant quantity, like gravity, and can neither be increased nor destroyed, but may be rotated by magnetism or electricity so that the entire magnet may have its poles reversed.

3. When a magnet seems to have lost its magnetism there is no actual loss, but the molecules have arranged themselves so as to satisfy their mutual attraction by the shortest path, forming a complete closed circuit of attraction.

4. When magnetic properties are evident, the molecules or their polar atoms have all rotated in a given direction, and we still have a symmetrical arrangement, but the circuit of attraction is not complete except through an external armature connecting both poles.

5. Permanent magnets are those in which the atoms are bound together with such rigidity (as in tempered steel) that they cannot rotate. Temporary magnets are those in which the atoms (as in soft iron) are held so loosely that they can readily rotate.

6. The neutral line of the magnet, or point of no attraction, found at a little distance from each extremity, does not indicate that there is no magnetism at that point, but that the attraction of the molecules is satisfied by a short circuit of attraction within the magnet itself.

MAGNETIC INDUCTION OR ATTRACTION ACROSS BODIES.

If a sheet of glass, wood or paper be placed between a magnet and iron filings, they will be seen to be influenced by the magnet, and will arrange themselves in lines as if in actual contact with it. It is found that magnetic force acts across a vacuum, water, and all known substances, except across a network of iron, or other magnetic material.

FORM OF MAGNETS.

Artificial magnets are generally in the form of a bar or U; the latter are called horseshoe magnets. Both forms may be *simple* or *compound*.

A *simple* magnet consists of a single piece of metal. A *compound* magnet consists of several simple magnets made of thin plates of steel, placed side by side with their like poles together. If one plate is thinner or smaller than the rest, it weakens the entire combination.

A *magnetic battery* consists of several compound magnets of the same shape and size bound together. A magnet of this kind is much more powerful than a solid one of the same weight, because thin plates can be more strongly magnetized than thick ones.

KEEPERS OR ARMATURES.

When a magnet is not in use, the molecules after awhile will commence to arrange themselves, as in Fig. 4, and it will gradually cease to exhibit magnetic properties. To preserve a horseshoe magnet, its two poles are connected by a piece of soft iron called an *armature* or *keeper*. Bar magnets must be arranged in pairs, with unlike poles parallel, and connected by a keeper.

TO CHARGE A MAGNET.

When a bar of slightly-tempered steel is held vertically and struck several blows with a wooden mallet, it will acquire magnetism, and will attract iron filings, or deflect a magnetic needle, the same as a natural magnet. Magnetism may be communicated from one bar to another in the following manner: lay the unmagnetized bar horizontally north and south; place one end of the magnet on its center and carefully draw it to the end of the horizontal bar; raise it, always carrying it back to its starting point in a curve through the air; repeat several times, then pursue the same course with the other half of the bar, first reversing the magnet. The latter loses none of its own magnetism by the operation, and the polarity of the new magnet is opposite to that of the inducing magnet.

TO PRESERVE THE POWER OF A MAGNET.

1. When laying it aside, place it as nearly as possible in the position which it would assume if freely suspended, so as to be acted upon by the earth's magnetism. When the poles

are kept for a long time in any other position than this, unless made of the hardest steel, the magnet will eventually lose the whole of its magnetic power.

2. Two magnets rapidly weaken each other, if placed even for a short time with similar poles opposite to, or facing, each other.

3. All rough and violent treatment, such as falls, blows from a hammer, scratching the surface with sandpaper, or great heat, weaken the power of a magnet.

4. Neither horseshoe nor bar magnets should be laid aside without an armature. They are improved by keeping dry iron filings around the poles.

LIFTING POWER OF MAGNETS.

Natural magnets do not increase in power in proportion to their increase in size. Sir Isaac Newton is said to have worn a loadstone, set in a ring, which weighed only three grains, yet could lift seven hundred and forty-six grains, or nearly two hundred and fifty times its own weight. One brought from Moscow to London, that weighed one hundred and twenty-five pounds, could support only about two hundred pounds. A horseshoe magnet is three or four times as powerful as a bar magnet. A horseshoe magnet weighing one pound ought to lift a weight of twenty pounds.

It has been observed that when a magnet attracts iron a reaction takes place, the iron in turn attracting the magnet. The lifting power of a magnet can be greatly increased by adding day after day small pieces of iron, until its limit is reached. If more pieces are added after this point is reached, they will tear off the armature and reduce the power of the magnet to its original value.

ANIMAL MAGNETISM.

Although the peculiar powers manifested by the torpedo and gymnotus were known to the ancients, it was not known until

1772 that these powers were due to electricity. The most eminent anatomists and physiologists have devoted much time to the investigation of animal magnetism since the discovery that shocks from these fish can magnetize needles and produce sparks.

A German philosopher, named Father Hehl, appears to have been the first to write on the subject of animal magnetism. His views were published in 1774, and subsequently they were adopted by Frederick Mesmer, of Suabia, who soon deviated from the tenets of his instructor, and in 1779 published what he termed a new system of treating disease, to which the name Mesmerism has been given. He claimed that the magnet was not directly necessary to produce the effects ascribed to it by Hehl, but that one human being acts magnetically on another, on concentrating the attention and making with the hands certain passes over the body of the person to be magnetized. His extravagant pretensions attracted so much attention, that the King of France appointed a committee, composed of members of the Royal Academy of Science, with Benjamin Franklin at its head, to investigate the subject. After numerous experiments, they decided that mesmerism had nothing to do with magnetism, and it soon lost its popularity.

THERAPEUTICAL PROPERTIES OF THE MAGNET.

The ancients ascribed various medical properties to the loadstone. Galen ascribed a purgative property to it, and recommended it in dropsies. Paracelsus, in the year 1503, recommended it in the treatment of epilepsy, and for the succeeding two hundred years it was extensively employed in disease. In 1760 amulets were employed, consisting of pieces of magnetized metal so united as to form collars, garters, bracelets, or plates adapted to various parts of the body. It was sometimes pulverized and mixed with plasters, which acquired the reputation of extracting iron and other metallic substances from the body. The chemists of those early times were not behind their brethren of the present day in extravagant pretensions, for they claimed to extract an oil of wonderful efficacy from the loadstone, which possessed all its properties in a concentrated form.

Recent observations in Paris hospitals, to determine the effect of the magnet upon patients, showed that it usually lessens the pulse, although sometimes it produces no effect upon it. Breathing is not modified, but patients sometimes complain of throbbing, pricking sensations at the positive pole.

Metallo-therapy* is a term used to designate the employment of metals, externally and internally, in the healing of certain diseases in which it is claimed they have been found serviceable. It includes also the magnet in its list of appliances. This subject has been thoroughly discussed in the French journals during the last five or six years, and Charcot and Vigoureaux having made numerous experiments, both pronounce their confidence in it as a valuable acquisition to medical science. The popular notion that sleeping with the head to the northward, so that the body will be parallel with the terrestrial magnetic currents, is useful in certain nervous complaints, has long been regarded as a harmless superstition; but the subject, in this day of enthusiastic investigation of all questions pertaining to electrical science, is again attracting attention, and we quote from *The Electrician*† the latest in regard to the subject:

M. G. De Rocquigny writes as follows to the editor of *Les Mondes:*

"M. C. Vignier wrote in the *Révue Philosophique* for 1882, No. 7, July, p. 31: 'Is there, then, an agency capable of exercising a continuous action on the apparata of the nerves (*canaux*), varying with the position of the head? To my mind this agency exists, and is none

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* Archives of Medicines, October 1883 (Dr. Peckham).

† November 1883.

other than terrestrial magnetism. That an all-pervading force should be without any action on our organism when we see it influenced by the least variation of light and heat, is surprising enough already. But it is beyond dispute that galvanic currents not only exercise a powerful effect on our nervous system, but that electro-magnets themselves produce well marked effects in certain nervous affections. The experiments undertaken at Salpetrière, by M. Charcot, leave no room for doubt on this point; and there must be some foundation for the practice adopted by the Swedish peasants, who cause themselves to be buried for several hours so as to lie North and South in order to cure neuralgia.'

"To this the author adds the note: 'I have this fact from M. Nordstrom, Swedish Consul at Alger. It is, moreover, sufficiently proved by physiological experiments that a very close relation exists between the nervous system and electricity, of which magnetism is but one form.' In another note the author quotes the following experiment, carried out by M. Ziégler, of which M. Vogt was a witness: 'M. Ziégler takes a lens of soft iron, he exposes it in a place where it will receive the lines of terrestrial magnetism and redirect them on to the organ to be studied. By thus projecting the magnetic lines concentrated in this manner on the heart of a rabbit, the rhythm of the heart is changed; if the lines are concentrated on the intestines, violent peristaltic movements (*péristaltiques*) are caused (*Journal Officiel*, May 18, 1881). The preceding facts will, perhaps, appear to you, Monsieur l'Abbé, to add some degree of probability to the theory put forward by *The Electrician* of London.'"

Dr. Hammond has reported some experiments in the use of the magnet that will be referred to elsewhere. In the present state of our knowledge of this subject the use of the magnet in the treatment of disease must be wholly empirical, and is only resorted to in isolated cases by way of experiment, when other forms of electricity have failed to produce a beneficial effect.

CHAPTER II.

FRANKLINISM.

Frictional or static electricity when applied to medical purposes is known as *Franklinism*, in honor of Benjamin Franklin, whose investigations marked an era in electrical science, and who was the first in this country to apply it to the treatment of disease. The presence of frictional electricity is manifested by the following effects:

1. *Luminous*, as when lightning flashes through the sky.

2. *Mechanical*, as when lightning strikes an object, rending and destroying it.

3. *Calorific*, when the object struck is at the same time set on fire.

4. *Chemical*, as shown by its power to convert oxygen into ozone. The change in the atmosphere after a thunderstorm is due to the development of ozone on a large scale by the lightning. Milk is soured during a thunderstorm by the chemical action of lightning.

5. *Magnetic*. When masses of metal receive a lightning stroke and afterward exhibit magnetic properties.

6. *Physiological*, as when a person has survived a stroke to remain paralyzed from the tremendous shock to the nerves; or as in those rare instances where sight or hearing has been suddenly restored by the same means.

ATTRACTION AND REPULSION.

Previous to the investigations of Gilbert, in 1600, jet was the only substance known to possess the same peculiar power of attraction and repulsion first discovered in amber. Subsequent observers have established the fact that under certain conditions, all substances exhibit, to a greater or less degree, the same properties.

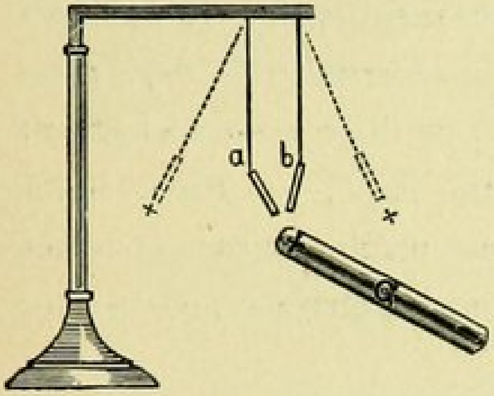

FIG. 6.

Fig. 6 illustrates these phenomena. A glass rod, G, having been excited by rubbing with a silk handkerchief, is brought near two straws, *a b*, suspended by fibers of silk thread. They are attracted by the glass for an instant and then repelled, not only by the glass, but by each other, in the direction marked by the dotted lines + +. Again, rub a stick of sealing-wax or shellac with flannel and bring it near the straws: they will behave as before. If, however, the wax be presented to them while repelled by glass, they will be instantly attracted by the wax. If an excited rod of glass be brought near one straw and another of wax near the second straw, while being respectively repelled from the excited rods, they will be mutually attracted; hence the law of electrical attraction:

Bodies electrified alike repel, those electrified unlike attract each other.

The phenomena of attraction and repulsion are exhibited by all forms of electricity, but franklinic electricity excels them all in exerting this influence at a distance. Its force varies inversely as the square of the distance between the bodies, through which this influence is exerted.

POSITIVE AND NEGATIVE ELECTRICITY.

The form of electricity developed by rubbing glass was formerly called *vitreous*, because it was erroneously supposed that the opposite kind could not be produced from glass. That kind developed from resin was called *resinous* for a similar reason. It is now known that the kind of electricity depends not alone upon the substance rubbed, but also upon the substance with which it is rubbed. Resinous electricity may be excited in glass by friction with fur, and vitreous from resin, when rubbed with amalgam spread on leather. *Vitreous* electricity is now called positive, and is marked with the sign +, while *resinous* electricity is called negative, and marked with the sign —. Since bodies in a like electrical state repel, and those unlike attract, it is easy to determine by comparison whether an electrified body is positive or negative.

THE ELECTROSCOPE.

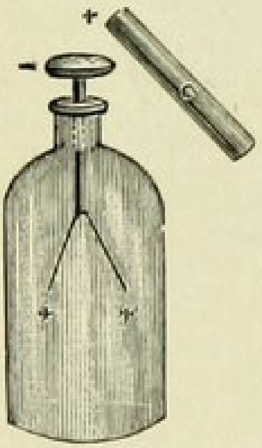

Fig. 7.
ELECTROSCOPE.
Ht. 12 in. Diam. 4¼ in.

This is an instrument for detecting minute quantities of *static* electricity, and determining whether a given charge is positive or negative. It consists of two strips of gold-leaf, hung together by the upper ends to a metal rod. This rod passes through the stopper in the neck of the glass bottle within which the gold-leaves hang. The upper end of the rod terminates in a nickel-plated brass disc.

PHENOMENA OBSERVED ON ATTEMPTING TO TEST AN ELECTRIFIED OBJECT.

1. Rub a glass rod briskly and bring it near the disc, the gold-leaves will become charged with the same kind of electricity, and repel each other.

2. While they are mutually repelled, touch the disc with the finger, they will instantly collapse.

3. Remove the finger, and then the glass rod, the leaves will separate again owing to their being similarly electrified.

4. Now bring the glass rod near, they collapse.

5. When brought nearer still, they separate again.

6. Remove the rod a little, they collapse.

7. Remove it further, they separate again and remain apart, showing that there is now a charge in the electroscope.

8. Now bring near the disc a rod of sealing-wax or hard rubber, electrified by rubbing, the leaves fly still further apart.

9. Take the rod away, and they resume their former divergence.

TO TEST AN ELECTRIFIED OBJECT.

To discover which kind of electricity it is charged with, proceed as above described, except 8 and 9. After having secured a charge in the electroscope from a glass rod, bring the object to be examined near the instrument. If it is charged with negative electricity, the gold-leaves will behave as when the rod of sealing-wax was presented to the disc; if positive, it will not disturb the gold-leaves.

To discover if an object is electrified at all. Bring it near the disc when the electroscope contains no charge, and the leaves are not divergent. If the object is electrified, the leaves instantly fly apart; if it is not electrified, they are not disturbed.

EXPLANATION OF THE PHENOMENA OBSERVED.

1. At first the plate and leaves are not electrified, and the glass rod (being +) attracts – electricity to the disc, and repels + electricity to the leaves, and they repel each other.

2. The hand and body become a part of the electroscope when the disc is touched, and the + electricity repelled by the glass passes through the body to the earth, the – electricity being retained in the disc chiefly by the attraction of the glass rod.

3. Removal of finger and glass rod permits the – electricity to spread over disc and leaves, and the latter again diverge.

4. The glass rod brought near now attracts the – electricity to the disc; there is none left free in the leaves, and they collapse.

5. The glass rod, on approaching nearer, sets more electricity free in the disc and leaves, and the same process is begun, and continued in 6th and 7th, as took place at first.

8. When the leaves are divergent from the positive charge produced by the glass rod, if a rod of sealing-wax, or a piece of rubber electrified by friction, be brought near, being negative it repels the — electricity from the disc to the leaves, and they diverge still more.

The electrical condition of a patient after receiving a charge may be determined in the same way, provided the electroscope is not brought near enough the machine to be influenced by the charge escaping from its surface.

CONDUCTORS AND NON-CONDUCTORS OR INSULATORS.

Bodies that have been electrically excited return to a neutral condition after a time, under the influence of the surrounding air, but they may be made to do so instantly if touched by the hand, a metal wire, etc. A rod of glass or sealing-wax held in contact with them does not lessen their electrical excitement. Those objects, such as the hand, metal wire, etc., which readily permit the passage of electricity over them, are called *conductors.* Glass, resin, and other substances which resist the passage of electricity, are called *non-conductors* or *insulators.* Heat lessens the conducting power of metals, while it increases that of most other substances.

These terms are relative, as there is no such thing as perfect insulators, or perfect conductors. The presence of moisture deposited by the air upon its surface converts the best insulator into a conductor.

DISCHARGE.

When an object is restored to a neutral condition by the touch of a conductor, it is said to be *discharged.* Any excited or charged body may be discharged by connecting it with the ground by a good conductor, or by passing it through a flame.

INSULATION.

A body is said to be insulated when it is supported or surrounded by some badly conducting substance which prevents free escape of electricity; when it is important to keep electricity from escaping, supports of glass, shellac, india-rubber. or other non-conducting substance, are used.

ACCIDENTAL INSULATION OF A DWELLING-HOUSE.

An instance* of this was reported some years ago as having occurred in New York city. "A new house was so thoroughly insulated in its construction, that the electricity set free by friction of carpets and furniture by the inmates, having no way to escape, accumulated to such an extent, that shocks were felt, and, in the dark, sparks were seen proceeding from the fingers, on touching the door-handles and other metallic objects in the house, and even when shaking hands. A ground connection being made from the interior of the house, the annoying phenomena ceased." A similar instance was reported in the local papers as having occurred in Iowa last year, and in this city as least one instance of the kind has come to our knowledge recently.

Many bodies formerly supposed to be incapable of being electrified are found such good conductors, that electricity flows away as fast as excited, and when they are properly insulated are easily electrified.

Glass, when kept dry and clean, is one of the best insulators for practical purposes; and if coated while hot with shellac varnish, deposits of moisture on its surface will interfere but little with its insulating power.

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* Prof. Loomis, 1850.

INDUCTION.

A body may be charged with electricity without touching it, by bringing near, but not in contact with it, an electrified body. This is *electrifying by induction*, and the charge received will be opposite to that possessed by the inducing body. Newton was the first to discover that when one surface of a plate of glass is charged with positive electricity by friction, a negative charge appears on the opposite surface without friction.

DIELECTRIC.

The plate of glass or other substance through which the charge is propagated is called a dielectric.

CONDUCTION.

When a body is charged with electricity by actual contact with an electrified body it is called charging by *conduction*.

INDUCTION AND CONDUCTION COMPARED.

BY INDUCTION.	BY CONDUCTION.
1. The inducing body does not lose any part of its electricity.	1. The conducing body loses part of its electricity.
2. The opposite kind of electricity is given to the induced body.	2. The same kind of electricity is given to the body acted upon.
3. The object to be electrified must be in contact with the earth, either directly or by means of a good conductor.	3. The object to be electrified must be insulated from the earth.

RETURN SHOCK.

Sometimes when a charged conductor is suddenly discharged a shock may be *induced* in persons standing near. This is called a "return shock" or "back stroke," and is sometimes felt by persons standing on the ground at some distance from an object struck by lightning.

DISTRIBUTION OF ELECTRICITY.

Electricity may exist on a surface as a charge, or flow over it as a current.

The charge is the amount of electricity produced, excited or set free in any body. When two bodies are rubbed together, the one whose particles are most easily moved by friction becomes *negatively* electrified; the harder body, *positively* electrified. Two plates of the same material may become oppositely electrified when they differ in temperature, the warm one becoming positive, the cold one negative. A charge is not spread uniformly over a surface; there is more on the edges and corners than on flat surfaces. Good conductors allow electricity to move freely over or through them; and if a charge be given to one part it instantly spreads over the whole surface. A charge given to a poor conductor takes a long time to distribute itself, and in many instances is practically confined to the part that received it.

When a charge of electricity is constantly carried off and as constantly renewed, it constitutes *a current.*

RESISTANCE.

Resistance is the converse of conduction. It may be defined as that quality of a conductor that impedes the passage of electricity.

ELECTRO-MOTIVE FORCE.

Electro-motive force is the power that urges electricity forward, or causes it to move from one point to another. It may be called the propelling force.

POTENTIAL OR TENSION.

Potential or *tension* may be briefly explained as the *electric level*, and usually refers to the difference between the electric distribution or condition of any object and that of the earth. When the potential of the object is above that of the earth, electricity tends to escape from it to the earth. When it is below that of the earth, electricity passes from the earth to the object. It is evident that the greater the surface over which electricity is diffused the less its potential at any given point.

DIFFERENCE OF POTENTIAL.

When any two objects are compared, the difference in electric level is called difference of potential; the greater this difference, the greater the electro-motive force, or power of overcoming the resistance, between them. Whenever a difference of potential exists between two objects that are brought within the sphere of mutual attraction or repulsion, there is a tendency for electricity to seek an equilibrium. An example of extreme difference in potential may be found in violent thunderstorms, when the earth and clouds have so great a difference of electrical level that electricity can no longer pass silently between them on the trees, spires, and other natural conductors, but darts in forked streaks or enormous flashes over miles of surface at every discharge.

MUTUAL POTENTIAL.

The mutual potential of two objects is measured by the amount of work done when allowed to separate under the influence of mutual repulsion, or to come together under the influence of mutual attraction. *Induction* can only take place between objects of different potential.

QUANTITY.

Quantity refers to the amount of electricity required to restore the equilibrium between two unequally electrified bodies.

DENSITY.

Density is the amount of electricity on a given surface *at any moment* while *quantity* is the total amount generated by the machine. Density is the same on all points of a ball, but on a plate it is greatest at the edges, and on a pointed conductor, at the points.

AN ACCUMULATOR.

An accumulator is an apparatus for receiving and retaining large quantities of electricity.

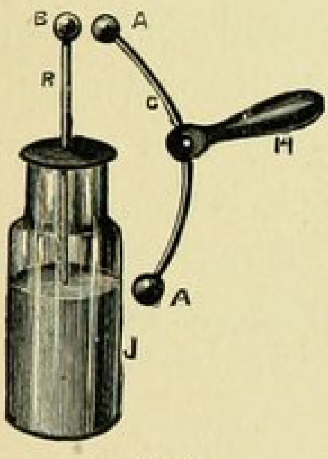

FIG. 8.

THE LEYDEN JAR AND DISCHARGER.

The Leyden jar, or jar of Kleist, used with modern electrical machines as an accumulator or condenser, was invented nearly at the same date both at Leyden and by Kleist, of Cammin. As usually made, it consists of a wide-mouthed glass jar, J, with a coating of tinfoil pasted inside and outside to within three or four inches of the top. The mouth is closed with a wooden stopper through which passes a brass rod, R, terminating two or three inches above the jar in the ball B. To the lower end of the rod is fastened a strip of foil or chain which extends to the bottom of the jar. The tinfoil coatings are two conductors, which are insulated from each other by the glass jar upon which they are fastened.

If the outer coating be connected with the earth, either by holding it in the hand or attaching it to a metal chain, and the brass knob be brought near to the conductor of an electrical machine, bright sparks will pass between the knob and the conductor. The positive electricity conveyed to the inside of the jar acts inductively, *through the glass*, upon the outer coating, producing a negative charge in it, and driving off its positive electricity through the hand or chain to the ground. It is more correct to say that the positive and negative charges are on the opposite sides of the glass (*dielectric*), for the tinfoil coatings serve merely as conductors to distribute and carry off the electricity.

THE DISCHARGER.

The one shown in Fig. 8 consists of a curved brass rod, C, terminating in the brass balls A A. The handle is of hard rubber. *To use it*, hold the lower ball near the outer coating of J and bring the upper ball near B, when instantly a brilliant flash, accompanied by a sharp report, will be seen to pass between the knob and the ball. This restores the electrical equilibrium or *discharges the jar*. If the fingers are brought in contact with the knob and the outer coating at the same instant, a sudden painful jarring sensation, termed an electric shock, is the result.

It has been found that the charge moves in curves when the jar is discharged, similar to the lines of magnetic force shown in Figs. 2 and 3.

RESIDUAL CHARGE.

If, after being discharged, the jar be left to itself a few minutes, it will be found to have again acquired a small charge. This is called the residual charge. The flash from a thunder-cloud is exactly analogous to the discharge from a Leyden jar. The cloud and surface of the earth form two coatings of the insulating layer of air between them, while a tree or a steeple, or other projecting object, acts the part of the discharging rod.

FRACTURE OF JARS.

A Leyden jar may become so intensely charged that the strain occurring at the instant of discharge may overcome the cohesion of the molecules of glass and a fracture occur. This is more likely to take place if the jar is very clean and dry.

Various measures have been recommended to avoid destruction of the glass, which does not very frequently occur when the manufacturer is careful to select well annealed jars. Breathing into them through a glass tube occasionally will keep the inner surface sufficiently moist. Instead of this, a slip of writing-paper, about one inch broad, may be pasted on the inner surface of the jar, so as to cover the uncoated space to the height of half an inch above the upper edge of the inner coating. This is believed to accomplish the purpose by extending the charged surface through the medium of an imperfect conductor, and thereby diminishing the intensity of the charge at that part which has the greatest tendency to fracture.

MODE OF DISCHARGE.

Franklinic electricity has immense potential or power of overcoming resistance, and tends to escape in three ways:

1. Conduction.
2. Disruptive discharge.
3. Convection.

When electricity is drawn silently from the clouds or machine by a pointed conductor, it is an example of a discharge by *conduction*. When lightning produces a flash of light and heat, accompanied by sound, or a jar is fractured by an electric spark, it is called a *disruptive discharge*.

The glow sometimes seen on the top of masts and lightning conductors during a thunderstorm is an example of *convection*. The same thing may be seen about the points of an electrical machine in motion in a dark room; the particles of air around these points become electrified, and, being repelled, others take their place, forming currents. When electricity is discharged by convection (through pointed electrodes) upon any part of the body, it produces the sensation of a wind blowing upon the part.

THE CONDENSER.

The Leyden jar is sometimes called a condenser because it was formerly supposed that the strong electrical effects produced by it were due to the condensation of an electric fluid or fluids. There are many other forms of condensers, but as they have not been employed for medical apparatus, no description is needed here.

CAPACITY.

The capacity of a condenser is measured by the quantity of electricity of unit potential which it can contain, or it is equal to the charge divided by the potential.

ELECTRIC MACHINES.

The first machine constructed for producing frictional electricity, of which we have any record, was invented by Otto von Guericke, a burgomaster of Magdeburg, in 1672. It consisted of a globe of sulphur, set on a wooden axle, turned by a handle and rubbed by a cloth pressed against it by the hand. In 1709 Hawksbee invented a machine in which a glass cylinder replaced the globe of sulphur.

After the discovery of the Leyden jar it was utilized as an accumulator. The machine was greatly improved from time to time, but owing to its uncertainty during unfavorable weather, and the great care required to keep it in order at all times, it was almost universally neglected for many years after the discoveries of Galvani and Volta had led to the construction of what is now known as the galvanic battery. Reynolds, of England, Arthius, Charcot and his pupil Vigoureaux, revived Franklinism, to which Holtz and Töpler added impetus by their valuable improvements in the electrical machine. Prof. Atkinson, of this city, has added later improvements; so that now there seems nothing more to be desired in an apparatus for administering franklinic electricity except portability, which has not yet been satisfactorily accomplished.

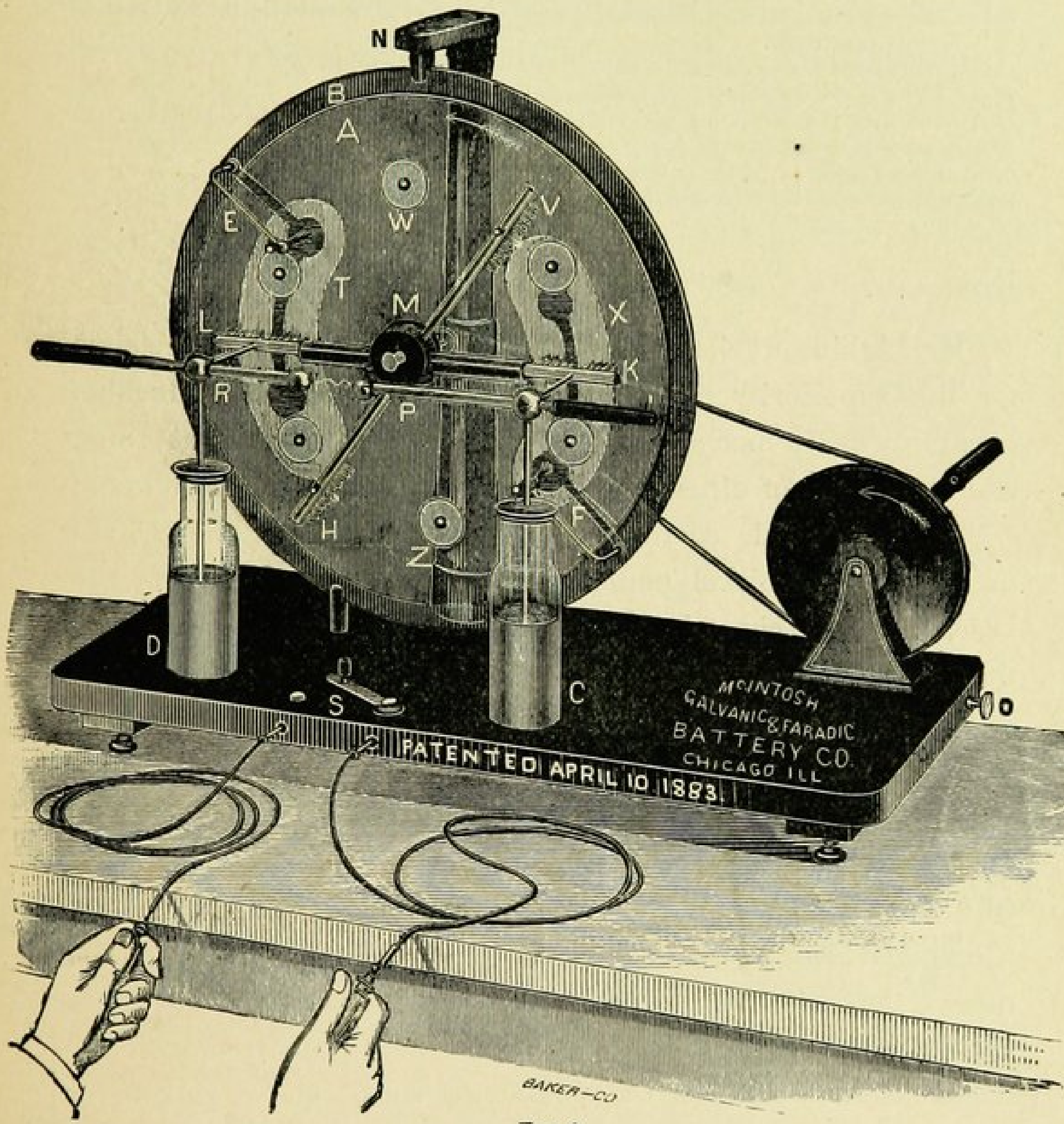

FIG. 9.

THE IMPROVED TÖPLER ELECTRIC MACHINE.

Size of base, 12x26 inches.

B. Stationary plate supported by hard-rubber insulators.
N. Cap with rubber insulator to hold upper edge of B firmly in place.
A. Revolving plate ¼ inch from B.
M. Axis on which A revolves. It is attached to the upright post through an opening in the center of plate B.
E & F. Brushes attached to plate B through holes near its edge.

T & X. Tinfoil and paper inductors on the surface of plate B next the upright post which supports it. The tinfoil inductors are represented by the dark shade, and the paper inductors by the light shade.

V & H. Uninsulated combs with brushes in front of A ¼ inch from its surface. They are screwed to a brass core at the center of the hard-rubber disc M.

D & C. Leyden jars.

P & R. Rods sliding through the knobs, which convey electricity to the internal coating of the Leyden jars.

L & K. Insulated combs connected with the sliding rods P and R.

W & Z. Two of the six discs or carriers attached to plate A.

S. The switch for obtaining the induced current from the outside coatings of the Leyden jars.

O. Adjusting screw to tighten or loosen the belt.

The arrow indicates the direction the drive-wheel must be turned.

CLAIMS OF THE INVENTOR.

Mr. Atkinson* has clearly and concisely stated his claims for the superiority of his Improved Töpler Electric Machine over any static machine in the market at the present time, and the points of difference covered by his patents, as follows:

1. The outside coatings of the Leyden jars *C* and *D*, are of sheet brass, nickel plated, and are screwed firmly to the base, forming cups into which the jars fit closely, and are thus held in a fixed position, affording a firm support to the parts connected with them, and preventing liability to accident or injury to the jars or plates.

2. The induced current from these outside coatings is conveyed down by the brass screws which attach them, and along copper wires underneath, to the terminals of the switch S, through which, when closed, it passes from one jar to the other; but when open, as in the cut, it passes by the brass sockets, seen on the edge, which are also connected with the terminals, out through the conducting cords, and a person, or other object, connected with their outer extremities. As this induced current flows simultaneously with the direct current from the inside coatings, the switch and sliding rods place it completely under control of the operator, either for medical

* The Electrician, October 1883.

or scientific purposes. With the switch open, a slight separation of the electrodes, *P* and *R*, produces a smooth, gentle current; this may be increased to any desired strength, a separation of one-half inch producing a current too severe for the strongest nerves. Geissler tubes, attached to the cords, show the beautiful effects of the interrupted current. Also the induced spark below, simultaneous with the direct spark above, is shown when the switch is open about one-half inch, as in cut.

3. The brush-holders, *E* and *F*, are attached to the plate *B*, through holes near its edge; thus giving a direct passage to the electricity from the carriers on the plate *A*, where it is generated, through the glass, to the tinfoil and paper inductors *T* and *X*. By passing the electric charge *through the glass inside its edge*, an insulating margin is interposed between the conductors and the edge, thus preventing loss from leakage, which is unavoidable when the brush-holders are attached by clamps or ears *on* the edge.

4. The carriers on the plate *A* are of sheet brass, with raised centers, and nickel plated, making them both durable and ornamental. The hard nickel surface is not affected by the action of the brushes, or the electricity, while tinfoil soon becomes defaced; and the carrier, being practically one piece, and its entire surface cemented to the glass, its raised center cannot become detached, as may happen when the center is put on separately over a tinfoil base.

5. The combs *V* and *K*, also *H* and *L*, radiate at an angle of 45 degrees from the central disc *M*, to which they are attached; so that any possibility of error in regard to their position, or of displacement, is practically impossible.

The following improvements may also be noticed:

The base is made of two-inch strips, glued together lengthways, and heavy cleats screwed on underneath; giving all the advantages of iron as to freedom from warping, with the insulation and elegant finish of the wood.

The iron casting, on which the driving-wheel is mounted, slides in grooves on an iron plate, and is moved by the adjusting screw *O*, to tighten or loosen the belt.

The hard-rubber insulators, which support the plate *B*, have soft-rubber packing, to ease the pressure on the glass.

The Leyden jars, *C* and *D*, have wooden caps, with cork attached, making a neat ornamental cap, and affording a firm support to the brass conducting rods which support the sliding rods *P* and *R*, and the combs *K* and *L*.

The machine thus described has only two plates, but four or more plates may be used if desired. Better results are obtained by increasing the size rather than the number of the plates. Machines with plates sixteen and eighteen inches in diameter respectively are very efficient; plates twenty-five and twenty-eight inches in diameter give great energy. The smoothness of the induced current increases with the size of the plates.

The energy of the discharge depends chiefly on the size of the Leyden jars, as increased size gives increased storage, and, consequently, greater energy and less rapidity of discharge.

THEORY OF ITS ACTION.

To comprehend the action of any electric generator, these essential principles, in their construction, must be kept distinctly in mind.

1. *To generate electricity* is to create a difference in electric potential or level.

2. *The efficiency of all generators*, whether batteries, dynamos or glass-plate machines, depends on the *difference of potential* which each is able to create and maintain within the apparatus itself.

3. *The work to be done* by such an apparatus is the *restoration of equilibrium* through an exterior circuit, and may consist in producing heat, light, chemical, mechanical or physiological action.

PRINCIPLES APPLIED.

As the plate *A* revolves, the raised centers of the six discs or carriers are brought into contact with the wire brushes attached to the holders *E* and *F*, each opposite pair of carriers touching opposite brushes successively at the same instant. The friction *generates electricity*, which diffuses itself over the carriers on *A* and the inductors on *B*, with which they are at the instant of contact in electric connection. The potential of carrier and inductor during contact will be the same; at the next instant the carrier passes on and is insulated from the inductor, and carrier and inductor now act inductively on each other, and multiply the initial charge given by the friction of contact. As it accumulates it spreads over the paper inductors; these act on opposite surfaces of the glass till both surfaces of both plates become charged, the initial charge being still continued by the constant friction of carriers and brushes.

The question now arises as to how any difference of potential can be accounted for, since both sides of the machine are of similar construction, and the mode of action on both sides is apparently the same.

It will be noticed that the position of the plates being vertical, their lower halves are nearer to the earth, by their semi-diameter, than the upper halves, and consequently more under the influence of its inductive action by the square of that distance. (A horizontal or any other position would not prevent this result; it could only be done by placing them between two worlds of equal size, and equally distant from both). The lower halves are also in close proximity to the Leyden jars, the driving-wheel and the belt, and are subject to their inductive influence: the plate *B* is supported on *two* hard-rubber insulators, while the upper half has but one, and hence has the advantage of the better insulation of the air.

To this lower half of *B*, and subject to these influences, is attached the brush-holder *F*, while *E* is attached to the upper half, and remote from them: hence the carriers brushed by *E*, and descending toward *L*, must acquire a higher potential than those brushed by *F*, and ascending toward *K*. An accumulation of electricity must also occur at the lower ends of the inductors *F* and *X*, from the inductive influence of the earth; and as the brush-holder *F* is placed at the lower end of *X*, it furnishes an outlet to a portion of this charge, as seen at night by the brushes of light from this holder to the outside of the jar *C*, and other parts in close proximity.

The lower end of *T*, on the contrary, is well insulated: hence the potential of *T* from the heavier charge at its upper end, and the better insulation at its lower end, must be much higher than that of *X*, where the influences are just the reverse. This accumulation, or high positive potential, at the lower end of *T* must produce a high negative potential at that point on the plate *A* and its carriers as it revolves; and this is shown by the brush of light marking the flow of electricity on to the plate from the uninsulated comb *H*; the outflow of the current received through *V* from the opposite side and upper half of *A*. This brush of light extends upward, as the charge increases almost to the comb *L*, showing the high negative condition of the plate and carriers after having parted with their electricity through *L* to the jar *D*. And here let it be noted, that a brush of light between comb and plate would have the same appearance whether the flow were from comb to plate or from plate to comb. Hence a similar brush extends upward from the comb *L*, as the plate and carriers descend charged from *E*, and gives off their electricity to *L*.

Following any opposite pair of carriers, as *W* and *Z*, we find that as *Z* passes under the brush *F*, *W* passes under *E*; and as *Z* moves on to the insulated comb *K*, *W* at the same instant arrives at *L*: but *W*, as already shown, has a higher potential than *Z*, and at this point a peculiar adjustment takes place. *W* gives up its charge through the comb *L*, to the inside of the Leyden jar *D*. This creates a positive charge on the inside of *D*, which induces a negative charge on its outside. The electricity thus repelled passes to the outside of *C*, making it positive, and inducing negative on its inside; and this repelled electricity flows through the comb *K* to the carrier *Z*. *Z* then passes on with a positive charge to the uninsulated comb *V*, while *W*, having become negative, as previously shown, arrives at *H*. Each now passes under the wire brush attached to its respective comb, and the combs being attached to the brass core at the center of *M*, the carriers are put in electric connection with each other, and their potential equalized by the flow of electricity from *V* to *H*; so that each arrives at the original position of the other at the same potential, ready to repeat the same process.

The combs *K* and *V*, *L* and *H*, have also performed the same office for the several sections of the plate *A*, as it has passed them; so that the section from *V* to *E* is now at the same potential, from center to circumference, as the section from *H* to *F*; each section having, like the carriers, performed its work on the Leyden jars.

The section from *R* to *H* having given up electricity, has become negative, while that from *K* to *V* having received electricity, has become positive.

This positive potential on the front surface of *A*, at this point, induces negative potential on its corresponding back surface; positive on the front of *B*, and negative on the back and on the inductor *X*. In the same way, but in reverse order, similar conditions occur on the opposite side.

It will thus be seen, that while the brushes *F* and *E* act as generators, the brushes *V* and *H* act as dischargers; and while the combs *K* and *L* create a difference of potential in the jars, the combs *V* and *H*, like their brushes, discharge, and restore equilibrium.

When the difference of potential between the inner coatings of the jars becomes sufficient to overcome the resistance of the air, a discharge from the inner coating of *D* to that of *C* takes place through the sliding electrodes *R* and *P;* and, at the same instant, a discharge from the outer coatings takes place through the switch and connections, from *C* to *D*, to restore equilibrium between them, and thus complete the circuit.

A spark and snap, from the resistance of the air, accompanies the discharge between the inner coatings; and the same will occur between the outer coatings if the switch is open; but, if closed, the discharge takes place silently. The plates and other parts being, at the same instant, relieved of strain, there is a restoration of equilibrium in the whole machine.

The above explanation applies to the machine when it is put in operation from a state of absolute rest; but when it is in a high state of activity, there frequently occurs a reversal of potential after a discharge, as shown by the reversal of the brushes of light from the combs. To account for this it must be considered, that after the primary discharge, a residual still remains; this, from unequal resistance, may be greater on one side than the other, and after being relieved from strain by the primary discharge, will operate to give a slight preponderance of potential to that side, which is rapidly multiplied by induction, as the rotation of the plate continues.

A reversal can also be produced by touching the inductors, or parts connected with them, while in action, which would reduce the potential at that point. Special conditions may also exist in certain machines, which will reverse the ordinary mode of action; as, for instance, a difference of thickness on opposite sides of a glass plate; or in opposite jars.

The condition of the air, as to its insulation, influences the whole operation of this machine. An air space insulates the plates, and also the jars, with their rods and balls, from each other; and as a damp atmosphere lessens this insulation, it will decrease the energy of the machine in like proportion. A film of moisture, settling on the plates, will often so reduce the insulation, that the slight initial charge by the action of the brushes is conducted over the damp surface as fast as it is generated; so that no difference of potential, and consequently no charge, can occur. And as the machine is much more sensitive to such influences than the operator, the latter is often puzzled to know why it will not generate. The simple and effectual remedy in all such cases is to dry it.

From this it is easy to see why a Holtz machine is so much more liable to stoppage than a Töpler; as the Holtz receives only a small initial charge, which is then discontinued, while that of the Töpler is constant, from the continuous action of the carriers and brushes; so that a well-constructed Töpler is perfectly reliable in any kind of weather.

The views here given are not mere theory, or hasty deductions from imperfect data. They are the result of constant, daily experiment and observation, for several years, with both Holtz and Töpler machines, of almost every conceivable style, size and variety, including a large number of the very best machines in use.

CARE OF THIS MACHINE.

It should be kept free not only from damp, but dust and dirt of every description. Since the attractive influence of electricity affects the floating materials in the air surrounding the machine, the latter should be inclosed in a case. When dampness interferes with its working, wipe the glass-plates dry, and set a lighted lamp in the case a few minutes, removing it as soon as sparks can be obtained. An alcohol lamp is not suitable, since the combustion of alcohol produces moisture, which will increase instead of remove the difficulty. A small lump of unslaked lime kept in the case when the machine is not in use, prevents any deposit of moisture on the plates. If it becomes necessary to place the machine before an open fire or hot stove to dry it, always turn the *edge of the plates* to the fire, as they are less liable to break than when the side is directly exposed to the heat.

ANIMAL ELECTRICITY.

J. J. Hemmer* carried out with great perseverance nearly five hundred experiments on men, women and children, from which he arrived at these conclusions:

1. The human body always possesses electricity—but its strength is not the same in all; in some it is *positive*, and in some *negative*.

2. The intensity and nature often varies in one and the same person.

3. The natural electricity of the body is positive, for this is always its character when there has been no violent exertion.

4. This normal positive electricity is changed into negative by exposure to cold, or else is greatly enfeebled.

5. The same change occurs from over-exertion or lassitude.

6. The natural electricity is also changed into negative by sudden, rapid and violent motion.

7. Prolonged mental exertion increases positive electricity.

8. Positive electricity is increased in winter and diminished in summer, ceasing entirely during perspiration.

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*Green's Journal of Physic, 1791, iii, p. 267.

9. This electricity is not due to the friction of the clothing, since it was still observed after remaining for hours on an insulating stool, without clothing.

Ahrens,* in 1817, also experimented extensively in the same direction, verifying the conclusions of Hemmer, and also adding that during rheumatic attacks the electricity peculiar to the body disappeared, and as the disease gave way, gradually returned.

PHYSIOLOGICAL AND THERAPEUTICAL EFFECTS OF FRANKLINISM.

This form of electricity very early in its history acquired the reputation of quickening the circulation, promoting the glandular secretions and insensible perspiration. The first authentic cure by means of the electrical machine occurred in 1744 in the practice of M. Kratzenstein, at Halle. He succeeded in curing a contracted finger in one-quarter of an hour. Experiments in treating the sick were carried on in nearly all countries simultaneously. M. Jallabert, of Geneva, in 1747 had acquired a reputation for curing a great variety of paralytics, and the following year published a treatise on the "Effects of electricity upon the living body," in which he stated that it increases the circulation and heat. Mauduyt four years later published a complete work, from which is borrowed the bulk of the literature of the present day, on the subject of the therapeutical applications of franklinic electricity.

In the Philosophical Transactions † we find the first record of an accident happening during treatment. A young person being electrified for paralysis of the right arm was seized with general paralysis, which was removed by subsequent medication, but the arm remained incurable.

* Deutches Archiv. für die Physiologie, von Meckel, Bd. iii, p. 161 (1817).

† Vol. 48, part ii, p. 785.

Dr. Franklin describes an accident which occurred to himself while treating paralysis. A number of persons joining hands with the patient and each other, he sent shocks from a battery, composed of several Leyden jars, through the circle.

At one time, inadvertently stepping backward under an iron hook which hung down from the ceiling to within two inches of his head and communicating by a wire with the outside of the jars, on attempting to discharge them, he was knocked senseless, while the company received no shock.

Mr. Singer had a charge passed through his head which gave him the sensation of a violent blow, followed by transient loss of memory and indistinctness of vision. Mr. Morgan says that if a strong shock be passed through the diaphragm, sudden contraction of muscles acts so violently on air in lungs as to produce a shout ; a small charge produces a violent fit of laughter. Persons of great nervous sensibility are affected more readily than others. A small charge through the spine instantly deprives the person, for a moment, of muscular power, and he generally falls to the ground. If the charge is very powerful instant death occurs. Bodies of animals killed by lightning undergo rapid putrefaction. The blood does not coagulate.

Dr. Watson* described the case of a child seven years old, who had suffered from universal rigidity of the muscles since infancy, so that her entire body felt more like that of a corpse than a living person. He electrified her at frequent intervals from the middle of November, 1762, to the end of January, 1763, when every muscle had become flexible and she could stand and walk like other children of her age. Another case† of very great contraction and rigidity of the sterno-mastoid muscle, was cured by sparks and shocks directed to the affected muscle. Dr. Wilson gave electricity a trial in deafness ; he

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* Phil. Trans., vol. 53, p. 10.

† Phil. Trans., vol. 48, part i, p. 97.

cured one case of seventeen years standing, but failed in all other trials. Mr. Wesley employed electricity extensively for the benefit of his followers and wrote an excellent book on this subject. He regarded it as almost a specific for obstinate headaches, toothache, sciatica, cramp, rigidities and wasting of muscles, although he acknowledges that he failed to give relief in any case of paralysis of over one year's standing. It proved useful in inflammations ; dispersed extravasated blood ; hastened suppuration in obstinate swellings, or dispersed them without suppuration. His method of application was simple electrification, or charging the patient while insulated at first one-half hour morning and night, especially in hysterical or nervous disorders ; this was followed after a few treatments by drawing sparks, and afterward moderate shocks. Tertian and quartan ague were usually completely cured by giving shocks to all parts of the body.

Dr. Antonius de Haen* states that trembling of the limbs, chorea, and some cases of deafness, are cured by electricity. Mr. Hey, surgeon of Leeds, successfully used it in several cases of amaurosis. He applied it twice daily ; the patient being insulated, sparks were drawn from the eyes and around the orbit, and especially at the points where the superciliary and infra-orbital branches of the fifth pair of nerves divide. After this operation had continued half an hour, slight shocks were directed to the affected parts, sometimes across the head from one temple to the other, but chiefly from the superciliary and infra-orbital foramina to the occiput. Mr. Ferguson had excellent success in rheumatism by drawing sparks from the painful parts until the skin was red and pimpled ; glowing warmth succeeded the application. Old sprains were cured the same way. In 1744 it was recommended, as an aid in restor-

*Dr. Priestley, History of Electricity, vol. 1, p. 485

ing the drowned, to pass vigorous shocks through the body, especially through the heart and lungs. This procedure formed one of the measures recommended by the humane society of England. The method recommended for curing toothache was to connect one wire with the inner coating of the Leyden jar, another with the outer coating, and include the tooth between the ends of these wires.

In recounting the experiments, successes and failures in the use of static electricity, we must not omit the occurrences in our own country.

In 1758 Benj. Franklin relates his experience as follows: * "Some years since, when the newspapers mentioned great cures performed in Italy and Germany by electricity, a number of paralytics were brought from different parts of Pennsylvania and the neighboring provinces to be electrified. My method was to place the patient in a chair on an insulated stool and draw a number of strong sparks from all parts of the affected limb or side, repeating the treatment three times a day. The first thing noticed was an immediate increase of warmth in the parts treated, and the next morning the patients usually stated that they had felt, during the night, a pricking sensation in the flesh of the paralytic limbs. Sometimes a number of small red spots were observed, apparently caused by the shocks. The limbs seemed to have more strength; for instance, a man that could not on the first day lift his lame hand from his knee could the next day lift it four or five inches, the next day a little more, and so on, until the fifth day he could usually, with a feeble, languid motion, take off his hat. Franklin never observed any change after this, and suggests that the journey, excitement, etc., might have done as much. The cases usually relapsed after a short time, although he adds, it is possible that

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* Phil. Trans., vol. 1, part 2, p. 481.

if they had been in charge of a medical man, who would have directed proper medicines and diet, much more would have been accomplished."

Brydone,* in a letter to Dr. Whytt, a professor in Edinburgh University, relates, among other cases, that of a woman deaf six months in consequence of a cold, whose hearing was entirely restored by the following measures: She was uninsulated while the operator was insulated; he held a wire within her ear and drew sparks. This brought on profuse perspiration about the head, which was promoted by wrapping the head in flannel. At the end of five days the cure was complete.

FORMS OF FRANKLINIC ELECTRICITY.

Franklinism may be administered in two ways.

1. The patient, seated on an insulated stool, receives electricity direct from the accumulator of the machine, and is said to be positively or negatively electrified or charged according as he is connected with the positive or negative jar.

2. Induced franklinism, or the franklinic current, consists in placing the patient in the circuit which electricity must traverse in passing from one jar to the other. The physiological effects already referred to belong to franklinism administered as a charge. The franklinic *induced current* produces effects very similar to those of the secondary faradic current, to be hereafter described. It excites vigorous muscular contractions with a minimum amount of pain, and on some persons produces an exhilarating effect wholly wanting to any other form of electricity.

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* Phil. Trans.

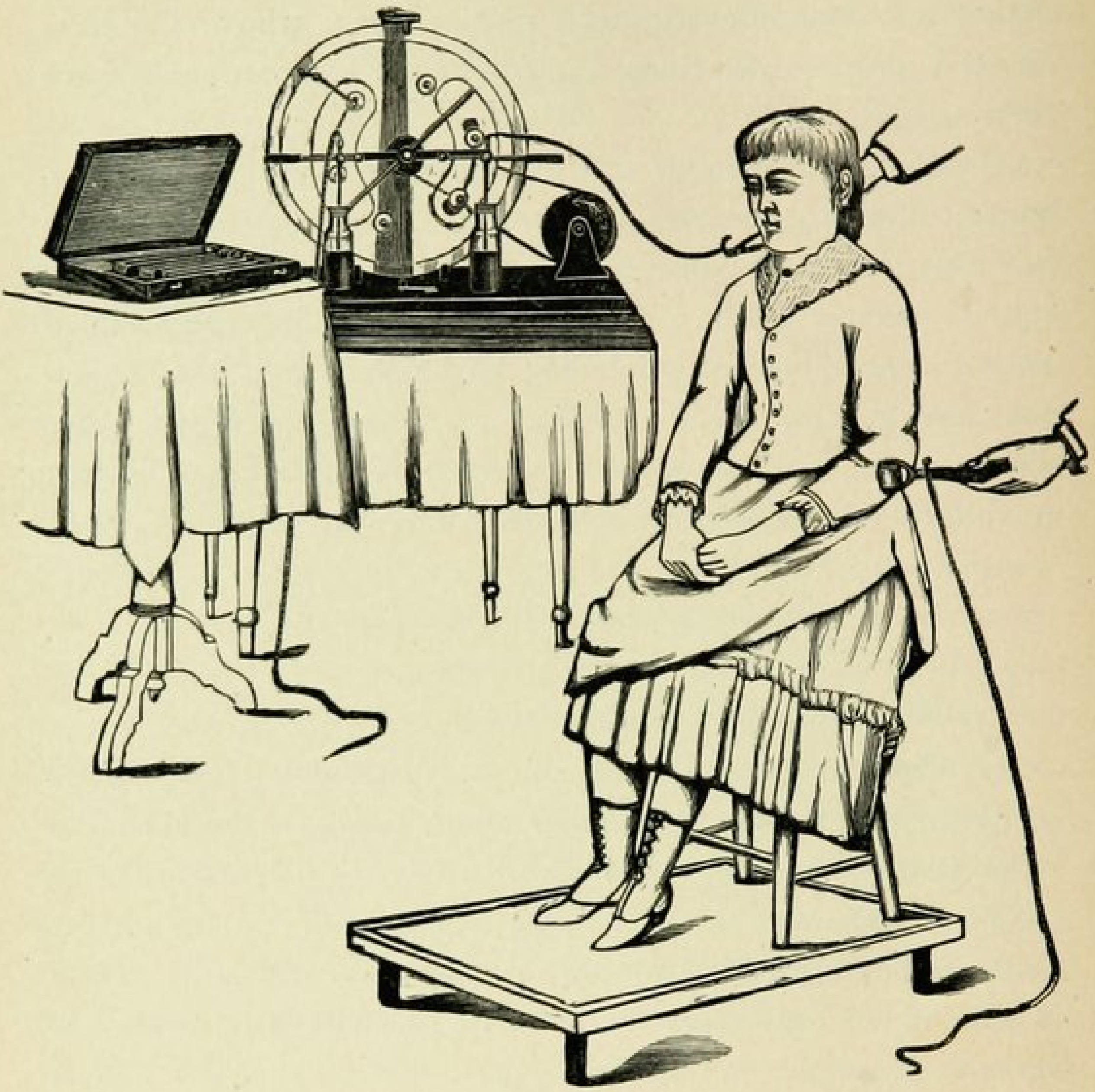

FIG. 10.

METHOD OF ELECTRIFYING A PATIENT.—POSITIVELY OR NEGATIVELY.

Attention is called both to the arrangement of the machine and the relative position of patient in the above illustration.

The Machine. Draw the horizontal rods apart as far as possible, and connect the jar that is not to be used with the ground. This is done by inserting the tip of one conducting cord in the ball at the end of the rod which passes into the jar, while its free end lies on the floor; or, better still, is connected with a gas or water pipe, which will allow the ready escape of electricity to the earth. This is sometimes called a *ground connection*. It is not essential; but since it is possible for the potential of the charge to become so great as to cause it to leap across from one rod to the other, thereby at the same time causing a severe shock to the patient, it is advisable to do so. *The switch should be closed.*

The Platform. The one represented above has hard-rubber legs, but glass may be used for the same purpose. Wooden legs encased in glass insulators, such as are used in telegraphy, answer a good purpose. If a film of moisture or dust is allowed to collect on these insulators, electricity will escape, and the operator will fail to electrify the patient. They may be varnished with shellac or coated with paraffine while warm, and the deposit of moisture will be prevented. The conducting portions of the platform must not touch table, chair, or clothing of the operator, during treatment.

The platform may be made large enough to contain several patients, and all can be treated at once.

The Patient. The patient, without removal or disarrangement of clothing, is seated on the platform. No conductor should be in contact with or near the dress. If tables, chairs, etc., are accidentally brought near, electricity will escape, either in the form of sparks or silently, and the result of treatment will be a failure. The conducting cord or chain, which must be well insulated, is attached to the ball surmounting the positive or negative jar, according as the patient is to be electrified positively or negatively. The cord may be attached directly to the patient outside the clothing, unless that be of silk (in the illustration it is fastened to the dress at the nape of the neck); it may terminate in an ordinary battery handle, which can be held by the patient without inconvenience; or the conductor may be fastened to the platform on which the patient is seated. After the patient is in readiness, the drive-wheel of the machine is turned in the direction of the arrow; an assistant is necessary unless the machine is run by a small motor. The potential, or intensity, of the charge depends upon the number and rapidity of the revolutions of the revolving glass plate. It is customary to note the number of turns of the driving-wheel in a first treatment, and on subsequent occasions it serves as a guide in regulating the charge.

The machine may be completely discharged after the patient is disconnected from it by moving the horizontal rods together so that their balls touch. Remembering this point, the operator will be saved many a severe shock in readjusting the machine.

CONDUCTORS.

Conducting cords and chains are both used to convey franklinic electricity, but the ease with which it leaps off from its conductor to surrounding objects makes it essential that the insulation be very perfect. Conducting cords must have a double-woven silk cover; yet this does not wholly restrain electricity from escaping; therefore in treating patients it is important that the cords be prevented from touching them, or other conductors. Some operators prefer chains, varnished and inclosed in rubber tubing, which may be still further insulated by a coating of paraffine.

ELECTRODES.

When electricity is to be localized, an instrument of some form is required unless the operator chooses to employ his fingers as a conductor.

The electrodes employed for *franklinism* differ but little from those used in the early days of its application to medical treatment. They are usually made of metal, attached to, or held by, a long handle of insulating material, covered with cloth or sponge. The handle should be made of glass or rubber, to which metal points, balls or rollers may be attached. These may be covered with cloth or sponge; if the latter is used it must be moist. It should be remembered that electricity is seeking to escape from the patient to the ground to equalize potential, and it may be concentrated at any point on the body to which a good conductor is presented, *provided that conductor has ground connection.* By reference to Fig. 10 the electrode is seen to be connected with the floor by a chain, which latter must not be allowed to touch either patient or platform, lest electricity escape direct to it and prevent a portion of the charge from being localized at the part to be treated.

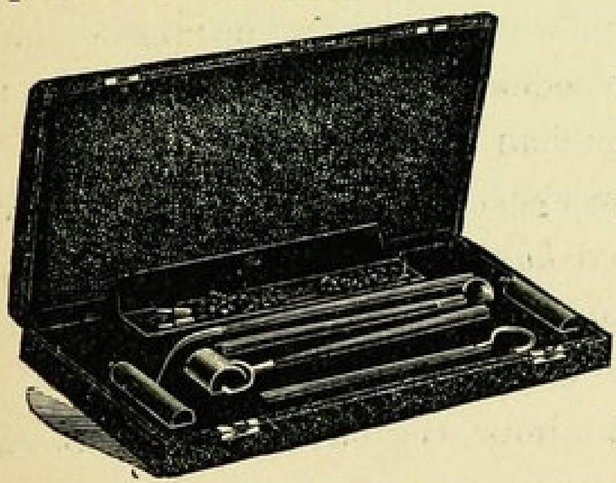

FIG. 11. ELECTRODE CASE.
Length, 15 inches; width, 7½ inches.

Fig. 11 illustrates a convenient case of electrodes, which are sufficient to meet all the requirements of franklinism as at present administered. The *first* in the case terminates in a hook; its use is shown in Fig. 10, to hold the conductors away from the patient. It is also used to detach the cord from the machine, or to replace it, if accidentally detached, since any approach of the operator's hand to the machine, while in motion, would draw off the charge and occasion an unpleasant shock. This electrode should not have ground connection. The *second* terminates in a metal roller, with which the muscles may be rapidly and uniformly compressed or kneaded. The *third* terminates in a metal ball for drawing sparks. The *fourth* has a slender, pointed metal tip; its use will be described on the next page. The last three have a socket in the metallic portion to receive a cord for ground connection. The depression in the back part of the case holds conducting cords, and at each end is a space for the metal handles which accompany the machine.

THE ELECTRO-POSITIVE OR ELECTRO-NEGATIVE BATH.

When the patient is charged with electricity as described, and no conductor is brought near, the air will gradually carry off the charge from all parts of the surface, and in a few minutes, the time varying according to the potential of the charge, it will be found to have entirely disappeared. This constitutes the bath which may be continued as long as desired by recharging the patient at frequent intervals while on the platform. It will be positive or negative, according to the jar with which the patient is connected. The time occupied in treatment should not exceed half an hour.

The charge escapes from every part of the surface, more or less, but more particularly from angles or projections—as the elbows, knuckles, knees, face and hair—creating a sensation as though air were smartly blowing upon the skin.

The bath is employed to improve the circulation, promote perspiration, to relieve nervousness, pain of neuralgia, rheumatism, spasms, and various hysterical affections. This was one of the earliest methods of treating paralysis. Mauduyt reported excellent success by the employment of it in this disease.

Effects of the Electric Bath.—They are claimed to be these: Acceleration of pulse, ease of respiration, increase of temperature, increased urinary secretion, tranquillity of the nerves, improved innervation, stimulation of the absorbents, stimulation of all the functions.

Some authorities advise that the conductor from the machine should be always located at the nape of the neck, from the belief that by this plan electricity will pass directly to the nerve centers, and from them along the nerves from their origin to the periphery.

ELECTRIC WIND.

When a patient seated on an insulated platform is fully charged with electricity, and a pointed electrode, like the one shown in the electrode case, is passed over the surface near to it, but not in contact with it, a sensation like a current of air blowing on the parts over which the electrode is moved will be felt. This is called "electric wind." The clothing being an imperfect conductor, small sparks will be seen, and a slight stinging or prickling sensation be felt.

The electric wind is a suitable treatment for the eyes, ears, and highly sensitive parts. It improves the nutrition when frequently applied, and is valuable in some hysterical complaints, where the patient is unusually sensitive to the slightest shock.

ELECTRIC FRICTION.

An electrode terminating in a ball instead of a point brought near the surfaces, produces sparks with more or less shock, according to the intensity of the charge and the nature of the clothing. When the skin is covered only with flannel and the ball is held near, as it passes over the surface a multitude of minute sparks are produced, accompanied by gentle prickling or stinging and contraction of muscles, this is called *electric friction.* The electrode instead of the skin may be covered with flannel, and the result will be the same. This is a valuable stimulant. It also produces a reflex action through its influence upon the cutaneous nerves. It is specially useful in spasm ; if this arises from irritation within the brain, electric friction of the head and back of the neck is indicated ; if of local origin, friction of the affected part ; if due to sympathy with some distant organ, the friction must be applied, as before, to the diseased part.

ELECTRIC MASSAGE.

This consists in kneading and rolling the muscles with the roller electrode, as shown in Fig. 10. When applied over the clothing, it produces a succession of prickling or tingling sensations; applied directly to the skin, it produces no distinct sensation apart from that due to the mechanical effect of the roller.

Electric massage excites the functions of organs and special senses, stimulates the skin, strengthens muscles and improves the nutrition of all parts to which it is applied.

ELECTRIC SHOCKS.

An insulated patient, thoroughly electrified, experiences a severe shock when an electrode is brought within a few inches. The greater the distance at which the electrode is held, provided it is not removed beyond the influence of the charge, the stronger will be the shock. In the earliest applications of electricity to invalids, this was the only method employed. The powerful shocks which first experimenters did not hesitate to apply to the eyes and head, seem to us now but little else than barbarous. Shocks of reasonable degree of severity are useful in some forms of paralysis to arouse sensation, but should be employed with caution at all times, as profuse perspiration, trembling of the knees, or mental confusion, may follow.

Caution.—When charging a patient positively, the person turning the drive-wheel is liable to receive a disagreeable shock from jar *C*, unless it be connected with the ground.

If the cord connecting patient with machine is allowed to touch the table, clothing of operator or any conductor, the electricity may be all drawn off and the patient will receive none; and since the patient perceives no sensation from a metal electrode in direct contact with the skin, this "leak" may not be noticed, and the operator may be at a loss to account for his failure to obtain sparks on presenting his electrode. If ground connection with the electrode is not made, no sparks will be obtained. Patients should not expose themselves to the open air immediately after this form of electrization, but delay at least ten minutes. Violent shocks must be avoided.

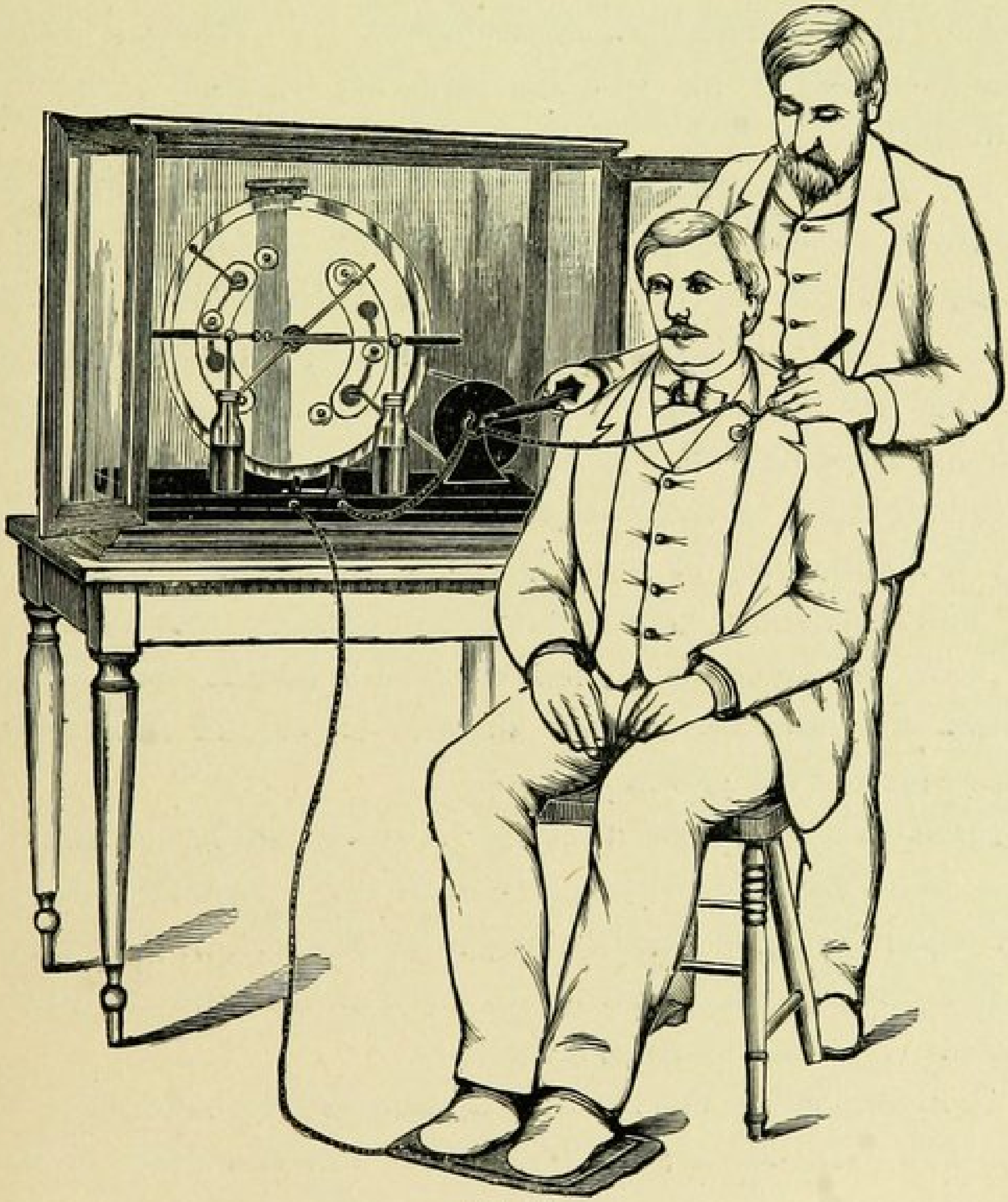

Fig. 12.

METHOD OF APPLYING INDUCED FRANKLINISM.

The arrangement of the machine and position of patient, both differ from that shown in the previous illustration.

The Machine.—This is shown in a glass case. The *switch must be open*, and the balls terminating the horizontal rods be brought very near together, not more than one-eighth of an inch intervening between the balls for a first treatment in a very sensitive patient. Neither jars nor electrodes require "ground connection." *To obtain a current from the outside of the jars*, the cord tips are inserted in the metal sockets in the base of the machine,—as shown above. *To obtain a current from the inside of the jars*, the cords are inserted in the balls surmounting the jars.

The Patient.—The patient does not require insulating, but the cords should be held away from the clothing; electricity readily leaps off the conducting cord in a shower of fine sparks. All forms of franklinic electricity pass readily through ordinary clothing, with the exception of silk. The patient above is shown with his stockings on. Boots or shoes, unless very thick or containing nails in the soles, need not be removed. Any ordinary foot-plate may be used, although the one shown in figure 76, with insulating soft-rubber cover between the metal and the floor, is preferable. The electrodes handle used for galvanism and faradism are not suitable to use for franklinism, as they are not sufficiently insulated.

Franklinic electricity produces a sharp cutting or stinging sensation in the skin, when given with the horizontal rods very near together; when drawn some distance apart, violent shocks are produced, which if directed to the head or neck are capable of destroying consciousness altogether.

The strength of the current is increased by separating the horizontal rods, which should be done with a screw-like motion, and very slowly, to avoid unpleasant shocks.

Any well moistened sponge electrodes may be used when the current is applied directly to the skin, but they must be attached to long insulating handles.

DIRECTION OF THE CURRENT.

It is doubtful if the franklinic current has a definite direction, being probably propagated in waves in both directions at the same time. According to the indications of the electroscope the ball surmounting jar C (Fig. 9) is negative, and the one at D is positive, or the current from the inner coatings of the jars may be regarded as passing from D to C, while that from the outer coatings passes from C to D. Muscular contractions may be greatly increased without pain or unpleasant shock by placing a hydro-rheostat (Fig. 51) in the circuit.

Caution.—When treating a lady with either direct or induced franklinism the operator should avoid presenting the electrodes over the metal portions of crinoline or corset, as a series of unpleasant shocks to all parts beneath will be the result.

When applying an induced current through thick clothing the horizontal rods should not be drawn further apart with the idea of increasing the power of electricity to overcome the resistance of the clothing. Such a proceeding greatly increases the pain and the disagreeable effects of the shocks produced and will detract from the beneficial effects of the treatment. A current that is not disagreeable when applied direct to the skin sometimes becomes very unpleasant when compelled to pass through a poor conducting material before reaching the skin.

Dr. Birch, an eminent surgeon of the latter part of the last century, considered franklinic electricity, in the form of a current, a sedative; sparks or friction, a stimulant, and a shock a deobstruent. Dr. Cullen considered it, when properly applied, one of the most powerful stimulants of the nervous system.

The following precepts will be found useful:

1. Give electricity at first in its mildest form, and increase it gradually as the patient can bear. 2. Use electrodes attached to long insulating handles. 3. Do not neglect the employment of other means while electricity is being tried.

CHAPTER III.

GALVANISM.

Galvanism is that form of electricity generated by chemical action. It is referred to by different authors under various names, such as voltaism or voltaic electricity (after Prof. Volta, of Pavia), chemic (produced by chemical action), primary (direct from the elements), and continued or constant (because the current flows without interruption). When it is artificially interrupted, it is then known as the *interrupted galvanic current.*

The first recorded observation of this form of electricity that we find was made by Swammerdam, the Dutch naturalist, in 1687. During a visit to Tuscany, he showed the grand duke that when a portion of the muscle of a frog's leg, hanging by a thread of nerve from a wire, was held over a copper support so that both nerve and wire touched the copper, the muscle immediately contracted. About sixty years afterward, Sultzer noticed the following fact: If a piece of lead and a similar piece of silver be laid together, and the edges of both be brought into contact with the tongue, a taste of copperas is perceived, when these metals separately have no such taste. He concluded that some peculiar vibrations took place from the contact of metals that induced this sensation, and his explanation was accepted as correct during many years.

In 1786 Galvani published the results of twenty years'*

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* Although it has been repeatedly stated that Galvani's discovery was accidental, and due to a physician's prescribing frog broth for his sick wife, we find that, like most other important discoveries attributed to accident, it was the result of laborious research. There is no more "royal road" to the discovery of scientific facts than to other branches of knowledge.

experiments which had led him to the conclusion that the contraction of the frog's leg when brought into contact with two dissimilar metals was due to electricity generated in the leg itself. Volta pursued the investigation of these phenomena with ardor, and after ten years of experimenting was able to prove that the electricity arose not from the muscle or nerve, but from the contact of two dissimilar pieces of metal, and the only part the muscle of the frog had in the work was to supply moisture. He showed that opposite kinds of electricity were produced on the two surfaces, one becoming positively and one negatively electrified. This discovery enabled him shortly afterward to construct the voltaic pile, from which all the galvanic batteries of the present day have been developed.

Many authors, regarding the researches of Volta of more importance than those of Galvani, continue to give the name of Volta to this form of electricity, although in this country it is generally called galvanism.

THE VOLTAIC PILE.

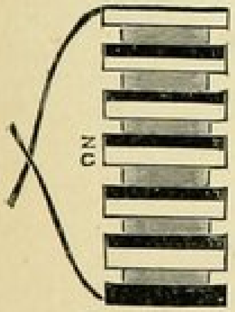
FIG. 13.

The pile, as originally constructed, consists of pairs of zinc and copper plates, with pieces of flannel or blotting-paper, moistened with an acid or saline solution, between each pair, and when the pile is complete, zinc will form one end and copper the other; attach a copper wire to each end of the pile, bring the free ends together, and a current will be set up proportional to the number of pairs. If the free ends of the wires are brought near each other, not in contact, and are immersed in water, they will decompose a portion of it.

THE GALVANIC CELL OR BATTERY.

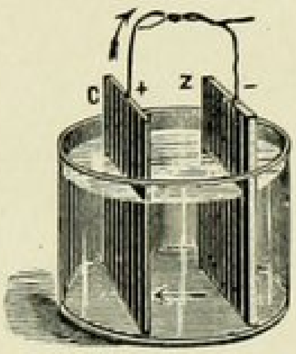

FIG. 14.

The simplest form of cell consists of two pieces of dissimilar metals, partially immersed in dilute sulphuric acid.* The metals shown in Fig. 14 are zinc and copper. If the zinc is perfectly pure, no action takes place so long as the metals are not connected. If they are made to touch by a single point, either within or without the fluid, or if they be connected by a wire, chemical action at once begins at the surface of the zinc, electricity is generated, which passes across the liquid to (or appears at) the copper.

THE GENERATING PLATE.

This is the name given to the zinc or other substance substituted for it in the cell, because by the chemical action occurring between it and the fluid, electricity is generated or set free. It will be found, after the action has continued for some time, that the zinc or its substitute has lost weight. In every combination that plate most easily acted upon by the fluid becomes the generating plate.

THE CONDUCTING OR COLLECTING PLATE.

This name is given to copper, carbon, platinum, or other substances substituted for them in the cell. It is essential that the collecting plate shall be acted upon by the fluid very slightly, if at all. After chemical action has continued some time, the weight of a carbon collecting plate will show no loss, copper or platinum a very slight loss.

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*Unless otherwise stated, dilute sulphuric acid means a mixture of seven parts (by measure) of water with one part of commercial acid.

THE ELEMENTS.

One generating and one collecting plate form a pair of elements. It is essential that one shall be acted on by the fluid more readily than the other.

COMPOUND BATTERY.

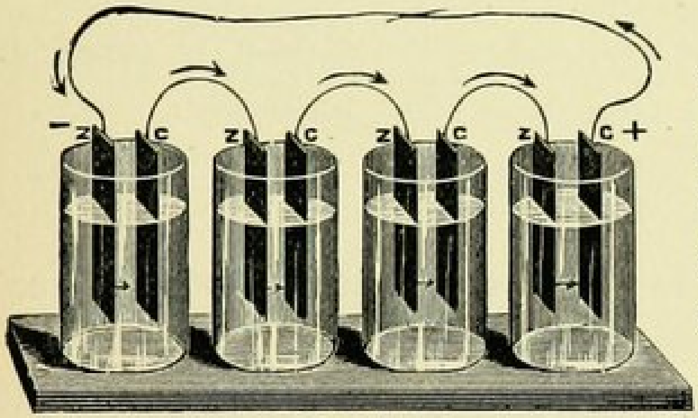

FIG. 15.

Several cells may be united to form a compound battery, as shown in Fig. 15. This illustration represents the copper of one cell united to the zinc of the next by a short wire, and the current passing in the direction of the arrows. The current from the first C and last Z will represent the total strength of current obtained from such a combination.

THE CIRCUIT.

This includes the fluid within the battery, the elements the connecting wires and any intervening body with which the free ends of the wires may be in contact.

A SHORT CIRCUIT.

When the first C and last Z are united by a short wire, as in Fig. 15, so that the current outside the cell passes directly from the copper to the zinc, it constitutes a short circuit. When the current passes to and fro between the copper and zinc within the fluid it is also called a short circuit.

CLOSED CIRCUIT.

The circuit is said to be closed or complete when the elements are connected outside the fluid. This may be done *directly*, as when a wire joined to the first copper element is brought into contact with a wire joined to the last zinc element; or *indirectly*, as when any substance or body (which permits the passage of a current through it) is placed in contact with the ends of the wires.

OPEN CIRCUIT.

The circuit is *open* or *broken* when the current is arrested by disconnecting the wires attached to the elements.

DIRECTION OF CURRENT.

For all practical purposes, the current may be regarded as starting at the zinc, passing through the fluid to the copper or its substitute, from thence through the connecting wires and any substance intervening, back to the zinc. It may be briefly stated thus:

"The direction of the current *in* the fluid is from zinc to copper; *outside* the fluid, from copper to zinc." The relative *size* of the elements has nothing to do with the direction of current, which will be the same if the zinc has a surface of a square inch, and the copper a square foot. The *kind of material* used for elements determines the direction of current, which always passes within the fluid, from the element where chemical action takes place most freely, to the element where chemical action is slight.

THE POLES.

The ends of the elements where the current leaves and reenters the cell are called *poles*.

POLARITY OF THE CURRENT.

It is possible to show by the electroscope (Fig. 7) that the current from the collecting plate is positive; it is commonly marked P or +. By the same test the current from the zinc is negative; it is marked N or —. These letters P and N refer only to the poles, and not to the elements within the fluid.

POLARITY OF ELEMENTS.

Since like electricities repel each other, and unlike attract, it follows that the portion of copper within the fluid at which positive electricity collects is electro-negative, and that part of the zinc within the fluid from which it was repelled is electro-positive.

A CURRENT IN BOTH DIRECTIONS.

There is really a current passing through the circuit in both directions at the same time, but on account of the physiological and chemical effects as well as for convenience, electro-therapeutists unanimously agree in ignoring the fact that the negative current is coming *from*, instead of going *to* the zinc, and the current direct from the battery cells is always spoken of as passing from the positive to the negative *poles* outside the fluid, and from the positive to the negative *elements* inside the fluid.

POLARIZATION.

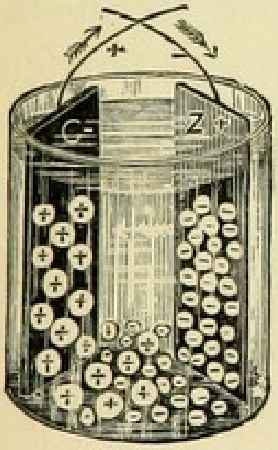

FIG. 16.
Atoms of hydrogen marked + collected upon — copper, atoms of oxygen marked — set free at + zinc. Arrows show direction of current before polarization occurs.

At the moment the elements within the cell are connected, the acid in the fluid attacks the zinc and dissolves a portion of it. This chemical action generates a current of electricity which decomposes a portion of the water in the fluid, and separates the oxygen from the hydrogen. Gases, as well as metals and all other substances, exhibit polarity when compared with each other. Oxygen is always negative (—) and hydrogen positive (+). The electro-negative O therefore appears or is set free at the electro-positive zinc with which it unites to form oxide of zinc (the latter again unites with the sulphuric acid and forms sulphate of zinc). The electro-positive H is set free at the electro-negative collecting plate, and collects in bubbles on its surface, forming a film over it in a short time if not prevented.

Hydrogen being more easily acted upon than zinc, by the fluid of the battery, will now form the *generating* plate, and *zinc* will become the *collecting* plate; the result will be that the current will pass back and forth entirely within the fluid, and cease to flow through the wires or any part of the external circuit. The battery is now said to be polarized. Since the working power of a battery is destroyed by polarization, it is very important that it be prevented, and various methods of doing this have been devised, varying according to the kind of battery used; among them may be named the following:

1. Shaking the elements or fluid occasionally when in use to disengage the gas bubbles, and cause them to escape from the fluid.

2. Blowing air over the surface of the conducting plate for the same purpose.

3. Adding some ingredient to the fluid which will unite with the hydrogen as fast as formed, such as bichromate of potash, sulphate of copper or nitric acid.

4. By employing two fluids instead of one, as in the gravity cell.

5. Making the collecting plate with an irregular surface. The platinum element is an example of this kind. It consists of a silver plate corrugated, and covered with a layer of granular platinum, so that a multitude of points will prevent adhesion of the gas to its surface and facilitate its escape from the fluid.

6. Allowing the battery to rest by opening the circuit a few minutes, permits the hydrogen gas to escape, and restores the current through the external circuit.

7. This will be hastened if a current can be passed through the cell in an opposite direction for a moment.

LOCAL ACTION.

A piece of pure zinc dipped into dilute sulphuric acid is not attacked by the acid, but the ordinary commercial zinc is not pure, and dissolves when placed in dilute acid. The particles of impurities, usually iron or arsenic, lying in contact with atoms of pure zinc, form a closed circuit when immersed in fluid, and chemical action is set up, which generates minute currents of electricity, precisely like the current between the elements. These minute currents use up the fluid, destroy the zinc, and interfere with the main current. When local action is violent, a buzzing or hissing sound will be heard within the cell.

AMALGAMATION.

Since chemically pure zinc is too expensive for battery purposes, a substitute for it is found in common commercial zinc coated with a thin film of mercury. The zinc is then said to be amalgamated. Although the presence of the mercury hinders local action when the circuit is open, it does not interfere with the chemical action of the fluid upon the zinc when the circuit is closed. Amalgamation is accomplished in two ways:

1. The zinc being moistened in acidulated water, quicksilver is brushed over it.

2. Bisulphate of mercury may form one ingredient of the battery-fluid, its purpose being to keep the surface of the zinc coated with mercury. (This must not be used with platinum elements.)

Whichever method is chosen, the result should be the same; that is, the surface of the zinc should be bright as silver.

In single-fluid cells, it is found that not even amalgamation entirely stops local action, when the circuit is open; therefore, to prevent waste of zinc, some device is necessary for removing the elements from the fluid when the battery is not in use.

POTENTIAL.

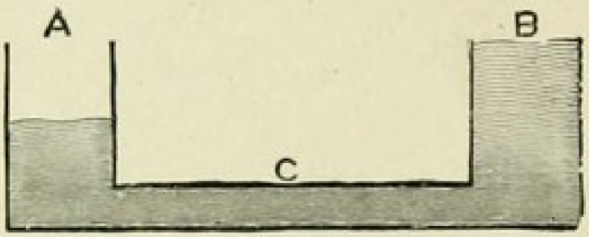

Fig. 17.

This term has the same significance when applied to dynamic as to static electricity; in both cases referring to the "electric level." The method of comparing difference of potential with difference of water-level, as illustrated in Fig. 17, gives a tolerably clear idea of the subject. Two reservoirs, A and B, containing an unequal amount of water, are joined by a small pipe C; water will flow from B to A until it stands at the same height in both, when the flow through C will cease. The difference in the original height of the two columns of water may represent the difference in the potential of two elements immersed in battery fluid. This difference of potential is developed by the chemical action within the cell, and a current of electricity is set up throughout the circuit in the effort to equalize the potential, or, in other words, to restore 'the electric level.'

The difference of potential grows gradually less and less from the moment the circuit is completed, and when the fluid is used up (exhausted) or the battery polarized, the potentials are at an equilibrium and the current ceases. As the length of time required to bring the water to the same level in both reservoirs depends upon the length of pipe C, the diameter of pipe C, the freedom of C from dirt or débris, the difference in level to start with, so the electric current is similarly modified by the length of the circuit, the diameter of the conductors, the freedom from débris, such as rust, dirt, deposits of crystals, and other resistance throughout the circuit, and the difference of potential between the elements when the battery is freshly started.

Difference of potential does not depend upon the size; it may be just as great between small as large elements.

MATERIALS OF WHICH THE ELEMENTS ARE MADE.

Many different metals, and even two fluids of different densities, have been used for battery elements. Zinc is commonly preferred for the positive plate in ordinary batteries, while either copper, platinum or carbon is selected for the negative plate. That metal which is most easily acted upon by the battery fluid becomes the positive plate in any combination. It must be borne in mind that the terms positive and negative here refer only to that part of the plate immersed in fluid. Volta made the following ingenious table, showing the relation of the metals to each other. A few, discovered since his day, have been added by recent investigators. He called it the

CONTACT SERIES,

because each metal in the list becomes positive when placed in contact with each one named below it, and the further they are separated on the list the greater their difference of potential.

+ Zinc,	Silver,
Lead,	Gold,
Tin,	Platinum,
Iron,	— Carbon.
Copper,	

For example, if zinc and lead are used as the two elements of a battery, zinc is + and lead is —. When lead and tin are used together lead becomes + and tin —.

The difference of potential between zinc and lead is less than between zinc and tin. It keeps on increasing between zinc and the others named in their order until carbon is reached. Between zinc and carbon the difference of potential is so great that it equals the sum of all the differences of potential between the other combinations on the list.

For this reason the zinc and carbon combination is preferred for batteries which are required to furnish a current possessing great power of overcoming resistance.

ELECTRO-MOTIVE FORCE.

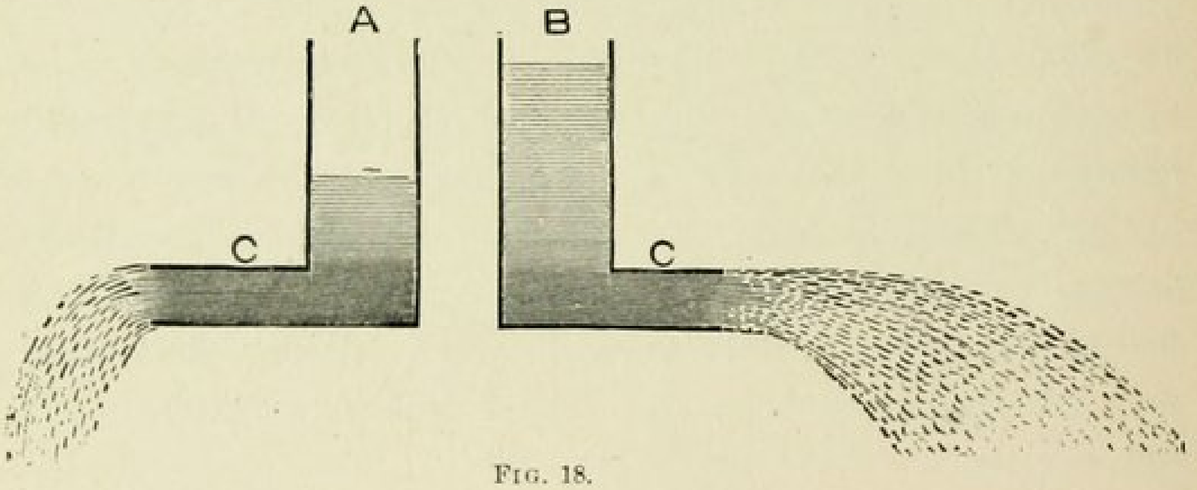

FIG. 18.

This is the same force referred to under static electricity as the "propelling power." It is that force which tends to move electricity through its circuit. Electricity is not propelled as a bullet on its course, but rather propagated in waves from point to point in its circuit.

Referring to Fig. 18, it will be noticed that reservoir B, having the higher level, propels the current with greater force than A. B not only drives the current branches further on a straight line, but causes them to separate more widely and cover a greater surface. The greater the difference of "electric level" between the elements, the greater will be the electro-motive force with which the current will be driven forward; and it is supposed that in sending a current through so great a resistance as the human body, it is broken up into branches or lines of force, which pass by different routes between the points of entrance and exit; the stronger the electro-motive force, the greater the number of these branches that will be able to overcome the resistance in their path, and come together to complete the circuit. *The total available strength of current for therapeutical purposes depends largely upon its electro-motive force.*

THE ELECTRO-MOTIVE FORCE IS MODIFIED:

1. *By the nature of the elements.* By reference to the "contact series," it will be seen that zinc and carbon furnish the greatest difference of potential, and consequently the strongest electro-motive force.

2. *By the quality of the battery fluid.* Strong fluid, which causes violent chemical action, produces the greatest electro-motive force. If, however, the elements are encrusted with salts, or partially worn out, only a small portion of their surface can be brought into actual contact with the fluid, and the electro-motive force will be lessened. If the zinc is not properly amalgamated, thus permitting local action, or if the carbon, from long use, has its pores filled with impurities, the same result occurs.

3. *By the number of cells in the circuit.* The *number* of cells, *not* their *size*, determine the amount of electro-motive force developed. "The electro-motive force of forty elements the size of a tumbler is no greater than from the same number the size of a thimble."*

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* M. Cyon, "Principles d'Electrothérapie."

4. *By the length of time the battery has been in use.* In all single-fluid cells the electro-motive force is the greatest when the circuit is first closed. The electro-motive force is greatly increased when strong fluid is used, but the zinc is consumed faster, and the fluid being used up in the same proportion as the zinc, the current will lose strength sooner, or the battery may be said to run down more rapidly than one which possesses less electro-motive force, and consequently less power of overcoming resistance.

QUANTITY.

The total amount of electricity passing through a circuit in a given time is called the *quantity*. It can be increased:

1. By increasing the size of the elements.
2. By bringing them closer together.
3. By exposing a larger portion of their surface to the action of the battery fluid.

CELLS ARRANGED IN MULTIPLE ARC (QUANTITY ARRANGEMENT).

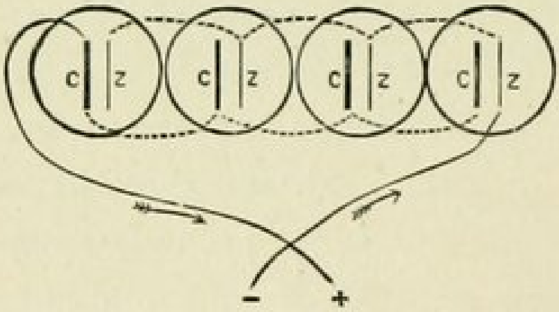


FIG. 19.

When electricity is required for producing cautery, and certain chemical effects, a current possessing large quantity must be selected. The cells for producing such a current are arranged in a special manner. For example: If we have one large cell containing elements, each four inches square, immersed in fluid, an inch apart, and connected outside the cell by a wire, a current is excited; in five minutes a certain amount of zinc will be dissolved, and a certain amount of hydrogen gas will be collected at the copper element. Let these same elements be cut into four parts, each four inches long and one inch wide, and arranged in pairs in separate cells, the elements in each cell being one inch apart, and immersed to the same depth in the fluid as in the first instance. Connect the elements of the separate cells as in Fig. 19, all the zinc-plates being joined together, and all the copper-plates joined together. When the wires from the first zinc and last copper are connected, the same current will traverse the circuit as before. The same amount of zinc will be dissolved, and the same amount of hydrogen be collected as from the single surface. The quantity obtained is large, the heating and magnetic properties are increased, but the power to decompose chemical compounds and affect the animal system is very slightly, if at all, increased.

POTENTIAL ARRANGEMENT.

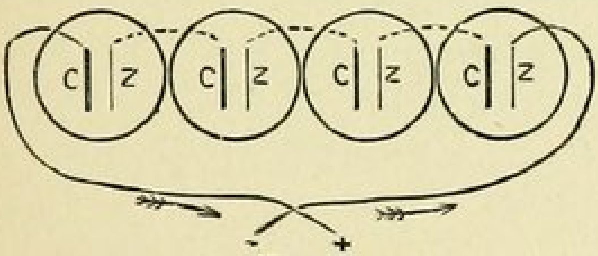


Fig. 20.

The same cells arranged as in Fig. 20, that is, with the elements joined in alternation, the zinc of one cell with the copper of the next, give a greater difference of potential than the one previously described. When the terminal wires from the ends of the series are connected, the amount of zinc dissolved and of hydrogen set free will be the same as before. The current must now cross each cell in succession, and therefore encounters greater resistance than in the arrangement shown in Fig. 19. The power now starts from four separate points, and each one adds energy or exerts an impulse in driving the current onward; hence the propelling power, or electro-motive force, is increased fourfold. Difference of potential does not depend upon the size of elements, but it does depend upon the number of them, provided they are united alternately. The total difference of potential is as many times that of a single cell as there are cells in the series. For instance, if the difference of potential in one cell be represented by 10, the difference in potential of four similar cells, joined as in Fig. 20, will be 40.

In uniting cells in series they should be exactly alike; otherwise, instead of the force bearing relation to the area of plate in each section, it will only be proportional to the smallest effective area,—that is, to that element which has the least surface immersed in fluid.

In illustration may be cited the well-known result of forcing water through a series of pipes of different calibre; the force of flow from the last pipe will only equal the force with which it flows through the smallest pipe in the series.

The potential arrangement is the one used for all ordinary applications of the galvanic current, and for electrolysis. It requires great electro-motive force to send the current to all parts of the human body, the resistance of which "is more than twice as great as that of the Atlantic cable."*

RESISTANCE.

Whatever impedes the passage of a current through its circuit, constitutes resistance.

Resistance is of two kinds:

1. *Internal or Essential*, due to
   - (*a*) The composition and condition of the battery fluid.
   - (*b*) The condition of the elements.
   - (*c*) The size and arrangement of the elements.
2. *External or non-essential*, due to
   - (*d*) The conducting cords or wires.
   - (*e*) The connections.
   - (*f*) The substance or body introduced into the external circuit.

(*a*) Fluids which contain a large amount of acid conduct better than more dilute solutions. Deposit of salts in the cell

* Text-Book of Electricity in Medicine and Surgery. [Poore.]

as well as dirt or grease in the fluid interfere with the passage of the current.

(*b*) The elements, when incrusted with salts, do not permit the passage of electricity freely. Carbon, being very porous, may, after long usage, become filled up with impurities, and this may escape notice.

(*c*) Large elements offer more paths for the current than small ones, hence afford less resistance. When placed near together, the resistance is still further diminished, just as water flows more easily through a large pipe than through a small one, or through a short pipe than a long one.

(*d*) The resistance of the conducting cords, or wires, depends upon

(1) The length. If a current of the same strength be made to pass over wires of the same metal and diameter, but of different lengths, it will be found that the current loses power in proportion to the length of wire over which it is made to pass.

(2) The diameter. If a current be sent over wires of the same material and length, but of different diameters, since electricity is supposed to pass over the surface of the conductor, it is evident that the greater the surface the less will be the resistance; therefore the power of the current will be greatest in the wire of largest diameter. For instance, a copper wire one hundred feet long and one-twelfth of an inch in diameter offers the same resistance as a copper wire two hundred feet long and one-sixth of an inch in diameter. For this reason the arm of a man offers nearly the same resistance as a leg, since the length and diameter of the latter are nearly double that of the arm.

(3) The material. Silver conducts best, but copper so nearly equals it that for practical purposes it is preferred. Platinum offers more than five times the resistance of copper.

(4) The temperature. As the metals conduct best when cold, the warmer the temperature the greater the resistance of the wire. The resistance of copper increases almost 30 per cent between freezing and boiling points.

(*e*) The elements should be securely fastened to the metal connections, and the conducting wires should be in even and firm contact with the same connections, otherwise the path for the current will be lessened, and also minute independent currents will be set up by the difference of pressure of the contact points, all of which increase resistance to the main current. Dirt, grease or rust between contact points increases resistance, which may thereby become so great as to stop the current.

(*f*) The resistance of bodies interposed in the circuit outside the battery varies according to their composition. They may be divided into three classes:

1. Those that offer least resistance, which include the metals and carbon. Heat increases their resistance.

2. Those which are decomposed by the passage of the current, which are principally the liquids. The resistance of these is diminished by heat. It is extremely difficult to discover the actual resistance of liquids, but Cavendish found that the electric fluid meets with as much resistance in passing through a column of water one inch long as through an iron wire of the same diameter 400,000,000 inches long, and that water containing in solution one part of salt conducts a hundred times better than fresh water, and that a saturated solution of salt conducts seven hundred and twenty times better than fresh water. It has been estimated that the human body, owing to the salts which it contains, conducts nearly twenty times better than water, when the skin is well moistened.

3. Those whose resistance is so enormous that the strongest electro-motive force can hardly send the feeblest current through

them. They include the gases, air, glass, paraffine, shellac, india-rubber, and some oils. The resistance of these is lessened by heat.

(4.) Resistance in the circuit.

(*a*) If many cells, exactly alike, are joined in series with a large wire, and with no other resistance in the external circuit, *no greater quantity* of electricity will pass through it than if a few such cells are joined. Although each additional cell adds its share of electro-motive force, it also adds resistance, which tends to counterbalance the gain in electro-motive force.

(*b*) *Large* cells joined together in series with great resistance, as the human body in the external circuit, send no greater quantity of electricity through it than the same number of small cells do.

The electro-motive force of large cells does not exceed that of small ones, as already explained, while the resistance is less; but the internal resistance in cells of either size is so small as compared with the human body, that practically the gain by increase of size need not be taken into account.

(*c*) For decomposing chemical substances, for performing surgical operations, and for electrolysis, many cells of medium size in which chemical action is powerful are required. The resistance of the skin is very great, but in these operations the current is carried beneath the skin by means of needles or wires placed near each other.

(*d*) When a short platinum wire in a short circuit is to be heated, as in galvano-cautery operations, a few large cells joined in multiple arc or a single very large cell is preferable to a large number of small cells.

ELECTRIC MEASUREMENTS.

We cannot conceive of a force that does not possess qualities that can be detected and measured, and for the other modes of motion, as heat, light, etc., we have terms by use of which ideas may be conveyed that are readily understood. Electricity has not been so fortunate until within a very recent period. Although electricians have long made use of special language in writing of this science, there has been a lack of uniformity in choice of terms and an obscurity of definition which prevented its general use.

OHM'S LAW FOR DETERMINING THE STRENGTH OF CURRENT.

Prof. Ohm, of Nuremberg, in 1827, discovered the law which bears his name, and which is now made the foundation of all electrical measurement. It is this: "The strength of the current passing through any part of a circuit varies *directly* as the difference of potential between its elements, and *inversely* as the resistance in the circuit itself." If there were no resistance, the quantity of electricity passing as a current would be exactly proportional to its electro-motive or propelling force. Since there is always resistance, both within the battery cell, and in that portion of the circuit outside the cell, it must be taken into account in estimating strength of current. If the resistance be doubled, only one-half the quantity (other conditions being equal) will pass through the circuit; if the resistance be trebled, there will be only one-third the quantity; that is, the quantity is inversely proportional to the resistance.

Beard and Rockwell * have clearly illustrated this point in the following manner: "Suppose a current of water is passed through an ordinary syringe. The quantity of water that flows through the tube will be directly proportioned to the force with which it is urged forward by the piston; this force would correspond with electro-motive force. The friction will correspond to the internal and external resistance of the battery.

* Medical and Surgical Electricity.

Now, if we divide the one by the other, we have a quantity of water which in a given time flows through the tube, or the *strength of the current.* In this way we can find the number of cubic inches of water that flow through the tube in a second of time, just as we can find the number of coulombs (or units of quantity) of electricity, that flow through the circuit. It follows, of course, that if the electro-motive force be very greatly increased, the resistance being the same, the total strength of current must be increased; but if the resistance be increased in proportion to the increase of electro-motive force, the current strength will not be any greater."

Another mode of expressing the law of Ohm is by the following formula, in which C represents the strength of the current, E the electro-motive force, and R the resistance both within and without the battery.

$$C = \frac{E}{R}$$

Before resistance, the difference of potential is not easily restored.

UNITS OF MEASUREMENT.

Writers are now adopting the terms agreed upon at the International Electrical Congress, and it is necessary to be acquainted with those which represent qualities of currents employed in medical practice in order to understand the electrical literature of the day.

The units of measurement are based on the French unit of length (centimetre), unit of mass (gramme), unit of time (second). These are usually referred to as the Centimetre-Gramme-Second or C.G.S. system of units.

The Volt (dynamic) is the unit of electro-motive force. It represents a force capable of generating a velocity of one metre per second through a mass of one gramme. The Daniells cell is selected as the standard for one volt. This is an approximate measure only; the Daniells cell varies in electro-motive force from .097 to 1.079 volts. The Grenet cell furnishes a current of about two volts.

The Ohm (dynamic) is the unit of resistance; it is very nearly equal to the resistance of a cylindrical wire of pure copper two hundred and fifty feet in length and one-twentieth of an inch in diameter.

The Coulomb (dynamic), formerly called the Weber, is the unit of quantity. It is equal to the quantity of electricity transmitted in one second through one ohm by one volt.

An Ampere (dynamic), also formerly called the Weber, is the unit of current. It is a current of one Coulomb per second, and is due to the electro-motive force of one volt working through a resistance of one ohm.

Mille-ampere, the thousandth part of an ampère.

The Farad (static) is the unit of capacity. The standard is the amount of electricity accumulated in a unit Leyden jar which holds one Coulomb at a potential of one volt.

The Coulomb (static) is equal to the charge produced in a jar of one Farad capacity by an electro-motive force of one volt.

RELATION OF CELLS TO STRENGTH OF CURRENT.

This depends, as we have seen, upon size of cells, number of cells, method by which they are joined in circuit, kind of elements, and resistance in the circuit.

Single-fluid and two-fluid cells in great variety are employed for medical purposes. In this country the single-fluid cells in common use are represented by the Smee and the Grenet; the two-fluid, by the Daniells and the Gravity.

THE SMEE CELL.

The elements of this cell consist of two plates of zinc and one of platinized silver. A thin silver plate is corrugated and coated with platinum in coarse powder; this furnishes a multitude of points from which hydrogen is more readily disengaged than from a smooth surface. The exciting fluid is dilute solution of sulphuric acid. The zinc plates are arranged parallel, with the platinized plate suspended between them. By this method both surfaces of the platinum serve as a collecting plate; but this arrangement does not furnish so powerful a current as the cell next described, in which the zinc is placed between two collecting plates so that both surfaces of the zinc are rendered effective in generating electricity.

BICHROMATE OF POTASH CELL.

The elements consist of a single pair of zinc and carbon plates and the fluid of a solution of bichromate of potash in water, acidulated with sulphuric acid. Chromic acid, which has great affinity for hydrogen, is set free by decomposition of the bichromate of potash, and prevents polarization. A useful form of single cell for experimental purposes or for brief applications of a powerful current is represented in Fig. 21.

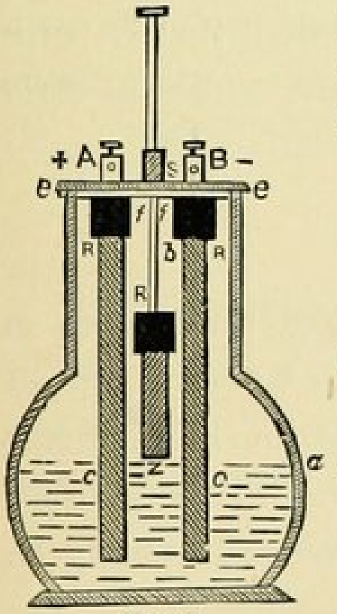


FIG. 21.

Size No. 1, 5 ozs., 5¼ inches high.

Size No. 4, 2 qts., 10½ inches high.

Nos. 2 and 3 are intermediate.

THE MC-INTOSH GRENET CELL.

a, is a globular glass bottle with cylindrical neck partially filled with fluid.

C C, pieces of carbon forming the collecting plates.

Z, zinc generating plate attached to a sliding rod; it can be lifted out of the fluid, or lowered to any depth.

S, binding screw for retaining the rod at any point.

e e, hard rubber cover to which the elements are fastened.

A, binding post with which both carbons are connected by a strip of metal.

B, binding post with which the zinc has metallic connection.

f f, soft rubber lining of e e, which covers and protects the metallic connections.

R R R, hard rubber insulators.

The special feature which distinguishes this from the ordinary Grenet cell, is the insulation of the metallic connections of the elements. The difficulty hitherto experienced in keeping this cell in good working order owing to the rapid oxidation of the connections, is completely overcome. The rubber is put on the elements in a soft state and vulcanized, which causes it to adhere so firmly that neither fluid nor its fumes can penetrate between the insulator and the metallic connections which it incloses.

The McIntosh Grenet cell is suitable for dental purposes, such as treating diseased teeth and obtunding the pain of extracting them; producing an electrolytic effect upon ulcers, etc.; supplying a current for an electro-magnet to extract particles of metal from the eye, and for testing battery connections. The zinc is but one-half the length of the carbons and can be drawn up above the fluid; it can be lowered in an instant, and on completing the circuit the current at once starts. As soon as its work is done, the zinc should be immediately raised out of the fluid and fastened there; with that precaution it will always be ready for use, until the fluid is exhausted.

BATTERY FLUID.

The composition of battery fluid is of great importance in securing the best working condition of any battery, and it must be adapted both to the special combination of elements employed and to the work to be done. It should be capable:

1. Of producing the greatest possible difference of potential.
2. Retarding polarization or preventing it entirely.
3. Offering little resistance to the passage of the current.
4. Giving forth no corrosive fumes.

All manufacturers determine by repeated experiments the kind of fluid best adapted to their own batteries, and the best results will be obtained by following their formula. Operators frequently are disappointed in consequence of using a fluid unsuited to the special combination of elements with which their instruments are supplied.

The fluid for the McIntosh Grenet cell should be made as follows:

Sulphuric acid, three fluid ounces.

Bichromate of potash, two ounces (avoirdupois).

Bisulphate of mercury, two drachms (avoirdupois).

Water, sixteen fluid ounces.

Dissolve the bichromate of potash in hot water; when it is cold, add the bisulphate of mercury, and lastly, very slowly, the sulphuric acid. *It is dangerous to pour water into sulphuric acid.*

This fluid should be prepared in an earthen or stoneware vessel, because the heat developed by the mingling of acid and water is so great as to damage glass or rubber cells. The fluid may be preserved indefinitely if kept in well stoppered bottles. *It should be labeled* POISON. It has a deep-red color, or an orange-red when looked at across its surface, which turns brown, dark-green, or black, when it is exhausted.

TWO-FLUID CELLS.

Although the galvanic current is commonly called a *constant* current, yet that obtained from a single-fluid cell varies constantly, owing to variable resistance, polarization, and rapid destruction of both fluid and zinc.

The great merit of having constructed the first cell from which a really constant current could be obtained, belongs to Becquerel, who proposed to immerse copper and zinc in separate fluids with a porous diaphragm between them which would permit communication between the two fluids, although keeping them apart. He used a bladder for the diaphragm.

THE DANIELLS CELL.

Daniells modified the cell invented by Becquerel. He replaced the bladder with a porous cup, and made other minor changes. Since a Daniells cell has been adopted as a comparative standard in estimating the electro-motive force of a galvanic current, a brief description of it may be of interest. A glass jar of about one gallon capacity is two-thirds filled with a concentrated solution of sulphate of copper. A thin cylindrical sheet of copper is immersed in this solution within the jar which it completely lines. A porous cup, of the same height as the jar, nearly filled with a mixture of one part sulphuric acid to eight parts water, is placed in the center of the jar and a rod of amalgamated zinc is immersed in the cup.

When the poles of this pair are connected, the following reaction occurs: Both water and solution of sulphate of copper are decomposed. One part of the liberated oxygen combines with the zinc to form oxide of zinc, which combines again with sulphuric acid to form sulphate of zinc; another part of the oxygen combines with hydrogen to form water, and finally a thin film of copper is deposited upon the surface of the copper cylinder, which, therefore, remains unchanged. The zinc being well amalgamated, resists local action, and the elements can be left in the fluid if their poles be disconnected when not in use.

GRAVITY CELLS.

The gravity cell is a modification of the Daniells, and is constructed on the principle that two fluids of different density can be arranged so that the heavier shall form a stratum at the bottom of the cell with the lighter floating upon it. This separation is never perfect, since the heavier fluid slowly diffuses upward. The elements are placed horizontally. When once charged and connected, these cells will run for months, the only attention required being to supply water as it evaporates, and occasionally a little sulphate of copper. They are employed for stationary apparatus of every kind, for which a

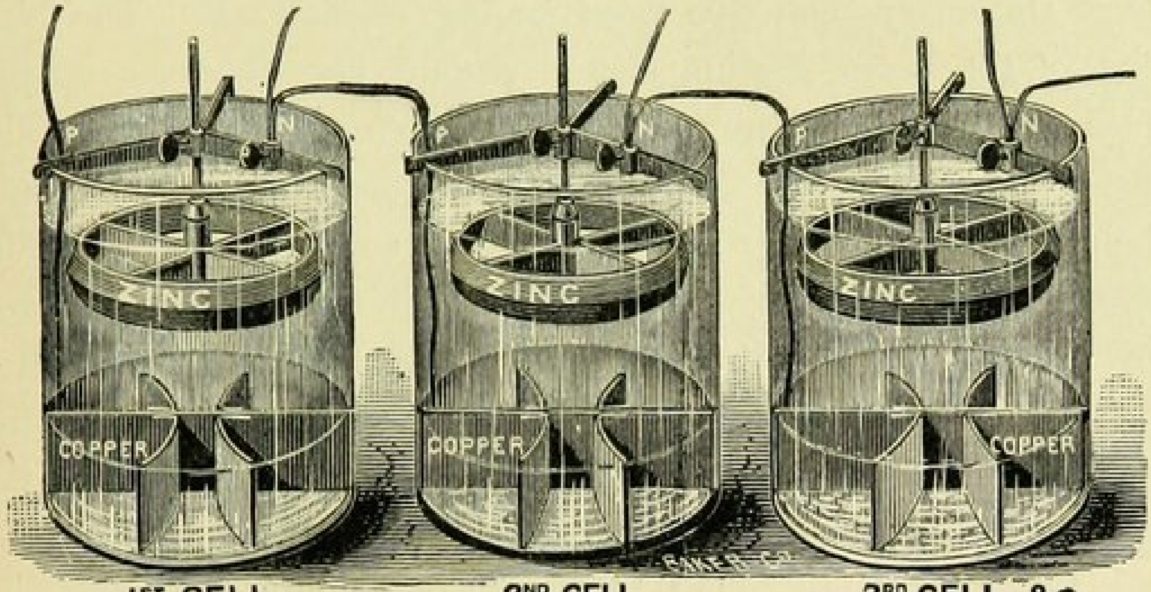


FIG. 22.

GRAVITY CELLS.
Capacity, ½ Gallon.

galvanic current is desired, such as office, table or cabinet batteries, electric chair, electric bath, vapor bath, etc.

TO PREPARE THE GRAVITY BATTERY FOR USE.

Fill each jar three-fourths full of clean soft water (three pints), add six ounces sulphate of zinc, stir to dissolve it, and remove the scum that rises. Unfold the copper element and place in the bottom of the jar. Suspend the zinc by means of the tripod, so that its upper surface is just below the surface of the water and parallel with it. Add six ounces sulphate of copper crystals to the fluid, taking care not to drop any upon the zinc. A convenient, though not essential, mode of accomplishing this is as follows:

A glass tube of sufficient size to permit the passage of the copper crystals is inserted vertically in the cell to a level with the upper surface of the copper element and the sulphate of copper dropped through. This gives a deep blue color and greater density to the lower stratum of the fluid. It can reach the zinc only by diffusion upward, provided the cell is kept stationary, and free from jarring or shaking. The blue tint of the lower stratum should extend just over the copper element, but should not be permitted to reach the zinc. The fluid around the zinc has a very slow downward motion and helps to retard upward motion of the copper solution. The mixing of the two layers of fluid may be still further hindered by inserting a syphon consisting of a glass tube filled with a cotton wick, one extremity being midway between the zinc and copper elements and the other in a vessel outside the cell, so that the liquid is very slowly drawn off near the middle of its depth. This, however, is seldom employed.

TO CONNECT GRAVITY CELLS.

The cells are connected in series by fastening the wire attached to the copper element of the second cell in the socket on one arm of the tripod of the first cell, where a thumbscrew may be seen in Fig. 22; the copper element of the third cell is connected in the same way with the tripod of the second cell, and so on; each copper element except the first being joined to the tripod of the preceding cell in the series.

The cells are connected with the apparatus thus: The wire from the copper element in the first cell is joined to a post or button which represents the positive pole. A wire from the zinc of the first cell (fastened in the same socket of the tripod arm as the wire from the second copper element) is connected with a post or button representing one negative pole, a wire similarly attached to the second zinc element is connected with a second button, and so on until the entire series are connected with corresponding buttons on the apparatus.

THE REACTION IN THE GRAVITY CELL.

When the elements are connected by closing the circuit, the sulphate of copper is decomposed into copper and sulphuric acid. The copper is deposited upon the copper plate, and the sulphuric acid travels slowly through the liquid to the zinc, with which it combines, forming sulphate of zinc. In this way the liquid at the bottom becomes less dense by the deposition of the copper, and the liquid at the top becomes more dense by the addition of the sulphate of zinc. To prevent this action from changing the order of density of the strata, and so producing instability and visible currents within the cell, it should be kept well supplied with crystals of sulphate of copper, and water must be supplied to replace loss by evaporation. The water must be added gently to the top of the liquid, so as to prevent jarring or stirring, which may set up currents that will mix the two liquids. The need of more blue vitriol may be known by fading of the blue color.

A hydrometer is convenient for testing the strength of the solution. When the specific gravity is less than 15°, there is too little sulphate of zinc; when it is 30° or over, there is too much in solution, and it must be diluted. These cells require no attention, except to supply water as it evaporates, for months at a time; but once or twice a year it will be necessary,

To recharge the gravity cells. When the elements become coated so as to interfere with the action of the battery, they must be removed, scraped, and rinsed clean; the jars also should be washed out and refilled. The clear portion of the fluid may be drawn off and used to recharge the cells; this solution contains so much sulphate of zinc, that after filling each jar one-half full, clear water can be used to fill up with.

TO KEEP GRAVITY CELLS IN ORDER.

Since the final result is that the sulphate of copper finds its way to the zinc and spoils the battery, to retard this as long as possible it is necessary to use certain precautions:

1. They must be placed so that their contents cannot be shaken up, as the action ceases when the two fluids become well mixed together.

2. If it is not convenient to keep a siphon in place to draw off the copper solution gradually, when it rises too high, a syringe may be used to draw a portion from the bottom of the jar.

3. Fresh water may be added to the top by a syringe, taking care to use little force.

4. The collection of salts about the top of the jar may be prevented by painting the inner surface for about one inch below the top either with paint or melted paraffine.

5. The tripod connections may also be kept free from deposits by coating them with paraffine. They should be warm when it is applied.

6. When the cells are used but little, say an hour a day, the current direct from the cells should be run through a rheostat, or resistance coil, for a few hours occasionally, to keep them in perfect working condition.

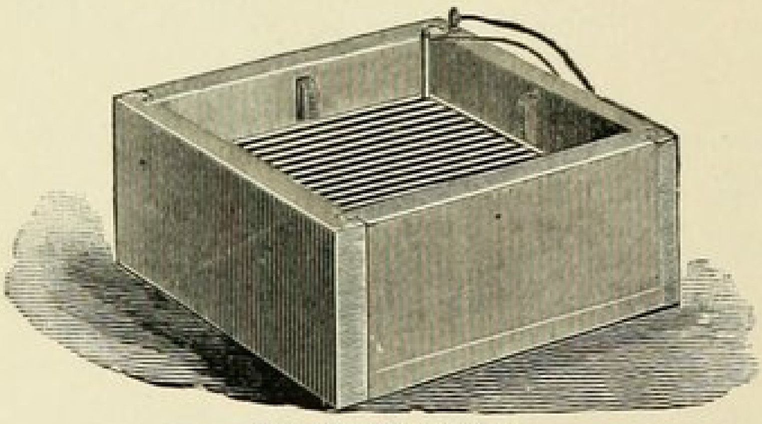


FIG. 23. TRAY CELL.
Size inside, 18×18×8 inches.

The *tray* cell consists of a square wooden box, lined with sheet lead, upon which copper is deposited by the electro-plate process. The zinc element is made in the form of a grating, to allow the gas to escape and give more surface. It is supported by wooden blocks placed at the four corners of the cell.

To prepare this cell for use.—Make a solution of sulphate of zinc in the proportion of six ounces (by weight) to each gallon of water (Epsom salts may be used instead of sulphate of zinc, it answers the same purpose and is much cheaper), and fill the cell so that the zinc grating is submerged an inch or two. Lift out the zinc element, add sulphate of copper crystals in the proportion of six ounces to each gallon of solution, and remove any scum that rises. *Do not stir the fluid after the sulphate of copper is added*, since this is a form of the gravity cell, and its action depends upon the difference of gravity between the upper and lower strata of the fluid. The connection between this cell and the apparatus is made with two large insulated copper wires, one of which is fastened to the binding post attached to the copper lining, and the other to the binding post attached to the zinc grating. The resistance within this cell is very small, being only .2 ohm. Sometimes several of these trays are placed one above another, the copper of one being connected with the zinc of the next, and the apparatus being connected with the first and last in the series, in the same way as with the ordinary gravity jars. *A single tray cell is used only for the faradic current.* The only attention it requires is to empty the cell once or twice a year, and scrape off any salts that may have accumulated on the elements. A part of the fluid poured out of the cell may be used to recharge it. If the copper at any time reaches the zinc, take out the zinc, rinse it off, add more water to the cell and replace.

SINGLE-FLUID AND TWO-FLUID CELLS COMPARED.

Since large cells do not necessarily give a more powerful remedial current than very small ones; the size to be selected must be determined by other considerations than the strength of current required. A comparison of their relative excellencies and defects is the best guide to selection:

SINGLE-FLUID CELLS.	TWO-FLUID CELLS.
(*a*) They become polarized rapidly.	(*a*) They polarize very slowly.
(*b*) The electro-motive force is great.	(*b*) The electro-motive force is small.
(*c*) The electro-motive force is greatest when freshly charged.	(*c*) The electro-motive force increases for several days before its maximum is reached.
(*d*) The electro-motive force steadily declines from the first.	(*d*) The electro-motive force continues for months with little variation.
(*e*) The cells may be small and portable.	(*e*) The cells must be comparatively large and heavy. It is essential that they be stationary.
(*f*) Best adapted to frequent short applications and general practice. The great E. M. F., of the zinc and carbon cells, makes them best suited for electrolysis.	(*f*) Best suited to office practice where many treatments must be given daily, and it is important to have the battery *always ready*.

TO DETECT THE PRESENCE OF THE GALVANIC CURRENT.

Since the galvanic current, when uninterrupted, passes silently through its circuit without producing shocks, flashes of light, or other phenomena that mark the presence of static electricity, it is frequently important to be able to determine whether a current is present. This must be determined from the effects produced when subjected to certain tests, among which are the following:

1. *Heat*, which is produced when the current is carried through very fine wire.

2. *Light*. If pieces of carbon are used for the poles, on bringing them together sparks are visible; these may usually

be obtained on touching the electrodes, or even the tips of the cords together, to complete the circuit. The sparks will be seen only when the current is interrupted.

3. *Sensation produced.* If the electrodes are held against opposite sides of the face or tongue, strong burning, stinging, or pricking sensation, will be felt on interrupting the current or moving the electrodes.

4. *The chemical effect.* A simple apparatus for determining this can be improvised from materials found in any medical office, on the principle of the voltameter.

An ordinary test tube has a cork fitted into its neck, through which are passed two needles, or wires, connected with the poles of the battery by conducting cords. When the circuit is complete, the water will be decomposed, provided the current has an electro-motive force equal to nearly two volts (it requires that amount of force to overcome the affinity of oxygen and hydrogen), and the amount of gases set free will be a measure of the working power of the current.

Fig. 24.
THE VOLTAMETER.

5. *Deflection of the magnetic needle.*

Sir H. Davy discovered that every conducting wire is a magnet while the current is passing, whether the latter comes from a static or galvanic machine. The effect is proportioned to the *quantity* of electricity that is passing through a given space, and the finer the conducting wire the stronger the magnetic force. This was the long-sought link connecting magnetism and electricity, and proving that they are but different properties of the same force, or different manifestations of the same power.

The conducting wire is capable of exerting magnetic attraction and repulsion so long as the current is passing, which properties have been utilized in the construction of the galvanometer.

THE GALVANOMETER.

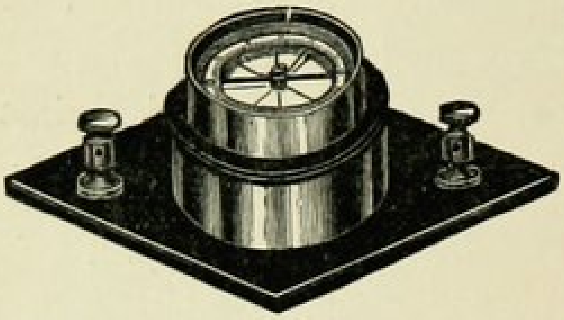


FIG. 25.
Size from point to point $3\frac{1}{2}\times7$ inches.

A *galvanometer* is an instrument for measuring a galvanic current and showing its direction.

A *galvanoscope* is an instrument which indicates the presence of a galvanic current.

These instruments are constructed on the principle (first discovered by Prof. Oersted, of Copenhagen) that if a wire conducting an electric current be placed in the magnetic meridian, it will cause a magnetic needle freely suspended above it to deflect from the magnetic north and south poles. The *amount* of deflection bears a relation to the quantity of electricity traversing the circuit, and the *direction* of the deflection depends upon the direction of the current.

Elaborate instruments are required for accurate current measurement, which are altogether too delicate, bulky or expensive for medical use. The instrument shown in Fig. 25 affords an approximate measurement, which is sufficiently accurate for all practical purposes.

It consists of a magnetic needle, freely movable over a graduated circle, fastened to a hard-rubber base, beneath which is a large coil of extremely fine wire. Each end of the coil is connected with one of the binding posts on the rubber base.

It is an important adjunct to the galvanic battery, for in many therapeutical applications it is of the greatest importance to know the working condition of the cells and the direction of the current. The purchaser will be saved some disappointment if it is borne in mind that the instrument above referred to *does not measure the actual strength of the current.* It is designed only to indicate:

1. The direction of the current.
2. Its polarity.
3. The relative strength of cells tested separately.
4. The variation in strength of any one cell at different periods, to determine when it has run down or needs replenishing.

The first cell connected with this galvanometer deflects the needle a certain number of degrees, *but joining a second cell to the first does not give twice the deflection, or a third, three times as much as one alone.* The reason of this may be found given under the head of arrangement of cells, where it was shown that joining cells, with elements in alternation, *increases the electro-motive force greatly, but increases the quantity slightly.* The *electro-motive* force of a current bears no direct relation to its magnetic force, but *quantity* of a current does bear a direct relation to its magnetic force; therefore, *increasing electro-motive* force does not increase the deflection of the needle, but *increasing the quantity* does increase the deflection up to a certain limit, beyond which it is impossible to increase the deflection by any number or arrangement of cells.

TO DETERMINE THE PRESENCE AND DIRECTION OF A GALVANIC CURRENT.

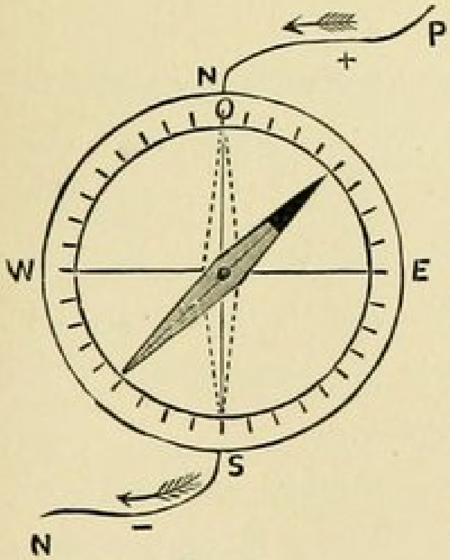


FIG. 26.

Place the galvanometer in such a position that O (or N) is toward the north, and the needle is pointing directly to N and S. Connect that pole of the battery supposed to be *positive* with binding post next O, and the negative with the other. The instant this is done, if there is a current, it passes through the coil beneath the base and deflects the north (loaded) end of the needle to the *east*. If the *negative* battery pole be connected with the binding post next O, and the circuit be completed with the positive at S, the north end of the needle will be deflected to the *west*.

No Deflection indicates either that the fluid is exhausted or the connections are defective.

THE COMPARATIVE STRENGTH OF THE CURRENT.

When the circuit is first completed, the needle moves rapidly to and fro, but soon becomes quiet at an angle with its former position. This angle is a measure of the deflection and a comparative measure of the strength of the current. The deflection will differ in two similar cells, provided, (*a*) The elements in one are immersed deeper in fluid than the other. (*b*) If the elements in one have been used longer than those in the other. (*c*) If the fluid of one has been used more than the other.

The following table is given as an example of the variations of this galvanometer when testing a series of cells which separately gave the same deflection, namely, 60°:

2 cells gave	68°	6 to 13 inc. gave	82°
3 " "	74°	14 and 15, "	83°
4 " "	78°	16 to 24, "	84°
5 " "	80°		

A subsequent test of this same series by electrolysis proved that the deflections of the needle were not an accurate measure of the working power of the current. Since the addition of cells one by one, from 6 to 13, did not increase the deflection, it might be supposed that there was a defect in the connections, but the amount of electrolysis performed each time a cell was added showed a regular increase.

The amount of deflection caused by a freshly charged cell is a guide to its subsequent condition. When it commences "to run down," the deflection grows less and less, and it ceases altogether when the fluid is exhausted or the elements destroyed.

THE DEFLECTION OF THE COMPASS-NEEDLE.

Minute quantities of electricity are sufficient to disturb the position of a compass-needle; and this fact is frequently taken advantage of by dealers in various so-called electrical appliances to convince the ignorant of the enormous amount of electricity furnished by them. A magnetized penknife will disturb the needle equally as much, and possesses fully as much therapeutical power, as many of the electrical devices put on the market in the guise of belts, jackets, discs, etc. etc.

BINDING POSTS.

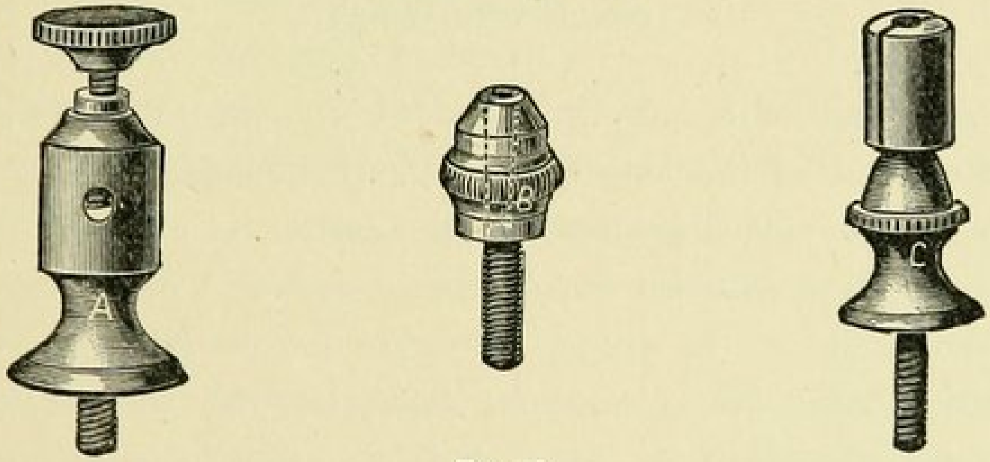


FIG. 27.

A, B and C represent binding posts, which are usually made of solid brass, and in the better class of batteries are nickel-plated to preserve them from rust, corrosion, etc. They terminate below in a screw, by which they are fastened upon the battery base and connected directly or indirectly with the elements. They serve frequently to fasten the elements to the lower surface of the base. Their upper part contains a hole or socket to receive the tips of conducting cords. A represents the style preferred for measuring apparatus, and other purposes where a very perfect connection is important. The cord tip is inserted in the side and the thumbscrew is turned firmly down upon it, giving firm and perfect contact over proportionately a considerable surface. B represents a common form of binding post, which receives the cord tip in the socket indicated by the dotted lines. This makes good connection, provided the tip fits tight and the socket is clean. Fluid dropped upon the post may cause rust in the socket, and as the current does not pass readily through rust, it is evident that its strength may easily be impaired by carelessness in this particular. Binding post C is similar to the others, except that it has a slot in addition to the socket. It is used on the end of battery bases to receive a movable bar which forms the connection between them as hereafter described.

CONDUCTING CORDS.

Every part of a battery circuit must be of metal, with the exception of the substance or body included between two points of the circuit upon which the current is expected to act. The connection between the binding posts and electrodes may be composed of a single wire, or a bundle of wires. In either case it is essential that they be well insulated, otherwise a portion of the electricity may escape, if accidentally brought in contact with a good conductor, and the operator will fail in securing the full strength of the current at the point where it is needed. When a single wire is employed, it is usually coated with gutta-percha or a woven covering saturated in paraffine. It should be of sufficient size, pure and well annealed. All conducting wires lose a portion of their conducting power by being frequently bent.

For medical application outside the bath, the conducting cords were formerly composed of a bundle of very fine wires, inclosed for insulation in a double woven covering of cotton, worsted or silk. Silver wire ranks as the best conductor, perfectly pure copper the second, and alloy the third on the list.

When great heat is required for any purpose, as in galvano-cautery, that part of the circuit between the conducting cords must be composed of a wire which offers great resistance to the passage of the current. Platinum, being a very poor conductor, is usually selected. At present, the best conducting cords for medical purposes are composed of alloy in the form of exceedingly fine flattened wire resembling foil, wound around a stout thread to give it strength, several of these threads being twisted in a strand, and several strands being twisted together after the manner of a cable, all being inclosed in a double woven covering. By this means a very large metallic surface is obtained in a very small space, which is perfectly flexible and less liable to breakage than conductors composed of a bundle of fine copper wires.

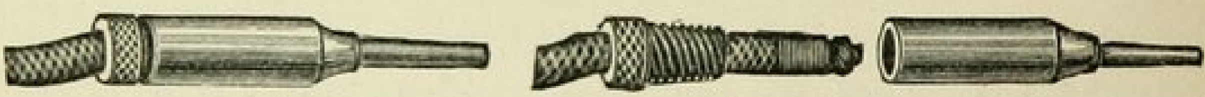
Bifurcated cords. A short cord is joined to a long one at such a distance from the end as to make two equal branches. It is used for two distinct purposes.

1. A current selector, to bring any number of cells in a given series into the circuit.

2. To divide the current. The single end of the cord is inserted in one binding post as usual, and the double end is attached to two electrodes, which are located on the points between which the current is to be divided. The single cord from the alternate pole is attached to an electrode that is usually located at some indifferent point.

Since every conducting cord, or wire, becomes a magnet while the current is passing, and ceases to be a magnet the instant the current stops, these changes in magnetic polarity after a time partially overcome the cohesion of the atoms, especially near the ends of the cords where the magnetic force is greatest; consequently they become brittle and easily break. This source of current interruption is frequently overlooked. When a battery is in good working order, and a current can be detected by the fingers placed on the binding posts, while a current cannot be obtained from the electrodes, it is almost certain that the metallic connection within the cord is severed.

Cord tips. It is necessary that there be close contact between the metal tips of the conducting cords and the sockets of the binding posts over their entire surface, or as much of it as possible. The tips should be adjustable, so that the operator can repair the cords when broken without the delay of sending them to the shop. There are two styles of adjustable tips. One is merely a thick wire turned up at one end to form a ring, to which the metallic portion of the cord is fastened by fine copper wire, the insulating cover being drawn back to expose it, and afterward drawn up close to the tip and fastened there.



A C B

FIG. 28.

THE McINTOSH TIP FOR CONDUCTING CORDS.

The style of tip shown in Fig. 28 is a convenient one, and gives very complete contact with the binding post. A shows it adjusted for use; B and C, the separate parts when unscrewed to mend the cord. After locating the break, C is moved past the point an inch or two and the cord cut off at the broken point; the metallic cable is exposed by drawing back its insulating cover and is tied in a knot to prevent its slipping through C. The cover is drawn up to the knot and fastened down with a thread, just behind the knot and trimmed off. C is now moved up to the knot, but not over it. B is screwed in place and the cord is as good as ever, except that it is shortened. It is important that the metallic threads of the cord should be in contact with the socket of B; if by any oversight the insulating cover be included in the knot so as to cover it in the socket, the passage of the current will be partially or wholly prevented.

FIG. 29. Connector. Length 1¼ inches.

The Connector is a convenient device for connecting conducting cords having tips of different size with various styles of instruments used in applying an electrical current.

A is a small socket in which the cord tip is firmly fastened by the thumbscrew.

B is a large socket cut in threads to receive the screw which terminates the instrument. Several styles and sizes of this useful little connector are made.

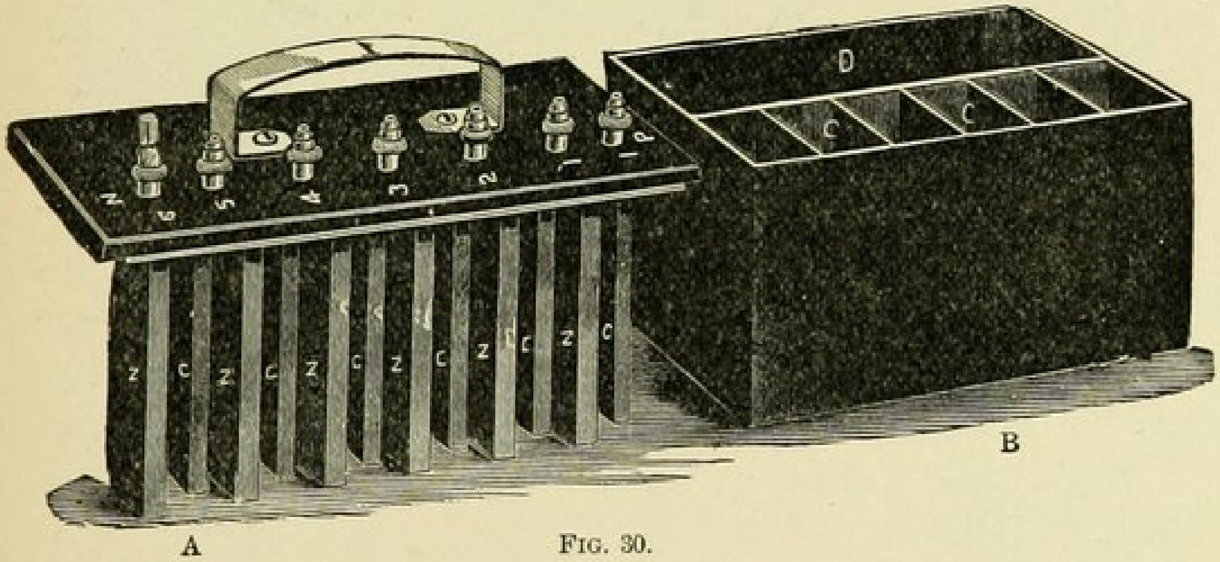


FIG. 30.

SECTION OF THE McINTOSH GALVANIC BATTERY.

A, base and elements. Base 3¾×7 inches. Elements 1×3¼.

B cell section. Length, 6¾ in.; width, 3⅜ in.; height, 4 in.

P & N, positive and negative poles.

1, 2, 3, etc., binding posts.

c, z, c, etc., carbon and zinc elements.

D, drip-cup.

C, C, cells.

Element section A is composed of a polished hard-rubber base, lined with soft rubber, which serves the purpose of a hydrostat. The elements are fastened direct to metal bridges, and these are attached to the base by the screws, which terminate the binding posts. They are arranged so that post P is connected with a single carbon, and post N with a single zinc; the remaining posts are each connected with a pair of elements.

The cell section B is composed of vulcanized rubber. It is divided in halves by a partition of the same material; one-half is subdivided into six equal parts called cells, which receive the fluid. The undivided half forms the drip-cup, in which the elements are placed when they are not in use.

Arrangement of Elements in the Fluid. When the elements are immersed in the fluid, their arrangement is as follows: The first cell contains the single carbon attached to post P 1, and the zinc attached to post 1. The second cell contains the carbon attached to post 1, and the zinc attached to post 2, and so on, the last cell containing the carbon attached to post 5 and the zinc attached to post 6.

Direction of current when one cell is in circuit. The current generated by the zinc in the first cell passes across the fluid to the carbon; from thence up through post P 1 and the circuit back to post 1 and down to the zinc. Binding post P 1 is the positive pole, and binding post 1 the negative.

When any number of cells are in circuit, the post to which the last zinc in the series (the one farthest from P 1) is attached forms the negative pole, while P 1 remains, as before, the positive pole. Suppose three cells are included. The current generated by the zinc in the third cell passes through the liquid to the carbon, up this to the metal bridge fastened to post 2, over the bridge to the zinc in cell 2; the zinc in cell 2 generates a current to which impetus is added by that received from cell 3. This augmented current passes across the fluid to the carbon, up to the metal bridge attached to post 1, and over to the zinc in cell 1, adding to it the additional impetus gained from the two preceding cells; this passes across to carbon connected with P 1, up through this post and the conducting cord attached to it, through the circuit to post 3, and thence to the zinc element where the current originated.

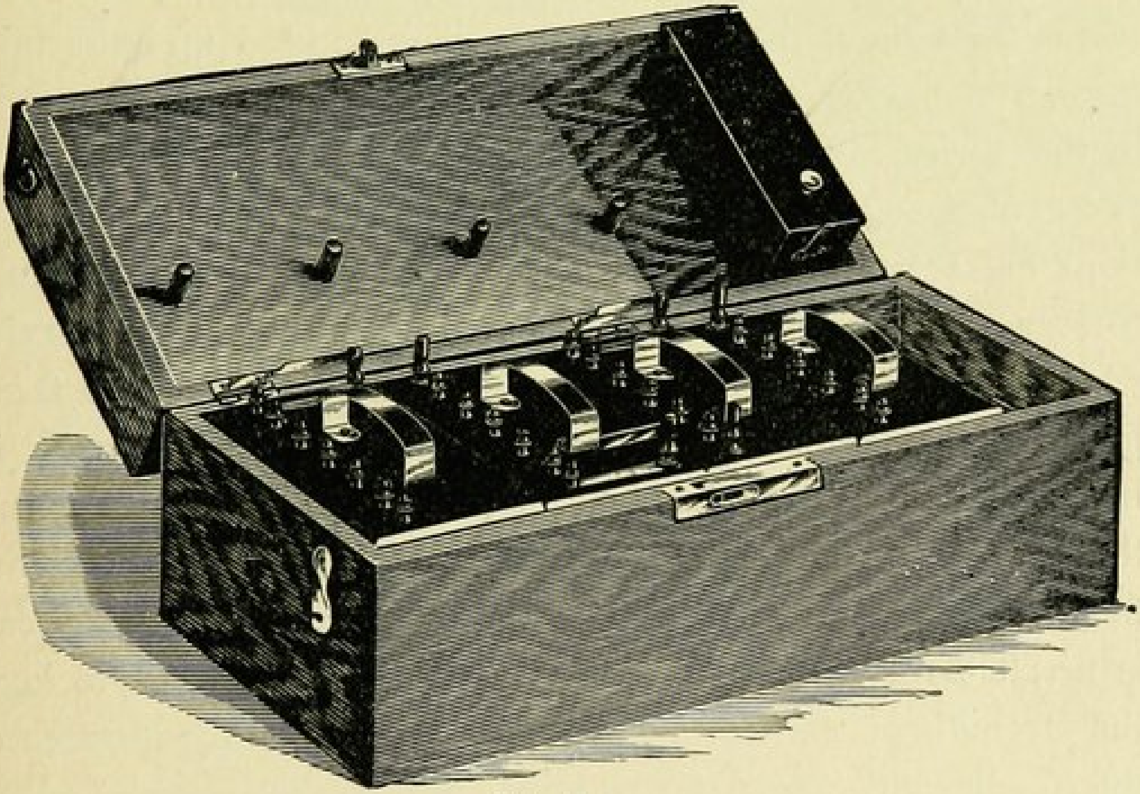


FIG. 31.

THE McINTOSH GALVANIC BATTERY.

TWENTY-FOUR CELLS.

Length, 18 in.; width, 8¼ in.; height, 7¼ in.; weight, 18½ lbs.

The physician who uses electricity in general practice has occasion frequently to apply the galvanic current at a distance from his office. For this purpose, a compact instrument capable of giving a current strong enough, not only for general application, but for any case of electrolysis that may be presented, is essential, and it is also essential that such an instrument be not too heavy to be conveniently portable. The galvanic batteries invented by Dr. McIntosh meet these requirements fully. They are not only compact, perfectly portable, and easily kept in order, but they are the most powerful galvanic batteries made, with the exception of those intended solely for galvano-cautery.

Each cell, when freshly charged, has an electro-motive force of two volts. These cells are arranged in sections of six, so that only six pairs of elements are exposed to the action of the fluid at once, and of these, any single pair may be used separately. By this ingenious arrangement, the fluid and elements throughout the entire battery may be used up uniformly, instead of having the bulk of the work fall upon the first cells in the series, as is usually the case. As the full number of twenty-four cells are rarely required for any operation, all sections not actually needed should be omitted from the circuit, to serve as a *reserve force*, ready to be brought into service when more power is required, or when the current from those in use falls below that necessary to accomplish the work in hand, either from polarization, exhaustion of fluid, or destruction of elements. As all single fluid cells, without exception, fall constantly from the power they possess, when the circuit is first closed, fresh cells may be added, one by one, to keep the strength of the current uniform. The following features of these admirable instruments need only to be referred to, as their value will be at once apparent:

1. When the battery is closed, each cell section is tightly covered, so that no liquid can escape from the cells.

2. When the battery is not in use, the elements are contained in empty drip-cups, thus preserving them from all possibility of waste from local action.

3. The electrode box is so placed that the battery cannot be closed so long as any section of elements remains in the fluid.

4. The current is started by simply lifting a section of elements to the right so as to immerse them in the fluid. The handles on the bases serve to lift the sections, and also as springs to press them down firmly on the cells when the battery is closed.

5. If at any time during treatment the current fails, new sections may be made ready in an instant, and those already used may be omitted from the circuit. This is an inestimable advantage in certain electrolytic operations. New cells may be added during the operation without shock to the patient, and without breaking the circuit, by using the bifurcated cord as a current selector.

7. The cells, being of hard rubber, are not injured by leaving the fluid in them constantly.

8. Since the *available* strength of current depends, among other conditions, upon uniformity of element surface immersed in fluid, a glass measure is sent out with these batteries, graduated to show the amount of fluid required for one cell, so that all may be filled alike.

9. When it is necessary to clean the cells, they can be lifted out, emptied, and washed like an ordinary cup. Since the connections between elements are not disturbed in the process, the work of cleaning the battery may be intrusted to any one who is sufficiently careful not to spill the fluid upon the metal work.

AUTOMATIC RHEOTOME.

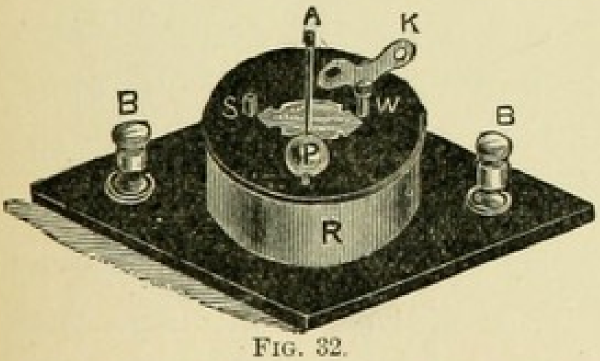


FIG. 32.

Length of base, 7½ in.; width, 4½ in.

R. The cylinder containing clockwork.

A P. Vibrating Pendulum

P. Movable ball to regulate length of vibration.

B B. Binding posts for connecting with battery.

K. Key for winding clockwork.

W. Winding post.

S. Starting and stopping post.

The automatic rheotome is designed to produce regular interruptions of the galvanic current.

To introduce it into the circuit. Connect one binding post B with the positive pole of the battery, and the other post B with an electrode that is applied to the patient. The negative pole of the battery is connected with the patient in the usual manner.

To start the rheotome. Turn post W with the key in the same direction as when winding a clock. Remove the key to post S, turn it slightly to the right, and A P will immediately begin to vibrate.

To regulate the interruptions. Moving P nearer A shortens the vibrator and increases the rapidity of the interruptions; moving P farther from A causes slower interruptions. They may be stopped instantly by turning post S to the left.

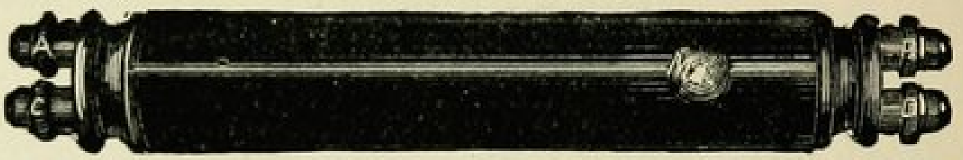


FIG. 33.
POLE CHANGER.
Length, 6¾ in.; diameter, 1 in.

The pole changer not only changes the direction of the current, but also produces the effect of a current interrupter while the change in polarity is being made. This instrument consists of a hollow polished-rubber cylinder, containing within it a long movable arm which carries a pair of parallel metal springs. At each end of the cylinder are two binding posts, which have metallic connection, with two brass buttons just within the cylinder, with which the springs make contact. The thumb-screw M is attached to the movable arm, and when moved the length of the slot, in the cylinder, carries the arm with it. When M is at one end of its slot, the metallic connections through the instrument are parallel; that is, the current which enters at A comes out at B, passes through the circuit and back to D, emerging at C. When M is moved to the other end of its slot, the current entering at A passes out at D, and, returning through the circuit at B, emerges at C.

To use the pole changer. Connect A and C with the two poles of the battery, B and D with two electrodes, and complete the circuit as usual. Move M to and fro to change the polarity at suitable intervals.

THE MC INTOSH GALVANIC BELT.

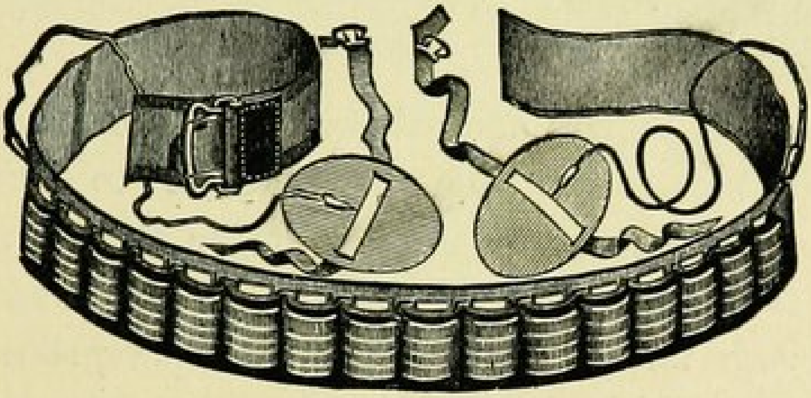


FIG. 34.
Weight of belt, 10½ oz.

The McIntosh galvanic belt is constructed on the principle of the voltaic pile. It consists of a series of cells placed in pockets on a belt.

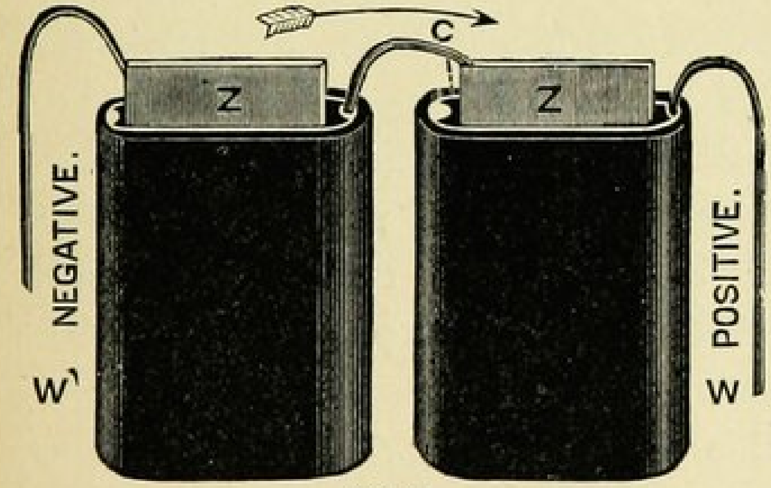


FIG. 35.
Section of Belt Cells.
Actual size.

The cells are composed of vulcanized rubber, lined with copper. The rubber serves two purposes; it prevents leakage and insulates the cells so that the electricity generated within cannot escape except through the conducting wires. The copper lining forms the collecting plate. The generating plate is zinc, wrapped in a porous material which absorbs the exciting fluid and prevents any accidental escape from the cells. The zinc element in one cell is joined to the copper of the next by a short copper wire, so fastened as to permit a hinge-like motion between the cells, making the belt perfectly pliable.

The belt is charged by dropping a little diluted vinegar or acetic acid * in each cell. A drop-tube is furnished with the belt to facilitate this process. The porous material of each cell (that is to be included in the circuit) must be thoroughly wet with fluid.

Caution. It is not unusual for those unfamiliar with the principle of the voltaic pile, to endeavor to increase the strength of the current by using a larger proportion of acid, or pure acid; the result is a sharp current and chemical action of such intensity as to produce rapid polarization, in consequence of which the current ceases to pass through the conducting cords.

The strength of the current. This varies constantly from the time the circuit is closed until the fluid becomes exhausted. When all the cells are in circuit and freshly charged, the current has a strength of about four volts, and, if kept working through a resistance equal to that of the human body, will retain this strength for nearly twelve hours; it then perceptibly decreases, but is capable of producing a therapeutical effect for about twenty-four hours after it is charged, or until the porous filling of the cells becomes dry. This belt furnishes a current of sufficient potential to decompose water, and this experiment is the best mode of testing the relative strength of the belt.

The Electrodes are thin plates of metal, covered with flannel, sponge, or chamois skin, connected with the cells by means of conducting cords, and are fastened on the parts to which the current is to be conveyed. Elastic bands, which fasten with a convenient clasp, are used to retain the electrodes in place. The cover of the electrodes must be moistened with

* Dilute acetic acid here referred to contains one part acid to ten parts water.

water (in rare cases with salt and water or acidulated water), and placed in contact with the skin. *The current will not pass through dry cloth, sponge or chamois.* The metal electrodes applied without a cover directly to the skin produce considerable irritation, and if left long in direct contact will blister, especially under the negative. Metallic instruments of any form, such as needles, metallic discs, etc., may be connected with the cords, and the current conveyed through them the same as through ordinary electrodes.

Conducting Cords.—These are similar to the conducting cords used with batteries. Two conducting cords can be attached to either pole when the current is to be divided between two parts, as the feet or arms, etc.

To increase or decrease the number of cells in the circuit. Always remove the cord in connection with the zinc to make any change in the number of cells in circuit, and replace it between the zinc and its cover in the last cell of the series to be used. For example, if five cells are wanted in circuit, leaving the cord attached to the copper undisturbed, connect the negative cord with the zinc in the fifth cell.

The practical advantages of the belt. The belt is especially adapted to those cases that require either a general or local application of an uninterrupted galvanic current of small quantity for a long time, either to *improve nutrition* (innervation) to *excite absorption*, or to produce a *chemical change* in *secretion.*

For the first purpose named, one electrode (to which a large sponge should be attached) is placed over that portion of the nerve-centers to be influenced, and the other over the special organ most implicated in the constitutional derangement.

When applied to single organs, to reduce irritation the positive electrode should be placed over the nerve-roots, as shown in Fig. 73, and the negative over the organ to be influenced; the best locality for this can be determined by consulting the "landmarks" on Fig. 74. If the male sexual organs are to be treated, a suspensory bandage specially made to accompany the belt can be used for one electrode, while the other pole is placed over the pelvic ganglia. To stimulate or to excite absorption, the current must be carried through the nerves in the opposite direction, that is, the negative over the brain, spine, or nerve-roots, and the positive over the periphery of the nerves.

In the treatment of ulcers, to change the nature of the secretions it must be remembered that those in contact with the positive pole are changed to an acid state, and those in contact with the negative to an alkaline, as a piece of litmus paper will readily show.

If it is thought desirable to apply this current to a single muscle, or group of muscles, the electrodes should be very small, and should be located according to the motor points of the special muscles to be treated.

Duchenne discovered that certain forms of paralysis received most benefit from electricity when its application was accompanied by what he termed "mental gymnastics," that is, when the patient exerted his will to produce contraction of the paralyzed muscles at the same time that a current was passing through them. The belt furnishes a current that may be conveniently applied for this purpose.

Dr. Poore* claims priority for the "combination of a continuous galvanic current with voluntary muscular exercise." His clinical observations lead him to believe that during the passage of the polarizing current the voluntary mental stimulus acts with greater effect on the muscles, or, in other words, the contracting power of the muscles is increased. Other uses of the belt will be suggested under electrolysis.

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* A Text-Book on Electricity in Medicine and Surgery. G. V. Poore, M.D., M.R.C.P., etc.

THE MCINTOSH GALVANIC SUPPORTER.

This consists of a metallic attachment to the McIntosh Uterine Supporter Cup, for the purpose of conveying a galvanic current directly to the cervix.

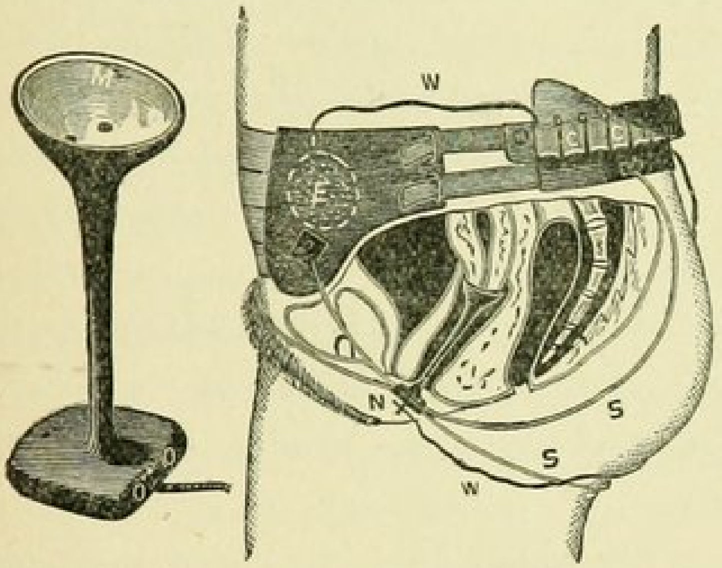

FIG. 36.

C C. Cells similar to the belt cells, fastened directly to the supporter belt. A morocco flap, which covers them, is shown partly lifted up.

E. Electrode (a little too high on the cut), located over the ovarian region.

M. The metal lined uterine cup which conveys the current to the cervix.

N. The end of the metal rod which extends through the rubber stem to M. It is enlarged in the cut to make it visible.

W W. Conducting cords.

S S. Soft-rubber cords which retain the cup in position.

Two conducting cords may be connected with O, to divide the current between two electrodes, so that one may be applied over each ovary, or one over the median line in front and the other over the sacrum. The cup, being of hard rubber, is a perfect insulator; the current passes only to that part of the cervix in contact with the metal lining the cup. The cervix should be examined from time to time to guard against too much action on the tissues. There exists great difference of opinion as to the value of an electrical current thus applied; the evidence for and against it is so incomplete that it is not deemed advisable to enter into a discussion of the subject here. This method is sometimes adopted in the treatment of atony, ulceration, prolapsus, etc., with alleged success.

THE PHYSIOLOGICAL EFFECT OF THE GALVANIC CURRENT.

The first definite knowledge of the effect of galvanism on muscular and nervous fiber, which we have, is derived from the experiments instituted by Humboldt. Aldini, pupil of Galvani, was the first to apply galvanism to the treatment of disease, and in 1804 he published a book at Bologna entitled "Theoretical and Experimental Essay on Galvanism."

Prof. C. Matteuci, of Pisa, made a long and thorough series of experiments to determine the influence of the galvanic current upon the animal tissues, and his conclusions are regarded as authoritative, having been repeatedly confirmed by others from time to time since he originally announced them. They may be briefly summed up as follows:

1. It excites sensation at one time and contraction at another, according to the direction in which it traverses a nerve.

2. It does not excite a nerve when passing through it transversely.

3. Neither contraction nor sensation is produced when its influence upon a nerve is prolonged.

4. It alone has the property of increasing or diminishing the excitability of a nerve, according to the direction in which it is made to flow.

5. It has the power of awakening the excitability of a nerve after all other stimulants have ceased to act.

6. When a galvanic current is sent through a limb in the opposite direction to the nerve current, a muscular contraction takes place.

7. When the electrical current passes in the same direction as the ramifications of the nerves, a stronger contraction takes place.

Rosenthal states that there is a great similarity between muscles and glands in this respect. If a nerve which is connected with a muscle is irritated, the muscle becomes active; that is, it contracts; and if a nerve that is connected with a gland is irritated, the gland becomes active; that is, it secretes.

ELECTROTONOS.

It was claimed by Matteuci that the galvanic current exerts an influence over the nerves it traverses only at the time when the circuit is closed or opened, since at those instants only can a muscular contraction be produced. Subsequent observers, among them Du Bois-Reymond, confirmed this opinion, and it was accepted as a fact until Ritter reported the following observation: During a long and persistent closure of a *strong* galvanic circuit, if the current be carried through both arms, the hand and arm in contact with the negative pole become less and less mobile until, finally, complete rigidity sets in; whereas, on the contrary, the hand and arm in contact with the positive become more and more mobile and easy to move. To this changed state of the nerve-current, during the continued passage of a galvanic current, has been given the name *electrotonos.*

Pflüger explains the fact, viz: The arm on the positive side is traversed by an upward, and on the negative side by a downward, current; no perceptible error occurs in considering it the same as if the positive pole be set on the shoulder of the downwardly traversed arm, and the negative in the hand of same; while in the upwardly traversed arm the position of electrodes is reversed. When the will acts out from the brain on both arms simultaneously, it acts *above* the *anode* in the downwardly traversed arm, or in the same direction as the current and behind it, while in the upwardly traversed arm, *above the cathode*, or *opposite* to the electric current. This experiment was the first discovery of electric law in the living human being.

ANELECTROTONOS AND CATELECTROTONOS.

Pflüger has also shown that when a *galvanic* current traverses a certain length of *nerve* it divides the latter into two sections or zones which physiologically differ, the portion nearer the negative pole having its irritability increased, and the portion nearer the positive having its irritability decreased. That condition of the nerve next the negative pole has been named *catelectrotonos;* that next the positive, *anelectrotonos.* These conditions pass into each other at a point between the poles called *point of indifference.*

LOCATION OF THE POINT OF INDIFFERENCE.

This depends upon

1. The size of the electrodes,
2. The distance they are apart,
3. The electro-motive force of the current,
4. The length of time the application is continued.

The altered or *polar* condition of the nerve extends only to a certain distance from the electrodes, and when they are very small or far apart a considerable extent of the circuit between them may constitute the "point of indifference," since the current traverses the fluids rather than the solids of the body. When the current is feeble (has small electro-motive force), the point of indifference is moved toward the positive pole, and almost the whole extent of nerve between the two electrodes may be in a state of *increased* excitability (catelectrotonos); with a strong current the reverse is true. When the current passes for a long time without interruption, the "point of indifference" is moved toward the negative pole, or the section of *diminished* irritability (anelectrotonos) is increased; and if the electro-motive force of the current be at the same time increased, the zone of increased irritability may be reduced to the small space in the immediate vicinity of the negative pole, and after this maximum condition is reached it is useless to continue the current longer.

Reaction. Immediately after breaking the connection reaction takes place in both sections of the nerve, the one which during the passage of the current was in a state of diminished irritability (anelectrotonos) assuming the catelectrotonos state, and vice versa. This gradually subsides and the nerve resumes its natural condition.

Alteration in conducting power of nerve. The galvanic current also changes the faculty of the nerve to transmit stimulation; that portion of the nerve which has its excitability diminished offers greater resistance to the transmission of the stimulation, and this resistance increases with the duration and electro-motive force of the polarizing current.

Effect of a strong current. Repeated and strong electrical shocks weaken and invert the nerve-current. It should be remembered that galvanic stimulation is *the first step in the electrolysis of the nerve.*

LAW OF GALVANIC STIMULATION.

The law of galvanic stimulation has been investigated by Du Bois-Reymond, and his conclusions are briefly these:

1. The *motor* nerve is stimulated not so much by the density or quantity of any given current as by its variations from one instant to another.

2. The more rapid and sudden the fluctuations of the current, the greater the effect produced by a minimum quantity of electricity.

3. Frequent change in direction is required in galvanic stimulation of a nerve, because the conductivity of a current flowing long in the same direction is decreased, while a change increases it.

4. There is no doubt that the brain and spinal marrow may be affected by the galvanic current, even through their

bony covering. The latter point has been confirmed by Ziemssen.

METHOD OF APPLYING GALVANISM.

Certain terms are applied to the galvanic current to distinguish the method of its application.

1. *Stabile* current is the name given it by Remak when the electrodes are kept stationary during a sitting.

2. *Labile* current, when the negative is made to glide over the surface in the direction of the nerves and muscles to be acted upon.

3. *Descending* current is the name given it when the positive electrode is placed over the plexus or roots of the nerve, and the negative at the extremities.

4. *Ascending current*, when the negative is placed over the roots of the nerves and the positive at their extremity or periphery.

5. *An increasing current.* A current from a circuit that is being increased by joining more cells in the series from time to time during a sitting.

6. *A decreasing current.* The current from a circuit from which cells are being disconnected from time to time during a sitting.

5. *General galvanization* is a term indicating that the current is applied to the whole surface during a sitting. It is sometimes called the *percutaneous* method. Beard and Rockwell have given the name *central galvanization* to that particular method of employing general galvanization which is original with them. Its object is to bring the brain, spinal cord, sympathetic and pneumogastric nerves under the influence of the galvanic current. The negative electrode is placed over the epigastrium while the positive is passed over the forehead, top of head, along the inner border of the sterno-cleido

mastoid muscle, from the mastoid fossa to the sternum, and at the nape of the neck and down the entire length of the spine.

6. *Localized galvanization.* This includes cutaneous galvanization, galvanization of nerves and muscles, and galvanization of special organs and senses. This is usually accomplished by placing one metal or sponge electrode over the part to be treated and the other over the root or trunk of the nerve supplying it. Another method, called by its inventor *galvanopuncture*, is supposed to have been first used by Fabré-Palaprat, in 1828. Its first scientific use, however, was made by Magendie. It is a combination of electricity with acupuncture, which is little used at present.

DETAILS OF TREATMENT.

To prepare the patient for general galvanization. Dynamic electricity does not possess sufficient potential to overcome the resistance of the clothing, therefore the conductors or electrodes used to convey the current to the body must be in *direct contact with the skin.* Since the current flows only when the circuit is complete, two separate parts of the body or tissues treated must be connected with the battery, one connection being made with the positive and the other with the negative pole of the battery. The clothing should be loosened, so that the current may be carried by suitable conductors down the whole length of the spine and over the principal organs of the body; and if the legs are to be included in the treatment, the feet should be bare and in contact with one of the conductors.

The room in which the treatment is given should be sufficiently warm, so that there can be no danger of the patient's becoming chilled; for the same reason the conductors or electrodes should be warm. All exposure of the person should be avoided so far as possible. It is convenient and customary to provide a shawl or blanket to be thrown over the patient if the sitting is to be long and the application very general.

The battery should be tested before commencing to ascertain whether it is in good working order or not. A galvanometer introduced into the circuit will be deflected if a current is passing, as already described. An excellent test that has several advantages over all others is to apply the current from the smallest number of cells to be used to the operator's tongue, and the current from the largest number to the back of his hand.

Strength of current. It is best to commence with a current from a very few cells, adding others, one by one, to the series, if necessary, to increase the strength.

The galvanic current, unless very powerful, produces no marked sensations when uninterrupted; frequently the patient does not feel it at all except at the instant the circuit is closed or opened; therefore, when it is desirable to prevent all shock, the electrodes should be placed in position before the circuit is closed, and at first include not more than two or three cells in circuit; as soon as the current is started cells may be added, one by one, without causing shock, and the electrodes may be moved over the surface without producing disagreeable sensations, provided their contact with the surface is not broken during the application. Before removing them or breaking the circuit the current should be decreased, cell by cell, until reduced to its original strength.

This mode of regulating the strength of the current (except for very sensitive patients) should be reserved for special cases, because the therapeutical effect of the *increasing* and *decreasing* currents differ from those which are maintained at a uniform strength during an entire sitting.

It may be laid down as a general principle that a feeble current used for a short time produces the greatest therapeutical *effect. A very powerful current almost always does harm instead of good, and more especially so when it is applied for a considerable length of time.*

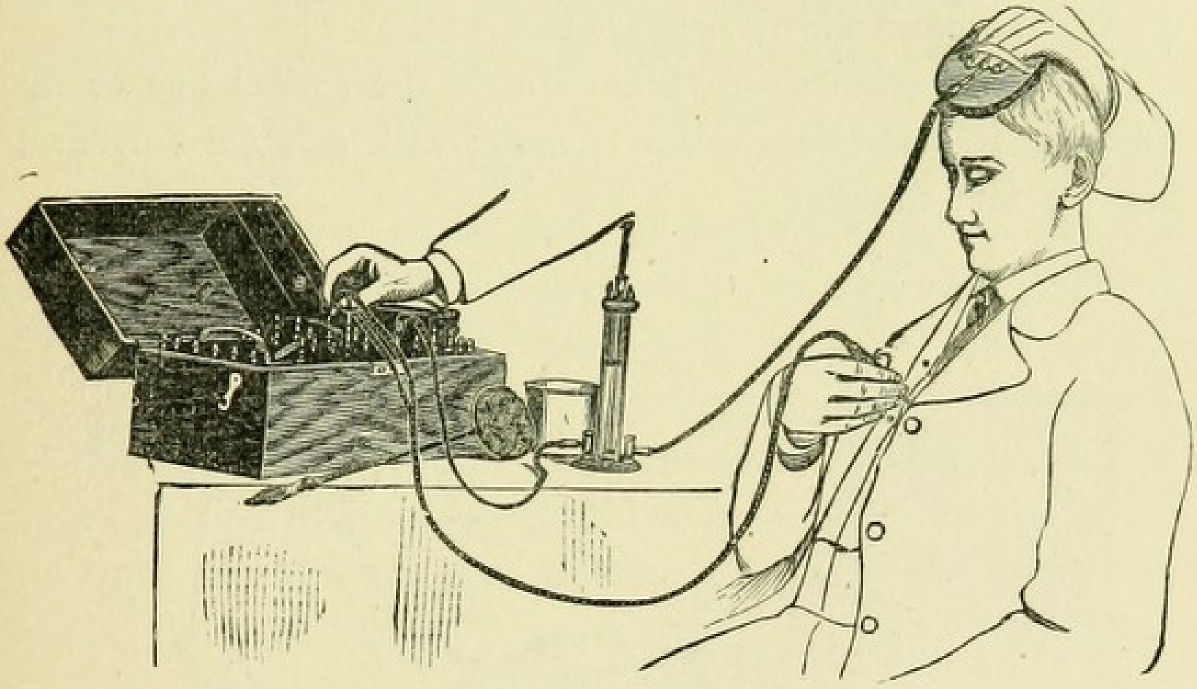

FIG. 37.

ONE STEP IN CENTRAL GALVANIZATION.

A McIntosh eighteen-cell combined galvanic and faradic battery is shown in this illustration. The positive pole is connected with the electrode on the head of the patient. Three cells are in circuit, and the operator is taking the fourth cell into circuit, showing the method of using the bifurcated cord as a current selector, and of producing an *increasing* current.

The long-handled electrode beside the battery is used in Fig. 38 for applying the current to the skin under the clothing. A hydro-rheostat is in the circuit (see Fig. 51) to prevent the current from producing an unpleasant effect upon the brain. It is not used with the galvanic current, except when the latter is interrupted.

The electrode on the head is faced with sponge, which should be moist, and the hair also, dry hair being a non-conductor. It should be pressed evenly and firmly over as large a space as possible. It should be located before the circuit is completed. The negative electrode is placed over the stomach; the vest should be unbuttoned and the underclothing drawn aside to permit the electrode to rest on the skin.

The application to the brain should not exceed one or two minutes, if a stabile current is used; with a labile current it may be four minutes.

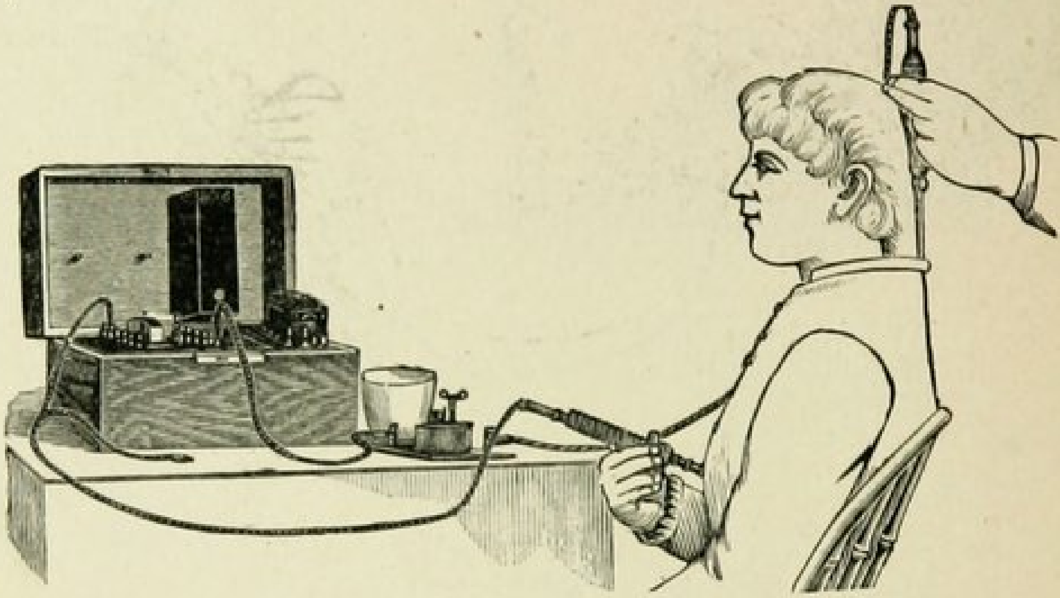

FIG. 38.

ANOTHER STEP IN CENTRAL GALVANIZATION.

Caution. All applications of electricity about the head should be made with every precaution, if made at all, in cases where the symptoms indicate that apoplexy or paralysis may be impending. *Dizziness* should be a warning that the current is too strong, applied too long, or is unsuitable to the case.

Galvanization of the neck must be practiced with caution, since giddiness and faintness are occasionally produced. While applying currents about the sides or front of the neck, the sensations excited in the patient must be carefully observed. Acts of swallowing and coughing are frequently produced, especially when the negative electrode is on the neck, being caused, probably, by the irritation of the superior laryngeal nerve.

A twelve-cell combined battery is shown in Fig. 38, with twelve cells in circuit. The sections are united by a bar, which may be seen between them, next the battery top. An automatic rheotome is in circuit to produce an interrupted galvanic current. It is not an essential feature in this treatment, but, being sometimes used, it is introduced in the illustration to show the method of employing it. A lady patient should loosen her clothing at the neck sufficiently to permit the free passage of the long-handled electrode down the entire length of the spine, and also over the stomach to permit locating the stationary electrode. When the liver, spleen, etc., need a special application of the current, the dress-waist and corset may be removed, and a shawl be thrown over the shoulders to avoid exposure. As a rule, that operator will be most successful in pleasing lady patients who manages to give the necessary treatment with least disarrangement of clothing.

Localized galvanization. This method of employing the galvanic current will be described in the chapter treating of the physiological and therapeutical effect of electricity upon the various nerves, muscles, and organs of special sense.

CHAPTER IV.

ELECTROLYSIS.

This is the process of decomposing a compound substance by passing electricity through it. One portion appears at the point where the current enters, and the other at the point where the current leaves the compound. Faraday gave it the name *electrolysis*, which is understood to refer only to the changes effected in a substance *subjected to*, but not *giving rise to*, the current.

The points at which the electricity passes in and out are called *electrodes* (from a Greek term signifying "way"). The point of entrance, connected with the collecting plate of the battery, is the *anode* (upward way); the point of exit, connected with the zinc, is the *cathode* (downward way). The substances acted upon, or decomposed, are called *the electrolytes*. The elements into which electrolytes are separated are called *ions*. Those which appear at the positive electrode are called *anions;* those at the negative electrodes the *cations*.

"Since like electricities repel, and unlike attract each other," the anions which appear at the positive electrode must be electro-negative, and the cations that appear at the negative electrode must be electro-positive.

LAWS OF ELECTROLYSIS.

The amount of decomposition that takes place in any given case and the products of it depend upon:

(*a*) The strength of the current.

(*b*) The nature of the substances acted upon,

(*c*) The material of which the electrodes are composed.

The amount of chemical effect produced on water, saline solutions, etc., will be in proportion to the strength of the current. It has been estimated that for every 32.7 grs. of zinc dissolved in any cell, provided local action is prevented, 9 grs. of water are decomposed. If the current developed by the decomposition going on within the cell could all be applied without loss, it would effect an equal amount of decomposition in the electrolyte.

Electrolysis can only occur when the substance is in a liquid or semi-liquid state, so that the particles can move freely. Gordon* gives this explanation of the electrolytic process. The molecule next one electrode is broken up, one atom going to the near electrode ; the other either travels across to the opposite electrode or else changes partners with its adjacent molecule, setting free a portion similar to, and equal to, itself, which in turn combines with the next in the same manner, until the last molecule is reached ; the last atom set free, finds nothing to combine with, and appears alone at the negative electrode. It will be seen that the mobility of the particles is a necessary condition.

All substances are decomposed by electricity in exactly the same proportions as they are chemically united, or in proportion to their atomic weight. Water is composed of 8 parts (by weight) of oxygen chemically united to 1 part (by weight) of hydrogen. When decomposed by electricity there appears at the negative electrode 1 part of hydrogen, and at the positive 8 parts of oxygen. Common salt consists of sodium 23.3 parts by weight, and chlorine 35.5 parts. When electrolyzed, the 23.3 parts of sodium appear at the negative electrode, and 35.5 of chlorine at the positive. It must be remembered that the human body is a mass of cells, and that these cells contain and are bathed in a

* Electricity and Magnetism.

saline solution, and it is not unlikely that, when a galvanic current is passed for some time in the same direction through the body, some of the resulting phenomena may be due to electrolytic changes in the tissues acted upon.

The material of which the electrodes are composed, their size, and distance apart, are of practical importance in certain therapeutical applications. Fig. 39 is designed to represent the branches into which a current is supposed to split up on passing through a substance. When a large electrode is used, these branches have a larger surface for entrance or exit, and are consequently not so dense or crowded together as in the case of the small electrode. As each branch is believed to do its part in the work to be accomplished, it is evident that the greatest decomposition must occur at the small electrode where the greatest number of current branches act together upon a comparatively limited space.

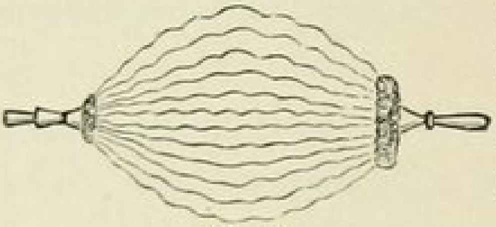

Fig. 39.

Fig. 40 represents what occurs when one of the electrodes is very small, and the distance between them is great.

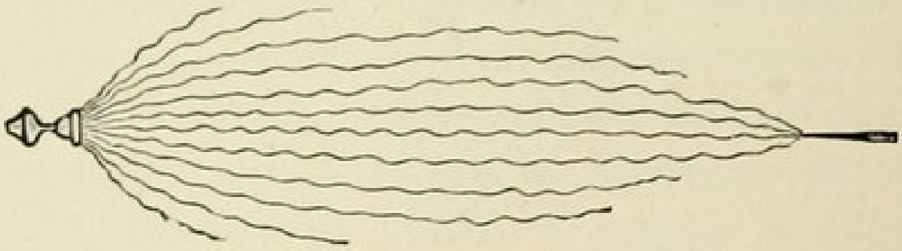

Fig. 40.

Many of the current branches starting from the flat electrode, being unable to overcome the resistance, are lost, and the decomposition will be much less at the needle than when they are placed nearer together. It is a question whether those currents possessing sufficient power to dissolve or break up tissue, and destroy tumors, may not be capable of producing serious injury to other and healthy tissues through which they must be carried when the electrodes are widely separated. It is, therefore, recommended, in all *electrolytic* operations, to place the two electrodes near together.

The *materials* of which electrodes are composed may be adapted, in certain cases, to the work to be done, since a substance which in combination with oxygen is capable of producing some special effect, can be selected for an electrode. This is done occasionally in treating stone in the bladder, tumors, etc. It must be recollected, in this connection, that during electrolysis the acids set free appear at the positive pole, and the alkalies at the negative. The immediate effect of decomposing the fluid of the body is that the oxygen and chlorine set free (acids) attack the needle, or positive electrode, *inserted in the tissues*, changing a portion of it into metallic salts. Since metals are not acted upon by hydrogen, or free alkali, the negative electrode remains bright, whatever may be the strength of the current, or the length of its application. When it is desirable to introduce salts of iron, copper, silver, gold, or any other metal, into a morbid growth, insert into it needles, or pointed electrodes, of the metal selected, and connect them with the carbon or copper element of the battery. When it is desirable to preserve the needle from corrosion, or to avoid introducing any foreign substance, insert the negative needle attached to the zinc battery element. Since the art of electro-plating proves that materials resulting from decomposition of the anode are carried to and deposited upon the cathode, this fact should be borne in mind when attempting to remove stricture, otherwise the trouble may be increased by the very means used to remove it.

TO DETECT THE DIRECTION OF THE CURRENT BY ELECTROLYSIS.

When a solution of common salt is exposed to the action of the current, as we have seen, both water and salt are decomposed, oxygen and chlorine appearing at the positive, hydrogen and sodium at the negative, electrode. A piece of blue litmus paper immersed at the negative electrode, where the alkaline atoms collect, will be rendered more intensely blue; but immersed at the positive electrode, where the acids go, will be reddened. A solution of iodide of potash and starch, when brought under the influence of the current, will give a blue color at the positive electrode, where the iodine is set free, while at the negative pole the solution remains colorless.

POLARITY OF IONS OR ATOMS OF ELECTROLYTES.

When a substance is electrolyzed, those atoms which travel toward the positive electrode are electro-negative, and are known in chemistry as *metals*. Those going to the negative electrode are electro-positive, and are known as *non-metals*. They gradually shade into each other.

TABLE SHOWING THE RESULT OF ELECTROLYZING A FEW COMMON SOLUTIONS.

ELECTROLYTES.	CATIONS.	ANIONS.
Water	+ Hydrogen	— Oxygen.
Salt	+ Sodium	— Chlorine.
Iodide potash	+ Hydrogen	— Iodine.
Nitric acid	+ { Nitrous acid Nitric oxide }	— Oxygen.
Sulphurous acid	+ { Sulphur Hydrogen }	— Oxygen.
Muriatic acid	+ Hydrogen	— Chlorine.
Chloride of lead	+ Lead	— Chlorine.
Sulphate of copper	+ Copper	— Sulphuric acid.

When electrolysis of tissues lying beneath the skin is to be performed, the galvanic current is conveyed to them through needles of suitable size and shape. Those shown in Fig. 41 are made of steel, gold-plated; they are called respectively straight, half-curved and curved. They are triangular like a surgical needle, and may be fastened directly to the cord by a needle-holder (see No. 4), or to a needle conductor (Fig. 42). The length varies from one inch upward, according to the mass to be acted upon, and the depth at which it is located. Round needles are also used for electrolysis, and the material may be any metal that can be made into a needle. Very fine platinum or steel needles are used to remove hairs.

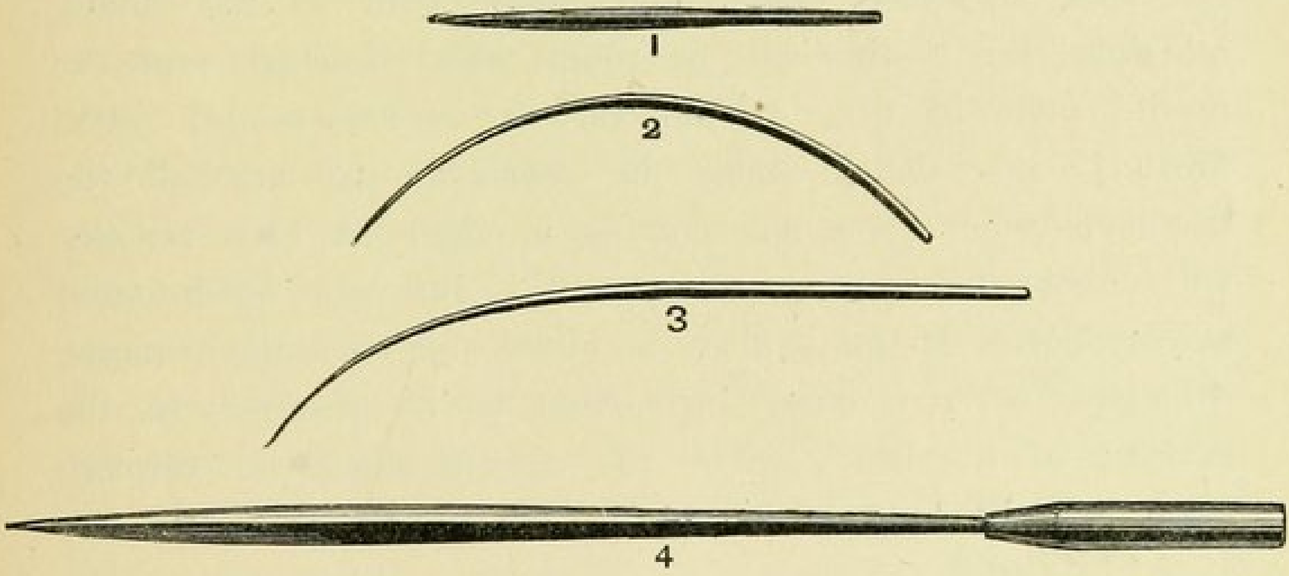

FIG. 41.

NEEDLES FOR ELECTROLYSIS.

To use electrolysis needles. 1. Connect with one pole of the battery, and insert them in the tissue to be acted upon. Complete the circuit by placing a large moistened sponge (connected with the alternate battery pole) outside, on the skin near by. 2. Instead of having the alternate pole represented by a sponge it may be connected with a needle, which is also carried into the tissues near, but not in contact with, the first.

To insulate an electrolysis needle. When it is desirable to prevent any action of the current upon the skin, the needle should be insulated, except at the point that is entirely within the tissues to be operated upon. It may be coated with rubber dissolved in collodion, or shellac. The last named forms an excellent insulator; it is prepared and applied as follows: Pulverized white shellac is covered with alcohol and allowed to stand over night, when it is ready to use; that part of the needle to be insulated is coated with a thin layer and held in a flame to evaporate the alcohol; the process is complete when bubbles cease to form. If any bubble does not immediately burst, it must be brushed off with the finger, the spot smoothed down, and again held in the flame, otherwise the coating will be rough when finished, and the needle unfit to use. If the surface is not smooth when finished, the shellac must be dissolved in alcohol, the needle cleaned and a new coating applied. A little practice will enable the operator to apply this insulator quickly and successfully. It may also be used for metallic sounds, catheters, or any other instrument to be inserted in the cavities of the body, when the current conveyed through them is to be localized at any particular part of the cavity.

EFFECT OF ELECTROLYSIS UPON ANIMAL TISSUES.

Althaus, during 1866 and 1867, made a series of microscopical observations on the changes which animal structures undergo, under the influence of the electrolytic action of the galvanic current. He studied its effect upon the intimate structure of the skin and cellular tissue, muscular fibers and tendons, cartilages and bones, liver and pancreas, spleen and thyroid body, kidneys and suprarenal capsules, testicles, breasts and ovaries. The general result of these investigations has proved *that no animal tissue whatever can withstand the disintegrating effect of the* *negative pole, and that the force and rapidity with which this disintegration is brought about are directly proportional to the electro-motive force which is employed, and to the softness and vascularity of the structures acted upon.* Thus ten cells of a battery have a more thorough and rapid effect than five, fifteen more than ten, and so on ; as regards the tissues, those containing most water, such as the muscles, the cellular tissue, the spleen, etc., are more rapidly disintegrated than those which contain less fluid. Bones and teeth withstand the action of the current for a considerable time.

The effect at the negative pole. Experiments on animals showed that needles attached to the negative pole of a battery could be inserted into and removed from the body without causing any loss of blood ; the current used did not appear to cause much pain beyond what was due to the introduction of the needles through the skin , the parts operated upon shrank sensibly after the operation, but there was neither inflammation, suppuration, nor sloughing. If the current was made to act upon the bloodvessels it was found that they were filled with a foreign body, due to disintegration of the blood, and round which afterward a slow deposition of lamellated fibrine took place ; they were thus changed into solid strings wherever the current had been made to act. It appears fair to conclude from these observations that the current can be safely and successfully applied to those parts of the body where shrinking and disintegration of tissue and obliteration of the bloodvessels may be required for surgical purposes. The sores produced on the skin by the negative pole resemble those produced by caustic potash, and the same may be said of the scars, for these latter are soft, and after some time wholly disappear.

A twofold effect is produced. 1. Under the microscope it may be seen that the mechanical action of the hydrogen forms no inconsiderable part of the effect produced at the negative pole.

Innumerable bubbles arise as soon as the circuit is closed, which force apart the structural elements of the tissues. 2. Alkalies, soda, potash and lime are also developed at the negative pole of the battery.

The effect produced at the positive pole. There is no collection of oxygen at the positive pole, because it unites with the metal of which the needle is composed. To the chlorine and acids which are developed at the positive pole, together with the metallic salts resulting from oxidizing of the needle, is due whatever changes are effected there.

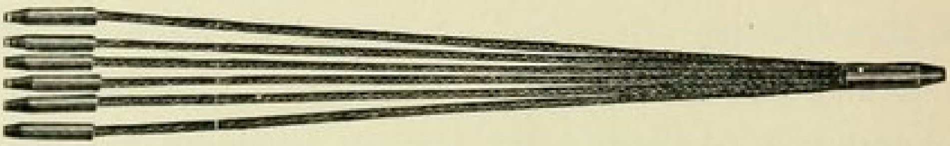

FIG. 42.

NEEDLE CONDUCTOR.

The needle conductor is composed of from one to six slender conducting cords, about four inches in length, attached at one end to a single metal holder for the conducting cord which connects it with the battery. Each one terminates at the free end in a metal needle holder.

To use the conductor. Introduce the needles one by one into the tissues to be operated upon, then fasten the needle holders upon them and connect the conductor with the battery. Complete the circuit with a single large moist sponge electrode placed on the skin at some indifferent point near by.

The introduction of needles through the skin. This is usually painful, and some means of lessening the pain must be adopted. When a large amount of work is to be done rapidly, which requires a powerful current, it is advisable to use ether by inhalation, or apply it in spray to render the skin insensible to pain, before introducing the needles. Beard and Rockwell state that a mixture of ether and carbolic acid in equal parts has a positively benumbing effect upon the skin where applied. The mixture can be localized upon a very small spot; the benumbing effect begins to be felt in less than five minutes. It is frequently quite difficult to introduce the needles, when the tissues to be acted upon are firm, or where the skin is thick, in which case it is best to introduce them only a little way before completing the circuit. As soon as electrolysis begins they can be pushed in more easily, provided they are connected with the negative pole of the battery.

Effect of electrolysis upon the needles. When decomposition of blood or animal tissues is effected by electrolysis, the *positive needle* (anode) is changed into a metallic salt, by the oxygen and chlorine set free. On the other hand, the *negative needle* (cathode) retains its brightness, because hydrogen and free alkali do not attack metal. It is desirable, when but one needle is introduced, that it be the negative, except when the secondary effects, resulting from the presence of acids and metallic salts, are required, because the positive becomes roughened and firmly imbedded, so that its removal is frequently attended with considerable difficulty. When both a positive and negative needle are inserted, the positive should be first introduced where it is to remain during the operation, and whenever it is necessary to change the relative position of the needles the negative should be moved.

Prof. Groh,* of Olmütz, employs zinc needles for the positive pole, when the parts to be destroyed are highly vascular, so as to secure the secondary effect of the chloride of zinc, resulting from the action of chlorine upon the needle. The eschar under these circumstances resembles that produced by chloride of zinc paste, being greyish white, firm and dry.

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* Die Electrolyse in der Chirurgie.

He employs electrolysis in two ways, either a powerful current for a short time under an anæsthetic, or a gentle current applied for days and nights consecutively.

THE McINTOSH NEEDLE-CASE FOR ELECTROLYSIS.

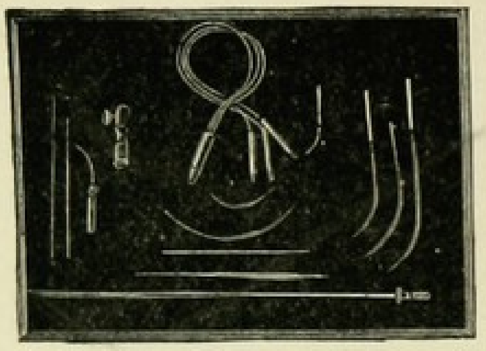

FIG. 43.

A convenient case for electrolysis needles is shown in Fig. 43. It contains needles of various shapes and sizes, from the exceedingly fine platinum or steel needle, for removing hairs, to the long and large needle suitable for operating upon uterine fibroids. A three-strand needle conductor is shown in the back part of the case; also a connector by means of which a single needle may be attached to any electrode that terminates in a screw. Many styles of needle-cases are made, so that the physician who wishes to be prepared for electrolytic operations will have no trouble in securing one which contains an assortment adapted to the demands of his practice.

BATTERIES FOR ELECTROLYSIS.

Galvanic batteries in which the elements are arranged in series (the zinc of one pair connected with the carbon of the next) are suitable for electrolysis. The zinc and carbon combination give a much more powerful electrolytic current than any other, for reasons already given. It is essential, when large masses are to be operated upon, that the battery have a sufficient number of cells to enable the operator to add more cells from time to time, to keep the current at an approximately uniform strength. For short operations, four to six zinc-carbon cells will be sufficient. A considerably greater number of zinc-copper or zinc-platinum cells will be required to accomplish the same work.

The pain produced within the tissues by the electrolytic current is not severe, but at the alternate electrode applied to the skin, the burning or stinging sensation may be very unpleasant. When an anæsthetic is not employed, the current at first should not be very strong; it may be gradually increased without inconvenience.

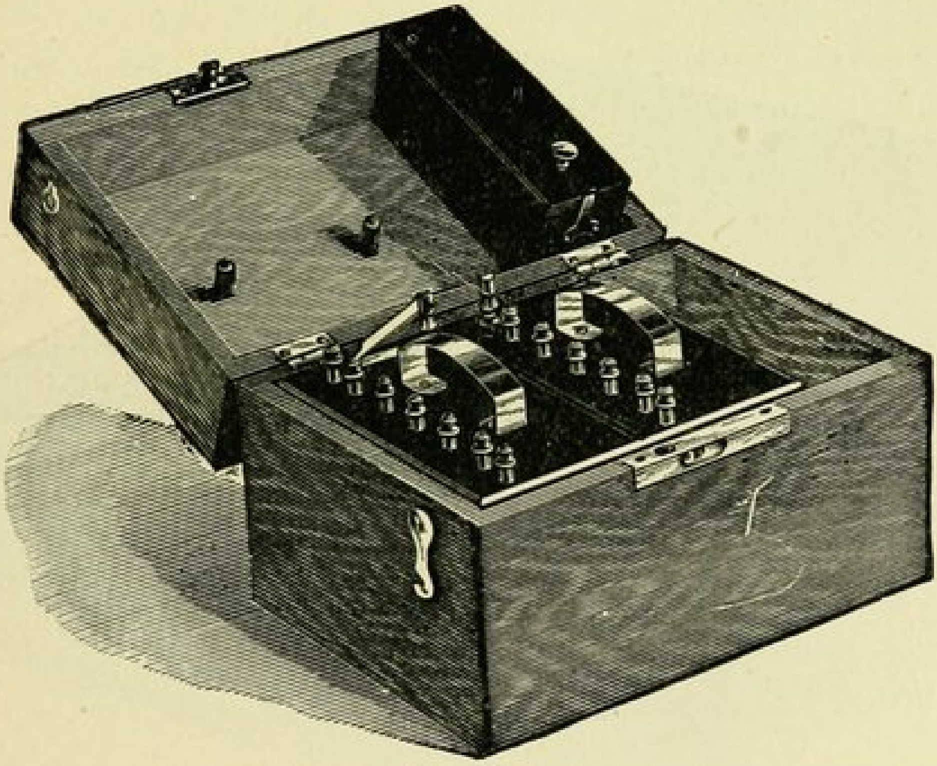

FIG. 44.

McINTOSH TWELVE-CELL GALVANIC BATTERY.

Length, 10¾ in.; width, 8¼ in.; height, 7¼ in.; weight, 12 lbs.

The battery represented in Fig. 44 is adapted to all the smaller electrolytic operations, for which a few cells only are needed. An apparatus supplied with a less number of cells is not to be recommended, because it is important that in any operation there should be a few reserve cells to add, as needed, to the circuit.

The battery shown in Fig. 45 is preferable for the general practitioner who wishes to apply electrolysis to a large variety of cases. It furnishes a current sufficiently powerful for any operation to which electrolysis is adapted, except certain malignant growths, for which the twenty-four-cell galvanic instrument (see Fig. 31) will be required.

DISEASES IN WHICH ELECTROLYSIS IS OF VALUE.

The diseases in which electrolysis has been successfully employed are chiefly tumors. serous effusions, strictures, wounds

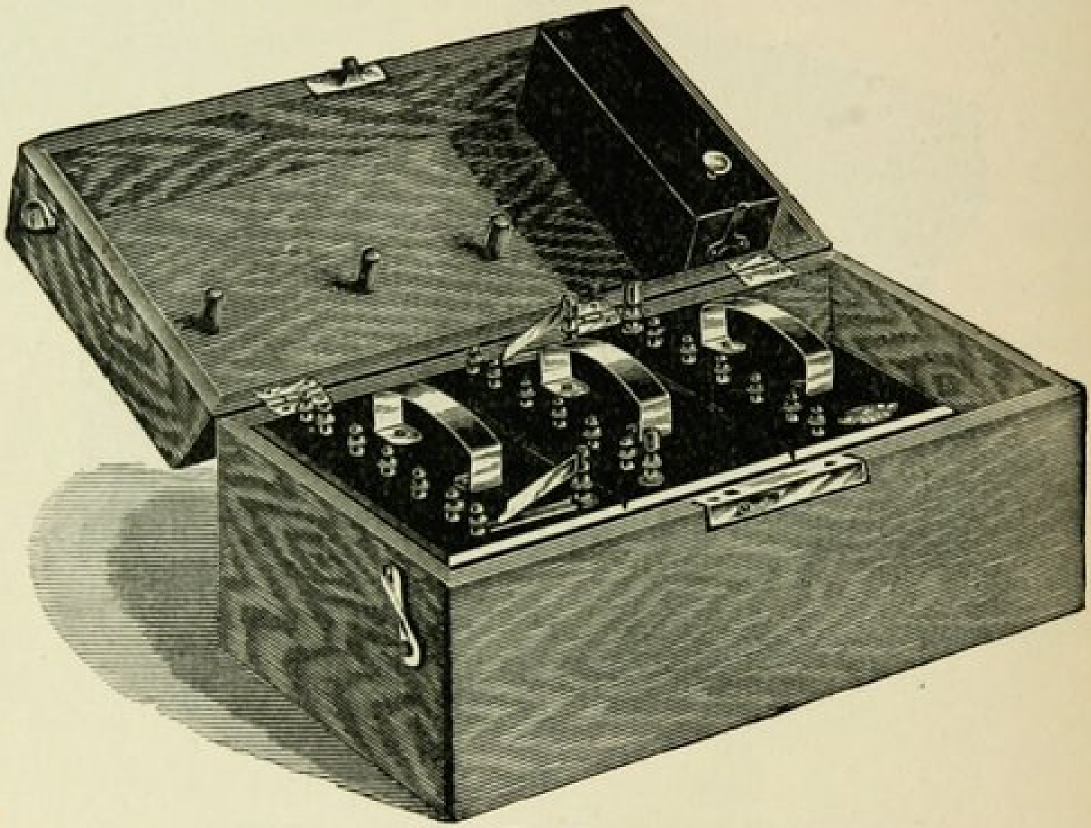

FIG. 45.

McINTOSH EIGHTEEN-CELL GALVANIC BATTERY.

Length, 14½ in.; width, 8¼ in.; height, 7¼ in.; weight, 15½ lbs.

and ulcers. It is also useful in the permanent removal of hairs.

Disadvantages of electrolysis. It is not always easy to introduce the needles so as to destroy as much as possible in the shortest time; and where extensive growths are to be destroyed, the applications must be frequently repeated or continued for a considerable time. The accumulation of hydrogen at the negative pole causes a swelling of the tissues, and, if the operation is carried too far, the separation of structural fibre by the hydrogen may cause too great destruction, so that the tissues do not recover themselves after the operation, and disfiguring scars result.

Advantages of electrolysis. According to Prof. Groh, they are as follows:

Very extensive tumors may be destroyed without the loss of a drop of blood, which is important in cases where there is prostration of strength. In three of his patients, the use of electrolysis enabled him to do without resection of the lower jaw, which otherwise would have been necessary, and would have caused great disfigurement. In a case of cancer of the rectum, where subcutaneous injections of morphine produced only slight and temporary relief of the intense pain, and where there was a most offensive smell from the ulceration, both fetor and pain disappeared after the first electrolytic operation. In a case of epithelioma of the lip, where the right submaxillary gland was considerably swollen, this swelling was dispersed a few days after one electrolysis. Finally, all cases progressed favorably without accident. The pain never continued beyond the application itself; there was only slight local and general reaction; the eschars which had been formed were rapidly thrown off; there was copious granulation, and such an amount of cicatricial contraction as to cover the loss of substance caused by the removal of the growth.

THE EXACT VALUE OF THE ELECTROLYTIC METHOD.

Dr. A. D. Rockwell* offers the following summary of the exact value of the electrolytic method in surgical diseases, according to his own experience:

1. The success to be met with in the treatment of malignant growths in general is but trifling. The size is sometimes reduced, and the pain is almost always greatly alleviated. In the class of cases, however, termed epithelioma, when the disease does not extensively involve the subjacent tissues, and where it is easily reached, it is probable that in the majority of cases the very best results will follow thorough and persistent treatment.

2. Fibroids, being dense and comparatively dry, do not readily shrink under electrolysis, and it is seldom that we can accomplish more than

*New England Medical Monthly, December, 1883.

some slight diminution in bulk. The results following this limited influence, however, are especially valuable in the case of uterine fibroids of an intramural character where the knife cannot be used. The pressure upon the bladder and rectum is in these cases greatly lessened, or entirely dissipated, and the relief that follows is immense.

3. It is in erectile and small cystic tumors that electrolysis is most effective. In these conditions it is indeed a specific. The cure that follows is complete, and with proper care scars can be avoided.

4. The ordinary form of goitre acts somewhat capriciously under electrolytic treatment. Goitres that are small and soft may not only be treated effectually by the introduction of needles, but external applications alone will sometimes cause them to entirely disappear. Even when they are quite large, if their density is not too great, a perfect cure may follow. Where they do not entirely disappear, they may almost invariably be reduced in size, affording in many cases marked relief from the pressure that is so distressing.

5. By this method hairs may be permanently removed. The negative pole and a weak current are to be used.

6. In many cases of urethral stricture permanent relief is afforded. A more extended experience, however, is necessary to establish its exact value.

CHAPTER V.

GALVANO-CAUTERY.

Galvano-cautery, also written galvano-causty, electric cautery, etc., consists in substituting a platinum wire or plate heated by electricity, for the ordinary actual cautery. This process is frequently confounded with electrolysis, from which it differs in important particulars. *It requires special apparatus that is not adapted to any other application of electricity.*

Electrolysis is the decomposition of compound substances by the *chemical action* of the galvanic current. During this process the needles or wires which convey the current to the tissues are not heated.

Galvano-cautery is the burning of tissues by the *heat developed in a suitable instrument* by the passage of a galvanic current through it. The effect produced is in no respect due to the action of the current on the tissues, and does not differ from that produced by a cautery instrument heated in the usual manner.

When the poles of a galvanic battery are connected by a conductor incapable of transmitting the current as fast as generated, the conductor becomes heated, the degree of heat being proportional to the quantity of electricity and the resistance of the conductor. Platinum is a poor conductor, both of heat and electricity, and when introduced into a metallic circuit between the two poles of a suitable battery may be raised to a white heat.

Advantages of galvano-cautery. 1. The great advantage of galvano-cautery is that we can manage the currents with precision and deliberation; very different from the haste required in using a red-hot iron. If the bottom of a cavity is to be cauterized, the instrument, while cold, is introduced slowly and gently; then, when located exactly where it is needed, the circuit is completed and cauterization begins. Breaking the circuit instantly arrests it.

2. This method of cauterizing occludes the vessels by clots, and thus not only guards against primary hemorrhage, but it also appears to lessen the liability to secondary hemorrhage.

3. It is infinitely less alarming to patients than the apparatus employed in ordinary cauterization, and protects them from any injury in the introduction or withdrawal of the cautery instrument.

4. It can be used in places where the employment of the knife would be inconvenient, if not impossible; as in the neighborhood of delicate organs or in the depth of some natural cavities.

5. The operation is comparatively painless; there is no shock to speak of, and the danger is reduced to a minimum. When the radiant heat is allowed to act, or the instrument is moved slowly, the pain may be quite severe; but during the operation the extremities of the nerves are destroyed, therefore there is no pain after it is completed.

6. It frequently preserves parts that would have to be removed in operating by the knife.

7. It is especially valuable in those cases where cauterization of the wound is indicated after the operation. The eschar is very firm and renders the wound less liable than a moist granulating surface to miasmatic, putrid or purulent infection.

CASES TO WHICH GALVANO-CAUTERY IS APPLICABLE.

1. Hemorrhages, which can be arrested in localities where a red-hot iron cannot penetrate and where vessels cannot be conveniently ligated.

2. Neuralgia, in which it is desirable either to destroy a nerve (as a dental nerve) or to cauterize certain parts of the surface of the body (as in sciatica).

3. Certain paralyses.

4. Gangrene of ulcerations.

5. Cancers and other malignant growths.

6. Fistulæ, sinuses, etc.

7. Removal of vascular tumors, such as nævi, external hemorrhoids, etc.

8. Removal of polypi and other tumors from situations where ordinary instruments cannot penetrate.

9. Small amputations, as of the tongue, cervix uteri, penis, etc.

10. Strictures, especially when very firm, and undilatable.

Disadvantages of galvano-cautery. There is considerable difference of opinion in regard to the range of cases in which galvano-cautery is to be preferred. Some restrict it to a limited field, while others are disposed to extend it, on account of its simplicity and convenience, to a large variety of operations. Certain disadvantages have prevented a more extensive employment of it by the surgeon, which are partially due to defects in the batteries designed for the purpose of furnishing a cautery current.

1. The galvano-cautery frequently cauterizes tissues very superficially, and consequently sometimes gives rise to hemorrhages.

2. The small mass of platinum that can be heated by the galvanic current, except by employing batteries out of proportion to the work to be accomplished, renders it unsuited to cases where voluminous tissues are to be destroyed. It is not impossible, however, to perform all amputations by it. Dr. Burns, of England, records twelve amputations, eight of the thigh, two of the leg, one of the fore-arm, and one of

the finger, performed by galvano-cautery. Bourdon, of Paris, has used it in eight cases of tracheotomy. With properly constructed batteries, the current keeps the cautery heated sufficiently, so as to compensate by the continuity of its action for what is wanting in regard to the mass that can be heated.

3. The great difficulty in the way of maintaining a uniform heat is due to contact of the tissues, bathed with liquid which prevents the wire arriving at the high temperature that it would possess in the air, not only by withdrawing heat from it, but by rendering it, in consequence of this cooling, a better conductor and less susceptible of becoming heated under the action of the current.

4. It is not impossible to raise a platinum wire to a white heat in the substance of the tissues gorged with moisture, but we are between two rocks, either not to heat the wire sufficiently, or to run the risk of melting it. This fusion is brought about in the small part of the wire which comes out close to the skin and which is more heated in proportion as the portion that is plunged into the tissues is more cooled by contact with the liquids.

5. Even when the wire, while still becoming greatly heated, does not melt in its entering and exit points it may only cauterize these points and not the interior, as we should expect.

GALVANO-CAUTERY BATTERIES.

The first requirement of a battery for galvano-cautery is that it furnish a current of large *quantity*, in order to develop the necessary heat. Consequently a large element surface must be exposed to the action of the fluid. The elements are united in multiple arc and are brought very near together. *The batteries constructed for galvano-cautery are unsuitable for electrolysis or any other purpose than the one for which they are designed.*

Since it is important to be able to use conductors of variable volume, the current provided must be capable of raising different sizes of platinum wire to a white heat, and of maintaining it there as long as is necessary to complete an operation of ordinary length. A galvano-cautery battery must therefore be provided with more than one cell, and a convenient current-selector for introducing additional power into the circuit as the current declines in strength, to maintain an even temperature in the platinum wire. When it is necessary to avoid the flow of blood, the wire must not be heated above a dull red, and the battery should be easily controlled in this respect. In brief, the essential requirements of a galvano-cautery instrument are portability, constancy, reliability, and simplicity of construction.

The storage battery, when it was first announced, was expected by continental authors to fulfill all requirements of a cautery battery; but for some reason it has failed to meet their expectations, in its present state of development. Numerous instruments have been contrived for this purpose, but the difficulties to be overcome in constructing one that shall provide a current just powerful enough to do the work required, without occasionally becoming uncontrollable, and either suddenly fail in the midst of an operation, or fuse the platinum, have seemed almost unsurmountable. Dr. McIntosh has been experimenting for several years with a view to constructing an instrument that shall be satisfactory in every respect, and has been rewarded with a degree of success that promises well. He has now completed a Cautery Battery that is being tested by several well-known surgeons to determine how it meets the demands of practice; and if future tests shall confirm those already made, it will prove to be the most desirable instrument yet constructed, and will add a new impetus to the practice of galvano-surgery.

The instruments necessary for galvano-cautery. That portion of the circuit which is brought into contact with the tissues is made of platinum, and is usually in the form of a *loop*, *point*, *knife* or *dome*. The handle is made to thoroughly insulate the current, and at the same time to resist the heat. The connection of the platinum with the conducting cords is made with pure copper wire, of large size, which passes through the handle. The conducting cords are composed of a large bundle of fine copper wire, or a single copper wire of sufficient size to convey a large *quantity* of electricity.

The *platinum loop* is managed like the écraseur, to which it is superior in that it sears as well as divides the tissues. It is used for pediculated tumors principally ; it may be used for tumors without a pedicle, by introducing needles through the base, and adjusting the loop between the needles and the surface to which the tumor is attached.

Platinum points may be introduced into vascular tumors and afterward rendered incandescent. The tissue should be thoroughly cauterized before withdrawing the points, to avoid the possibility of hemorrhage. They may also be used to destroy dental nerves, granulations, to open abscesses and fistulæ, to cauterize the prolapsed recti of children (using a director if necessary).

The *platinum knife* is simply a very small thin plate ; the best method of using it consists in successively repeating the contact of the incandescent metal with the parts operated upon. It is an error to suppose that this instrument will cut directly through a mass of tissue, like a surgical knife. It is extremely difficult to regulate the heat in a piece of platinum of this shape, so that it shall be just hot enough to do the work required, and at the same time not do injury to surrounding tissue by radiating heat, or even setting it on fire.

The *platinum dome* consists of wire wound spirally in the form of a dome, as its name would imply. It is used as a *cauterizer*, where a larger surface is to be acted upon than the points are adapted to, and as a *moxa* for counter-irritation.

HISTORY OF GALVANO-CAUTERY.

Dr. Fabrè-Palaprat was the first to employ a platinum wire heated by a galvanic battery to produce moxas. A long time after, in 1845, M. Heider employed the same method to cauterize the dental nerves when painfully affected. In 1846, M. Crusell, of St. Petersburg, conceived the idea of cutting and cauterizing the tissues by means of a wire, or a thin plate of platinum, rendered incandescent by a powerful electric current, making it act after the fashion of a saw, by means of a backward and forward motion.

Mr. Marshall, of England, soon after made numerous experiments in cauterizing the tissues of animals, corpses, and then of patients. He succeeded in curing a fistula of the cheek by means of a platinum wire $\frac{1}{50}$ of an inch in diameter; he afterward used it for small tumors, cauterizing wounds, etc. M. Nélaton, from the year 1850, used it in the cure of erectile subcutaneous tumors, while preserving the skin. Dr. Amusat, Jr., by means of a platinum wire $\frac{1}{50}$ of an inch in diameter and 5 or 6 inches in length, removed cancerous tumors; he also used thin plates, or ribbons of platinum, heated in the same way, and to which he imparted a backward and forward sawing motion to separate the tissues. Prof. Middeldorpff, of Breslau, published the first important work on this subject in 1855.

Dr. Maas* has collected 130 cases of *nævus*, treated by galvano-cautery, most of which were operated upon by Dr. Middeldorpff, in which the loop was used 39 times, the dome

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*Langenbeck's Archiv. für Chirurgie, 1871, p. 520.

17, and other forms in the remainder. In 112 cases there was a complete cure, 11 improved, three died, and in 4 the result was not known; 4 cases relapsed; death resulted once from hemorrhage, twice from lockjaw (once trismus and once tetanus). Duration of treatment was short; in many cases the eschar separated between the fifth and tenth day, and a good cicatrix was formed without perceptible suppuration.

M. Zielewicz* has collected fifty cases of *amputation of the penis* by the galvano-cautery loop. The operations were performed for cancer, gangrene, and once for an enormous papilloma; 8 of the patients died of blood poisoning in hospital; none died in private practice. No hemorrhage ever occurred, in spite of numerous introductions of the catheter or bougies; no surgical fever followed the operation. Contraction of urethra took place only in one case, which easily yielded to the use of bougies.

Dr. Voltolini, of Breslau, † was the first to use the galvano-cautery loop for the removal of a *tumor from within the larynx.* This operation has since been successfully repeated by others. Tracheotomy has been performed with the galvano-cautery knife. Mr. Erichsen‡ has employed it in a considerable number of cases of *cancer of the tongue* with success. He considers the galvano-cautery loop one of the most valuable of modern applications of physical science to medicine. He emphasizes this point—*avoid undue haste, and screw up the instrument slowly in proportion to the vascularity of the part operated on.*

Mr. Bryant, of Guy's Hospital, successfully removed an *epithelial cancer* of the perineum, and also a *spreading lupus of the face*, by galvano-cautery. The former was accomplished after this manner without the loss of a drop of blood: It occupied the perineum, involving the anus and a portion of the

* Langenbeck's Archiv. für Chirurgie, 1871, p. 589.

† Ibid, 1865, p. 693.

‡ *British Medical Journal*, February 15. 1873.

recto-vaginal septum. He isolated the base by passing three large pins beneath it into the healthy tissues, the patient being under the influence of chloroform. A strong platinum wire was next passed around the base of the tumor beneath the pins, and fixed to the écraseur, was screwed home ; junction was then made with a cautery battery, and with a few careful turns of the screw the growth was removed, leaving an ash-colored surface. Rapid recovery followed.

Galvano-cautery has been used by oculists for cauterizing granular lids, and in diseases of the lachrymal ducts. Aurists have employed it for removal of polypi and other tumors from the auditory canal. It is so well adapted to nearly all the minor operations in surgery, and the advantages in its favor are so many, that only the want of reliable and convenient battery has hitherto prevented it from coming into universal use.

CHAPTER VI.

FARADISM.

When a current of electricity from one or more galvanic cells is passed through a coil of wire, the galvanic properties are modified and practically a new current is obtained, which is known under the various names of *induced*, *interrupted* or *faradic* current.

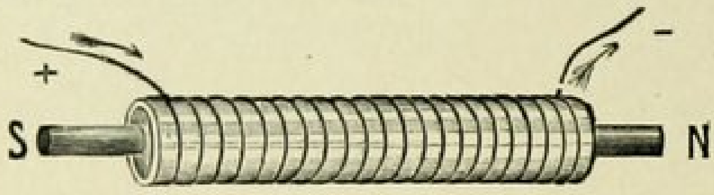


Fig. 46.

Among those who sought to explain the principle discovered by Oersted (see p. 118 galvanometer) was Arago, who found that the electric current imparted a strong magnetic force to pieces of soft iron, steel, etc. He showed that if copper wire covered with silk or gutta-percha be coiled around a bar of soft iron, and a current be passed through the wire, the soft iron, although it does not form a part of the circuit, becomes powerfully excited. Each winding of wire increases the magnetism of the iron, and by employing a large number of windings a magnet of enormous power may be produced.

This magnetism is not permanent; it ceases at once when the circuit is broken. In an instant the electric current may magnetize a bar by its passage and demagnetize it by its cessation. The same result follows if the coiled wire is separated from the bar by an insulating cylinder, as shown in Fig. 46. A bar magnetized in this way is called an *electro-magnet*. Electro-magnets possess much greater lifting power than natural magnets of the same weight. Prof. Henry describes one that could lift thirty-five times its own weight, while the most powerful natural magnet known at the present day sustains but six times its own weight.

Nearly all the practical applications of electricity have been made by combining electricity and magnetism. No telegraph sends a message from one place to another, no telephone acts, no electric motor or electric light can be operated, without a magnet of this kind. Its great usefulness lies in the fact that its magnetization is wholly under the control of the current.

In 1831 Faraday discovered that a galvanic current passing through a wire induces a current in another wire near to and parallel with it. The wire through which the galvanic current passes is called the *primary* wire, and the current *primary* or *direct*. The parallel wire is called the *secondary* or *induced* circuit, and the current passing through it an *induction*, *secondary* or *faradic*, in honor of its discoverer.

These wires are usually arranged in coils composed of many layers of wire, the primary coil lying within the secondary, from which it is separated by insulation. A steady flow of electricity through the primary coil will produce no effect over the secondary so long as it flows without interruption ; yet if it be suddenly broken, a momentary wave or current will instantly flow through the other in the same direction as the original current. If now the current be re-established through the first coil, another momentary wave will pass through the second coil, but in an opposite direction to the one passing through the first coil. Increasing or decreasing the current affects the direction of the momentary current in the same way as starting or stopping the primary current.

INDUCED CURRENTS.

Induced currents include *primary*, *secondary*, *tertiary* and *extra* currents. They are distinguished from galvanic or direct currents by certain properties, that will be considered in the following order: 1. Direction. 2. Magnetic induction. 3. Self-induction. 4. Potential.

The direction of the primary current. The moment the circuit, including one or more galvanic cells, is completed, a current passes through it from the positive to the negative pole, as already explained, and *induces* a current in a wire near and parallel to some portion of the wire of the circuit.

The direction of the secondary current. This induced current is in an *opposite direction* to that passing through the circuit, as may be shown by a delicate galvanometer, but it is momentary only, and the needle, at first deflected, quickly resumes its natural position. As soon as the needle is at rest, break the circuit to arrest the current from the cells: the needle will be again deflected, but in a direction opposite to its first deflection, showing that, at the instant the circuit is broken, a current is induced in the parallel wire in the *same direction* as that passing through the circuit. The direction of the secondary or induced current varies continually, as follows:

(*a*) At the instant the galvanic circuit is *closed* the induced current moves from negative to positive, or opposite to the *primary* current.

(*b*) At the instant the galvanic circuit is *opened* the induced current moves from positive to negative, or in the same direction as the primary current.

(*c*) If the original current be increased in strength it has the same effect on the induced as *closing the circuit.*

(*d*) If the original current is decreased in strength it affects the secondary the same as opening the circuit.

Faraday termed that passive state of the secondary wire which exists when the primary current is uninterrupted *electro-tonic*, and the wave that passes at the instant of making or breaking the circuit the *electric throb*.

Magnetic Induction.—If the primary wire be replaced by a magnet it will be found that induced currents will be produced in parallel wires, either by motion of the magnet or by altering its strength. If the secondary or parallel wire be wound in an open coil and a magnet be passed through its axis, as in Fig. 46, when the strength of the magnet is altered by bringing to the N pole, first the S and then the N pole of another magnet, induced currents will pass through the coil precisely equal to those produced by the passage of an electric current through the primary wire; magnetic induction, like electric induction, occurs only at the instant the magnetism is disturbed.

Self-induction.—Since a circuit carrying a current acts inductively upon every neighboring circuit, it naturally follows that it must also have a similar action upon the different parts of itself; since these parts may be regarded as cases of very near neighboring circuits, this is called *self-induction.* Jenkin discovered that when the circuit from a single galvanic cell *is broken*, a sharp shock can be felt if an electro-magnet is included in the circuit (none is felt when the circuit is closed). Faraday, having been informed of this, soon traced it to its cause, "the induction of the current on itself." Self-induction reveals the fact that when a circuit is closed, the current does not all at once reach its full strength, but takes some very short time to do so, and that during that time the current is retarded by the *opposite current*, due to self-induction. In the same way, when the circuit is broken, the current strength does not fall to zero all at once, its gradual fall being prolonged by the current due to self-induction, which in this case is in the *same direction* as the main current. *Extra currents* are those due to self-induction.

We have thus far supposed the two wires to be parallel; if now we arrange them at right angles, the extra currents disappear almost entirely, showing that for two wires to act inductively on each other, it is necessary for them to be near together and not at right angles.

Tertiary currents.—As the current induced in a wire by the direct battery circuit is called *secondary*, so the name *tertiary* is given to the current induced by the secondary in a third wire or coil; this third may induce a current in a fourth, and so on for a series. In each additional wire or coil the current moves in a direction opposite to the preceding; for example, the *secondary* moves opposite to the *primary* at the instant of closing the circuit, and in the same direction at the instant of breaking the circuit. The *tertiary* moves opposite the *secondary* at the instant of closing, and in the same direction at breaking the circuit, each current becoming weaker as its distance from the *primary* is increased.

The *potential* of the galvanic current from a single cell is enormously increased by induction, and the potential of induction currents is still further increased by introducing into the cavity of the coil a center-piece of soft iron which is called the *core*.

RHEOTOME OR CURRENT INTERRUPTER.

It is necessary that the *primary* current be constantly interrupted in order to secure a *secondary* current; therefore some mechanical device must be employed which shall automatically keep up a regular succession of interruptions.

Mode of Action. When the elements are immersed in fluid and the external circuit is closed, the current from the conducting plate passes directly to and through the primary coil of wire, which renders M a magnet. M then attracts

H and draws the spring away from X′, against which it naturally rests. This breaks the current, for the circuit is complete only when X′ touches X.

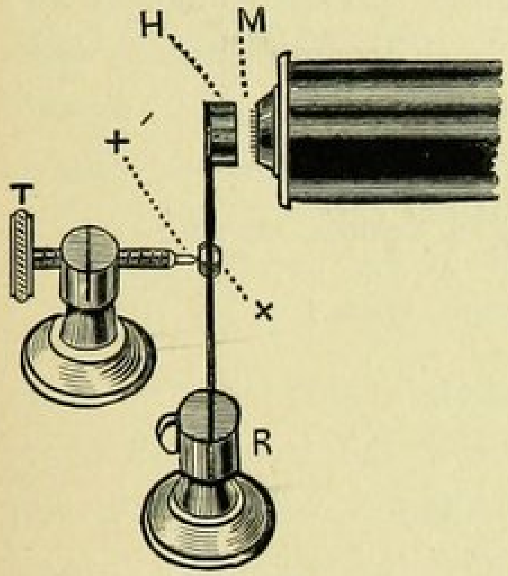


FIG. 47.

Fig. 47 represents a current interrupter or rheotome, also called a "make and break," a "vibrator," etc.

M, the end of the core within the coil, composed of a bundle of soft iron wires.

H, the hammer on a moderately stiff spring, fastened to post R, which has direct connection with the primary circuit, as may be seen in Fig. 48.

X, a platinum point on the spring. Platinum is used because it does not easily corrode.

X′, the platinum tip of screw, which merely touches X.

T, the thumbscrew, which may be turned to regulate the contact of X′ with X.

When the current is broken, M loses its magnetism and no longer attracts H, therefore the spring is free to rest against X′. The instant the spring flies back to permit X to touch X′ the circuit is complete again. M becomes a magnet, attracts H and the current is interrupted; thus H is kept rapidly vibrating back and forth between M and X′ and gives rise to a buzzing sound. These constant interruptions keep up an induced current in the secondary coil, through which, as we have already seen, the current passes in one direction at the instant the circuit is complete, and in the opposite direction when the circuit is opened, hence the induced current must move equally "to and fro," instead of principally from positive to negative points, like the primary current. If the vibrating spring is too weak, the current will be broken at a time when the core has but small magnetic strength, and a feeble induction current is produced. If the spring is sufficiently stiff it may be so arranged, by increasing or decreasing the pressure of the screw T, that the current is not broken till the core has received nearly its full amount of magnetism, and consequently a much stronger induction current is generated. When a current, with an electro-motive force too great for the capacity of the coil, is sent through it, the platinum points, X′ X, may be fused by the heat of the sparks produced, and the coil itself be damaged, since wires become heated when a current of greater quantity than they are capable of readily conducting is carried over them. For this reason but one or two cells are employed for producing a faradic current.

THE HELIX OR FARADIC COIL.

Fig. 48 represents the arrangement of the coils of wire forming a helix. It will be noticed that the inner coil alone is connected with the elements. The outer coil is connected only with the binding posts, from which the secondary current is obtained. The vibrator attached to R magnetizes and demagnetizes the core with great rapidity.

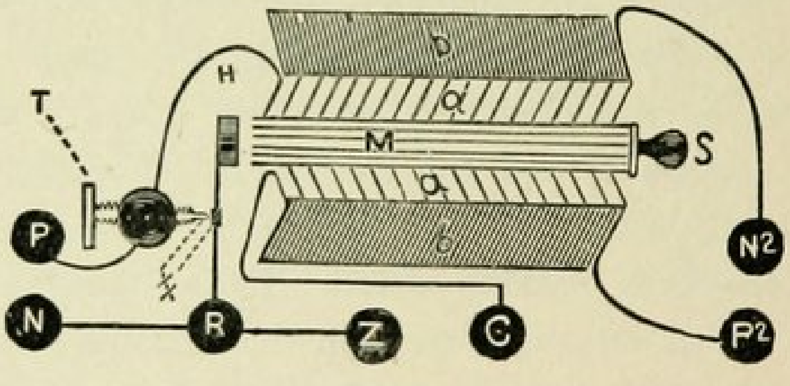


FIG. 48.

a a, several layers of coarse insulated copper wire wound around an insulating spool. This is the *primary coil*.

b b, many layers very fine insuated copper wire wound over a a, from which it is separated by an insulating material. This forms the *secondary coil*.

M, the core or magnet, composed of soft iron wires inclosed within the insulating spool.

S, the shield covering the core, which can be drawn out when necessary.

C, the conducting plate of the battery, connected with one end of the coarse wire forming the inner coil.

Z, the generating plate connected with the post R.

R, the post of the current interrupter or rheotome.

H, hammer at end of rheotome spring. The wire above H is the outer end of the coarse wire coil connecting R with the post holding screw T, and also with P, the positive pole of the *primary* current.

N, the negative pole of the primary current, is connected with R.

X X, platinum points on tip of screw and on spring.

P 2, positive pole of *secondary* current.

N 2, negative pole of *secondary* current.

The primary or inner coil is composed of comparatively coarse wire, in order that it may offer little resistance to the passage of the current from the cell, and at the same time exert a powerful magnetic effect upon the core and layers of the outer coil.

The secondary or outer coil is composed of a great length of fine wire (the length and size of which must be proportioned to that of the primary), because the potential of the induced current is proportional to the length and fineness of the wire over which it passes. This coil is completely insulated from the primary coil, and receives its electricity purely by induction. *The quality of the faradic currents* depends not only upon the *length* of wire composing the two coils, but also upon the *relative size*, *perfect insulation*, the *care with which the windings are made*, and *the connections.* The value of a faradic battery depends very much upon the skill of the mechanic who makes the helix and connects it with the base. *The strength of the faradic current* depends almost entirely upon the construction of the helix; *the strength of the galvanic current*, upon the kind and number of cells in the circuit. There is seldom any advantage to be gained by using more than one or two cells for the faradic current, since, as before explained, a current possessing greater quantity than a wire can easily conduct, heats it in passing, and, in consequence, is liable to damage the insulating covering of the wire; or the current may overcome the resistance of the insulation, and pass across from one layer of wire to another, completing the circuit within the helix itself, in which case it will cease to pass through the external circuit.

The primary current. The current passing through the primary coil is called the primary current. It is direct from the cell, and passes in the same direction as the galvanic current, from positive to negative; it deflects the galvanometer needle, and possesses feeble electrolytic power.

The secondary current is that which is obtained from the secondary coil. Its direction at the instant of closing the circuit is opposite to the primary current, at the instant of opening the circuit in the same direction; therefore it is appropriately called a "to and fro" current.

The core or magnet. The primary current has its inductive power greatly increased by putting a bar of soft iron or a bundle of iron wires through the center. At the instant the primary current starts, it renders the central bar a magnet, but the magnetic power is lost instantly on arresting the current. At the instant of acquiring and losing its magnetism, it induces a current in the primary coil in the *same direction as the primary current*, and therefore strenghtens it. A bundle of wires is superior to a solid bar of iron for the central core, because the former acquires and loses its magnetism more readily than the latter.

The shield. Prof. Dove, of Berlin, has shown that the potential of an induced current is much diminished by covering the core with a closed tube of non-magnetic material, such as brass or copper. Induced currents are developed in the shield, whereby the magnetism of the soft iron core is counterbalanced; as the shield is withdrawn to permit the inductive influence of the core to act upon the primary coil, the strength of the current is increased.

NUMBER OF CURRENTS A BATTERY SHOULD FURNISH.

Since attention is frequently called to batteries which are said to furnish ten or more distinct currents, it may be well to explain how these numerous currents are obtained. The secondary coil being composed of many layers of wire is tapped at intervals throughout its length, and each branch wire is connected with a binding post. The post, to which the inner extremity of the secondary coil is attached, is always used as one pole, while each of the other posts in turn may serve as the alternate pole. By this method it is possible to obtain as many currents as there are layers of wire in the coil; these only differ in having passed through different lengths of wire; they are all "to and fro" currents, and do not differ therapeutically from the various modifications of the secondary current from the entire coil produced by withdrawing the shield from or replacing it over the core.

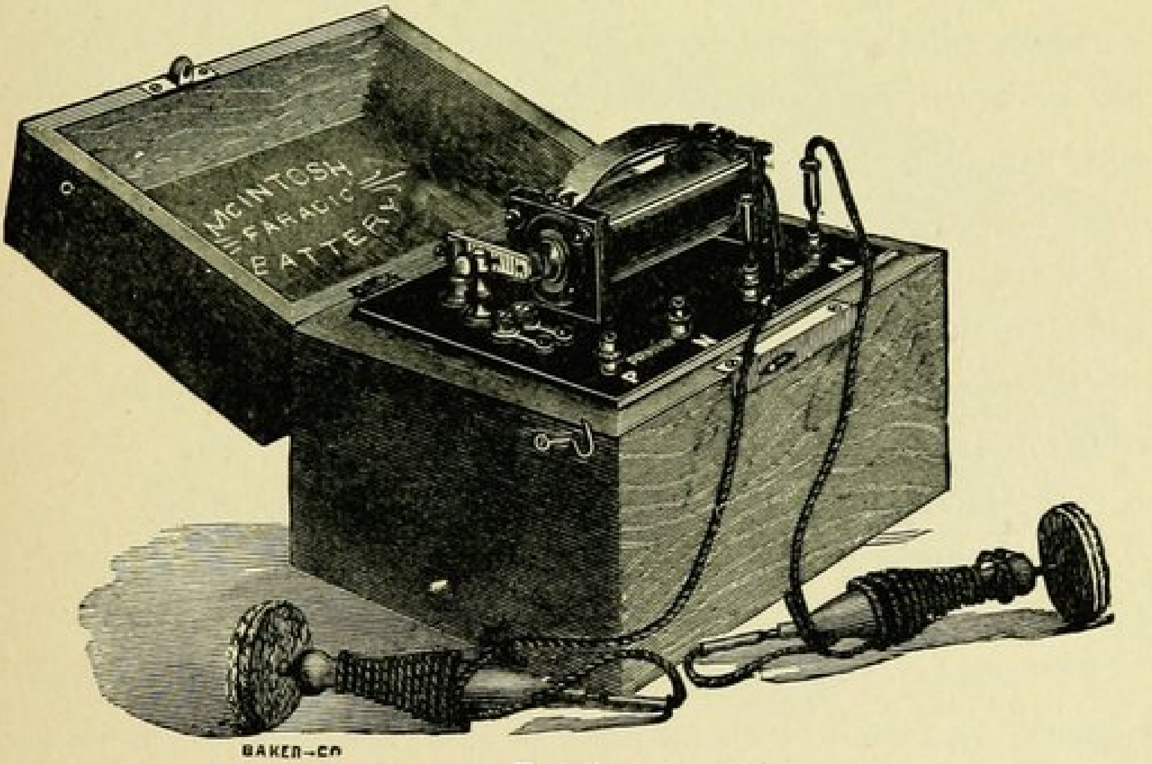


FIG. 49.

McINTOSH PHYSICIANS' FARADIC BATTERY No. 1.
Length, 8 in.; width, 6½ in.; height, 7 in; weight, 7 lbs.

A simple and convenient form of a physicians' faradic battery is shown in Fig. 49.

The base, upon which is fastened the helix, rheotome and binding posts, is made of polished black rubber. It is covered on its lower surface with a sheet of soft rubber, which insulates and protects the connections lying beneath the hard-rubber base.

The connections consist of copper wires that join the primary coil with the elements, and both primary and secondary coils with the binding posts.

The binding posts, *rheotome*, and metal parts on the base, are heavily nickel-plated, which enables them with reasonable care to resist corrosion or tarnishing for years.

The helix is skillfully constructed of a great length of well insulated pure copper wire; the two coils are perfectly insulated from each other; their relative size and length is such that the currents furnished are exceedingly smooth and yet possess great potential; they can be graded perfectly, so that currents suitable for the most delicate applications to the eye, ear or brain, or too powerful to be endured by a healthy person, are alike at the command of the operator.

The primary current is obtained by inserting the conducting cords in binding posts P (positive) and N (negative), at each end of the word "primary."

The secondary current. The electrodes in Fig. 49 are shown connected with the binding posts from which the secondary current is obtained.

Both currents are increased by withdrawing the shield from the helix.

The elements are a single pair of zinc-carbon plates fastened beneath the base to the screws seen in the illustration beneath the rheotome hammer.

The cell. This is a hard-rubber section comprising a cell and drip-cup, which is illustrated and described on page 198.

The battery fluid is made after the formula given under the Grenet cell. The battery in Fig. 49 is ready for use, the elements being immersed in the fluid of the cell. When the battery is not in use, the base should be reversed, which places the elements in the empty drip-cup.

The spring on the top of the helix serves as a handle, by which to lift the base, when the battery is open; when it is closed, the top of the cover presses on this spring and holds the base firmly over the cell; the soft rubber lining the base acts as a hydrostat and prevents any spilling of fluid when the battery is carried about.

A space each side of the cell section affords room for the conducting cords and a pair of electrodes like those in the illustration.

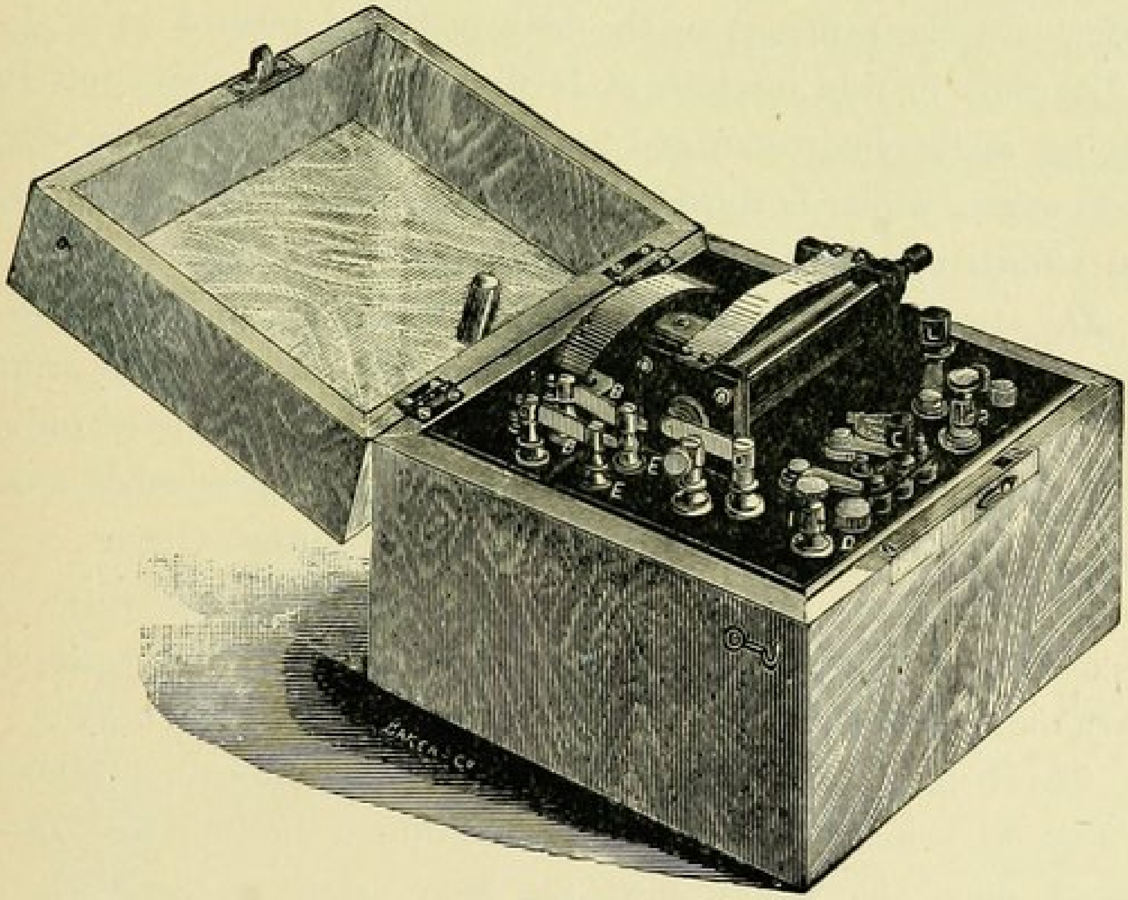


FIG. 50.

McINTOSH PHYSICIANS' FARADIC BATTERY No. 3.
Length, 8 in.; width, 8 in.; height, 7¼ in.; weight, 7½ lbs.

B B, bars connecting the elements with posts on large base.
E E, posts having direct connection with the primary coil.
1, 2, binding posts.
D, indicator which points out the polarity of the current.
C, pole changer.
L, switch which connects the primary and secondary coils with the binding posts.

The lock and hooks which fasten the cover upon the battery are heavily nickel-plated, of special design and extra strength. They are manufactured by the McIntosh Galvanic & Faradic Battery Company expressly for this purpose, and are much superior to similar fastenings usually found on batteries. The instrument illustrated in Fig. 49 is a type of the simplest form of medical battery It is sufficient for most general applications of faradism, but certain other accessories are convenient, and for localized faradization sometimes essential.

The helix, rheotome, elements and cell section of No. 3 battery are the same as in the battery last described.

The base in this instrument is divided, the narrow portion serving as the hydrostat, and the wide as a cover for the electrode space, which is considerably larger than in battery No. 1, and affords room for several additional instruments.

The elements are attached to the narrow base, and connected with the helix through the bars B B; they are removed from the cell to the drip-cup by reversing this narrow base only. They are insulated over the upper fourth of their surface after the same manner as the elements in the McIntosh Grenet cell, so as to perfectly protect their connections from corrosion or deposits of salts, and insure perfect connection until the zinc is worn out. (The fluid has little effect upon the carbon.)

The switch L turned upon the button next the coil, as shown in Fig. 50, sends a *secondary* current through the binding posts; turned upon the button next the front edge of the base, it sends a *primary* current through the binding posts; turned on the central button, no current passes through the binding posts. When it is desirable to locate the electrodes before sending a current through the circuit, as is sometimes the case, the battery may be made ready, and everything adjusted, while the switch is on the central button, and either current may then be sent through the patient by moving the switch forward or backward. Switch L may be used as a *current interrupter* when it is desirable to artificially regulate the rapidity of the faradic interruptions; it is moved back and forth between the central button and the one from which the current is taken, at suitable intervals.

The pole changer C is a double switch, which in the cut is represented moved toward binding post 2, so as to uncover button D, upon which is a hand pointing toward binding post 1, indicating that the latter is positive, and consequently post 2 is negative. Moving C toward post 1 uncovers a button, upon which is a hand pointing toward binding post 2 as positive, when post 1 becomes negative; by this means it is possible to change the polarity of the current in an instant without removing the electrodes from the patient.

The binding posts are of the style represented by A in Fig. 27, which give the most perfect and durable connection between conducting cords and battery. The nickel-plated metallic parts of this battery, contrasted with the polished black rubber base, make a beautiful appearance, while its light weight and perfect construction render it a most desirable instrument for those who employ faradism only.

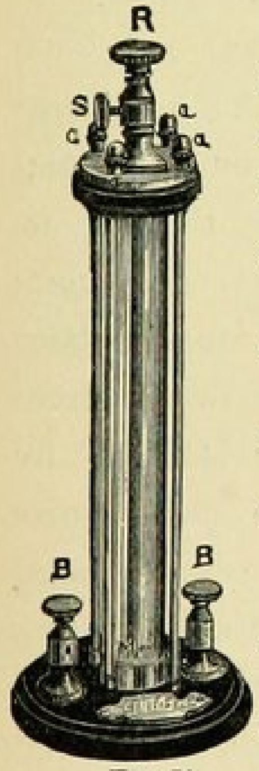


FIG. 51.
HYDRO-RHEOSTAT.
Height, 9¼ inches.

The hydro-rheostat is used to interpose resistance in the circuit, so as to delicately modify or soften the current for applications to the eye, ear, brain, or in the treatment of patients who are excessively sensitive to electricity.

Fig. 51 consists of a glass tube, 6½ inches long, for holding water, securely fastened to a hard-rubber base below, and a metal cap above.

M is a metal plate that closes the lower end to prevent the escape of water, and affords a metallic connection with one binding post.

R, a metal rod passing through the center of the glass tube; it may be raised any distance above M.

S, a setscrew to fasten R at any height required.

a a a, nuts terminating metal rods that hold the rubber base and metal cap firmly against the glass tube.

B B, binding posts, one of which is connected with the metal cap through the rods, and the other with M as before stated.

To use the hydro-rheostat. Connect one pole of the battery with a binding post B; connect the other binding post with any suitable electrode. The alternate pole of the battery is connected directly with another electrode. Locate the electrodes precisely the same as when no rheostat is used. The method of introducing it into the circuit is illustrated in Fig. 37. The rod R is raised to interpose two, three or more inches of water between its lower end and M. Raising R increases the interposed resistance; lowering R lessens it. The operator can test the effect it produces by holding the electrodes while a current is passing through the circuit and R is being moved.

METHODS OF EMPLOYING FARADIC CURRENTS.

The application of faradic currents to the treatment of disease began in 1832, within a year after their discovery, and has continued in use ever since, having been probably more extensively employed both by the profession and public than any other form of electricity. This is owing, in a measure at least, to the simplicity of the apparatus for its production, as compared with those for franklinism or galvanism.

The decline in professional favor of franklinism has been attributed by some authors to the circumstance that electrical machines used to be hauled about the streets on carts and exhibited at fairs for the purpose of "shocking the curious by scores," as a cure for all imaginable ailments. The same objection may be urged against faradism, with equal justice. The "peripatetic electrician" now uses an elaborate street battery, ornamented with the legend "Electricity is Life," by which the faradic current is administered to the public promiscuously. While it is natural that the professional man, conscious of superficial attainments, and correspondingly jealous of any assumption of his peculiar privileges, should, in self-defense, ignore or condemn everything that smacks of what he may deem charlatanry; yet it is nevertheless true that those who possess the qualification for deciding upon the comparative merits of remedial measures do not reject an agent that is of value from fear that they may be styled a specialist in the use of that agent, or be classed with charlatans in consequence of using it. There is scarcely an article of value in the materia medica that, between the patent medicine vender and the ignorant self-prescribing of the laity, has not perhaps accomplished more harm than good, and yet this is not offered as a pretext for rejecting all drug medication; neither should an agent that is capable, in skillful hands, of accomplishing such excellent results as electricity be discarded by the profession for any other reason than its failure to accomplish the purpose intended.

To Duchenne is due the honor of reducing faradism to a system. In the year 1855 he published a work* describing his method of "*localized faradization*," which he had been engaged nearly ten years in developing. He carefully studied the functions of the muscles in the living body, and succeeded in producing contractions of all the muscles separately and in groups; mapped out those which give expression to the face, and made some remarkable discoveries in regard to the condition of the muscles in certain forms of paralysis. He pointed out that there is a difference both in the physiological and therapeutical effect of the primary and secondary currents.

PRIMARY AND SECONDARY FARADIC CURRENTS COMPARED.

(*a*) The primary current is composed of a single induced current, always going in the same direction.	(*a*) The secondary current is composed of two currents going alternately in contrary directions.
(*b*) The primary exhibits galvanic properties, in that it deflects the galvanometer, and possesses feeble electrolytic power.	(*b*) The secondary does not deflect the galvanometer, although it may cause a very delicate magnetic needle to oscillate slightly.

* "De l'Electrisation Localisée, et de son Application à la Physiologie, à la Pathologie, et à l a Thérapeutique."

(*c*) The primary has more power to excite the sensory and motor nerves of the muscles.

(*c*) The secondary excites more acutely the cutaneous nerves, and penetrates more deeply into the tissues.

(*d*) The primary is relatively less rapidly interrupted.

(*d*) The secondary possesses distinct properties in virtue of its rapid interruptions, and far surpasses any other form as a stimulant to the nerves of sensation.

LOCAL FARADIZATION.

This term should not be understood to mean that the current can be confined to the electrodes and the limited place between them. Every form of electricity is propagated in waves from the electrodes in every direction through the tissues; and although it may follow the course of nerve or muscle a little way from the electrodes, the fluids of the body are so much better conductors, that electricity traverses them in preference to the solids. Duchenne claimed that the faradic current could be made to influence the skin only, without penetrating to the organs beneath, or it could be made to pass through the skin without irritating it, and act on the nerves or muscles beneath. He employed induction currents according to four methods:

1. Faradization of the skin.
2. Direct muscular faradization.
3. Indirect muscular faradization.
4. Faradization of the internal organs and special senses.

1. According to the first method, the skin and electrodes should be dry; if the former is naturally moist, starch or lycopodium powder must be dusted over it to absorb the moisture. Various names have been given to the different methods of faradizing the skin, among which are the following:

The electric nail, a small metal disc, held at one point for some time, while a faradic current passes through it, produces a sensation like a red-hot nail pressing into the flesh, hence the name.

Electric cauterization, a wire brush moved over the skin produces a sharp, burning sensation, that has been compared to that caused by cautery.

Electric fustigation, a tinsel brush struck lightly against the flesh; it is exceedingly painful, and has been compared to the sensation produced by beating with sticks.

Electric moxa, the same brush held steadily against the skin produces a burning sensation, which increases as long as the brush is held there, hence the name *moxa*. It is very painful.

2. Direct muscular faradization may be performed in either of two ways:

(*a*) The *percutaneous method*, in which the electrode is placed on the skin.

(*b*) *Electric acupuncture*, in which needles are passed directly into the muscle.

The first is the usual method. The skin and electrodes should both be well moistened with warm water, and the contact be firm and even, so as to lessen, as much as possible, the resistance of the skin. Electric acupuncture was introduced into practice by Salandiere more than fifty years ago. He employed static electricity through needles. Fabrè-Palaprat was probably the first to apply the galvanic current in this way; it is not certain who first employed the faradic current in electric acupuncture. It was revived some years ago in England by Dr. Morgan, with such remarkable success in certain cases as to prove that it is worthy a place as an accepted mode of applying electricity. The needles used were the finest manufactured, about two to four inches in length, terminating in a knob at one end. They are *not* insulated, and are inserted in the muscle to be contracted. One electrode, usually the positive, is placed at some indifferent spot, and the negative metallic electrode is touched to each needle separately, and in succession. The instantaneous upward and downward movement of the needle shows contraction of the muscle.

3. Indirect muscular faradization consists in localizing the current in the nerve plexuses or branches which supply the muscles. Duchenne discovered that at certain points on the skin, muscular contractions could be produced more readily than at others. Remak pointed out that these spots were located wherever a *motor nerve* enters a muscle.

Ziemssen * demonstrated the precise location of these points, first by marking the points on the living body where the current produced muscular contraction, and afterward by dissecting the motor branches of the nerves in dead bodies, marking their points of entrance into the muscles, these markings were found to exactly agree; therefore a knowledge of these motor points is now regarded as essential to the scientific faradization of the muscles.

4. The last method, treatment of special organs and senses, requires suitable instruments adapted to the parts, so that the current may be carried direct to their tissues, or to the origin of their nerve supply, and will be described in connection with the diseases of those parts.

GENERAL FARADIZATION.

M. Dropsy, of Cracow, published in 1857 what he termed "a new method of applying electricity," which consisted in dividing the current from one pole, by means of a bifurcated conductor, placing one electrode over the head, the other over the stomach; while the current from the alternate pole is divided in the same manner between the hands and the feet.

* Die Elektricetät in der Medecin, 1857, Berlin.

M. Gubler, in 1863, proposed a better method of general faradization, which was to place both hands and feet in four separate basins of salt water, with which the four conductors were connected, so that water became the electrodes through which the current was conveyed to the body. Beard and Rockwell recommend a different mode of general faradization, in which one electrode is used for a *stabile* and the other for a *labile* current. The application is made in either of these ways: (*a*) One electrode is placed at the feet (usually the negative) to furnish a stabile current, while the other is moved over the whole body (labile current). (*b*) One electrode is placed at the coccyx (stabile), the other as before is moved over the body (labile). They claim that general faradization is a tonic indicated in a large class of cases suffering from general debility. By means of it all the muscles of the body may be vigorously and regularly exercised, and in consequence will increase in firmness, possibly also in size, and the tonic effects will influence the entire system. There will be improvement in sleep, appetite, digestive capacity and regularity of the bowels. If faradization is carried to excess, the effect is similar to that produced by over-exercise, that is, soreness of muscles, a sense of exhaustion, and sometimes an aggravation of unpleasant symptoms. The tonic effects of general faradization frequently can be detected long after treatment ceases, proving that it profoundly influences the general system.

FIRST STEP IN GENERAL FARADIZATION.

Fig. 52. *The patient.* The bare feet are placed on a moist foot-plate (which must be warm) connected with one pole of the battery. An electrode holding a large moist sponge is placed on the upper part of the forehead. The operator is shown changing the polarity of the current. The positive pole is usually applied to the head; the direction of the current should

be changed while passing through the nead only in exceptional cases. Dizziness, flashes of light, or other unpleasant phenomena, should be a warning not to proceed without at least modifying the current. A hydro-rheostat in the circuit makes a stronger current endurable, and helps to avert disagreeable after-effects.

All applications of electricity to the head should be brief, and made with a current of moderate strength. It is a prudent

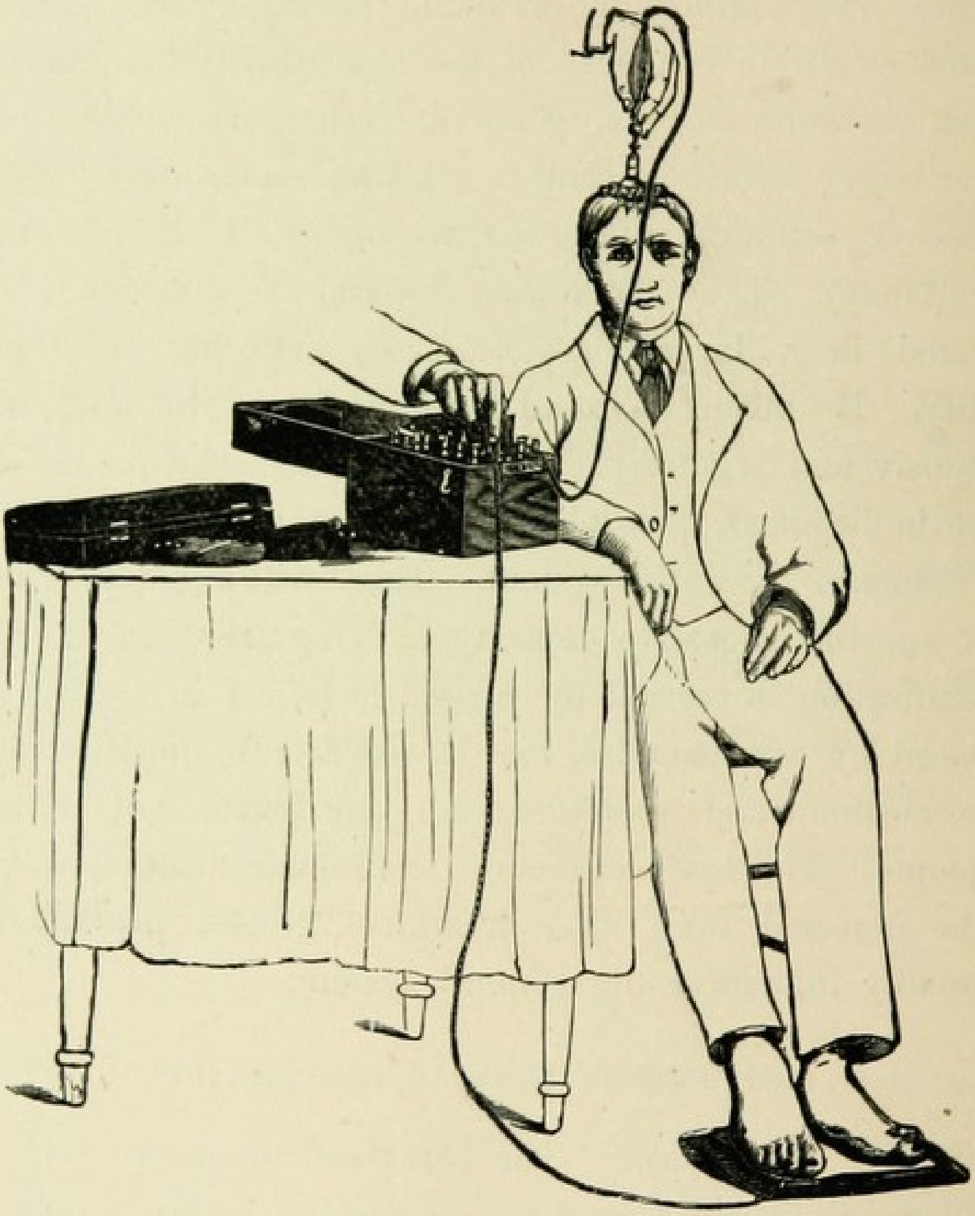


Fig. 52.

Instruments shown in the illustration:

The Physicians' Faradic Battery No. 3, arranged to give a primary current.

Adjustable sponge-holder, which should have a large sponge attached.

An electrode case closed, hand and neck electrodes beside it.

Folding foot-plate.

measure for the operator to test the current to be used upon his own head before applying it to the patient. After holding the sponge upon the forehead one or two minutes, it is moved down the side of the head in front of the ear, first on one side, then on the other, and then held stationary upon the back of the neck about two minutes.

ANOTHER STEP IN GENERAL FARADIZATION.

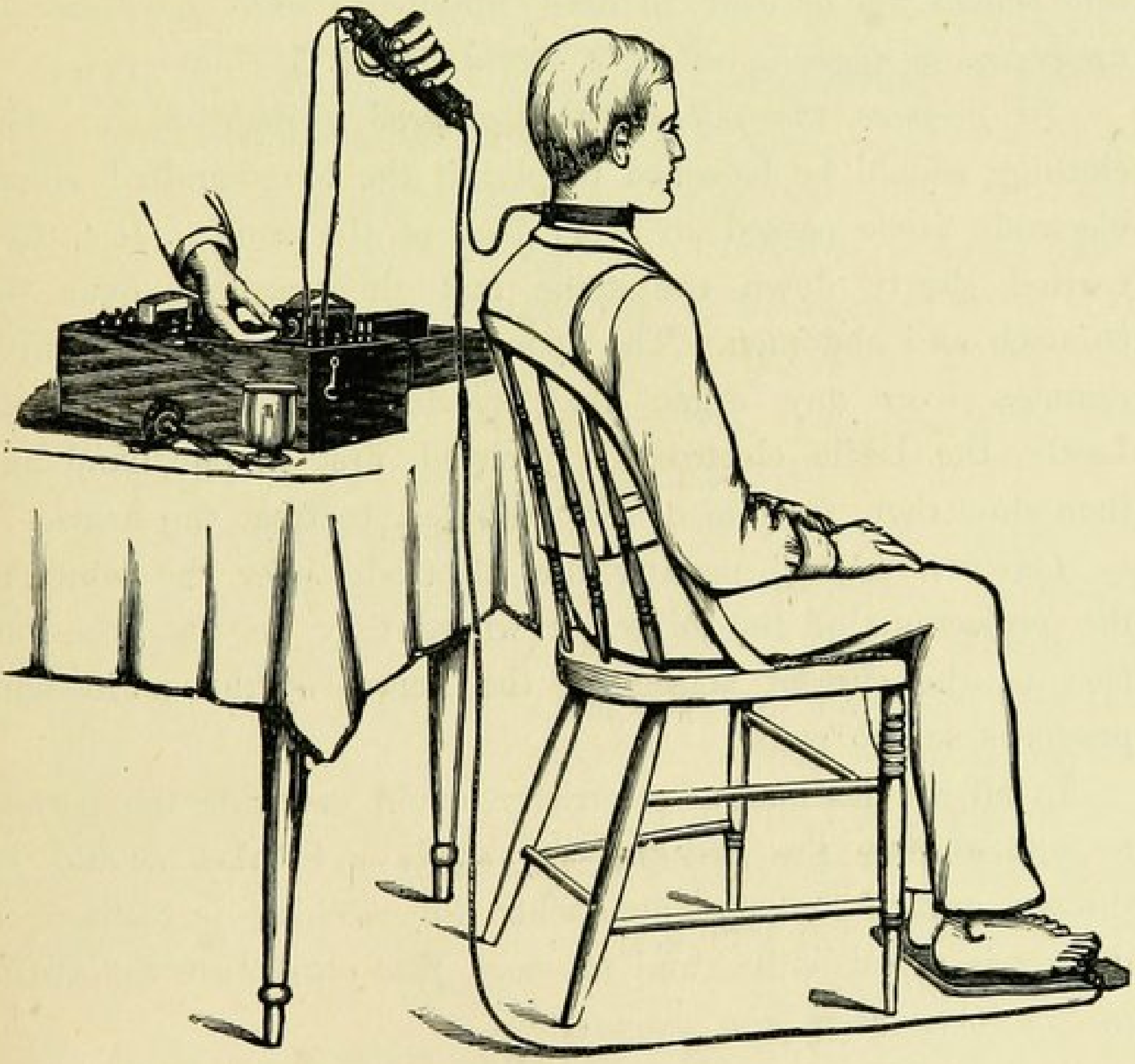


Fig. 53.

Instruments shown in the Illustration:

12-cell combined battery, the faradic part only, ready for use.

Pole changer, held by the operator, who is changing the polarity of the current.

Bowl for warm water.

A neck electrode, which consists of a rubber spring that holds a moist sponge against the back of the neck.

It is unnecessary to change electrodes during a sitting, when a general treatment is given. The change in the illustration is made merely to show the use of the neck electrode. The operator is shown applying an *increasing secondary current.* In general faradization it is not usual to introduce the pole changer into the circuit or to change the polarity of the current during the sitting. A current administered according to the method shown in Fig. 53 is an energetic stimulant, *and should not be used in cases threatened with paralysis or apoplexy, or those in which a recent attack has occurred.*

To prepare the patient for general faradization. The clothing should be loosened to permit the long-handled spinal electrode to be passed to every part of the trunk. It is first carried slowly down the spine and then around over the stomach and abdomen. The sponge may be held two or three minutes over any organ that specially needs stimulating. Lastly, the labile electrode is grasped, first in one hand and then the other, for one or two minutes, to treat the arms.

Caution. Avoid passing the electrode over the bones at the projections of the joints, or where they lie near the surface, as the current acting on the nerves of the periosteum produces severe pain.

In all applications of electricity, avoid exposing the patient to cold during the sitting. A shawl or blanket should be thrown around the shoulders when the clothing is opened, if the air is at all chilly, and *the bare feet must have something thrown over them for warmth.*

It is sometimes necessary to apply general faradization to a patient who is unable to sit up. In this case, the electrodes should be passed under the bed-clothing and the treatment carried on without uncovering the patient.

CHAPTER VII.

THE McINTOSH COMBINED GALVANIC AND FARADIC BATTERIES.

Formerly the physician who employed electricity in general practice was obliged to carry two batteries, if he wished to avail himself of the advantages of both galvanism and faradism. Galvanic instruments were apt to be cumbersome and complicated, requiring too much attention to commend them to the busy practitioner. To Dr. McIntosh is due the credit of first constructing an apparatus in a convenient, portable form, that furnishes both a galvanic and faradic current.

The McIntosh combined batteries are composed of two distinct batteries, one galvanic and one faradic, in the same case. Although it is possible to attach all the galvanic cells to the faradic coil, and thus obtain a so-called combined current, reference to preceding pages will show why this is neither essential nor desirable. The large faradic cell contains fluid sufficient for at least thirty treatments before it will need renewal, and as this cell alone is capable of producing a current too strong for any ordinary case, it is unnecessary to add more cells. The advantages claimed for the combination are these :

1. Both forms of electricity are provided in one case, which is as portable as a single battery.

2. This renders both faradism and galvanism available, not only for office, but for general practice.

That portion which furnishes the faradic currents is alike in all the McIntosh combined portable batteries. The portion which furnishes the galvanic current is arranged in sections of six cells each, and the number of cells in any instrument is indicated by its name; thus one which has one faradic and two galvanic sections is called a twelve-cell combined battery; one faradic and three galvanic sections form an eighteen-cell combined; one faradic and four galvanic sections, a twenty-four-cell combined. It is not usual to make these batteries with more than twenty-four cells, as beyond that number they become too heavy to be comfortably carried by hand.

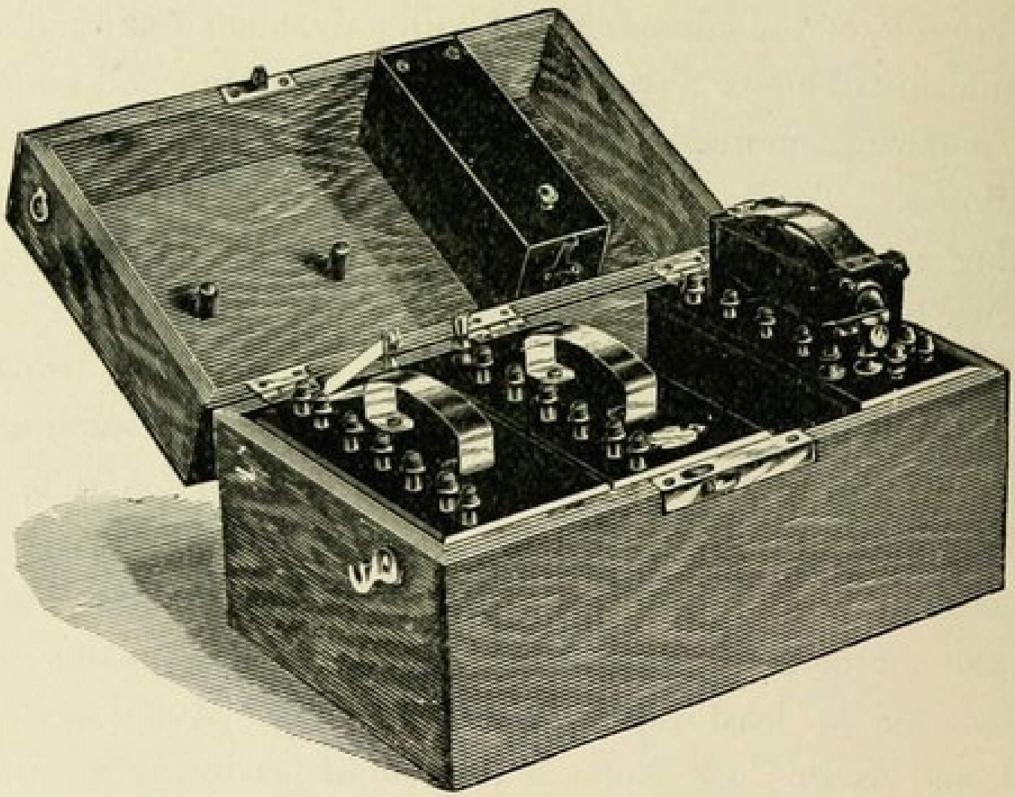


FIG. 54.

McINTOSH TWELVE-CELL COMBINED GALVANIC AND FARADIC BATTERY.

Length, 13½ in.; width, 8½ in.; height, 7 in.; weight, 15 lbs.

This illustration represents a twelve-cell combined battery as it appears when not in use. The faradic portion occupies the right hand end of the battery-box, the galvanic portion the left hand; the space between them receives the electrode case fastened in the top of the battery. Arranged in this manner, when the cover is closed, the posts in the top press upon the spring handle of each base and hold it firmly over the cells, while narrow partitions prevent the cell sections from moving out of place. When the cover is raised, the space occupied by the electrode case affords room to move the galvanic bases to the right to immerse their elements in the fluid within the cells.

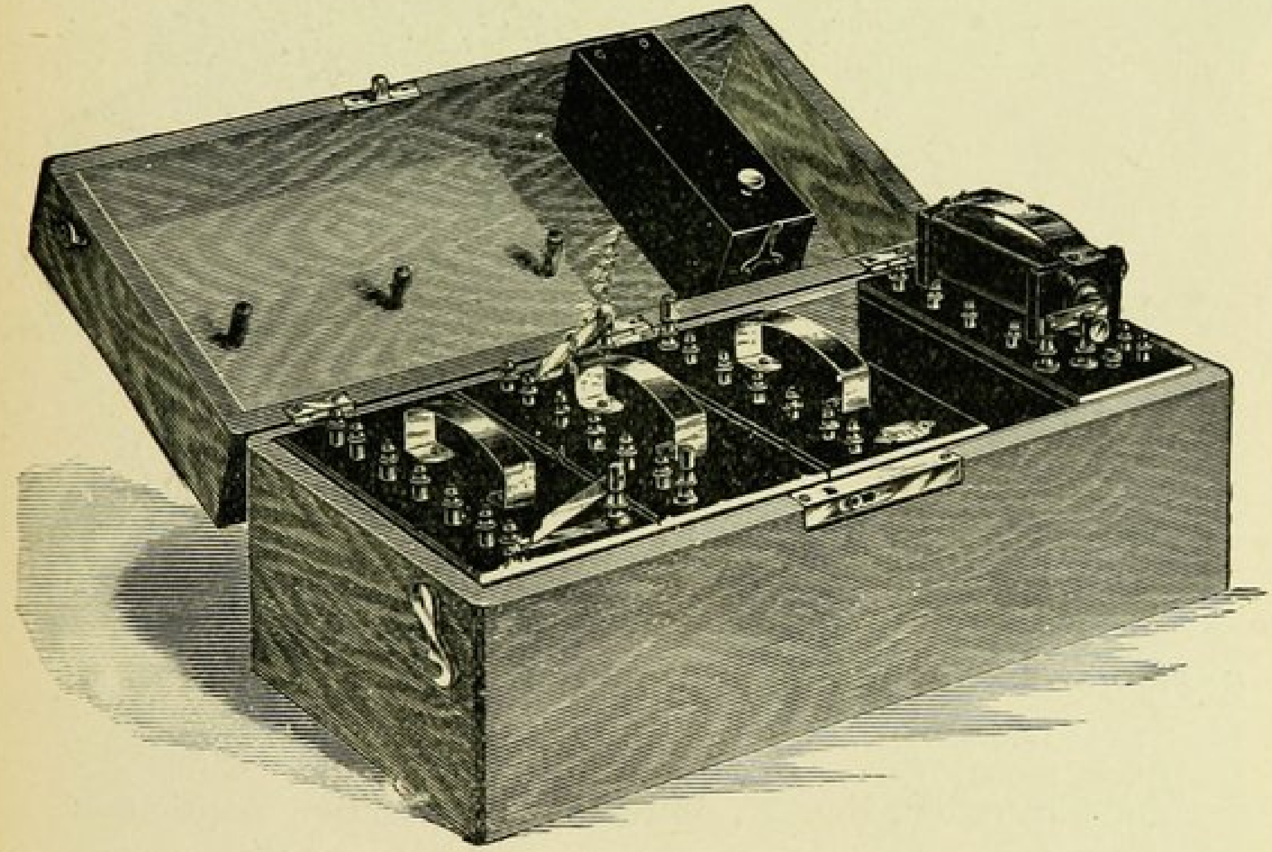


FIG. 55.

McINTOSH EIGHTEEN-CELL COMBINED GALVANIC AND FARADIC BATTERY.

Length, 17 in.; width, 8½ in.; height, 7 in.; weight, 19 lbs.

The apparatus shown in Fig. 55 differs from the one shown in Fig. 54, in having one more galvanic section. It is the one best adapted to the wants of the general practitioner. When freshly charged it gives a galvanic current of thirty-six volts.

The apparatus represented in Fig. 56 meets the requirements of the general practitioner, who is called upon to do considerable surgical work. It can furnish a current sufficiently powerful for any purpose to which electricity is therapeutically applied, with the exception of galvano-cautery, which, as already explained, requires a special apparatus.

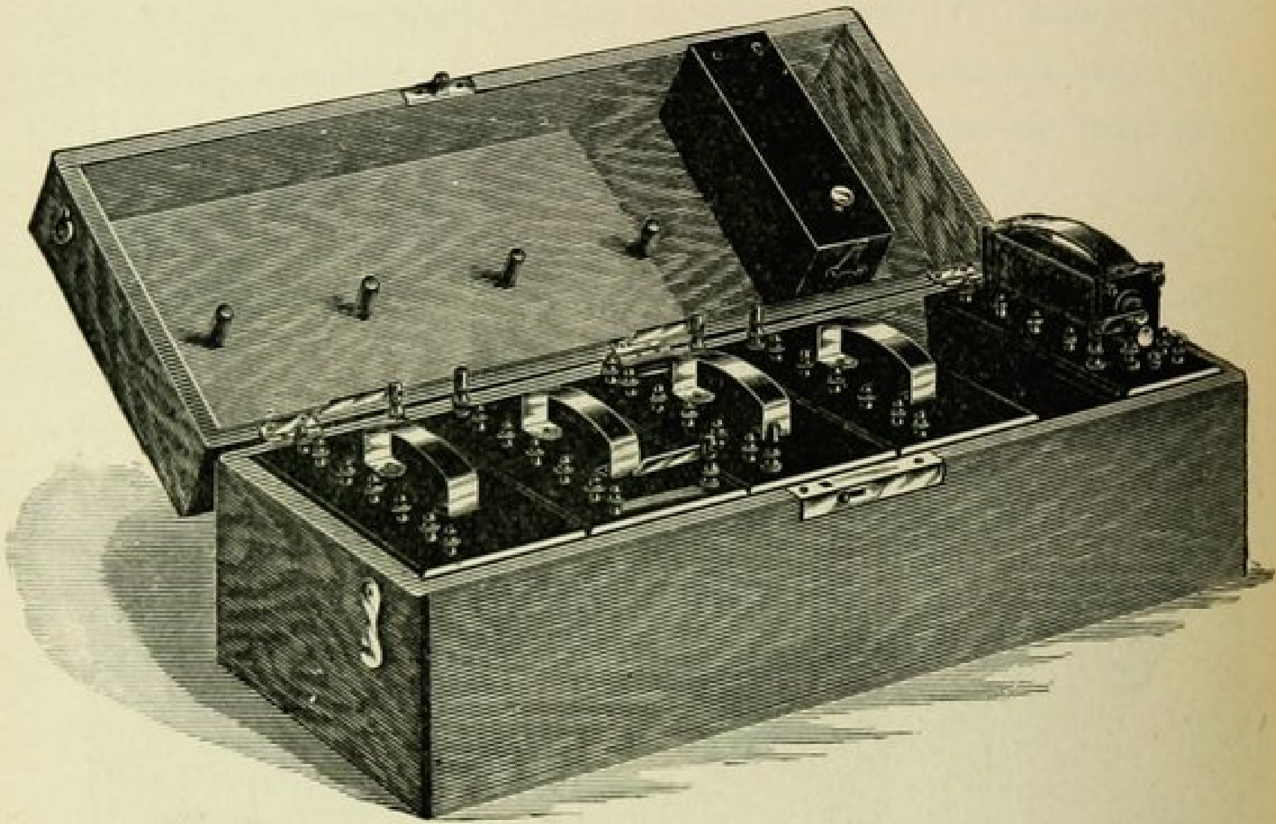


FIG. 56.

McINTOSH TWENTY-FOUR-CELL COMBINED GALVANIC AND FARADIC BATTERY.

Length, 20¾ in.; width, 8½ in.; height, 7 in.; weight, 24 lbs.

The illustration, Fig. 57, represents the relative position of the faradic and galvanic cell sections. They should always be replaced in the box in the same order, after being removed for any purpose.

The fluid for charging these cells is made after the formula given under the Grenet cell.

The cells should be filled to a uniform height. The glass measure provided with these batteries is marked to indicate the quantity for one galvanic cell. This is an important item, because the current obtained from any series of cells is proportioned to that cell which has the smallest area of zinc immersed in fluid. The cell sections for the galvanic part of this battery are like the one shown in Fig. 30, and the description given of it applies equally to those in Fig. 57. The hard rubber forming the cells is not acted upon by the fluid, and the method of fastening the bases over them prevents spilling when the battery is carried upright; therefore the fluid is left in the cells until exhausted.

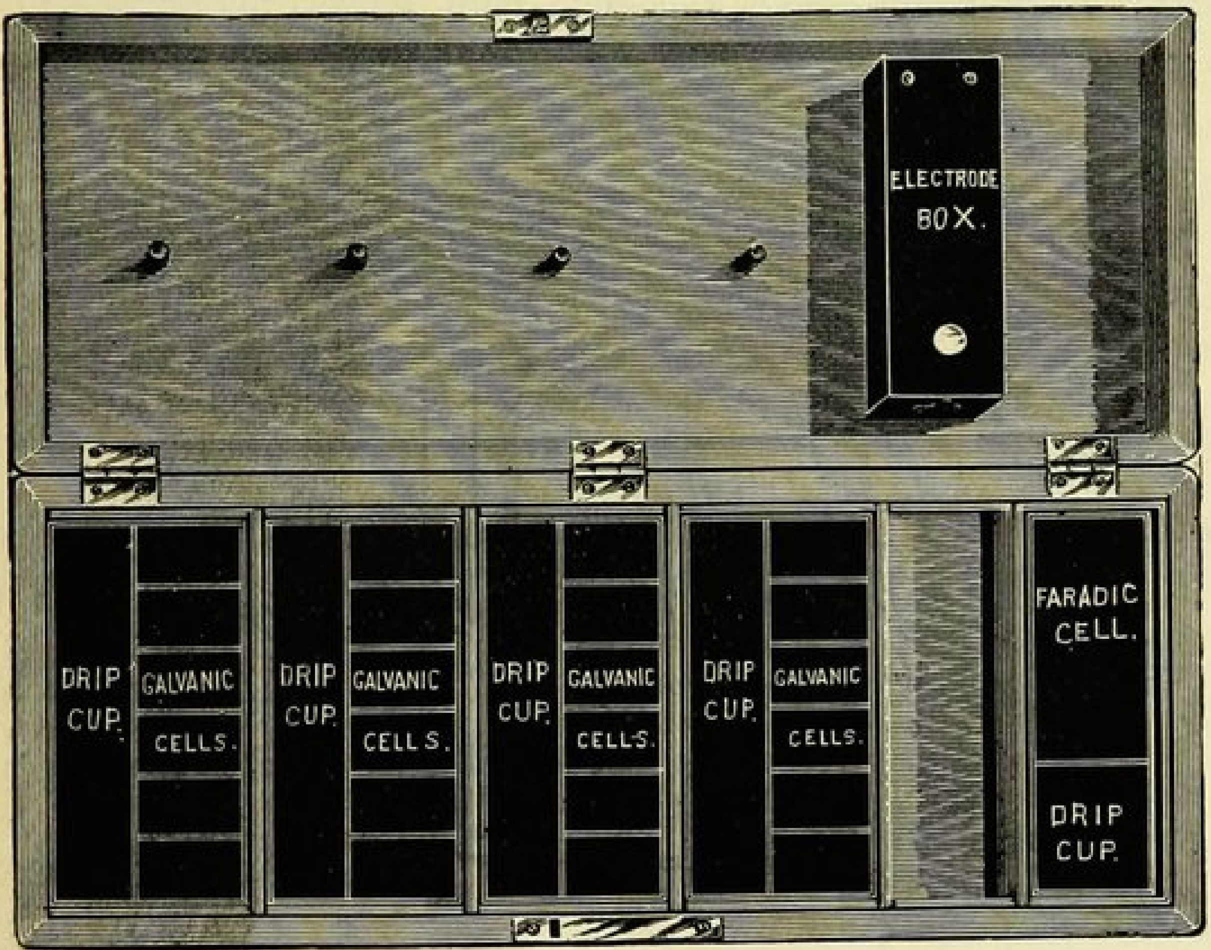


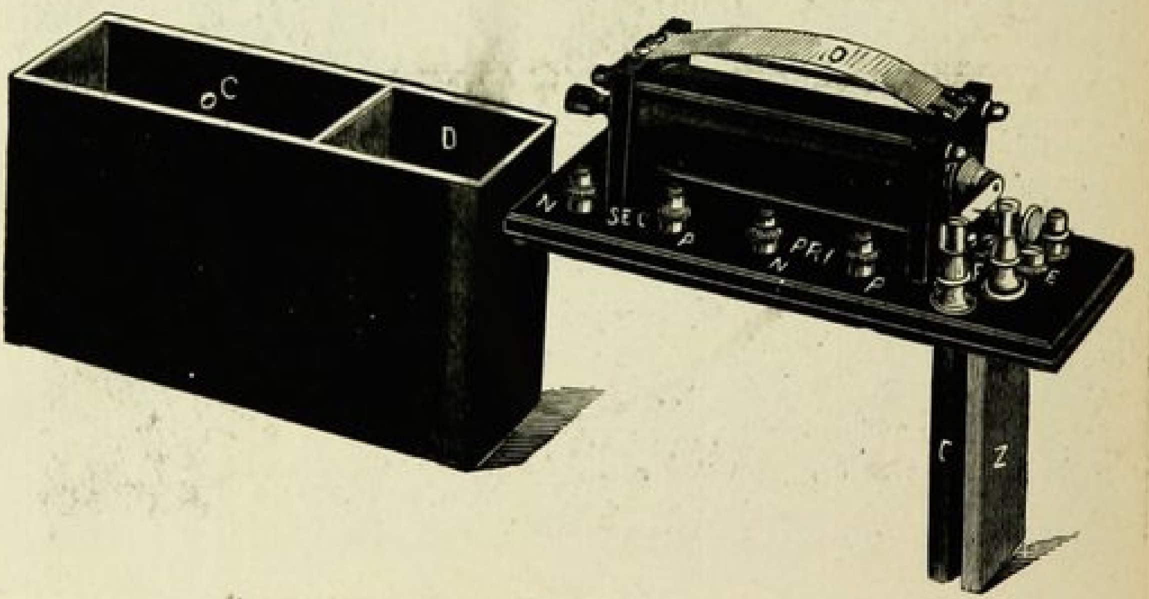
FIG. 57.

McINTOSH TWENTY-FOUR-CELL COMBINED GALVANIC AND FARADIC BATTERY WITH BASES REMOVED.

When the fluid is renewed, all sediment, crystals, etc., should be first removed from the cells and drip-cup; warm water will dissolve the chrome alum deposited as a result of the chemical action within the fluid, and if necessary the cells should be allowed to soak for several hours, as these deposits interfere with the perfect working of the instrument. There is danger of breaking the cells if force is used to break up and remove the débris.

If the drainage into the drip-cups is sufficient to envelop the ends of the elements in fluid before the fluid in the cells is exhausted, it may be drawn out with a syringe, or the entire section emptied and the cells refilled.

The electrode case is made of hard rubber, impervious to moisture or acid fumes, and fastened by a reliable spring. When the cover of the battery-box is closed, this electrode case fills the space between the galvanic and faradic portions. When the battery top is raised, this space permits the galvanic bases to be removed to the right to immerse their elements in fluid.



A FIG. 58. B

Size of A: Length, 6¾ in.; width, 2¾ in.; height, 4 in.

Size of B: Length of base, 7 in.; width, 3 in.; elements, 3¼ by 1¼ in.

No. 58 represents the faradic portion of the McIntosh combined batteries. A is the *cell section*, made of hard rubber, which resists the action of acids as well as glass, and is less brittle. It is divided into two compartments by a partition, the larger portion, C, being the cell to contain the fluid, and the smaller, D, the drip-cup, to receive the elements when the battery is not in use.

B is a black, hard-rubber base, upon which the coil, the binding posts and vibrator are fastened.

The *elements* are carbon and zinc, which are fastened to metal bridges by screws, the bridges being fastened to the base by screws E E. The wire connections between the elements and coil, as well as those between the coil and binding posts, lie underneath and next to the hard-rubber base. They are thoroughly insulated, coated with impervious cement, and still further protected by a sheet of soft rubber immovably fastened to the under surface of the base. This soft rubber serves a double purpose. It not only covers the connecting wires but serves as a *hydrostat*, as it overreaches the edges of the cell section, and when the battery is closed a post in the top of cover rests on the spring O, and firmly presses the soft rubber down upon the cell so that the fluid cannot escape.

THE FARADIC PORTION OF THE COMBINED BATTERIES.

To prepare for use. Lift the base by the handle P and reverse it. This immerses the elements in the battery fluid. The cut shows the base reversed and cords attached for applying the secondary faradic current. The rheotome spring should commence to vibrate (known by its buzzing sound) as soon as the elements touch the fluid. If it does not, lightly tap the hammer to start the vibration.

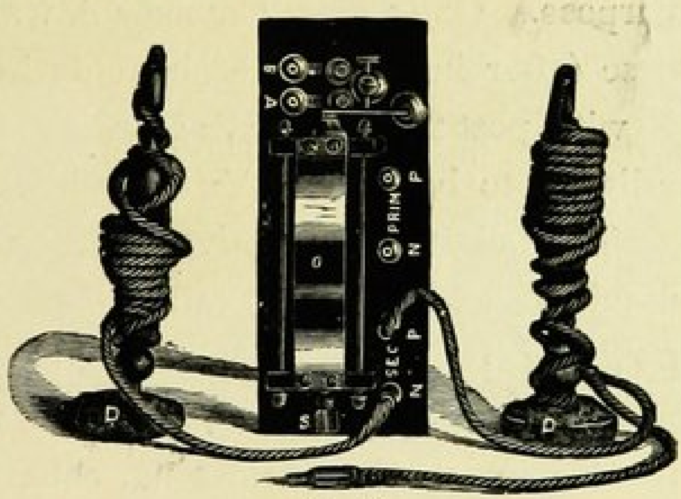


FIG. 59.

To obtain the primary current. Insert the tips of conducting cords in posts N and P, on either side of "Prim."

To obtain the secondary current. Insert the cord tips in posts N and P, on either side of "Sec." Both currents are made stronger by drawing out the shield S from the coil.

To apply the current. Wet the sponge discs D D in warm water and apply directly to the uncovered skin, locating them according to directions in following pages, remembering that caution must be exercised in applying the current to the finger tips, edges of bones, over nerves, etc., to avoid an unpleasant shock to the patient. The operator can handle any sponge or metal electrode freely without receiving the current, if all contact of the hand with the patient or other electrode is avoided. *Beginners are reminded that the current cannot pass through either the patient or operator unless included in the circuit, and to be included in the circuit it is essential that there be two points* (entrance and exit) *connected directly with the battery.* ALWAYS REVERSE THE BASE BETWEEN TREATMENTS, AND AS SOON AS THE BATTERY IS NO LONGER NEEDED.

(a) *To connect galvanic cells with the faradic coil.* The long coiled wire springs sent out with the battery are used for this purpose. One spring connects A with post P 1 of the galvanic base (after inserting the elements in fluid), the other connects B with post 2, 3, 4, etc., according as two, three, four or more cells are to be included in the circuit.

The addition of galvanic cells to the faradic circuit is required seldom, if at all, when the faradic elements and fluid are in good order. The only instance where it might possibly be demanded would be in restoring animation in desperate cases, such as drowning, chloroform or narcotic poisoning. If, however, the faradic fluid becomes unexpectedly exhausted, and it becomes necessary to use this current before the fluid can be renewed, three or four galvanic cells may be substituted for the faradic by proceeding as described. The destruction of the faradic elements may necessitate the same procedure.

(b) *To connect the last cells of any galvanic section with the faradic.* If it desired to use up the elements uniformly, those galvanic cells which are not required for galvanic purposes may be utilized by placing the section of which they form a part adjacent to the faradic section, and connecting the cells to be used as already described. A must always be joined to that post nearest P (on the galvanic base); it forms the positive element of the circuit. For example, suppose the last three cells on base 1, Fig. 60, are to be joined in faradic circuit; the coiled wire spring from A is inserted in post 3, and 3 is regarded as positive; the spring from B is inserted in 6, which is now negative.

To use other forms of electrodes. All electrodes manufactured by the McIntosh Galvanic and Faradic Battery Co. that are not attached directly to the conducting cords will fit the wooden handles shown above after unscrewing and removing the sponge discs D D.

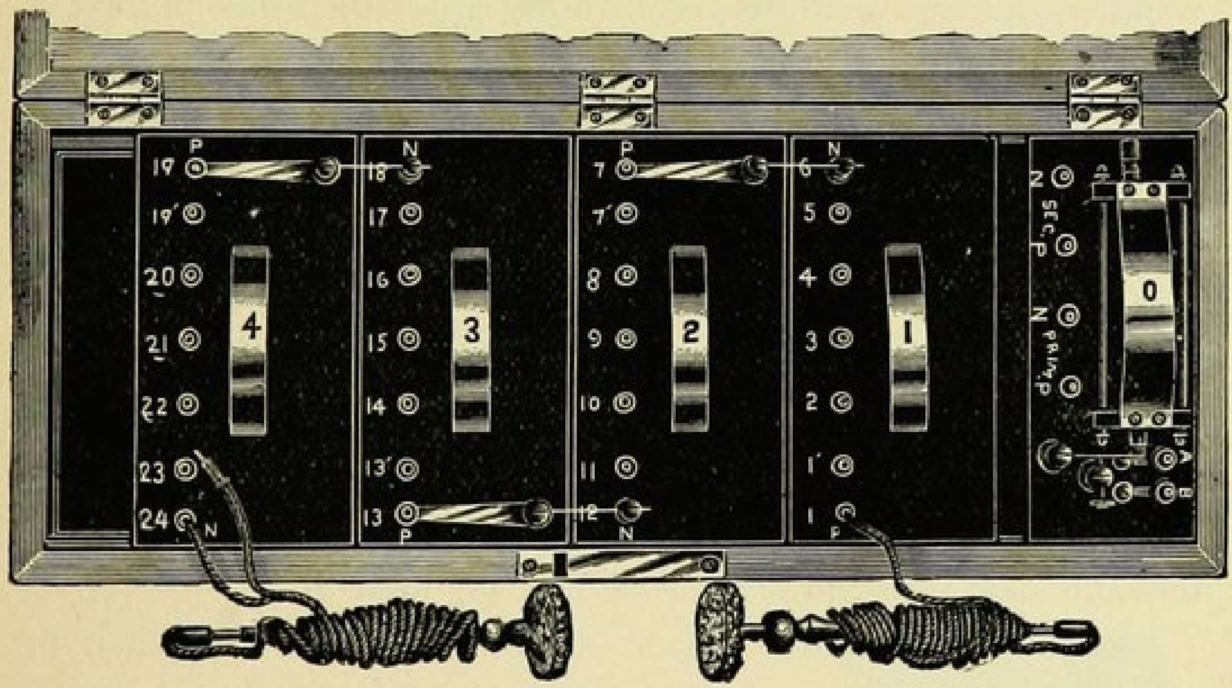


FIG. 60.

McINTOSH 24-CELL COMBINED GALVANIC AND FARADIC BATTERY.—THE GALVANIC PORTION READY FOR USE.

0 represents the faradic base with elements in drip-cup. 1, the first galvanic section of six cells. 2, the second. 3, the third. 4, the fourth. N marks the negative poles. P, the positive poles.

To use one section. Lift the first base by its handle, 1; remove to the right and immerse the elements in the cells; the base overlaps the space for the electrode case and leaves space on its left for the overlapping portion of base 2 when moved forward. The instant the elements enter the fluid the current starts.

The galvanic current is silent and can be detected only by its effects.

(a) To use one cell, insert one cord-tip in post 1 P, and another in post 1′. P 1 is the positive pole, 1′ the negative.

(b) To use three cells, remove the tip from 1′ to 3; the latter is now negative.

(c) To use six cells, remove the tip from 3 to 6; the latter is now negative.

To add cells without interrupting the current. Use the bifurcated cord for the negative, leaving one end next the battery free. When more cells are wanted insert the free tip in the required number, and then remove the tip of the other branch of the bifurcation.

To use two sections. Immerse the elements on base 2 in fluid by moving to the right, and slide its movable bar into the slot in 6 N on base 1.

(d) To use seven cells. Leaving the first cord attached to post 1 P, as before, insert the tip of the other in 7′ on base 2; 7′ is now the negative pole.

(e) To use twelve cells, remove the cord-tip from 7′ to 12 N.

To use three sections. Move base 3 forward and press its movable bar into the slot in post N on base 2.

(f) To use 13 cells. Leaving the first cord attached to post 1 P, insert the second in 13′.

To use four sections. Move base 4 forward, and connect with base 3 by means of the movable bar.

(g) To use 19 cells. Connect the last cord with 19′, which becomes the negative pole of the circuit.

(h) To use 24 cells. Remove cord from 19 to 24, and the latter becomes negative.

Polarity of base 1. Post P 1 is always positive, and each of the other posts becomes negative in relation to it when joined in circuit. If, however, one cord is at 2 or 3, etc., and the other at 4, 5 or 6, the one nearest P 1 is positive, the one nearest N negative.

Polarity of base 2. The same as base 1, when it is used singly, 7 P being the positive end and 12 the negative in relation to it.

Polarity of base 3. Similar to bases 1 and 2, 13 being positive and 18 negative.

Polarity of base 4. Positive pole 19 and negative 24. When the bases are joined together, the polarity of each separate base varies as follows:

Polarity of bases 1 and 2 united. When the first cord is at P 1, or any other post on base 1, *each post* of base 2 becomes negative when it terminates the circuit.

Polarity of bases 1, 2 and 3 united. With first cord as in last, each post of both 2 and 3 will become negative when attached to the second cord.

Polarity of all united. When any number of cells are united in circuit, that cord on P 1, base 1, or the one nearest it, marks the positive battery pole, and all the rest are negative in relation to it.

TO REPLACE THE ELEMENTS.

Loosen the binding post by the fingers, the same as an ordinary thumbscrew, and detach the metal bridge holding the elements to be replaced. They are removed from the bridge by a screwdriver, and the new ones are fastened in their places as before. Zincs need to be replaced as soon as they become consumed, so that their length in the fluid is considerably less than the carbon. Carbons, if cleansed with warm

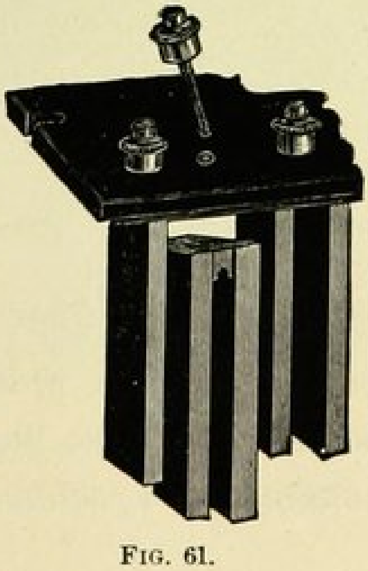


FIG. 61.

water each time the cells are replenished, may be used for years, unless accidentally broken.

An apparatus designed to be stationary should have numerous accessories which cannot be attached to an instrument whose first requisite is portability.

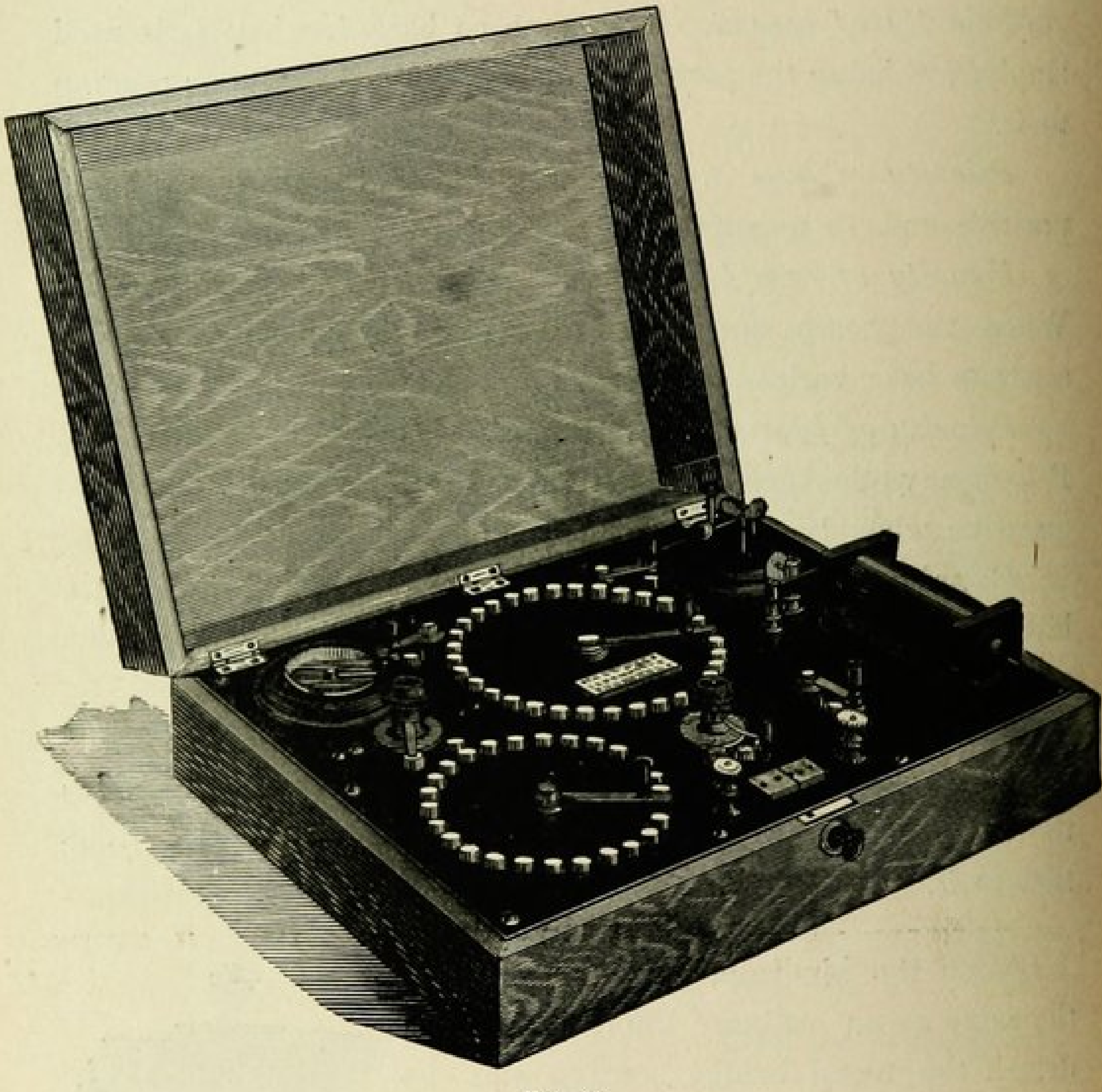


FIG. 62.

THE McINTOSH OFFICE BATTERY.

The Table Plate shown in Fig. 62 is put up in a large variety of cases, presenting more or less elaborate cabinet-work, according to the taste and means of the purchaser. It is suitable for a cabinet, office table, book-case, desk, or may be

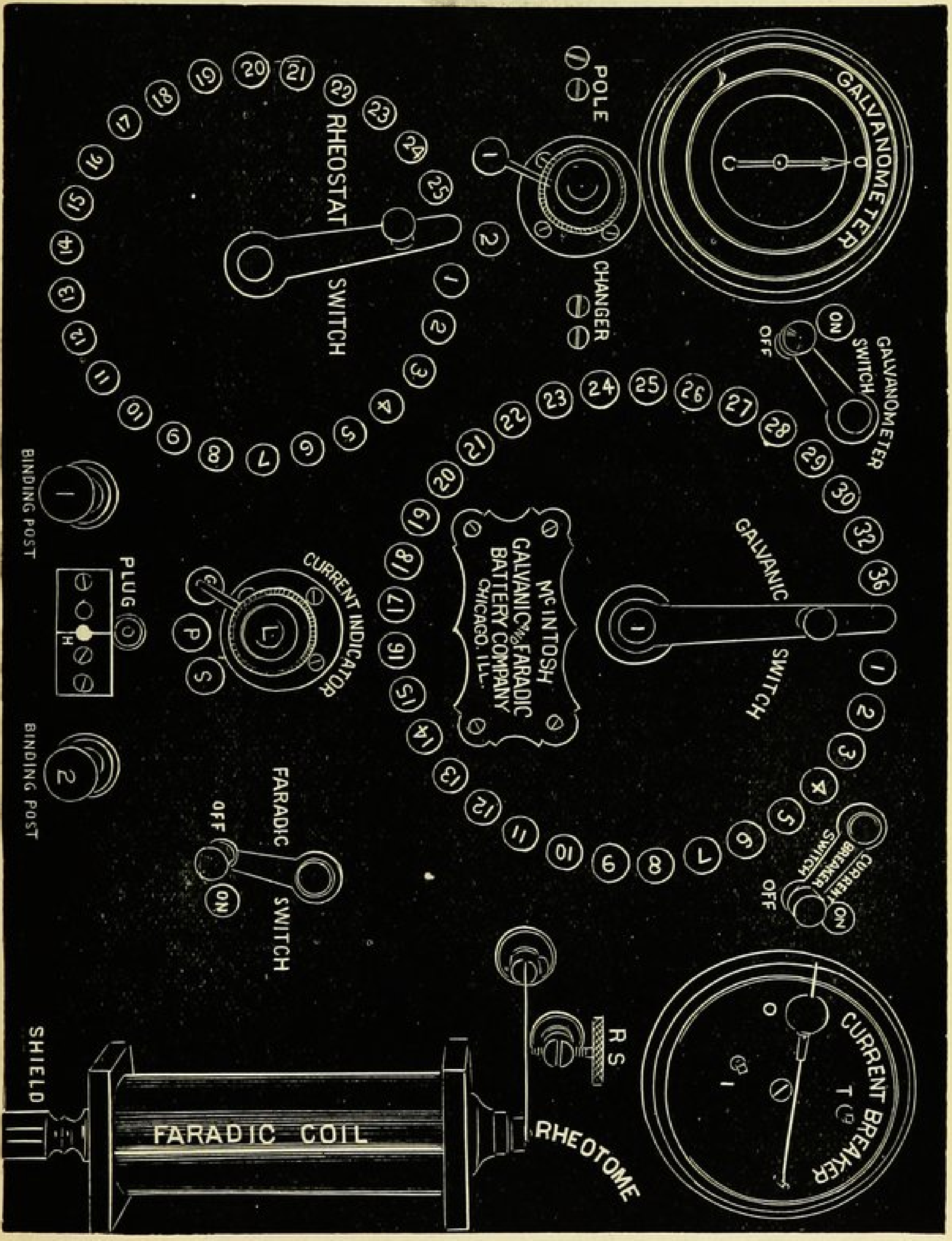


FIG. 63.

DIAGRAM OF OFFICE TABLE-PLATE.

Size, 12 × 16 inches.

simply furnished as a stand in a case like that shown in the cut. The metal work is nickel-plated, and the contrast between the highly-polished rubber base and the nickel makes an ornamental piece of work worthy of a place in the most elegantly furnished office.

Gravity cells are commonly used with this apparatus, since they require very little attention, and do not need new fluid oftener than once or twice a year. These cells may be placed in a cellar, closet or cupboard when there is no place for them in the office. An enlarged diagram of this table-plate is shown in figure 63.

To connect the gravity cells with the plate. Buttons 1 to 36 terminate below the base in a screw upon which plays a nut, to which the wires from the zinc elements of the gravity cells are fastened. The galvanic switch revolves on the post marked 1, in the center of the circle. The wire from the copper element in the first cell is connected with post inside circle. (As will be seen by reference to Fig. 22, the copper element of the first cell only is connected with the switch-board; each of the other copper elements is connected with the zinc element of the adjacent cell, while each zinc element is connected directly with a corresponding button on the switch-board). The wire from the zinc element of the first cell is fastened to button 1 in the galvanic circle. The wire from the zinc element of the second cell is fastened to button No. 2, and so on, until the entire thirty-six cells are joined in series.

Direction for operating. To obtain a galvanic current. *Turn all the switches upon the buttons marked* OFF.

Turn the *galvanic switch* on the button marked with the number of cells wanted in circuit. Turn the current-indicator on button *G.* Insert the conducting cords in binding posts 1 and 2, and apply the current as from an ordinary battery.

The direction of the current. When the pointer of the pole-changer points to button 1, binding post No. 1 is *positive* and No. 2 *negative;* when it is turned upon button 2, binding post No. 2 becomes *positive*, and No. 1 *negative.* This applies alike to both currents.

To increase the strength of the current. Suppose the galvanic switch is at first moved upon button 4, then four cells are included in circuit; moving the switch forward upon buttons 5, 6, 7, etc., includes 5, 6, 7 cells respectively in the circuit; therefore, to increase the strength of the current, move the switch forward over the button marked with the number of cells required.

To use the galvanometer. Turn the galvanic switch on the button marked with the number of cells to be tested. Turn galvanometer switch *on*. Place the plug in the socket *H* to complete the circuit through the galvanometer. Let all the switches be in the same position as described for obtaining the galvanic current. The needle will be deflected if any current is passing through the circuit. The deflection of the needle will be increased up to a certain angle (see page 120) by each additional cell included in the circuit; beyond that no increase is possible, but each cell added after the maximum deflection is reached should keep the needle at this point; if the deflection is decreased at any button in the remainder of the circle, it will be found that the connection between that button and its cell is imperfect or broken, or that the cell is out of order. For example, suppose that the maximum deflection is reached when ten cells are brought into circuit; moving the switch on buttons 11, 12, 13 retains the needle at this point, but button 14 lessens the deflection; it will be found that either the connection of the fourteenth cell with the table-plate is at fault, or from leakage, evaporation of water, mixing of the fluids, or corrosion of elements, no current is generated in the cell.

The galvanometer should be set in the table-plate so that the needle may point to the north and O, when at rest.

Turn off the galvanometer switch and remove plug from H as soon as the current is tested, otherwise the current will pass directly through the metal circuit completed by the plug, and none can be obtained from the binding posts.

To use the current-breaker. Arrange the switch and indicator as described for the galvanic current, and in addition turn the current-breaker switch on. This is operated the same as the automatic rheotome, Fig. 32.

The rheostat. This is composed of twenty-five small coils, each of which offer a resistance of 100 ohms. The buttons attached to these coils are numbered from 1 to 25, the ciphers being omitted for want of room.

The rheostat is introduced into the circuit by simply moving its switch upon the button corresponding with the number of ohms resistance wanted. If the switch is upon button 4, and the rheostat is included in the circuit traversed by the current, the latter must overcome 400 ohms resistance in addition to the ordinary resistance of the circuit. If the switch is placed on button 25, the resistance is 2,500 ohms.

The use of this rheostat. It is useful in central galvanization, in treatment of the eyes and ears, and in very nervous subjects. It may also be used in faradization. A mild current, such as is suitable for many purposes, does not possess sufficient energy to overcome the resistance of the body, but a current of sufficiently great electro-motive force to overcome the 2,500 ohms resistance in the circuit, can easily penetrate the body, while in penetrating through such a resistance it loses that quality which causes a shock, or painful sensation, when the circuit is opened or closed.

The rheostat is also essential in keeping the cells in good working order when used but little.

To keep the cells in order when little used. To preserve the difference in density between the strata of fluid in the cells, they should be run an hour or two daily, and since a short circuit with little resistance permits a speedy restoration of electric level (potential), it is essential to interpose resistance in the circuit to preserve the difference in potential, upon which the working power of the cells depends; therefore, turn the galvanic switch upon button 36, the current indicator upon *G*, and the rheostat switch on button 25. *Let all the other switches be turned off.*

To use the faradic current. Turn all the switches *off*, then turn the galvanic switch upon button 3 or 4 (not more than four cells are needed to run the coil). Turn the faradic switch *on;* also turn the current indicator upon *P* for the primary or *S* for the secondary current. If the rheotome spring does not at once begin to vibrate, tap it lightly against the coil. The currents are regulated by the shield.

The polarity of the current is indicated by the pole changer.

To preserve this apparatus in good working order, it is important that all the switches be turned off when it is not in actual use, except when run through the resistance coil, as already described.

The switch-board shown in illustration 64 is designed for those who employ stationary cells, but do not want so elaborate or expensive an office apparatus as the one shown in Fig. 62. The base and cover of the coil are made of polished black rubber, and the metal parts are nickel-plated.

The galvanic circle may be made to include any number of cells.

The faradic coil is constructed like those on the portable batteries.

The polarity of current is changed by the double switch on the front of the base , uncovering button *P* makes the binding post to the right positive; covering button *P* makes binding post to the left positive.

The faradic current is sent through the binding posts when the switch beside the coil is moved *on;* the primary or secondary current may be selected by moving the switch to the left on *P* or *S*.

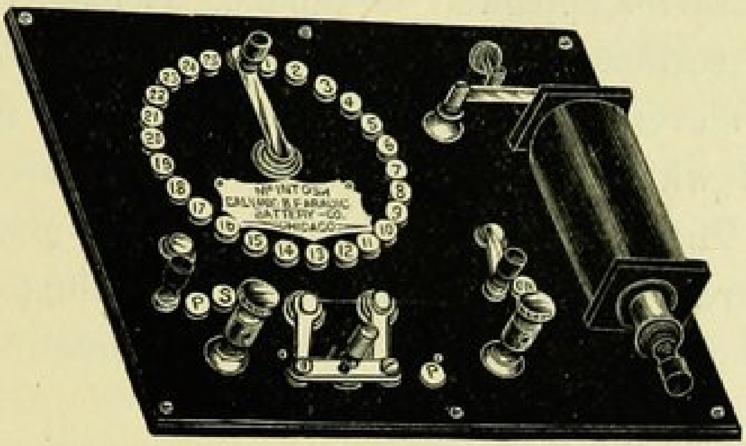


FIG. 64.
McINTOSH COMBINED SWITCH-BOARD.
Size, 10 × 12 inches.

SUGGESTIONS IN REGARD TO SELECTING A BATTERY.

The physician who is about to begin the use of electricity in his practice is frequently at a loss to know what kind of an instrument to select; therefore it may not be out of place to offer some suggestions dictated by experience, as an aid in making a selection.

The first thing to be considered is the purpose for which an electrical apparatus is required. If it is designed merely to meet the popular demand for electrical treatment, and the purchaser has neither the time nor inclination to master the principles underlying electro-therapeutics, a good faradic battery should be selected. The sound and sensation it produces impresses the patient with the idea that something is being done, while there is little danger of doing harm with it in any reasonable application, as painful muscular contractions speedily warn the operator when the current is too severe.

Those practitioners who are convinced that we have in electricity a valuable remedial agent, and desire to apply it scientifically, either generally or specially, should take into consideration the class of disease to be treated and the kind of electricity they wish to employ. Any extended use of this agent will call for apparatus to produce at least the galvanic and faradic currents; while those who wish to use electricity according to every effective method will find it necessary to be provided with the static as well as the above-mentioned apparatus. The magneto-electric battery for generating the magnetic current is but little used at present, owing to the uneven quality of the current, which produces pain greatly out of proportion to the muscular contraction.

The surgeon will need a galvanic battery for electrolysis, and a galvano-cautery battery for operations in which cauterization is essential.

Those who are unacquainted with the distinctive characteristics of the instruments required for the production of different forms of electricity may be saved from some disappointment by observing that:

1. All faradic batteries produce a buzzing noise, and muscular contractions, which in very sensitive subjects are always accompanied by pain or unpleasant sensations. In ordinary patients the sensation is not considered painful unless the current is very strong.

2. All galvanic batteries are silent, and produce no muscular contractions, except at the instant the current is closed or opened.

The current from a large number of cells produces a distinctly burning or smarting sensation, or in some cases a tremor, while flowing uninterruptedly through the circuit. The current from a few cells may produce no sensation whatever, under the same circumstances; therefore the *sensations of the patient cannot be relied upon* to determine whether a current is actually passing through the circuit.

3. No *single* battery can give both a galvanic and faradic current that is efficient. A faradic current, it will be noticed by reference to preceding pages, is produced by passing a current from one or more galvanic cells through a faradic coil. A very few cells will produce as strong induced currents as the wire in a given coil is capable of carrying, and adding more cells does not increase the current proportionately; while so much force may be applied as to fuse the platinum points of the vibrator, or to compel the currents to overcome the resistance interposed by the insulating covering between the layers of wire, and make short circuits within the coil, thereby lessening or destroying the currents that should pass through the connecting wires and electrodes. A galvanic current, on the contrary, has its electro-motive force (propelling force) greatly increased by increasing the number of cells in circuit, provided they are united in series (the zinc of one cell with the carbon of the adjacent one). As the power of overcoming resistance depends upon the electro-motive force, it is evident that the number of cells in the circuit must be in proportion to the resistance to be overcome. As we have already stated, the size of cells is of little importance as regards the strength of current from a freshly-charged series. If, however, chemical or heating effects are required as for galvano-cautery, the size of the elements is an important factor, and the larger the amount of element surface (within a certain limit) immersed in fluid, provided they are connected in multiple arc, the greater the cautery power.

4. The term, combined galvanic and faradic, as applied to certain apparatus herein described, is not intended to imply that there is any combination of the two currents. It simply means that each battery contains the necessary combinations for producing two distinct forms of electricity. When the faradic current is in use, that portion of the instrument which generates the

galvanic current is not in action, and vice versa. The only exception to this is in case it is necessary to apply a galvanic current to one patient and a faradic current to another at the same time, when the two portions of the battery may be employed precisely the same as if they were two separate batteries. The only object in combining two instruments in one case is merely for convenience. The combined instruments weigh less than two separate batteries that furnish currents of equal power.

5. The static machine should not be relied upon to furnish all the electricity required in practice, because it is too fragile to be portable. It is, however, an excellent adjunct to an office outfit and is especially valuable in nervous diseases. One excellent point in its favor is that there is no necessity of disrobing the patient or even disarranging the clothing. It furnishes electricity of immense potential (power of overcoming resistance).

6. Galvano-cautery instruments, as before stated, are suitable for no other purpose than for cauterization.

7. The qualities required in both galvanic and faradic instruments are: high and constant electro-motive force; small internal resistance; a constant current free from polarization, not liable to rapid exhaustion, and consequently requiring frequent renewal of battery fluid. There should be no local action when the circuit is open, and no corrosive fumes at any time; they should be easily managed; they should be durable and not too expensive.

No battery has yet been invented that possesses all these qualities in the highest attainable degree; therefore it becomes necessary to choose an instrument which combines those most essential for the purposes for which it is to be employed.

For *office practice*, where a battery is reeded frequently and portability is no object, a constant current from cells that require little attention is to be preferred. There is gain in steadiness of current at the expense of loss of electro-motive force, which may be compensated for by using a larger number of cells. Those which require little attention are necessarily bulky. For *general practice* small cells are essential to portability, although they require frequent renewal of fluid, for the number of cells must be limited and the small number that can be carried, to be effective, must have great electro-motive force. Since the latter is in direct proportion to the amount of zinc used up, batteries of great electro-motive force and working capacity need new zincs much oftener than those in which chemical action is slight and the resulting currents comparatively feeble.

TO DISCOVER THE CAUSE WHEN A BATTERY FAILS TO WORK.

The passage of a current through the circuit from a *faradic battery* is made known by sound made by the vibrator, but the *galvanic battery*, being noiseless, requires other tests, which are given on page 116. The cause of failure in either battery may be (1) that no current is generated ; (2) that the connections are imperfect. The former may be due to the fact that the fluid is exhausted or the zinc element destroyed, so that it does not extend below the surface of the fluid, and fresh fluid or a new zinc must be supplied. *Deposits of chrome alum crystals* in the cell may interfere with the passage of the current; they should be dissolved in warm water, and never broken up forcibly, as the cells are liable to be cracked or broken in the process. *The elements* may become incrusted with salts, and thereby interfere with the generation or conduction of the current ; they may also be cleaned by soaking in warm water. Copper and zinc may be scraped, but carbon is brittle and must be handled with care. In case there is a current generated, while none passes through the circuit, the fault may be in the *binding posts*, *the cords*, *the electrodes*, or in the faradic battery, *the adjustment of the rheotome.* The sockets in the *binding posts* may have become corroded (this can only occur through carelessness in spilling acid upon them) or partially filled with dirt, so as to prevent close contact with the conducting cord; in either case they must be cleaned. The *conducting cords* may be broken. To determine if this has occurred, a galvanometer may be included in the circuit, when a galvanic or primary faradic current is being tested. Two iron or copper wires may be used to connect the galvanometer with the battery; if the needle is deflected, it shows that a current is present; substitute first one cord and then the other for one wire; the broken cord will prevent any deflection of the needle. The secondary faradic current does not affect the galvanometer, therefore it must be tested by its effect on sensation. A faradic current can be distinctly felt by placing one finger on the positive and another on the negative binding post; or connect one cord with either post, hold its free tip, and at the same time touch the other post. If the cord is broken, no current will be felt.

The *electrodes* are at fault when a current passes through the cords but none through the circuit. There may be imperfect junction of conducting-cord tips with electrode, or the surface of the electrode in contact with the patient may be covered with non-conducting material, such as dry sponge or cloth, in which case the covering must be moistened. The *rheotome* of the faradic battery may need attention. The directions for adjusting the spring will be found under Fig. 47. The platinum points may be covered with rust, which must be scraped off with a knife or emery paper; the presence of rust, when it does not arrest the current altogether, makes it uneven and harsh. In addition to the causes already given, the rheotome spring may become too weak and need replacing; the coil or platinum points may be damaged by connecting too many cells in circuit, or the battery connections be broken. The latter can only occur as a result of violent usage, such as falls, etc. If the spring, coil or connections need repairs, the instrument must be sent to the maker; when this becomes necessary, *always see that the cells are empty before shipping.*

AXIOMS FOR THE APPLICATION OF DYNAMIC ELECTRICITY.

1. Both galvanism and faradism require that there should be two separate points of the body connected with the battery, one with the negative and one with the positive pole.

2. The conductors must be in direct contact with the skin or other tissues to be treated; dynamic currents cannot pass through the clothing.

3. Electricity given in such a way as to frighten, excite or hurt a patient does more harm than good.

4. A current so strong, or applied so long, as to produce soreness of muscles, cramps, or great fatigue, does more harm than good.

5. The operator should try the various currents by finger tips, face or tongue, until thoroughly familiar with the sensations normally produced, and *then make great allowance for the nervous fears of the patient, especially if the latter is not familiar with electrical treatment.*

6. Too weak a current can never do harm, but too strong a current is capable of producing irreparable mischief. A little experience will soon enable the operator to strike the golden mean.

7. Every precaution should be taken against exposing a patient to drafts or chills during a sitting. If any part of the clothing must be removed, an extra wrap should be thrown over, and the treatment be carried on under cover. The operator should scrupulously avoid using sponges moistened in cold

water, or applying a cold metal conductor to the bare feet or other part of the body.

8. Galvanic and primary faradic currents have a definite direction, that is from positive to negative points in the circuit, and the location of electrodes must be determined by the effect to be produced. The secondary faradic current moves in both directions.

ELECTRODES.

Faraday named the points at which electricity enters and leaves a substance, *electrodes;* the same term is now applied to the conductors through which electricity is conveyed to and from the body in medical treatment. The effect produced by the current depends, to some extent, upon the electrodes, and may be modified by the *material* of which they are made, their *shape*, their *size*, and their *location.* Electrodes are usually made of brass, carbon, sponge; steel, silver, gold, platinum, and some other materials, are occasionally employed. The size and shape must be adapted to the purpose for which they are to be used. To treat single nerves, or muscles, and to localize a current, requires at least one small electrode, shaped so that it may be accurately applied. Large electrodes give a greater surface of contact, therefore there are more paths for electricity to traverse; consequently the current branches are less crowded together (less dense), and produce less effect on the cutaneous nerves of sensation; for this reason a much stronger current can be borne when applied through large electrodes evenly pressed on the surface. When a very sensitive patient is to receive treatment for the first time, or one in whom an ill effect is feared, it may be advisable for the operator to apply a very mild current, using the hand as one electrode. To do this it is necessary to connect one large electrode with some part of the patient which has little sensitiveness, while the operator holds the other electrode in one hand,

and applies the free hand to the surface of the patient. There are certain advantages arising from this procedure; the hand can be better adapted to all the inequalities of the surface than any instrument; the arms and hands of the operator thus interposed in the circuit act the part of a rheostat in modifying the current, and it is possible to judge of the strength of the current passing through the circuit. The disadvantages which will readily occur to any physician are so many, that it is advisable to reserve this method for exceptional cases. It is highly recommended by some authors, who state that it produces no injurious effect upon the operator, even when practiced for many hours daily. Patients are quite apt to be curious in regard to this point, and it is not easy to explain why electricity is expected to materially benefit them, and at the same time produce absolutely no effect on the operator, through whom it is first carried. It may be true that with a battery of feeble power no marked effect is produced, but it is a different affair when the energetic zinc and carbon battery is in question. Electrodes in such variety are now provided, that it is no longer *necessary* to use the hand at all. The location of electrodes exerts an important influence upon the effect of the current; placed very near together, electricity is concentrated, and produces a much greater effect upon the tissues between the electrodes than when the latter are far apart, since in this case the current branches diverge, taking the paths of least resistance. As a rule, the electrodes are placed far apart in general, and near together in localized electrization.

Electrode covers. Large sponges are extensively employed for general electrodes; when moist, they are excellent conductors, can be readily adapted to different parts of the surface, and produce the effect of a rheostat in modifying the current.

It is surprising to note how extremely regardless of cleanliness even fastidious practitioners become when electrodes are in question. It is exceedingly rare to find one who provides a fresh sponge or a clean cover for each patient, and yet its importance will be readily admitted. Sponge very quickly becomes foul, it is capable of conveying contagious material, it is difficult to dry, and soon corrodes the surface to which it is fastened, impairs conduction of current, and when packed with other instruments causes them to rust. Manufacturers supply sponge-covered electrodes because such are demanded by the profession; but the latter would never consent to have applied to their own persons the filthy sponges reeking in the accumulations of perspiration and other excretions derived from the mucous and cutaneous surfaces of many individuals, the clean and dirty alike, which *some*, at least, do not scruple to apply to their patients. For a universal electrode, the one provided with a carbon disc is incomparably superior to those of ordinary metal, sponge-covered.

If metal is preferred, one like Fig. 86 is convenient, as the sponge, or cover, can be fastened on or removed in an instant, and each patient be provided with a separate one.

To purify sponge Electrodes. It is said that sponges that have been soaked in pus and infectious materials may be not only perfectly purified, but even the marine odor may be restored, by the following process: Soak them in a four per cent solution permanganate of potash, then in twenty-five per cent solution sulphurous acid, finally wash in abundance of water.*

A bag made of waterproof material is useful for carrying sponge, and with an adjustable handle, and due attention to cleansing and disinfection, most of the objections to sponge may be overcome. Its numerous excellent qualities for electrical purposes make it almost indispensable. When it is impossible

* *American Journal of Pharmacy*, Vol. xliv, p. 335.

to provide a sufficient supply of sponges, or to keep them in good order, thin flannel covers should be substituted for them. They may be bound with elastic tape or rubber bands, can then be slipped over a sponge or metal electrode, and are self-retaining.

The flannel should be wet when used. The current does not pass quite so readily through this as through sponge alone, but if the battery supplies a current of sufficient electro-motive force to penetrate deeply into the tissues, it can overcome the resistance of the covers sufficiently for all practical purposes. The covers are inexpensive, may be laundried, and serve repeatedly.

The various styles of electrodes will be described in connection with the diseases in which they are employed.

CHAPTER VIII.

ELECTRO-THERMAL BATHS.

The application of franklinism as an electric bath has been described on page 76. Dynamic electricity is applied in conjunction with water, vapor or hot air, under the general name of electro-thermal baths.

Galvanism has been applied through the bath with the idea of extracting certain metals from the body, and also to introduce medicinal substances into it, but there is no well-established proof that either can be done. The bath is advantageously employed when general applications of either the galvanic or faradic current are to be made.

Volta, Humboldt, Ritter, Weber, Lentz, etc., experimented to determine the comparative resistance offered by the skin. Weber asserts that a thin, moist and cold epidermis opposes a greater resistance than the rest of the body, but a dry epidermis offers fifty times greater. Owing to this, when conductors are in contact with skin, the galvanic current does not spread over its surface, but, penetrating it, flows inside the body to some other part of the epidermis. Resistance is greatly diminished by long soaking in water, or when the capillaries are filled with blood. Lenz and Du Bois-Reymond found that resistance of the body is nearly inversely to the extent of wet skin in contact with the electrodes. The effect depends to some extent upon the temperature of the water ; to the effect produced by an ordinary bath at a given temperature is added that which results from the electric current. It is believed that there is less liability to take cold than when an electric current is not employed, and greater tolerance of electricity when given through the bath than when a general application is made without the bath.

Tepid baths are those from 85° to 95° F. Their effect, independent of the current, is confined to the peripheral extremities of the nerves; they produce a sensation of either heat or cold, according to the temperature of the body at the time of immersion. They are not followed by reaction, and may be continued longer than any other variety of bath. They cleanse the skin, promote perspiration, and allay thirst. If there is a tendency to apoplexy, cold water should be applied to the head while the patient is in the bath. The effect of electricity will vary according to the kind of current that is employed, the direction of the current, and its strength. These should be determined by the same rules that guide us in ordinary electrizations. It is important that caution should be exercised in applying the *galvanic current* in the bath, since it produces very slight sensation, and there is a temptation to join too many cells in circuit. Six to twelve zinc-carbon, or possibly eighteen gravity cells may be well borne, but the effect of galvanism upon the patient should be observed before employing the largest number of cells named.

The warm bath has a temperature of 96° to 104°; this causes a sensation of warmth, or coolness, according to the condition of the skin on entering the bath. It increases the circulation and perspiration, and quickens the respiration. It produces relaxation of muscles, languor and a tendency to sleep. It is employed to assist in the reduction of dislocations of the larger joints, and herniæ. It is used with the greatest advantage in the passage of calculi, whether urinary or biliary: it relaxes the ducts, and thereby alleviates the pain, and facilitates the passage of the concretion. In inflammations of the stomach, kidneys, bowels, bladder, it has proven a valuable and powerful agent; eruptive diseases, such as scarlet fever, measles, etc., when the eruption has receded from the surface; in chronic skin diseases, rheumatism, amenorrhea and dysmenorrhea, it is highly serviceable.

The hot bath has a temperature of 102° to 110°. This causes a sensation of heat, renders the pulse stronger and fuller, quickens respiration, produces at first intense redness of the skin, resulting later in profuse perspiration; it occasions violent throbbing and fullness of the head, with frequently a feeling of suffocation and anxiety; being a powerful excitant, it must be used with caution. It is employed principally in paralysis, rheumatism, and some other chronic diseases; it is also employed in collapse, and has proven valuable in this stage of cholera.

Very hot baths comprise everything above 110°; over 120° they are scalding. A bath from 119° to 126° causes a rise of 2° to 4½° in the temperature of the blood, and can be borne but a few minutes. It produces violent reflex action on the heart and arterial system, great congestion of the skin, followed by excessive perspiration.

Objections to the electric bath. Numerous objections have been made to this method of applying electricity, on the ground that it is depressing in its effect, produces chilliness, has been known to precipitate attacks of apoplexy, heart affections, fainting, and even death. There are persons who cannot take an ordinary bath without great depression or chilliness following it. Electric baths are contra-indicated in these cases.

In regard to the accidents referred to, electric baths can never cause them if administered with ordinary prudence unless the patient is in such a condition that the attack is inevitable. It is scarcely necessary to add that such patients should never be permitted to take an electric bath.

These baths should not be taken immediately after eating; they may be repeated from one to three times weekly. They should not be given when strictly local treatment is required.

When a feeling of languor or debility follows for some hours, it is an indicatior that too powerful a current was employed, that it was continued too long, or that it is not adapted to the case. Electric baths of suitable strength, and administered with judgment, will not disagree except with patients who cannot tolerate immersion in a simple water bath.

METHOD OF EMPLOYING THE ELECTRIC BATH.

The tub shown in Fig. 66 should be filled a few inches above the stationary electrodes with water of the temperature required. This should always be determined by the thermometer. The patient, after removing the clothing, wraps up in a dry sheet and steps into the tub *before the circuit is closed.* (The sheet is retained around the patient until the bath is over.) An oil silk or rubber cap, made in the form of a "sweeping cap," should be snugly drawn over the hair to protect it from moisture, and the rack raised high enough to keep the head out of the water. The galvanic or faradic circuit is completed and the switches on the apparatus are arranged to send the current through the parts to be treated.

The bath, as a rule, should not continue longer than fifteen to twenty minutes, unless tepid water is employed, and even in that case electricity should not be applied longer than the time named, with rare exceptions. The patient may step out of the bath upon a rug or carpet (never upon oilcloth or the bare floor) and be quickly dried. The towels should be dry and warm when used; and usually after the bath, if its temperature has been above that of tepid water, it is advisable to cool the surface by showering with water that is at first warm and gradually cooled down to about 90°, or a little lower in cold weather, for two or three minutes, after which the patient exercises the muscles in drying the surface, so as to cause a reaction and prevent chilliness. This measure is not of so much importance after a faradic as after a galvanic bath. A delay of twenty to thirty minutes before going into the open air is desirable. The therapeutical effects of these two baths differ; one should not be substituted for the other. The reader is referred to the article on differential diagnosis for suggestions in regard to selection of current.

THE MCINTOSH OFFICE AND BATH APPARATUS.

Fig. 65 represents an attractive and valuable apparatus designed for office practice, and also including the necessary attachments for the electric bath. The switches, binding posts and all metal parts are heavily nickel-plated, and mounted on highly-polished black rubber, which not only affords an effective contrast, but enhances the durability of the apparatus. It furnishes a galvanic current from any number of cells required. The faradic coil is constructed on an original plan, by means of which currents are produced possessing much greater quantity than ordinary induction current; they are consequently smoother and at the same time more efficient. They can be graduated so as to be suitable for the most delicate organ and sensitive patient, or increased to a strength which enables them to overcome an enormous resistance in the external circuit. Faradic coils of usual size are not sufficiently powerful for all the requirements of the bath.

THE BATH-TUB.

The bath-tub for electrical purposes must be made of some non-conducting material, such as wood, soapstone, porcelain, vulcanized rubber or glass. When economy must be consulted, wood or rubber-cloth tubs must be selected. The latter are neither very durable or convenient (since no permanent connection with water or drain pipes can be made), therefore wooden tubs are to be preferred. The inside must be kept well painted, otherwise the wood will become water-soaked, and in consequence a good conductor of electricity. The size of the tub shown in the illustration is sufficient for almost any patient. The rack is fastened to the tub, at its lower edge, by hinges, which permit it to be raised to accommodate a patient of short stature; hooks attached to it (not shown in cut) fasten it to the sides of the tub at any angle required. The electrodes at the head and foot cannot be seen; they are of the same material as those in the sides of the tub, which are of carbon or nickel-plated brass.

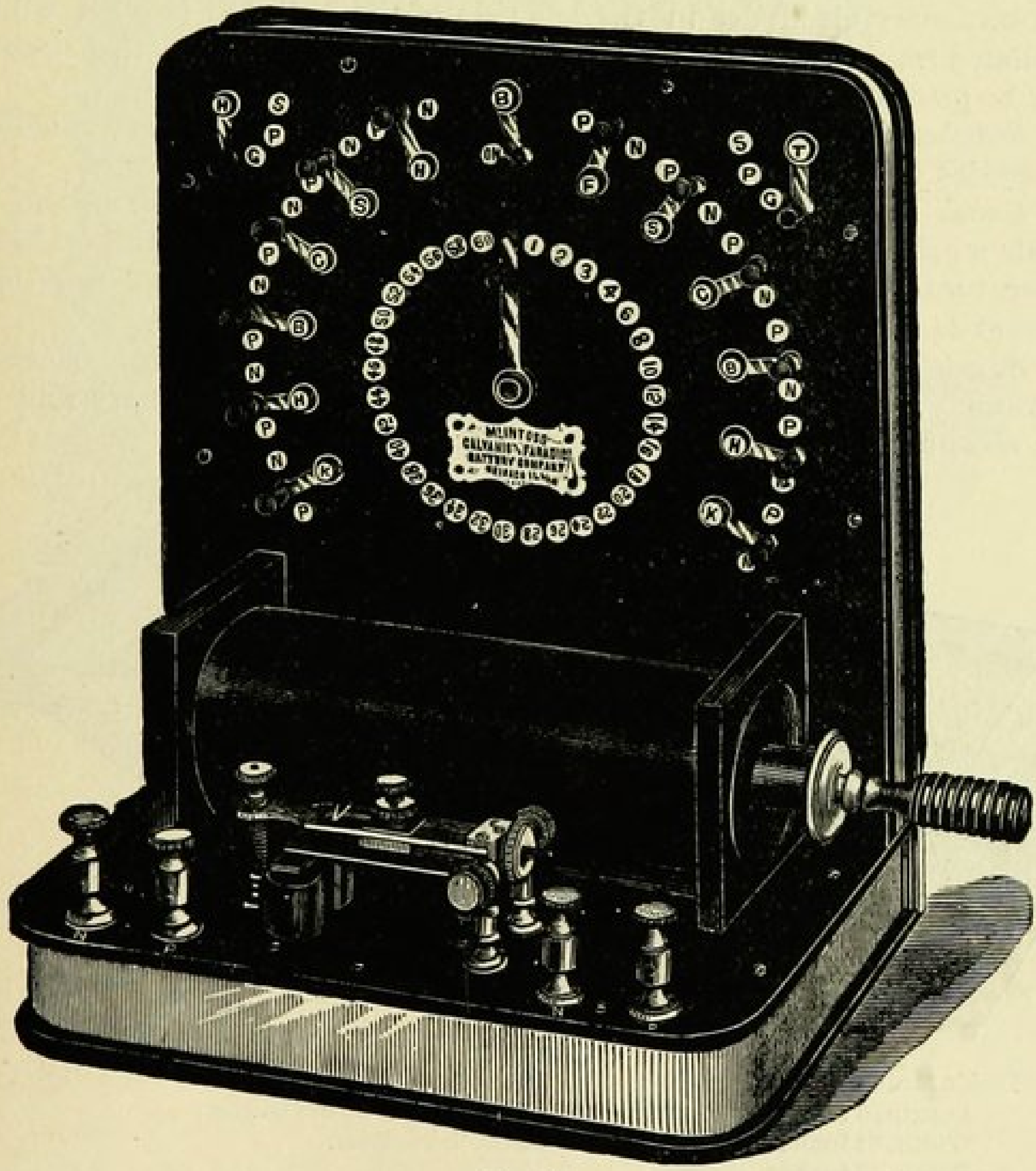


Fig. 65.

McINTOSH OFFICE AND BATH APPARATUS No. 1.

Horizontal base, 15 × 10½ inches. Upright base, 18½ × 15 inches.

The horizontal base has arranged upon it the large faradic coil, rheotome and two pairs of binding posts. The faradic coil is operated by the tray cell, Fig. 23.

The upright base. The circle of buttons in the center, numbered from 1 to 60, are connected with sixty gravity cells, and are used only to supply a galvanic current. (These may be arranged for a greater or less number of cells.)

The switch in the center is represented turned on button O, between 60 and 1, which has no connection with the cells. It is called the *galvanic switch.*

The switch above, marked B, is called the *battery* switch; it is turned "on" when the faradic current is used, and at no other time.

The switches marked H, S, C, B, H, K, on the left, are connected with the stationary electrodes in the left side of the bath-tub (see Fig. 66) by insulated copper wires; these wires may be of any length, so that the tub can be placed in a room distant from the apparatus.

Switches F, S, C, etc., on the right are connected with the stationary electrodes in the right side of the tub.

Switch H, at the upper left-hand corner, when turned on button G, sends a *galvanic* current through the *binding posts* on the horizontal base; when turned on P, a *primary faradic* current, and on S a *secondary faradic* current is sent through the *binding posts.*

Switch T, at the upper right-hand corner, when turned on G, sends a galvanic current through *the tub*; when turned on P, a primary and on S a secondary faradic current through *the tub.*

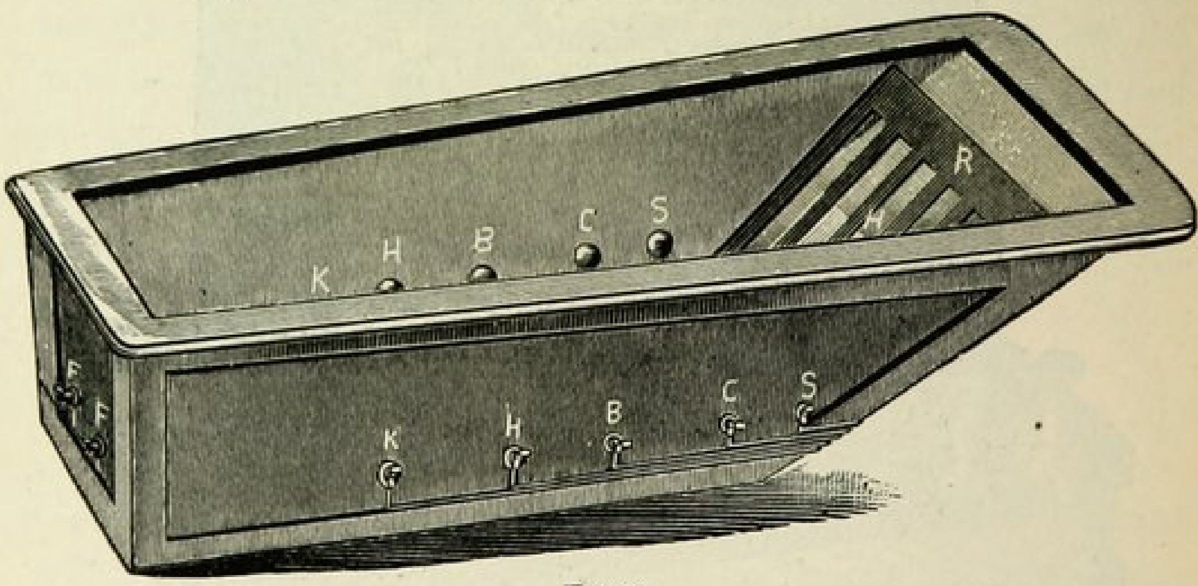


FIG. 66.

Inside measurements:

Length, 6 feet 2 inches at the top; 4 feet 2 inches at the bottom.

Width, 22 inches at the top; 19 inches at the bottom.

Depth, 17 inches.

R, rack; H, electrode fastened to head of the tub; F F, electrode fastened to foot of the tub; S S, shoulder electrode, so called because when one is connected with the positive and the other with the negative pole of the apparatus, a current passes through the shoulders; C C, chest electrodes; B B, back electrodes; H H, hip electrodes; K K, knee electrodes.

These are connected by insulated copper wires with buttons on the table plate or switch-board, marked with the same letters, so that, with the tub in one room and the switch-board in another, the operator can manipulate the switches and send a current through any part of the patient in the tub.

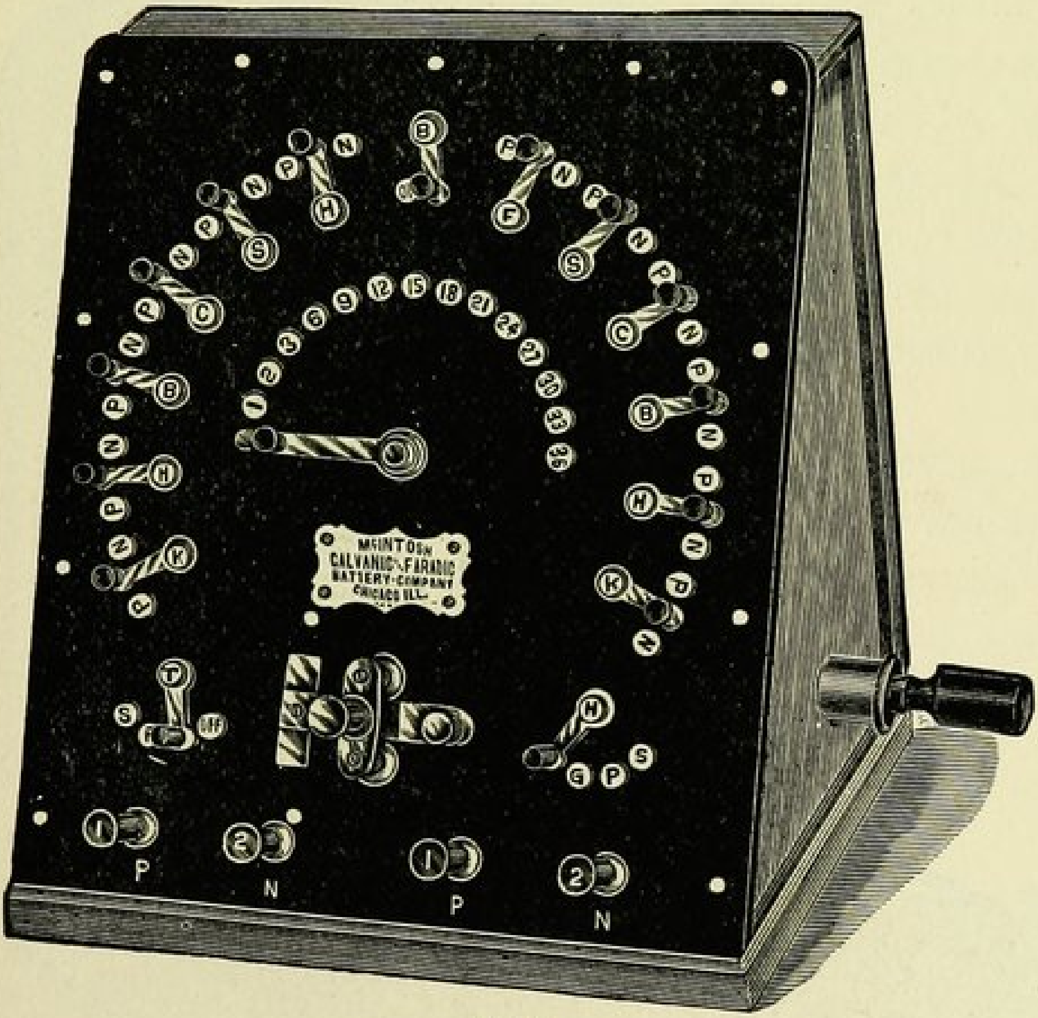


Fig 67.

COMBINED OFFICE AND BATH APPARATUS NO. 2.

Base, 11 × 14½ inches. Front, 16 × 14½ inches.

This apparatus is constructed on the same principle as No. 1, but on a less expensive plan. The coil is inclosed in a triangular wooden case, the front of which is composed of polished black rubber. The switches, binding posts and rheotome are nickel-plated and arranged on the sloping front. Any number of galvanic cells may be used with it; the tray cell is connected with the coil. The apparatus is manipulated in the manner described under Fig. 65.

This beautiful and elaborate apparatus is especially designed for hospitals, health institutions and medical-bath establishments, where many patients are treated. It may be connected with one bath-tub and one cabinet-bath, in separate rooms, and while sup-

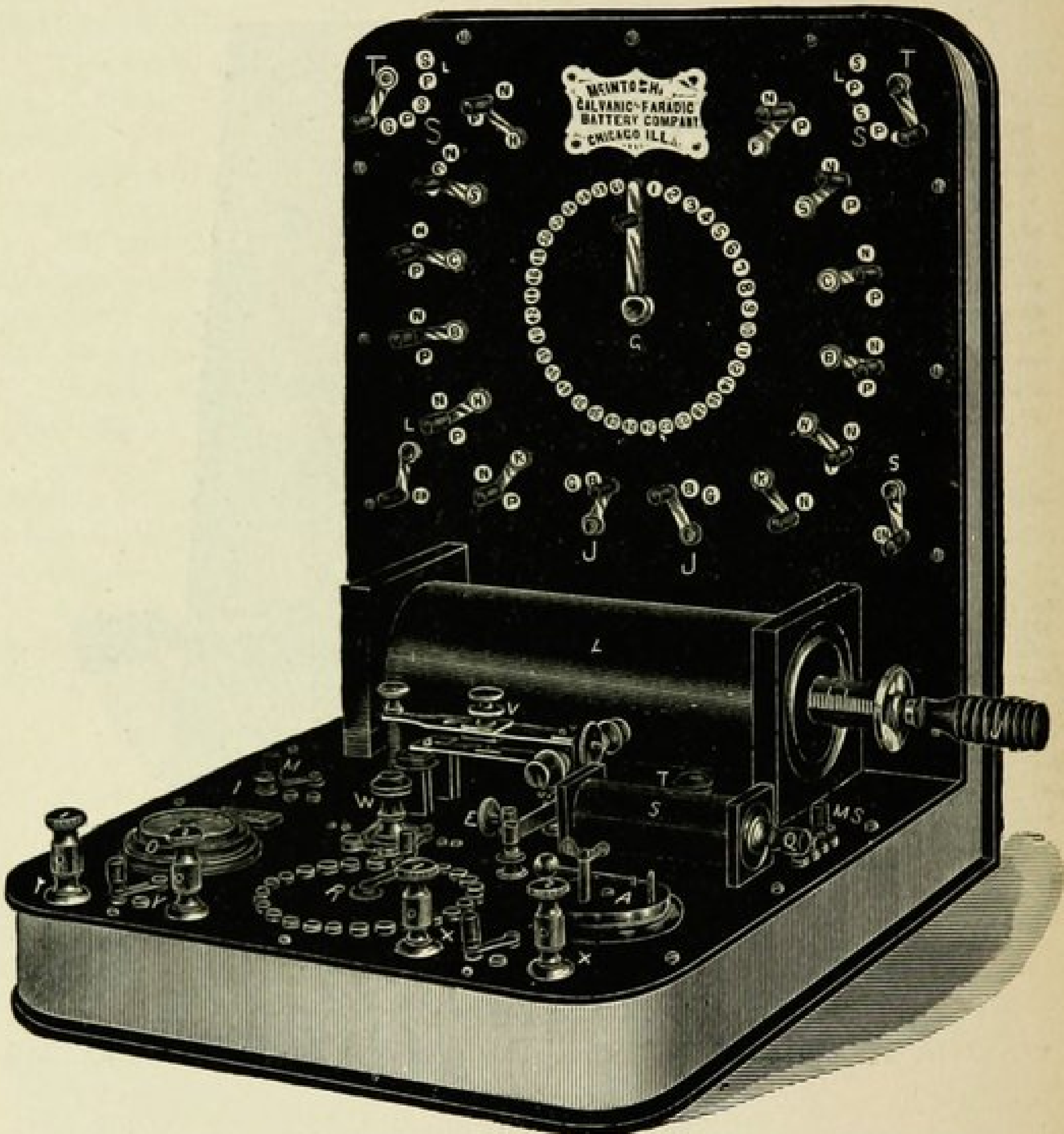


FIG. 68

McINTOSH COMBINED OFFICE AND BATH APPARATUS.
Size of horizontal base, 18 × 20 in. Size of upright base, 18 × 20 in.

plying a current to them, can at the same time be employed in treating two patients in the operating room. The metal work is all heavily nickel-plated, and mounted on polished black rubber, which presents a pleasing contrast, in addition to the perfect insulation secured by the use of the rubber, and the durability of the metal parts, protected as they are by the nickel-plate, which is not easily tarnished or corroded.

It is constructed on a plan similar to No. 1, but has several accessories not found on any other electrical apparatus.

The galvanic current is supplied from any number of gravity cells that may be required. The faradic current for the bath is supplied by the large coil connected with a tray cell. The small coil to be used either for office electrization or the cabinet bath, is connected either with the tray cell or the requisite number of gravity cells, according to the arrangement of the switches J J.

The greatest number of currents that possess distinct therapeutical effects ever obtained from any single apparatus is supplied by the one illustrated in Fig. 68. Those interested in learning further particulars in regard to it are referred to the manufacturers.

VAPOR AND HOT-AIR ELECTRIC BATHS.

The application of electricity in conjunction with vapor of water or dry air possesses certain therapeutical advantages over other forms of electrization that are not at present fully appreciated by the profession at large. Patients in whom immersion in water produces great depression or alarming symptoms can be submitted to the vapor or hot-air electric bath, when the head is not exposed to heat, not only without any disagreeable effects, but with positive benefit in diseases which it would be exceedingly rash to treat with the electric water bath. Hot air, at a temperature of 90° to 100° F. produces perspiration, and is adapted to chronic rheumatism, stiffness of joints and chronic skin diseases; at a temperature of from 100° to 130° it is stimulating, and promotes perspiration; it is a powerful remedial agent in all acute cases where, from any cause, the blood has receded from the superficial parts of the body and the internal organs are in a state of congestion. Patients suffering from the preliminary symptoms of delirium tremens have been preserved from an attack by several of these hot-air electric baths given in quick succession. The vapor of water cannot be borne so long as hot air, or at so high a degree of temperature, because vapor, being a bad conductor of heat, prevents radiation from the body; 106° to 110° is usually the limit. Vapor electric baths are more relaxing and soothing than hot air. They soften the cutaneous tissues, fill the capillaries, and bring about that very condition which favors conduction of electricity. They are adapted to dry, scaly skin eruptions, old paralytic cases without signs of vascular excitement of the brain; chlorosis, amenorrhea, irritable uterus; dropsy of aged, debilitated subjects; old liver complaints, and some scrofulous affections. The advantages to be derived from the vapor and hot-air electric baths were formerly out of the reach of the ordinary practitioner, because they were supposed to require an establishment fitted up especially for the purpose, which involved too great an outlay to be feasible, except in the larger cities.

THE CABINET BATH.

The Cabinet Bath, constructed for the purpose of combining the application of hot vapor or air with any form of electrization enables the practitioner, in the most sparsely settled localities, to avail himself, at a trifling expense, of all the remedial advantages to be obtained in the most expensive bath establishments.

The apparatus, described below, is simple, convenient, occupies but a limited space, and can be used in offices where it is not possible to furnish the conveniences for the water bath. It is not even essential that a dressing-room be provided, and the supply of water may be very limited; with the hot-air bath two quarts of water per patient will suffice for all necessary cleansing; vapor will require in all nearly a gallon. Any style of portable or stationary electrical apparatus may be employed to supply electricity.

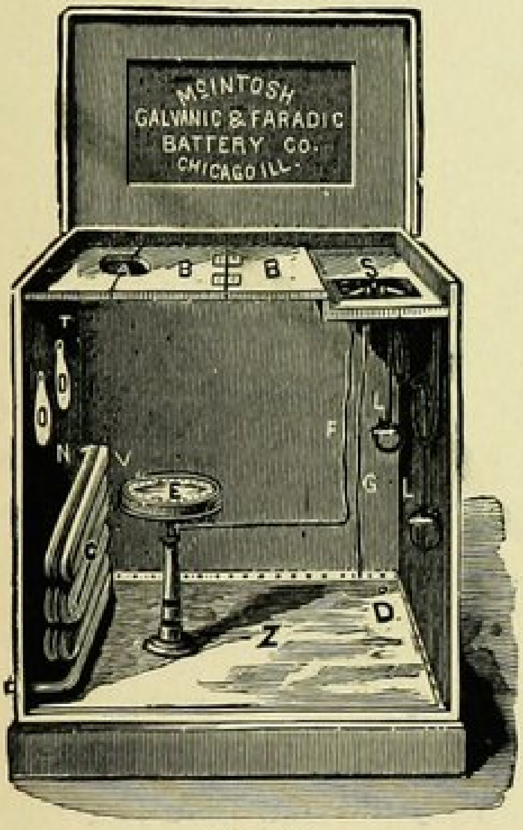


FIG. 69.

CABINET BATH.

Length, 3½ feet. Width, 2¼ feet. Height, 4 feet.

The apparatus in Fig. 69 is shown with the cover raised and the front removed.

BB. Folding and sliding cover.

S. Depression for holding switch-board and electrodes.

E. Revolving stool.

Z. Zinc, lining the bottom of the cabinet.

OO. Openings through which the operator can manipulate the electrodes.

LL. Flexible electrode connections, to which spring electrodes are attached.

G. Wire which connects the switch-board with the zinc when the latter is used for a foot-plate.

F. Wire connecting switch-board with stool.

C. Steam coil.

N. The pipe where steam enters the coil.

V. Valve to admit steam or vapor into the cabinet.

D. Drain pipe.

T. Marks the location of the thermometer, which fits in a groove in the box, permitting the temperature to be observed without opening the bath.

A. The opening for the patient's neck.

The heat is supplied by steam from a tin or copper vessel heated by a coal-oil or gasoline stove which sets outside the bath. A tin pipe or rubber hose connects the vessel with the coil within the cabinet. There is no possibility of explosion or accident within the bath, because the steam coil opens outside at the lower end to permit escape of the condensed steam, and the heater is also outside. Steam is admitted from valve V in a downward direction to prevent its striking the patient seated on the stool. After the water begins to boil, it requires from fifteen to twenty minutes to raise the temperature to 130° with a small coal-oil heater.

To give a hot-air electric bath. If there is no dressing-room, let the patient disrobe in the cabinet, first folding and sliding B B out of the way, closing the door and spreading a sheet or blanket from the raised top, over the cabinet to conceal the patient; remove the clothing from the bath; let the patient be seated on the stool adjusted at such a height as to permit the patient's neck to come within the space A; unfold B B and slide it along its groove to close the bath; the space around the neck must be covered with a towel loosely laid about it. General electrization is accomplished by making Z a foot-plate, while the operator reaching through O O at the back of the patient, or a similar opening in the door at the side, carries the electrode over the surface in the same manner as when treating the patient without the bath. If electricity is to be localized, electrodes L L are adjusted to the parts to be treated (the springs hold them in place), and the current is sent through them from switch-board S, to which the apparatus supplying electricity is joined by conducting cords. If perspiration is not started within ten minutes (the temperature should be from 90° to 100° when the patient enters the bath), turn V and let in a little steam to moisten the patient slightly, then close it; this usually causes profuse perspiration immediately. Should the patient appear faint, or complain of headache, moisten the forehead with cold water from time to time, and permit cold water to be drank freely; at the end of twenty or thirty minutes, shut off the heat and rinse off the patient, still within the cabinet, with warm or cool water, as the judgment of the operator may dictate. A common sprinkling-pot may be employed for this purpose, if nothing better is at hand. The room in which the bath is given should be well ventilated. Steam electric baths are given in the same manner. After the patient is thoroughly dried, the clothing may be replaced before leaving the cabinet in case the air in the room is not sufficiently warm to prevent a chill in passing from the bath to dressing-room.

ELECTRIC CHAIRS.

Electric chairs are intended to be used in applying electricity in office practice. The one illustrated in Fig. 70 is manufactured by the McIntosh Galvanic and Faradic Battery Co., and is an ornamental piece of apparatus worthy of a place in the most elegantly-appointed office. Any form of current electricity may be applied through it. The physician who is provided with a good portable battery can attach it to the chair, and thus provide himself, at a comparatively small outlay, with an office outfit that will compare favorably in convenience and attractiveness with the most elaborate and expensive apparatus in the market. As represented here, this chair is designed for office purposes. The same company also manufacture a cabinet bath after a much more elaborate design than shown in Fig. 69, of which the chair forms a part; the connections are so arranged that the chair may be taken out of the cabinet to be employed in the office, and replaced in the cabinet in a few moments, ready for the bath.

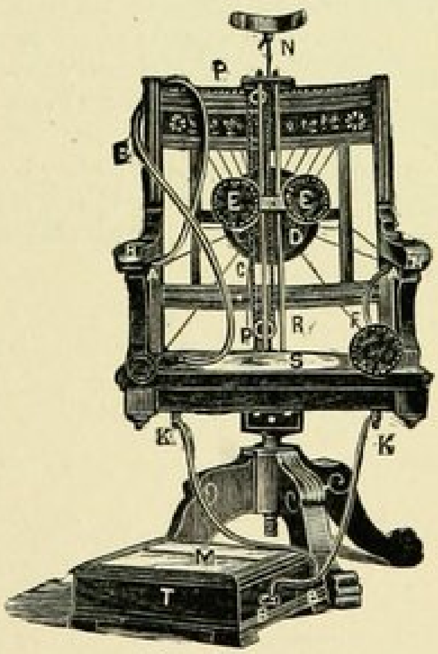


FIG. 70.

R. Two rods extending the length of the chair-back, upon which moves a sliding bar.

E E. Sponge-covered electrodes fastened upon a metal crosspiece upon which they may be moved near together or apart. The crosspiece is fastened to the sliding bar by a pivot, about which it revolves so that the electrodes may be horizontal, as shown in cut, perpendicular, or at any angle; one electrode may be removed and the other turned in any position required.

P P. Pulleys which carry a chain C.

C. The chain which raises or lowers the sliding bar on the rods R.

D. The switch-board on the back of the chair, also shown in Fig. 71.

N. Neck electrode adjusted on a metal rod by means of a thumbscrew. It may be turned in any direction, raised, lowered, or removed altogether.

F F. Flexible insulated metallic conductors attached to the arms of the chair. They terminate in sponge-covered electrodes in the illustration, but any style of electrode may be attached. These conductors are of sufficient length to reach any part of the patient sitting in the chair. They may be removed entirely.

A A. Binding posts to which the conductors are fastened.

H H. Metallic plates fastened on the end of the chair-arms, upon which the patient's hands rest when a current is to be sent through them.

S. Metal plate, or seat electrode.

K K. Binding posts to which are fastened the cords connecting the footstool T with the chair.

B B. Binding posts on the footstool T.

M. Metal foot plates attached to T.

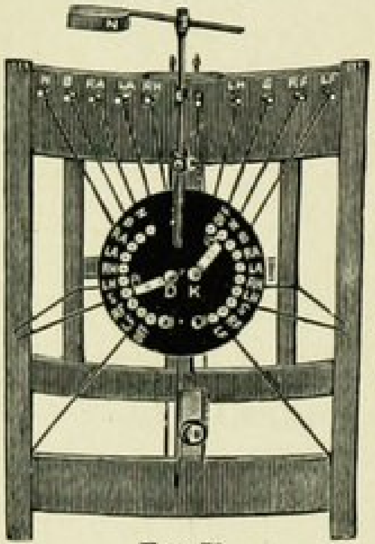


FIG. 71.
BACK OF CHAIR.

The circular switch-board in the center is made of polished rubber, and all the metallic attachments to the chair are nickel plated.

The two binding posts on the lower part of the switch-board are connected with the cells or battery, which furnish the current. The polarity of the buttons depends upon the method of connecting the battery; if the positive pole be joined to the binding post on the right, the semi-circle of buttons on the right will be positive; if the negative be joined to this binding post, the buttons on the right will be negative. In either case the buttons on the left will have opposite polarity.

D K, switches or current directors. They also serve as pole changers.

Off, the buttons upon which the switches are turned to open the circuit.

N, neck; B, back· A, arm; H, hand; S, seat; F, foot.

L and R, prefixed, respectively indicate the left and right side.

The direction of the current passing through the patient will depend upon the position of the switches.

The row of binding posts across the top are lettered to correspond with the buttons on the switch-board. They are only used when the chair is employed in the cabinet. Connecting wires from a switch-board outside the cabinet, similar to the one here shown, are joined to this row of binding posts on the chair so that the operator can, from the outside, apply the current accurately to the different parts of the patient inside the cabinet.

C, the thumbscrew which fastens the rod carrying the neck electrode at any height.

D, wheel which turns the chain that moves electrodes E E in Fig. 70. It prevents the chain from rolling over the pulleys except when necessary.

The wires which extend from the switch-board to the sides of the chair-back form the connections through which electricity is conveyed to the electrodes.

The therapeutical effect of a current carried to a patient through an apparatus of this kind produces no other effect than that direct from the cells or battery which furnish the current, except that which may be produced through the imagination; but the convenience with which the electrodes may be manipulated and the current directed, together with the ornamental character of the apparatus, commend it to many practitioners.

CHAPTER IX.

ELECTRO-PHYSIOLOGY AND THERAPEUTICS.

It is an extremely difficult matter for the beginner in electro-therapeutics to decide in a given case which form of electricity to select. Authors, who in other respects are very explicit, have ignored this subject to such an extent that comparatively little is to be gleaned which can be regarded of practical value. There is no reason to believe that franklinic electricity is adapted only to one class of diseases, galvanism to another, and faradism to still another. There are certain diseased conditions, however, in which one form of electricity is to be preferred to another. The following pages contain the substance of what has been written on the subject of the different physiological and therapeutical effects of the various forms of electricity.

Effect on the skin. Franklinic electricity, in the form of sparks from the machine, produces, when applied to the skin, a sensation of pricking and pain. If the sparks are long, redness is produced, and frequently a papular eruption resembling lichen urticatus. It relieves cutaneous anæsthesia more quickly than either galvanism or faradism.

Galvanism excites a sensation of pricking and heat, redness, and when a powerful current is applied a long time, inflammation and sloughing of the skin and adjacent structures.

Faradism produces sensations which vary with its electromotive force, from a slight pricking to an acute burning or cutting pain, but never, even when a very powerful current is applied, produces nutritive disturbances.

Effect on the face. Franklinic electricity applied to the face produces a faint sensation of light.

Galvanism, a more or less brilliant flash according to its electro-motive force.

Faradism produces no sensation of light, but it does produce contraction of the facial muscles, and more or less severe pricking sensations.

Effect on muscles. Franklinic electricity produces muscular contractions with less pain than faradism.

Faradism has very little effect on healthy muscle deprived of its nerve influence (some observers say none), whatever be the number of interruptions.

Galvanism, on the contrary, in this case produces increased response, and this in proportion to the strength of current and slowness of interruptions.

Effect on nerves. Franklinic electricity is capable of producing reflex action from irritation of peripheral distribution of nerves. Dr. Wilks, a physician of long experience at Guy's hospital, London, where static electricity was formerly largely used, believes that "patients suffering from paraplegia, who are now *benefited* by the constant current, were previously *cured* by static electricity." It is more powerful than faradism in rousing the dormant nerve centers.

Faradism is the most powerful stimulant of healthy nerve we possess, and this increases in proportion to the strength of current and rapidity of interruption. Dr. A. Hughes Bennet* believes that practically the faradic current acts on nerve alone.

Galvanism excites both nerve and muscular fiber, but each in a different manner.

Franklinic electricity cures certain diseases by changing the electrical condition of the patient, which may be rendered positive or negative at will.

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* Electro-diagnosis in nervous diseases.

Ordinary faradic and galvanic electricity, on the other hand, do not charge the patient with electricity, neither do they leave any more electricity in the body than they find there, except as they improve nutrition.

Franklinic electricity has this advantage over galvanism and faradism: it is easily manipulated, agreeable to the patient, safe in its application to points demanding great caution with galvanism, and especially in brow neuralgias, in which the faradic current is obnoxious to many people.

GALVANISM AND FARADISM COMPARED.

Galvanism possesses great chemical, heating and magnetic properties, with comparatively small difference of potential between its poles.

Faradism has much less chemical and magnetic power but an enormous difference of potential. An idea of this difference may be obtained from the experiments of Messrs. De La Rue, Müller and Spottiswoode. They found that 1080 galvanic cells gave a spark only $\frac{1}{263}$ to $\frac{1}{250}$ inch long, while even a small faradic coil connected with one or two of the same cells gave a spark one inch long.

Galvanism is indicated in those cases in which we wish

(*a*) To excite the nerves of the skin;

(*b*) To destroy the outer skin or mucous membrane;

(*c*) To produce an increase of warmth;

(*d*) To produce a chemical process and also blood coagulation.

(*e*) In certain peripheric paralyses in which faradism fails, galvanism, probably in consequence of its uninterrupted duration, produces effects which cannot be brought about by the necessarily rapidly interrupted faradic current.

(*f*) When a muscle has lost all power of responding to the stimulus of a faradic current, in many cases its sensitiveness may be restored by the application of a tolerably strong galvanic current.

Faradism is indicated where we wish

(*a*) To excite either the motor or sensory nerves ;

(*b*) To produce contractions of the blood or lymphatic vessels ;

(*c*) To affect certain organs supplied by the sympathetic nerve ;

(*d*) To increase the volume of a muscle. This it accomplishes through exciting muscular contraction, which increases the temperature and at the same time improves its nutrition.

(*e*) To relax a tense muscle, or to loosen a peripheric contractor, single shocks from a strong faradic current are generally more useful than the galvanic.

Galvanism not only acts as a powerful stimulant to nerves and muscles when interrupted, but during the time it is passing without interruption it produces a marked alteration in nutrition. To this effect Remak gave the name *catalytic action.*

When paralyzed muscles exhibit the reaction of degeneration they are more sensitive to galvanism than faradism, therefore the former should be selected to improve their nutrition.

With this exception faradism is a more powerful agent in the direct treatment of paralyzed muscles than galvanism.

COMPARISON OF THE THERAPEUTICAL EFFECT OF GALVANIC AND FARADIC CURRENTS.

According to Dr. Rockwell,* in paralysis of one side of the body, when the muscles contract more readily under the influence of electricity than in health, electricity if used at all should be in the form of a very mild *faradic* current; even though the muscular contractions are not excited quite so readily as in a normal condition, the faradic is still to be

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*Dr. A. D. Rockwell, M. M.D., Electro-Therapeutist to the New York State Woman's Hospital; Author of Medical and Surgical Electricity.

preferred. On the contrary, when the contractility of the muscles is very greatly diminished, the *galvanic* current is indicated, the faradic being only employed after the muscles begin to contract under its influence. In most cases of paralysis of the lower half of the body there will be found, after a short time, more or less complete loss of farado-muscular contractility; the *galvanic* current alone is useful in these cases to restore nerve excitability, although the *faradic* may be usefully employed to improve the impaired nutrition of the paralyzed members.

Facial paralysis resulting from cold illustrates the difference in reaction of the two currents. In these cases the *faradic* current does not cause contractions, while a much weaker *galvanic* current than is required in health, excites muscular contractions. As the patient improves a stronger galvanic current must be used, until finally the muscles will again respond to faradism. Neuralgia, when pressure over the affected nerves aggravates pain, is generally relieved by a *galvanic* current, while the *faradic* current has greater power to relieve when firm pressure does not increase the pain. Cases of hysterical hyperæsthesia, when slight pressure increases distress while firm and prolonged pressure lessens it, are relieved by *faradism*, the *galvanic* current having very little effect over them. General debility is benefited by the faradic current, which seems to exert a constitutional tonic effect in these cases. The tonic effect undoubtedly, to some extent, is due to the mechanical agitations of the superficial and even deeper seated nerve and muscular fiber.

Dr. Jacobi* mentions one class of cases that will terminate fatally unless treated energetically and promptly—namely, that in which the patient suffers from paralysis of the respiratory muscles in diphtheria. Sometimes this occurs in other par-

*Medical Record, January 1883.

alyses, and unless quickly relieved the patient dies of apnœa. A strong faradic current should be applied and frequently repeated.

MOTOR POINTS.

Electro-therapeutics requires a knowledge of those points of the body where the nerves, muscles, and organs beneath, may be most directly reached. Duchenne* carefully investigated the action of the faradic current upon separate muscles, and found that, contrary to the teachings of many anatomical text-books, most movements are caused by a single muscle, and not by the simultaneous action of different muscles. He found that, when the faradic current was directed to some particular points on the skin, muscular contraction was more readily produced than at other points, and these he called "points of election." Remak,† who tried similar experiments with the galvanic current, discovered that these points were where the *motor nerves* enter the muscle. Ziemssen‡ still further developed the theory of Duchenne, and first clinically determined the precise location of the motor points, and marked them on the skin with nitrate of silver. He afterward dissected the motor branches of the nerves in dead bodies, and marked their points of entrance into the muscles, when it was discovered that the two series of experiments completely agreed with one another. A third series of experiments was undertaken on bodies immediately after death, before the excitability of nerves and muscles had disappeared. The motor points were first determined by faradization, marked with nitrate of silver, and afterward dissected to see whether they really corresponded to the points of entrance of the motor nerves into the muscular substance, which was found to be the case. These points are illustrated in Fig. 72, and fully described in the following pages.

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* Physiologie des Mouvements. Paris, 1867.

† De L'Application, etc., p. 27.

‡ Die Elektricität in der Medicin, 1872.

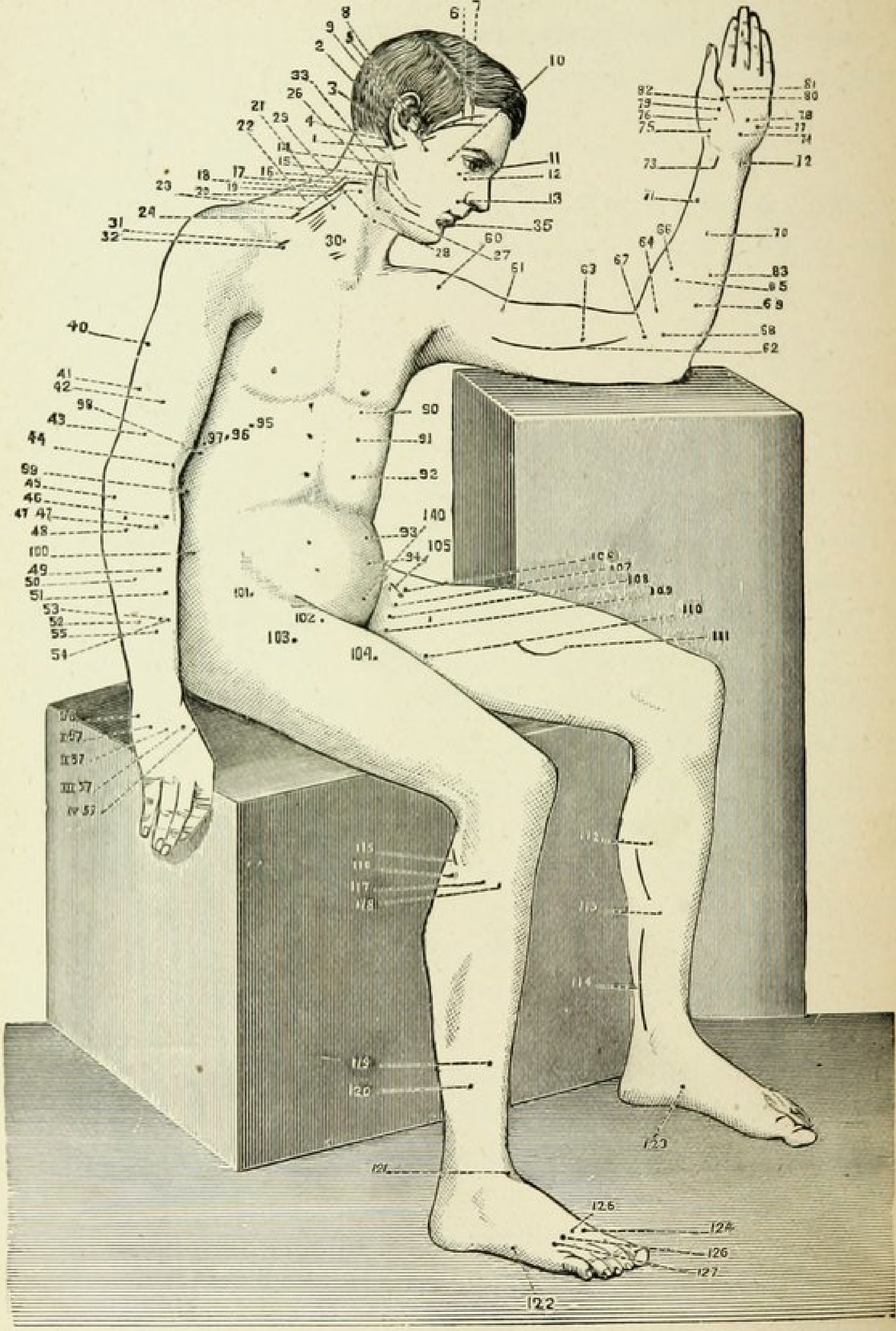

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Fig. 72.

MOTOR POINTS CONCERNED IN VARIOUS MOVEMENTS OF THE BODY.

The Face—
- Drawn to either side, 1, 18.
- " upward, 18.
- Wrinkled, 1, 3, 4, 6, 9.
- Rotated, 18.

Eyes—
- Closed, 1, 8.
- Opened, 8, 3.

Ears—
- Drawn backward, 2.
- " upward, 2, 5.
- " forward, 5.

Mouth—
- Drawn obliquely downward, 1, 15, 26, 33, 35.
- Contracted, 14.
- Outward, 9, 10, 15, 19, 26, 33.
- Upward, 9 10, 11, 13.

Tongue—
- Shortened, 27.
- Curved sidewise, 27.

Nose—
- Obliquely downward, 1.
- " upward, 11.
- Wrinkled, 12.

Forehead—
- Wrinkled horizontally, 3, 6.
- " vertically, 7.

Eyebrow—
- Drawn downward, 7, 12.
- " inward, 7, 12.

Lower Jaw—
- Depressed, 15, 19.
- Protruded, 18.

Head—
- Turned to shoulder, 15, 16, 17, 18, 19.
- " down, 18.
- " backward, 17, 18.
- " forward, 15, 18, 19.

Neck—
- Bent forward, 15, 17, 18, 28, 30.
- " backward, 17, 18, 22.
- " to either side, 16.
- Wrinkled, 19, 15.

Shoulder—
- Raised, 17, 18.
- Backward, 18.
- Inward, 18.
- Depressed, 60.

Scapula—
- Drawn toward spine, 17, 18, 20, 22.
- " upward, 20, 18, 22.
- " forward, 23, 20.
- " outward, 23.

Ribs—
- Lifted up, 21, 22.
- Depressed, 95, 96, 97, 98, 100.
- Backward, 95, 96, 97, 98, 100.
- Inward, 97, 99.

Clavicle—
- Up from thorax, 23.

Humerus—
- Outward, 24, 62.
- Forward, 31, 32, 60, 61, 64.
- Backward, 24, 60.
- Inward, 24, 32, 63, 73.

Forearm—
- Forward, 31, 41, 42, 43, 61, 62, 63, 64, 67, 74.
- Backward, 40, 41, 45, 67.
- Inward, 62, 64, 67, 69, 73, 72.
- Outward, 31, 41.

Hand—
- Flexion, 65, 66, 69, 71, 73, 62, 68, 72.
- Extension, 41, 44, 46, 47, 49, 48, 50, 52.
- Outward, 41.
- Inward, 62, 69, 62, 48, 49, 72.

Thumb—
- Extended, 41, 49, 53.
- Backward, 51, 54, 55.
- Forward across palm, 53, 71, 76, 79, 80.
- Drawn away from fingers, 49, 51, 75.

Fingers—
- Extended, 41, 47, 48, 50, 52, 57.
- Inward, 48, 56, 72.
- Flexed, 41, 57, 62, 65, 66, 70, 73, 77, 78, 81, 82, 83.

Trunk—
- Bent forward, 90, 91, 92, 93, 94, 95, 96, 97, 98.
- " backward, 18, 22, 90, 91, 92, 93, 94.
- Rotated, 95, 96, 97, 98, 100.

Abdomen—
- Contracted, 95, 96, 97, 98, 99, 100.
- Bulging outward, 21.

Pelvis—
- Bent forward, 106, 107, 102.
- " backward, 106.

Thigh—
- Forward, 101, 102, 107, 108, 109, 110, 140.
- Backward, 140.
- Inward, 106, 140.
- Outward, 107, 140.

Leg—
- Forward, 102, 103, 111, 105, 118, 120, 140.
- Backward, 102, 103, 106, 110, 111, 114.
- Extended, 102, 103, 104, 105, 111.

Foot—
- Forward, or flexed, 115, 117, 118, 120, 112.
- Backward, or extended, 104, 112, 113, 117.
- Inward, 104, 118.
- Outward, 115, 116, 117, 120.

Toes—
- Forward, or extended, 117, 119, 121, 124, 125, 126, 127.
- Backward, or flexed, 113, 114, 122, 123, 124, 125, 126, 127, 117.
- Outward, 115, 116, 117, 120, 122.
- Inward, 124, 125, 126, 127.

The muscles contributing to these movements, which cannot be stimulated by the motor points shown on Fig. 72, must be reached by direct application of the electrode to the muscles themselves.

MOTOR POINTS OF THE HUMAN BODY.

The Head.

1. Facial nerve at its exit from the stylo-mastoid foramen. This is the motor nerve of all the facial muscles of expression. If the one electrode be placed upon this point the muscles of the whole face will be stimulated; half is drawn toward that side, the skin is thrown into countless wrinkles, the eye shut and the nose and mouth are drawn obliquely downward.

2. The auriculo-posterior branch of the facial nerve; when an electrode is placed at this point the attrahens and retrahens auricular muscles are contracted, drawing the scalp downward and the ear backward and upward.

3. The branch of the facial supplied to the occipito-frontalis muscle. It wrinkles the skin of the forehead transversely, and by its interlacing with fibres of the orbicularis palpebrarum contributes to opening the eyes.

4. Branch of facial nerve passing to the tragicus and antitragicus muscles. Stimulating it causes wrinkling of the skin about the ear.

5. The auriculo-anterior branch of the facial nerve through which the attrahens and attolens auricular muscles may be stimulated. They raise the ears upward and forward.

6. Branch of facial passing to the frontalis muscle. Its stimulation causes the muscle to contract and throw the brow in horizontal wrinkles, curved slightly downward on the median line.

7. Facial branch to the corrugator supercilii muscle. When stimulated it flattens and depresses the eyebrow and draws its base downward and inward. Its maximum contraction causes the brow to cover the upper eyelid and vertically wrinkles the forehead.

8. Branch of facial to the orbicularis palpebrarum muscle which closes the eye and wrinkles up the eyelids.

9. Branch of nerve to the zygomaticus major which draws the angle of the mouth outward and upward and produces on the cheek deep wrinkles, radiating outward from this angle.

10. Branch of facial to the zygomaticus minor. Stimulation of this point is painful and draws the upper lip upward and somewhat outward.

11. Branch of facial to levator labii superioris et alæ nasi. Stimulation of this point also produces pain and lifts the upper lip and wing of the nose.

12. Facial branch to the compressor nasi which wrinkles the nose and draws the eyebrow downward and inward.

13. Branch of facial to the levator labii superioris proprius. Stimulating it produces pain and lifts the upper lip almost vertically so as to uncover the teeth.

14. The buccal branches which supply the buccinator and orbicularis oris muscles. Stimulating the buccinator draws the cheek against the teeth and contracts or compresses the lips. The orbicularis receives four branches from the facial nerve, one for each side of each lip, and can be uniformly stimulated by using four electrodes at once.

15. Infra maxillary cutaneous branches that supply the platysma. This muscle depresses the commissure of the lips and carries it outward. It helps depress the lower jaw, and wrinkles the skin of the neck transversely.

16. Subcutaneous branches of the superficialis colli supplying the anterior and lateral muscles of the neck.

17, 18. Branches of the spinal accessory nerve.

17. Accessory branch supposed to be the nerve of voice.

18. Spinal part which gives off branches to the sterno-mastoid, and terminates in the deep surface of the *trapezius*. Let the positive electrode cover 17 and 18 and both muscles will be contracted simultaneously. The neck will bend, the lower jaw protrudes, and the head is twisted toward the shoulder, which is strongly raised and drawn backward and inward.

The *sterno-cleido mastoid* muscle may be stimulated separately by placing the electrode a little lower down; it draws the head down so that the ear faces the shoulder, while the face looks somewhat upward, backward and to the opposite side.

The *trapezius* may be acted on separately by placing the positive electrode on the nerve, entering the muscle about one-half inch below motor point 17, and there results either a raising of the shoulder backward with drawing of scapula toward the spine, or a pulling of the head backward and outward, or both motions, according to the action of antagonist, of trapezius muscle on the head or shoulder.

19. The motor point of the superficialis colli branches lying beneath the platysma myoides and distributed to anterior and lateral parts of the neck. To stimulate the platysma, place the *negative* electrode on 19, and the positive near the middle of the inner margin of the sterno-cleido-mastoid muscle.

20. Nerve branch from the cervical plexus to the levator anguli scapula. Stimulation of this point draws the internal angle of the scapula upward, inward and forward, while the acromion, fixed by the weight of the arm and the action of the antagonists, moves very little.

21. *Phrenic nerve.* This is the important motor point for the production of artificial respiration. The positive electrode should be large, and must be pressed gently against the outer margin of the sterno cleido-mastoid muscle, near the omo-hyoid muscle. The result is rapid contraction of the diaphragm, bulging out of the abdomen, and the forcible entry of air into the trachea, giving rise to a sobbing sound. By faradization of this nerve it is possible to maintain respiration some time after death.

22. Motor point of the dorsalis scapulae nerves supplying the rhomboid and serratus posticus superior. When stimulated it causes the scapula to be drawn upward toward the spinal column and feebly lifts the upper ribs.

23. Motor point of the posterior thoracic nerve supplying the serratus magnus. Stimulating this causes the muscles to contract, thereby raising the acromial angle of the scapula, pushing this bone very far outward and forward, and lifting the clavicle some distance from the thorax.

24. Supra-scapular nerve supplying the supra and infra-spinatus muscles. Raises the arm, turns it outward and backward.

25.

26. Branch of facial nerve to the triangularis menti muscle. When stimulated this muscle draws the angle of the mouth downward and strongly outward, lengthening the opening between the lips, but not causing the lips to separate from each other.

27. The hypoglossus nerve, the motor nerve of the tongue which shortens and curves toward the side stimulated.

Branches of the decendens noni.
- 28. Motor point of omo-hyoid muscle. Depresses os hyoides.
- 29. Motor point of sterno-thyroid. Depresses thyroid cartilage and os hyoides.
- 30. Motor point of sterno-hyoid. Depresses os hyoides.

31. Motor point of the outer cord of the brachial plexus, from which arises the musculo-cutaneous nerve and one root of the median nerve. Stimulation of this point is painful, but it causes the simultaneous contraction of the biceps and brachialis internus muscles, which powerfully flexes forearm.

32. Anterior thoracic nerve supplying the pectoralis major. Its stimulation draws the arm far toward the median line, or adducts it to the chest, so that the elbow is on the mammillary line.

33. Branch of facial supplying the depressor labii inferioris, which draws the lip downward and outward.

34.

35. Also a motor point of the depressor labii inferioris.

40. Branch of radial nerve supplying the outer head of the triceps.

41. Radial nerve. Stimulation causes supination of forearm with extension of hand and thumb, and extension of first phalanges of the other fingers.

42. Branch of radial nerve supplying the brachialis anticus muscle. To stimulate this muscle the positive electrode must be placed where the lower half or third of the biceps begins, pushing the median nerve aside, while the negative electrode rests on the outer edge of the other muscle. It bends the forearm on the arm.

43. Branch of radial nerve (covered over by muscle) distributed to the supinator longus. When the latter contracts it flexes the forearm on the arm in a position between pronation and supination.

44. Branch of radial nerve (covered with muscle) distributed to the extensor carpi radialis longior. When stimulated it extends the hand on the forearm.

45. Branch of radical nerve to the anconeus quartus. When directly stimulated it extends the forearm feebly.

46. Nerve distributed to the extensor carpi radialis brevior. Like 44, it extends hand on forearm when stimulated.

47. Branches of radial nerve supplying the extensor communis digitorum. Both branches should be excited simultaneously to produce contraction of this muscle. This extends the phalanges of the last four fingers on each other, and on the metacarpal bone. It can also extend hand on forearm.

48. Nerve supplying the extensor carpi ulnaris. Stimulating it extends the hand, inclining it a little inward.

49. Common motor point for the abductor pollicis longus, extensor digiti and indicis proprius muscles.

50. Motor point for the extensor minimi digiti proprius. Stimulating the last two points extends the fingers and even the hand.

51. Motor point of the abductor pollicis longus.

52. Motor point of the extensor indicis proprius.

53. Motor point of the common to the extensor pollicis longus and brevis.

54. Motor point of the extensor pollicis brevis.

55. Motor point of the extensor pollicis longus.

56. Motor point of the abductor digiti minimi.

57. Motor point of the four interossei externi. When stimulated the fingers are abducted, adducted and extended.

58, 59.

60. Branch of the anterior-thoracic nerve supplying the deltoid. It raises the arm directly up, and, if the shoulder is fixed, carries it forward or backward according to the direction of the fibres thrown into action. When the arm is rendered immovable the deltoid acts inversely and depresses the shoulder.

61. Musculo-cutaneous nerve. Its stimulation is painful, and causes the simultaneous contraction of the biceps and brachialis internus, which flexes the forearm powerfully.

62. Median nerve. This can be easily reached along the sulcus bicipitalis, but can be most readily stimulated at the lower third of the humerus, where it can be fixed against the bone. The stimulation of this nerve excites peculiar pain in the hand and fingers, and causes strong pronation of the forearm, flexion of the hand toward the radial side, flexion of the fingers with opposition of the thumb.

63. Motor point of that branch of the musculo-cutaneous nerve distributed to the brachialis internus. Its stimulation bends the forearm.

64. Branch of the median nerve sent to the pronator teres muscle. The stimulation of this muscle is quite painful, in consequence of the great number of sensitive nerves on the flexion side of the arm. It causes the radius to turn on the ulna to produce pronation. It also bends forearm on arm.

65, 66. Motor points of flexor digitor. sublimis. This muscle bends the second phalanges on the first.

67. Internal branch of median nerve sent the pronator teres. This turns the radius on the ulna to produce pronation. It also bends forearm on the arm, and extends forearm.

68. Branch of median nerve to the radialis internus muscle. } These bend the hand.
69. Branch of median nerve to the palmaris longus. }

70. Branch of median nerve to the flexor digitor sublimis. This bends the second phalanges on the first, these on the carpal bones, and the hand on the forearm.

71. Branch of median nerve to the pollicis longus. This bends the second phalanx of thumb on first, the first on the corresponding metacarpal bone, and this on the radius.

72. Branch of the ulnar nerve distributed to the inner part of the palm and last two or three fingers.

73. The median nerve. (See 62.)

74. Motor point of volaris profundus ulnar nerve distributed to the muscles of forearm and hand.

75. Motor point of abductor pollicis brevis.

76. Motor point of opponens pollicis.

77. Motor point of abductor digiti minimi.

78. Motor point of flexor digiti minimi.

79. Motor point of flexor pollicis brevis.

80. Motor point of ulnar branch supplying the adductor pollicis.

81. Motor point of median branch supplying the lumbricalis I I.

82. Motor point of median branch supplying the lumbricalis I.

83. Motor point of flexor digitor. communis profundis.

90 to 94. Motor point of rectus abdominis externus. It bends the chest on the pelvis and conversely.

95 to 98. Motor points of obliquus abdominis externus, which depresses the ribs and carries them backward during a strong expiration, excites rotation of chest, bends thorax on pelvis and back again, and contracts the abdominal cavity.

99. Motor point of transversus abdominis. This constricts abdomen, diminishes base of chest by drawing ribs inward.

100. Motor point of obliquus abdominis internus. Its stimulation produces about the same effect as abdominis externus.

101. Branch of crural nerve supplying the tensor fasciæ latæ which helps move the thigh forward.

102. Branch of crural nerve supplying the rectus femoris. This muscle has another motor point four or five inches from the anterior superior spinous process of the ilium. It extends the leg on the thigh and conversely; also bends thigh on pelvis or carries pelvis forward.

103. Upper motor point of the vastus externus, the other motor point is two or three inches lower. This muscle acts best if one electrode is placed on each motor point. To lessen the pain, turn the electrode handle so that the nerve of this muscle may be pressed outward. It helps extend the leg on the thigh and conversely.

104. Motor point of the crural muscle which assists vastus (103) and rectus (102) in extension of leg.

105. Crural nerve. The stimulation of this nerve occasions severe pain along the front and inner side of the thigh, the knee and the leg down to the big toe, accompanied by powerful contraction of the muscles of the leg. In thin persons it is possible to stimulate the chief branch of crural nerve going to the quadriceps extensor cruris, and this excites not only that muscle, but also the extensors on the front of the thigh. It causes extension of leg.

106. Branch of crural distributed to the sartorius muscle; bends pelvis on thigh and conversely.

107. Motor point of the pectineus muscle bends the thigh on the pelvis and carries it outward in adduction and rotation. It may also bend the pelvis on the thigh.

108. Motor point of the adductor brevis. } These draw the thigh toward the axis of the body.
109. Motor point of the adductor longus. }

110. Motor point of the gracillis muscle bends leg, adducts thigh.

111. Lower motor point of vastus internus (see 103).

112. Motor point of the soleus muscle extends foot on leg conversely.

113. Branch of tibialis nerve to the flexor digitor, communis longus.

114. Tibial nerve. It causes contraction of all muscles at the back of the leg and sole of foot.

115. Peroneal nerve. It is distributed to the posterior muscles of the leg and sole of the foot.

116. Superficial peroneal nerve (popliteal).

117. Motor point of the extensor digitor communis longus. It causes the three phalanges to bend on each other, the toes on the metatarsus, and extends the foot on the leg.

118. Motor point of the tibialis anticus muscle. It bends the foot on the leg, directs its point inward, and at the same time raises its inner edge. It also bends the leg on the foot and prevents its falling backward in standing.

119. Motor point of extensor hallucis longus. This extends the last phalanx of the great toe upon the first, and the first upon the first metacarpal bone.

120. Motor point of the peronæus tertius. This bends the foot on the leg by raising its outer edge. It can also bend the leg on the foot.

121. Branch of the peronæus profundus, distributed to the extensor digitor. communis brevis. It extends three phalanges of last four toes.

122. Motor point of the abductor digiti minimi, which draws the little toe outward.

123. Motor point of the hallucis muscle which pulls the great toe from the rest.

124–127. Motor points of the interossei externi which abducts and adducts the toes.

140. Obturator nerve. Stimulating it, rotates the thigh outward, draws the thigh to the pelvis, and bends the leg.

The motor point of the sciatic nerve (not shown on cut) lies between the trochanter major and tuber. ischii; stimulating it, causes flexion of the leg and contraction of all the muscles of the leg and foot.

THE RELATION OF ELECTRICITY TO THE FUNCTIONS OF THE NERVOUS SYSTEM.

Our present knowledge of the pathology of the nervous system owes its origin to the experiments of Galvani in his laboratory at Bologna in 1759.* Step by step the functions of the different parts have been discovered. All the variations in the effect produced by electric stimulus of different kinds, the comparative influence of upward and downward currents, the exhaustion of nerves by continued stimulation and their recovery by repose, have all been thoroughly studied.

Motor and sensory nerves. The distinction of *motor* and *sensitive* properties in the two roots of the spinal nerves was discovered in 1822, by Charles Bell. Magendie, following the line of investigation begun by Bell, showed that galvanization of the anterior roots caused muscular contraction, and that of the posterior roots sensation. It was believed at this time that the motor and sensitive properties of the nervous system were under the control of the brain, and that the spinal cord was a portion of the apparatus for transmission; through it and the motor nerves the commands of the will were conveyed to the muscles, and impressions received at the periphery of the sensitive nerves were conveyed through them to the brain.

Reflex action of the spinal cord. Marshall Hall made the discovery that while the spinal cord acts independently of the

* John C. Dalton, M.D., professor of physiology in the College of Physicians and Surgeons, New York, 1882.

brain, it is a medium of communication between the skin and muscles. The stimulus conveyed inward through the sensitive nerves to the cord is *reflected* outward through the motor nerves to the muscles. From this circumstance is derived the name "reflex action." It was afterward found that this same form of activity is not confined to the spinal cord. Wherever there is a ganglionic mass of nervous matter with motor and sensitive fibers originating from it, there is a similar focus of nervous power often quite disconnected with consciousness and volition. For example, in a state of absolute insensibility, a touch on the cornea will cause closure of the eyelids, the contact of a solid body with the fauces will excite the movement of deglutition. In these instances the reaction disappears when its special nervous center is destroyed.

Vaso-motor nerves. Claude Bernard marked a new epoch in the history of the circulation by the discovery that division of the sympathetic nerve in the neck is followed by enlargement of the bloodvessels of the head. Brown-Séquard and Bernard almost simultaneously discovered that the circulation, after the sympathetic is divided, may be controlled and regulated by galvanization of the divided nerve above the point of section. It thus appeared that the arteries were supplied by nerve fibers from the sympathetic, and the circulation is influenced by them nearly in the same way as the voluntary muscles are controlled by the cerebro-spinal nerves. Those nerve fibers which produce, under stimulation, contraction of the bloodvessels are called the vaso-motor nerves.

Dilator nerves. Bernard discovered still another kind of nerve fiber, which under the stimulus of galvanism produced enlargement of bloodvessels, and more active circulation while the stimulus lasts, and these are called dilator nerves. This discovery explained another curious phenomenon previously observed. As a general rule, if a nerve going to a muscular organ be divided, the muscle is paralyzed; if the nerve be stimulated, there is a muscular contraction. The heart is an exception to this rule.

Action of arrest. Since the heart is supplied with filaments from the pneumogastric, we should naturally expect that its action would be diminished by the section of this nerve, and increased when it is stimulated. The effect is exactly contrary. When the poles of a galvanic current are applied to the pneumogastric in the neck, the cardiac pulsations are reduced in frequency, and when the strength of a current is increased, they are stopped altogether. The heart lies still, in a relaxed state, while galvanization is going on; when the current ceases, pulsations commence again. This is not due to reflex but to direct action, as may be proved in animals by dividing the sympathetic. If it be galvanized above the section, the heart remains unaffected, but if the stimulus be applied below the section the effect upon the heart-beats is immediately observed. The power of this nerve to restrain the heart movements, like the motor power of the spinal nerves, is limited in duration. If the galvanization be continued a sufficient time the heart will begin to beat again, at first slowly, afterward naturally, notwithstanding the continuance of the galvanic current. The nerve has lost its controlling power, and cannot be again excited to manifest it, unless allowed a period of rest.

The heart still retains its sensitiveness to the same influence, and if the electrodes be shifted to the pneumogastric of the opposite side, it stops as quickly as before. This is the so-called "action of arrest," an influence which passes through a nerve from its center to a muscle and suspends the contraction of that muscle. Besides the *heart*, all the *sphincter muscles*, the *secretory glands*, *the uterus* and *alimentary canal* are affected in the same way. The *bloodvessels* are affected both by the *motor* nerves and the *dilator* nerves and by the varying preponderance of the one or the other they are made to alternately contract and dilate.

Special centers for motion and sensation in the cerebral convolutions. It was not until 1870 that the first discovery* was made, by experiments on dog's brain, that there are certain parts of the cerebral convolutions where stimulus always produces definite and unmistakable movements on the opposite side of the body. The contraction of certain groups of muscles, and consequently particular movements in the trunk or limbs, are connected with the stimulation of particular points in the brain. By comparing these points in different animals, aided by observations in human pathology, it appears that in man the motor centers for the body and limbs of the opposite side are mainly located in the anterior and posterior central convolutions, immediately bordering on the fissure of Rolando. The location of the centers of *sensation* is still a subject of investigation. In one instance only can it be said to be determined beyond a doubt the location of one of these points. If the "angular convolution" on the posterior and lateral part of the cerebral hemisphere be removed, the operation is followed by blindness of the opposite eye without any other perceptible disturbance of either motion or sensibility. The effect of electricity upon the vaso-motor system is a subject of the greatest importance, for upon this system of nerves depends the connection between secretion and blood supply, the mechanism of congestions, the dependence of external disturbance of the circulation on disease of the internal parts, the red cheeks of pneumonia, and the hectic of consumption.

The method of reaching the spinal ganglia, through which these various kinds of nerves may be brought under the influ-

*Fritsch Hitzig, Archive für Anatomie, Physiologie und Wissenschaftliche Medicin, Leipzig, 1870, p. 300.

ence of electricity, may be determined from the illustration, Fig. 73.

THE GREAT SYMPATHETIC NERVE.

This nerve, which owes its name to the belief that "through it is produced a *sympathy* between the affections of distant organs," is of great practical interest to the electro-therapeutist, consisting as it does of a series of ganglia forming a double chain, extending from its origin within the skull the entire length of the spine, on each side, and sending branches either directly or indirectly to all the large bloodvessels, and to every important organ in the body.

Prof. Weber was the first to describe the method of stimulating various groups of muscles and organs through their ganglia or nerve centers.

By using a broad electrode, with the skin well moistened, and the electrode also (unless it be made of carbon or metal), it is possible to send a current from the *nerve roots* or *centers* (which these ganglia are) to any organ or bloodvessel with which they are in communication.

Applications to the head are made through the forehead vertex and occiput. The forehead is very sensitive, and it is best to include a rheostat in the circuit when the current is to be passed through the head.

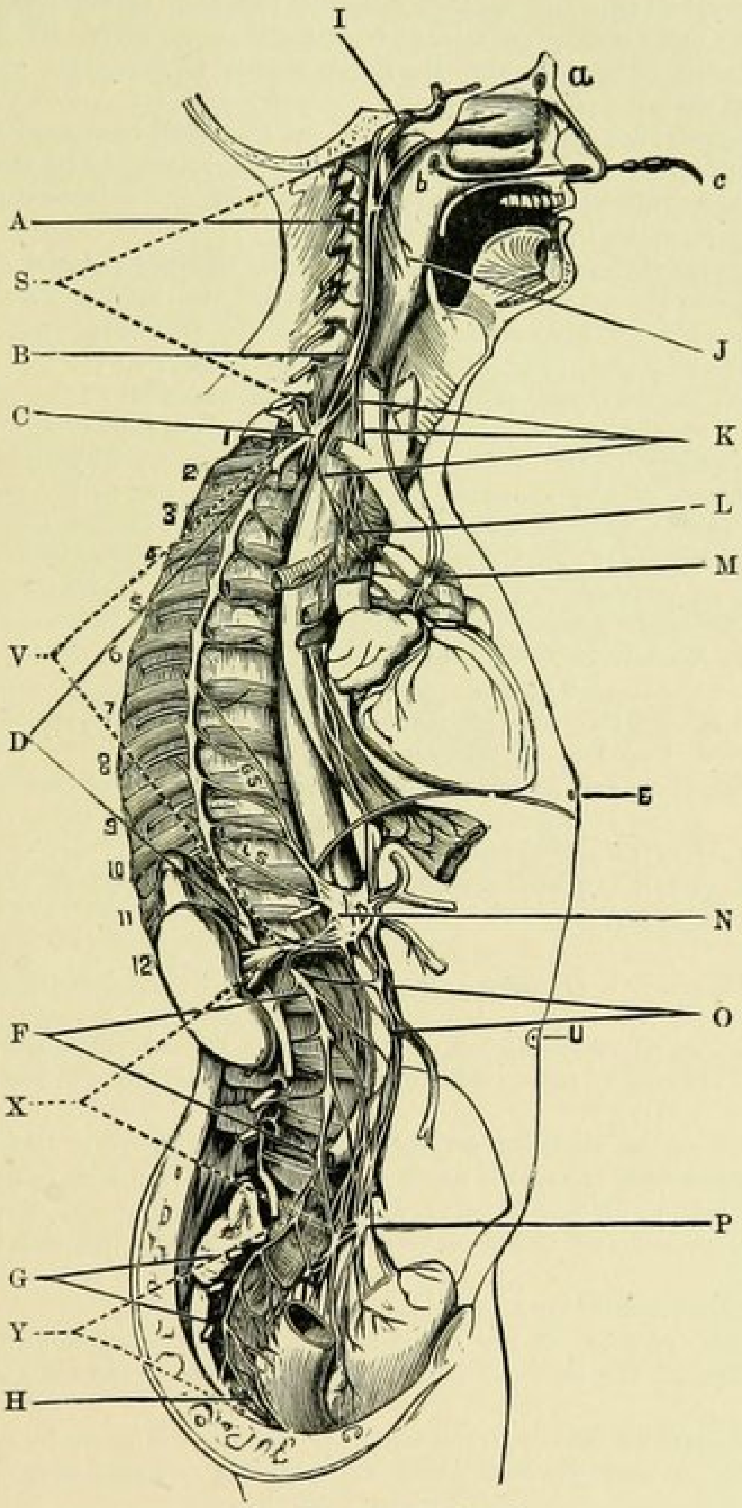

FIG. 73. (After Gray).

S includes the seven cervical vertebræ.
V includes the twelve dorsal vertebræ.
X includes the five lumbar vertebræ.
Y includes the five sacral and four coccygeal vertebræ.

Cervical Ganglia.

A, superior cervical ganglion lying in front of the second and third cervical vertebræ. It sends branches to (1) the carotid artery, (2) carotid plexus, (3) cavernous plexus, (4) the heart. These send nerve twigs to the eyes, nose and various parts of the head.

B, middle cervical ganglion, located opposite the fifth cervical vertebra. It sends branches to (1) fifth and sixth spinal nerves, (2) thyroid gland, (3) heart. These form a part of the brachial plexus which furnishes the nerve supply to the upper extremities. They also communicate with the phrenic nerve.

C, inferior cervical ganglion. Located in front of the last cervical vertebra and the neck of the first rib (at the nape of the neck). It sends branches to (1) the heart, (2) vertebral artery, (3) cervical spinal nerves. Nerves from this ganglia preside over the contraction of the radiated fibers of the iris.

To send a current through these ganglia place one electrode over the sixth or seventh cervical vertebræ and the other directly below the ear and behind the angle of the jaw (auriculo-maxillary fossa). They may also be reached by placing the first electrode at the point indicated by electrode A, Fig. 74, and the second as before.

D includes the twelve dorsal ganglia or the thoracic portion of the great sympathetic. They are located against the heads of the ribs, on each side of the spine, and send branches to (1) the aorta, (2) the dorsal spinal nerves which are distributed to the muscles and skin of the trunk, (3) the *six upper* ganglia send branches to the vertebræ and ligaments; the *third* and *fourth* send branches to the pulmonary plexus, and through it communicate with the lungs; the *six* lower send branches to form the splanchnic nerves.

F includes the four lumbar ganglia, located in front of the vertebral column, along the inner margin of the psoas muscle. It supplies branches to (1) the lumbar spinal nerves and through these communicate with the organs of the pelvis and the muscles and skin of the thighs, (2) the lumbar aortic plexus, (3) the hypogastric plexus, (4) the lumbar vertebræ and their ligaments. An electrode placed over the fourth lumbar vertebra can be made to produce contraction of the bowels, bladder, uterus, etc.

G includes the five sacral ganglia; they are located in front of the sacrum, along the inner side of the anterior sacral foramina. They send branches to (1) the sacral nerves, (2) middle sacral artery, (3) pelvic plexus.

H, a single ganglion in which the great sympathetic terminates. It is located in front of and at the end of the coccyx.

Plexuses with which the Sympathetic Communicates.

I, carotid plexus which sends nerve filaments to (1) carotid artery, (2) dura mater, (3) eyes, (4) teeth. It may be reached indirectly through the superior and middle cervical ganglia.

J, branches from the superior cervical ganglia distributed to the pharynx. These pharyngeal branches form the motor nerve of the pharynx and soft palate, and also give sensation to the palate. When treating disease of these parts one electrode should be placed over the second and third cervical vertebræ, where the nerve center may be reached.

K, branches from the cervical ganglia to the heart.

L, deep cardiac plexus. It lies behind the arch of the arota and can be reached only indirectly through the cervical ganglia and the pneumogastric. (See motor point. Fig. 72.)

M, superficial cardiac plexus lies beneath the arch of the aorta in front of the right pulmonary artery. It may be stimulated through the cervical ganglia and the pneumogastric.

N, solar plexus, located behind the stomach and in front of the aorta and crura of the diaphragm. It supplies all the viscera of the abdominal cavity. To thoroughly stimulate this plexus and the organs which it supplies, the spinal electrode should be moved over both the dorsal and lumbar ganglia, and the other electrode over the pit of the stomach and extending to within two finger-breadths of the umbilicus. Any local irritation of this important plexus may affect (1) the diaphragm, (2) the stomach, (3) the liver, (4) the spleen, (5) the kidneys, (6) the intestines (both large and small), (7) the sexual organs, (8) the circulation, especially below the diaphragm, which, of course, exerts an influence upon the total circulation.

O, aortic plexus is derived from the solar. The electrode should be placed over the lower lumbar vertebræ to influence this plexus. It supplies the inferior vena cava, the descending and sigmoid flexure of the colon, the upper part of the rectum.

P, hypogastric plexus supplies all the organs of the pelvis. It lies in front of the promontory of the sacrum and between the two common iliac veins. It receives filaments from the lumbar and first two sacral ganglia, over which the electrodes may be placed when a current is to be sent to the bladder, rectum or sexual organs. It is also connected with the aortic plexus, and hence may be reached by the same treatment which influences either the aortic plexus or the solar from whence the aortic is derived.

G. S. The Great Splanchnic Nerve. L. S. The Lesser Splanchnic Nerve.	These, together with the renal splanchnic, not shown on cut, all arise from the thoracic ganglia and supply filaments to all the important organs of the abdominal cavity.

The Splanchnic Nerves.

Strong faradization of these nerves arrests the peristaltic movements of the small intestines.*

E, the ensiform cartilage terminating the sternum (breast bone), to which the diaphragm is attached; (u) the umbilicus, (a) nasal duct, (b) orifice of Eustachian tube, (c) Eustachian Electrode.

Figures 1 to 12 mark the location of the ribs. It will be observed by comparison with Fig. 74 that they are joined to the spine at points considerably higher than the terminal ends in front.

The Scapula, not shown on the cut, lies on the ribs from the 2d to the 7th inclusive.

The Vertebræ may be easily counted by drawing the fingers two or three times down the entire length of the spine, with firm pressure; red spots will mark the projections on the vertebræ.

The Kidney is most accessible below the last rib on the outer edge of the erector spinæ muscles. A portion of the ascending and descending colon may be reached by an electrode placed on either side of the spine between the kidney and the upper edge of the hip bone outlined on above cut.

*——Pflüger, 1856.

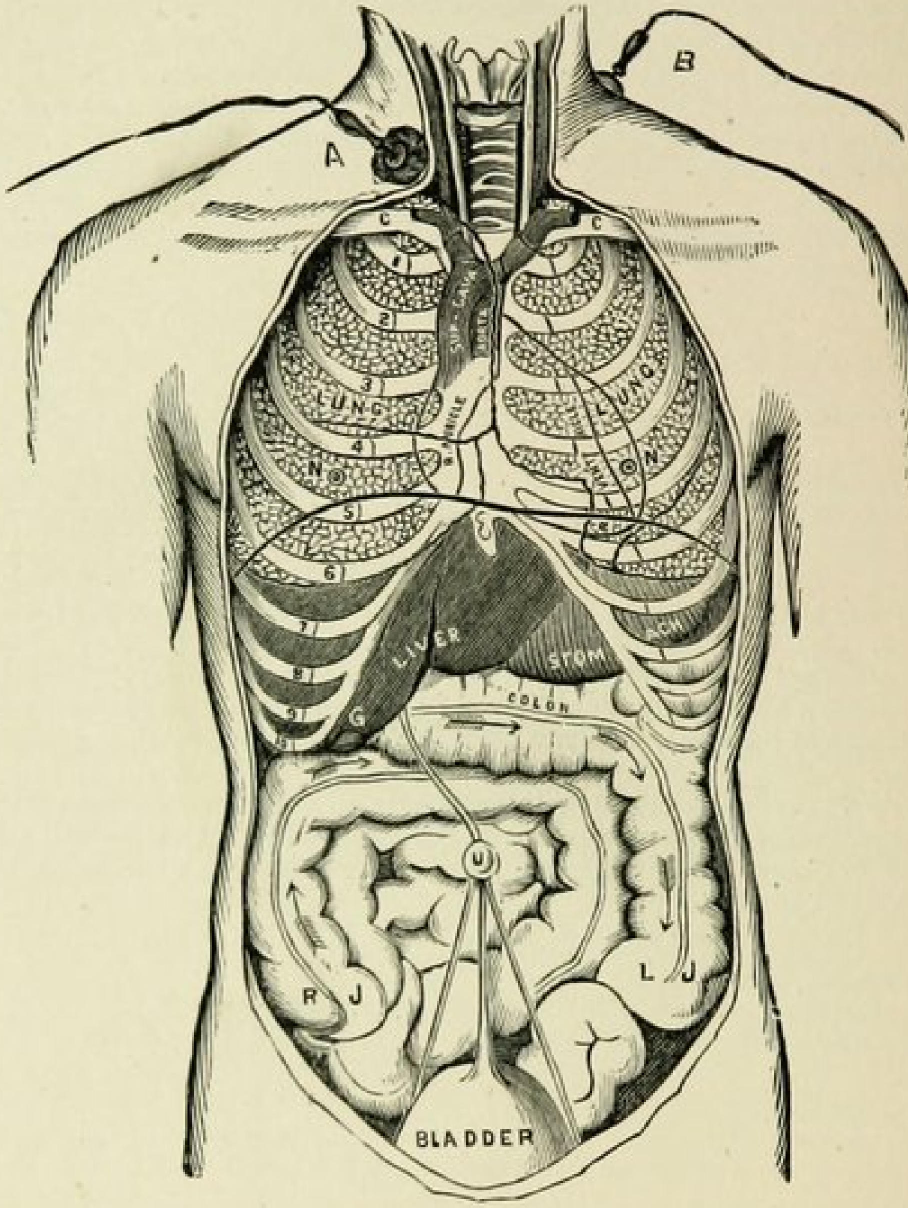

FIG. 74. (After Gray.)

This illustration shows the principal landmarks for locating the internal organs with sufficient accuracy for the purposes of electro-therapeutics.

C C marks the clavicle.

The ribs are numbered to correspond with the numbers at their spinal termini given in Fig. 73. It is useful to remember that the sternal end of each rib lies on a lower level than its corresponding vertebra. A line drawn horizontally backward from the middle of the third costal cartilage at its junction with the sternum would touch the body, not of the third dorsal but of the sixth dorsal. This varies a little according to the length of the sternum.

The eleventh and twelfth ribs can be felt even in corpulent persons, sloping downward. The head of the last rib is on a level with the spine of the last dorsal vertebra.

The nipples (of males) usually lie between the fourth and fifth ribs, about three-fourths of an inch external to their cartilages.

The *right lung*, directly in front, is shown terminating on a level with the sixth rib, and the *left lung*, between the sixth and seventh ribs.

The heart is marked by a dark outline. The usual place to locate the electrodes for reaching it is over the sternum (breast bone) just above E, while the other is placed over the cervical ganglia (see Fig. 73), or at the *right* side of the neck at the point where the electrode A is placed in the cut. An electrode at the same spot on the *left* side of the neck modifies the respiratory movements.*

The *lobes of the lungs* are outlined by the wavy dark line just above the fourth rib on the right, and between the fifth and sixth on the left.

The diaphragm is marked by the irregular dark line extending across the cut. This shows its attachment in front to the ribs and sternum.

E marks the cartilage ending the sternum (ensiform cartilage).

The stomach may be electrized by placing a large, broad electrode between the false ribs below E and two fingers' breadth above U.

The liver may be reached by pressing one electrode inward and upward just below the tenth rib. When the stomach is empty the liver may also be reached by pressing the electrode located below the sternum a little inward to the right, and upward.

G indicates the location of the gall bladder.

The colon, when treated for torpidity, should have the negative electrode carried over it from R J to L J, in the direction indicated by the arrows.

U is the umbilicus. It is located as a rule above the level of the body of the third lumbar vertebra.

The spleen. Place a broad electrode over the tenth and eleventh ribs on the left.

The bladder may be reached by placing one electrode above the pubic bone and the other over the ganglia F and G, Fig. 73.

Electrode B marks the location from which a current may be made to reach the brachial plexus of the corresponding side.

Electrode A marks the point at which the current may be made to stimulate the pneumogastrics and cervical sympathetics.

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* Arloing and Tripier, Brown-Séquard's Arch. Phys., 1873.

CHAPTER X.

ELECTRO-DIAGNOSIS.

Electricity is employed as an aid in diagnosis in the following cases:

1. To distinguish between apparent and real death (electro-bioscopy);

2. Between feigned and real disease (to detect malingerers);

3. To distinguish between different forms of paralysis (central and peripheral);

4. To detect the presence and location of the bullet in gunshot wounds.

The horrible fate of being buried alive is so much to be dreaded, that any means which will aid in determining whether life is extinct in doubtful cases should be regarded worthy of a trial. The signs of death which are most generally relied upon are cessation of respiration and the heart's action, a considerable fall in temperature, stiffening of the muscles (rigor mortis), the dull cornea, the dilated pupil, non-transparency of the fingers to lamplight, and, finally, decomposition. These signs, however, are occasionally of doubtful value, since all except the last have been present in cases of trance. Decomposition, when it occurs, is an unquestionable sign of death; but occasionally it is very much delayed, especially in cases of poisoning, habitual drunkards, and those who die from wasting disease. Althaus claims that "*none of these signs are as ready and decisive as faradization, which indicates death with absolute certainty within two or three hours after its occurrence.*" Authors are not agreed as to the length of time after death at which the power of the faradic current to excite muscular contractions ceases. Onimus experimented on the body of a criminal soon after decapitation, to determine the effect of the faradic current on muscular contractility after death. He found that it is lost in the diaphragm and tongue first, and within two hours and a half in all the facial muscles. In the limbs the extensor muscles are the first to die, while the flexors retain their excitability about one hour longer. Five or six hours after death the muscles of the trunk still answer to faradization, and the abdominal muscles are particularly tenacious in this respect. Long after the muscles of the extremities have become insensible to the faradic stimulus, the abdominal muscles, when exposed to the air and cut up, may be seen to contract.

Prof. Rosenthal* states that muscular death does not correspond with general death of the body, but follows the latter at a period varying from thirty minutes to several hours. He followed the gradual extinction of both faradic and galvanic excitability of the nerves and muscles after death in twenty cases, the patients having died from various diseases, such as pneumonia, apoplexy, fever, etc. He found that post-mortem electric excitability disappears more rapidly after death from chronic than acute disease; that it remains longer in well-nourished than in wasted bodies, and that it is generally extinguished in from ninety minutes to three hours. In a case of drowning, a feeble faradic current produced good contractions within the first hour; after that it was necessary to increase the power of the current in order to cause contractions of the same strength as before. In three and one-quarter hours electric excitability had everywhere vanished. Stiffening of the muscles (rigor mortis) appeared only after five hours in the hand and six in the elbow. He reports attending a case of trance, a

* Professor of Physiology in the University of Erlangen. Physiology of Muscles and Nerves, 1881.

hysterical woman, who had been apparently dead for thirty-two hours. All the muscles of the face and extremities contracted under the faradic current, therefore he recommended measures for resuscitation; twelve hours afterward she spontaneously awoke, recovered, and was alive two years after.

M. Crimotel, of Paris, having experimented in a number of cases of apparent death, and also upon persons who had died from the most varied complaints, arrived at these conclusions:

1. Death is certain when all the muscles have entirely lost their faradic contractility. No disease, poisoning or asphyxia will, during life, abolish electric contractility in *all the muscles* of the body.

2. Faradic electricity is an indispensable test whether life is extinct, in all cases of apparent death occurring suddenly. When there are several victims, as after accidents, it enables the attendants to distinguish the dead from the living, and also the order in which the dead ceased to live.

3. In newly-born infants, muscular contractility, under the influence of the faradic current, continues fifty to sixty minutes after the heart has ceased to beat. When they have never exhibited signs of life, the faradic test shows whether life is really extinct.

4. In some cases of cholera, electro-muscular contractions cease within half an hour after death.

FEIGNED DISEASE (MALINGERING).

Diseases are frequently feigned for the purpose of exciting sympathy, extorting charity, evading work, and in some instances with a view to obtaining damages after accidents. Faradization of the skin with the wire brush (electric fustigation), especially over bony projections, is an excellent means of settling the question in most cases. It is exceedingly painful, and yet never does harm, except where there is disease of the brain, when it should be avoided. Paralysis, ankylosis and epilepsy are the favorite diseases with malingerers. In the former disease the symptoms complained of are such as are due to peripheral (formerly called functional) paralysis, as the class of persons who would lend themselves to such imposture seldom are sufficiently acquainted with the symptoms due to diseases of the nerve or brain substance to successfully imitate them; therefore, if the muscles respond to stimulation by electricity after the patient has complained two weeks, we may conclude that it is a case of imposition. In cases that are obscure, and where a correct diagnosis is of importance in settling the question of damages, the examination should be conducted as directed for diagnosing obscure cases of paralysis.

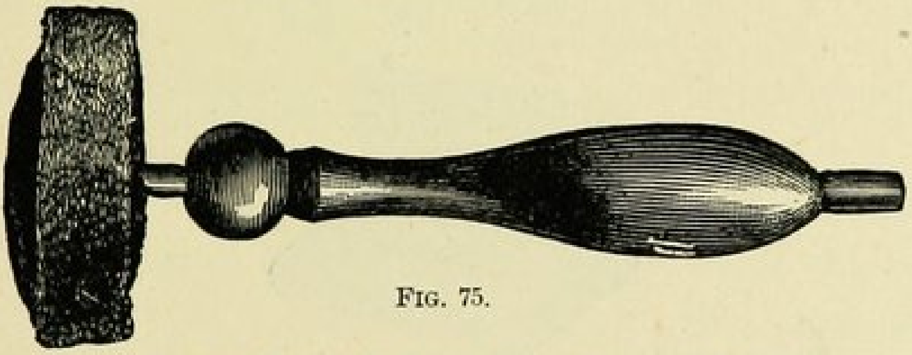

FIG. 75.

UNIVERSAL HANDLE WITH SPONGE-COVERED DISC.
Length of handle, 4½ in.
Diam. of disc, 2 in.

This electrode handle is made of wood, well seasoned, and varnished to insulate it. A metal rod passes through the center, having at one end a smooth socket to receive the conducting cord, and at the other end a socket cut in threads to receive any style of electrode that terminates in a screw, in the place of the disc shown in the cut.

Method of electro-diagnosis in paralysis. It is necessary that the physician be provided with both the galvanic and faradic currents, since one is frequently capable of exciting contractions when the other fails. The difficulties formerly attending the employment of electricity in diagnosis have been almost entirely done away with since the introduction of the McIntosh Combined Batteries, which render it as easy to use one current as the other. There are three methods of applying the currents, *indirect*, *direct* and *polar*.

Indirect method. This consists in placing one electrode over the ganglia (see Fig. 73) or nerve trunk that supplies the muscle, and the other over some indifferent point.

Direct method. In this, one electrode is placed (*a*) over the motor point (Fig. 72) of the muscle, or (*b*) direct to the muscle itself, and in either case the alternate electrode is placed at some indifferent point.

Polar method. This is accomplished (*a*) by placing both poles of the battery on the nerve or muscle to be acted upon, or (*b*) placing first one pole and then the other on the nerve or muscle, while the alternate pole in each case is on some distant part of the body. In this way the action of the two poles is not confused, and the results can be observed separately.

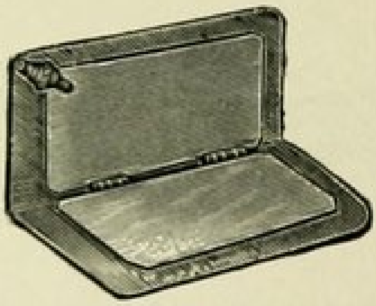

FIG. 76.
FOLDING FOOT-PLATE.
Each half is $8\frac{1}{2} \times 4$ in.

This electrode is composed of two equal nickel-plated pieces of metal, hinged in the middle, so that they may be folded together to occupy less space when not in use. A binding post at one corner receives the conducting cord. A flannel cover is placed over the metal when used, and fastened on two buttons attached to the under surface of the metal plates. (It must be wet in warm water when applied to the feet.) Beneath these plates is a piece of rubber-cloth, also held in place by the buttons, which insulates the foot-plate and prevents moistening the carpet.

Instruments required for electro-diagnosis. The operator, while sitting or standing near the patient, must have all his apparatus around him within easy reach, and a variety of electrodes suited to the parts to be examined. He will find it convenient to be provided with (in addition to the sponge-covered electrodes (Fig. 75) that accompany the combined batteries), a foot-plate (Fig. 76), a pair of Duchenne's points

(Fig. 77), a pole changer (Fig. 33), if the battery is not provided with one, one or more metallic discs (Fig. 78) with suitable covers (Fig. 79), a comb electrode (Fig. 80), a seven-toothed metallic electrode (Fig. 81), and to these might be added others, provided special organs are to be examined. If a lady patient is to be submitted to this method of diagnosis, a long-handled sponge electrode (Fig. 82) is almost essential, and if the operator is without an assistant, a self-retaining neck electrode (Fig. 83) will also be required.

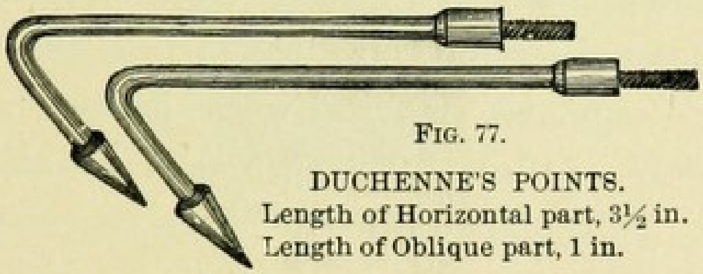

FIG. 77.
DUCHENNE'S POINTS.
Length of Horizontal part, 3½ in.
Length of Oblique part, 1 in.

These consist of nickel-plated rods terminating in gold points, and are especially adapted to localizing a current at motor points.

To prepare the patient for examination. The patient must be placed in a good light, perfectly at rest, with all the muscles relaxed and both sides of the body in the same position. The upper extremities are best examined with the patient sitting on one chair with the forearms resting on the back of another. To test the condition of the lower half of the trunk and the lower extremities, the recumbent position is best. Throughout the examination the electrodes and skin must be well moistened to enable the current to penetrate to the nerve or muscle. Warm water is the best fluid to use, and it is scarcely necessary to add that towels should be placed so as to prevent the bedclothes or dress of the patient from becoming damp. When the *upper part of the body* is to be examined, the necklet adjusted to hold the sponge over the nape of the neck is a suitable arrangement. If the *lower part of the body* is to be examined, the foot-plate may be laid under the sacrum, and the patient can lie upon it to keep it in position, or the universal electrode may be held over the sternum or in front of the abdomen by the hand. The most suitable method to pursue in most cases of extended examination is to bind a broad, flat, moist electrode over the front of the abdomen with elastic tapes, and proceed in the following order: 1. Test the effect of the faradic current upon the nerve trunks. 2. Upon the motor points. 3. On the muscular tissue. 4. Apply the galvanic current in the same order. It is customary to apply the negative electrode of the secondary current, when faradism is used, to the part to be tested. The galvanic current necessitates observing the effect of first one pole and then the other. Commence with a weak current and press the electrode firmly in place. The patella is recommended as an "indifferent" point upon which to place one electrode.

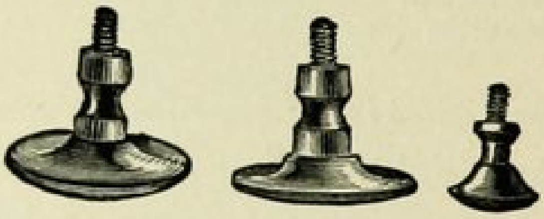

FIG. 78.

METALLIC DISCS.

Diam. 1⅜, 1⅛, ⅝ in.

These are nickel-plated metallic disc electrodes, adapted to the purpose of localizing the current on a comparatively small space, as over a nerve trunk, ganglion, or upon a muscle. They are also employed to apply a current to an ulcer, indolent swellings, and in all localities to which their size is adapted. For lengthy applications they may be retained in place by an elastic band or simple bandage. They should be covered, when used, with moist flannel or cloth, which may be tied over them.

ELECTRICAL REACTIONS IN HEALTH.

In health, the muscles supplied by the symmetrical nerves of the two sides of the body are *excited* to contraction by the same strength of current. On irritating a *motor* nerve with electricity, the only *visible* phenomenon which follows is contraction of all the muscles which it supplies. Contraction does not depend simply upon the power of the nerve to *conduct* electricity. The latter excites the nerve cells to exercise their functions. This is proven by the fact that if a nerve be injured or diseased, no electric stimulation and no contractions are produced, although its power of conducting the current is in no way interfered with. It is also shown by this additional fact, that the *further from the muscle* a healthy nerve is irritated, the *greater* is the *effect produced*, and this is increased if a portion of the nerve center be included in the circuit.

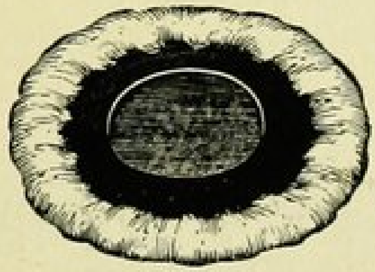

FIG. 79.

ELECTRODE COVER.

This is suitable for discs, universal sponge or other electrodes, either to protect sponge or to lessen the pain produced by direct metallic contact with skin. Thin flannel or muslin, cut in circular form large enough to slip over the electrode for which it is made, is gathered upon a rubber band. It may be laundried repeatedly.

Effect of faradism. Each shock of the current produces a muscular contraction, immediately followed by relaxation; but as in the ordinary apparatus these interruptions rapidly succeed one another, there are no apparent intermissions, one contraction not having ceased before another takes place; hence there is tetanus of the muscle so long as the current is passing. Rapidly interrupted faradism is the most powerful electrical stimulant to healthy nerve.

Effect of galvanism. The muscular contraction produced by a galvanic current occurs at the moments when the circuit is opened and closed, no contraction occurring while the current passes without interruption. The negative pole always produces a stronger contraction than the positive. These practical facts should not be lost sight of in electro-diagnosis:

1. In healthy persons, the contraction produced by *closing* the circuit at the *negative* pole exceeds that produced by *closing* the circuit at the *positive* pole.

2. Also the *opening* of the circuit at the *positive* pole produces stronger contractions than when the circuit is *opened* at the *negative* pole.

3. In health, the *galvanic* current applied to a nerve does not produce as strong contractions as the *faradic* current.

4. When a muscle is deprived of its nerve influence by poison or otherwise, leaving its fibers healthy, the reactions are very different.

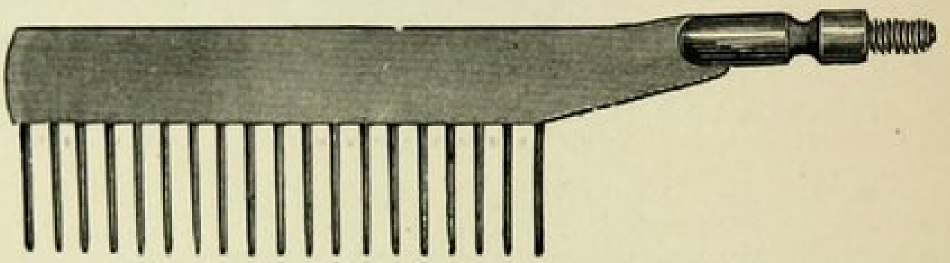

FIG. 80.

COMB ELECTRODE.
Length, 4 in.

This is a nickel-plated comb, with a single row of stiff wire teeth, used to localize a current along the course of a nerve or slender muscle.

(*a*) The *faradic* will then produce no contraction of the muscle whatever, no matter how slowly the interruptions may be made.

(*b*) The influence of the *galvanic* current is increased so that a weaker power is required to produce contractions than in the normal state.

In this condition there is not only contraction at the instant of opening and closing the galvanic current, but, if the current be strong, there is often a tetanic spasm during its continued passage.

5. With a normal nerve supply, the more rapidly the galvanic current is interrupted, the more vigorous is the mus-

cular contraction. When the nerve supply is cut off, the reverse is true.

6. The relative excitability of different nerves and muscles depends upon the tissues lying between the electrode and the nerve or muscle to be examined. When one side only is diseased, it can be readily compared with the healthy side; but if both sides are attacked it is more difficult to determine the amount of change that has resulted.

The comparative irritability of the different nerves and muscles throughout the body. This is an important point, since we cannot compare one leg with the other when both are diseased; but, knowing the relative irritability of certain points, the lower extremities may be compared with healthy regions, and their condition be thus indirectly determined.

FIG. 81.

METALLIC POINTS.
Length, 2 in.

This electrode resembles the comb electrode, but is better adapted to the examination of short muscles of the face, hands and feet.

Dr. Hughes Bennett* has made a series of observations on the normal subject, with the view of attempting to deduce some definite facts concerning the electric excitability of the nerve trunks, the motor points, and the muscles, from which he has derived these conclusions: When a very weak faradic current is in turn applied to all the nerve-trunks of the body, and very gradually increased in strength, the first to show any

* Member of Royal College of Physicians, London; physician to the Hospital for Epilepsy and Paralysis, etc. etc.; author of "Electro-Diagnosis in Nervous Disease."

signs of response is the spinal accessory. (See Fig. 72.) This seems to be the most sensitive to electric irritation in the body. As the current is slowly increased, the next nerve to respond is the branch from the cervical plexus to the levator anguli scapulæ muscle. A further but very slight increase brings the ulnar into action. Increased a little more the median facial, remainder of cervical plexus, anterior crural and external popliteal, react, all, as nearly as possible, being of equal excitability, varying a little in different individuals. A further increase brings into action the musculo-spiral and the internal popliteal. The following table gives the order of excitability in the various superficial nerve-trunks:

1. Spinal accessory.
2. Branch to levator anguli scapulæ.
3. Ulnar.
4. Median.
5. Facial.
6. Cervical plexus.
7. Anterior crural.
8. External popliteal.
9. Musculo-spiral.
10. Internal popliteal.

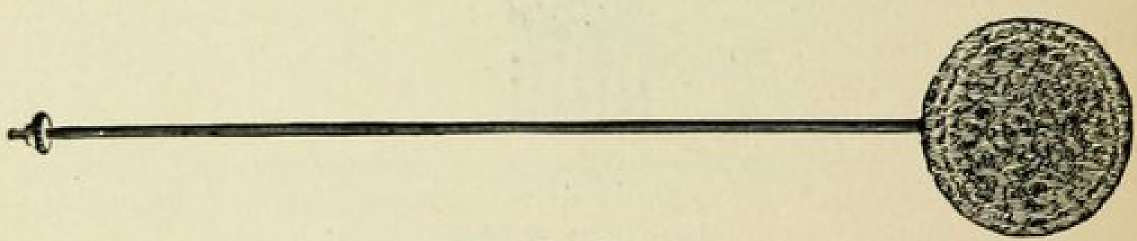

FIG. 82.

SPINAL ELECTRODE.

Length of stem, 12 in. Diameter of disc, 4 in.

The disc of this electrode consists of a metallic plate, covered with sponge upon the anterior and soft rubber on the posterior surface. The long metallic stem is insulated with hard rubber and is made to fit the universal handle, which adds 4½ inches to its length. It is designed to be used beneath the clothing.

Suppose a case to be examined has both legs paralyzed, we cannot compare one with the other, but we may arrive at an approximate idea of the truth by comparison with healthy parts of the body. Thus the *anterior crural* and *external popliteal* nerves in health are about equal to the *median* and *facial* in excitability. The *internal popliteal* is about the same as the *musculo-spiral*, or somewhat less excitable than the *median*.

The motor points diminish somewhat in irritability at the peripheral as compared with the central portions of the body. The best general guide is the nearest healthy *nerve-trunk*, the excitability of which is a little greater than the motor points near it. For example, a current which produces vigorous contractions when applied to the ulnar nerve will cause well-marked action of all motor points in front of the forearm, but not to the same extent as when the trunk is stimulated.

The muscle substance requires a stronger current to produce contraction than is necessary when the latter is applied directly to the nerve supplying the muscle. Muscular irritability varies thus:

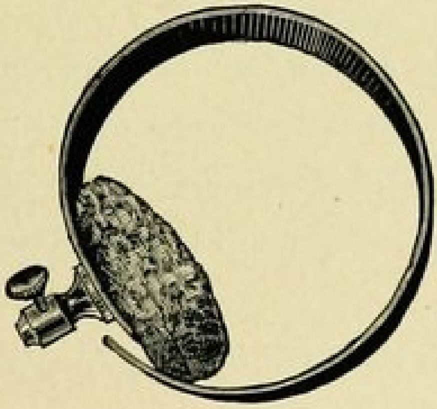

FIG. 83.

NECK ELECTRODE OR NECKLET.

This consists of a sponge-covered disc fastened to a black hard-rubber spring to retain the disc in place. A binding post receives the conducting cord. A similar device is made to retain one electrode on the arm or about the body, which is much used in the electro-thermal bath. It is very convenient for the operator since it leaves both hands free.

(*a*) Those best supplied with nerve branches are most readily stimulated by the faradic current.

(*b*) The larger and coarser the fiber of the muscle the more powerful a *galvanic* current must be used to produce contraction.

(*c*) The conducting media (skin, fat, connective tissue) and state of skin (moist or dry) vary in different localities, and modify the action of both currents.

(*d*) The muscles of the upper extremities are more easily stimulated than those of the lower; the flexors of the arms more than the extensors, and the inner and anterior aspects of the legs more than the outer and posterior. Those of the trunk, and especially the large muscles of the back and abdomen, are less irritable, as a rule, than those of the limbs, and the back less than the front of the body.

GENERAL PRINCIPLES IN ELECTRO-DIAGNOSIS OF PARALYSIS.

Cases of paralysis giving *normal electrical reaction* usually indicate that the disease originates in the *brain* or *white columns of the cord.*

Cases of paralysis giving *abnormal electrical reaction* usually indicate disease of either the *grey matter* of the *cord*, or the *peripheral nerves.* The evidence is stronger if the electrical responses are changed in quality and character in addition to quantity and degree.

Paralysis of one side of the body (hemiplegia) is usually due to *brain disease.*

Paralysis of the lower half of the body, including the bladder and rectum (paraplegia), is generally due to *spinal disease.*

Cross paralysis, where the loss of power is irregular, as when it affects the face on one side and a limb on the other (hemiplegia alternate), may be dependent on *disease of the brain* or the *white columns of the cord.*

The reaction in hemiplegia alternate is *normal*, therefore the disease cannot be exactly located by electricity, but must be determined by general symptoms, often a matter of great difficulty. Fortunately the latter form is extremely rare.

When electrical reaction is *greatly increased*, it indicates hyper-excitability of the nervous system; and when, in addition, reflex muscular contractions are produced in various parts of the body by stimulation of a nerve in the paralyzed parts, it is further evidence of great irritability of the spinal cord almost, if not quite, amounting to organic disease. When paralysis is confined to the branches, and muscles supplied by a single nerve-trunk, the probability is that the lesion is of *peripheral origin*.

When a limb has lost its power of motion as a result of disease of the *cord*, the *abnormal electrical responses* may exist in one of three ways.

(*a*) They may be *uniformly* distributed throughout the entire paralyzed member, all the muscles being equally affected. This takes place in *gross lesions*, involving a *mass of the structure of the cord.*

(*b*) They may be distributed only to certain muscles forming *physiological groups*, irrespective of their nerve supply. For example, all the flexors of a limb, or its extensors, may present abnormal reactions, although they receive their nutritive supply from different sources. This occurs in chronic affections of the anterior roots of the spinal nerves.

(*c*) They may be *irregularly* distributed, affecting muscles neither in anatomical nor physiological groups. This often follows *acute inflammation* of the *grey matter*.

(*d*) They are always distributed according to *anatomical* relations in *peripheral* paralysis; in other words, the abnormal reactions occur only in those structures which receive their nerve supply from a special nerve-trunk totally irrespective of their function.

Hence *limited paralysis*, originating in the *cord*, may be distinguished from that originating in a *peripheral nerve* lesion, since in the *former* the limb is uniformly affected, or its muscles are attacked in physiological or irregular groups, while in the *latter* they are affected according to their anatomical distribution.

Paralysis arising from disease of the grey matter of the cord.

(*a*) When the *abnormal* reactions are uniform, extending over an entire limb, the disease occupies a mass of its substance, as in inflammation of the substance of the brain (myelitis).

(*b*) If they are confined to certain physiological groups of muscles, the disease has generally been chronic, and implicates the anterior roots of the spinal nerves, as in progressive muscular atrophy.

(*c*) If the degenerate muscles react in an irregular manner, neither according to distribution or function, the disease has usually been the result of an acute inflammation of the anterior cornua which has destroyed some of the nutritive centers, and left others intact.

When a nerve is found deficient in response, and muscle normal, it shows alteration in the former, the latter remaining intact, as is sometimes seen in the early stage of infantile paralysis.

The electrical reactions in peripheral paralysis indicate with exactitude the extent and distribution of the disease.

(*a*) When electrical reactions are normal, it indicates a paralysis of slight and temporary form; prognosis is favorable.

(*b*) Loss of response when either current is applied to *nerve-trunks* points to nerve-alteration, and this in proportion to diminution of action.

(*c*) Loss of response to *faradism* applied direct to a muscle, indicates changes in the intra-muscular nerves, without necessary alteration of the fibers themselves.

(*d*) Loss of response with *galvanism* applied to the muscles, shows a modification or destruction of the muscular tissue, and this in proportion to the physical changes induced.

Reaction of degeneration. Immediately after a muscle has been injured severely enough to destroy a portion of a motor, or mixed nerve, it has been found by Erb that atrophy of the muscular fibers sets in, which may be seen during the second week, and reaches its limit about the fifth or sixth week. At first it ceases to respond to the faradic current, then follows a period when it will act only to a slowly interrupted galvanic current, and finally ceases to react to any form of electrical stimulation; he termed this the reaction of degeneration. It is present in paralyses arising from rheumatism, lead palsy, the paralysis peculiar to writers, telegraph operators, etc. In those difficult cases after railway and other accidents, when persons demand compensation for damages, the existence of the reaction of degeneration would be a fact of vital importance in favor of the applicant, as it would indicate that he was suffering from a serious injury of the nerves. Such a demonstration in a court of justice is more conclusive than any amount of authoritative opinion.

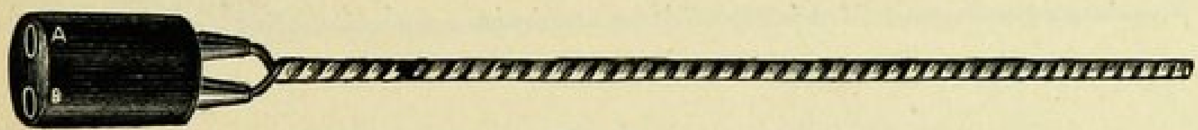

FIG. 84.

McINTOSH ELECTRIC PROBE.

Prognosis in peripheral paralysis. Provided the cause can be removed, as a rule, if there be but little wasting of the muscles and they respond somewhat to the faradic current, a cure may be expected in a comparatively short time. If the muscles are much wasted, the disease has existed a long time, and the muscles refuse to respond to the application of either kind of a current, the case, though possibly curable, requires a guarded prognosis. In case of complete wasting of muscles following paralysis, it is useless to expect improvement.

TO DETECT THE PRESENCE AND LOCATION OF A BULLET, OR PIECES OF METAL IN WOUNDS.

The electric probe, Fig. 84, is used principally to ascertain the location of the bullet in gunshot wounds, but it may be used for other metals. It consists of a pair of spiral wires insulated from each other and connected through the sockets A and B with the poles of a single galvanic cell. A galvanometer is included in the circuit; when the probe touches a piece of metal, either at the end or at any part of its length, both wires are in contact with it, the circuit is completed, and the galvanometer needle will be deflected. If a powerful cell is attached to the probe the circuit may be completed through electrolytic action in the tissues, and the needle will be deflected when no metal is present. To prevent this, use very weak fluid to excite the elements.

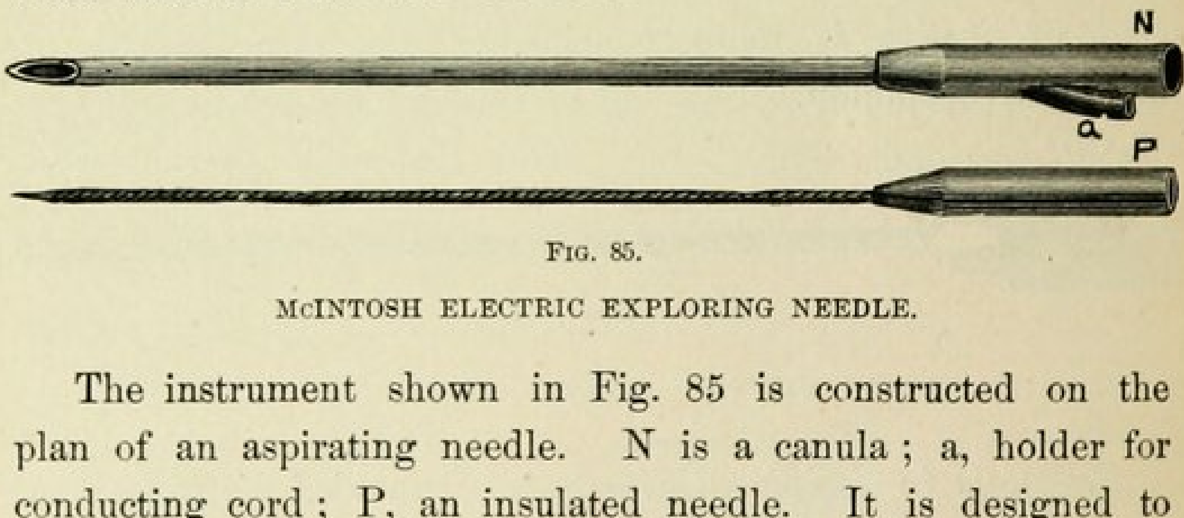

FIG. 85.

McINTOSH ELECTRIC EXPLORING NEEDLE.

The instrument shown in Fig. 85 is constructed on the plan of an aspirating needle. N is a canula; a, holder for conducting cord; P, an insulated needle. It is designed to be used when the course of the missile has become obliterated. One pole of a single galvanic cell is attached to P, the other to a. N is introduced until it strikes the suspected foreign body, then P is inserted through N. A galvanometer is included in the circuit, and the deflection of the needle shows when both points strike a piece of any metallic substance.

THE BRAIN.

The possibility of sending a current of electricity through the substance of the brain has been satisfactorily demonstrated, first by Erb, and subsequently by others. It is believed that the *galvanic* current penetrates the substance of the brain, while the *faradic* current is distributed chiefly to the membranes. Erb claims that electricity enters the brain only at the openings in the skull through which the bloodvessels pass, but it is probable that a current can also be guided to the brain through the reflex function of the fifth pair of cerebral nerves.

Althaus reports a case where he had an exceptional opportunity to observe the influence of these nerves upon the brain. There was complete anæsthesia of the entire fifth pair, and no cerebral symptoms were produced even when a current powerful enough to cause intolerable sensations to a healthy person was sent straight through the head. As the reflex function of the nerves was restored, the patient could no longer bear a current without decided cerebral symptoms.

Löwenfeld discovered that a *descending galvanic* current (positive at nape of neck, and negative at forehead) contracts the vessels of the brain and its membranes; an *ascending galvanic* current dilates them; a *cross galvanic* current, *i.e.* the positive pole applied to one side of the head and the negative to the other, dilates the vessels on the side of the positive and contracts them on the side of the negative pole. *Faradic* currents in any direction through the brain produce the same effect upon the bloodvessels as when applied elsewhere. According to Weber, they produce at first anæmia through contraction, followed by hyperæmia through paralytic affection of the vessels. Kölliker and Remak also verified these observations.

Some persons suffer, after galvanization of the head, from a feeling of dullness and confusion or faintness, and, in certain cases, nausea or vomiting. These symptoms are usually caused by an injudicious selection of current, or too long an application of a suitable one. Formerly it was common to employ much more powerful and long-continued treatments than are at present deemed justifiable, and in a few instances attacks of cerebral hemorrhage, followed by general convulsions, paralysis, etc., have resulted.

Diseases in which the application of electricity to the brain has proven beneficial:

Cerebral anemia,
Cerebral hyperæmia,
Cerebral exhaustion,
Cerebral paralysis,
Dipsomania,
Headache,
Incipient insanity,
Morbid depositions in the brain,
Neuralgia,
Opium habit, etc.,
Sleeplessness,
Spasmodic diseases originating in the brain.

Method of applying electricity to the brain. There are certain general rules which govern the application of electricity to all parts of the body, but it is impossible to formulate specific rules for its application to any single organ or disease. The *dose* of electricity, like that of a drug, must be regulated by the age, race and habits of life of the patient under treatment.

The skin of the aged is firm, frequently dry, and is less easily penetrated; therefore it will require not only larger electrodes, but that they be placed as near as possible to the organ or muscle through which the current is sent. The skin of dark races does not permit a current to pass as readily as lighter ones; therefore they need to have the electrodes large and near together. Those accustomed to laborious pursuits, involving severe muscular exercise, offer great resistance to the passage of the current, on account of the firmness of the muscular tissue, and will require the same arrangement of electrodes as the preceding.

There are several ways in which electrization of the brain may be performed: 1. Place one pole on the forehead, the other on the back of the head (occiput). 2. Place one pole over each temple. 3. Place one pole behind each ear (on mastoid process). 4. One very large electrode on the top of the head and another at the feet, in the hands, along the spine or under the chin. 5. To electrize one-half the brain, place one pole on the eyebrow and the other on the mastoid process, or in the hand of the same side. Less dizziness is caused when the current passes through one side of the head only, or from forehead to occiput, than when sent from one side to the other through the temples or mastoid processes. To avoid shock or unpleasant symptoms, *locate the electrodes before completing the circuit, and always open the circuit before removing them.* They may be moved over the surface when necessary, without causing irritation while the circuit is complete, *provided that they are not raised so as to break contact with the patient.* One or two zinc-carbon cells are sufficient to begin with. Others may be joined in circuit one by one with a current selector. When cells have been added in this way they must be removed one by one before breaking the circuit. A much more convenient method of regulating the current and avoiding shock is to introduce a rheostat in the circuit, interpose such a resistance that a current can scarcely be detected on closing the circuit, and then increase the strength by lowering the rod if a water rheostat is employed, or lessening the number of buttons included in the rheostat circuit when the one shown on Fig. 63 is employed. The resistance must be again increased before the circuit is opened. The reason for this will be apparent if the operator will test a galvanic current upon his own head. The best authorities now recommend, for applications of galvanism to the brain, a few cells only in circuit, three to six freshly charged zinc-carbon or twice that number of gravity cells. Faradism, in the form of a primary current, may be employed direct from the battery.

If the therapeutic effect of the secondary is required, it should be carried through a rheostat, or some substitute for it, as the arm of the patient or operator, or a very large moist sponge electrode covered with moist flannel. The length of sitting depends largely upon the condition of the case ; it varies from thirty seconds to half an hour.

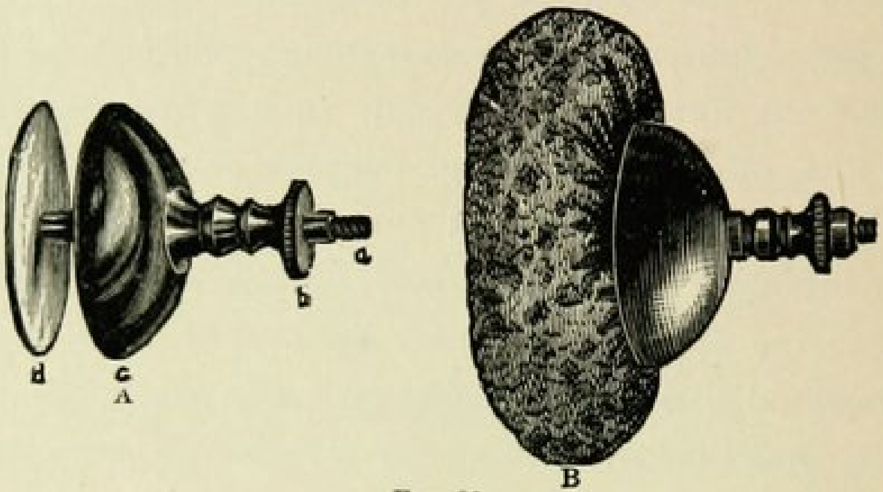

FIG. 86.

ADJUSTABLE SPONGE HOLDER.

A, metallic holder; diam. 1½ in.
c, sponge cup.
d, plate upon which the sponge is fastened, the edge being held between d and c.
b, the nut which holds c and d together.
a, screw which fits the universal handle.
B shows the sponge adjusted and fastened.

This sponge holder cannot be too highly commended ; a sponge of any size may be attached or removed in a moment, making it possible to employ a clean sponge in every case. The metal holder is nickel plated and does not corrode easily ; a little care in removing the wet sponge after using will keep it in good order for years.

Electrodes suitable to use in electrization of the brain. The universal electrodes may be employed for this purpose, or any other style which offers a sufficiently large surface of contact. When they are placed on the hair, the latter must be moist, as it is a non-conductor when dry. Sponge electrodes are preferable for the top of the head, forehead or temples. Those illustrated in Figs. 86, 87, 88 and 89 will be found very satisfactory for all purposes where a comparatively large electrode is required.

Anæmia and Hyperæmia.— All diseases accompanied by anæmia or deficiency of blood in the brain, should be treated with an *ascending* current; those which are accompanied by too much blood in the brain (congestion or hyperæmia) require a *descending* current. It should be understood that electricity is not employed to regulate the blood supply of the brain when the circulation is obstructed by tumors, aneurism, heart or lung disease.

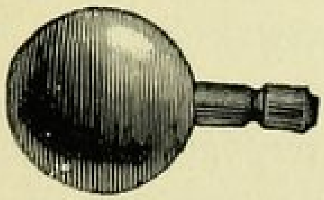

Fig. 87.

BALL ELECTRODE.

Diam. 1¼ in.

This nickel plated ball is placed in the center of a large sponge and attached directly to a conducting-cord.

Cerebral Exhaustion.—"Wherever sleeplessness is a prominent symptom, the production of anelectrotonus should be the rule. Catelectrotonus, on the other hand, is an excellent remedy where there is drowsiness in the daytime."—[*Althaus*]. To produce anelectrotonus, the galvanic current is employed, a large sponge upon the head forming the positive pole, and an ordinary electrode in the patient's hands the negative. Catelectrotonus is produced in a similar manner, the electrode on the head in this case being negative, the one in the hands positive. One to five minutes is the usual length of the application. The treatment of paralytic affections due to disease of the brain will be described under *paralysis*.

Dipsomania.— Habitual drunkards frequently present disordered conditions of the brain, in which electricity doubtless would prove beneficial. Althaus states that he has seen many instances where mental depression and nervousness had led the sufferers to indulge in intoxicating drinks in order to overcome their wretched sensations, where catelectrotonos of the brain, spine and cervical sympathetic had resulted in recovery. He treated one case successfully that presented a state of complete nervous derangement from this cause. Forty-five sittings were required. Electro-thermal baths are a valuable aid in restoring the constitutional vigor after it has become impaired by excesses of any kind.

Opium Eating, Excessive Smoking, etc.—The mental and nervous symptoms that accompany the effort to break up these habits may be very greatly allayed by galvanization. Sleeplessness is usually a symptom demanding an application of the positive pole to the brain to produce anelectrotonos.

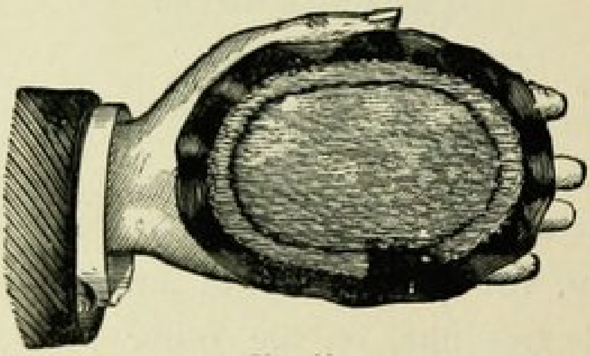

Fig. 88.

SPONGE-COVERED HAND ELECTRODE.

Size, $4\frac{1}{2} \times 4$ inches.

This consists of a thin plate of metal, covered on its anterior surface with sponge, on the posterior with soft rubber, to which a loop of soft rubber is attached, through which the operator's hand is passed when the electrode is used. The rubber insulates it and protects the patient's clothing from moisture when employed for general electrization. A binding post beneath the rubber receives the conducting cord.

Spasmodic Diseases resulting from disease of the brain will be considered in connection with those arising from other will causes.

Headache.—*Galvanism.* Headache confined to one-half the head (hemicrania) was first treated systematically by Holst, who applied the galvanic current. One small electrode is located at the inner edge of the sterno cleido-mastoid muscle, at the point indicated by motor point 21, Fig. 72, and the other in the palm of the hand. Hemicrania, attended by contracted condition of the bloodvessels, sunken eye and features, should have the *positive* current applied through the electrode at the neck. The electrodes are located, and then the circuit, including from six to ten zinc-carbon cells, is closed ; after two to three minutes the current is gradually reduced in strength by disconnecting cells one by one from the circuit. On the contrary, when there is a paralytic condition of the vaso-motor nerves, shown by fullness of the bloodvessels and injected eye, the electrode at the neck should be *negative*, and the current should be interrupted, or in some cases repeatedly reversed, by means of a pole-changer. This treatment usually brings a sense of comfort and relief in a very short time, and in some cases it appears to produce a lengthening of the interval between attacks.

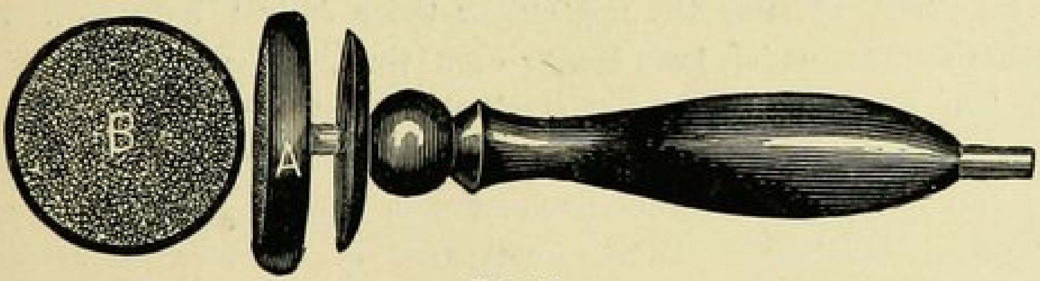

FIG. 89.

CARBON ELECTRODE.
Diam. of disc, 1¾ in.

The handle of this electrode is made of polished black rubber, in the same style as the universal handle, to which it is superior in that it is not affected by moisture. A is a disc of carbon, insulated, except on its anterior face, with hard rubber. B represents the carbon face of the disc. A sponge may be attached to it in the same manner as described under Fig. 86, or it may be used with the cover shown in Fig. 79. When located over a point that has little sensitiveness, it may be used without a cover. Carbon is superior to all other substances employed for electrodes in cleanliness and freedom from corrosion.

Faradism. Frommhold and Fieber recommend the *induced* current. The former prefers the primary faradic, with one pole high up the back of the neck in the median line, and the other over the forehead or over the eyebrows. Fieber prefers the *electric hand.* The patient holds one electrode and the operator the uninsulated portion of the other, while his free hand is passed over the patient's head. Forms of headache, dependent upon disease of some other organ, require treatment applied at the seat of the disease, instead of to the brain exclusively. General faradization and central galvanization are both beneficial in many cases where headache is a frequently recurring symptom.

INCIPIENT INSANITY.—*Galvanism* possesses great value as an adjuvant, when properly applied, in antagonizing various congestive states of the brain, which, if unchecked, would undoubtedly result in organic disease.

Typical cases of nerve exhaustion, accompanied by congestion of the brain, impaired nutrition, dullness of perception, melancholia, inability to bear stimulants, with restlessness, sleeplessness, perspirations, and loss of elasticity of the skin, are relieved by applying the galvanic current to the head daily for a period of not more than five minutes at each sitting, as a rule, but repeating the application twice daily if necessary. Amelioration follows, which lasts longer each time, and results finally in a cure. The most severe forms of cerebral congestion are amenable to this treatment, even when accompanied by a loss of consciousness. A proper tonic contraction of the cerebral bloodvessels is secured, thus heading off, perhaps, mental disease. In the application of the constant current to the brain to antagonize various congestive states, the positive pole is to be placed at the level of the first cervical vertebra, and the negative at the level of the superior ganglia of one of the cervical sympathetic nerves. The current should be interrupted, since vascular contraction occurs most markedly at the opening and closing of the circuit.—DR. MANN.

Dr. Arndt, of Greifswald, has thoroughly tested electricity in many forms of insanity, and has arrived at these conclusions:

Faradism is a powerful stimulant upon diseased nervous centers, and should therefore not be employed where the symptoms point to increased excitability, *i.e.*, in all so-called primary cases. It also does not answer in secondary cases, if they are marked by a high degree of irritable weakness and a tendency to reflex actions. It is an excellent remedy in cases of simple atony of the brain, depression, or paralysis of function. It must not be forgotten that some conditions of excitability are not owing to irritation, but to paralysis; and some forms of stupor may be caused by spasm and not by depression. The latter may be looked for when there are symptoms of irritation in other organs; for instance, where respiration is sighing or jerky, where there is much hiccough or gaping, irregularity of the heart's action, dilatation of the pupils or difference in their size, spasms of voluntary musles, etc. When no such symptoms are present, the condition may be looked upon as one of depression, which faradism will relieve.

Faradization of the dry skin, and especially electric fustigation of the upper half of the body, sometimes proves an excellent measure in disease of the brain, through its reflex action.

Arndt recommends faradization of the phrenic nerves at the neck (see Fig. 72) in depression of the nerve centers. This rule has been given for the use of galvanism in insanity: *Recent cases and functional diseases are benefited by it, while old cases and structural diseases resist its influence.*

MELANCHOLIA.—*Franklinism.* Dr. Blackwood* reports a case illustrating the beneficial effects of franklinic electricity in suitable cases.

A B, a case of melancholia persistent for four years, in all except the mental state, healthy, and not at any time hysterical or excitable. Drugs failing, she was referred to me for electrical treatment, her physician being glad to drop the case. I put her on general faradization four times a week, with some benefit after a month's trial, but, not being satisfied myself, I substituted static electricity, and her improvement in another month was decidedly greater, and then she was at times not only cheerful, but her interest in surrounding affairs was noticeable to her associates. This method of treatment, without any auxiliary, in four months did more toward recovery than all former plans combined, and so far the improve-

* *Medical Times*, October 22, 1881.

ment is permanent. She was treated by simple charging when insulated, triweekly, the condition being maintained for half an hour at each time; and although to my mind she is yet abnormally depressed at times, she is in every way better, and her friends consider her recovery perfect.

NEURALGIA of the brain will be considered in connection with neuralgia of other organs.

MORBID DEPOSITIONS IN THE BRAIN. *Galvanism* has been used by Althaus to remove morbid depositions from the brain. Hughes* states that he has seen paralysis of one side of the body, loss of voice, and difficulty in swallowing, from disease of the brain, disappear under its use combined with internal medication.

Dr. Barraquer has employed *magnetism* in a case of paralysis from cerebral hemorrhage occurring three years previously. A powerful electro-magnet, weighing 250 to 300 pounds, was held within an inch of the crown of the head for a few minutes. There was visible improvement after the first sitting, and after four the patient could fully extend his forearm and fingers.

SLEEPLESSNESS (Insomnia).—Cases of sleeplessness frequently prove very difficult to relieve, and it sometimes occurs that after drugs have failed to overcome it, electricity proves successful. It is a desirable substitute for hypnotics, where it can be made to answer the purpose, and precludes all danger of rendering the patient a victim of opium or chloral.

Franklinism, galvanism and faradism have each proved successful, and no general rule can be given for selection, unless this may be regarded as one. That form of electricity best adapted to the disease which gives rise to insomnia should be given the first trial: frequently an application to the diseased organs will be followed by sleep. When insomnia is produced

*G. H. Hughes, M.D., St. Louis, in a paper read before the Association of American Institutions for the Insane, at Toronto, Canada, June 14, 1881.

by mental anxiety or exhaustion, electricity may temporarily produce sleep, but in all cases the removal of the cause is an essential factor in treatment. A prolonged application of a very mild current is advisable when the trouble is due to an excited or irritated condition of the brain or nerves; no muscular contractions should be produced when the faradic current is used, and no burning or stinging sensations with the galvanic.

Faradism. Apply a mild faradic current, one electrode over the solar plexus, the uninsulated portion of the other in the left hand of the operator. The whole person of the patient is then gently stroked with the dry right hand of the operator; the sponges or electrode covers must be well moistened. The most grateful effects are obtained while brushing over the back and limbs. A very mild current may be applied half an hour; a current that will produce the crackling of dry cuticle is enough.

Galvanism. When the above measure fails, galvanism may succeed. Two to four zinc-carbon cells are sufficient. The negative pole is placed over the solar plexus, and the positive is applied through the hand of the operator to the top of the head (avoiding the forehead), down the neck on each side as in central galvanization. [Blackwood.]

THE EYES.

Effect of the galvanic current. The eyes, owing to the large amount of water they contain, are excellent conductors. Volta, so long ago as 1800, discovered that the galvanic current has a special effect upon the optic nerve. The current from a single pair of elements, when an electrode is placed on each eye, produces a faint flash of light at the commencement of the current; while the current is passing, a luminous appearance is present to a person with sensitive retina, and there is again a distinct flash when the circuit is broken.

Helmholtz made a real advance in electro-physiology. He observed that the *descending* current (the positive electrode on the forehead and the negative held in the hand) produces not only irritation, but alteration of excitability, external objects becoming less distinct. The effect of the *ascending* current (the positive electrode in the hand and the negative to the forehead) is to render objects more distinct. To carry the current directly to the optic nerve, according to Brenner, the most favorable arrangement is to place one electrode over the eye and the other at the nape of the neck.

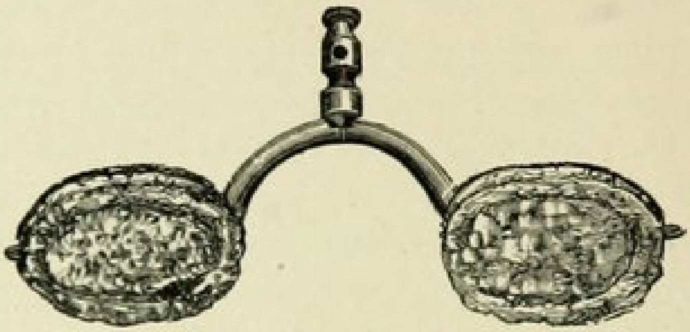

FIG. 90.

SPONGE-COVERED EYE ELECTRODE.

This electrode is to be used when the current is to be applied equally to both eyes at once. The flat sponge-covered plates are moistened in warm water and placed on the closed eyelids, and connected through the binding post with one pole of the battery. The bow is insulated with hard rubber. This electrode is retained in place by means of an elastic cord passing around the head and tied in the small loops projecting from each eye-piece.

Effect of the faradic current. The primary current produces no appreciable effect, but the secondary gives a more or less rapid succession of slight blue flashes, or glimmer, similar to that observed in hyperæsthesia of the retina.

Caution. The fact that the physiological effects of galvanism differ from those of faradism cannot be made too emphatic. Duchenne, being unaware of this important fact, after treating a patient suffering from paralysis of the facial nerve with faradism without accident, afterward applied a galvanic current. Immediately after the circuit had been completed, the patient cried out that the whole room was in a blaze, and found his sight on the side where the electrodes had been applied was lost, and he never regained it. Faradism has much less effect on the retina than galvanism, and is not so likely to do harm.

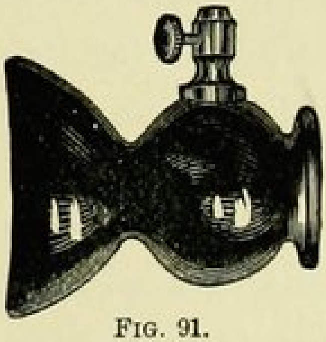

FIG. 91.

EYE-CUP ELECTRODE.

This is a glass eye-cup with a metal binding post attached and projecting a little into it. When used, the cup is filled with water and connected with one pole of the battery. It is very useful in treating paralysis of the muscles of the eye. The water serves as a rheostat to modify the current.

DISEASES TO WHICH ELECTRICITY HAS BEEN SUCCESSFULLY APPLIED.

Amaurosis,
Amblyopia,
Atony of optic nerve,
Blindness following fevers, etc.,
Double vision (diplopia),
Granular lids,
Strabismus (cross-eyes),
Hallucinations of sight.
Nævus of eyelid,
Opacities of cornea and vitreous humor.
Paralysis of the muscles,
Removing fragments of metal,
Spasm of eyelids,
Trichiasis (inverted eyelashes).

Electricity may be applied,

1. Directly, one pole being applied to one or both eyes, and the other at some distant point.
2. Indirectly through the sympathetic nerve.
3. Indirectly by reflex action of the fifth nerve.

AMAUROSIS.—*Galvanism.* A mild current may be passed through the eyeball so as to traverse the retina, or confined to those twigs of the fifth pair of nerves that ramify on the forehead. When these nerves are to be stimulated, interrupt the current with a rheotome introduced into the circuit. Grapengresser introduced a nasal electrode, connected with the positive pole, into the nose, and placed the negative upon the forehead. It is rare, when sight is completely gone, that it can be restored by any means; yet Magendie cured one case of complete amaurosis by galvanism and electro-puncture. M. Pürjinke believed that the direction of the current is important. When the amaurosis is at its commencement, and is accompanied by subjective pains, he placed the negative as near as possible to the eye upon which he desires to act, while it is the positive electrode which he thus places when the amaurosis commences by a weakening of the sensibility of the retina. The opposite pole is placed near, as, for instance, in contact with the buccal gland. Amaurosis, accompanied by congestion of the brain, should not be treated by electricity.

Franklinism. De Saussure cured a case by shocks directed from eyeball to the neck.

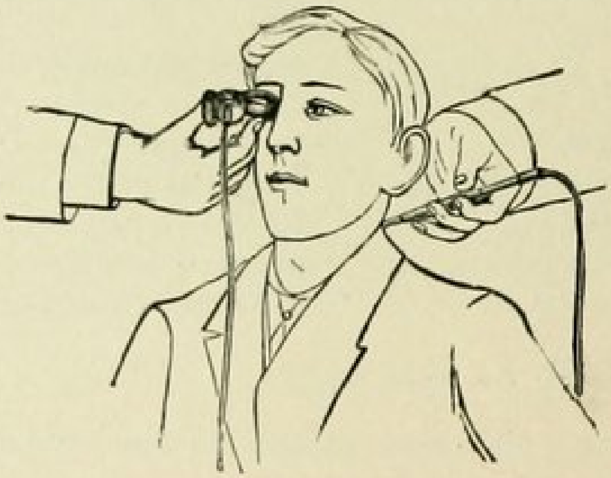

FIG. 92.

METHOD OF USING THE EYE-CUP.

After filling the cup full of water, let the patient bow the head, close the eye, and press the cup up firmly around the eyeball, so that when the head is raised water will cover the eyelid. If the patient remembers to bow the head before the electrode is removed, not a drop of water need be spilled. Warm water conducts better than cold, and should be used when not contra-indicated.

AMBLYOPIA.—*Faradism.* Weakness of sight, with aching of the eyes when used before breakfast, or at twilight or in reading fine print, is frequently accompanied by general feebleness, dyspepsia or hysteria. Beard and Rockwell recommend, for this condition, to place the negative pole at the back of the neck and move the positive electrode over the closed eye, using a mild faradic current (labile faradization) for five to ten minutes.

Galvanism. If faradization, both local and general, fails, try a galvanic current from a few cells only; in this case the positive electrode must be kept stationary. Dr. Mittendorf has found that galvanism is best adapted to amblyopia caused by tobacco or loss of blood, probably from the beneficial effect produced upon the bloodvessels, and consequently upon nutrition.

FIG. 93.

SMALL EYE ELECTRODE.
Length, 3¾ inches.

The stem of this electrode is insulated and fits the universal handle. It terminates in a small, thin spatula-shaped plate. It may be used in treating the muscles, or margins, of the eyelids.

ATONY OF THE OPTIC NERVE.—*Galvanism.* Benedict, Erb and Driver recommend placing the positive pole to the nape of the neck and the negative over the closed eyelids, and moving it gently over and around them, for one or two minutes, not to exceed three minutes. The number of cells at first should not be more than two or three; in subsequent sittings they may be increased to twelve. If dizziness occurs during treatment or headache after, this treatment will do harm. Better a very short application every day than a longer one at longer intervals.

Blindness, originating in a protracted attack of chills and fever, cerebro-spinal meningitis, and other acute diseases, have been reported cured, in a few cases, by the downward galvanic current, the negative pole being held in the hand or against the spine, while the positive was placed on the top of the head, the hair being moistened.

Granular Lids.—*Electrolysis.* Dr. Arcola, of Palermo, has employed electrolysis with success in removing granulations of the conjunctiva. Dr. Kohn, of Berlin, has also reported many successful cases. The negative current is applied by means of a suitable electrode (Fig. 93) to the inverted surface of the upper lid. The positive is applied over the nape of the neck. The first operation continues about ten minutes. Dr. Schivardi publishes three cases of old granulations, lasting, respectively, two, three and eight years. The first was cured in five sittings, the second was greatly improved after two sittings, the third was cured in nine sittings, and the sight, previously obscured, was regained. It requires three persons to perform this operation—one to hold the head steady and lid reversed, one to hold the negative pole, one to hold the positive and manipulate the battery.

Cystic Tumors of the eyelid are effectually destroyed either by electrolysis or galvano-cautery.

Hallucinations of Sight.—*Galvanism.* Flashes of light before the eyes, dimness of sight, hallucinations of sight, etc., not dependent upon organic disease, have been relieved by a *downward* galvanic current, beginning with a current from two cells and increasing from day to day as it can be borne, to twelve cells. The sittings may be repeated daily.

Nævus of the Eyelid.—*Electrolysis.* This has been successfully removed after the following method: Introduce the negative pole into the tumor and close the circuit with a large sponge for the positive, located on the neck; use a current from six to ten zinc-carbon cells (this to be decided by the size of tumor and condition of cells). Let the current operate for two minutes and withdraw the needle; unless the patient is very sensitive an anæsthetic is unnecessary.

Opacities of the Vitreous Humor.—*Galvanism.* M. Teulon,* in writing upon opacities of the vitreous body, gives the results in twenty-four cases observed by him and treated by the continued current; he reckoned twenty-two as radically cured. He employs a very small number of elements, and applies the positive pole upon the closed eyelids, and the negative upon the mastoid process, or upon the superior cervical ganglion. The application lasts only two or three minutes. M. Teulon considers that in every opacity of the vitreous body, no matter what be its degree or extent, provided that its development has not assumed the confirmed form of hypertrophy, the constant continued current is the most efficacious treatment.

Le Fort and Onimus have also advised the use of the galvanic current as an aid to clearing up vitreous opacities. Galvanism has also been employed to remove opacities of the cornea and produce absorption of iritic membranes. Von Graefe claimed quick absorption of *cataract*, but others have not been so fortunate. Four freshly charged zinc-carbon cells are sufficient, as a rule. There is danger of increasing the opacity by a too careless use of the current.

Paralysis of ocular muscles. Electricity, both faradization and galvanization, is often of great service in the treatment of paralysis of the muscles of the eye, especially if the cause is peripheral. The negative pole is placed on the closed eyelid, in a situation corresponding to the affected muscle, the positive being located on the temple or back of the neck, the sitting not to last beyond two or three minutes.

Galvanism. Benedict applies a feeble current from a few cells (three to seven zinc-carbon are sufficient) as follows: Paralysis of the muscle that draws the eyeball outward; place the positive on the forehead and stroke the cheek bones for several minutes with the negative.

**Medical Press and Circular*; November 9, 1881.

Paralysis of the muscles that turn the eyeball in toward the nose and obliquely downward; apply the negative to the skin on the side of the nose near the inner angle of the eye.

Paralysis of the muscle that raises the eyelid (ptosis); apply the negative to the upper eyelid, over which it may be moved while the current is passing.

Paralysis of the muscle that moves the eyeball downward; apply the negative to the lower border of the orbit.

Paralysis of the muscle that raises the eyeball upward and inward; apply the negative to the inside of the nose in the neighborhood of the inner angle of the eye. The alternative electrode in each case being located on the forehead.

Faradism is recommended by Althaus, M. Meyer and Soelberg Wells. The positive pole is placed below the ear and a small moistened sponge electrode connected with the negative is placed on the closed eyelid, as near as possible to the paralyzed muscle, sending the current through it for two or three minutes. In some cases improvement follows in one or two sittings, and in others it may not appear until fifteen or twenty. Persistent treatment will sometimes be rewarded with success in very obstinate cases. Dr. Mittendorf has observed that pain which frequently accompanies weakness of the internal recti muscles has been greatly relieved by faradism.

DIPLOPIA.—*Galvanism.* The field in which double vision is present, according to Benedict, is lessened immediately by the treatment above described. When this is not the case, a longer continuance and increased strength of the current is not indicated, but rather a change in the kind of electricity employed. In one case Duchenne applied a moist electrode over each eye, closed, and opened the circuit twice at intervals of a second; the patient saw a dazzling flame, and on opening the eyes discovered that he was cured.

STRABISMUS.—*Faradism.* Cross-eyes, dependent merely upon debility of the muscles, may be relieved by faradizing the muscles that are at fault. Dr. Poore reports a case of paralytic strabismus in which localized faradization aided in the cure. After tenotomy had been performed and the wound healed, the eye was found in the old position of extreme inversion. The external rectus was faradized for some weeks by an electrode placed on the muscle. The patient steadily improved.

SPASM OF THE EYELIDS.—*Galvanism.* Apply the positive to the eye through the eye-cup, and the negative to the palm of the patient's hand.

TRICHIASIS.—*Electrolysis.* Dr. J. Elliott Colburn,* in a paper read before the Chicago Medical Society, describes the usual method of removing inverted eyelashes by electrolysis, which he had used in fifty cases at the State Eye and Ear Infirmary and at the Central Free Dispensary, twenty-two of which had been under observations through periods of from six months to three and a half years.

The instruments necessary for this operation are a battery which furnishes six or more zinc-carbon cells, a light needle-holder and a suitable needle. The patient being placed in a strong light, the surgeon fixes the lid in a Desmarc's or Knapp's clamps. The patient holds the handle of a positive electrode in the right hand, and places the moist sponge on the palm of the left, after the needle is introduced into the hair gland. The needle may be withdrawn after about ten seconds. The patient should remove the sponge from the left hand simultaneously with the withdrawal of the needle. The number of cells to be used should be decided by the surgeon's knowledge of the condition of his battery. I use from six to ten cells of a zinc-carbon battery. Where the hairs are very fine and obscure, the use of three-inch lens will be found quite serviceable. After electrolysis, the hairs should be removed with epilation forceps. The only objection to the operation, in my experience, is, that when there is a large number of hairs to be removed the pain becomes somewhat tedious; though with the clamp I find the pain

* *The Weekly Medical Review*, November 1883.

is not so great. Only about fifteen per cent of the hairs return. The irritation following the operation is slight. The lids will be swollen for a day or two. In one case from which I removed but two or three hairs, the operation was followed by the growth of fifteen or twenty minute hairs, which were promptly removed. The results in all cases were good and permanent.

The method of performing this operation will be more fully described under Hirsuties.

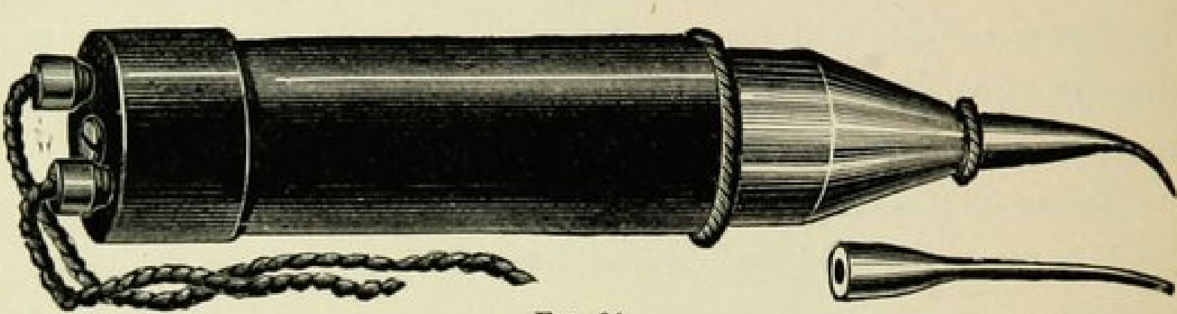

FIG. 94.

McINTOSH EYE MAGNET.
Weight, 2¾ oz.

The core of this instrument is made of soft iron, and is surrounded by many convolutions of insulated copper wire, all inclosed in and insulated by a black hard-rubber cover. It may be connected with a single Grenet cell, or with any number of the zinc-carbon cells of the McIntosh galvanic battery. The *size* of a magnet should be in proportion to the body acted upon. Large magnets capable of lifting many pounds weight offer no advantage over small ones magnetized to saturation, where small fragments of metal are to be removed.

TO REMOVE FRAGMENTS OF IRON OR STEEL FROM THE EYE.—The electro-magnet is extensively used at present for this purpose. The method of applying it is as follows:

The point of the magnet is brought in direct contact with the foreign body, and then moved away to the distance of a fourth of an inch; this manœuver is repeated several times, and if the case is seen before the corneal wound has had a chance to heal, the foreign body will finally be found adhering to the point of the instrument. If, however, the wound has healed, a change in the procedure is necessary. While keeping the magnet in close proximity to the foreign body, an incision through the wound is to be made for the purpose of allowing a free exit, the maneuver of touching and withdrawing the instrument must be gone through with again and again, and ultimately the foreign body will be easily removed. These two methods are entirely sufficient for the extraction of all fragments in this tissue, as long as any part of them is in the cornea, even though the greater portion of their bulk projects into the anterior chamber.

The anterior chamber may be the resting-place of a fragment, and if so, it should be drawn to the margin of the cornea, and extracted through an incision in that region, either by the forceps or magnet, at the option of the operator, who should bear in mind the importance of keeping the magnet in close proximity to the metal to be extracted if forceps are used, in order that the fragments may not be lost by means of the forceps slipping.

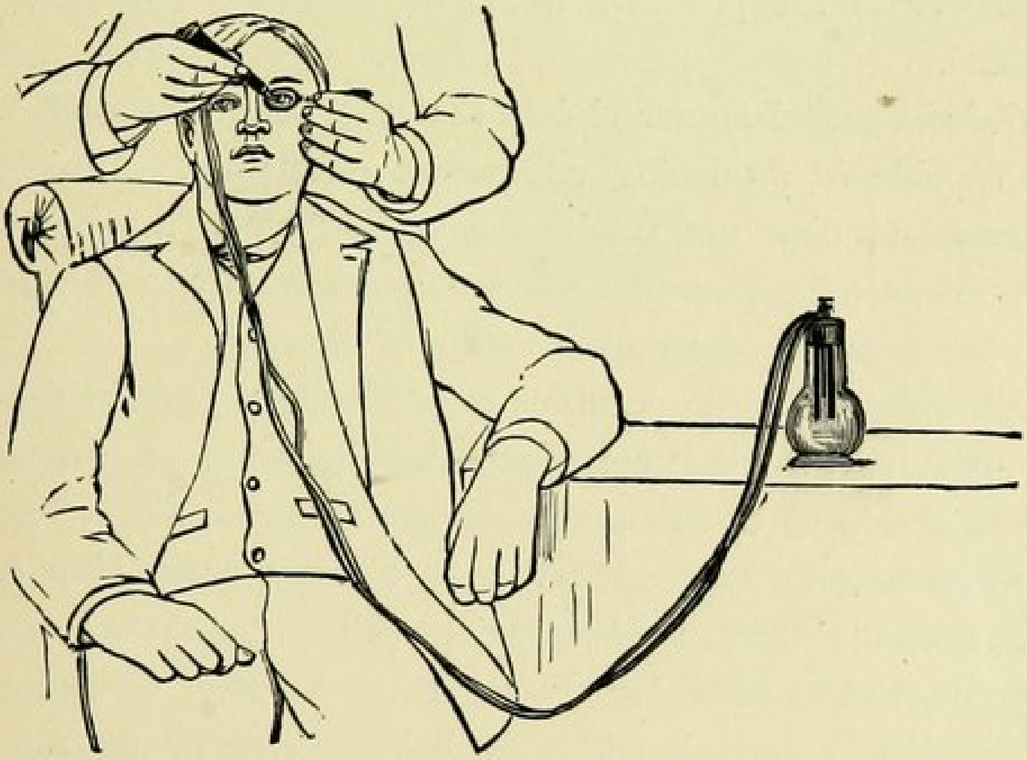

FIG. 95.

METHOD OF USING THE McINTOSH EYE MAGNET.

The patient should be seated in a good light, and, as a rule, the eyelids should be kept far apart, and the eyeball fixed. Fine particles of metal lying on the conjunctiva can usually be picked off by the magnet with the greatest facility by the method shown above.

One important point in regard to all incisions made for the entrance of the magnet and the removal of a foreign body from the eye, is *that the cut should be not one with parallel edges, but T-shaped;* as, in the former case, when the extraction of the foreign body takes place, it is invariably stripped off the end of the magnet, and is retained at the site of the wound, or drops into the interior of the eye. This is a foregone conclusion unless the lips of the wound be held apart, and no amount of skill or carefulness upon the part of the operator can guard against it unless the incision is of the above-mentioned shape.—[Dr. Bradford.] *

THE EAR.

The difference of opinion among writers in regard to the relative value of the different forms of electricity in the treatment of diseases of the ear is greater than in regard to any other part of the body. The difficulty of localizing a current in the ear is the probable cause of the difference in results obtained.

Galvanism. Brenner claims that the faradic current, while it is capable of producing unpleasant effects upon the nerves of sensation, does not produce any effect upon the nerves of special sense; therefore the galvanic current only is of value in restoring sensitiveness to the nerve of hearing.

Faradism. The application of a faradic current within the ear gives rise to an unpleasant metallic taste on the corresponding side of the tongue, and an increased flow of saliva, and according to some observers, a roaring or rushing sound in the ear, with a tickling or prickling that may become unendurable by increasing the current. In cases of congestion of the middle ear, electricity is liable to aggravate the congestion.

THE DISEASES IN WHICH ELECTRICITY HAS BEEN EMPLOYED.

Chronic suppuration of the ear.	Relaxation of the auricle.
Inflammation of the drum.	Stricture of the Eustachian canal.
Nervous deafness.	Tinnitus aurium.

Methods of Applying Electricity to the Ear.—Pürjinke† observed that a current sent through both ears at once causes fullness of the head and general dizziness. Benedict recom-

* Mass. Eye and Ear Hospital.

† *Rust's Magazin für Chirurgie.*

mends one electrode applied in or over the ear, and the other held in the patient's hand to interpose the resistance of the arm.

Beard and Rockwell describe two methods which they term — 1. The internal. 2. The external.

By the internal method, the current from either pole may be directed to one ear, or divided between both, the alternate electrode being placed at the nape of the neck, on the mastoid process, in the hand, or applied to the orifice of the Eustachian tube. (See Fig. 73, location of electrode c.)

The *external* method. Press one electrode firmly on the tragus, the other electrode being held in the hand of the opposite side. The ear may be filled with warm water, although it is not necessary. In regard to this method Beard and Rockwell say: "We have used it for several years with both the galvanic and faradic currents, and prefer it for all cases, *except when it is desired to act directly on the inflamed surfaces of the drum, or middle ear*. It is far less painful, and more satisfactory than the internal method. It may be used on the most sensitive children who would rebel against the internal method, however skillfully employed. The sitting should not usually be more than five or ten minutes, and in some cases even less, especially if the galvanic current be employed.

CHRONIC SUPPURATION OF THE EAR.—*Galvanism.* A very mild galvanic current may be used to change the nature of the secretion. If the reaction is acid, introduce the negative pole; if alkaline, the positive, the alternate electrode being held in the hand of the patient.

INFLAMMATION OF THE DRUM. A rheostat should be in the circuit when a galvanic current is employed in a case of this kind. The positive may be applied to the ear, and the negative to the hand. Only two or three cells should be included in the circuit.

Nervous Deafness.—*Faradism.* M. Duchenne succeeded in curing, almost entirely, one child born deaf and dumb. The current within the external ear was sent through warm water, and a sponge electrode placed at the nape of the neck. He used a very mild faradic current for a few minutes at a time. He repeated this treatment in a large number of cases, with almost as many failures as successes, but his experience in ameliorating cases of nervous deafness, which had previously been regarded as incurable, were such as to show that electricity is of considerable value, and its application should be tried in these cases.

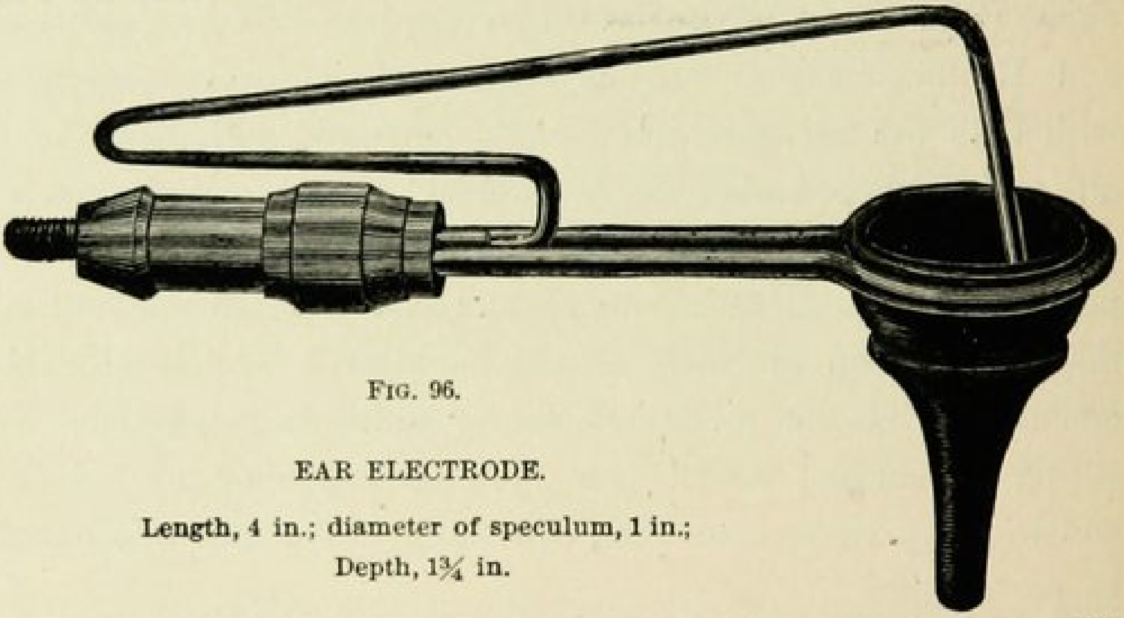

Fig. 96.

EAR ELECTRODE.

Length, 4 in.; diameter of speculum, 1 in.;
Depth, 1¾ in.

This electrode consists of a rubber speculum fastened in a wire frame, into which the wire-spring fastened to the same frame may be pressed to close the capillary opening in the speculum. The latter is filled with warm water when used; the spring prevents its escape while being placed in the ear. This electrode fits the universal handle.

Dr. Edward C. Mann * reports an interesting case of blindness and deafness resulting from cerebro-spinal meningitis, successfully treated by him with the galvanic current.

Deafness caused by Muscular Paralysis.—*Faradism.* Dr. Woakes † believes that muscular paralysis is an important

* *London Jour. Physiol. Med. and Ment. Pathology,* Vol. VII, Part 2.

† *British Medical Journal.*

factor in causing deafness in adult life. Such cases will be benefited by a mild faradic current applied to the paralyzed muscles, the positive electrode being placed at the insertion and the negative at the origin of the muscles. Duchenne's Points are convenient electrodes for this purpose.

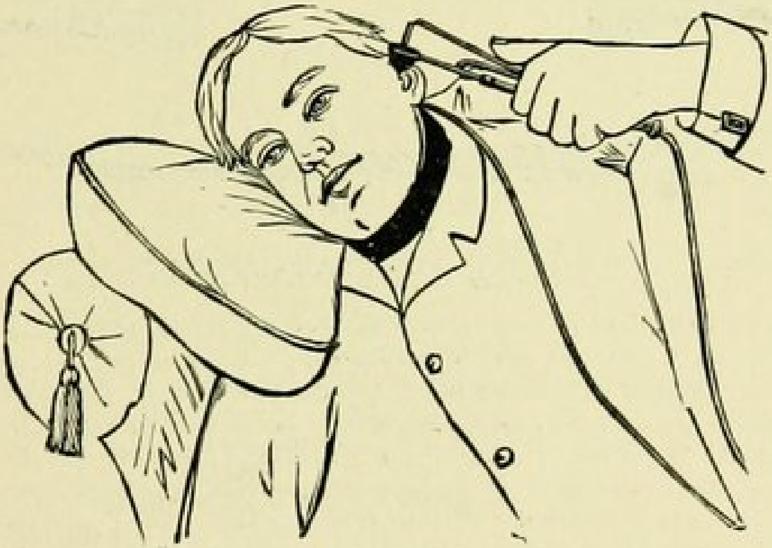

FIG. 97.

EAR ELECTRODE IN SITU.

After the ear electrode is introduced the spring is released, flies back and leaves a column of water interposed between it and the drum of the ear. The current from the battery passes through the spring and column of water to the ear. In the illustration the alternate pole is held on the nape of the neck by the neck electrode already described.

DILATATION OF THE EUSTACHIAN CANAL.—*Electrolysis.* Mons. J. Mercié* has been applying with success electrolysis in dilatation of the Eustachian tube. He first introduces an ordinary Eustachian catheter, and passes through it a fine bougie while the patient pronounces the syllable *mi*, and allows it to remain in position five or ten minutes. This process is repeated from day to day until it has been found that the sound has reached the middle ear. When the tube has been dilated to this extent, the elastic sound is replaced by a flexible metal one connected with the negative pole of a galvanic battery, while a tuft of wet sponge, connected with the positive pole, is placed in the

* *Rev. de Therap.*

external auditory canal. This procedure is unaccompanied by any danger if the current is weak and great care is exercised in inserting the metal sound. Although it has not been very frequently employed, the success was such in those instances as to encourage its subsequent use.

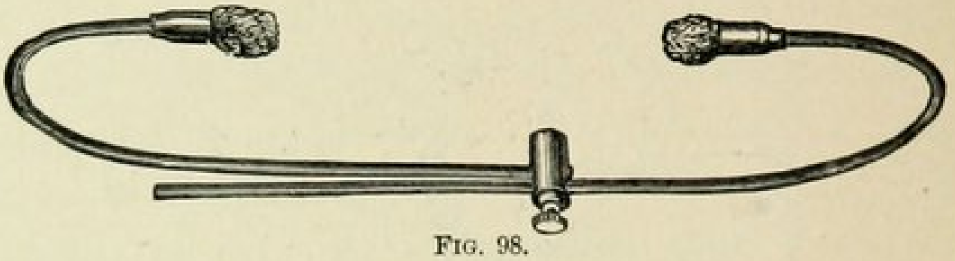

FIG. 98.

DOUBLE EAR ELECTRODE.

This electrode is formed of two curved insulated metallic rods, terminating in small sponge cups. One of the curved rods is fastened to a binding post, and the other slides through it, so as to adjust the electrode to heads of different size, and can be fastened at any point by a thumbscrew; the sponge cups may be separated 8½ inches. The sponge is securely fastened to prevent its being left in the ear; but it can be removed and replaced in a moment, so that there is no necessity for using the same sponge on different patients. This electrode conveys the current from one pole of the battery equally to both ears; the other pole may be located on the neck or in the hand.

DEAFNESS FROM AURAL CATARRH. Dr. H. Campbell* recommends a galvanic current for the cure of accumulations of mucus in the middle ear, which are caused by aural catarrh and followed by deafness. He introduces a catheter, as already described, injects a little warm water, then inserts a metal wire through it, and applies a gentle current to decompose the water. He claims that the condition of the mucous membrane is so altered that there is no tendency to a relapse.

FIG. 99.

SMALL AURAL AND NASAL ELECTRODE.
Length, 4¾ in.

This is simply a nickel-plated rod, terminating at one end in a screw that fits the universal handle, and at the other in a roughened point, to which bits of sponge or lint may be securely fastened. It is useful in localizing the current either within the ear or nose, since it may be introduced through a rubber tube, and the extent of contact with the tissues be limited to a single point if desired.

TINNITUS AURIUM.—*Galvanism.* Noises in the ear may frequently be relieved, even when dependent upon disease of the

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* *Electro-Surgery,* London.

brain, by a very mild galvanic current. A rheostat should be included in the circuit; the direction of the current cannot be definitely stated, for in some cases the positive, and in others the negative, gives most relief. As a rule, the positive is found to be more quieting and the negative more stimulating in diseases of the ear.

THE NOSE.

Galvanism produces an impression upon the olfactory nerve which is followed by giddiness and a peculiar acid odor. During and immediately after the passage of the current, it is impossible to sneeze. Meyer noticed that when the negative pole is applied within the nose and the positive to the hand or back of the neck, there is an increased mucous secretion as well as a prickling, stinging sensation in the nose, and an alkaline taste on the tongue. By reversing the current there was a sour taste on the tongue.

Faradism and *Franklinism* produce a stimulating effect when carried directly to the mucous lining of the nose, and frequently are accompanied by sneezing.

Diseases in which electricity has been employed:

- Loss of smell (anosmia),
- Catarrh,
- Obliteration of nasal duct,
- Coryza,
- Polypi.

The manner in which electricity produces a favorable effect upon mucous membranes, whether of the eye, ear, throat, or other passages, is explained by the language which Stellwag used in describing the effect of irritants upon mucous inflammations:

> The irritation which they set up in the sensory nerves being carried over to the vaso-motor nerves may cause a contraction of the calibre of the vessels, when they are in a condition of relaxation. This is done by the excitation and invigoration of the atomic muscular fibers. The resolution of inflammation is favored by the lessening or removal of the congestion, which is one of the causes of the unfavorable course.

LOSS OF SMELL.—*Faradism.* A moist sponge electrode is placed over the nape of the neck, and a nasal electrode (Fig. 100) carries the current to all parts of the nasal passages. A gentle current should be employed, and shocks should be avoided; therefore it is advisable to locate the electrodes before completing the circuit. Another method is to apply a powerful current on each side of the bridge of the nose, near the eyes. Repeat daily.

Galvanism. The nasal electrode is employed to carry the negative current into the nose to the branches of the cerebral nerves, while the positive is placed on the cheek and the current continued for five minutes. It must not be strong enough to produce flashes or other unpleasant effect upon the optic nerve.

CATARRH.—*Faradism.* A mild faradic current applied through electrodes located respectively on the nape of the neck and bridge of the nose, for about five minutes, repeated daily, or twice daily, relieves the disagreeable sensation attending both catarrh and coryza.

Galvanism. The same rule applies in this case as in other applications of galvanism. When an irritable condition of the mucous lining exists, apply the positive through a moist sponge (see Fig. 99), and the negative at a distant point, as the palm of the hand. When a debilitated condition exists, which needs stimulating, apply the negative current through the metal-tipped nasal electrode directly to the membrane, and the positive through a large sponge, located on the cheek. When the nature of the secretions need changing, it should be remembered that acids are set free at the positive and alkalies at the negative pole.

Galvano-Cautery. In cases which have undergone great structural change, Dr. Pipino* recommends galvano-cautery

* Dr. W. C. Pipino, of St. Louis (St. Louis *Medical and Surgical Journal*, 1881).

for the removal of hypertrophied tissues. The cicatricial contraction of the tissues from the heated wires deprives it of its erectile nature, removes the obstruction, allowing the free passage of air through the nose.

He cautions against mistaking deflection of the septum to the right or left for hypertrophy of membrane covering it.

Since Dr. Wm. Meyer's effort to direct the attention of the profession to the frequency of the hypertrophied glandular tissue in the posterior nasal region, and its influence in the production of organic and functional changes in the conditions and uses of the upper air passages, *galvano-cautery* has frequently been employed to remedy the condition. Dr. R. P. Lincoln, of New York, has reported, through the *Medical Record*, a number of cases in which this operation, aided by therapeutical measures, has relieved hoarseness, cough, defective enunciation, and in a few instances, a "growing stupidity," evidently due to long obstruction of the nasal passages.

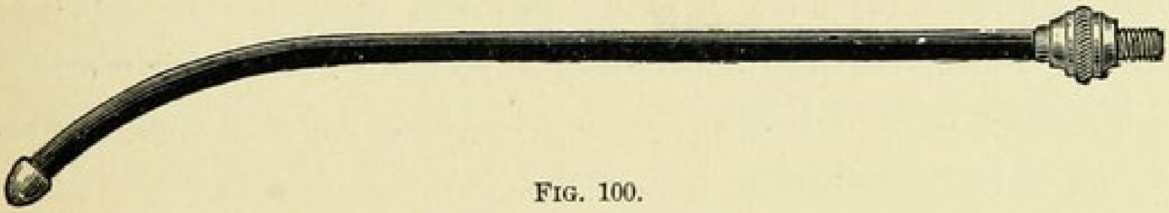

FIG. 100.

NASAL ELECTRODE.

Length, 6 inches.

The nasal electrode is an insulated metal rod, terminating in an uninsulated nickel-plated tip. Its size and shape adapt it to conducting the current either to the anterior or posterior nasal passage, when electricity is to be localized. The one shown in Fig. 99 is to be preferred when the current is to be diffused over a larger space.

NASO-PHARYNGEAL POLYPI.—*Electrolysis.* Dr. Bruns* has successfully employed the galvanic current to destroy these tumors. He considers that this operation should be tried before proceeding to a more serious operation. There is no risk of bleeding, no danger, and very little liability to a relapse after electrolysis.

*Berliner Klinische Wochenschrift.

Fungoid Growths are also removed by electrolysis when accessible. *Galvano-cautery* is, however, the most radical measure for the removal of polypi, granulations, and all foreign growths from the nose.

Closure of the Nasal Duct.—*Electrolysis.* Dr. Tripier has successfully operated for obliteration of the nasal duct. The probe should be insulated, except at the point, and connected with the negative pole of the battery. Only a few cells will be required.

THE MOUTH.

Galvanism. The sensation of taste can be excited only by the galvanic current. One electrode placed against each cheek produces a strong metallic taste, when the galvanic circuit is complete. The positive at the sacrum and the negative at the nape of the neck will frequently cause a metallic taste in the mouth; applied directly to the tongue, the galvanic current not only excites the sense of taste, but the optic nerve also, producing flashes of light. Whatever has a tendency to blunt the sensibility of the tongue, such as acids, pepper, liquor, etc., diminishes the effect of galvanism.

Franklinism produces effects similar to galvanism.

Faradism produces pain and muscular contractions, but no taste.

Electricity has been employed for

Paralysis of the tongue,	Toothache,
Loss of taste,	Extraction of teeth,
Tumors in the mouth,	Removal of the tongue.

Paralysis of the Tongue usually accompanies paralysis of other parts, and may depend upon disease of the brain, in which case caution should be exercised in applying electricity, that reflex action be not set up with unfortunate results. After paralysis has existed some time, or when not of central origin, electricity may be applied as follows: A tongue plate (Fig. 101) connected with the negative pole is placed on the tongue, and a sponge electrode (Fig. 108) pressed firmly upward, beneath the lower jaw on one side of the œsophagus, when the paralysis is confined to one half of the tongue; if both halves are affected, divide the positive current by a bifurcated cord between two electrodes, and locate them on each side of the œsophagus. Another method is to locate one electrode on the tongue and the other at the nape of the neck. If the *faradic* current does not produce contractions of the tongue, employ the interrupted *galvanic* current, taking care not to use it of such a strength as to unpleasantly affect the optic nerve.

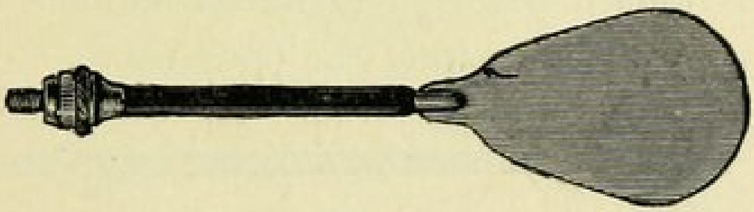

FIG. 101.

TONGUE PLATE.

Length, 5 inches.

The stem of this electrode is insulated, and the uninsulated portion is nickel-plated.

LOSS OF TASTE is usually due to an affection of the third branch of the fifth nerve, or the glosso-pharyngeal nerve, or the chorda tympani. *Galvanism.* Locate the negative electrode on the tongue, and the positive at the nape of the neck, beneath the jaw or below the ear. *Faradism.* When loss of taste is due to an affection of the chorda tympani, one electrode may be placed on the tongue and the other within the ear against the drum; this not only excites a sensation of taste, but produces an abundant flow of saliva. A very mild current should be employed with a rheostat in the circuit, not to exceed two or three minutes.

TOOTHACHE. *Franklinism* was formerly much used to relieve toothache. The patient was insulated, charged with electricity, and sparks drawn from around the affected tooth. Sometimes the operator was insulated and charged, then directed the charge to the tooth of the patient through the finger.

Galvanism, applied through a suitable dental electrode (Fig. 102), will frequently relieve pain by putting the nerve in a state of anelectrotonus, the positive current being directed to the tooth and the negative electrode being held in the hand. Five to ten minutes are usually sufficient for one application, and a mild current should be used; it may be repeated two or three times daily. When there is swelling and threatened suppuration, the negative pole applied to it and the positive on some distant part is said to be a preventive. The current should be continued from ten to fifteen minutes, as strong as can be borne without exciting the optic nerve.

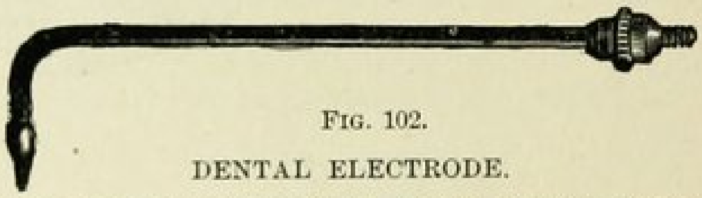

FIG. 102.

DENTAL ELECTRODE.

Length, horizontal, 5 inches. Vertical length, 1 inch.

This consists of an insulated metal rod terminating in a nickel-plated point, by means of which a current may be localized upon a nerve or motor point.

Faradism. A faradic current will sometimes relieve the pain instantly. The current is conducted to the tooth through the dental electrode, and the alternate pole applied at the nape of the neck. If a mild current for a few minutes does not relieve, it is useless to repeat it. The faradic current applied through a sponge which covers the tooth and gum is also credited with preventing suppuration, and reducing swelling about a diseased tooth.

EXTRACTION OF TEETH. The *faradic* current has been employed to lessen the pain attending extraction of teeth. It seems to benumb the nerve, in a measure. The patient holds the uninsulated portion of one electrode in the hand while the forceps are made the other electrode, being joined to the conducting cord by a suitable connector. When the forceps grasp the tooth the circuit is completed.

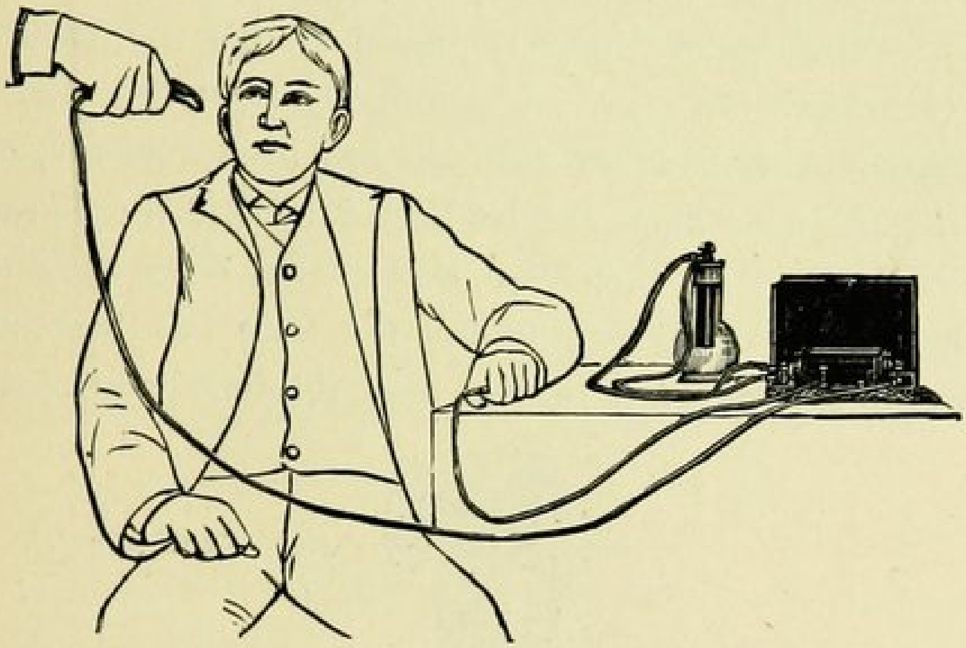

FIG. 103.

METHOD OF EMPLOYING ELECTRICITY IN EXTRACTING TEETH.

The dental battery here shown is operated by a Grenet cell. It can be used with any other form of cell. A strong secondary current is required. The method of completing the circuit is sufficiently obvious without further explanation.

TUMORS IN THE MOUTH. — *Electrolysis.* Small vascular growths may be effectually destroyed by electrolysis. The dispersion of tumors is sometimes brought about by passing a mild galvanic current through them from ten to fifteen minutes at a time, the positive being applied direct and the negative at some indifferent point. *Faradism.* It has been claimed that the faradic current is capable of exciting absorption of growths within the mouth, even when of a bony nature (osteo-sarcoma). *Galvano-cautery* furnishes the most satisfactory method of removing these foreign growths.

REMOVAL OF THE TONGUE. — *Galvano-cautery.* By this method all hemorrhage may be avoided. It is considered the most effectual method of eradicating cancer of the tongue.

Mr. Bryant* recommends this procedure: Isolate the growth by introduction of curved needles beneath the base, fix the mouth open with a gag, draw the tongue forward by a tongue forceps or a ligature passed through the tip of the tongue. The cautery loop is passed around the base of the disease, behind the pins, and gradually tightened, the circuit being complete as soon as the loop has been adjusted, but not sooner. The wire must not be heated beyond a dull red, and the drawing up of the loop should be done very slowly. Hemorrhage never occurs unless the wire has been used at too high a temperature, or has been tightened too rapidly.

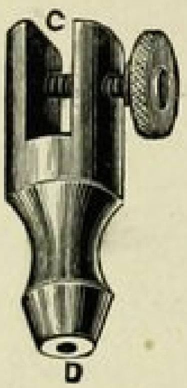

FIG. 104.

DENTAL CONNECTOR.
Length, 1½ in. Slot, 3-16 by ⅝ in.

This is a nickel-plated clamp. C receives one handle of the forceps, which is fastened by the thumbscrew. D is a socket to receive the conducting cord.

THE PHARYNX AND LARYNX.

Electricity may be applied to the treatment of diseases of the throat in three ways: 1. Internally, by placing one or both electrodes directly on the diseased tissues. 2. Externally, by placing one electrode on the neck in front of the larynx, and closing the circuit by placing the other on the nape of the neck, or on the sides along the inner margin of the sterno cleido-mastoid muscle. 3. Through the nerves, distributed to the pharynx and larynx.

* Of Guy's Hospital.

Caution. In all applications of electricity about the neck, the operator should be very careful, when the electrodes are located over the pneumogastric nerve, to use a very mild current. A rheostat in the circuit is advisable. Prolonged syncope is sometimes produced, and other exceedingly alarming symptoms. Several observers have reported accidents of this kind, which may also result from the accidental displacement of electrodes applied within the throat; with care, however, the current may be safely applied to this nerve, and with advantage in disorders of parts to which its branches are distributed.

Diseases in which electricity has proven useful:

Anæmia,	Spasm of glottis,
Enlarged tonsils,	Loss of voice (aphonia),
Clergyman's sore throat,	Paralysis,
Hyperæsthesia	Nervous cough.

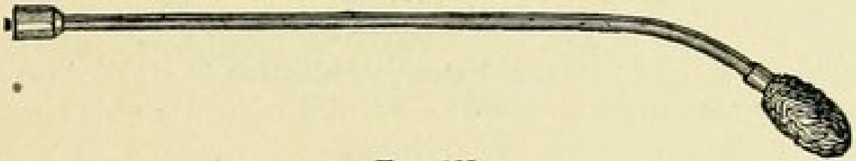

FIG. 105.

SPONGE-TIPPED LARYNGEAL ELECTRODE.
Length, 8½ inches.

This consists of an insulated stem, to which, by a simple device, a piece of sponge, or absorbent cotton, may be fastened securely. It is removable, and can be exchanged in an instant. By using a very small piece of wet sponge, a current may be localized almost as closely as with electrode in Fig. 106, and with less pain or irritation If a comparatively large piece of sponge is used, the current may be distributed over a larger surface, which is sometimes advantageous. By warming the insulated covering of the stem over a lamp, it may be bent in suitable shape to carry a current to the posterior nares.

ANÆMIA of the throat usually accompanies general debility, and is improved by general electrizations, and such other therapeutical measures as improve the strength of the patient. *Faradism* may be applied directly within the throat through the moist sponge-tipped electrode (Fig. 105) connected with the negative pole, the positive being placed on the nape of the neck, or on the sides along the inner margin of the sterno cleido-mastoid muscle. The interrupted *galvanic* current sometimes proves serviceable, the poles being located as before.

INFLAMMATION AND IRRITATION of the throat, on the contrary, are benefited by applying the positive directly to the tissues and the negative outside. This is not, however, an invariable rule ; very much depends upon the other conditions present in a given case. According to Ziemssen, hyperæmia of tissues is more lasting after a long application of the negative pole, while anemia follows a similar application of the positive pole; but in either instance there occurs sooner or later a reaction, followed, in favorable cases, by a normal condition.

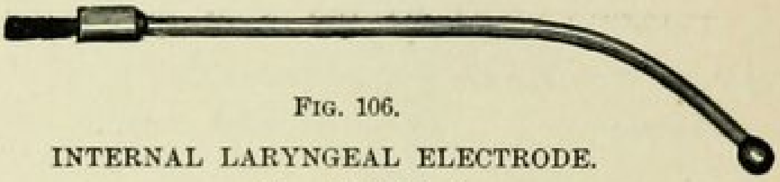

FIG. 106.
INTERNAL LARYNGEAL ELECTRODE.
Length, 7⅜ inches.

This consists of a curved insulated stem, terminating in a nickel-plated knob, for localizing electricity upon single muscles.

PARALYSIS of the muscles of the throat may give rise to difficulty in swallowing, and, if the muscles of the larynx are involved, loss of voice. The method of applying electricity direct to the affected muscles requires considerable skill. The fauces, root of the tongue, uvula, etc., must be avoided, as the slightest touch will render them intolerant of treatment. The electrode shown in Fig. 106 conveys the current direct to the muscle, while the alternate one is applied on the nape or sides of the neck. McKenzie and Ziemssen recommend a double electrode, attached to an interrupting handle, by means of which both the positive and negative poles are applied directly to the paralyzed muscles.

The reader who wishes to employ this treatment is referred to standard works on laryngoscopy, etc., for information in regard to the delicate manipulations necessary to localize the current. A method which has the merit of being simple, and often quite as efficacious, is to locate both electrodes outside the neck, employing a wire brush (Fig. 107) for the one applied to the sides of the neck. The prognosis in these cases is favorable when the disease is ot a purely functional character. If the muscles respond to stimulation by the *faradic* current, that is the form of electricity to employ; if they fail to respond to it, *galvanism* alone can produce a curative effect. Sometimes electrization of the laryngeal nerves is indicated. A reference to Figs. 72 and 73 will indicate where the electrodes must be located.

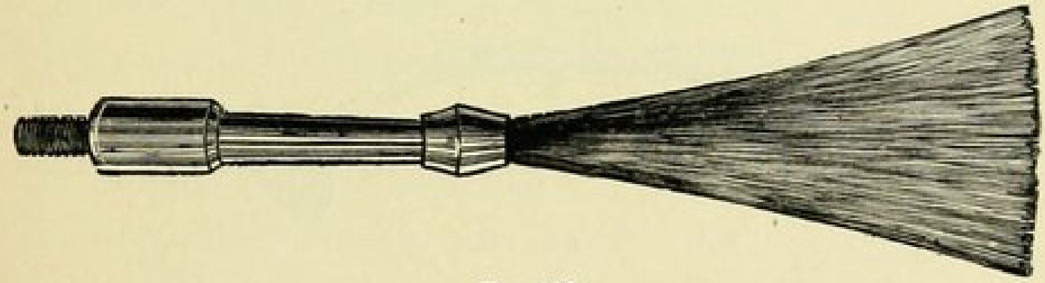

FIG. 107.

METALLIC BRUSH.
Length, 4 inches.

This is composed of a bundle of stiff metal wires. It divides the current into rays each of which produces a separate impression on the sentient nerves of the skin. To produce reflex influence, merely touch the end of the brush to the skin; to transmit this divided current to the deeper tissues press the brush firmly on the skin. The wires may be separated considerably to cover a larger surface, but in that case the impression produced will be proportionately less intense.

APHONIA.—*Faradism.* Robert Torrance, L.R.C.P.,* reports a case of five years' standing, the result of an ulcerated sore throat. All the usual remedial measures had been exhausted, including galvanism. The cords were then faradized by a double electrode through which the current from both poles was localized at different points on the vocal cords, and the voice was permanently restored after a number of sittings at varying intervals. Loss of voice due to paralysis of the recurrent laryngeal

*Surgeon to the Newcastle-on-Tyne Throat and Ear Infirmary.

nerve requires *galvanism*. The motor points to which the current should be applied are shown on Figs. 72 and 73. Meyer recommends the electric moxa applied to the larynx in these cases. Aphonia, due to spasm of the muscles of the throat, will require a current in an opposite direction to that which is indicated in paralysis. Hysterical aphonia has been cured by every form of electricity.

APHASIA, loss of speech from disease of the brain, has never been cured by electricity, according to Althaus. On the contrary, Arthius claims to have relieved it in a measure by franklinism, administered daily in the form of electric bath, for two or three months.

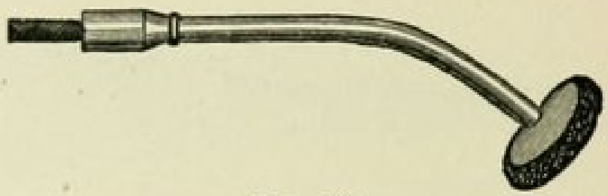

FIG. 108.

EXTERNAL LARYNGEAL ELECTRODE.
Length, 4½ inches. Diameter of Disc, 1¾ inches.

This is a curved insulated stem, terminating in a sponge-covered disc, designed for application about the neck.

STAMMERING. The galvanic current applied two or three times a week through the laryngeal nerves, accompanied by daily gymnastic education of the vocal and respiratory organs, has proved of benefit.

THE TENSOR PALATI may be electrized by a laryngeal electrode applied over the soft palate in the course of the muscle on each side of the uvula, the circuit being completed by placing the other pole over the mastoid process of that side corresponding to the side of the palate to which the laryngeal electrode is being applied.

NERVOUS COUGH AND HYPERÆSTHESIA must be treated according to general principles, as already described. Central galvanization is usually indicated. Franklinism is also recommended.

WHOOPING-COUGH. Dr. Beard made a series of experiments in the Sheltering Arms Institution in Brooklyn, and Dr. Rockwell in private practice, in the treatment of this disease by electricity. The method which proved most successful was central galvanization. The paroxysms were diminished in frequency and violence, and in some instances the duration of the disease was shortened.

HAY FEVER. The method of arresting this disease is by galvanization of the pneumogastric nerve. The location of the electrode is shown in Fig. 74. Neftel, Hutchinson and Beard and Rockwell recommend this method. The latter recommend as a prophylatic a prolonged course of central galvanization or general faradization. Caution should be observed, however, in applying a current to the pneumogastric nerve.

SPASM OF THE GLOTTIS. Central galvanization and faradization of the larynx have both been successfully employed.

Dr. Strassman* reports the case of a boy eight years old who had with each expiration a sound like that of a dying animal, with some tickling in the throat and pains in the abdomen. It was a constant crying about every five minutes. During the night there was perfect rest. The galvanic current cured him completely after the second sitting.

CLERGYMAN'S SORE THROAT.—*Galvano-Cautery.* When the follicles of the throat are enlarged for any length of time, medicines have no effect upon them. The only means of relief is to destroy them, and galvano-cautery is to be preferred for this purpose, as it is effectual and causes little pain.

The *platinum point* is suited to this purpose. The operator stands by the side of the patient, whose head is thrown backward; the tongue is depressed and each follicle cauterized. It produces a slight prickling only. The inflammation set up produces cicatrix and contraction of the follicle.

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* Berlin Klin. Woch.

TONSILLITIS has been reported relieved by the application of an electric current, but as the articles describing the method of its application failed to state what kind of electricity or the strength of current used, we give but a passing mention.

Enlarged tonsils have been reduced in some instances by means of a very mild galvanic current, the positive applied direct, the negative externally to the side of the neck. The current is better borne if carried through a rheostat. Fig. 109 is an electrode of suitable shape to localize the current.

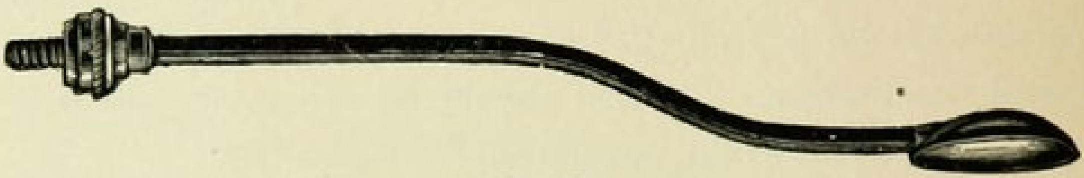

FIG. 109.

TONSIL ELECTRODE.
Length, 5 inches. Diameter of cup, 1 inch.

The peculiar curve of the insulated stem of this electrode makes it possible to apply the nickel-plated cup closely over the tonsil, without producing irritation of any other part of the pharynx.

DIPHTHERIA. The *galvanic* current has been applied to change the nature of the secretions, and reduce the swelling of the tissues. Dr. G. K. Smith* claims remarkable success in its use. Diphtheritic paralysis affecting the muscles of the throat has been relieved by *faradism*.

STRICTURE OF ŒSOPHAGUS.—*Electrolysis.* Some cases of impassable stricture of the œsophagus have been relieved by electrolysis. The electrode required is a flexible insulated instrument, terminating in a blunt olive. It is connected with the negative pole of the battery while the positive electrode of large size is placed to the left side of the spine, at a level with the eighth or ninth rib. A mild current is passed through the circuit for two or three minutes. A sound is then passed

*Proceed. Med. Soc. King's Co., Aug. 1881.

through the stricture, if possible. This can be done after a few sittings, if not at first, and the remainder of the treatment may be by dilatation, as usual. Dr. Boeckel operated after this plan on an impassable cicatricial stricture, and after the second sitting passed a No. 13 sound through it; after the tenth, a No. 16, and one month later, No. 19. Dilatation was kept up for some time regularly, and afterward once a month. Seven years later the patient could himself pass a No. 23. He also successfully treated a child for the same difficulty. After the first sitting he could pass a urethral bougie No. 6, and after the second, a No. 10. After five more sittings, at varying intervals, No. 17 passed the stricture. He recommends a weak current in order to guard against exciting inflammation in neighboring parts.

TUMORS, ETC. *Galvano-cautery* is especially adapted to the removal of foreign growths, both benign and malignant, from within the fauces.

THE HEART AND LUNGS.

Electricity is believed to influence the heart through the nerves, and the lungs *directly* through the nerves and *indirectly* through its action upon the muscles of the chest. The pneumogastric nerve, when stimulated by electricity at the right side of the neck, acts more energetically upon the *heart*; at the left side upon the *respiratory movements.* The cervical ganglia and the pneumogastric nerve are the points to which electricity should be applied to reach the heart; the twelve dorsal ganglia, the phrenic and pneumogastric for the lungs. Faradization of the pneumogastric by a strong current, as we have seen, arrests the heart's action. Prof. Rosenthal states that faradization of the superior laryngeal nerve arrests respiration. Prof. Von Ziemssen lately had a patient, a woman, aged forty-six, who had lost the greater part of the precordial structures, exposing the heart; and he commenced a series of experiments to determine the effects of the galvanic and faradic currents respectively on that organ. He distinctly discovered that the *faradic* current had no effect whatever, while the galvanic current acted as a powerful stimulant. He therefore believes it is useless in cases of chloroform syncope to waste time in applications of the faradic current, as is commonly done.

Diseases of the chest in which electricity has been employed :

Angina pectoris,	Asphyxia,
Asthma,	Cardiac pain,
Consumption,	Pleuritic effusion.

ANGINA PECTORIS.—*Galvanism.* Dr. Löwenfeld* relates a case of angina pectoris in which galvanization proved beneficial. The patient, a man aged forty-seven, was subject to attacks of the disease occurring every month or two. These were characterized by excited respiration, oppression, small, frequent pulse, sternal pain radiating to the left arm, and convulsive tremors of the limbs, which lasted about one hour. The heart was normal. The constant current was applied for one minute to each side of the neck, along the course of the pneumogastric. The sense of oppression was immediately relieved. Ten such applications in the course of three weeks were followed by complete freedom from the attacks for more than two years.

Faradism. M. Duchenne removed the pain during an attack of angina pectoris in two cases by applying one electrode over each nipple, using a strong faradic current. Cutaneous faradization at intervals completely removed the angina.

ASTHMA.—*Faradism.* Dr. Max Schaeffer, of Bremen, advocates the treatment of asthma according to the following method: The morbid state upon which asthma depends may

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* *Aerztl. Intelligenzbl.*, No. 39, 1881.

affect—1. The nerve itself. 2. The coverings of the nerve. 3. The tissue adjacent to the nerve. He lays great stress on the last condition. Tumors, such as nasal polypi, hypertrophied tonsils, swollen cervical or bronchial glands (temporary hyperæmia of these glands), can, according to their position, cause irritative pressure on nerve-filaments connected with the respipiratory centers. He found that many of his asthmatic patients were the subjects of nasal catarrh, or pharyngeal catarrh, or laryngo-tracheal catarrh. He noticed that swellings of the mucous membranes of these parts were attended with asthmatic paroxysms, and patients would constantly refer the seat of their discomfort lower or higher in the throat, according to the seat of the swelling, and he concludes that all the symptoms of asthma are symptoms of irritation brought on by pressure on nerves which are in connection with the pulmonary portion of the vagus, and especially in the upper part of the respiratory tract — the pharynx, larynx and trachea.

He examines carefully the nose and throat, and applies the electrodes according to the seat of the disease. Usually the two electrodes are placed on each side of the neck about $\frac{3}{4}$ of an inch below the angle of the jaw, and sometimes a little lower down in front of the sterno cleido-mastoideus. The current must be of good strength, so that the patient can feel the stream go across the larynx and soft palate. In bad cases it should be applied twice a day, from fifteen to thirty minutes each sitting. He states that in the most severe cases it has acted "like witchcraft."

Althaus advises faradization of the phrenic nerve as above described in chronic cases, where the asthmatic attack is prolonged and followed by bronchial congestion, with insufficient expansion of thorax and imperfect aeration of the blood.

Galvanism. Asthma due to a morbid state of the nerve or its coverings is relieved by placing the positive pole over the pneumogastric in the left side of the neck and the negative over the nape of the neck. A very mild current should be employed, lest the heart's action be arrested or the difficulty in breathing increased. Asthma due to reflex action of the nerves, caused by disease of other parts than those named, cannot be permanently relieved by electricity until the disease giving rise to it is removed. Habitual asthma has been greatly benefited by a continued galvanic current administered through the galvanic belt, the positive pole being located at the nape of the neck and the negative over the stomach. During an attack, counter-irritation over the neck and upper part of the thorax, by means of the wire brush, has proven of advantage.

Franklinism. Arthius states that when asthma exists without organic lesion, the franklinic electric bath, the patient being seated upon an insulated platform, will cure it. When due to catarrh, electricity alone will not cure, but is the surest means to obtain a notable amelioration and to make life endurable. He advises an electrization for ten minutes daily, and in some cases three or four times daily, during the paroxysms.

Consumption.—*Galvanism.* The well known influence of a mild galvanic current in relieving inflamed and ulcerated tissues ought to make it a valuable agent in alleviating many of the distressing symptoms accompanying chronic disease of the lungs. It is stated that this effect is produced by a current from a very few cells; only two or three cells should be used at first, and not continued beyond ten minutes. One small metal electrode is placed in the depression behind the angle of the lower jaw, and the other over the pneumogastric, near the sterno-clavicular articulation. The effect is to dilate the lungs and increase the respiratory movements. It increases the expectoration considerably at first, but after a few sittings lessens it, unless there is extensive softening and destruction of lung. The fever is lessened and the condition of the blood improves; the appetite returns, night sweats disappear, and in a few cases the process of repair begins.

Faradism. Bastings, of Brussels, claims marvelous results from faradization of the muscles of the chest. "This is not done with a view to directly affect the tuberculous deposit at all, but, by strengthening the muscles of the chest, to so improve the respiratory power that more air can be inspired, and so benefit result to the healthy portion of the lung, and indirectly, through better oxygenation of the blood, to a certain extent on the diseased portion and on the whole system." Each muscle is faradized for about half a minute in turn, about five minutes being consumed at a sitting. *Prolonged treatment was found injurious.* Dr. McIntosh has found the hot-air electric bath exceedingly efficacious in allaying the distressing symptoms, improving the general health and apparently prolonging life. In one remarkable case, the particulars of which cannot be given for want of space, it restored a patient apparently in the last stage of the disease to a degree of health that enabled him to attend to business for nearly two years longer. It should be added that the treatment also included a strict attention to hygiene and much open-air exercise.

ASPHYXIA. Suspended animation, whether resulting from inhalation of chloroform or coal-gas, poisoning, drowning, disease, or in new-born children, should not be treated by electricity alone. As an adjunct to other active measures the latter is invaluable. It is employed principally to stimulate the heart, lungs and diaphragm through the nerves that supply them. Formerly franklinism was used by passing powerful shocks through the chest in various directions. After the discovery of galvanism some physicians carried canes which were ingeniously contrived to inclose a large number of small elements, a vial of acid, a tiny cup, the size of a thimble, in which to mix the fluid, with connecting wires, etc., complete for the production of a galvanic current of sufficient power to relieve asphyxia.

Galvanism. To produce respiration, place the negative pole over the cartilage of the seventh rib, to bring it as near as possible to the great head of the diaphragm, and apply the positive to the phrenic nerve in the neck. Onimus and Legros recommended that the negative pole be placed in the mouth and the positive in the rectum, and the current be applied from eighteen or twenty cells continuously, till the heart's action is quite re-established. According to Du Bois, in sudden syncope from chloroform, the muscles of the heart lose their contractility within four minutes, but in suspended animation from other causes they retain contractility for ten minutes; therefore it is advisable to apply electricity simultaneously with other measures, that no time may be lost.

Faradism. Friedberg* restored a boy, aged four, after respiration had ceased, under the influence of chloroform, by applying the electrodes over the phrenic nerve and diaphragm. He closed the circuit for one second at a time with regular intermissions. After ten such applications the child began to breathe, when faradization was discontinued and methodical compression of the abdomen was substituted. In twenty minutes restoration was complete. One electrode may be applied at the nape of the neck instead of over the phrenic at the side. *The operator should know the exact location of the motor point of the phrenic nerve on the side of the neck, otherwise he is liable to apply the electrode over the pneumogastric, which may destroy the last chance of restoration.* (The reason for this is explained under "action of arrest.") It is better to err on the side of safety when the motor points are not well known, and place the electrode on the nape of the neck, or on the spine between the shoulderblades. By

*Virchow's Archives.

reference to Fig. 73 it may be seen where to locate the electrodes over the roots of those nerves that send branches to the heart and lungs.

The following suggestions may be found useful in these cases:

1. Do not omit artificial respiration.

2. Use either the faradic or interrupted galvanic current intermittently, closing the circuit for one second, opening it for one second, and so continue, and persevere in the application until the patient breathes naturally.

3. If the muscles fail to respond to faradism, it will be useless to employ it. Galvanism should be immediately substituted.

NERVOUS CARDIAC PAIN near the apex of heart, a common and distressing symptom, is alleviated by central galvanization.

CHRONIC PLEURITIC EFFUSION. Dr. Gunther* places the positive pole over the breastbone and the negative over the effusion. A galvanic current from any number of zinc-carbon cells up to eighteen may be used, according to the sensitiveness and condition of the patient, to promote absorption.

PARALYSIS OF THE MUSCLES OF THE DIAPHRAGM. M. Duchenne made a special study of this lesion. It consists in an alteration of the regular movements of the chest and abdomen, during inspiration and expiration, which produces a short respiration insufficient for the wants of the voice; this is not a fatal disease of itself, because respiration is not completely prevented, but the most simple bronchitis is able to occasion death by suffocation, expectoration being difficult and even impossible. The remedy is electrization through the phrenic and cutaneous nerves; in the latter case, to exert a reflex influence upon the paralyzed muscles.

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* Centralblatt für Chir. Med.

DIGESTIVE ORGANS.

Action of electricity upon the salivary glands. Claude Bernard states that faradization of the lingual and auriculo-temporal nerves, the chorda tympani and posterior parotideal branches of the facial nerve causes an abundant flow of saliva, while faradization of the sympathetic nerve arrests salivary secretion. The current applied to the drum of the ear for the purpose of stimulating the salivary glands through the chorda tympani should be very mild, and should be carried through a rheostat. *Galvanization* applied only through the sympathetic nerve in the neck is sufficient to influence the secretion in these glands.

The *œsophagus.* Faradization causes a contraction of both the longitudinal and circular fibres, and if the current is kept up some time, the action is not limited to the part directly operated upon, but proceeds downward to the stomach. One electrode may be located over the œsophagus in front, and the other, a large moist sponge, over the middle and inferior cervical and upper dorsal ganglia. (See Fig. 73.) Galvanization of the left pneumogastric nerve also produces contraction of the muscles of the œsophagus. (See A, Fig. 74.) This action of electricity upon the œsophagus is of value in treating difficulty in swallowing (dysphagia) not due to stricture.

The *stomach* responds to electric stimulus by shortening of its diameter. When one electrode is placed over the stomach in front, and the other on the spine in the position to influence the solar plexus (see N, Fig. 73), the transverse diameter is shortened. When one electrode is placed at the left over the point where the œsophagus joins the stomach (cardia), and the other at the right where the stomach joins the intestinal canal (pylorus), the longitudinal diameter is shortened, but in either case the direction of the movements is from the cardia to the pylorus.

The liver. As a result of very carefully conducted experiments, Dr. Sigrist* came to the conclusion that faradization of the liver makes its circulation more active, and consequently leads to an increase of the excreted urea. In one case the amount of urea was raised from 18–20 grms. to 35 grms., and the size of the liver became perceptibly larger.

The *gall-bladder*. A current sent through the point indicated by G, Fig. 74, contracts the gall-bladder, and throws out a part of the bile into the duodenum.

The *spleen*. There is much difference of opinion in regard to the power of electricity to produce contractions of this organ. The experiments of Bernard indicate that a powerful faradic current does cause contractions. Chvostek claims that he has reduced enlargement of the spleen, caused by ague, by faradization of the skin over this organ.

The intestines. Peristaltic action is the term applied to the constant motion within the intestinal canal. It is due to the alternate contraction of the circular and longitudinal fibres; the former close the tube, while the latter draw back the walls of the tube, thus providing for the propulsion of the contents. It takes place along the whole digestive canal from the throat to the anus, and effects the forward motion of the food, and the expulsion of the undigested residue.

This motion can be stimulated by electricity, either by irritating some part of the digestive canal directly or by irritating the nerves supplying it. The most striking feature is the slowness with which these motions take place. Not only does a long time elapse after the application of the irritant before the motion begins, but even if the irritation is sudden and instantaneous, the motion excited at one point passes along gradually, slowly increasing up to a definite point, and then gradually decreasing. In 1856 Pflüger discovered that faradization of

* *Vratsch*, 1880, No. 2.

those nerves that take their rise from the six lower dorsal ganglia arrests the peristaltic action of the small intestines.

According to Aldini, a feeble galvanic current, applied by means of the positive pole in the mouth and the negative in the rectum, will cause contraction of the abdominal muscles, and the contents of the bowels are propelled toward the rectum. The *small intestines* are more easily excited by electricity than the *colon* or *rectum*, although the latter also respond to electric stimulus.

When the electrodes are placed very near each other on the intestines, and afterward removed, the canal becomes constricted at the points upon which the electrodes were applied. This constriction reaches its maximum a few minutes after the electrodes have been removed, then slowly disappears. There is at the same time increased secretion of intestinal mucus. The contractions may be studied during life in patients afflicted with hernia.

This practical fact in regard to the action of electricity upon the digestive organs should not be lost sight of. *Those muscles that are not subject to the will* (*involuntary*) *are not affected by electricity until a little time after they have been acted upon. The movements excited by electricity continue for a time after the application ceases, and extend in each direction beyond the parts included between the electrodes.*

The diseases of the digestive organs to which electricity has been applied with more or less benefit include almost the entire list of disorders that affect these organs; the methods of treatment varying with different operators, but may all be included under these four divisions:

1. The application of electricity to the muscles.
2. To the nerves of the organ to be treated.
3. Chemical changes produced by electrolysis.
4. Destruction of morbid tissue by galvano-cautery.

No fixed rule can be given for the selection of current, the length or direction of its application, that can be invariably followed. The operator must be guided by the circumstances of the case; but the following suggestions, based on principles already described, may prove useful: When spasmodic action is to be arrested by the application of electricity to the *muscles*, a mild current should be selected, with the positive on the organ and the negative at some indifferent point; when applying electricity through the *nerves* to allay irritation, that portion of the nerve near the diseased organ, when accessible, may be put into a state of *anelectrotonus* by placing the positive over the organ and the negative on the nerve some distance away, and employing a very mild current for fifteen or twenty minutes. When the nerve is not directly accessible, place the positive over the ganglia, from which the organ receives its nerve supply, and the negative over the organ affected. The location of the electrodes should be reversed when the muscles or nerves are to be stimulated, to increase the functional activity of an organ. Beard and Rockwell state this as a fundamental fact: "*The faradic current is usually preferable to the galvanic for applications to the stomach, spleen, liver, intestines and uterus.*"

A new method of applying electricity to the stomach:

Dr. Kussmaul has suggested a method of localizing a current upon the interior walls of the stomach that has been tried to a limited extent only. The patient having filled the stomach with water, an instrument like an œsophageal bougie, insulated, except at the tip, is passed into the stomach through the œsophagus and connected with one pole of the battery; the alternate pole is placed outside on the skin over the stomach.

VOMITING. Dr. Leven * reports several cases of persistent vomiting successfully treated by the application of electricity in the interior of the stomach by the method above described.

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* Progres Medical.

Four or five applications have checked it in cases that had resisted all other measures. No other particulars were given.

Faradism. Obstinate vomiting from any cause is often promptly relieved by placing the electrodes respectively on the pit of the stomach and over the lower dorsal ganglia. It is frequently necessary to use as strong a current as the patient can comfortably endure, and to prolong the sitting beyond the usual limit; twenty to thirty minutes will sometimes answer better than a shorter time. Dr. Lente, of Cold Spring, New York, reports a large number of cases relieved of the most troublesome and intractable vomiting by this method.

GALVANISM. Bartholow recommends a galvanic current applied by placing the positive pole in the depression behind the angle of the jaw and the negative over the stomach; or the positive may be applied over the spine instead of behind the jaw.

VOMITING OF PREGNANCY has been relieved by both forms of electricity. Each case requires special treatment.

Faradism. A mild primary faradic current may be used with the positive electrode on the pneumogastric in the neck, and the negative over the pit of the stomach. The caution already given in regard to electrizing the pneumogastric should not be forgotten. The sitting should not be more than five minutes in duration, and may be repeated for three or four days in succession. Electricity applied to the interior of the stomach has entirely relieved vomiting from this cause that had resisted all other treatment. The method already described, of passing a strong current directly through from the pit of the stomach to the spine, sometimes succeeds.

Galvanism applied through the pneumogastric has also relieved a few cases. A very mild current should be used. Another method is to apply a feeble galvanic current, from two or three cells only, for several hours in succession. A broad, flat, moist sponge electrode is fastened over the stomach, and another opposite to it over the spine, extending from the seventh to the tenth dorsal vertebræ. The patient may lie on her back during the passage of the current; when it is impossible for the patient to remain in bed during treatment, the galvanic belt may be worn to supply a current.

Hysterical Vomiting Attended by Epigastric Pains. Dr. Apostoli has successfully treated cases of this kind as follows:

The positive pole is applied in the subclavicular region and the negative pole over the seat of the pain. It is continued for five to fifteen minutes; the gastralgia and epigastric pains have been stopped after ten to fifteen applications.

Vomiting from Gastric Atony. The repeated application of a mild galvanic current by placing the positive electrode over the pneumogastric alternately at each side of the neck, and the negative over the pit of the stomach, sometimes relieves. The sitting should be very brief.

To Produce Vomiting. Dr. Fox* has used faradism to produce *emesis* in the case of two children, who were in a state of collapse, and unable to swallow in consequence of having eaten poisonous fungi. One was apparently dying and insensible to the vapor of ammonia. He applied one electrode to the top of the œsophagus, and the other over the stomach. Vomiting immediately followed, and both children were evidently saved by this means.

Gastrodynia or Nervous Cardialgia. Those painful affections of the stomach not dependent upon perceptible changes in structure sometimes called neuralgic stomach-ache, and due to functional derangement of the solar plexus of nerves, are generally relieved by *galvanism*. Relief is frequently immediate, but treatment should be persevered in for some time to render it permanent. *Faradism* with a strong current some-

* *British Medical Journal*, vol. ii, p. 493.

times gives relief. The current in either case may be carried through from the dorsal ganglia to the pit of the stomach. It is sometimes advantageous to combine general faradization and central galvanization with the local treatment, especially in the intervals.

GASTRALGIA, ENTERALGIA, HEPATALGIA are treated in the same manner. Vizioli relates the following as an example of what can be accomplished by galvanism in some cases:*

A woman, thirty-five years old, had been bitten ten years previously by a supposed mad dog. The patient was at first intensely excited, but became calmer after a few days, though she lost her appetite and strength, menstruation ceased, the senses of hearing and smell became abnormally acute, and paroxysmal attacks of intestinal colic set in. The latter became more and more frequent, and so violent as to cause the patient to shriek with pain, sometimes causing fainting-fits, or violent tonic and clonic convulsions. For the relief of the gastralgia, cauterization of the cervix uteri was practiced. At this stage, when the affection had existed for more than ten years, Vizioli began to treat the patient with the constant current of twenty-four to thirty-six cells, placing one pole over the stomach. The sittings were given every other day. Amelioration was rapid. After the twentieth sitting the paroxysms ceased altogether, though there were faint reminders when the uterus was cauterized.

Franklinism, in the form of electro-positive or electro-negative baths, has an excellent reputation in the neuralgic affections of the stomach, liver and bowels, and also in nervous vomiting. The bath may be combined with local treatment by drawing sparks from the painful region. Immediate relief occurs in cases to which this form of electricity is adapted.

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* *Med.-Chirurg. Rundschau*, August 1881.

Dyspepsia dependent upon spinal exhaustion will be relieved by a mild *galvanic* current applied to the spine, one pole being located high up over the superior cervical vertebra, the other over the end of the coccyx. The current need not be applied directly to the stomach. Dyspepsia arising from atony or weakness, should be treated with a strong faradic current. Some of these cases will be greatly improved by simply holding one uninsulated electrode in each hand, while as strong a faradic current as can be endured is passed through the circuit. The first sitting may be about five minutes, and subsequent ones may be increased until they occupy twenty minutes. A sensation of soreness in the muscles of the arm indicate that the application was continued too long. The treatments may be repeated daily for one month, then omitted for the same length of time, and again repeated if necessary. The muscles of the arms and chest are considerably developed by this means, the appetite and digestion improved. It is scarcely necessary to add that in all diseases of the digestive organs the diet should be regulated. Dyspepsia caused by over-eating, indulgence in intoxicating liquors, or where poisons have been taken, is usually accompanied by a congested condition of the walls of the stomach. A mild faradic current may be employed to excite contraction of bloodvessels and lessen congestion. Sometimes a mild galvanic current applied through the nerves will be needed. The treatment of dyspepsia of every form should be conducted according to the general principles already given. A carefully regulated diet and patient application of the indicated form of electricity for a considerable period of time will almost invariably be rewarded with success, provided the disease is not attended by organic changes. The *electro-thermal baths* are undoubtedly better adapted to the treatment of chronic disorders of the digestive organs than any other method which the profession has yet adopted.

Acidity of the stomach, loss of appetite, nausea, waterbrash (pyrosis), and all the other disagreeable symptoms with which dyspeptic patients suffer, may be treated by some one of the methods described for dyspepsia. A galvanic belt with the electrodes fastened respectively over the nape of the neck and pit of the stomach is sometimes beneficial, the current being continued for weeks. In severe cases the electrodes may be applied without a cover to produce strong counter-irritation. Many years ago it was customary, in cases which could not be relieved by milder measures, to apply a blister, and fasten upon the sore a disc of silver for the positive electrode, and employ a mild galvanic current, to keep up a discharge. Electric fustigation with the wire brush on the dry skin over the stomach, the other electrode being located on the spine, is especially adapted to cases suffering from a persistent gnawing, burning sensation in the stomach.

DILATATION, AND CATARRH OF THE STOMACH. The method of applying electricity within the stomach is highly recommended both by Kussmaul and Ziemssen in these cases.

CONGESTION OF THE LIVER. Passive cases may be relieved in a few days by *faradism.* Place a broad moist sponge positive electrode over the spine in the lower dorsal region, and draw the negative over the liver, making firm pressure, which may be gradually increased during the sitting so as to carry the electrode partially under the ribs; lift it off in front and carry it back to the starting-point without contact with the skin. Caution should be used in regulating the current to start with, which should be very mild until the tolerance of the organ to electricity is known. In some cases severe cramps will be caused by non-observance of this rule, and if they occur it is difficult to persuade the patient to risk their recurrence by permitting any further electrical treatment. Cases in which the liver has given the impression of stony hardness on palpation, have been materially relieved in a few days by this course. The electro-thermal baths are also to be recommended in liver complaints arising from disordered circulation of blood through the organ.

Cirrhosis of the Liver. Beard and Rockwell state that the pains accompanying this disease are alleviated by electrical applications.

Hydatids of the Liver.—*Electrolysis.* At Guy's Hospital and the Royal Infirmary for Children, a number of cases have been operated upon by the method described in the following case: "Two needles were introduced into the most prominent part of the swelling, one piercing the space between the eighth and ninth costal cartilages and the other about two inches behind it, between the ninth and tenth ribs. The needles were passed in to a depth of two or three inches, so as to be free in fluid. Both needles were attached to the negative conductor; the positive being connected with a large sponge was placed on the skin near the needles; a current from ten freshly charged cells was allowed to pass for twenty-five minutes. There was some pain for four or five hours afterward. Twenty days after, all traces of the abdominal tumor had disappeared." The surgeons at the hospitals referred to claim that this operation is free from danger, and not liable to set up suppuration within the cyst. It has been suggested that the transformation of chloride of sodium into caustic soda by the chemical process which electricity sets up within the cyst renders its contents poisonous to the parasite.

Spleen. Enlarged spleen, the result of malarial poisoning, has been relieved by the same measures described under congestion of the liver. It is believed that the effect produced is due partly to the mechanical action resulting from the contractions of the abdominal muscles and partly to the reflex action of the current, especially if a metal electrode be used on the dry skin over the spleen.

CATARRHAL JAUNDICE. Prof. Gerhardt, of Würtzburg, recommends faradization of the gall-bladder for this disease. One electrode is placed over it (see G, Fig. 74) and the other on the back, opposite to it. A strong current is passed through it for several minutes. This will be more effective if the current is interrupted by removing and replacing the electrode over the gall-bladder at intervals of a few seconds. Sometimes a disappearance of the dullness occurs during the sitting. Success is certain if a bilious stool is passed within the next two days. Generally the vaso-motor nerves of the kidneys are excited at the same time, and consequently the urine that is passed within twenty-four hours after treatment is paler and more dilute than usual.

CATARRHAL AND ULCERATIVE INFLAMMATION OF THE COLON. Dr. Karetzky* adopted the following plan of treatment in a case of chronic colitis, with ulcerations and atony of the intestines, which had resisted for five years every mode of treatment: The positive pole was introduced into the rectum, while the negative was moved along the entire length of the colon for a few minutes. After each application he also faradized with the brush the skin over the affected region. After the first few séances, a very marked improvement was noticed in patient's general and local condition, and he recovered entirely after fifteen applications had been made.

CONSTIPATION caused by impaired peristaltic motion, loss of power in the abdominal muscles, protracted diarrhœa, the abuse of aperient medicines, and in some cerebral and spinal disorders, may be relieved by electricity.

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* *Vratch*, 1880, No. 43.

Faradism. Habital constipation is treated by connecting one pole with a rectal electrode, or placing a large electrode on the perineum, while the other is carried along the course of the colon in the direction of the arrows on Fig. 74 from R J to L J. The electrode should be moved slowly in one direction only, a mild current being employed. A powerful current produces distressing cramps in the abdomen; they also result from a very mild current occasionally in a subject who exhibits the muscular reactions peculiar to some forms of paralysis. *It is unnecessary to employ a current of sufficient strength to cause pain.*

Dr. Blackwood * expresses his views on the subject of constipation in these words:

> Electricity is beyond question intrinsically more valuable than any other remedy we possess in restoring tone to the intestine in long-standing cases. Contrary to general rule, faradism is here preferable to galvanism; but care is requisite in its application, that painful parietal muscular contraction does not occur. The current should be rapidly applied over the whole abdomen, one pole brushing gently the parietes, the other being located over the solar plexus or anus.

FLATULENCE, COLIC, TYMPANITES, are relieved by faradism, the positive being inserted in the rectum and the negative carried over the abdomen. The condition which gives rise to the formation of gas in the intestinal canal should be treated in the intervals between attacks. *Central galvanization* will sometimes permanently cure. It may be applied two or three times per week. Althaus relates a case of excessive flatulency, the result of an attack of dysentery fifteen years previously, which he permanently cured in three weeks; the positive pole was inserted in the rectum and the negative passed over the abdominal muscles, *twenty-five cells* being included in the circuit. He does not name the kind or condition of the cells employed; but any physician

* Neurologist and electrician to the Presbyterian Hospital, physician to St. Mary's Hospital, etc.

who has experimented upon a piece of beef with a galvanic current from a large number of cells and noticed the effect produced at the poles, would hesitate to apply a current from twenty-five freshly charged zinc-carbon cells anywhere about the body except for the purpose of electrolysis. The treatment described for dyspepsia is appropriate in cases here referred to, to prevent the recurrence of attacks.

DIARRHŒA.—*Faradization.* Beard and Rockwell give particulars of treatment which proved successful in several obstinate cases of chronic diarrhœa. The method pursued was general faradization, averaging three times per week, with local application to any tender spots in the abdomen. The treatment was prolonged, and the current strong. Immediate improvement was observable in favorable cases. Excessive peristaltic action upon which diarrhœa sometimes apparently depends may be lessened by applying a strong current to the lower dorsal ganglia to influence the splanchnic nerves.

CHOLERA INFANTUM. Dr. O'Reilley, of Louisville, Ky., has successfully employed faradization in the treatment of this disease. The method of applying it is similar to that described for vomiting and diarrhœa.

INTESTINAL OBSTRUCTION.—*Faradism.* A case of this kind in the Hotel-Dieu of Rheims was apparently saved by electricity.

A laborer, aged sixty years, fell upon a heap of stones, receiving slight contusions on the right side. Four days after he was brought to the hospital in a state of profound collapse; there was considerable tympanites, but no tenderness on pressure. He had two hernias, complete on the right, with the inguinal ring enlarged to admit three fingers; on the left, a very small hernia. All the usual means were made use of without effect. Stercoraceous vomiting persisted, and on the next day recourse was had to electricity,—the first application of twenty minutes' duration was made at noon; one pole was placed in the anus, while the other was moved over the abdomen. No effect being obtained it was repeated at five o'clock P.M. At nine P.M. the patient had a considerable stool; he had a better night, the vomiting having ceased. Next day he had two electrizations, and in the afternoon the bowels were thoroughly cleared out. His recovery progressed without interruption, and four days later he was well.

Mr. Cauhet* reports a similar case occurring in a man aged forty-five. Six days after the attack began, electricity was tried according to the same method, but without relief. The seventh day a negative electrode was introduced into the anus, and the positive moved over the surface of the abdomen for fifteen minutes. A few hours after free evacuation occurred, and the patient recovered.

REDUCTION OF HERNIA.—*Faradism.* A large number of cases are reported in medical literature of strangulated hernia reduced by faradism. The usual procedure is to place one electrode in the rectum and the other either upon the hernia or at different points over the abdomen.

Dr. Suprunenko † reports the following case:

A slight inguinal hernia, which had been three hours strangulated resisted half an hour's taxis. A moderately strong faradic current was then used. The positive electrode was pressed against the tumor, while the negative was applied first against the lumbar vertebræ, afterward over the umbilicus. The hernia at once diminished, and in two minutes disappeared. In a second case, reported by Dr. Pergamin, the patient, a man of eighty, suffered from strangulated hernia for twelve hours. Two hours' persistent taxis failed. The faradic current was used for fifteen minutes without success. The current being still maintained, manipulation was tried, and in about two minutes the bowel returned into the abdomen with a gurgling sound.

ASCITES.—*Faradism.* Dropsy of the abdomen, due to various causes, has been successfully treated by faradization alone.

Popow‡ reports a case of persistent anasarca and ascites in a patient sixty-three years of age, who for many years had been a sufferer from malaria. On admission to the hospital he had considerable œdema of feet and legs, and oppressive ascites. Jaborandi and Fowler's solution

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* *Revue Médicale de Toulouse.*

† *Wratsch*, No. 40, 1882.

‡ *Vratsch*, 22, 1880.

were given, and slight improvement noticed. The induced current was then daily applied over the abdomen and the region of the spleen. The urinary secretion was found to become much more abundant, and, as soon as faradization was discontinued, again grew less. Albumen, after awhile, ceased to appear in the urine, the patient's general health improved, his abdomen became flat, and he was soon discharged cured. The spleen, however, remained large.

Dr. Sigrist* reports a second case of ascites successfully treated in this manner. Ascites was due to hypertrophic cirrhosis of liver. Every muscle of the abdomen was made to contract from fifteen to twenty-five times; two séances per day. Under this treatment the patient began to lose in weight about 200 grms. per diem; amount of urine became double, and abdominal circumference was diminishing from one-half to one centimetre per day. On the tenth day an abdominal bandage was applied. In three weeks ascites entirely disappeared and had not recurred when seen three months later.

Skibnewski† has recently reported two additional cases; the first, a little girl, æt. 9, very anæmic and with marked ascites. For ten days the patient took digitalis and iron without any diuretic effect, and during these ten days the circumference of the abdomen sensibly increased. The digitalis was then discontinued, the iron being kept up. Faradism was applied to the abdominal muscles two or three times a day. Each séance lasted fifteen or twenty minutes. The currents were sufficiently strong to produce muscular contraction. During the same séance each muscle was made to contract fifteen or twenty times. After twelve days the circumference of the abdomen was reduced from thirty-six and four-fifth inches to thirty; the quantity of urine was considerably increased. After three weeks the circumference of the abdomen was only twenty-four inches, and the quantity of urine normal. A month and a half after leaving the hospital, the patient had a return of the ascites. As before, medication had practically no effect, and faradization was resorted to with the former result.

The second case was that of a young man, æt. 17. Ascites and augmentation of the spleen commenced after an infectious disease. The urine was small, and contained no albumen. Faradization was performed twice a day for fifteen days, and then thrice a day, until within four weeks a cure was effected, both of the ascites and splenic enlargement.

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* *Medic.-chir. Rundschau*, January 1881.

† *Revue des Sc. Méd.*, July 1883.

PENDULOUS ABDOMEN (PHYSCONIA).—*Faradism.** One electrode is placed at the motor points of the rectus abdominis (Fig. 72, 90 to 94), while the other is carried up and down the muscle. The current should be strong enough to forcibly contract the biceps.

THE RECTUM.

Electricity is applied so frequently through the rectum, not only for disorders of the intestinal canal, but also for those of adjacent organs, that it may not be out of place in this connection to call attention to its peculiar shape and direction; this seems especially necessary, in view of the fact that the majority of electrodes intended to convey electricity within it are so illy adapted to the purpose. The length of the rectum in the adult varies from four to eight inches; the *lower* third, averaging one inch in length, curves forward from the anus; the *middle* third curves backward along the sacrum; the *upper* third is one-half the length of the entire tube, and bends toward the left. The shape of the lower and middle may be compared to an exaggerated letter S, with its lower curve one inch long and its upper three inches. It is obvious that any considerable force used to insert a rigid rectal electrode several inches in length into a tube curved as described, may cause serious and even fatal injury. A flexible electrode, terminating in a ball or oval-shaped body, is preferable, when it is to be used simply as a director for the current.

The nerves which supply it being derived from the plexus and ganglia, represented by P and G, Fig. 73, it is possible to treat some local disorders of the rectum through its nerves by locating the electrodes at the points named. Large, moist sponge-electrodes are best, and the effect of the current is most apparent when applied through warm water, as in the electro-thermal bath.

* *Centralblätt*, 1883.

Diseases of the rectum for which electricity may be employed:

Hemorrhoids (piles),
Prolapsus ani,
Pruritus ani,
Fistula in ano,
Paralysis of the sphincter,
Stricture,
Tumors.

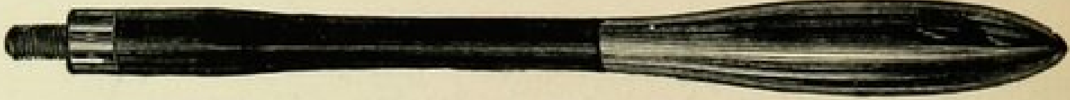

FIG. 110.

INSULATED RECTAL ELECTRODE.
Length, 5 inches.

This is the usual form of rectal electrode. It is insulated for nearly one-half its length with polished hard rubber. The metal part is nickel-plated. Various sizes are made so that it forms a suitable instrument for dilating strictures either with or without electrolysis.

HEMORRHOIDS.—*Galvanism.* Before each sitting direct the rectum to be well cleansed with an injection of hot water; anoint the rectal electrode before inserting it. If the tumors do not involve the sphincter, it is best to have that portion of the instrument in contact with the sphincter insulated. When the piles are very sensitive, or ulcerated, connect the rectal electrode with the positive; if not sensitive, and especially if they have existed a long time, connect it with the negative pole. The external electrode should be large, and may be moved over the liver, stomach and abdomen, in the direction of the colon.

Faradism is indicated to improve the venous circulation and prevent recurrence.

Electrolysis has been employed to destroy old tumors that resist other treatment. After bringing the tumor into view, insert the negative neeale and apply the positive pole over the nates or any convenient place, and carry a current from four to six cells through it for twenty minutes.

Galvano-cautery is pronounced by far the most efficient and satisfactory method of operating upon piles for their radical removal. The patient is put under the influence of an anæsthetic, the rectum having been previously cleared by an injection. Forcibly dilate the sphincter. The tumors are brought below it, if possible, but if not they are encircled by the loop and removed after the method for removing tumors described in the chapter on galvano-cautery. When they are of such a shape that they cannot be inclosed in a loop, they must be destroyed with the platinum point. Dr. Butler directs attention to these points in operating. 1. Apply the loop snugly around the diseased tissue before heating. 2. Tighten slowly, so that the mechanical action of the tightening loop may not anticipate the cauterizing action. 3. Protect the adjacent parts from being burned by radiation. Hamilton recommends running into the tumors platinum needles heated to a dull red heat, which obliterates the vessels without setting up active inflammation beyond; atrophy follows. It is well to protect surrounding parts with cotton saturated with water.

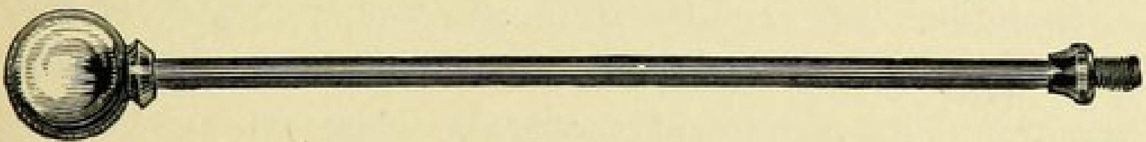

FIG. 111.

BALL RECTAL ELECTRODE.
Length, 5 inches.

This electrode consists of a rod of metal, insulated with hard rubber, and terminating in a nickel-plated ball. It is preferable to the one shown in Fig. 110 as a conductor, owing to its blunt extremity, but is not suitable for treating strictures.

PROLAPSUS ANI.—*Galvano-cautery.* The operation for this disease does not differ in its details from the one performed with actual cautery. It is fully described in textbooks on surgery.

Faradism. This disease in children may sometimes be cured by persistent treatment with a faradic current locally applied, the negative within the rectum or against the anus.

PRURITUS ANI. A mild faradic current applied through electrode 112 to and within the anus, with a sponge electrode upon the lower part of the spine, frequently gives temporary relief. Permanent relief can be had only through a cure of the disease which causes it. Occasionally a galvanic current applied the same way has been successful.

Paralysis of Sphincter Ani. When this disease accompanies paralysis of other parts, electricity locally applied will produce little effect. When it is the result of local causes, such as pressure during labor, forcible dilatation, etc., it may be relieved by applying the positive electrode within the sphincter, and the negative on the spine at the point indicated by G, Fig. 73. The secondary faradic may be employed, as strong as can be borne comfortably, for five minutes daily. If improvement does not follow after two or three treatments, the slowly interrupted galvanic should be substituted. Galvanism will not need to be repeated more than three times per week, and six to twelve freshly-charged zinc-carbon cells will be sufficient.

Stricture of the Rectum.—*Electrolysis.* An electrode similar to Fig. 110 is selected of suitable size to engage in the stricture. The instrument should be insulated except at the point which is to act on the tissues. The process described for insulating electrolysis needles may be employed. Hamilton recommends the following formula:

Gum shellac (brown)..................	1	drachm.
Solution india-rubber (Squibb's)......	1½	"
Wood naphtha.........................	2	"

On account of Tripier's observation that the scars which form at the point where the negative pole is applied are softer and contract less than at the positive pole, it is customary to connect the rectal electrode with the negative pole of the battery, while the positive is applied to the nates. *A very mild current is more efficient than a powerful one* in giving permanent relief. In this operation the shape of the rectum must be taken into account, otherwise the instrument may produce electrolysis of the healthy membrane, an accident to be avoided.

TUMORS, FOREIGN GROWTHS AND MALIGNANT AFFECTIONS have been removed from the rectum both by *electrolysis* and *galvano-cautery*. In the case of malignant disease, although a radical cure cannot be expected, yet suffering is diminished, and life has been prolonged.

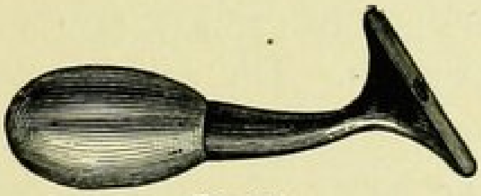

FIG. 112.

NEW STYLE RECTAL ELECTRODE.
Length, 2¾ inches. Diameter, ¾ inch.

This is unquestionably the best form of electrode for localizing the current in the lower portion of the rectum. It is insulated for a little more than one-half its length with hard rubber. The portion of it in contact with the sphincter is so small that not the least irritation is produced during the treatment, and the curve follows the natural curve of the rectum. A socket in the base receives the conducting cord.

FISTULA IN ANO.—*Electrolysis*. It has been recommended to destroy the lining membrane by inserting a wire through the entire length of the canal, and connecting it with the positive pole of the battery, the negative being placed on an indifferent point on the skin. A current from six to eight cells is employed for fifteen minutes. One application is sufficient. It causes little pain, and an anæsthetic is not required. Some authorities recommend that the bowels should be confined for several days after the operation.

Galvano-cautery. Insert a platinum wire in the fistula through a suitable director; with the finger that is in the rectum hook the end of the wire downward through the anus and remove the director; both ends of the wire are connected with the battery, and the loop is slowly drawn up, after the circuit is completed. The adjacent tissues must be protected by lint saturated with water. The subsequent treatment is the same as after an operation with the knife.

THE URINARY ORGANS.

Electricity may be applied to these organs through the pneumogastric and phrenic nerves at the motor points in the neck; through semi-lunar ganglia by placing a broad electrode on the lower dorsal vertebræ; through the solar plexus by pressing an electrode firmly against the empty stomach.

General faradization and central galvanization increase the amount of urine excreted. The *kidneys* may be directly electrized by including them between two electrodes placed on opposite sides of the body. A galvanic current carried to the base of the brain is said to exert a direct influence over the amount of sugar found in the urine.

The *ureters* respond readily to both kinds of electricity. They are shortened and constricted. The contractions proceed in the direction from the kidneys to the bladder, and continue long after the application has ceased.

The *bladder* contracts vigorously when its muscular fibers are directly faradized. It has been shown that electric stimulus applied to certain parts of the brain can cause contractions of the bladder, and that this stimulus is transmitted through the anterior columns of the cord. A current applied through the posterior roots of the sacral nerves also produces contraction of the muscular fibers of the bladder by reflex action. Another nervous center for the bladder is found in the lower portion of the lumbar cord, motor fibres from which pass through the hypogastric plexus on their way to the bladder. An electric current may be applied directly to this plexus through an electrode in the upper third of the rectum. This electrode is also in contact with the posterior wall of the bladder. in males. A current may be applied to the bladder by placing a broad electrode on the lower part of the abdomen, directly over the pubic arch, and another on the spine at the point indicated by G, Fig. 73, or within the bladder through an insulated electrode like those shown in Figs. 113 and 114. Both poles may be introduced into the bladder through the electrode illustrated by Fig. 116.

The *sphincter of the bladder* is, physiologically speaking, not a sphincter at all. Faradization of any part of the bladder causes urine to be voided, but faradization of those whitish elastic circular fibers that surround the neck of the bladder, and to which the name sphincter has been given, does not arrest the flow of the urine. It may be checked immediately by directing the current to the membranous portion of the urethra. This may be accomplished by the introduction of an electrode into the urethra, or into the lower third of the rectum.

Diseases to which electricity has been applied.

Addison's disease.
Bright's disease.
Diabetes insipidus.
Catarrh of the bladder.
Chronic inflammation of the bladder (cystitis).
Frequent micturition.
Paralysis.
Incontinence of urine.

ADDISON'S DISEASE.—*Faradism.* Dr. Rockwell describes a remarkable case of this disease in which general faradization relieved the symptoms, and imparted so great vigor to the patient that considerable doubt was expressed in regard to the correctness of the diagnosis by the gentlemen of the association to whom the patient was presented. He lived two years in the improved condition at which he had arrived under the influence of electricity, and at last died quite suddenly. A post-mortem confirmed the diagnosis.

BRIGHT'S DISEASE.—*Galvanism.* Dr. Hughes recommends galvanization of the spine for both Bright's and Addison's disease, believing they are associated with disease of the renal ganglia. Albumen and tube casts have disappeared under this treatment.

Diabetes Insipidus.—*Galvanism.* Althaus* has successfully treated this by galvanizing the medulla. Hughes reports a case of this disease, associated with profound melancholia and sexual apathy (loss of sexual desire without spermatorrhea for six months), cured by galvanization of the head and spine conjoined with proper medication. Each application was continued six minutes.

Faradism. Dr. Clubbe† reported a case treated with a faradic current applied over the kidneys about twenty minutes at a time, every day. The amount of urine was reduced more than one-half, and the patient's condition greatly improved for a number of months.

Catarrh of the Bladder.—*Galvanism.* The bladder after being emptied is partially filled with warm water, and an electrode (Fig. 114) is introduced and connected with the negative pole; a broad flat electrode applied over the bladder or sacrum is connected with the positive. A very mild galvanic current is carried through the circuit for a few minutes only. If the bladder be full, the gas set free at the negative might cause disagreeable distention. The presence of urine may, by its decomposition, produce great irritation. It has been suggested that certain drugs be added to the water, which, after decomposition, are capable of exerting an alterative influence upon the lining membrane.

Dr. R. M. Murray ‡ offers these hints as to the mode of conducting the application of galvanism to the bladder.

1. The current employed must be of the very gentlest, and the increase must be slow and gradual. The bladder is often morbidly sensitive, and anything like a violent shock may produce a very acute cystitis.

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* *Med. Times and Gaz.*

† C. P. B. Clubbe, in *London Lancet.*

‡ *Edinburgh Medical Journal,* April 1881.

Faradism has been employed externally with good effect in some cases of vesical catarrh.

Chronic Cystitis. *Galvanism* is best adapted to this condition. * When erosions or ulcers of the vesical mucous membrane are present, faradism must not be applied. When there is thickening of the walls, and incontinence without ulceration, one pole may be placed on the perineum, the other over the symphisis ; or one over symphisis and the other inserted as a catheter into the bladder.

Frequent micturition, where no special cause appears, is best treated by passing a weak galvanic current from the lumbar region to the region of the bladder.

Calculi. It is more than eighty years since experiments were begun to determine the feasibility of dissolving calculi within the bladder by means of electricity. Prevost and Dumas made the most complete experiments on animals, and succeeded in one or two instances. Dr. Bence Jones, following out their experiments, determined that a concentrated solution of nitrate of potash is the best in which to plunge calculi of any composition in order to dissolve them by the galvanic current. There are no reliable records of experiments made upon living human beings to determine whether this operation can be performed with safety. Dr. Melicher, of Vienna, claims to have done so, but no particulars are reported. The distressing pains in the neck of the bladder attending inflammation, with or without the presence of stone, are materially alleviated by faradism applied to the dry surface over the bladder through a metallic brush, also by a mild galvanic current from a belt. In the latter case a metal electrode, without a cover, connected with the positive pole, is fastened over the os pubis, and the negative, enclosed in a moist cover, is fastened to some indifferent point. It must be applied until irritation is pro-

* *Centralblatt, für Chir. Med.*, No. 30, 1880.

duced, and may be worn continually, changing the location of the positive a little from time to time to prevent the formation of a troublesome sore.

Paralysis. There is little to be expected from electricity in paralysis of the bladder due to brain or spinal disease; but when due to other causes, such as operations on the bladder or rectum, pressure during childbirth, or to certain drugs, electricity will nearly always produce a cure.

Galvanism. If the cause is located in the brain, place the negative electrode on the back of the head and the other over the os pubis; if due to spinal disease, place the negative on the spine below the diseased portion and the positive as before; when the disease is from other causes apply the electrodes as in the last case, or both may be applied over the bladder a little distance apart. The current is more effective when interrupted. Five minutes is ordinarily sufficient for each sitting.

Faradism may be applied with the electrodes located respectively over the lumbar vertebræ and the os pubis. Both forms of electricity are applied internally according to the following method: The bladder is first emptied and afterward filled with warm water; the patient lies upon the back with an electrode applied to the small of the back; a urethral electrode is introduced within the bladder, the water diffuses the current to all parts of the vesical membrane. The current must be very mild and the application short. When paralysis is caused by overdistention, this method of applying a faradic current within the bladder will be the most successful. When there is inability to expel the contents of the bladder from this cause, requiring the use of the catheter, the electrode shown in Fig. 118 will be found a serviceable instrument for the double purpose of conveying a current to the bladder and relieving it of its contents.

Franklinism, according to Arthius, is exceedingly efficacious in paralysis of the bladder not due to organic disease of the brain or spinal cord.

INCONTINENCE OF URINE.—*Faradism.* A primary faradic current, with one pole applied in the lower third of the rectum in the male, or to the meatus urinarius in the female, and the other over the os pubis, will sometimes relieve when the trouble is the result of debility, and especially if there is almost no control over the bladder. Sometimes it answers an excellent purpose to employ the electric brush on the dry surface over the hypogastric region, the opposite pole being on the spine.

Galvanism. The galvanic belt sometimes proves useful in these cases, one broad flat electrode being fastened over the bladder and an oblong one over the lumbar spine, and both connected with the belt. Only a few cells should be included in the circuit at first; the number may be increased as the current falls. This application of galvanism is continued for weeks at a time, with a view to bringing about nutritive changes in the muscular tissue.

HYPERTROPHY OF THE PROSTATE.—*Electrolysis.* Dr. Bredert* reports five cases of senile hypertrophies of the prostate, in which either one or both lobes of the gland were enlarged; and in all of these catheterization was impossible or could only be performed with great difficulty by bending the instrument. He inserted a needle electrode, insulated except at the point, which he pushed into the enlarged gland. This was connected with the negative pole of the battery, while the positive was applied to the abdomen. The diminution of the organ took place with astonishing rapidity. In one case it occurred after the third application. Hypertrophy of prostate, in recent cases, may be reduced by the measures recommended for the reduction of other hypertrophied glands. The electrode intro-

* *Berlin Klin. Woch.*

duced into the middle third of the rectum conveys a current directly to the prostate.

IRRITABLE URETHRA. — *Galvanism.* This condition of the urethra can be relieved by a properly applied mild galvanic current. In some cases, where it is impossible to make a local application, owing to the excessive sensitiveness of the urethra, a few galvanic water baths will subdue the sensitiveness sufficiently to permit the introduction of the sound, Fig. 119. This instrument should be warmed and oiled before attempting to introduce it. The negative pole may be connected with the sound after it is in place; the circuit must be closed by placing the positive on the lower part of the spine, and opened by removing it before the sound is withdrawn from the urethra. Two or three zinc-carbon cells are sufficient, and it is advisable to carry the current through a rheostat to prevent electrolysis of the urethral canal. The current should not be continued longer than five minutes.

GLEET.—*Galvanism.* Dr. Blackwood* advocates the treatment of gleet by electricity. He proceeds as follows: A sound (see Fig. 119), slightly oiled, and which fully distends the stricture or canal, is passed. The negative pole is attached to the sound. The positive pole or sponge should be wet with warm water, and a current which is plainly felt, but not painful, used. If an area is found more sensitive than the remaining tract, this portion should receive especial attention. The application should last from fifteen to thirty minutes. The bowels should be kept lax, all excesses prohibited, and non-stimulating food be taken.

STRICTURE OF URETHRA.—*Electrolysis.* The results of treating stricture are very satisfactory and more permanent than when dilatation alone is employed. Its advocates claim for this operation freedom from pain, hemorrhage, febrile reac-

* *Phila. Med. Times,* November 1882.

tion, or any ill effect, if conducted with ordinary skill. The patient is not confined to his bed after the operation and can pass water immediately after it. Dr. Newman,* who has done most to direct the attention of the profession to this subject, makes these valuable suggestions:

1. Before operating, the susceptibility of the patient to the electric current should be tested.

2. The problem is to produce absorption, and not cautery; therefore, weak currents at long intervals are best.

3. The best position for the patient to assume during the operation is that which is most comfortable to him and the operator. It may be either the erect or recumbent.

4. Anæsthetics are to be avoided, as it is better to have the patient conscious and able to tell how he feels. Care must be taken to keep the electrode in line, so that the point will not deviate and make a false passage.

5. Force should never be used. The bougie must be guided in the most gentle way, and electricity alone be allowed to do the work.

6. During one séance two electrodes in succession should never be used.

7. It must not be forgotten *to stop the current before withdrawing the electrode*, otherwise acute pain will be induced in the course of the urethra, which often remains some time. Pain should never be inflicted during electrolysis; therefore it should not be applied when the urethra is in an acute or even subacute inflammatory condition.

8. It is well to leave a little urine in the bladder. It serves to diffuse the stimulus and is more agreeable to the patient than when the bladder is empty.

Dr. W. H. Dukeman,† of Olean, N. Y., reports a remarkable case treated successfully after this method: The patient,

* *N. E. Med. Monthly.*

† *The Medical Record*, June 23, 1883.

aged sixty-five, had suffered from stricture twenty-five years. Four distinct strictures were discovered. An insulated urethral electrode, tipped with a No. 9 olive (French scale), was introduced and arrested at the third stricture. The negative pole of a McIntosh galvanic battery was connected with the urethral electrode, six cells were included in circuit and the circuit completed by placing a large wet sponge electrode on the left thigh ; after eighteen minutes it passed through the third stricture but was arrested at the fourth, which it failed to pass after fifteen minutes' steady application of the current. The patient returned next day for further treatment. A No. 3 French filiform bougie on trial failed to pass the fourth stricture, and the current was reapplied as on the previous day ; the current was increased cell by cell until twelve were included in circuit ; the electrode entered the bladder at the end of nineteen minutes. The patient did well in every respect, and at intervals of one week were passed a No. 13 olive (French scale), a No. 17 and lastly a No. 21, when the operation was considered complete, the patient being entirely relieved. *It is important that the negative pole be connected with the urethral electrode, otherwise it will become glued to the tissues so that it cannot be removed without violence, and the cicatrix, which forms where the positive has been applied, is liable to contract and form a worse stricture than the one it was intended to remove.*

IMPOTENCE.—*Galvanism.* Dr. Robert Newman* has published a series of valuable articles on impotence, which he defines as "any deviation from the normal status of sexual vigor." He prefers galvanism, and when an interrupted current is needed, he makes use of the automatic rheotome. He excludes from the cases to which electricity is adapted—

1. Males in whom sexual vigor never existed, as in congenital malformations.

* *The Planet*, Nov. 15, 1883.

2. Those cases dependent on the decay of age.

3. Mutilation, or loss of parts by accident.

4. Diseases of testicles.

5. Those cases in which impotence is only a symptom of other grave diseases, as ataxia, diabetes, etc.

We have three centers governing erection:

1. Nerve centers in cerebrum (*Psychical*).

2. Lumbar plexus, presiding direct over erection.

3. Peripheric nerves of genitals.

The mechanism of erection is not merely a retention of venous blood, but more an afflux of arterial blood into the elastic erectile tissues of the penis, which is well recognized by our modern physiologists.* But this mechanism cannot take place by itself, and is induced and governed by the power of the nervous system, as explained. This knowledge is of the greatest importance in making a correct diagnosis, and selecting the course of an intelligent treatment, both of which can be accomplished by electricity.

He uses a galvanic battery of twenty or more zinc-carbon cells. The electro-sensibility will decide how many cells are needed. The current of six cells may be sufficient, while another case needs thirty cells. Twelve to sixteen cells are used generally as an average. The strength of the current must always be regulated, and on some points of applications in the same patient, made stronger or weaker, according to his sensibility. The duration of each séance is about ten minutes.

The electric brush has done excellent service in those patients who had lost almost the entire sensation in genitals, with impaired nutrition and atrophy of the parts. Strong currents of galvanism made no impression, and caused no sensation, but the cautious use of the electric brush, alternated with galvanic interruptions, restored the power and finally cured.

*Flint's Textbook on Physiology, page 108.

He mentions another method, which is even more powerful in its tonic action than any other.

The positive sponge electrode is placed on the back, and as negative pole an insulated urethral electrode is introduced into the urethra (Fig. 113). The duration of such a séance is from five to ten minutes, as a rule.

Such applications are not repeated often, and only given in intervals of one to three weeks. Meanwhile, the external applications are given as described before, about four times a week. If an insulated electrode is used, the power of galvanism is concentrated at one point, covered by the olive, and this place has the full benefit, and may be even cauterized if the current is strong enough.

The simple nickel-plated sound (Fig. 119), not insulated at all, as negative pole in the urethra is preferable when it is desired to diffuse the electric current through the whole urethra, or even to the whole member. The advantage of this procedure is that it exerts a tonic effect on a large surface and groups of muscles, while at the same time the current can be used stronger. If the penis is cold, numb, atrophied, in fact almost lifeless and useless, this method will give the best chance for recovery, in combination with other applications referred to before.

The prognosis of these cases of impotence under consideration is favorable in almost all instances; this means that impaired vigor, or functional impotence, will be cured under judicious treatment, if there is not complete paralysis.

Faradism. Dr. William F. Hutchinson* remarks that for nearly ten years he has used the faradic current in the treatment of impotence. He prefers a current as strong as a patient can bear without pain and without shocks. He applies a large negative sponge electrode under the lumbar vertebræ, the

* *N. E. Med. Monthly*, October 15, 1883.

patient being comfortably recumbent, and for the positive a pad of surgeon's sponge moistened is pressed against the glans. The result is a strong stimulation of those branches of the sacral plexus composing the genito-urinary tract, and a corresponding increase in muscular nutrition. The penis becomes turgid, the dartos contracted, and a close watch must be kept upon the patient, lest by continuing the application too long an emission be produced. By discontinuing the current after five minutes, or by increasing the electro-motive force until it becomes painful, this result may be avoided. By a steady persistence for several months in this form ot treatment, he had succeeded in completely restoring several patients. The applications should be made daily.

Dr. A. Gunther, of Zurich, places the testes between two wet sponge electrodes, or applies the faradic current direct to the glans, according to the indications.

Franklinism furnishes a most valuable means for the relief of impotence, according to Dr. Vance.

SPERMATORRHEA.—*Galvanism.* All sources of irritation of the genital organs, such as stricture, piles, constipation, acrid urine, must be removed before any treatment will relieve spermatorrhea except temporarily. Non-stimulating diet should be insisted upon; intoxicating drinks, excessive use of tobacco and all excesses must be prohibited, and the bladder thoroughly emptied before retiring. In some cases it will be well to direct the urine to be voided whenever the patient awakes during the night. A mild galvanic current should be applied three times a week, the positive electrode at the lumbar sacral promontory, and the negative to the perineum and supra-pubic region alternately. It will require about three months to effect a cure.

NEURALGIA OF THE TESTES.—*Galvanism.* This very painful affection may be relieved by the uninterrupted galvanic current.

The testicles are extremely sensitive to electricity, and the pains excited by a careless application extend to the loins and are exceedingly disagreeable to the patient. The best method of electrizing them is to immerse them in warm water contained in a cup of suitable shape, which is connected with one pole of the battery in the same manner as the eye-cup. A very mild current should be employed. The positive pole may be connected with the cup, and the negative be held in the hand or placed on the thigh, or the positive may be placed on the lower part of the spine and the negative connected with the cup.

HYDROCELE. There are three methods employed: 1. *Electrolysis*, needles attached to both poles being introduced into the sac. 2. *Electrolysis* with the negative needle only introduced. 3. *Farado-puncture*, i.e., a faradic current applied to needles introduced into the sac. Whichever method is selected it is essential that the needles penetrate into the fluid, and that they be insulated at the point where they pass through the coverings of the testicle.

The Galvanic Bandage. Mr. S. Osborn read before the London Medical Society notes of two cases of hydrocele cured by single tapping, with the subsequent use of the galvano-suspension bandage. The first was a case of hydrocele of the tunica vaginalis, which had been present for seven or eight years; and the second was a case of double encysted hydrocele, present for six years. Both patients were affected with rupture on the same side as the hydrocele, showing a preternatural weakness of the parts in the vicinity. The ages were seventy and sixty-three respectively. After tapping and manipulation the galvanic suspensory bandage was applied. The galvanism was believed not only to cause contraction of the muscular fibers of the scrotum, but to impart a healthy action to the serous sac, aiding absorption. Mr. Osborn recommended a trial of this bandage in other diseases of the testicle, such as varicocele and neuralgia. The galvano-suspension bandage referred to is supplied with the McIntosh Galvanic Belt.

THE UTERUS AND ITS APPENDAGES.

Röhrig* demonstrated that the center of uterine action is in the lumbar spinal cord. Stimulation as high up as the medulla, and even as far as the crura cerebri and optic thalmi, also gives rise to slight uterine contraction, probably due to indirect stimulation of the lumbar center.† Experiments on lower animals indicate that impulses may pass from the central nervous system to the uterus along the sympathetic, from the inferior mesenteric ganglion, and also along branches of the sacral nerves, respectively, to the hypogastric plexus.‡ M. Dembo§ has endeavored to decide the question, upon which authors differ, as to the influence of electricity upon the uterus, whether empty or pregnant. His conclusions are that it is impossible to excite contractions in the non-pregnant uterus by a faradic current applied through the abdominal walls. If both electrodes are applied to the anterior (vesical) wall of the vagina, a manifest contraction is produced in both parts of the uterus, vermicular in character, passing from below upward. If the current be applied to either lateral wall of the vagina, a contraction is produced only in the corresponding cornu. Faradization of the vaginal wall caused pallor of the mucous membrane and also of the whole uterus, due apparently to contraction of the vessels, but no contraction of the substance of the uterus occurs. Frankenhauser found that stimulation of the aortic plexus (see Fig. 73) caused a manifest contraction of both cornua. The hypogastric plexus lying in front of the sacrum

* Virchow's Archiv., 1879.

† Körner, Studien Phys. Inst. Breslau, iii, 34.

‡ Basch and Hofman, Wien. Med. Jahrb., 1877.

§ *The Lancet.*

furnishes the nerves distributed to the uterus and vagina, and here Budge and Wall located the genito-spinal center. Electricity may be conducted to these organs by locating one large electrode on the sacrum and another in front of the abdomen, over the pubic arch, or the current applied in front may be divided by means of a bifurcated cord between two electrodes, one being located in each inguinal region. Another method of electrizing these organs is to introduce one electrode into the upper third of the rectum, where the current is divided between the sacral nerves and the posterior surface of the uterus and its appendages, the alternate electrode being located as before.

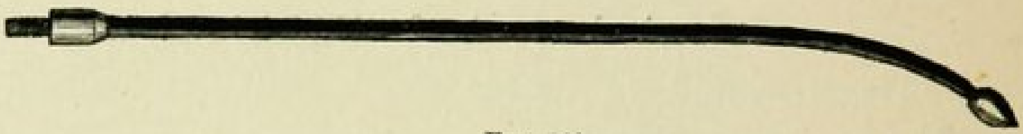


FIG. 113.

Length, 11 inches.
UTERINE OR URETHRAL ELECTRODE.

This is an inflexible metallic rod insulated with hard black rubber. Its diameter equals a No. 16 olive (French scale). It is curved at one end, and terminates in a small screw that fits olives of any size.

M. Apostoli* recommends, instead of the unipolar method of faradization, in which one pole is placed in the uterus and the other pole on the abdomen, the bipolar method, in which both poles are carried into the uterus. It is claimed for this new method :

1. That it is more easily employed, and does away with the necessity of an assistant.

2. That it is less painful.

3. That it is more active, localizes the action of the electricity in the uterus, permits of an easy elevation of the intensity of the electricity to the maximum point, which was only rarely possible by the unipolar method.

* *Gazette Des Hopitaux*, February 1883.

4. It is more effective in increasing uterine contractility and in securing the therapeutic effects for which it is directed. The electrode illustrated in Fig. 116 may be used for this purpose.

DISEASES IN WHICH ELECTRICITY IS BENEFICIAL.

Atrophy of uterus,	Menstrual derangements,	Ulceration,
Hypertrophy,	Labor,	Polypi,
Sub-involution,	Leucorrhea,	Fibroids,
Irritable uterus,	Vaginismus,	Displacements.

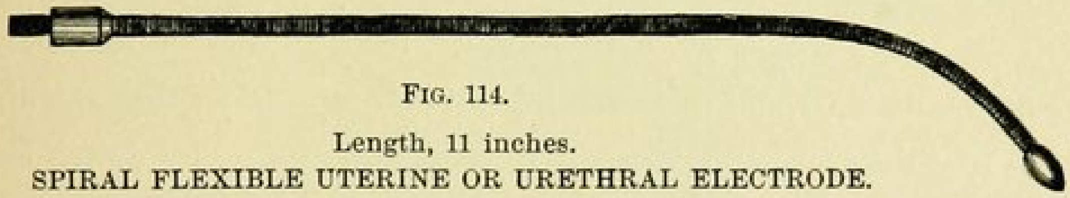


FIG. 114.

Length, 11 inches.

SPIRAL FLEXIBLE UTERINE OR URETHRAL ELECTRODE.

The stem of this electrode is made of closely-coiled wire, which renders it perfectly flexible while preserving a sufficient degree of firmness. It is covered with soft rubber, which insulates it perfectly without interfering with its flexibility. The terminal screw fits olives of all sizes. The diameter is equal to a No. 16 olive (French scale).

Nearly all the diseases of the uterus and its appendages require the methodical application of electricity for several months before its remedial power will be exhausted. Its chief effect is accomplished through the improved nutritive changes which it sets up, and these are necessarily slow. Functional disorders may be relieved quite promptly by a properly-selected current. General faradization and central galvanization will be found especially useful in subduing the sympathetic disturbances which accompany disease of these organs, and treatment should be used not only to overcome or relieve attacks of suffering or check a hemorrhage, but in the intervals to improve the morbid condition upon which the disease depends. The practitioner who relies solely on local applications and a single form of electricity will meet with frequent failures where, under other circumstances, he would have been rewarded with success.

ATROPHY OF THE UTERUS. *Galvanism* has been used successfully, more especially in cases of undeveloped uterus, than when atrophy has resulted after the establishment of the monthlies. An insulated electrode, like the one shown in Fig. 114, is introduced into the uterus and connected with the negative pole of the battery; the circuit is completed by passing the positive electrode alternately over the abdomen in the ovarian region and over the lumbar vertebræ. An interrupted current from twelve to fifteen zinc-carbon cells may be used if it can be borne; the sitting may continue fifteen minutes and be repeated twice a week. If the patient begins to complain of pain in the back, with a feeling of tension and uneasiness in the hypogastric region, indicating an attempt at menstruation, it is well to substitute the *faradic* current for one or two sittings, discontinuing all treatment on the appearance of a colored discharge for one week, then resume galvanism once a week as before. This method of treatment will generally succeed, although it may require many months to establish a regular return of the menses. Galvanic baths given in the tub, with the current directed through the electrodes opposite the hips, the patient lying on one side meantime, and repeated twice a week for several months, is an efficient and much more agreeable mode of treatment than the one previously described.

Fig. 115.

OLIVES.

These are made of brass, nickel-plated, and are of all sizes, to correspond with the American and French scales. They contain a socket cut in threads to receive a screw. *Caution:* Olives should be firmly attached to the electrodes; if the screw does not fit perfectly there is danger of losing them off within the bladder or urethra.

Amenorrhea. In the case of young girls, it is advisable to apply electricity by the external method, one pole being located over the hypogastric plexus and the other the ovaries; at the same time the current may be applied through the phrenic nerve. Central galvanization is so useful a measure that the physician is not justified in employing electricity locally in these cases until a faithful trial of the above measures make it evident that there is no other alternative. The hot-air electric bath is indicated if there is reason to believe the non-appearance of the monthlies is due to a cold.

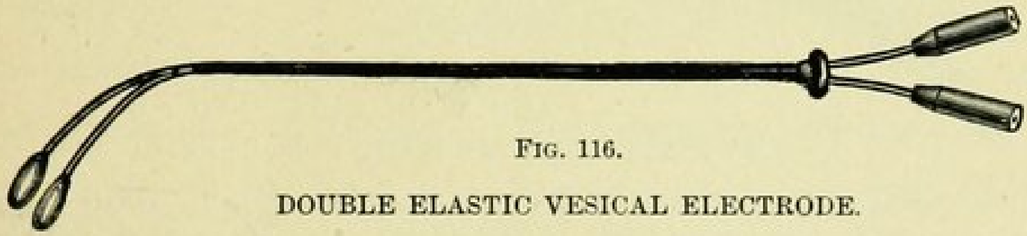


FIG. 116.

DOUBLE ELASTIC VESICAL ELECTRODE.

This instrument consists of a flattened black hard-rubber tube, 10 inches long, with a diameter equal to a No. 22 olive through which passes two wires 12 inches long, insulated with hard rubber, each terminating at one end in a half olive, permanently and securely fastened to them, and at the other end, in a socket for connection with a conducting cord. Before introduction into the bladder or uterus the wires are drawn back so that the terminal tips touch and form a No. 23 olive at the end of the common tube; after introduction the wires are pushed through the tube; this separates the terminal tips, which now represent the two poles of the battery with which they are connected.

Galvanism. Dr. R. R. Good* reports excellent success in the treatment of this affection when it is due to inertia of the utero-ovarian apparatus, disturbance in circulation, or to defective nutrition. It would be useless to resort to galvanism when the disorder originated in mechanical obstruction. From five to forty sittings are required to effect a cure. His method is to employ the descending current, with twenty to thirty elements for the upper part of the spine, the lumbar and ovarian regions, and from six to ten elements for the sympathetic nerve, applied along the inner border of the sterno cleido-mastoid muscle.

The method of internal application varies, some operators using the faradic current only, some the galvanic, and others alternate the two. The current may be directed to the vagina through a vaginal electrode (Fig. 121), to the cervix through electrode shown in Fig. 124, or within the cervical canal by those shown in Figs. 114 and 125. The external electrode may be located over the sacrum or any portion of the spine,

* *Med. Times and Gaz.*, 1880.

or applied over the uterine or ovarian region on the anterior surface of the abdomen. Amenorrhea in women from thirty to thirty-five, with a tendency to obesity, is sometimes relieved, according to Dr. Goodell* by the galvanic pessary.

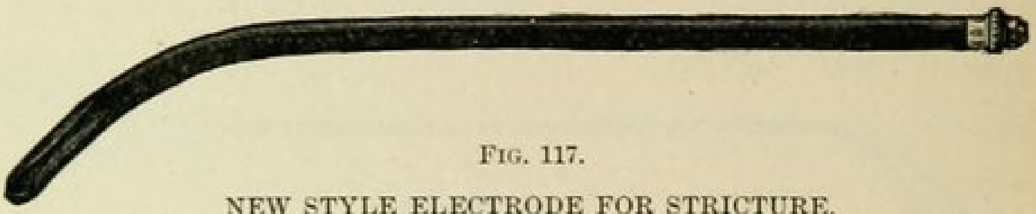


FIG. 117.

NEW STYLE ELECTRODE FOR STRICTURE.

This electrode is pronounced, by those who have employed it, better suited to the treatment of stricture than any other form. It consists of a black hard-rubber closed tube 11 inches long, within which is enclosed a metal rod that may be connected with the negative pole of the battery. At the closed end of the tube are three long and wide slots; when the circuit is complete, electrolysis of the secretions within the urethra around these slots takes place, and the stricture is acted upon without direct contact with the metal. It is claimed that there is less danger of making a false passage with this instrument than with the usual form of urethral electrode, and that it is equally as effective.

MENORRHAGIA.—*Faradism.* Electricity is especially indicated in those cases of passive hemorrhage not dependent upon organic changes. The current applied to the abdominal muscles so as to produce vigorous but not painful contractions, for fifteen minutes at a time, and repeated two or three times per week, will frequently produce an immediate diminution in the flow, and, if persevered in, a cure. It will sometimes be more effective applied within the vagina or cervix. *General* applications of faradism or galvanism, selected according to the symptoms of the case, are an important aid in removing accompanying debility. If the patient takes little exercise and has sluggish circulation, *general faradization* is commonly indicated; if, on the contrary, she is of active habits, and especially if the condition has been induced by over-exertion, *central galvanization* to improve nutrition is preferable.

It may be necessary to continue treatment for several months before the nutrition of the uterus is sufficiently improved to put an end to excessive flow, but as the result is permanent

* *Phila. Med. Times*, 1883.

when accomplished by this method, it is well worth the perseverance required in carrying it out.

DYSMENORRHEA.—*Faradism.* Karl Kihn,* having had opportunities to test the value of the faradic current, both in dysmenorrhea and amenorrhea, advises it used in connection with hot infusions of juniperaceæ and warm foot-baths. He places one electrode in the hand of the patient and the other in the water of the foot-bath. In a number of instances this simple measure increased the flow, relieved the pain, and established a regular and comparatively comfortable return of the periods.

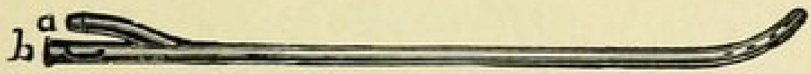


FIG. 118.

CATHETER ELECTRODE.

This instrument is an ordinary silver catheter, to which is attached a holder *a* to receive a conducting cord; a rubber tube may be connected with *b* to convey the urine into a receptacle. When it is desirable to prevent the current from affecting the urethra, the instrument may be insulated, except at the perforated extremity, with the same material that is used for electrolysis needles.

Dr. Wm. R. D. Blackwood † is an enthusiastic advocate of electrical treatment in all forms of dysmenorrhea, except the membranous variety. He employs faradism, galvanism and franklinism, and bases his conclusions on an experience of more than fifteen years. He believes the applications should be made directly, one pole being applied to the exterior of the cervix, to the cervical canal at any desired point, to the fundus, or to the ovary (which can be reached near enough by pushing the instrument well up on either side of the cervix), while the other is applied both to the hypogastrium and lumbar spine by means of two sponge-holders attached to a bifurcated cord.

* Allg. Med. Cent. Zeitung, Nov. 10, 1880.

† *Phila. Med. Times*, Jan. 1880.

The direction of the faradic current is a matter of no moment, but the galvanic current appears to produce different results, according as it is ascending or descending. In *neuralgic* cases the rheotome is necessary, and more or less frequent reversion of the current heightens its value, while in *congestion* a downward uninterrupted current is better. *Static* electricity is a most valuable but neglected method in neuralgia, not alone of uterine origin, but of all types, and will often succeed after the failure of other proceedings.

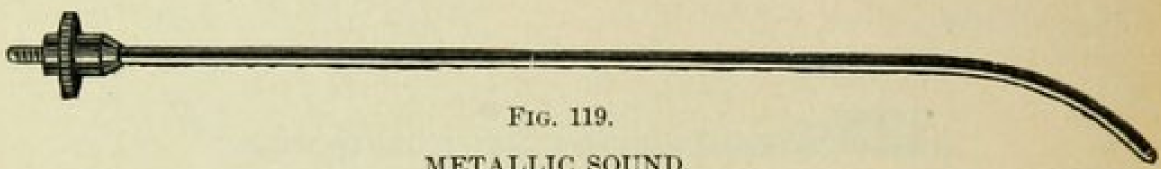


FIG. 119.

METALLIC SOUND.

This is an ordinary nickel-plated sound with a screw attachment, which fits a universal handle. Caution is required in conveying a galvanic current through this electrode, lest electrolysis of the entire urethral membrane be produced.

Galvanism is sometimes indispensable in these cases. It is employed during the attack to quiet the pain, and two or three times weekly, in the intervals, to prevent a return of suffering. One pole may be introduced into the uterus, the other being applied to the lumbar spine, and a current of from ten to twenty volts passed for ten minutes. Electro-thermal baths of all kinds, but especially the water, or vapor electric baths, taken at intervals for several months, relieve cases not dependent upon obstruction.

VAGINISMUS.—*Galvanism.* Cases of excessive hyperæsthesia of vagina, accompanied by vaginismus, forbidding all examination of the parts, have been relieved by this procedure: Connect the vaginal electrode (Fig. 121) with the negative post of the battery and apply, after warming it, to the orifice of the vulva. Place the positive electrode in position C, Fig. 120, and close the circuit, including not more than four freshly-charged zinc and carbon cells, or six that have been used some time. Do not exert any force on the negative electrode, but hold it steadily in place with gentle pressure; after a few seconds it will gradually slip into the vagina; the current may be continued twenty minutes, and usually after the second treatment a digital examination may be made without difficulty, provided it be done immediately after removing the electrode. Any exciting cause of the distressing condition that can be found should be removed, after which the persistent use of galvanism will relieve and restore the patient to a normal condition, in a larger proportion of cases than any other treatment.

Irritable Uterus.—*Galvanism.* The cup-shaped uterine electrode (Fig. 124) is applied to the cervix and connected with the negative pole of the battery, the positive completes the circuit at the sacrum, or in the ovarian region.

Leucorrhea.—*Galvanism.* This disease, when due to a catarrh of the uterus, or vagina, may be treated by a mild galvanic current applied within the uterus, to produce a feeble electrolytic effect upon the lining membrane, with a view of stimulating it or altering the nature of its secretion. Since an acid is set free at the positive and an alkali at the negative, it is important to consider the special effect to be produced in selecting the pole to be connected with the internal electrode. Uterine leucorrhea, without organic disease, may be relieved by a galvanic current applied through electrodes, shown in Figs. 124 or 125; vaginal leucorrhea, through electrode Fig. 121. Leucorrhea, both uterine and vaginal, not dependent upon ulceration or foreign growths, can be effectually and permanently relieved by the hot-air electric bath. A series of these baths, from twelve to thirty in number, repeated twice a week, with intermission during the menses, has relieved cases of many years' standing without local treatment. The attention of the profession is earnestly called to this method of radically curing an almost universal complaint by a measure at once agreeable, effectual, and especially desirable in the case of unmarried ladies, where the disease is more likely to be due to constitutional than local causes.

CHRONIC METRITIS.—*Galvanism.* Chronic inflammation of the uterus, with enlargement, may be materially relieved by the use of the galvanic pessary; the external electrode being located over the sacral ganglia. The latter may be retained in place by means of straps of adhesive plaster. Tripier recommends that a current from a battery be applied according to this method. One electrode (Fig. 124) is placed against the os, and connected with one pole, while the current from the other is divided between two electrodes, one of which is introduced into the upper third of the rectum to bring it in connection with the posterior wall of the uterus, and the other is placed over the abdomen. An insulated rectal electrode is required for the former, and a large wet sponge for the other. The object of the application is to allay irritation and improve nutrition; therefore a very mild current should be employed, and for a few minutes only when the battery is used, because electrolysis is to be avoided. When the belt is employed with the pessary, the negative current will be less likely to irritate the cervix. The full number of belt cells should not be wet up at first; four or five are enough to commence with, and after a few hours one or two more may be charged with fluid and added to the circuit.

ENGORGEMENTS, HYPERTROPHY, etc., have been relieved by the method described above. In these cases, however, when inflammation is not present, the current should be interrupted. The *faradic* current applied by a vaginal electrode (Fig. 122), so that the anterior and posterior walls are respectively affected by the current, is sometimes very effectual in reducing the size of the uterus.

Faradism applied with an insulated rectal electrode in contact with the posterior uterine wall, and a broad sponge on the abdomen is sometimes preferable, but should never be applied when there exists evidence of sub-acute inflammation.

Ovarian Irritation.—*Faradism.* When there exists tenderness on pressure, or dull aching pain, especially in the left ovarian region, the faradic current, applied after the manner described for constipation, sometimes proves curative.

Galvanism. Ovarian irritation, accompanied by neuralgia, may be relieved by galvanism when a point can be detected, along the spine or a nerve, where pressure by the finger causes pain. One pole must be located on the tender spot, and the other on one or both ovaries, according as one or both are affected. Congestion of ovary, attended by hysterical symptoms, is sometimes relieved by the galvanic belt; the electrodes being located over the ovaries, and the application being continued for several weeks, or months if necessary.

Displacements of the Uterus. Simple displacements are easily rectified under the influence of electricity by its external application through the walls of the abdomen. This is believed to be accomplished, partially at least, through the contraction of the abdominal muscles. The general application of all forms of electricity affect the uterine supports through the spinal nerves and hypogastric plexus. The current conveyed to the pelvic organs through these nerves improves nutrition, and consequently lessens the weight of the womb, when the latter is in a hypertrophied state. When the vagina is relaxed, the introduction of the current through a vaginal electrode will be found most efficient to restore its tonicity.

The vaginal electrode should be warmed and oiled before introduction, and *the circuit must not be completed until after the electrode is in place.* The alternate pole may be located on the sacrum, or by means of a divided cord over both ovaries.

Faradism is used for its mechanical effect; *galvanism*, for its chemical effect. When it is interrupted, the galvanic exerts both a mechanical and chemical effect.

This important point should not be overlooked in the treatment of uterine displacements by electricity. The patient should be instructed to clear out the rectum, by means of an injection if necessary, immediately before presenting herself for treatment, and the bladder must be empty. *The uterus should be replaced as nearly as possible to a natural position before applying the current.*

Tripier reports thirty cases of uterine disease treated by faradism locally applied. The plan he pursued for the various forms of displacements are:

Prolapsus. One pole applied against the neck of the womb, the other is connected through a bifurcated cord with two electrodes, one of which is applied in each groin.

Anteversion and *Anteflexion.* The negative, an insulated rectal electrode, was introduced so as to carry the current to the upper third of the rectum, and the positive in the vagina.

Retroversion and *Retroflexion.* The positive over the abdomen or introduced into the bladder (a plan that can scarcely be recommended), and the negative to the neck of the womb. If the application of electricity causes the monthlies to appear when not due, it is an indication that the current was too strong, applied too long, or repeated too frequently.

LABOR.—*Faradism.* Dr. W. J. Kilner,* electrician to St. Thomas's Hospital, has made a valuable study of the effects of faradism in forty-one cases of labor. He uses it especially where the pains are short, feeble, and at long intervals, and states that his first experiments were directed to discovering whether the pregnant uterus, like the voluntary muscles, possessed *motor points.* After many trials he arrived at the con-

* *Lancet*, Jan. 1, 1881.

clusion that motor points exist, and can be easily found by bisecting the line drawn from the umbilicus to the middle of Poupart's ligament. This point is approximate, being only applicable before the head has descended, to allow the head of the child to enter the pelvis, and the spot varies in each case, according to the position of the uterus. The muscles of the uterus are of the unstriped variety (involuntary), and they do not respond to electric stimulation so quickly as the striped muscles.

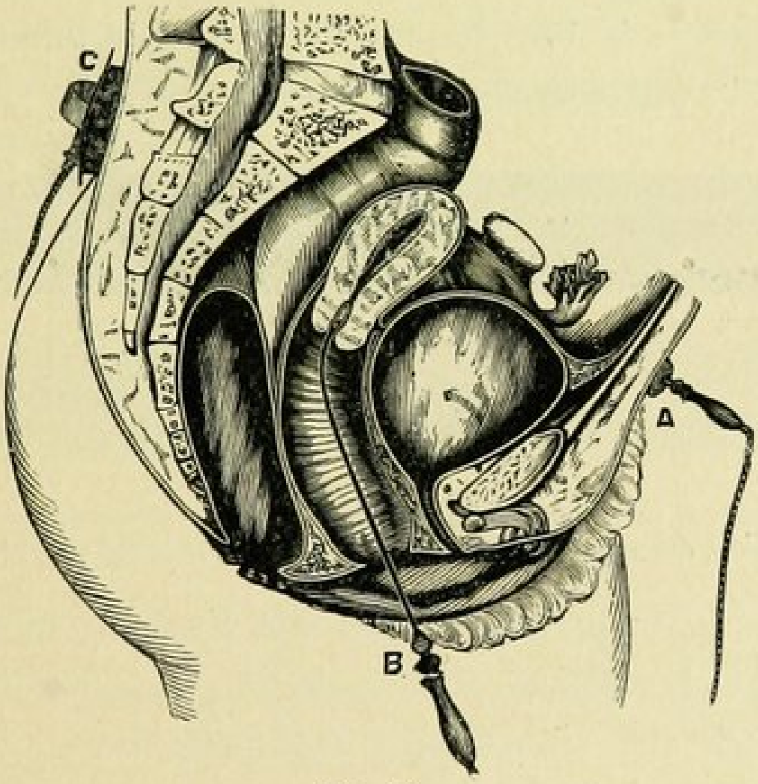


FIG. 120.

METHOD OF APPLYING ELECTRICITY TO THE UTERUS.

This illustration shows where to locate the electrodes to convey electricity through the uterus and its appendages. B represents electrode, Fig. 114, connected with one pole, introduced into the cervical canal. A and C are two electrodes connected by a bifurcated cord with the alternate pole; A and C indicate the points to locate the electrodes when external treatment only is required; also the points where they are located when electricity is employed during labor.

When the faradic poles are placed upon the spot just indicated, the first thing observed is the immediate contraction of the abdominal muscles, the intensity of which depends upon the strength of the current. Occasionally, at the instant of contact, uterine contractions commence, but more often a lapse of about a quarter of a minute is required, and not infrequently they are delayed for two or three minutes. But still the current is taking effect, as the intermittent use, for instance, half a minute on and the same off, rarely fails to induce contractions in a few minutes; these increasing gradually in severity and duration, while the intermissions become less and less. Latterly, however, he has applied the current only during the contraction, to obtain the benefit of the relief of pain.

If it be wished merely to prolong any one uterine contraction, the current is best applied near the termination of the pain, when it will commence *de novo*.

FIG. 121.

VAGINAL ELECTRODE.
Length, 6 in.; diameter, ¾ in.

This electrode is made of brass, nickel-plated, and is designed to be used for conveying a current to all parts of the vaginal wall. It fits the universal handle.

The ones most likely to be affected favorably by the induced current, viz: (1) Those of a nervous temperament, who are easily excited, and who usually feel pain acutely. (2) Those who have sympathetic disturbances, such as vomiting and hiccough. (3) Those who require stimulation.

The best way of applying the current is to place the electrodes (each being about three inches in diameter) upon the abdomen, over the motor points, these being retained in their proper places by the binder.

Large electrodes are preferable to small ones, because the same current spread over a large surface is not felt so acutely as when it is concentrated into a small space. For the relief of pain, a very mild current only is required, but for the production of uterine contractions, a variable strength is necessary.

The following conclusions are derived from a total of five hundred electrizations of the uterus:*

1. That faradization of the uterus is entirely harmless.

2. Faradization is a uterine sedative.

3. Faradization abridges considerably the convalescence and accelerates the involution and retraction of the uterus. That it also hastens the restoration, and promotes regularity of function.

4. Faradization guards the woman from the uterine complications of labor.

5. That faradization is the correct preventive treatment of uterine malpositions.

6. The action of faradization on the uterus is similar to that of ergot, only its action is more prompt and more energetic.

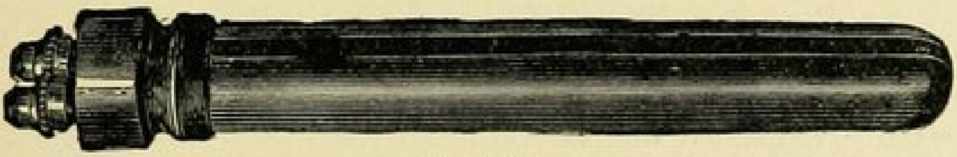


FIG. 122.

VAGINAL ELECTRODE INSULATED IN LATERAL HALVES.

This electrode consists of two cylindrical halves separated by hard rubber, which insulates them so that electricity cannot pass directly from one to the other. A binding post is attached to each half for connection with the conducting cords. It is designed to be used when a positive current is to be applied to one half the vagina and the negative to the other half. The current is localized on the lateral halves, or anterior and posterior halves, according to the direction in which it is introduced.

In conclusion, it is a marvelous therapeutic agent in obstetrics, simple in application, rapid and energetic in action, perfectly harmless, and can be interrupted or renewed at will.

It not only restores the uterus to the normal condition, but its use prevents further uterine complications. The method of employing it for this purpose is this: Immediately after the delivery, an induced current is applied to the uterus, and gradually increased in intensity. This operation is repeated from eight to ten times, during about six days after normal labor.

* M. Apostoli, in *Gazette des Hôpitaux.*

SUPERINVOLUTION AND SUBINVOLUTION OF THE UTERUS. Dr. Rockwell has successfully treated a few cases with both galvanism and faradism, the applications being made almost daily for a number of months.

Dr. Murray* regards the galvanic pessary an efficient instrument in subinvolution following childbirth. In one case of this kind with retroversion where pessaries had failed to remedy the condition, the introduction of a galvanic pessary was followed by the reduction of a large flabby uterus nearly to a healthy, natural condition in the course of a fortnight.

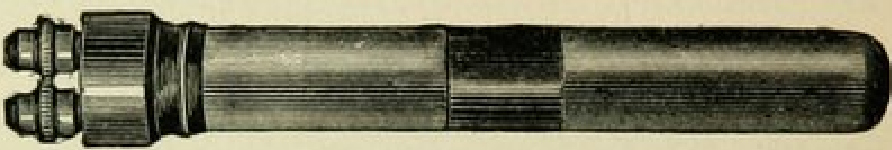


FIG. 123.

VAGINAL ELECTRODE INSULATED IN VERTICAL HALVES.

This electrode consists of two short nickel-plated brass cylinders, separated by a cylindrical piece of hard rubber placed between their adjacent ends. Two binding posts, one having metallic connection with each cylinder, receive the conducting cords. This instrument is designed to apply one pole to the upper and the opposite pole to the lower half of the vagina.

EXTRA-UTERINE PREGNANCY.—*Galvanism.* Dr. Rockwell has succeeded in a number of instances in destroying the fœtus by electricity, without injury to the mother. One was of an unusual character, the tubal or extra-uterine pregnancy being associated with normal uterine pregnancy. The diagnosis was confirmed by Dr. Thomas and others. The galvanic current was employed, with one pole introduced to the mass through the vagina and the other over the tumor externally; the current was rapidly interrupted. A current of twenty-four volts was employed and the treatment repeated the first, third and sixth days thereafter. The tumor, at first the size of a billiard ball, gradually grew smaller, while the natural pregnancy progressed favorably. Another case of tubal pregnancy had reached the

* *The Lancet.*

fourth month of development when first examined. One electrode was introduced into the rectum; the other was placed externally over the tumor. On account of the danger of rupture, owing to the great distention of the Fallopian tube, a current of only sixteen volts (12 cells) was used when interrupted; the current was increased without interruptions and allowed to pass a moment continuously; it was then decreased. This treatment was repeated on the following day, and without any further electrization the patient recovered and the tumor disappeared. He states that it is an error to suppose that abortions are readily produced by electricity unless measures are employed that would produce abortion without electricity.

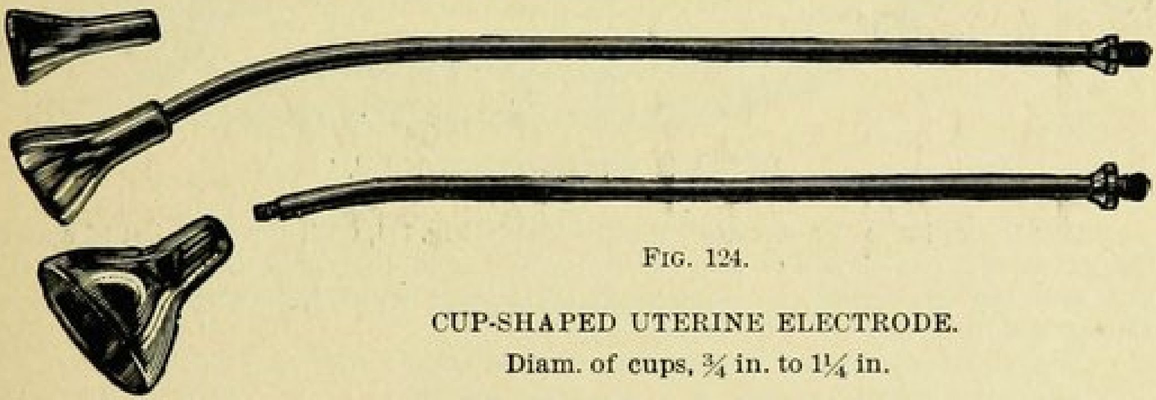


FIG. 124.

CUP-SHAPED UTERINE ELECTRODE.
Diam. of cups, ¾ in. to 1¼ in.

This is composed of a curved metal rod, insulated in hard rubber, terminating in a screw, to which may be attached cups of various sizes. The instrument is shown complete in the upper part of the cut; the lower represents the stem and cup separated. The cup is lined with metal, which is connected with the metal rod through the screw. It is designed to localize the current upon the lower external surface of the cervix uteri, the alternate pole of the current being applied externally over the abdomen or sacrum.

Faradism. Dr. J. C. Reeves,* in one case where diagnosis was positive at the end of the third month, used faradization for nine days as strong as could be borne for ten minutes at a time. One electrode was in the vagina upon the tumor and the other upon the abdomen; recovery followed. Lusk, Bache, Emmet and others have succeeded with faradism when the diagnosis was made early. Dr. T. G. Thomas, from a study of twenty-one cases, formulates the following rules for guidance in treating this condition:

* Trans. Ani. Gynecolog. Soc., 1879.

1. If the diagnosis be well settled before the fourth month of gestation, he would destroy the life of the fœtus by electricity in preference to all other methods.

2. Should the fourth month of gestation have passed, and surgical interference be called for, laparotomy, or, with the tumor low down in the pelvis, elytrotomy should be preferred to electricity.

3. Should the pregnancy be abdominal, the practitioner might watch and wait until full term, and deliver by laparotomy, or by elytrotomy and the forceps, or manual delivery.

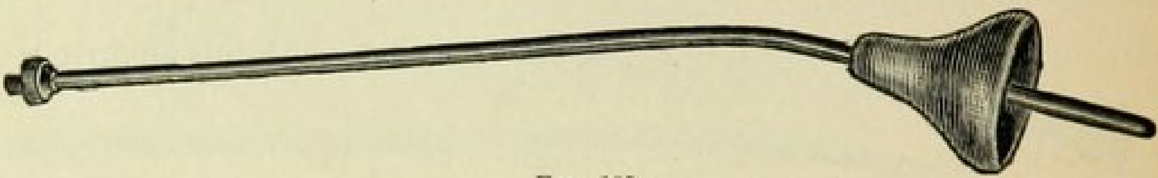


FIG. 125.

INTRA-UTERINE ELECTRODE.

This is similar to the electrode represented in Fig. 124, with the addition of a metal rod, 1 inch long, which screws into the base of the metal-lined cup. It is designed to be used in localizing a current upon the cervix and within its canal, the alternate pole being applied externally.

Caution. It is important that no force be used when introducing this electrode. The cervical canal is slightly constricted at the point where the neck and body of the womb unite, and it is here that flexion occurs. When flexion of the womb exists, the canal is bent if not completely closed, and since its length averages but three-fourths of an inch to one inch, if force is employed to push this cup into close contact with the external surface of the uterine neck, the prong or projecting rod might be forced into or through the tissues, an accident that is liable to prove very dangerous.

4. Should the full term be passed and the fœtus be dead, wait and watch and aid nature when she demonstrates the outlet by which she desires extrusion to be effected. If bad symptoms under these circumstances at any time develop, perform laparotomy under strict antiseptic precautions.

5. Should rupture of the fœtal nest have occurred before diagnosis has been fully made, wait and see whether nature is powerful enough to overcome the shock, to control hemorrhage, and further, if the patient is going to escape the dangers of peritonitis and septicæmia. If these favorable results do

not occur, if hemorrhage is about to destroy the patient immediately, or if septicæmia attacks her later, laparotomy, followed by antiseptic cleansing, should be promptly adopted.

Franklinism. Dr. Kochmann, of Strasburg, reports a case of extra-uterine pregnancy, six months advanced, in which the fœtus was destroyed by a single application of sparks from a static machine. The duration of the sitting was about fifteen minutes, and sparks about one and one-half centimetres long were drawn.

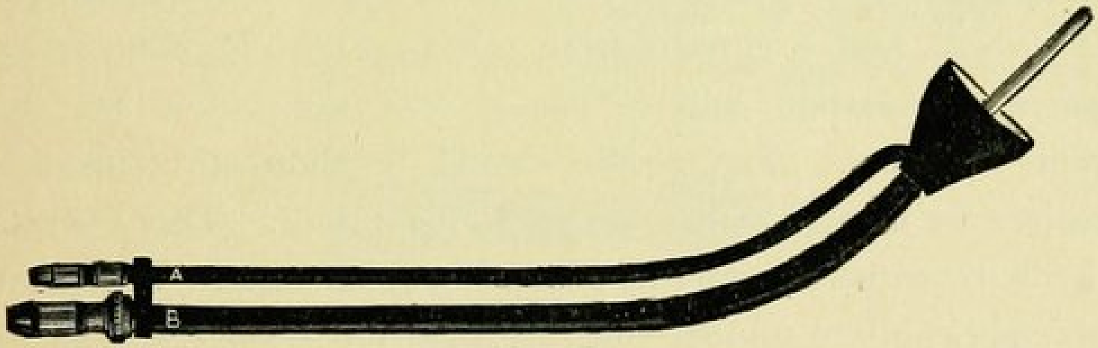


FIG. 126.

DOUBLE UTERINE ELECTRODE.

This electrode is constructed similar to Fig. 125, with the addition of a second insulated metal rod, A, parallel with the first; both terminate in a binding post to receive the cord. The rod A is connected with the metal lining of the cup, and B with the projecting rod. The central rod and cup are insulated from each other in this instrument. It is designed to be used in conveying both poles of the current to the cervix, one pole, being connected with A, is applied to the outside, and the other pole, connected with B, is applied within the cervical canal.

HYPERTROPHY OF THE CERVIX.—*Electrolysis.* When the cervix is found to be in a state of hypertrophy from long-continued irritation, and usual measures for reducing it fail, electrolysis has occasionally succeeded. Two needles connected with the negative pole are inserted, one in each lip of the cervix to the depth of about half an inch. The positive electrode is located on the nates, or some other indifferent point ; four to six zinc-carbon cells are included in the circuit, and the current is continued about fifteen minutes. The operation should not be repeated more frequently than once a month, and the time selected should be midway between the menstrual periods.

Galvano-cautery has been employed to amputate an elongated cervix, for which it is well adapted. The loop is adjusted and tightened slowly like the ordinary écraseur chain.

FIBROIDS.— *Electrolysis.* When these tumors are attached to the posterior surface of the uterus they may be treated through the vaginal wall, when it is important to avoid all discharge through the opening made by the needle. The positive electrode should be large, and may be applied over some indifferent spot. The negative pole attached to a suitable needle is introduced into the growth, and a current from twelve to twenty-four freshly-charged zinc-carbon cells is passed into the tumor for about twenty minutes. The needle should be thoroughly insulated, except over that part that is within the tumor. This operation may be repeated at intervals of ten to twenty days. This plan is only applicable to tumors that are near the surface, where they may afterward be opened to permit the discharge of pus that forms in consequence of the operation. When this plan is objectionable, several very fine needles, insulated, except at the point, may be introduced, using a current from four to six freshly-charged zinc-carbon cells. This produces a limited destruction of tissue that is not followed by suppuration, but the blood supply is interfered with, and absorption is excited.

FUNGOID GROWTHS may be destroyed by electrolysis.

CANCERS.—*Galvano-cautery* is undoubtedly superior to any other method of performing operations for the destruction of tissue within the uterus, or vagina, because the instrument can be located while cold, the action of the heat can be limited, and hemorrhage can be prevented. The removal of portions of cancerous growths by galvano-cautery is frequently useful in arresting hemorrhages and retarding their growth.

Electrolysis. The introduction of electrolysis needles to destroy a portion of the growth, not only checks the advance of the disease, but in some instances produces a notable diminution in the pain attending it.

THE SKIN.

Faradization produces a prickling or tingling sensation when the skin is dry. The effects are intensified by applying the current through a wire brush, and are most severe when the brush barely touches the skin. The effect of a brush made of tinsel lightly passed over the surface is so painful that an electrode made in this form has been named the electric scourge.

FIG. 127.

ELECTRIC SCOURGE.
Length, 3 in.

This consists of a bundle of tinsel-covered threads fastened in a nickel-plated head that fits a universal handle. When lightly brushed over the skin it produces a sharp stinging, exceedingly painful sensation. It is employed to arouse dormant sensibility of either nerve, muscle or cutaneous surface.

The effect of the faradic current upon the bloodvessels of the skin has been microscopically studied by Weber, Pflüger and others, who agree that it causes, first contraction and afterward dilatation of these vessels, through its action upon the vaso-motor nerves. Intense redness is easily produced in persons with delicate skin, and this is more marked at the negative than the positive pole. The effects are greater if the skin is dry, for if it is moistened electricity passes through it to the deeper structures, although a very powerful current affects both the skin and the structures beneath.

Galvanization. The sensation produced by it has been compared to that produced by mustard paste; if the skin be dry and the current feeble, the sensation is very slight; but if the skin be moist or previously irritated by blisters, the effects are greatly intensified. The positive enlarges the bloodvessels and reddens the skin; the negative has an opposite effect. The positive produces a depression of the skin, and the negative a swelling of the epidermis and cutis.

Franklinism produces redness of the skin, and, if sparks are taken, a peculiar eruption which resembles nettle-rash, but this form of electricity does not destroy the tissue.

Diseases for which electricity has been employed:

Anæsthesia,	Baldness,	Ulcers,	Tumors,
Eruptions,	Pain and itching,	Bed-sores,	Hirsuties.

It is to be understood that in the treatment of diseases of the skin, as in those of other portions of the body, electricity is most successful when *employed as an adjuvant* to other indicated measures. The physician who employs electricity alone, to the exclusion of suitable medicines and regimen, will frequently fail where he most confidently expects success. It has not been thought necessary to emphasize this fact in connection with every subject referred to in these pages, but it applies equally to all.

Galvanism. Chronic eczema, prurigo, herpes zoster, and all eruptions dependent upon some disturbance of the nervous system, may be materially benefited by electricity applied through the sympathetic nerve. Beard and Rockwell have cured cases of eczema and prurigo by their method of central galvanization without local applications of any kind.

Electrolysis. Dr. Hardaway* enumerates the diseases of the skin in which electrolysis may be confidently employed, viz:

Pigmented nævi, small fibromata, miliary nodules of lupus, sebaceous cysts, xanthoma (Fox), warts, cutaneous horns, and some stages of epithelioma. From certain observations that he has made in regard to the

* *St. Louis Courier of Medicine*, July 1880.

action of this means in hypertrophied scar tissue, he is inclined to look upon it favorably in keloid. In short, it may be confidently stated that whenever it is necessary to use a destructive agent on the skin—one that is readily managed, that causes no hemorrhage, and leaves few scars—there is none better or more efficient than electrolysis.

Galvano-Cautery has been successfully employed to remove tumors, destroy malignant ulceration, and for all purposes where radical destruction of tissue is indicated.

ANÆSTHESIA. It is important to distinguish between cutaneous and muscular anæsthesia. In the former the patient is insensible to touch or pain, and is unable to keep the lightest substance in his hands; neither can he determine the weight or temperature of a body; in the latter case, however, the patient suffering from muscular anæsthesia feels the touch or pain, but the grasp of his hand is powerless; he cannot hold even the slightest body unless he fixes it with his eyes.

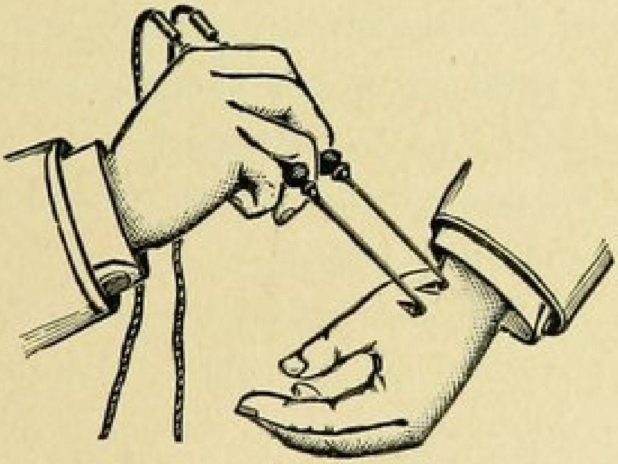


FIG. 128.

Fig. 128 represents one method of testing the cutaneous sensitiveness with Duchenne's points. The operator should become familiar by actual experiment upon the healthy, with the relative sensitiveness of the different parts of the cutaneous surface and the distance apart the electrodes must be applied to detect distinct sensations at both poles. The following points should be borne in mind while treating these cases: 1. They require a divided current applied when the affection is superficial, to the dry surface through electrodes 107, 127, or in some cases 129. 2. When the deeper layers of the skin or muscles are in a state of anæsthesia, the skin must be moistened before the brush is applied. 3. With the gradual return of sensibility the strength of the exciting current is also gradually diminished. 4. Where anæsthesia exists along with other disturbances of nervous function, whether hyperæsthesia or motor paralysis, the anæsthesia is first to be treated, and the removal of this condition is frequently followed by a disappearance of all the other symptoms. 5. If anæsthesia is the result of section of the nerves, the treatment by electricity should never be begun sooner than four weeks after the accident, as this is the shortest time in which the entirely severed nerves will reunite. 6. Generally in anæsthesia following a peripheral cause, faradism will give a more favorable result. When galvanism is employed, the negative is placed upon the affected portion of the skin and the positive upon the respective nerve-trunk: the latter is moved along the nerve-trunk to the negative repeatedly. 7. Anæsthesia from inflammation of a nerve usually disappears without local treatment through galvanization of the affected nerve.

ACNE INDURATA has been cured by central galvanization.

ACNE ROSACEA.—*Faradism.* Place the positive electrode on the back of the neck and the negative over the affected region. *Galvanism* applied in the same way has also been reported successful in some instances.

HERPES ZOSTER (SHINGLES). *Galvanism* has cured this eruption and relieved the neuralgic pains accompanying it when applied directly, the negative being placed on the eruption, the positive over that part of the spine from which the affected part receives its nerve supply. Nagel* says the in-

* Kl. Monatsbl., 1871, p. 331.

tense neuralgic pains are sometimes instantaneously relieved by galvanism.

PSORIASIS (SCALY TETTER). *Galvanism* has cured a few cases. The current is applied the same as for herpes zoster, the negative pole being retained over each patch from one to three minutes. It requires several weeks and frequent sittings to make an impression upon cases of long standing.

RINGWORM.—*Galvanism.* A mild galvanic current applied twenty to thirty minutes through a metal electrode in contact with the eruption, and a sponge or carbon electrode near it sometimes cures after only one or two sittings.

Franklinism. Dr. Despine d'Aix states that franklinic electricity in the form of sparks is a valuable aid in curing ringworm, which at the same time is receiving suitable medication.

ELEPHANTIASIS ARABUM.—*Electrolysis.* Mons. Raynaud* read a communication on the above subject from two physicians at Rio de Janeiro. The writers of that communication had had constructed suitable needles, which were introduced into the affected members to the number of about three to five. Six cells were at first employed, and the number then gradually increased to sixty. Local anæsthesia was produced before insertion of the needles, and the latter were washed in antiseptic solutions. This, together with other precautions, constituted, according to the authors, the Listerian electrolysis. The success following this kind of treatment was said to be very gratifying.

CARBUNCLES AND FURUNCLES.—*Galvanism.* They may be dissipated in early stages by applying the negative electrode upon them and the positive on a neighboring part.

WOUNDS, ULCERS, ETC.—*Galvanism.* A very weak current is capable of exercising considerable influence over the secre-

*At a meeting of the Academy of Medicine (*Bull. de l'Acad. de Medicine,* March 1, 1881).

tions from wounds, etc. The positive when applied to the wound produces greater irritation than the negative. It should only be applied when the secretions are alkaline; in this case, when it is kept in constant contact for a sufficient length of time, the tissue is restored to a healthy state.

Dr. Apostoli has suggested the use of Potter's clay as an electrode for the treatment of ulcers. When saturated with pure water, or salt and water, it becomes an excellent conductor, and as it dries slowly it is well adapted for use with the galvanic belt when a continuous current for many hours' duration is indicated. It can be readily adapted to the most irregular surface, and as its contact can be close or limited, its value will be readily appreciated. Applied to the epidermis, it diminishes the pain of the application and lessens the tendency to blister.

BLISTERS.—*Galvanism.* The galvanic current is sometimes applied to a blister to increase the effect of the latter, in the following manner: Snip the skin of the blister, raised in the usual way; fasten upon it the positive metal electrode, uncovered, and the negative with its cover well moistened at some distant point. Connect two or three cells of a battery or twice the number of the belt cells, according to the degree of irritation required. After a few hours the surface of the skin beneath the blister will have a white appearance, as if rubbed with nitrate of silver. In forty-eight hours a decided eschar will appear, which, still keeping on the electrode or disc, will begin to separate at the edges. Remove the electrodes, then apply a common poultice, and a healthy granulating sore with well defined edges, freely discharging pus, will be left. If the patient complains of pain or irritation at all, it will be at the negative electrode only.

BED-SORES.—*Galvanism.* Dr. Mills* has been successful

* Neurologist to Philadelphia Hospital.

in the treatment of bed-sores, which, in spite of the best of care, are apt to form in cases of spinal and cerebral disease. A silver plate connected with the negative pole is applied to the sore; any ordinary electrode connected with the positive is placed on the surface near. A mild galvanic current is sent through the circuit from five to ten minutes daily. Electricity is very effectual in stimulating granulations.

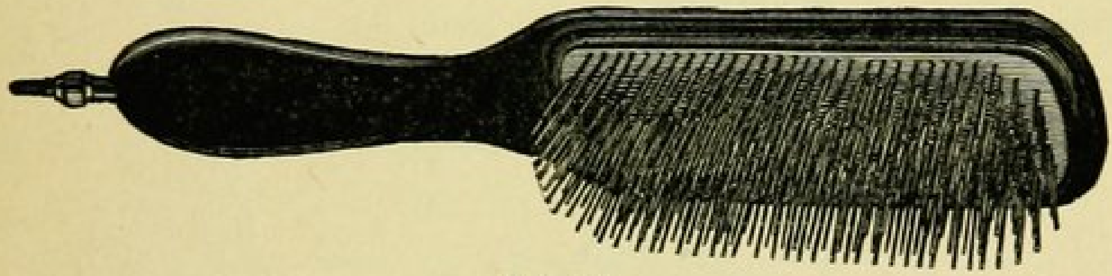


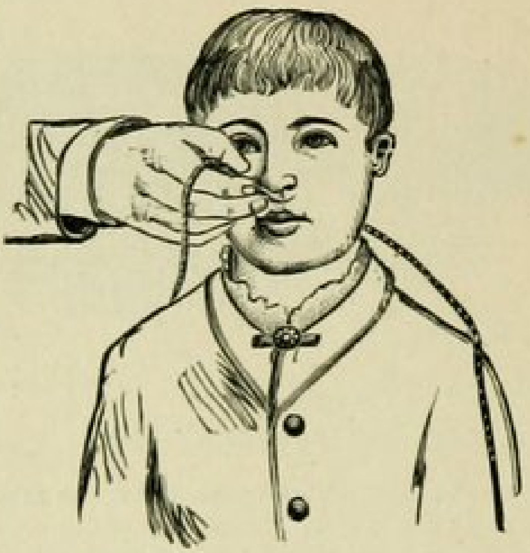
FIG. 129.

HAIRBRUSH ELECTRODE.

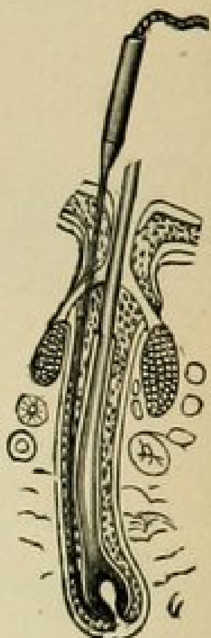
Size of brush, 4×1½ inches. Length of electrode, 9 inches.

This electrode consists of a highly-polished black rubber frame, holding a metal plate, to which are fastened flexible metal wires to form a brush. There is metallic connection between the brush and screw at end of the handle. This is not an electric brush which furnishes a current of electricity; it is simply an electrode, which must be connected with a battery when used. Although designed for the scalp, it is employed for cutaneous stimulation when large areas are to be acted upon. The current applied through this is not so painful as through the tinsel or small wire brush.

ALOPECIA (baldness). Electricity may be beneficially employed to improve the circulation through the scalp and stimulate the hair follicles. When caused by parasites, this treatment should be preceded by the application of a parasiticide. If the scalp is smooth, shiny and indurated, presenting the appearance of being "hide-bound," the following is an efficient method of restoring it to a natural condition: Let the positive pole of a faradic current be fastened at the nape of the neck, while the operator holds the uninsulated portion of the negative in one hand, and with the other vigorously kneads the dry scalp for several minutes. The fingers should be dry; in some cases they may be lubricated with carbolized oil to advantage. The current should be moderately strong. This operation requires repeating once a week until the scalp feels natural and has lost its shiny appearance. During the intervals the patient may advantageously employ a faradic current daily through the hairbrush electrode. If the treatment be so vigorous as to cause soreness of the scalp, it may be omitted a few days.



A.



B.

FIG. 130.

REMOVAL OF HAIRS.

A represents the patient in a chair with operator inserting a needle. B represents an enlarged hair follicle, with the needle in the position it must occupy to make the operation successful.

SEBORRHEA OF THE SCALP. *Faradism* restores the functions of the glands and partially controls the morbid process. The hair is moistened and the negative pole is applied upon it, while the positive is held in the hand of the patient ; a mild current is kept up for about fifteen minutes.

HIRSUTIES.— *Electrolysis.* The instruments required for the removal of hairs are a galvanic battery of at least twelve cells, an exceedingly fine needle, or what is still better, a delicate, flexible broach, much finer than those commonly employed by dentists in extracting nerves, and a convenient needle-holder. The positive pole of the battery should be connected with a sponge-covered electrode and applied to the nape of the neck; the necklet is suitable, as this is self-retaining. The patient may be placed in a reclining chair, or on a lounge, in a good light, in such a position that when the operator is seated his eyes will be on a level with the patient's chin. The needle is connected with the negative pole and introduced into the follicle beside the hair. A few cells only are needed in circuit, from six to twelve, according to their condition, the delicacy of the patient's skin and the strength of the hairs to be removed. In a few seconds a little froth will appear at the mouth of the follicle. If the hair be now seized with a pair of forceps and the gentlest traction exerted, it will be found to be loose in the follicle; this occurs in the course of from ten to twenty seconds. The number of hairs removed at a sitting varies from twenty-five to fifty per hour, according to the location of the hairs and the endurance of patient and operator. It is said to take longer to destroy hair upon the neck than upon the chin or cheeks. It is better at each sitting to operate upon hairs here and there rather than on those close together, as this is less likely to produce scarring. If the operation is not carried too far, there will be very few marks resulting from it.

A considerable amount of pain is experienced during the passage of the current through the tissue, which ceases almost entirely on the removal of the sponge. Sometimes, in addition to the frothing, the skin surrounding the needle is thrown up into an urticarial elevation, and is greatly reddened. Later the follicle may become inflamed, and form a crust, which adheres to the skin above it for a week or more. Sometimes a hard infiltration may be felt beneath the surface for a considerable time. Ordinarily the after-effects are very trivial, unless a small area be acted on repeatedly at short intervals. Finally, the parts return to their natural condition, leaving, in some instances, a minute pit or depression to indicate the seat of the operation. Some operators report that 50 per cent of the hairs reappear; others claim that but 10 per cent return. The operation needs only to be repeated upon those which reappear until all are finally destroyed. If the hair follicle is destroyed, of course the hair cannot reappear. When an extensive hirsuties is to be treated, a long time is required for the successful primary removal of the hairs, and some of the follicles will, without fail, require a repetition of the operation. For the fine, downy hairs occurring alone or interspersed with a stronger growth, nothing had better be done until they attain a more conspicuous development.

Galvanism. Dr. J. Crichton Brown, in a lecture on menstrual insanity, referred to a case* seen in consultation many years ago, in which a bearded lady had been benefited by the introduction of a galvanic pessary. The beard subsequently fell off and the patient's mental condition, which was that of melancholia, improved so that she recovered completely.

PARALYSIS.

The method of electro-diagnosis in cases of paralysis has already been given, but the attention of those who have never employed electricity in this disease is earnestly called to the following suggestions:

1. When muscles cannot be made to contract by the faradic, galvanic or franklinic current, it is useless to treat them with electricity. If even a few slight contractions can be produced, it will indicate a favorable result under a *careful* and persistent treatment.

2. If contractions are forced, as is very likely to be done by those unskilled in the use of electricity, it will be found at the next sitting no contraction at all can be produced.

3. The slight power of contraction still left in paralyzed muscles is often destroyed by too strong or too frequently repeated electrizations.

* Philadelphia *Med. Times*, 1880.

4. Before commencing treatment each time, *restore the muscle as nearly as possible to its natural position by some artificial support, so that when stimulated to contract it can do so without carrying any weight.*

5. The length of application to any one muscle or group of muscles should not exceed five minutes every day or every other day.

6. Do not apply too strong currents. They give rise to over-fatigue, which is just as injurious as if produced by over-exertion.

7. A muscle which refuses to respond to any current may sometimes be made to contract by interrupting the current slowly so as to give time for the impression to be carried to the motor roots and return. Investigations to discover the rate of transmission of nerve force have brought out an important fact, namely, that the rapidity of transmission of nerve force varies in different persons, and in the same person on different occasions. There is a difference in the quickness with which they receive impressions on the senses. In every case there is slight delay, so that no phenomenon is perceived at the instant of its occurrence. If interruptions occur with greater rapidity than the impressions can be transmitted, the nerve is thrown into a tetanic state, which causes pain and liability to reflex action that in cases due to cerebral hemorrhage might excite a fresh attack.

8. So long as muscles preserve electric contractility they can be preserved from complete fatty degeneration by judicious use of electricity. Cases resulting from forced or continuous work are most hopeful. The sitting should not exceed eight to ten minutes each day. Electric massage with a roller electrode, like the one shown in Fig. 131, will be found very effective in improving the nutrition of paralyzed muscles.

9. Some sort of gymnastic exercise, which will bring into action the paralyzed muscles, should be devised by the practitioner, and the patient should be instructed to make daily systematic attempts to produce *voluntary motion* in the affected parts. This is the most important part of the treatment.

10. The paralyzed muscles should be excited individually, so as to rouse up their movements equally. The current should be made to traverse the nerves in the direction of their length. This is especially important after cerebral hemorrhage.

11. The treatment must not be too prolonged. If the muscles do not recover their movements after fifteen or twenty sittings, discontinue for a time and then recommence.

12. Where the nerves and muscles of the affected side react equally to those on the healthy side under the influence of electricity, the galvanic current will accomplish more than the faradic.

13. Twitchings of the fingers and toes, so often connected with hemiplegia, which occur at night and interfere with sleep, are relieved more certainly by galvanism than by faradism.

14. Althaus concludes, as the result of his observation on out-patients of the hospital, in whom he had an opportunity of witnessing the effects of protracted treatment, that few cases, however bad, are utterly incapable of amendment.

Caution. Before treating paralysis of any of the muscles about the head it is important to distinguish between those cases in which the affection is due to disease of the brain and that due to paralysis of the seventh pair of nerves. The latter can be readily relieved by electricity, but great care must be exercised in treating the former lest a fresh attack be produced. It is many times very difficult to distinguish between them, but this is said to be a reliable indication: When the contractility of the muscles under the stimulus of the faradic current is perfect, the cause is in the brain; when the orbicular muscles of the eyeball are paralyzed, it is an indication that the paralysis does not originate in the brain, but depends upon the nerve alone.

Electrization of nerve-centers, when they are affected by inflammatory action, may cause serious accident. Duchenne relates the following circumstance, which is quoted to emphasize the importance of caution in these cases: "A young man, twenty-two years of age, having suffered from the results of cerebral hemorrhage for one year, thought to reduce the continuous rigidity of some of the muscles, which still persisted, by reflex action instead of localizing the current in the affected muscles. He grasped one electrode in each hand, and caused a strong faradic current to pass through the circuit. He was seized with another attack of cerebral hemorrhage; his life was for a long time in danger, and when he at last recovered he retained in his right side stronger rigidities than those which he desired to cure."

Paralysis Originating in the Brain.—*Galvanism.* The time which must elapse after an attack of paralysis occurs from cerebral hemorrhage, before it is safe to employ electricity, is one upon which authors are not agreed. Remak advises to begin early to galvanize the sympathetic and the cerebral vessels of the side opposite to the paralysis, in order to promote absorption of the clot. Onimus and Legros agree with him, and say that this may be begun within seven or eight days after the attack. The positive pole should be applied to the forehead on the side of the lesion, and the negative at the nape of the neck; a current of from three to four cells is passed through the seat of injury for two or three minutes. Afterward the superior cervical ganglia is galvanized with a more powerful current (five to seven cells) for about five minutes. *All shocks from interruption of the current must be avoided.* Althaus states emphatically that electric treatment should be postponed until all danger of cerebral fever is passed, and if this occurs it comes on in the second or third week; therefore the application of *galvanism* is safe after fourteen to eighteen days have elapsed since the attack. Prof. Fürck, of Vienna, has shown that if the paralysis continues for six months or longer, atrophy of the nervous fibers of the opposite antero-lateral columns of the spinal cord are apt to come on, and when this process has reached a certain stage, any treatment will inevitably fail; this emphasizes the importance of beginning early. If the patient is seen within three weeks after an attack, the method of Onimus and Legros is to be preferred. When several months have elapsed, galvanization or faradization of the affected muscles must be undertaken. It will sometimes occur that a muscle which at first fails to respond to faradism will, after galvanization, exhibit traces of faradic contractility. In these cases both currents may be advantageously employed.

Facial Paralysis. When the mouth is drawn toward the affected side, bend a silver wire in the form of a hook, slip it over the angle of the mouth and fasten the other end around the ear, drawing the mouth into its natural position, and then apply the current to the facial muscles one by one by means of Duchenne's Points.

Lead Paralysis. This form of paralysis affects certain groups of muscles leaving others intact. The arms and hands suffer, but the lower extremities do not, in many instances; and in the arm the flexor muscles are spared and the extensors are attacked. The common extensor muscle of the fingers is first affected; the extensor of the first and little finger in their turn, and at last the tensors of the wrist and ball of the thumb. Faradic excitability is always diminished and often lost, even before the muscles have wasted but slightly. This is regarded as an important means of diagnosis between paralysis due to lead and that dependent upon other causes. *Wrist drop* is frequently the first symptom that attracts attention.

Faradism. The treatment by the faradic current, according to Duchenne, is very tedious, requiring from thirty to one hundred sittings. Sulphur baths, iodide of potash, shampooing and "nervous gymnastics," should form a part of the treatment. Duchenne coined the latter term, which refers to repeated exercise of the voluntary contractility so long as the patient possesses any power over the muscles.

Galvanism. When faradic contractility is gone, the galvanic current must be employed. Galvanic baths have been tried with a view of removing the lead from the system. Vergnes in 1852 had an obstinate ulceration of the hands caused by electro-plating. Holding them in an electric bath in contact with the positive pole for fifteen minutes, the negative plate in the bath was covered with gold and silver from the ulcer. A few repetitions of this treatment cured the ulceration. This method has since been tried to remove both mercury and lead *from* the body, as well as to convey medicines *into* the body. It has been suggested that galvanism be used in connection with sulphur baths, the patient being connected with the positive electrode, and the water being made the negative electrode. The positive may be fastened on the nape of the neck, or be held in the patient's hands above the water. Dr. Anstie successfully treated an extreme case of this disease. He employed the galvanic current daily for eight weeks to the affected muscles; faradic excitability having returned at that time, faradization for another month almost completely restored the power and bulk of the muscles.

TREMORS.—*Galvanism.* Dr. M. C. Paul* reported at a meeting of the Société de Thérapeutique fourteen cases from his own practice, which included cases of mercurial trembling, chorea,

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* Bull. de la Soc. de Thérap., 1881, p. 123.

paralytic ataxia, scrivener's palsy, and trembling of the hands caused by sclerosis in patches. All were greatly benefited.

Speaking of the characteristics of mercurial tremor, Dr. Paul says that its onset is sudden and unexpected. The patient perceives that his arm has failed him, and from this moment the tremor invades successively the left arm, and then first one leg and then the other. It preserves during its whole course, and until cured, three characters:

1. The onset is sudden.
2. The tremor is continuous; once having appeared, it does not cease.
3. It is progressive, the interval between its extension from one limb to another being very brief, though it is longer between the upper and the lower members. In one case the attack first involved the masseter; but this is rare.

In alcoholic tremor the course of the affection is quite different. It is slow, progressive, and proceeds by successive attacks. Thus, the day after a debauch the patient observes that his hands tremble and fail, but after the effect of the debauch has passed off the tremor disappears. At a subsequent debauch the tremor again appears, lasting this time a little longer. At each new attack the tremor lasts a little longer, until at last the drunkard cannot work. Although slight alcoholic tremor is not rare, yet tremor to such a degree as to prevent work or locomotion or eating, is rare.

Both mercurial and alcoholic trembling are amenable to treatment by the galvanic bath. But, while twenty-five baths are required to cure mercurial tremor, six to eight are sufficient to cause alcoholic tremor to disappear.

PROGRESSIVE MUSCULAR ATROPHY.—*Galvanism.* Dr. Neumann, of Madgeburg, has succeeded in curing one case which had proceeded to paralysis of all four extremities. A galvanic current equal to that from ten zinc-carbon cells was directed to the sympathetic, the positive being directed to the nape of the neck, and the negative on the throat, five minutes at each side for three months, every day, and then the negative was applied to the upper cervical ganglion, and the positive to the lower ganglion likewise for five minutes each time. It required nearly a year and a half to completely restore the patient.

LOCOMOTOR ATAXIA.—*Faradism.* At the meeting of German physicians and scientists at Eisenach, Dr. Th. Rumpf* reported two cases of locomotor ataxia greatly benefited by the use of faradic electricity applied with the brush, and in whom the symptoms had not returned after several years. He uses a current not quite strong enough to cause pain. The positive pole is applied to the sternum; the other, represented by the brush, is applied in rapid succession to the back and lower limbs. The duration of the application is ten minutes. The effect upon the lancinating pains is quite marked, and common sensation is greatly improved. In cases where the disturbances of sensibility and pain are very marked, and the disease is not too far advanced, this method gives praiseworthy results, which are unattainable by the older methods of treatment. He has since reported a successful trial of the brush in a series of cases, though more time is required to determine the permanency of the result. He† described one, however, in which the patient had been in good condition for two years after a six weeks' course of treatment. He had had lightning pains, paræsthesiæ and ataxia, impotence and disturbed micturition. The knee-jerk was not abolished. All the symptoms disappeared except the sexual weakness.

Galvanism. Dr. Engelskjon found that the galvanic current applied in the same way produces the same effect, and further that it is due solely to the peripheral nerve irritation. He claims that this treatment is of no value when the first symptoms of the disease are referable to atrophy of the optic nerve.

EPILEPSY.—*Faradism.* Dr. Edward C. Mann‡ reports three cases cured by means of the faradic current in addition to phosphide of zinc and massage. The bromides were not used

* *Berlin Klin. Wochen.*

† *Brain*, April 1883.

‡ Physician-in-chief to the Sunnyside Medical Retreat for Diseases of the Nervous System, etc.

at all. He believes electricity in the form of general faradization possesses a special power for good, over the nervous system, in these cases.

Galvanism. A few cases are reported cured by the long-continued application of a galvanic current from a belt. The positive electrode uncovered was fastened to the nape of the neck while the negative in a moist cover was placed on the knee (patella). The current continued to act twenty-four hours, when it became necessary to recharge the cells with fluid and clean the electrodes. It required six months of this treatment to effect a cure.

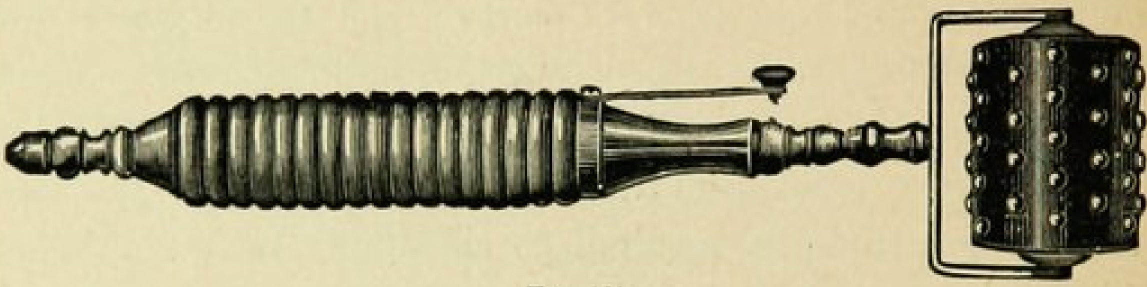

FIG. 131.

ROLLER ELECTRODE.

Handle length, 6 in. Roller diam., 1⅜ in.

The instrument illustrated above is formed by two separate electrodes: 1. The roller; 2. The interrupting handle. The roller is brass, studded with nickel-plated rounded projections, insulated from each other by black hard rubber. The nickel-plated frame to which it is fastened terminates in a screw which fits the universal handle, with which it may be used when the special effect of the interrupting handle is not needed. The latter is made of polished black rubber. The nickel-spring shown upon the end next the roller when pressed down completes the connection through the handle; when released, the circuit is broken, therefore the interruptions can be controlled at will.

Franklinism. Arthius relates a remarkable instance of recovery under the influence of franklinism in the case of a boy of twelve, epileptic for ten years, with paralysis and atrophy of right arm. A very gentle application was given at first; treatment was continued two months. At the end of that time he had partially regained the use of his arm, and from the first treatment he had no return of epilepsy. Six months after he had continued free from any symptoms of the disease.

MISCELLANEOUS DISEASES.

INTERMITTENTS. Electricity has been employed by continental physicians with excellent success, according to their reports, in various forms of intermittents. Prof. Rienzi* has found that in a majority of cases the fever is stopped, and frequently more promptly than with quinine. In nine cases he had five complete cures, two improved, and two failures. They were treated with the galvanic and faradic current, but the latter has proven the more efficient. He has not been able to ascertain why some cases were rapidly and completely cured, and others but little benefited; or when electricity is to be preferred to quinine.

FIG. 132.

ELECTRODE CASE.
Size $10\frac{1}{2} \times 12$ inches.

This case contains the electrodes ordinarily required for electrization. It is morocco-covered and velvet-lined. The highly polished black rubber and the bright nickel-plated metal forming the electrodes make a beautiful contrast with the blue or crimson shade of the velvet. It is of light weight and may easily be carried in the hand, making not only an attractive but an exceedingly convenient addition to a physician's outfit.

Dr. Schröder, of St. Petersburg, reports forty-two cases of intermittent fever, some of which were old, and in most of which the usual medication had proved of little use, in which he had almost uniform success by faradizing the spleen. His

* *Annals Univerzali*, 1882.

method is to hold one electrode on the left hypochondrium, while the other is carried slowly along the edges of the enlarged spleen for five minutes, daily.

Dr. Blackwood* reports thirty cases of ague, including twenty-two of the tertian type, five quotidian and three quartan, treated by electricity without medicine of any kind, with the exception of a single dose of sulphate of magnesia in water, acidulated with a drachm of aromatic sulphuric acid, to commence on. The quartan cases were all adults, the quotidian all children. In eighteen it was their first attack ; the remaining twelve had suffered from previous attacks, and all the latter had enlarged spleen. The plan of treatment was the same, except that a larger dose of electricity was given to those with enlarged spleen. Faradism was principally used, but in those having large "ague cakes" galvanism was applied at the close of the sitting, not from any attempt to control the disease, but because the reduction of glandular hypertrophy is, in curable cases, more readily secured by galvanism. A current as strong as could be comfortably borne was passed first, one pole being located over the solar plexus ; the other over the liver, before and behind, for five minutes, and then over the spleen for five more. After that about five minutes were spent in general faradization of the abdomen and spine. He lays great stress on the importance of taking treatment early in the morning. When galvanism was employed, a current from ten to fifteen cells was sent as directly as possible through the spleen, without interruption, for from five to fifteen minutes' duration. Although galvanism promptly reduces the size of the liver, it has no effect in relieving the ague. In the tertian and quartan cases, with few exceptions, they were treated daily without reference to the hour of invasion of the chill. The exceptional cases were treated two or three times daily,

* *The Medical Bulletin*, November 1883.

and the results indicated that this is preferable to a single sitting. The quotidian cases had two sittings daily. The result of treatment was favorable in all cases, a cure resulting in from six to thirteen days. The most stubborn case was a quartan, the chill returning with full force four times before being checked. Twelve of the tertian subjects had no return after the first application, seven had one chill, and three two chills after commencing electrization. The returning chills were always in children.

The disadvantage of this mode of treatment is that the patient must visit the office. He protests against turning the application over to the patient, as the latter is almost certain to repeat too often or fail to reach the solar plexus. He believes that success can be assured only in the hands of the physician who clearly understands the motor points and the method of applying the current in a scientific manner.

NEURALGIA.—*Galvanism.* Dr. Moritz Meyer strongly insists upon the importance of carefully searching for spots that are painful on pressure in all cases of obstinate neuralgia. The first case described, the attack affected the right arm and shoulder. A painful pressure point was found at the upper part of the brachial plexus. The positive pole of a current from ten cells applied to it, the negative being held in the hand, considerably alleviated the pain within five minutes. A repetition of the operation four times during the ensuing week was sufficient to effect a complete cure. Two other cases in which galvanism applied to the arm had failed to relieve were cured when it was directed to painful pressure-points; one had suffered nine months and was completely relieved by seventeen applications; the other, after two years of suffering, fully recovered after fifty applications. Prof. Meyer does not limit this mode of treatment to neuralgia, but recommends it for sick headache, twitching of facial muscles, paralysis following a sprain, and all neuroses in which pain is elicited by pressure at any points along the spine or the course of a nerve trunk. Remak and Brenner also emphasize the importance of examining for and treating these points; in every instance they recommend that the positive be placed on them.

M. Magendie was the first to employ needles in the treatment of neuralgia. He introduced two platinum needles, one at the origin of the nerve, or in its vicinity, and the other at its termination, using an increasing galvanic current. After the cessation of pain, which does not generally take place until after several sittings, the needles were not immediately withdrawn, but the patient was made to perform some of the movements that generally bring on the neuralgia. He sometimes applied the faradic current in the same manner.

Faradism. Becquerel was one of the first to recommend the use of strong and very rapid currents. He advised a secondary faradic current with wet sponge electrodes, and directed the positive pole to be placed over the part of the nerve nearest the nerve center and the negative over the branches. If the poles are reversed, the final effect will be the same, but the pain during the sitting will be much more acute.

NEURALGIA OF THE BRAIN.—*Galvanism.* This may lead to insanity if not checked. In addition to rest, sleep, and an improved or suitable diet, a mild galvanic current passed through the brain for a few minutes daily will generally improve nutrition of the brain and relieve the nervous prostration.

SUPRA-ORBITAL NEURALGIA.—*Faradism.* Becquerel reported the following method successfully employed in numerous cases. A primary faradic current is passed through the head by placing a moist sponge electrode on each temple during the first half of the sitting and between the two supra-orbital nerves during the second half. The sittings may be repeated when the pain reappears.

Franklinism. Supra-orbital neuralgia has been relieved by electrifying a patient on an insulated platform and then drawing sparks from the brow and temple for some minutes. Relief follows immediately, if at all.

TIC DOLOUREUX. Neuralgia of the face is of two kinds; a mild and a severe form. The former generally comes on after exposure to cold and damp, or after mental emotions, or is owing to caries of a tooth; it is not made worse by moving the face, and it occurs at all periods of life, while the latter occurs, generally, without any apparent cause, is almost entirely confined to advanced age, and is brought on or made worse by the least movement of the face. The mild form yields to many remedies, and especially to electricity, while the latter defies almost every method of treatment; yet it sometimes yields to *galvanism* and *franklinism.* Each case will require special treatment; therefore, only general suggestions can be given. One pole may be located over the cervical ganglia, and the other attached to a suitable electrode may be passed over the face, or one may be applied within the mouth against the cheek, and the other to the temple and external surface of the cheek. The direction of the current must be determined by experiment in each individual case.

Franklinism is employed by the method of charging the patient and drawing sparks from the affected parts.

BRACHIAL NEURALGIA.—*Galvanism* should be applied through the brachial plexus, one electrode being located at the point indicated by electrode B, Fig. 74, and the other being moved repeatedly downward along the course of the pain.

INTERCOSTAL NEURALGIA.—*Franklinism.* When there is no discoverable cause, and galvanism and faradism both fail to give relief, this form of neuralgia has been cured by charging the patient with franklinic electricity, and drawing sparks from the painful region for ten or fifteen minutes. Sittings may be repeated daily.

Franklinism. Dr. V. J. Drosdoff,* St. Petersburg, has tried the effects of static electricity on twenty patients, suffering from various reflex and rheumatic neuralgiæ or muscular rheumatism. The franklinic currents of all degrees were applied; all the patients were left uninsulated and franklinized during from five to fifteen minutes at a sitting, by the positive pole alone. The conclusions the author arrived at are as follows: 1. The sensation of the franklinic current is different from that of the faradic and galvanic. The weak currents cause a burning sensation, the strong ones a sensation of concussion or stroke, at the point where a spark is produced. 2. The electricity distributes itself all over the body, and, during a sitting, sparks may be produced by contact at any desired point of the surface. The strength of a spark lessens with the increase of distance from the franklinized point. 3. The skin, at the point of franklinization, at first becomes red and anserine, then pale and nearly white; an artificially produced erythema disappears. 4. The general functions undergo some considerable changes; the heart's reaction shows retardation (four to twelve beats less in a minute); the pulse becomes fuller; the respiration deeper and slower; the quantity of urine voided after a sitting is often considerably increased. 5. The most striking changes, however, are observed in parts affected with neuralgia or rheumatism. Immediately after a sitting, pain and tenderness disappear, and, during the remaining part of the day, the patients feel much better than before a sitting. Each successive franklinization brings a further decrease in intensity of neuralgia. In cases of short standing, three or four sittings suffice to completely remove the agonizing pains. Ten to fifteen sittings

* *Medical Record*, Nov. 15, 1883, p. 452.

cured even cases of neuralgia of twelve years' standing, which had obstinately resisted galvanization, faradization, and all possible therapeutic means. In each of the author's cases either complete cure, or very considerable improvement, followed. 6. There is no necessity to undress a franklinized patient, as the therapeutic effects of this excellent agent remain unchanged—a circumstance of practical importance in female cases.

SCIATICA. Those cases in which the pain is of a dull and aching character rather than sharp and darting, where vigorous rubbing or firm pressure are not disagreeable and frequently give relief, sometimes resist the faradic as well as the continuous galvanic current. They may be permanently cured by a powerful galvanic current, which is interrupted at regular intervals, so as to produce violent muscular contractions.

Dr. V. P. Gibney reported * thirty-two cases of sciatica treated with a very strong current; in some instances lively erythema was observed around the electrode, and in two patients an eschar was found after the electrode was removed. No bad effects were found to follow these strong currents. With regard to the direction of the current, Dr. Gibney believes that it is immaterial, though all his cases were treated with the ascending current. In the earlier cases the positive pole was placed over the lumbo-sacral region, and the negative over the seat of the pain. In the latter cases, the positive pole was placed over the trunk of the nerve at its exit, and the negative over the seat of the pain. It is best not to move the sponges from place to place during one sitting, as the contractions which follow the breaking of the current prove too irritating to the nerve. If the pains are diffuse, it is better to reach the distribution of a single branch at a single sitting. At the next sitting another branch can be embraced in the galvanic current. The sitting should vary from five to fifteen minutes, and should

* Trans. Am. Med. Assoc., 1880.

be held daily, or at least every other day. No internal remedies were employed in any of the cases reported.

Muscular Rheumatism.—*Galvanism.* A galvanic current, from eight to ten zinc-carbon cells, should be carried through each muscle for about two minutes at a time. The best results from the employment of electricity in rheumatism are obtained in cases where the disease affects the muscles only.

Lumbago.—It is said that about one half of these cases yield to faradism, about one-third to galvanism, and the remainder only to electro-puncture of the affected muscles. Electro-thermal baths of all kinds are the most effective remedy for the various forms of rheumatism and some forms of neuralgia. Water, vapor or hot air should be selected according to general indications given in the chapter on baths. The patient needs to be impressed with the importance of perseverance and regularity in receiving treatment. If these conditions can be secured and the practitioner has reasonable skill in the management of electricity, it is very rare, indeed, that the patient will not be greatly benefited, even though the disease may be accompanied by organic changes that forbid a perfect cure.

Articular Rheumatism.—*Galvanism.* * Professor Seeligmüller claims to have met with remarkable success in the treatment of chronic articular rheumatism by electricity. He uses a metallic brush electrode with stiff wires, which he connects with the negative pole, the positive pole being attached to a flat sponge electrode. The latter is dampened and placed on the limb near the offending articulation, then the metallic brush is applied over different parts of the joint, being held in contact with the integument in each place for the space of from one to ten seconds. The application is very painful, but the professor remarks that the patients soon grow

* *Deutsche Medicinisene Wochenschrift*, October 17, 1883.

used to it. After a sitting the skin is covered all over with little dots, looking as if the Baunscheid instrument had been employed. The mode of action the author does not explain, but thinks it cannot be entirely owing to the counter-irritation, for he has used other equally severe cutaneous irritants without meeting with anything near the success obtained by this method. One patient, who had been treated for eight years for chronic rheumatism by all sorts of methods, was able, after the first application of electricity, to raise his arm, which had been powerless for six months; after the third application all the movements were normal. Another man was unable to move either his wrist or his shoulder, owing to rheumatism, and after five sittings was discharged as cured, and was able to resume his work as a stonemason.

ARTHRITIS DEFORMANS. — Rheumatic gout calls for the general application of electricity in addition to other remedies for building up the system. The deformities of the joints of the hands and feet require great patience and perseverance on the part of both physician and patient to accomplish any marked reduction. Althaus says that no one who has not seen it can have any idea of the beneficial effects which galvanism will produce in the long run on these deformities, even when they are extensive, and where the patients are not very old. He recommends galvanization of the sympathetic nerve. The current should be used daily or three or four times a week for at least one month or six weeks. If after this time there is no decided progress, it should be omitted for a time and then resumed. Dr. Butler has had success by immersing the affected joints in a weak solution of carbonate of soda, which he makes the positive electrode, the negative being placed high up on the affected limb or on the spine near the origin of the nerve supply.

CRICKS IN THE NECK AND SHOULDERS.—When rigidity of the muscles is midway between the acute and chronic state, and not yet permanently contracted, place the antagonistic muscles in a state of artificial rigidity by means of localized electrizations with rapid intermissions. Either the faradic or interrupted galvanic may be employed.

TORTICOLLIS (WRY NECK).—*Always restore the head to the natural position, and keep it there while electrizing the muscles.* When wry neck is caused by paralysis of certain muscles in the neck, treatment should be addressed to these muscles for the purpose of restoring their tonicity and power of antagonizing the muscles of the opposite side. The faradic or interrupted galvanic currents are indicated for this purpose. When the affection is due to spasmodic muscular contraction, a mild continuous downward galvanic current is indicated. The positive electrode is placed on the nape of the neck, and the negative is slowly passed from the origin to the insertion of the muscles to be treated.

CHOREA.—*Galvanism.* Dr. A. D. Rockwell says:

> In regard to chorea, I wish that the profession could be impressed with the value of electricity in this disease. I do not refer to recent cases, where in a few weeks the symptoms spontaneously subside, aided perhaps by some form of tonic treatment, but to those of a chronic character, which persist in spite of judicious medication.
>
> I may, perhaps, be accused of undue enthusiasm, when I say that I have never known a case, even of long standing, fail to recover when the methods of central galvanization and general faradization were faithfully and properly carried out.

His method is to cover the head almost entirely with large sponge electrodes, and to send through it a gradually increasing and decreasing galvanic current.

Dr. Charles Dana* believes that he has devised a way by which more powerful effects can be gotten in the galvanization of the

* *Archives of Medicine*, December 1883.

brain than by the ordinary methods. It consist in placing the foot upon a metal plate connected with the negative pole, and placing the positive, a large, moist sponge electrode, upon the head. He has succeeded in sending a current from forty to sixty Daniells cells (equal to about twenty to thirty zinc-carbon) from head to foot without unpleasant after-effects. *Great caution should be observed in passing such a current as this through the brain, and the possibility of producing electrolysis of the brain-substance should not be lost sight of.* He claims that this is a most valuable adjunct to the treatment of chorea, and that given daily for a week or ten days, with arsenic and probably without, it will materially shorten the duration of the disease. If there is no improvement after ten days, it may be discontinued. The majority of the authorities recommend a mild galvanic current applied to the spine as an adjuvant in this disease. Althaus commends central galvanization with faradization of the affected muscles. Rosenbach and Steifert apply galvanism to the tender points along the spine.

Magnetism. Dr. Hammond has employed magnets in several cases of chorea with the following reported results :

Case 1. Girl, aged ten, was attacked about six weeks previous to treatment by magnetism. There was spasmodic twitching of muscles of limbs, trunk and face, with loss of speech. By means of a yoke lapping over the neck and shoulders, he attached two horseshoe magnets, each capable of supporting four pounds of iron, in such a way that one rested over the cervico-dorsal region of the spine, and the other over the sternum, the poles pointing downward. The magnets were applied at 1:30 P.M., at 1:55 all choreic movements had ceased. At 1:57 she spoke a few words,—"Yes; no; I don't know." At 2:05 she said: "I want to go home, mamma." The magnets were then removed. No relapse three weeks after, when case was reported.

He also treated another girl, aged eleven, in which the movements were confined to the left side. One magnet was applied in front of the left thigh, and the other to the cervical region of the spine. Movements ceased in eleven minutes. No relapse.

HEMI-CHOREA. When the affection is confined to one-half the body one electrode is placed over that side of the head opposite to the affected side of the body, and the other electrode is placed in the hand of the affected side. The electrode on the head is made positive, and a stabile current of from two to four zinc-carbon cells is sent through the circuit.

HYSTERIA. Hysterical affections of every description, whether spasmodic or paralytic in their nature, have been cured by all forms of electricity. General *faradization* speedily removes the debility present in many cases, and is especially adapted to those in which there is loss of power or sensitiveness in any part. Central *galvanization* relieves pain, spasms, hyperæsthesia.

Franklinism is regarded by those who have had an opportunity to witness its effects as superior to all other forms of electricity in purely hysterical affections, whether characterized by pain or anæsthesia, by spasmodic contractions or paralysis of muscles. The electro-positive or electro-negative bath, with electric friction or massage of the affected muscles, is the usual method pursued. Prof. Charcot, Dr. Morton, Dr. Blackwood and others place an exalted value uoon this agent in these affections.

GALACTAGOGUE.—*Franklinism.* The blood supply of the mammary glands is ample and can be readily increased by excitation. Blackwood claims that franklinic electricity is best adapted to do this, and claims to have treated three cases successfully that had repeatedly suffered from scanty milk supply. Sparks were passed through the breast, and in ten days an abundant supply was obtained, which continued until the babe was weaned. The static induced current is also recommended for the same purpose.

Faradism. Becquerel employed a mild faradic current, which was applied through moist sponges placed successively on different parts of the breast. The sittings continued fifteen minutes; three or four restored the secretion, which continued in abundance.

Enlarged Glands.—*Galvanism.* The following method of applying electricity to enlarged glands has proven eminently successful in the practice of Dr. H. H. MacDonnell (Dublin). Having selected the gland or mass of glands to be treated, moisten the surface and apply the negative electrode over the most prominent part, and the positive about three inches distant; keep moving the positive in a circle around the negative quite slowly until the stimulus has been sufficiently applied. Five to six minutes is long enough, and at first two cells only are necessary. At following sittings more cells may be used, but the number should be increased cautiously, and if there is the slightest appearance of inflammatory action, as evinced by a bluish-white tint under the negative electrode, a couple of cells must be at once disconnected, or the sitting ended on that occasion. He has never used more than eighteen cells continued for three minutes, and has found that eight to twelve cells give the most satisfactory results. Some patients need the application of the current three or four minutes twice daily; in others a longer application once only answered better. Even different glands or masses of glands in the same individual progressed more rapidly under varying conditions of strength, length and frequency of application. He believes fair-skinned patients bear a more heroic line of treatment than dark ones, and react more quickly to electrical stimulus.

Faradism. M. Boulin endeavored to cause the current to penetrate the tumor in the following manner: He inserted fine needles around the circumference of the tumor, and connected them with the negative pole; the positive was connected with a disc insulated in points (see Fig. 133), and applied to the surface of the tumor. He reported a large number of both lymphatic and glandular tumors, wholly or partially dispersed by this treatment.

GLANDULAR TUMORS.—*Faradism.* M. Mayer recommends placing moist electrodes on the tumor, and sending through it as strong a current as possible. There follows a distinct separation of the tumor into separate parts, and gradual reduction in size follows.

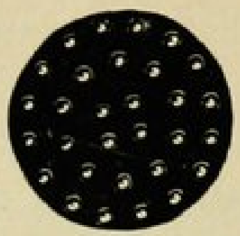

FIG. 133.

DISC ELECTRODE WITH INSULATED POINTS.
Diameter, 1¼ inch.

This is a metal disc, studded with nickel-plated projections, which are insulated from each other by hard rubber. It may be employed to disperse enlarged glands, threatened abscesses, or on any surface where it is important to excite absorption.

GOITRE.—*Electrolysis.* Dr. Henrot* proposes the use of the capillary trocar as an electrolytic needle in those cases of goitre containing *cysts*, and permeated by large veins. While the fluid is removed through the canula, the latter as a needle transmitting the galvanic current, brings about the closure of the great veins.

EXOPHTHALMIC GOITRE (BASEDOW'S DISEASE).—*Galvanism.* Dr. E. A. Bartlett* believes that there are two forms of this disease, the first being characterized by symptoms of paralysis, the second by symptoms indicating irritation of fibers of the sympathetic. In those cases dependent upon irritation of the sympathetic, a galvanic current passed from the periphery to the nerve centers produces no beneficial effect, and in some cases not only aggravates existing symptoms, but produces other

*Read before the Albany Academy of Medicine, April 19, 1883. Medical Annals.

unfavorable ones. On the contrary, the application of the positive pole to the cervical ganglia, or along the course of the cervical sympathetic produces immediately beneficial effects, the pulse being sometimes greatly reduced. Those cases of paralytic origin are most favorably influenced by the ascending current (positive to the nerve extremities, negative to the nerve centers).

Chvostek, Moritz Meyer, Soelberg Wells, Rockwell and others have reported success in the treatment of this disease by electricity. Dr. Chvostek recommends the following method:

1. The ascending constant current applied to the cervical sympathetic, on each side, for at least one minute.

2. The same to the spinal cord; the anode at about the fifth dorsal spine, the cathode high up in the cervical region.

3. Through the occiput one pole at each mastoid process, and in certain cases also through the temples, a constant current, for, at the longest, one minute, and so weak that the patient can feel but the slightest sensation of burning. Sometimes also local galvanization of the thyroid gland, with a weak, constant current, for about four minutes, the current to be reversed at the end of each minute.

The application should be made every day if possible. Wells locates the positive at the auriculo-maxillary fossa, while he moves the negative gently over the closed eyelids, and afterward over the goitre. He uses six to ten cells for the eye, eight to fourteen for the goitre, applying the current for one and a half to two minutes. He also galvanizes the cervical ganglia, placing the positive electrode on the auriculo-maxillary fossa, and the negative on the sixth or seventh cervical vertebra, or manubrium sterni. It may take twenty to thirty sittings before any marked improvement is observed, but considering the little that can be accomplished by other treatment, galvanism is worthy an extended trial. Dr. Rockwell has reported the results of treatment in nine cases, of which three entirely recovered, and two were greatly improved. He galvanizes the cervical ganglia as above described for a few minutes, then gradually draws the positive along the inner border of the sterno cleido-mastoid muscle to its lower extremity. The second step in the process is to place the positive on the seventh cervical vertebra, and the negative over the solar plexus, using for a few moments a greatly increased current. He employs general faradization as a part of the treatment in some cases.

MALIGNANT TUMORS. — *Electrolysis.* Prof. Semmola,* of Naples, has treated six cases — one of epithelium of the right breast, the size of an orange; a fibro-sarcoma of the right breast; two cases of sarcoma of the right breast; one case of sarcoma of the left breast, and one cysto-sarcomatous tumor, growing from the upper third of the arm. In five of the cases amputation of the diseased part had been recommended by experienced surgeons, and the sixth was a case of recurrence eighteen months after the removal of the primary sarcomatous tumor. The tumors are said to have had all the clinical characters of malignant growths, and to have been examined microscopically by Prof. Petrone. The needles employed were those in common use for electrolytic purposes, and they were passed deeply into the tumor, converging toward its center. In his earlier experiments only the negative pole was thus inserted, the positive pole being placed on the chest, but in the later ones he found it beneficial to pass in both poles of the battery. In small tumors one inserted needle was found sufficient. As a rule, passing the needle causes next to no pain or difficulty, but at times small sclerotic foci interfere with their transit. Very rarely did any painful inflammation attack the spots of puncture. The constant current should be used fre-

* *Lancet*, November 22, 1882.

quently, even three times in the twenty-four hours, and allowed to flow through the new growth for an hour each time. A weak current, long continued, seemed to be better in its effects than a stronger current acting only for a short interval, and it is stated that the former has a greater modifying effect upon the local chemistry of nutrition. In one case the treatment was ended in twenty-four sittings, but in another it extended over seven months. In the case of cystic sarcoma, after two applications of electricity, inflammation and destructive suppuration set in. In none of the cases were the lymphatic glands affected. Dr. Semmola suggests that electrolysis cures malignant tumors in one of three ways: by producing small foci of inflammation with consecutive sclerosis, the tumor being converted into a small, indurated and harmless lump; by producing a colloid and fatty degeneration, especially in tumors with this tendency; and by exciting destructive inflammation and suppuration of the tumor. Along with this treatment he has combined the administration of large doses of iodide of potash, with a view of gravely modifying the general nutrition.

Neftel has returned to this method of treating malignant tumors, destroying them at a single operation. A platinum anode is plunged perpendicularly into the tumor down to its presumed point of implantation, and from three to five cathodes placed on the periphery of the tumor. The current is then closed and rapidly carried to its greatest power (thirty to sixty elements). The position of the cathodes is changed about every five minutes, so as to cover every part of the tumor. The operation lasts about an hour. The tumor becomes livid, grey, and finally black. There is a very slight general and local reaction. In two or three days the part operated upon becomes cold, and after some discharge finally comes away *en bloc*, leaving a denuded surface which is soon covered by healthy granulations. Neftel has also treated benign tumors by this method, though they do not require such energetic treatment as those of the malignant type. The conclusions which he draws are:

1. Electrolysis is an antiseptic method, and as such may be combined with the ordinary methods of operation.

2. It is preferable to any other method in the treatment of malignant tumors.

3. Malignant tumors should be entirely destroyed by the operation, and at a single séance. In benign tumors it is sufficient to establish a retrograde metamorphosis.

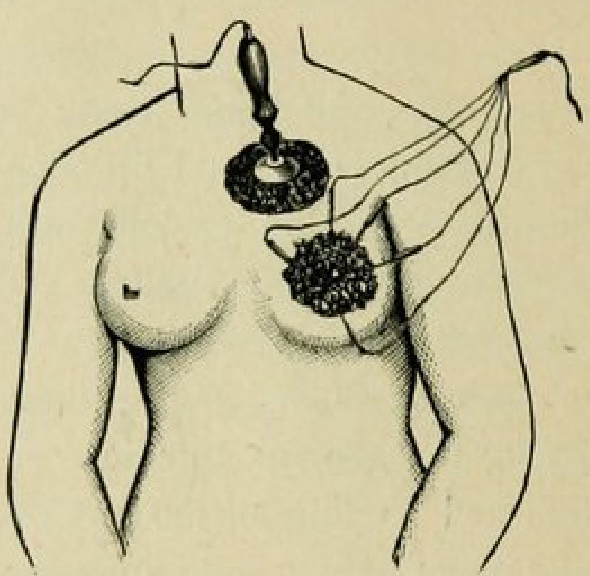

FIG. 134.

ELECTROLYSIS OF TUMORS. METHOD OF INSERTING NEEDLES.

When very small growths are to be destroyed, it is not necessary to give anæsthetics, except in very sensitive cases, and then it is better applied locally. To prevent scars, insert the needles through the same opening at each sitting, but vary their direction so as to reach every portion of the contents. Five to ten minutes is the average duration of the operation for benign growths.

To render the skin insensible in operations, M. Guérin reported, at the *Academie des Sciences*, that a circular layer of Vienna paste, limited by a double band of diachylon, applied around the tumor for twenty minutes and then removed, leaving in its trace a black ribbon-like line, so destroys the sensitiveness of the skin that the knife can be used without causing the slightest pain. He had employed this plan when chloroform was forbidden, on account of bronchial and cardiac trouble. It is suggested that it will serve equally as well when malignant growths are to be destroyed, to lessen the pain attendant upon introduction of the needles.

JOINT DISEASES.—*Galvanism.* Chronic inflammation about the joints may be removed by the judicious use of galvanism.* Many electro-therapeutists believe it contra-indicated in the acute and sub-acute stage, but in chronic rheumatism, and especially the form which follows after gonorrhea, the puerperal state or after injury, good results are obtained. The positive electrode, holding a large sponge moistened in warm water, is placed over the diseased joint, while the negative electrode, also carrying a large sponge, is moved around it. The skin beneath the positive electrode will be reddened. When the inflammation is located in the tissues surrounding the joint, and the bone is not affected, a complete cure may be expected, or, at least, a rapid improvement and restored movement. Remak advises the same treatment for inflamed joints from any cause.

CHRONIC PERIOSTITIS.—*Galvanism* exerts a favorable influence over this disease, this negative being applied direct to the seat of the disease.†

SCOLIOSIS (Distortion of the Spine).—*Faradism.* A case of this disease, occurring as a sequel to typhoid fever, was successfully treated by M. Despres‡ after the plan first proposed by Duchenne. This may be briefly summed up, viz:

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* Dr. Joffroy, Medical Record, Nov. 15, 1883.

† Dr. Gunther, in *Centralblatt.*

‡ Union Medicale.

1. Faradization daily, or at least every other day.

2. Rational gymnastics.

*3. Physiological support of the trunk by a special corset. Electricity was localized in the insufficient muscles and also applied generally to all the muscles of the back. The gymnastic exercises consisted in the elevation of the body on a trapeze by the strength of the arms. Lateral motion is less useful, as the patient will instinctively lean to one side. He considers a dependence upon corsets to rectify curvature of the spine, due to debility or paralysis of muscles, as an error, only useful at best to hide the deformity.

NÆVI.—*Electrolysis.* Insert one or more needles (according to the size of the nævus), insulated except on their tips, attached to one pole, and place the other pole connected with a moist sponge near by, where there is little sensitiveness, and use four to six freshly-charged cells, or a greater number if not freshly charged. The tumor will be seen to whiten at once, as if frozen. The time of treatment varies from two or three to fifteen minutes, according to the size and solidity of the nævus. Vascular tumors of the eyelid frequently seem much larger after treatment, from the bulging caused by the gas formed during the operation, but this quickly passes away, and it will be apparent that the size is lessened. Sometimes needles connected with both poles are inserted.

*The differential indications for the employment of electrolysis in the destruction of nævi have been briefly summed up as follows:

1. Superficial, dark-colored, sluggish, vascular growths which do not possess special or abundant blood supply, waste away after one or two sittings, and are permanently removed.

2. Those which resemble the preceding in vascularity, yet have much more surface covering, and the blood supply of

*Dr. William Newman, *British Med. Jour.*, 1883.

which cannot be determined by mere inspection. A majority of these can be cured by electrolysis.

3. Those which are intensely vascular, which are growing rapidly and have more or less direct connection with bloodvessels near at hand, cannot be removed by electrolysis.

4. If there are local pulsations or increase of temperature, and they fill rapidly after compression and have a bright red color, this treatment will disappoint the operator.

5. Almost equally unsuited for electrolysis are those which are more solid, have tortuous bloodvessels, and in which there is evidently a large amount of connective tissue.

To sum up, the vascularity present may be taken as a tolerable guide as to the chances of success.

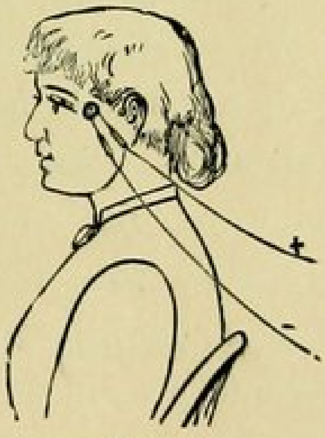

FIG. 135.

ELECTROLYSIS OF A NÆVUS.

One needle connected with each pole of the battery, insulated except at the tips, are inserted within the nævus, with their points as far apart as possible.

ANEURISM.—Heidenreich found that when we expose fresh arterial or venous blood to the action of the galvanic current, the coagulation of same was thereby hastened; the albumen, fibrin, fat, acids, chlorine, etc., separate at the positive pole, while the watery and alcoholic extracts, the alkaline and earthy bases, iron and coloring matter appear at the negative pole. If the current is applied within the bloodvessels there is produced a plug which adheres to the walls of the vessel and stops the circulation. The clot becomes firm in ten to thirty minutes, and is then sufficient to close the vessel.

Electrolysis.—The use of electricity to produce coagulation within an aneurism was first employed by Prof. Pétrequin, and has been tried by most of the leading surgeons of the world. Some unqualifiedly condemn the operation, but in the case of aneurism in the thoracic aorta or arch of the aorta, and other locations where ligation of the trunk is impossible, and death is inevitable, the majority of surgeons at the present time are in favor of giving the patient this chance of prolonging life. Althaus believes the most effective application of the current is when both poles are inserted in the sac. The positive produces a small, firm clot, and the negative a large, soft one. Prof. Wm. Pepper (Philadelphia) proceeds as follows: After freezing the skin with ice or ether-spray, plunge one needle, previously connected with a galvanic battery, boldly in with a single stroke until all resistance ceases; the second needle is to be introduced in the same way. It is important that the needles be well insulated where they pass through the skin. The moment the circuit is complete the heart will give a great bound, and the pulse become greatly accelerated. This should not cause alarm. Employ but a few cells at first, and gradually increase the strength of the current. Althaus thinks there is no cause to fear that any portion of the clot may become detached and block up a cerebral artery, as this has never occurred in any case reported. The first application should not exceed twenty minutes, but at subsequent sittings it may be prolonged to an hour in case the needles are sufficiently insulated. A rheostat should invariably be included in the circuit so as to turn the current on and off without producing shock. Hamilton* makes these valuable suggestions in regard to the operation: Place the patient on an animal diet, to increase, if possible, the

*Clinical Therapeutics.

plastic elements of the blood. For several days previous to the first operation he should be given digitalis or aconite. During the operation he should lie on a perfectly level bed, the surface warm and the mind free from excitement. He advises ether anæsthesia, as the pain is intense. The needles are introduced as above described. The tumor becomes red and greatly distended. After removing the needle the finger should be placed over the puncture until it can be covered with adhesive plaster. If hemorrhage occurs, stanch the flow with a styptic. The positive needle is glued to the clot, and requires slow, steady traction to separate it. He advises to compress the distal end of the artery which the aneurism involves during the operation, as coagulation is increased, and danger of a portion being carried into the circulation is lessened. He collected statistics including one hundred and twenty-six cases, of which forty-eight were believed to be cured.

Varicose Veins.—*Electrolysis* has been employed to produce occlusion of the vein. The positive needle only is inserted, because the clot formed about it is more firm than about the negative, and when small vessels are to be closed, this will be of sufficient size.

Purpura Hemorrhagica.—*Faradism.* * Mr. Shand, of Glasgow, reports a case of purpura hemorrhagica in which the use of electricity was productive of most pleasing results. Mineral and vegetable astringents, ergot, tonics, were tried, but the patient continued to sink rapidly. On the fifth day of treatment bleeding was taking place from vagina and bowels; she looked bloodless, collapsed, and apparently dying. She refused all medicines. Electricity was thought of and applied; the faradic current was used, running the sponges over the whole surface of the body. This was repeated every two hours, and at midnight no more motions had taken place, but

* *The Lancet*, July 1879.

griping had set in. A piece of soap was now injected, and soon relieved her by producing two evacuations; the first consisted of blood, but the second was almost natural. The next day she was much improved, and the bleeding had almost entirely ceased. Tonics and astringents were again prescribed, and a speedy recovery followed. The electricity is supposed to act by exalting the tone of the nervous system, by facilitating coagulation, by toning the exhausted capillaries, and by encouraging the capillary circulation through acting as a general stimulant.

THE DANGERS OF ELECTRICITY.

Electricity judiciously applied with due regard to its direct effect upon the tissues, and its influence on distant organs through the reflex action of the nerves, can be employed with perfect freedom from immediate or remote ill effect. The dangers to be specially guarded against are, with the *faradic* and *franklinic* currents, violent shocks, the tiring out of muscles, or exhaustion of nerves in consequence of a protracted sitting; with the *galvanic*, a protracted application of a powerful current may set up destructive electrolysis. This fact should be kept in mind when treating vital organs. Blindness has occasionally been caused by shocks as well as paralysis, spasms, fainting, etc. Hemorrhages have also occurred after a lengthy sitting. Dr. Newman* reports a case, that of a young man suffering from nervous exhaustion, in consequence of bad habits, who was treated for a time with a galvanic current from eight to fourteen cells. He improved slowly a few weeks, then for the sake of economy procured a battery, so that he could make the applications himself. A few weeks later he suddenly became a violent lunatic. It was found that, instead of doing as advised, he applied the battery several times every day,

* *The Planet*, Nov. 1883.

prolonging each séance to a considerable length of time. Under proper treatment, and galvanism given at regular intervals, he improved steadily, and recovered fully in a few months.

It is not uncommon for patients to injure themselves with a faradic battery, for the popular idea seems to be that "if a little electricity is good, more must be better." The practitioner who places any apparatus for supplying an electric current in the hands of patients for self-treatment will do well to warn them of the consequences of disregarding advice. The success of electro-therapeutics depends mainly upon the attention given to details of treatment. Skill in its use can be acquired by any practitioner of ordinary intelligence. Slowly but surely it is gaining recognition as an important and even indispensable aid, both to the physician and surgeon, and the time has already arrived when an acquaintance with the principles of medical electricity is essential to those who endeavor to keep abreast with the advances that are constantly being made in every department of medical science.

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