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ELECTRICITY

IN DISEASES OF THE NOSE, THROAT AND EAR

SCHEPPEGRELL

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ELECTRICITY

IN

THE DIAGNOSIS AND TREATMENT

OF DISEASES OF THE

NOSE, THROAT AND EAR

WITH 161 ILLUSTRATIONS

BY

W. SCHEPPEGRELL, A.M., M.D.

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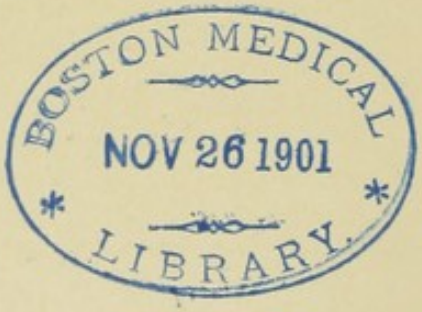
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ELECTRICITY
IN THE DIAGNOSIS AND TREATMENT OF DISEASES OF THE NOSE, THROAT AND EAR.

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ELECTRICITY IN THE DIAGNOSIS AND TREATMENT OF DISEASES OF THE NOSE, THROAT AND EAR.

INTRODUCTION.

WHILE a number of more or less important works on the subject of electricity applied to medicine and surgery have been published in recent years, still the subject of the application of this force to diseases of the nose, throat and ear has received but little consideration in these publications. Although the general character of the work may be excellent, it will usually be found that the references to oto-laryngology are not only meagre but vague and unreliable. A notable exception to this, however, is the monograph of Voltolini (1), who was an earnest investigator of this subject, especially in reference to the electro-cautery. Chas. E. Sajous also, as one of the collaborators of the *International System of Electro-Therapeutics* (2), has given a brief synopsis of this subject and devoted 36 pages to its consideration.

In reviewing the literature of this subject, a large amount of material is met with. Many of these communications are of considerable importance, but others show a lack of knowledge of the fundamental principles of electric energy, which vitiates their value for statistic purposes.

With a view of systematizing this subject, the author has considered it advisable to collect, as far as practicable, the more valuable part of these promiscuous publications on the application of electricity to rhinology, laryngology and otology, and, from a careful consideration of the merits of the different methods suggested and of the results obtained, added to a considerable personal experience in this department, to present certain deductions and statistics which will form a useful guide to the student or practitioner in the application of electricity to this branch of medicine.

As far as can be learned by the writer, no systematic attempt has heretofore been made to present a work which is limited to the consideration of the application of electricity to diseases of the nose, throat and ear. Such a work it is hoped will form a convenient and useful reference book for the busy specialist and general practitioner, enabling them to learn from statistical information the merits of the different methods of treatment and applications that have been suggested, and to note the results of the various procedures that may be used in such cases. In such a manner only can we arrive at a scientific comprehension of this subject and obtain for it the position in electro-therapeutics and oto-rhino-laryngology to which it is so well entitled.

In order to obtain good results in electro-therapeutics, it must be applied by competent physicians—physicians familiar not only with the anatomy, physiology and pathology of the human body, but also with electro-physics and electro-physiology. In this way only can the best result be obtained. Even in those cases in which electricity is applied to mechanical contrivances for its thermic or motor effect, it is important to have a sufficient knowledge of electro-physics in order to use these appliances satisfactorily. Unless the rudiments of electro-physics are well established, the physician is not only helpless in the first interruption of the current, or irregularity of the batteries, coils, rheostats etc., even when due to the simplest causes, but is even liable to inflict injury on his patient from his ignorance of these principles.

In referring to electricity in its application to diseases of the nose, throat and ear, it is not intended to be inferred that electricity is, by any means, a panacea for all diseases of this region. On the contrary, if, after a careful consideration of the results obtained by the various methods suggested, these are not found to be as reliable as those which have been obtained by other means, this will be stated, and this negative information will be as valuable as those cases in which electricity has been found to be of benefit. On the other hand, electricity forms the basis of so many modes of applications and methods of treatment, and has such important possibilities not only in therapeusis, but also in the prognosis and diagnosis of many affections in this region, that it is important to systematize the results, which have been heretofore obtained, as landmarks for our work in the future.

When the comparatively recent date is considered since electricity has been used with any degree of accuracy and precision in

this department, the results are not only gratifying, but surprising. The enthusiast, who claims great results by a special method which he has followed, may err in his zeal ; but the work and study, which he gives to his favorite method, if faithfully reported, may furnish important points to be placed in the storehouse of our knowledge of this subject.

The most important consideration, however, is that our methods should be applied more methodically and the results reported with more regard to important details. The observer who reports his case only with reference to certain theories which he has formed, may give results which will contribute but little to our general stock of knowledge. But the conscientious worker who reports his results whether good or bad, who specifies points in the treatment of the case whether he understands them or not, and who applies himself more to facts than to theories, will add not a little to our practical knowledge.

But a few years ago, a prominent writer (3) stated that the technical knowledge of electricity will soon be no longer needed, as primary batteries will soon be a thing of the past, and we will receive the electric energy required in surgery from central stations or from dynamos. This is a dangerous doctrine to teach the student or the practitioner of medicine, as its observance might lead to disastrous results.

A physician ignorant of the elements of electricity and its application in pathologic conditions resembles some of the older practitioners, who, from their inability to use it, refuse to admit the utility of the stethoscope, and who, in consequence, fail to take advantage of this means of diagnosis with which modern discovery has provided them.

In referring to the difference made by physicians in the application of therapeutics and of electro-therapeutics, William Harvey King (4) states, with much truth, that many physicians use electricity simply because they have heard that this agent is good for certain conditions. He may even take the trouble to look up how it is to be given and the kind of electricity, whether faradic or galvanic. He does not, however, know anything about the battery itself, and knows nothing of the action of the coils constructed of wires of different lengths and sizes, or any other part of the physics or physiology of electricity. He, therefore, does not recognize the necessity of being as careful in selecting them as he is of his drugs.

The worthlessness of many reported cases is also complained of by C. M. Haynes (5), on account of their lack of details. He insists upon the necessity of the following points in these cases:

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 the electrodes.

4. The length and number of the sittings, and the interval between these sittings, and the power of the battery current used.

These are important points to be observed, and their omission frequently vitiates a report which might have been of importance had proper attention been given to its details.

Electro-therapeutics covers a large field and the farther we advance in the study of its methods, the more we appreciate the many beneficial results which may be obtained from its scientific application. We can relieve pain not only by the direct use of galvanism, but also by the cataphoric application of anæsthetizing chemicals. We can increase absorption and stimulate torpid metabolic processes; secretions may be excited, or excessive secretion modified; muscular action may be stimulated and nerve activity revived. We can use it for arresting hemorrhages, for destroying tumors, enlarging strictures, and healing ulcerations. These are among the various effects which may be obtained by the proper use of this remarkable agent.

To obtain satisfactory results, however, it is as important to thoroughly understand the principles involved in the application of electro-therapeutics and the various known properties of electric energy, as it is to be familiar with the physiologic and pathologic conditions of the parts to be treated. The physician who attempts to apply electro-therapeutics, or even to perform an operation in which electricity is the motive, chemic or thermal agent, without understanding the principles involved, and who is unable to recognize the various conditions which may contra-indicate the application, is assuming an unjustifiable risk.

In medical therapeutics, where the chemicals are prepared by reliable houses, and where the prescriptions are compounded by druggists who have been specially trained in this work, the administration presents no very great difficulty. In electro-therapeutics, however, we are compelled very often to be the manufacturing chemist, distributing agent, the druggist and the physician. We must be able to distinguish the various forms of

electric energy to be used, to understand the apparatus with which they are to be applied, and the manner in which the instruments should be used; the rheostat with which the strength of the current is controlled, and the meters and scales by which the current is measured.

There are also certain physical conditions of the patient to be considered. It is important to know the difference in the applications to the skin and to the mucous membrane, and even in the different conditions of these tissues. The galvanic current that would be soothing, stimulating and beneficial to the moist mucous membrane, might be irritating and injurious to a dry and atrophic membrane, and the electrodes should be prepared with regard to these conditions.

There are also certain variations in the resistance of the patient to be remembered, and the physical condition has an important bearing. The part of the body to which an application is to be made demands consideration, and the tissues to be traversed by the current in its passage from the active to the dispersing electrode, as in the unipolar method of electrolysis.

This knowledge can be obtained only by a thorough understanding of the first principles of electric energy, familiarity with the various known methods, and personal experience in their application. Without such knowledge, the results will be unscientific, unreliable and frequently not only ineffective but even harmful.

CHAPTER I.

General Principles.

WHILE the exact nature of electricity is still unknown, scientists agree, in the main, that it is a form of motion similar to light and heat, and that it differs from these simply in the manner and form of the vibrations. The interchangeability of electricity, light, heat and motion favors this theory, which is also supported from a mathematical standpoint.

An every-day example of the transformation into different forms of energy is shown in our commercial electric systems. The coal, whose potential energy was derived from the sun in primæval ages, gives up its heat to the water in the boiler, and this thermal energy is transmitted into motive-power in the cylinder of the engine. This motive-power is transformed in the dynamo into electric energy, which is carried by means of conduits to the various parts of the city, and may be exchanged at will into light, as in the incandescent or arc lamps; heat, as in the electric culinary utensils and the various heating methods used in the arts; magnetism, as in the telegraph, or motive-power through motors which now have such a wide range of usefulness, the electric street-car systems being a good example of this principle.

Of the change of electric energy into heat energy we also have examples in the electro-cautery, electro-caustic snare etc. *Heat is the form of energy generated whenever work is done against frictional resistance.* As all conductors offer some resistance to electric currents, and, as electric resistance may be considered a form of friction, heat is generated to some extent by every current. In the ordinary conductors, this effect is avoided as much as possible, and the heat is usually inappreciable, but, when the resistance is relatively very great, we have a visible manifestation of heat, as in the electro-cautery.

As the inverse of this, electricity may be produced by heat.

Seebeck was the first to produce transformation of thermal energy directly into electric energy. He found that in a circuit of only two metals, a current could be produced by simply heating one junction to a higher temperature than the other. This principle has been extended in the thermopiles and thermo-electric batteries. The thermopile is used as a very sensitive detector of heat, and when this instrument is exposed to a source of heat, a current will be indicated by a galvanometer in circuit with the thermopile.

The *thermo-electric batteries* are used to generate currents, but it has been found that they are practicable only for currents which do not require a heavy electro-motive force, as the electro-cautery, telegraphy etc. Pouillet, Becquerel and Clamond have given considerable attention to this subject, and have devised effective batteries in which currents are obtained from the application of thermal energy.

The identity of light and electro-magnetic waves has been proved mathematically by Maxwell. It has also been shown by Hertz, of Bonn, that light vibrations of ether are electric vibrations, but that electric vibrations, by reason of their short wave-length, cannot be perceived; their length being such that the retina cannot take them up. This investigator has succeeded in making these electric vibrations visible by simply increasing their wave-length, and has shown moreover that they obey the laws of optics and can be reflected and refracted, as is the case with waves of light.

In order to have a current of electricity, there must exist between two points of a circuit a difference of potential. In the same way as in water, we must have a difference of height in order to establish a flow.

While we frequently speak of various forms of electricity, such as *frictional* electricity, *chemical* electricity, *induced* electricity, *animal* electricity etc., it must not be inferred that these are really different forces. Electric energy, as we understand it, is always the same form of energy, although differing in the method of its generation and in its effects. Electric energy itself varies only in certain special characteristics, such as pressure and quantity.

The galvanic, faradic and static currents are each forms of electric energy which vary simply in potential, quantity and direction. In the galvanic current used for medicine, the quantity, as compared with the faradic and static, is high, one to two hundred

and fifty milliamperes being the usual range, and the voltage from one to thirty-five. In the faradic, the quantity is exceedingly small, being one-thousandth of a milliampere or less, while the voltage is several hundreds or even thousands, as in the currents of high frequency recently introduced. The alternating current when applied in electro-therapeutics rarely exceeds fifty volts.

Electricity as applied to medicine may be either *electro-therapeutic*, properly, such as the application of galvanism, faradism, the destruction of neoplasms by electrolysis etc., or it may be used simply for its *thermic* and *motive* effects, as in the electro-cautery and electro-motor respectively. Lercercle (59) states that the electric energy, in spreading from the point in which it penetrates the body, is transformed into mechanical energy, chemical energy or physiological energy (vasomotor effects, nervous effects etc.), and it is this transformation which is the cause of the curative effects obtained by this treatment.

In order to have a proper understanding of the application of electricity to medicine, it is important to understand the three most common units of measurements; these are the *volt*, the *ohm* and the *ampere*. The volt is the unit measure of electro-motive force or difference of potential, the ohm is the unit measure of resistance offered to the passage of the electric current, and the ampere is the standard unit of the rate of flow of an electric current. The *milliampere*, which is the unit of measure most used in medicine, is the one-thousandth part of an ampere. A volt is approximately equal to the electro-motive force possessed by one Daniel cell; accurately it is 0.95 of the potential capacity of this cell. The ohm is approximately equal to the resistance of 250 ft. of copper wire one-twentieth of an inch in diameter. The ampere is the strength of the current produced by the application of an electro-motive force of one volt to send a current through a resistance of one ohm.

Where two of these measurements are known, the third may always be obtained by the application of *Ohm's law*, viz., the *quantity of electricity* (in amperes) *varies directly as the electro-motive force* (in volts) *and inversely as the resistance* (in ohms). This law should be carefully studied, as it forms the foundation of some of the most important calculations in electricity.

In addition to these units, there are several others with which the electro-therapeutist should be familiar. A *Henry* is the unit of induction and is equivalent to the induction of a circuit when

the electro-motive force induced in this circuit is one volt, while the inducing current varies at the rate of one ampere per second.

A *Watt* is the unit of electric power. It is equal to 10,000,000 units of power in the centimeter-gram-second system. It is practically equivalent to the work done at the rate of one joule per second.

A *Joule* is the unit of work. It is equal to 10,000,000 units of work in the centimeter-gram-second system and is practically equivalent to the energy expended in one second by an ampere against the resistance of one ohm.

A *Farad* is the unit of capacity. It is the capacity of a condenser charged to a potential of one volt by one coulomb of electricity. As the farad is such a large unit, the *micro-farad* or one-millionth of a farad is more commonly used.

A *Coulomb* is the unit of quantity. It is the quantity of electricity transferred by a current of one ampere in one second.

In order to understand the difference between the amperage and the voltage of an electric current, and to obtain an appreciation of what is meant by resistance, let us imagine a tank which has attached to its bottom an iron pipe of definite length. It will easily be understood that the pressure of this water is not influenced by the area of the base of the tank; provided always that the surface is kept at the same definite distance from the level of the pipe, we will always have the same pressure. The area, however, of the surface of the tank will influence the quantity of water in the tank, and consequently the length of time that the water would flow from the pipe. If the area were 100 square feet instead of 10 square feet, the tank would contain 10 times the quantity of water, and therefore other things being equal, the water would flow 10 times as long. If, however, the height of the water in the tank were raised or lowered, this would cause an increase or decrease of pressure respectively in the tank which would show itself by the greater or less discharge of water during any given time. The flow of water from the pipe would also be influenced by conditions of the pipe itself, as its length, its diameter and even the material of which it is made. A pipe three inches in diameter would naturally discharge more water than a pipe one inch in diameter, and a pipe one inch in length would discharge more than a pipe 100 ft. in length, even if of the same diameter, on account of the resistance caused by the length of the pipe.

In electric energy, the water in the tank represents the quan-

tity of electric energy which we measure in coulombs; the height of the water would be tne electro-motive force or difference of potential, measured in volts, and the resistance to the water, due to the length, diameter and material of the pipe, would represent resistance measured in ohms. The quantity of water from the pipe in a second of time represents the flow of the electric current measured in amperes.

The Ohm's law, the importance of which has already been stated, was published by Professor Ohm, of Nuremberg. The understanding of this law is facilitated by the following illustration given by Beard and Rockwell in their work on *Medical and Surgical Electricity :*

"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 to the internal and external resistance of the battery. 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."

In applying electricity in the diagnosis of lesions of the nerves and muscles, we may use either the *indirect*, the *direct* or the *polar* method. In the indirect method, the application is made to the trunk of the nerve at some distance from the muscle or muscles it supplies, while in the direct method, the current is applied to the muscle itself. The direct method may be either *extra-muscular*, in which a motor point is stimulated, or *intra-muscular*, in which the irritation is applied to the muscular fibre itself. In the polar method, the specific effect of each pole of the battery may be obtained. One electrode is applied to the nerve or muscle to be stimulated, and the other at some distant part of the body thus eliminating its effect. In this manner the effect of each pole may be determined.

Loss of motion from cerebral affections gives rise to certain electric reactions totally different from those caused by disease in other portions of the nervous system. Electric tests, therefore, give us distinctive evidence whether loss of voluntary motion is due to failure of the muscle, peripheral nerve, spinal cord or

brain, and without such an examination the diagnosis would frequently be uncertain and impossible.

From the result of his experiments, D'Arsonval (60) offers the following conclusions:

1. Nerve excitability is brought into play, especially by the rapidity and extent of the variation of the potential. The quantity of current plays a similar role.

2. Muscle excitability is brought into play by the quantity of current and the height and variation of the potential.

3. Alternating currents with sinusoidal variations do not produce a shock upon the system. With low frequency they give neither pain, muscular contraction nor electrolysis, and their influence on the economy consists in their degree of absorption of oxygen and the elimination of carbonic acid.

Ordinary faradization with very feeble sinusoidal current can increase respiratory combustion without pain.

The physiological effects of *electric currents of high frequency* have recently received a great deal of consideration.

A number of experiments have been made by Tesla, who passed currents of enormous voltage through the human body without injury. In some of these experiments, 10,000 volts were used with but scarcely perceptible effects on the tissues. The explanation of the harmlessness of these currents of high tension is due to the fact, that, while the potential was exceedingly high, the magnitude of the current was proportionally small. The electric energy expended in the current is a product of the amperes and the voltage, and, although in these cases the voltage was very high, the exceedingly small fraction of an ampere used was probably the reason of the harmless effects of these currents.

The *dosage of electricity* depends not only upon the age, sex and physical condition of the patient, but, as individuals have a different degree of susceptibility to morphine and other drugs, so there are persons who have a special susceptibility to the electric current. Generally speaking, the resistance in an electric circuit is proportional directly as the length and inversely as the diameter of the conductor.

Omitting the consideration of pathological conditions of the muscles, nerves, skin and lesions of the brain and spinal cord, we find that where a certain adjustment of the rheostat allows, for instance, three milliamperes to pass through one patient, it will

allow four, five and even six milliamperes to pass through another patient, the electrodes in both cases being similarly applied. If the current is passed through the hand, the difference may be caused by the various degrees of thickness of the epidermis, which depends upon the amount of manual labor done by the individual. But even in other regions uninfluenced by such causes, we find a marked difference in the amount of resistance which different persons offer to the electric current. In some cases this is due to the moisture in the skin; in other cases it may be influenced by the amount of adipose tissue, the condition of the plasma within the tissues etc.

Where for diagnostic purposes it is advisable to determine the resistance of the patient to the electric current, this may be easily calculated by Ohm's law.[1]

Reference will occasionally be made to the methods of *central galvanization* and *general faradization*. In central galvanization, one pole, usually the negative, is placed at the epigastrium, while the other is passed over the forehead and top of the head to the inner borders of the sterno-cleido-mastoid muscles from the mastoid fossa to the sternum, to the nape of the neck and down the entire length of the spine.

In general faradization, one electrode, usually the negative, is placed to the feet, while the other, labile, is moved over the whole body, or one electrode is placed at the coccyx and the other, as before, is moved over the body. It is claimed by Beard and Rockwell (6), who introduced this method, that general faradization is a tonic indicated for a large class of patients suffering from general debility.

Generally speaking, it is preferable to use a mild galvanic current of long duration than a strong current for a shorter time, as it is difficult, in the latter, to prevent the chemical action of the current and the irritation which results therefrom.

Static, or *Franklinic*, electricity is the form of electric energy which was first known, its recognition dating back as far as six hundred years before the Christian era. It was at one time considered a panacea for all pathological conditions, but the reaction afterwards set in and for many years it was almost entirely

[1] The methods of calculating this resistance by means of the electric-light current, or by means of chemical or storage cells, is described in an article entitled "The Electric-Light Current in Medicine and Surgery," published by the author in the Jan., Feb. and March, 1893, numbers of the *New Orleans Medical and Surgical Journal.*

neglected. In recent years it has been applied again to a considerable extent, especially in nervous diseases.

For therapeutic purposes, static electricity is usually generated by means of some form of frictional machine, of which one of the many modifications of the Toepler electric machine is the most used (Fig. 1).

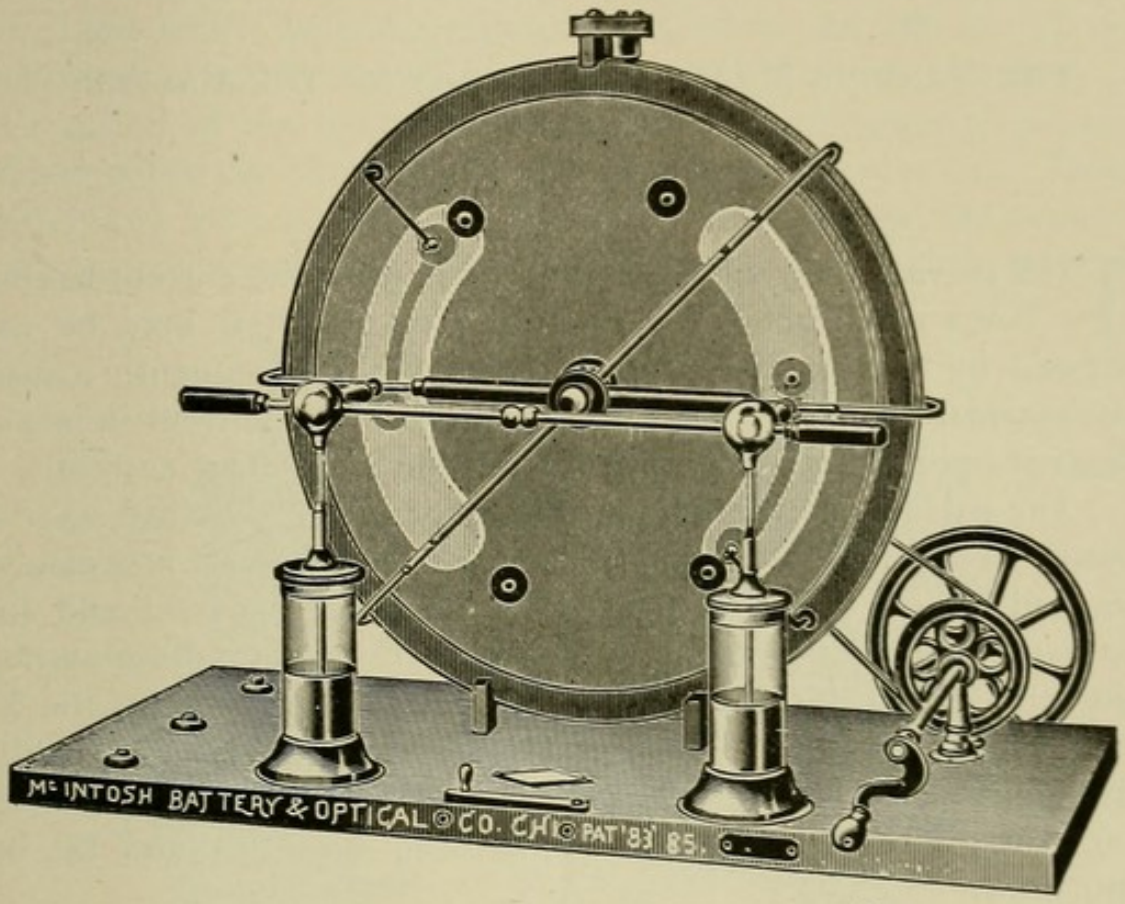


Fig. 1. Toepler Electric Machine.

The application of static electricity to diseases of the nose, throat and ear is somewhat limited, and is but rarely referred to in the literature of this subject.

CHAPTER II.

The Various Means of Generating the Galvanic Current.

CHEMICAL BATTERIES.

THE galvanic current [1] is one in which, after the current has become established, the difference of potential may be expressed by two parallel lines, and is therefore frequently called the *constant* current. It is also called the *direct* current in incandescent lighting to distinguish it from the *alternating* current.

The galvanic current has a wide range of applicability, as it is used directly for galvanism, electrolysis, cataphoresis and catalysis, and is also used for generating the faradic current and for operating the electro-magnet. It may be utilized for illumination, the drill motor, for operating the induction coil and for the X-rays, although in these the alternating current is also applicable. The galvanic current may be generated (1) by chemical batteries, (2) storage batteries, (3) thermo-electric batteries and (4) by dynamos.

Animal electricity was discovered by Galvani in 1786. When the results were published, Volta commenced his investigation of this subject, which resulted in the construction of the "Voltaic pile." This consists of pairs of zinc and copper plates, separated by pieces of blotting paper or cloth moistened with a solution of salt or acid, the connecting wires being attached to the copper plate at one extremity and the zinc plate at the other. If the free ends of the copper are attached to a galvanometer, it will give evidence of an electric current.

The efficacy of a chemical cell in regard to electro-therapeutics, will depend upon the amount of constancy of the electro-motive force, the slowness of variation, the rapidity of depolarization and

[1] In order to avoid circumlocution, the word "current" is used, although, as already explained, electricity is supposed to be a form of vibration similar to light and heat.

the durability of the elements subjected to the chemical action for the generation of electric energy.

The bichromate of potash cell (Fig. 2) consists of a pair of carbon plates submerged in a solution of bichromate of potash in water acidulated with sulphuric acid. A zinc plate is so arranged that it may be submerged in the solution between these plates. When chemical action takes place, the hydrogen, which is set free, and which by polarization would effect the efficacy of the cell, is absorbed by the chromic acid, which is developed through the action of the liberated oxygen on the bichromate of potash. When not in use, the zinc plate is raised from the solution. These cells were formerly much used for operating the electro-cautery, and are still frequently employed in the portable faradic battery.



Fig. 2. Grenet or Bichromate of Potash Cell.

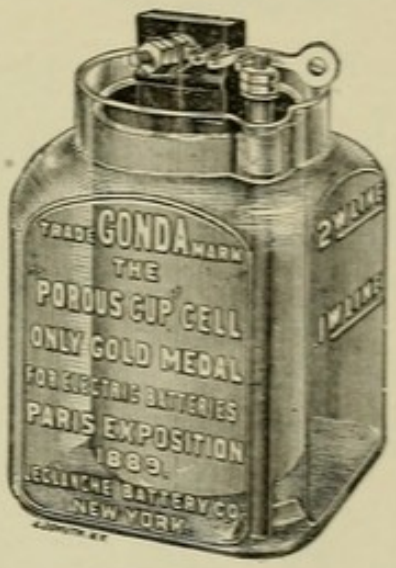


Fig. 3. The Gonda Cell.

One of the most convenient stationary batteries for generating the galvanic current is the salammoniac, of which the Gonda (Fig. 3), the Law (Fig. 4) and others are types. These cells are easily polarized, when short-circuited, but in electro-therapeutics they are required to operate through the resistance of the tissues, and this does not therefore occur in practice. This battery (Fig. 4) consists of a carbon cell of very large area submerged in a saturated solution of ammonium chloride. The zinc, whose surface is amalgamated, is usually in the form of a bar, which is submerged between the carbon surfaces. For galvanism 30 to 40 of these cells are sufficient for ordinary purposes, and the cost is quite low. Where the proper amount of attention is given to such a battery,

it will keep in good condition for a very long time, and I have used them for twelve months without renewal.



Fig. 4. Law Cell.



Fig. 5. Axo Cell.

This battery is not portable, but as the majority of cases that require electric applications are treated in the hospital and private office, it is applicable for the greater number of cases.

The Axo cells (Fig. 5) made by the Leclanché Battery Co. have all the advantages of a sealed cell. The flange of the cup closes the jar and prevents evaporation, so that when once put up with care the cells may run almost a year without attention.

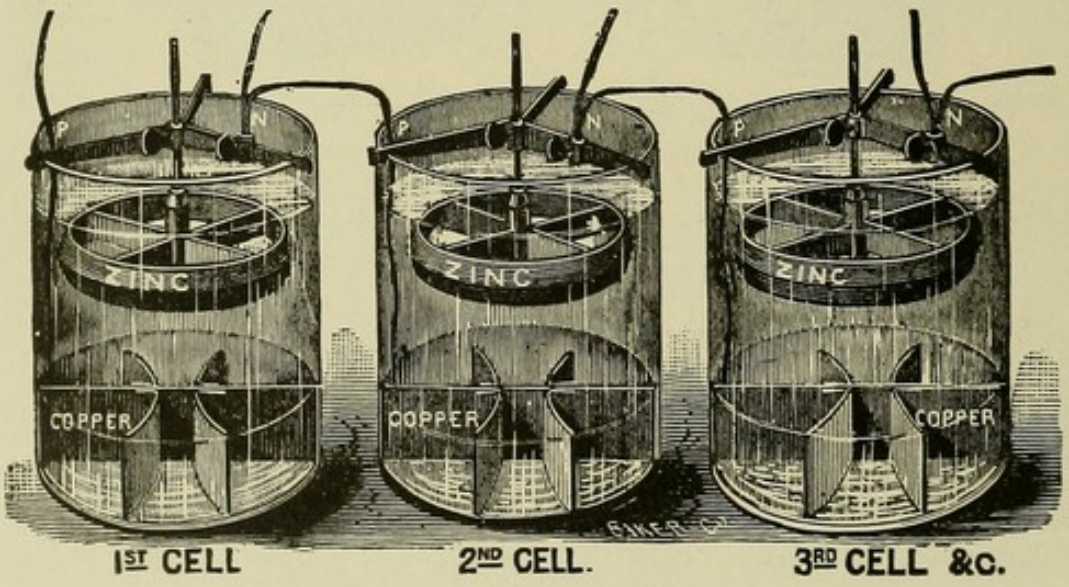


Fig. 6. Gravity Cells.

The gravity cell (Fig. 6) consists of a glass jar containing a solution of cupric sulphate, the copper plates being at the bottom

of the jar, and the zinc suspended near the top of the solution. When once charged and connected, it will run for months without the necessity of removing and cleaning the elements; the only attention it requires is to supply water as it evaporates, and occasionally a little sulphate of copper. It is extensively used in telegraphy, and is one of the most convenient chemical batteries for charging a storage battery; it is applicable whenever a continued closed circuit is required, for which the chloride of ammonium batteries are not applicable on account of their rapid polarization.

The Partz battery (Fig. 7A) is a compact Bunsen cell which contains slotted carbons attached to a ring surrounding the

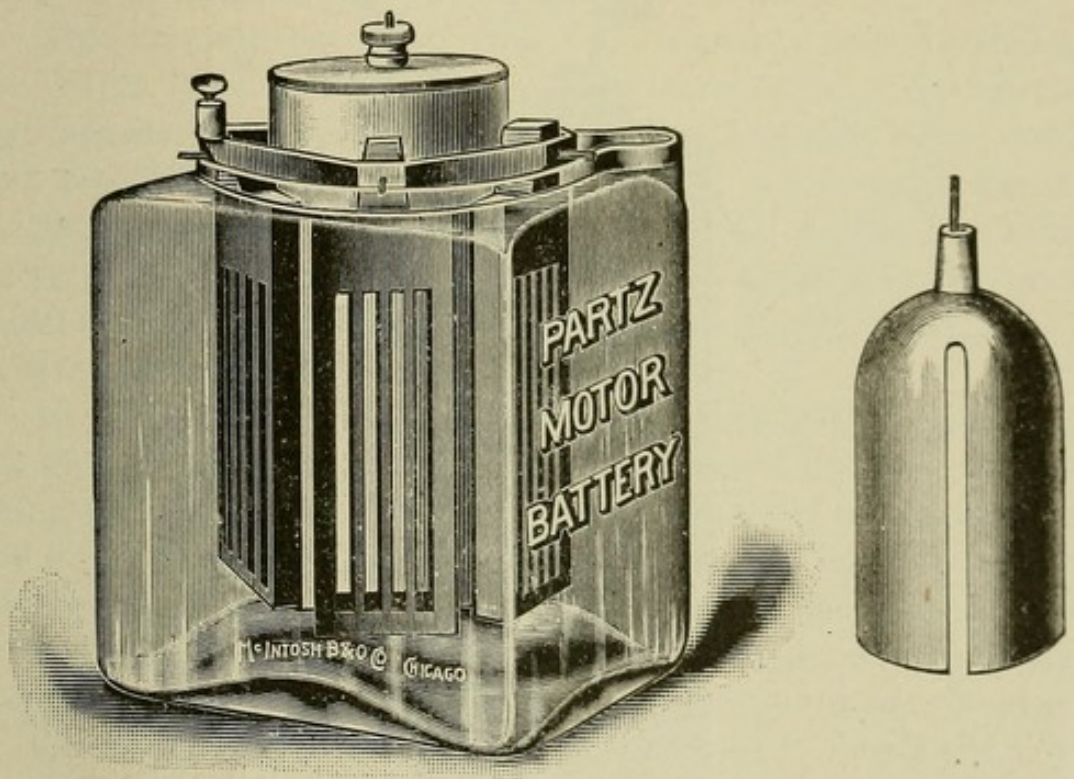


Fig. 7A. Partz Motor Cell.

porous cup, within which the zinc is suspended. The space outside the porous cup is filled with a saturated solution of sulphochromic salt in water, the porous cup being filled with a strong solution of salt. This is a very effective cell.

The Edison-Lalande battery (Figs. 105, 137) is especially applicable where quantity is needed and great tension is not required, such as cautery work, faradic coil, dental motor etc. For galvanism, electrolysis and cataphoresis it is not as useful as some of the other batteries, as it needs more attention and requires a larger number of cells.

Among the most useful batteries for electro-therapeutics are the various forms of dry cells, such as the Mesco (Fig. 7B) and others. These cells are low-priced, require no attention and are free from the danger of spilling the liquids, as in the ordinary chemical cell, and have a wide range of usefulness.

In cities in which both the incandescent and arc-light systems are used, and in which the application of the former for galvanism is endangered by the possibility of a short circuit with a high-tension current, the chemical battery must necessarily come again into favor. For this purpose the dry cell is one of the most convenient forms of generating the galvanic current.



Fig. 7B. Mesco Cell.

The batteries of the Chloride of Silver Dry Cell Battery Co. have the advantage of compactness, portability and ease of renewal. Their constancy and durability are disputed by other manufacturers, and for stationary batteries they do not possess the merit of a number of other cells on the market. But for a battery which is to be carried about, the dry cell, undoubtedly, has great advantages. A battery of 50 cells in a mahogany case, with electrodes, cords, handles and rheostat, is so light that it

may be carried about without inconvenience. The cost of these batteries is higher than the others on the market, but the manufacturers offer to take back exhausted galvanic cells at two-thirds of the catalogue price in exchange for new ones.

In regard to the efficacy of the various chemical batteries which are used, it will be interesting to note the report of the Committee on Constant Current Generators and Controllers appointed by the American Electro-Therapeutic Association, which made its report at the meeting (1895) of the Society at Toronto (7), in regard to the following cells which had been tested, viz., the Partz Acid Gravity No. 3; the Partz No. 5; the Laclede "B"; the "Axo" Leclanché; the Fitch Perfect; the Law; the "Vole" Leclanché; the Edison-Lalande.

This Committee found that the constancy and durability of the Partz Acid Gravity No. 3 cells were such, that they were well adapted to electro-therapeutic work, and that a less number was needed than in some other forms, because of the high electro-motive force furnished by each cell. In the Partz No. 5 battery, however, they found a lack of constancy in the electro-motive force, which would prove a serious impediment in its use in electro-therapeutic work.

In the Laclede battery, which was tested, it was found after the end of one year that the current ceased to flow, the cause being the zinc rods, which had become severed at the surface of the liquid and had fallen to the bottom. This result happened within six months after the cells had again been set up. This lack of durability is unfortunate, as the cells are otherwise of the most reliable and satisfactory character for therapeutic work.

The Axo Leclanché battery exhibited very constant and uniform action, and gave no evidence of the weakness in advance of the natural destruction that resulted from the chemical action that generated the electric current.

The Vole battery was found to have the same defect as the Laclede in the local electrolysis of the zinc at the surface of the liquid.

The Law batteries (Fig. 4) were found to have continued in action for two years when tested, but exhibited some decrease in the electro-motive force between the commencement and termination of a treatment lasting from 10 to 30 minutes. On the whole, this battery was found to give satisfaction for electro-therapeutic work.

In the Fitch Perfect battery, there was also a local action on the zinc; the evaporation of the fluid from the cells also showed the necessity of sealing them at the top.

The Vetter and Chloride of Silver Dry cells, while possessing the advantage of being *portable* batteries, are not as reliable as the many forms of chloride of ammonium batteries for general electro-therapeutic work.

In testing the Edison-Lalande cells, the record showed a low internal resistance, great constancy of electro-motive force and uniformity of the current output in these cells during the entire period over which their examination lasted. Six months after the cells had been set up, however, a zinc plate in one of the cells was found cut off at the surface of the liquid, and no further current could be obtained from the series. Four months later, three more of the zinc plates had likewise fallen.

In regard to the efficacy of the Edison-Lalande cells, my investigations have led me to believe that, where the Edison-Lalande battery becomes inefficient from internal action, this is due to the fact that the caustic potash, which is used, has absorbed carbonic acid from the atmosphere, or that the strength of the solution varies from the required standard (25 per cent.).

Although the caustic potash is shipped in sealed cases, it is sometimes found to have already absorbed carbonic acid, and before placing the solution in the cells it should be tested. This can easily be done by the addition of an acid, such as hydrochloric or sulphuric, to the solution, and, if any carbonic acid is present, there will be an effervescence, and when this is the case the potash should not be used. This may, perhaps, explain to some extent the complaints which have been made against this battery.

A convenient portable galvanic battery is made by the Chloride of Silver Dry Cell Battery Co. (Fig. 8). It is supplied with the Willm's current controller for regulating the current, and their new "mil-am-meter" for measuring it. A water rheostat, which they supply with their smaller battery, is shown in Fig. 9. It is made of hard rubber, has a movable screw cap for putting in fluid, and a small socket in the top of its piston to receive the electrode conducting cord.

The portable battery of the McIntosh Co. is shown in Fig. 10. It consists of zinc and carbon plates arranged in couples and securely clamped to hard-rubber plates with thumb-screws, the

latter being also used as binding-posts. The cells are made in sections of six, and a drip cup composed of one solid piece of

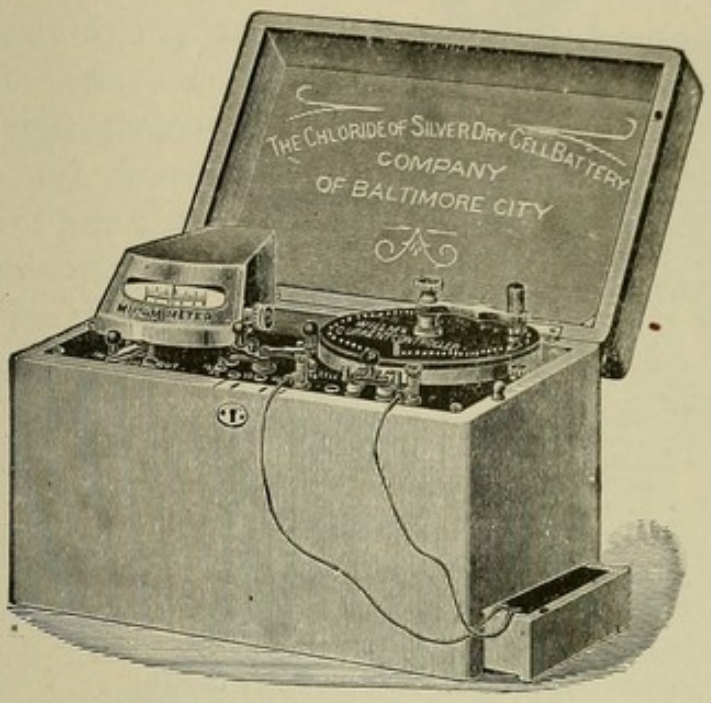


Fig. 8. Chloride of Silver Dry Cell Portable Battery.

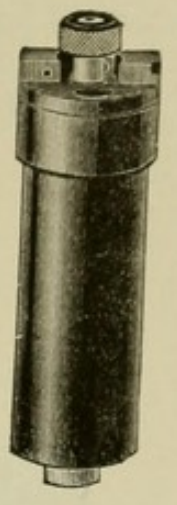


Fig. 9. Water Rheostat.

hard rubber. The drip cup on the side of each section of the cells is to receive the zinc and carbon plates when removed from the cells. When the cells are not in use and the lid of the battery box is closed, it presses on a spring handle of the section and holds the soft rubber firmly over the cells and drip cup, thus making it water-tight. This battery may be used by means of a

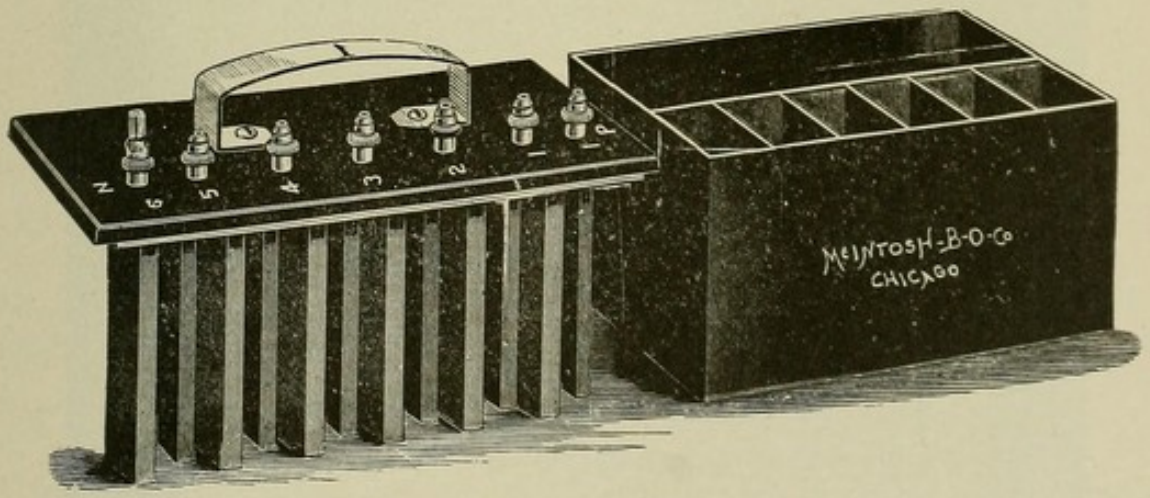


Fig. 10. McIntosh Portable Battery.

cell selector. It is also so arranged that it may be used in connection with the faradic coil. While this battery is portable, it

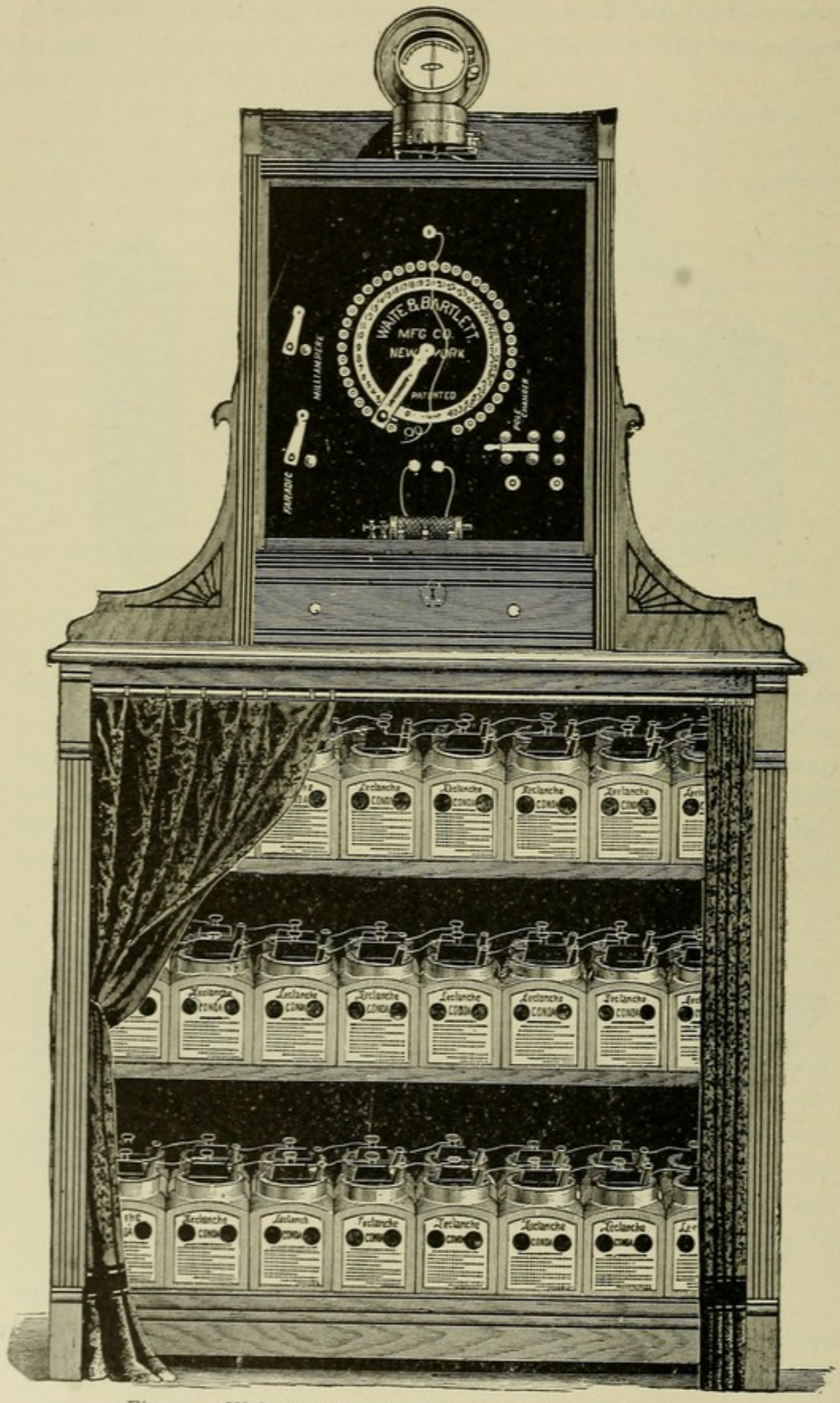


Fig. 11. Waite and Bartlett Galvanic and Faradic Cabinet.

is by no means light and does not compare in convenience with the various forms of dry-cell batteries.

A convenient stationary cabinet for galvanic and faradic work is shown in Fig. 11. The chemical cells in the cabinet are of the Gonda type, and the strength of the current is adjusted by means of a cell selector, which is, undoubtedly, more convenient than the water rheostat sometimes used in chemical batteries. The cabinet has also a pole changer, which is much more useful than the majority of rheostats used in chemical batteries.

The stationary cabinet of the McIntosh Co., shown in Fig.

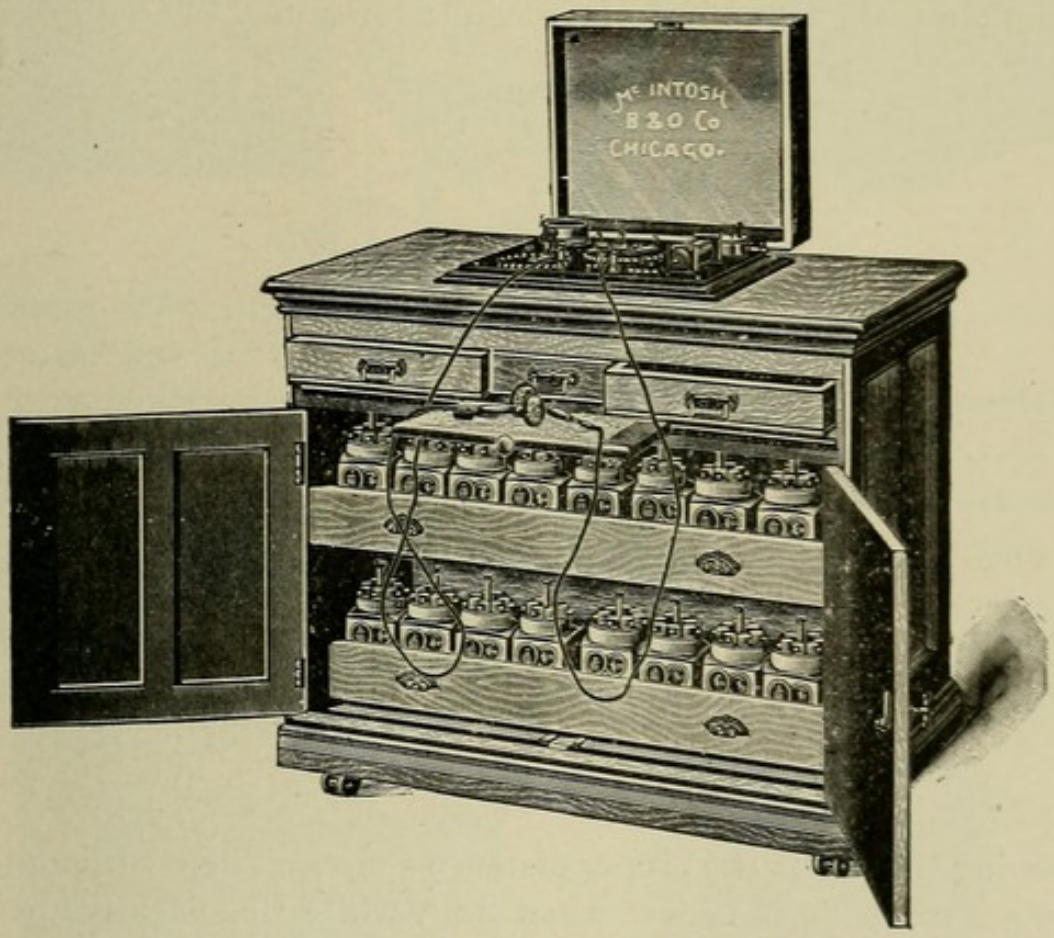


Fig. 12. The McIntosh Galvanic and Faradic Cabinet.

12, is a useful and convenient cabinet for galvanic and faradic work.

STORAGE BATTERIES.

The storage battery was originally the invention of Planté, who utilized the electro-motive force developed by the polarization of lead electrodes employed in the electrolysis of acidulated water. These batteries as originally devised were improved

upon from time to time, and soon established their superiority over the chemical batteries for certain kinds of work.

Although we speak of "storing" electricity, and of the "storage" batteries, there is really no actual storing of electricity. The charging current of electricity, which passes through a storage battery, gives rise to certain chemical changes, and the current which is afterward obtained is derived solely from the chemical reaction that is taking place.

A storage battery consists of a containing jar or cell, a liquid consisting of dilute sulphuric or other acid called the "electrolyte" and an assemblage of plates called the "pile" (Fig. 13), together with a number of vulcanite forks or "separators," for

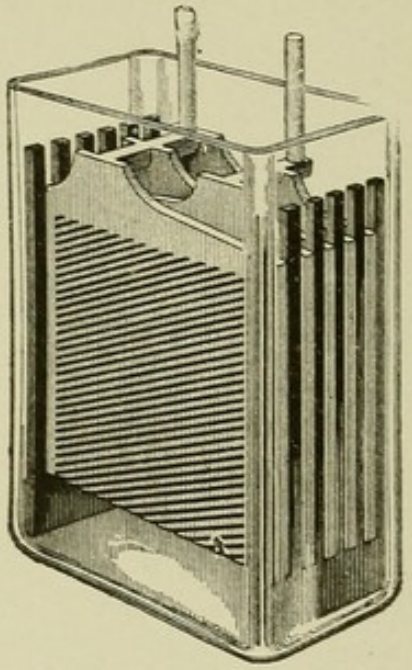


Fig. 13. Storage Cell.

keeping the plates the proper distance apart. The positive plates are generally light brown when new, while the negative have a grayish color.

In storage batteries we have not only a supply of electricity which we can use at will, but a supply of electric energy so modified that it is adapted to purposes for which the charging battery cannot be used. This refers especially to the lowered voltage.

A useful storage battery is the Sorely Accumulator. Fig. 14 shows the appearance of a cell, a plate and the manner of constructing the pile; each cell has a capacity of two volts and two hundred ampere hours.

An excellent battery for general use is the American storage battery (Fig. 15), which has an established reputation for dura-

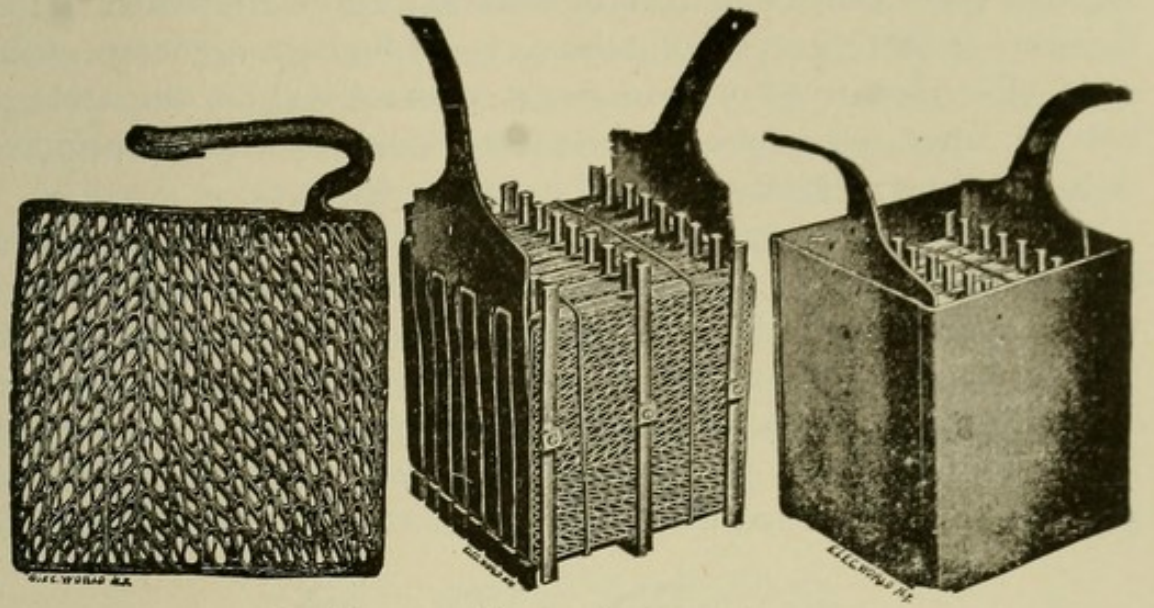


Fig. 14. The Sorely Accumulator.

bility and efficiency. They are made in two principal styles, one for stationary and the other for portable work.

Storage batteries require charging at least every three months, even when not in use, and oftener in proportion to the extent to which they are used. They may be charged from a dynamo of low voltage, as, for instance, from a motor-dynamo (Fig. 84), or

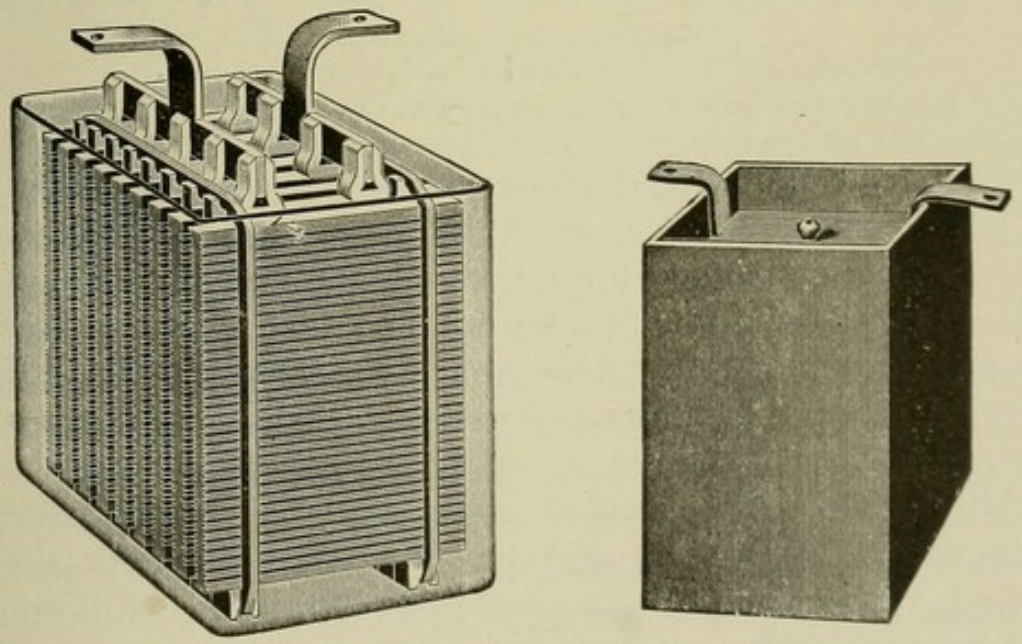


Fig. 15. American Storage Battery.

from the incandescent-light current, by the introduction of a proper resistance, as, for instance, a one-hundred-candle-power

lamp. When these are not available, they may be charged by means of the ordinary blue vitriol or gravity battery (Fig. 16). Four of these cells connected in series will suffice for each cell of the storage battery. It will take 24 to 48 hours to generate sufficient electro-motive force to begin with; after this the storage battery, when not in use, may remain connected with the primary cells and thus be always ready for use.

To avoid deterioration, a storage battery requires attention. Care should be taken that the covers of the cells do not become wet or covered with dirt. The cover should be removed once in two weeks, and if it is found that a portion of the solution (electrolyte) has evaporated, a sufficient amount should be added to cover the tops of the plates by one-fourth of an inch. The solution consists of sulphuric acid one part, water nine parts.

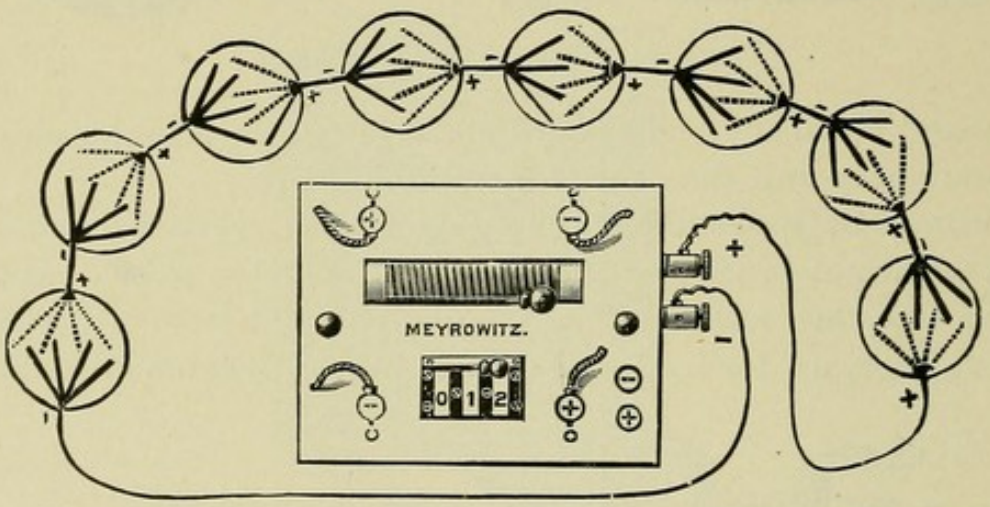


Fig. 16. Storage Battery Connected with Gravity Cells for Charging.

Storage cells are useful where a current of large quantity and low voltage is required, as in the electro-cautery, motors, small incandescent lamps, and for operating faradic coils. Their low tension makes them inapplicable where a current of considerable voltage is required, as in galvanism, electrolysis and cataphoresis. It would require such a large number of cells as to make it impracticable.

After giving an excellent synopsis of the application of accumulators in oto-laryngology, and describing the various methods of charging storage batteries, Lichtwitz, of Bordeaux (58), states that they are especially efficacious for electro-cautery and electric-light work, but he is evidently carried away by his enthusiasm when he states that they are superior for galvanic and electrolytic work.

In this form of electro-therapeusis, in which a small current of high potential is needed, a large number of accumulators would be required, and, as the efficiency of these batteries depends upon the regular charging and discharging of the cells, their employment would not only be expensive, but would also cause an unnecessary amount of labor and inconvenience.

When it is considered that an ordinary salammoniac battery, such as the Gonda, Law and others, which can be purchased for about 60 cts. each, and some of the dry cells at a still lower price, will answer effectively in galvanic and electrolytic work for as long as one or two years with little or no attention, the impracticability of substituting the bulky and expensive storage cell, with the attention that it requires for charging, etc., will be easily seen.

THERMO-ELECTRIC BATTERIES.

Thermo-electric batteries may be used to generate a galvanic current, but it has been found that they are practicable only in currents which require a light electro-motive force, as for the electro-cautery, telegraphy etc. They are rarely used in electro-therapeutics. A convenient thermo-electric battery has recently been introduced, the heat being generated by means of oil or gas. It gives sufficient current for small incandescent lamps and fan motors.

DYNAMOS.

The current generated by dynamos is now used so extensively that it has, to a large extent, replaced the former methods of generating electric energy. The most common method of utilizing the constant current from dynamos is the Edison current used for incandescent lighting.

As there are four varieties of current used for electric lighting, it is well to understand which of these can, and which cannot, be used. There is first the *constant potential* current, in which the volts are constant, but the amperes vary according to the number of lamps in the circuit. The Edison is the type of this current, and this is the one which offers the greatest amount of usefulness in electro-therapeutics. Then there is the *direct* current, in which the amperes are constant, but in which the volts vary according to the number of lamps in the circuit. If, for instance, there is a current of ten amperes, and each lamp in the circuit

requires fifty volts, then forty lamps would require 2000 volts, a current of a difference of potential that would be dangerous to life. This current is used principally for the arc lights which illuminate our streets so effectually at night.

Besides these, there is an *alternating* current, of which two varieties are used: the first is constant in volts and varying in amperes, and, in this respect, resembles the Edison current already referred to. It possesses, however, no chemical property, as this is nullified by the rapid alternations, and this current, therefore, cannot be used for electrolysis, cataphoresis or catalysis. It is occasionally applied for its stimulating effects, and may be used, like the Edison, for illumination, operating motors and for heating the electro-cauteries. The other alternating current is constant in amperes, but varies in volts according to the number of lamps in the circuit. This current is dangerous and should not be used.

The potential of the Edison current ranges from 100 to 125 volts, but is kept at a constant potential at each station. This is a safe current, as the resistance of the human body does not allow the passage of a sufficient current to be dangerous to life. The potential of each cell of the Law battery is 1.50 volts, so that the electro-motive force of 75 of these in series would be about equal to that of the Edison current. This current may be utilized in medicine for (1) illumination, (2) galvanism, (3) electrolysis, (4) catalysis, (5) cataphoresis. By acting on accumulators, motor-dynamos and current controllers, it may further be used for (6) heating the electro-cautery, (7) operating the drill motor, (8) generating the faradic current, (9) the induction coil for the X-rays, and (10) for the electro-magnet.

Except in the difference of its origin, the Edison current has all the effects and properties of the chemical galvanic current, and where the galvanic current is referred to in this work, the Edison current may likewise be applied.

The Edison current offers many advantages for the application of galvanism. A galvanic battery requires more or less attention, according to its construction and the chemicals of which it is composed, and unless this is given, it may not be found in working order when needed. It also requires considerable space, and must be renewed at certain intervals. The busy practitioner desires to have the electric current ready for use, and prefers to give his time and attention to its application rather than to its prepa-

ration. The Edison current, being kept practically always at the same voltage, has therefore always the same capacity, and does not run down like a galvanic battery.

There are certain variations in the incandescent light current which have been complained of by those who have used this current in gynecology, and elaborate curves have been given showing the manner and rate in which these variations take place. Where very powerful currents are used, as is sometimes the case in gynecology, a variation of 5 per cent. might make a difference, in the application, of 5 to 10 milliamperes, which would be painful to the patient; but in the application of electricity to the ear, nose or throat, these variations rarely amount to more than a small fraction of a milliampere, and are rarely perceived by the patient. The only cases in which heavy currents are usually required, are in the electrolytic operations of fibroid tumors of the naso-pharynx, in which very heavy currents are sometimes successfully used. In these cases, however, it is advisable to use the bipolar method, and if the tissues are thoroughly anæsthetized or chloroform is given, no pain is complained of that can be attributed to the variation of the current. After having used the Edison current in the treatment of diseases of the nose, throat and ear for many years, I do not recall a single instance in which pain resulted from this cause.

There is one danger, however, of employing the Edison current in cities, to which I desire to call particular attention. This is the danger of a cross from a high-potential current, and, in cities where both of these systems are used, the application of the Edison current is undoubtedly attended with danger. The grounding of the high-tension current through the Edison is not of infrequent occurrence, and a number of fires have been attributed to this cause. If this grounding should take place while an application is being made to the patient, the charge in the supply wires would rise from 115 volts to 1000 or more, so that the amount of current applied to the patient would be increased tenfold, and this would cause a shock which might be dangerous in character.

In cities, therefore, in which the high-tension current passes in any part of its course near the Edison current, so as to make a cross a possibility, some other means of generating the galvanic current should be used.

This danger applies principally where the current is passed

directly through the tissues, as in galvanism, electrolysis and cataphoresis. Where the current is used for its motor or thermic effects, or for operating the faradic coil, the danger is more remote.

Even where there is no danger of a cross with a current of high potential, the Edison current should rarely be taken directly from the mains. As the difference of potential of these is 115 volts, it is difficult to reduce the current directly by means of a rheostat with the delicacy that is necessary in administering it to the patient.

The author has experimented for a considerable time with a view of devising an apparatus by means of which the potential of the original current could be so reduced, that it would facilitate the use of this current as a substitute for the chemical batteries. This was first described in the *New Orleans Medical and Surgical Journal*, January, 1893, the apparatus being called the *volt selector and shunt*. Before describing it, it is well to explain how the electro-motive force of a current is affected by resistance.

Let N and P (Fig. 17) represent the main wires of the Edison

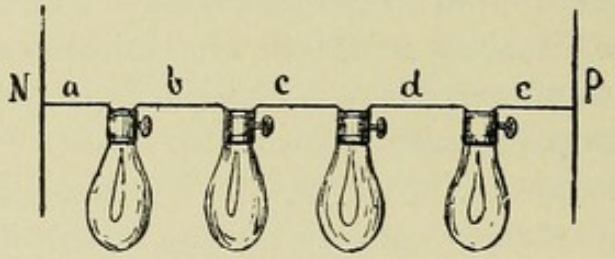


Fig. 17. Lamp Resistance.

current, with a difference of potential of 120 volts. If the current be passed through four lamps of *equal capacity*, and therefore of equal resistance, we find that instead of the brilliant white light, we have a scarcely perceptible glow. The cause of this is that these lamps require 120 volts to become incandescent, and where more than one lamp is placed *in the same circuit* the voltage is divided among them according to their respective resistances, and the lowered electro-motive force is unable to make them incandescent. If the cables of a volt-meter be placed at *a* and *b* (Fig. 17) respectively, it will register 30 volts, or one-fourth of the electro-motive force of the whole current; if the potential be measured between *b* and *c*, the volt-meter will again register 30 volts, and the same between *c* and *d* and between *d* and *e*. The

measure of potential between these points will be the same, whether the lamps are 20, 50 or other candle-power, provided only that each of the four lamps has the same candle-power, or, in other words, has the same resistance. If, however, we place the cords of the volt-meter at *a* and *c* (Fig. 17), it will register 60 volts, or the sum of the volts between *a* and *b*, and *b* and *c*. In the same manner the difference of potential between *a* and *d* will be found to be 90 volts, and between *a* and *e* 120 volts, or the whole difference of potential N and P.

If we allow the electric current to pass through these lamps, and attach wires to any two points, as *a* and *c*, and take our current from these wires, the lamp circuit will form a *shunt* to the circuit which we are using, and we will have an available electromotive force of 30, 60, 90 or 120 volts, depending upon the connection of our wires.

This principle is used in the volt selector and shunt (Fig. 18).

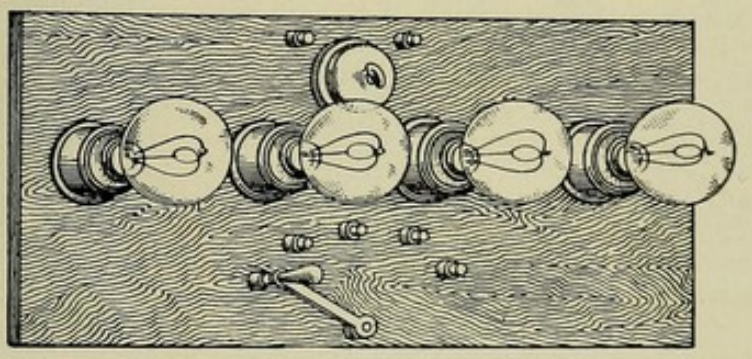


Fig. 18. Scheppegrell's Volt Selector and Shunt.

Four lamps *in the same circuit* (in series) are placed in the case, or in the cabinet if this is used. The buttons of the switch are connected with the points *b*, *c*, *d*, *e* of the shunt (Fig. 17) respectively, the fifth button being the zero point. The left binding-post connects with one of the wires of the Edison mains (N wire of the shunt, Fig. 17), and the second binding-post connects with the arm of the switch. The buttons are marked 100, 75, 50, 25 and 0, these figures referring to the *percentage* of the volts of the current used. In a current of 120 volts, these figures would indicate 120, 90, 60, 30 and 0 volts respectively. By adjusting the arm of the switch, we can thus select 30, 60, 90 or 120 available volts, as the initial current. The initial current of 30 volts can be still further lowered by increasing the capacity of the lamp *a*, *b*, or this effect may be obtained by introducing a larger number of lamps in the shunt.

By placing the rheostat in series with this selector, we are enabled to make use of a delicacy of application, which is impossible when the rheostat is connected directly with the mains.

There is a source of danger in using the incandescent service for illumination, and especially in galvanism, this being the possibility of *grounding* the current. In order to understand this, it should be remembered that, while the mains are insulated by non-conducting material surrounding the wire and also by the glass insulators by which they are attached to the poles, in spite of all precautions, there is always more or less leakage to the ground.

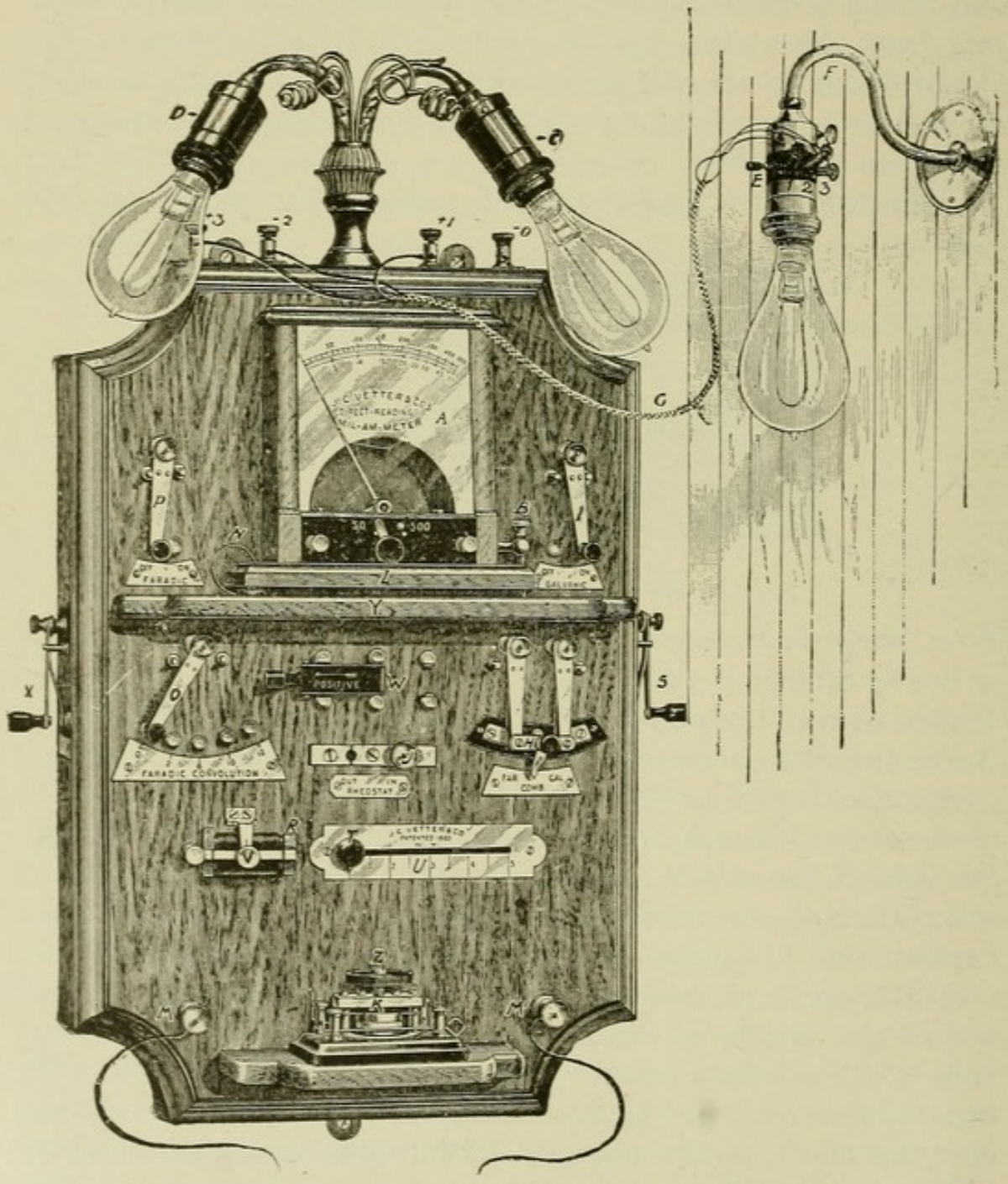


Fig. 19. Electro-Medical Wall Base for Constant Electric Current.

The leakage is proportionately greater in damp climates, as the moisture affects the conductivity of the insulating material, and this is especially the case during rainy weather. In many cases, this leakage is sufficient to light an incandescent lamp if one of the wires of the mains be connected with some well-grounded conductor, as a water- or gas-pipe.

I recall the experience of a confrere who was about to make an application of galvanism to a patient; with the electrode in one hand, he applied the other hand to a faucet of the water service to moisten the electrode. He received a severe shock, his body having completed the circuit between the electric mains, with which the electrode was connected, and the water-pipe which was connected with the ground. The physician was much alarmed by his experience, and requested me to explain the phenomenon, which I did as above stated.

In the cabinet made by the Carter Mfg. Co., of Louisville, Ky., the dynamo generates a direct current of sufficient intensity to be applicable for galvanism. This dynamo is driven by means of a motor, which may be operated by either the alternating or direct incandescent current. As the dynamo is connected with the motor by means of an insulated shaft, the current generated is not exposed to the danger of a short circuit from a dangerous current without, which is undoubtedly an advantage in this cabinet.

A wall base for applying the incandescent light current for galvanism and faradism is shown in Fig. 19.

CHAPTER III.

ARRANGEMENT OF CELLS—RHEOSTATS—MILLIAMPERE-METERS.

ARRANGEMENT OF CELLS.

WHEN a number of cells of a chemical or storage battery is used, the relative capacity in volts and amperes will depend upon the manner in which the cells are connected. If they are connected *in series* (Fig. 20), that is, if the positive pole of one

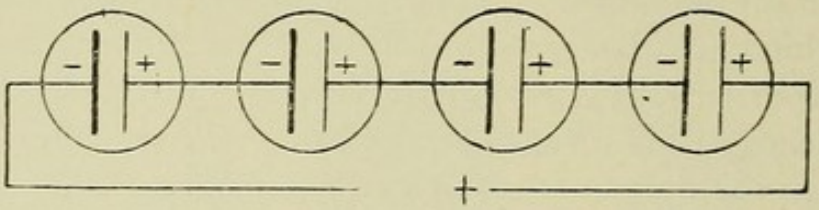


Fig. 20. Cells Connected in Series.

cell is connected with the negative pole of the second cell, and so on through the battery, the voltage will be increased by each cell thus added, and the electro-motive force of the battery will be represented by the product of the electro-motive force of each cell and the number of cells of the battery, thus giving eight volts in a battery of four cells of two volts each. Such a battery is said to be connected for *tension.*

If, however, the cells are connected in *parallel circuit* (Fig. 21),

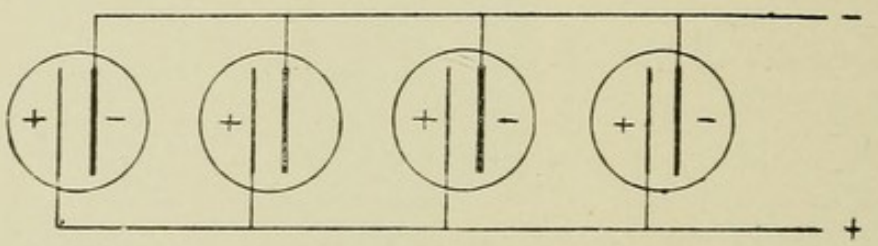


Fig. 21. Cells Connected in Parallel Circuit.

that is, if the positive poles of all the cells are connected together on one side of the circuit, and all the negative poles on the other,

this will be equivalent to having one large cell, and the voltage will be the same as one cell. But the quantity, or amperes, will be represented by the product of the ampere capacity of each cell and the number of cells. Such a battery is said to be connected for *quantity*. In this case the volts will remain constant, and in the former the amperes.

The arrangement of the cells will depend upon the resistance to be overcome. In galvanism, electrolysis, cataphoresis and catalysis, the resistance to the current, due to the interposition of the tissues, is high, and the cells should be connected in series so as to obtain the required difference of potential.

For energizing the faradic coil, a low voltage is sufficient, as also for the electro-cautery, motors and many of the small incandescent lamps. Although the tension of the currents used for the latter purposes is low, it requires considerable quantity and the cells should be selected with a view to this requisition. Under certain conditions, a combination of these two systems is required, and then some of the cells are connected in series and others in parallel circuit.

The same battery should not be used for galvanism and faradism. In galvanism, a current of high potential and small quantity is needed to overcome the resistance of the tissues of the body. The faradic current, however, is generated by an induction coil, and the galvanic current required to operate this coil, is one of low intensity but of quantity capacity, so that the effect may be continued for a long duration of time if necessary. If the ordinary galvanic current is used for the faradic coil, the low resistance of the wires of the primary coil would soon exhaust the capacity of the battery, and this current would, if sufficiently strong, probably also prove injurious to the interrupting apparatus of the faradic coil.

RHEOSTATS AND CELL SELECTORS.

When a serviceable current is available, certain appliances are needed for using it. The necessary instruments are the *rheostat* for controlling the current, the *milliampere-meter* for measuring it, and the various *electrodes* for applying it. Besides these, it is convenient to have a *pole-changer* for reversing the current, a *rheotome* for interrupting the current, etc.

Although many prefer a rheostat even when a chemical battery is used, the objection is that the resistance of most of these

instruments is so high that a sufficient capacity of the battery cannot be applied unless it is actually short-circuited, and it therefore makes it necessary to have a battery of a number of cells that would not be needed if a good cell selector were used.

The object of the rheostat or cell selector is not only to graduate the current according to the requirements of the case, but also to turn it on and off gradually, so as to avoid any unpleasant shock to the patient. When a *cell selector* is used, the current from one or more of the cells may be applied, and, in the improved selectors, it is so arranged that this current may be taken from any part of the battery. This is of importance, as in those selectors in which the switch is fixed to the first cell and the current increased by the addition of the adjoining cells, the first part of the series is frequently worn out, whereas the more distant cells have been but little used. This is avoided by the double cell selector.

The resisting agents used in the *rheostat* for the application of the galvanic current are water, carbon, graphite, German-silver wire etc. In the Bailey current regulator, which was formerly extensively used, the resistance was diminished by lowering two pairs of carbon plates into the water, each set of the carbon plates connecting with a binding-post. When this rheostat is used with the Edison current, it reduces the resistance too rapidly, and the dipping into the water of the second pair of carbons frequently causes an unpleasant shock. This rheostat I have modified, so that it has been effectively used for several years at the Eye, Ear, Nose and Throat Hospital, New Orleans. The middle pair of carbons was entirely removed, and the form of the remaining pair changed into an acute angle so that the resistance could be reduced very slowly, and the instrument then gave good results.

In the new Bailey current controller there are several mechanical improvements, as, for instance, the independent working of the two carbon plates. This rheostat may be serviceable when used in connection with the chemical batteries, but with the Edison current it reduces the resistance too rapidly, and it has, therefore, not given me satisfactory results for ear, nose and throat work.

Among the objections to the water rheostats, is that the current passing through the fluid causes decomposition by its electrolytic action, and thus produces corrosion of all metals with which it is brought in contact, if these are corrodible. If they resist this electrolytic action, as, for instance, if they are made of platinum, it greatly increases the cost of the instrument.

A rheostat which is now extensively used, and which has given me excellent results, is the Massey current controller. It consists of a porcelain plate (Fig. 22) provided with a sickle-shaped conducting area of graphite (soft pencil) broadening and thickening

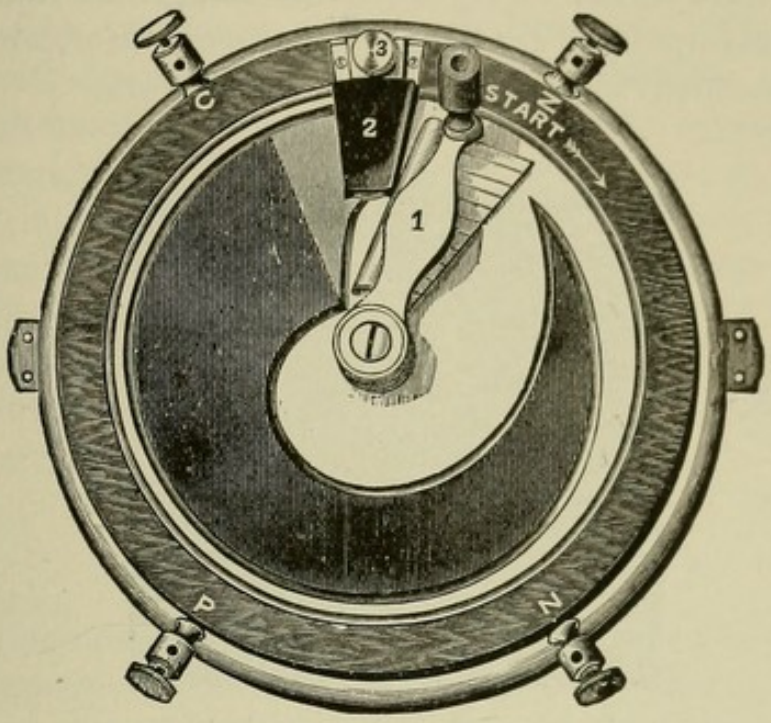


Fig. 22. Massey Current Controller.

up to the terminal where the graphite unites with the metallic surface, which is in direct contact with the battery without any material resistance. When the crank 1 (Fig. 22) is placed to the right of the hard-rubber bridge, the contact comb of the crank rests entirely on the porcelain and the circuit is open ; moving it slightly forward, it so touches the sickle point that the graphite circuit permits the least amount of current to pass through, since the current must pass over the whole area of the graphite. By turning the crank slowly and steadily onward, there is a gradual increase of current without shock, until finally the metallic surface is reached when the whole power of the battery is turned on. A reversed movement turns the current off. If the motion is made slowly the increase and decrease is extremely gradual, a very important point in these applications.

In using this rheostat with the incandescent current, it should be connected with a volt selector (Fig. 18) to regulate the initial current instead of using the current directly from the mains. In using this current, the comb should never be carried as far as the metallic surface, as the resistance is so rapidly reduced at this point that it would cause a shock.

The Jewell graphite rheostat (Fig. 23), which is made on the principle of the Massey current controller, is also a useful instrument.

In order to use the graphite rheostat without the aid of an assistant, I have devised a *cog-wheel attachment*, so that the rheostat can be manipulated by the foot of the operator, which I have found a convenient arrangement for routine work.

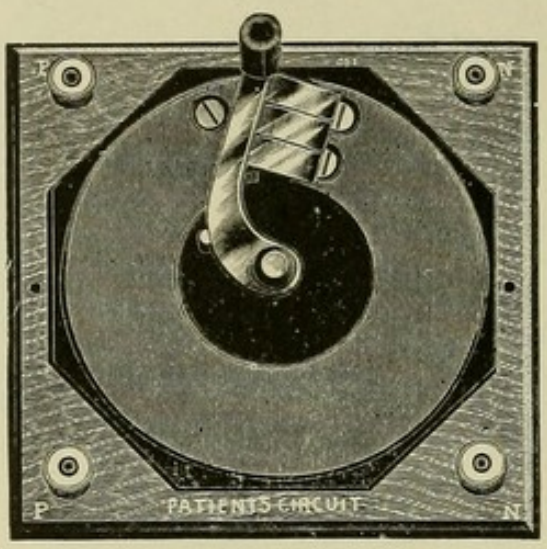


Fig. 23. Jewell Graphite Rheostat.

A number of instruments have been made for controlling the incandescent light current for general therapeutic work. Among these are the McIntosh current controller, the Gish rheostat, and the Vetter current controller. All these instruments work on the shunt principle by allowing the main current to pass through a continuous wire or other material offering a certain amount of resistance, and, by a special mechanism, the quantity of current to be used is diverted at the will of the operator into a circuit which includes the patient.

The McIntosh and the Gish rheostat are both serviceable instruments. The Vetter is also satisfactory when weak currents are used. It is not practicable for strong currents on account of its proneness to burn out if these are used. In this instrument it is also difficult to see whether the current in the rheostat is off or on, and this may be the cause of producing an unintentional shock to the patient.

The Committee on Constant Current Generators and Controllers of the American Electro-Therapeutic Association (8) has tested the following graphite rheostats: the Willms, the Vetter, the Massey, the Gebhart, the Reiniger and the Schall.

They found that the absence of liquid, and consequently of electrolytic action, renders this class of rheostat more universally serviceable than any form of liquid rheostat that was tested by the Committee.

The wire rheostats, when intended to be used in electro-therapeutic practice, are made of German-silver wire, which alone furnishes a resistance sufficiently high for this purpose. The quality of the workmanship and the amount of wire necessary render this very expensive, and they are not often seen in cabinets of American manufacture. When properly constructed, a wire rheostat has much greater exactness and constancy than other forms of rheostat, and, by regulating the quantity of wire resistance, any degree and amount of current may be obtained. Very excellent instruments of this type are made by Gaiffe, Gebhart, Reiniger and Schall.

MILLIAMPERE-METERS.

The milliampere-meter used for measuring the galvanic current should be sensitive, accurate and "dead beat," that is, the pointer of the instrument should come to a standstill without an unnecessary number of vibrations. There is a large number of milliampere-meters on the market, but it is difficult to obtain one which can be relied on with any degree of precision. Unfortunately, the few meters, such as the Weston, D'Arsonval, etc., which are reliable, are very high-priced. Where one of the cheaper instruments is used, it should be gauged by means of a standard meter, and the records will then be fairly satisfactory. Without such form of measurement, the results will be as unsatisfactory as the druggist who would dispense chemicals without his scales.

Very few meters are sufficiently accurate to differ less than 5 per cent. from the standard instruments, and some meters, which I have examined, varied to the extent of 30 per cent. Unless a standard meter is used, a list of corrections should be made with such a meter, so that when cases are reported, an intelligible idea may be had of the strength of the current used.

In the older milliampere-meters, the measure of the current was made by the deflections of a magnetic needle from the North Pole. These instruments were influenced by so many extraneous causes that they were especially unreliable. In the milliampere-meter of the chloride of silver dry cell battery (Fig. 24), the mag-

netic needles are so arranged that they are free from the influence of the earth's magnetism, and the instrument need not be set with reference to the North Pole. This instrument contains three reading scales stamped on the three faces of a celluloid roller; the range

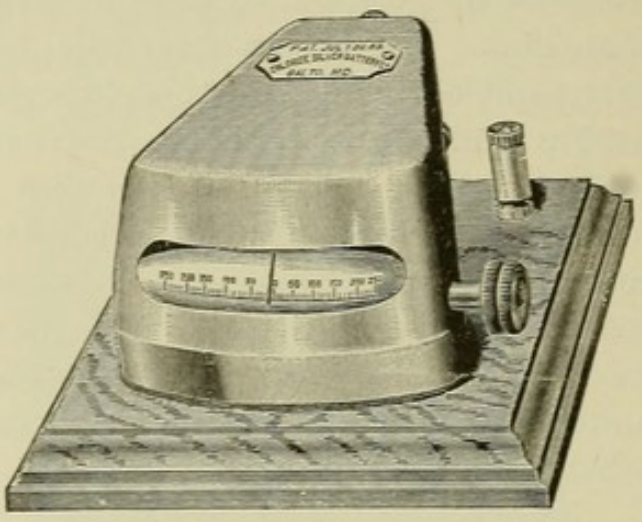


Fig. 24. Milliampere-Meter.

of the scales is from $\frac{1}{2}$ to 5, 25 and 250 milliamperes respectively, thus making the measure capacity of the meter from $\frac{1}{2}$ to 250 milliamperes. This instrument is not claimed to be an absolute test of precision, but is a convenient and comparatively inexpensive guide to the practitioner in his therapeutic work.

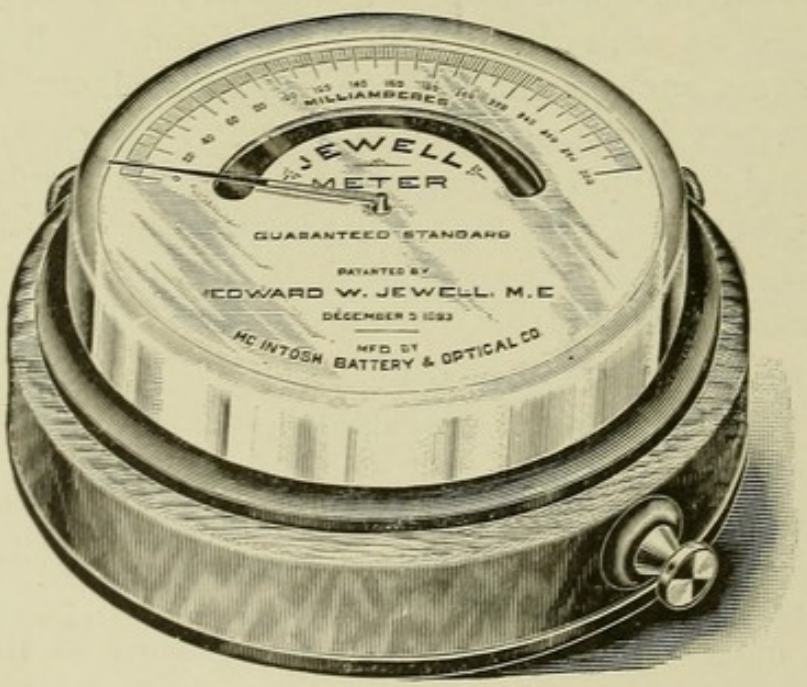


Fig. 25. The Jewell Milliampere-Meter.

A standard portable instrument should not be affected by extraneous influences, such as fan-motors, permanent or electro-

magnets etc., and should, therefore, have no iron or steel in its moving system. The Jewell meter (Fig. 25) is made on this principle and the permanent magnet, which is used in the D'Arsonval meters, has been replaced by a new form of magnet and magnetic circuit, which it is claimed is superior in that it prevents the magnets from losing their strength. The Jewell meter has the following advantages claimed for it: It is not influenced by neighboring magnets, motors, dynamos etc., the only force that will affect the needle being the current to be measured. The meter is portable and can be arranged to be used in any position, either horizontal, inclined or upright. It has two scales, one being arranged to read from the side of the instrument and the other from the top. The range of the meter is from 0 to 300 milliamperes. A pole-changer is placed in the instrument circuit so that currents flowing in either direction may be measured without disconnecting the wires from the binding-posts.

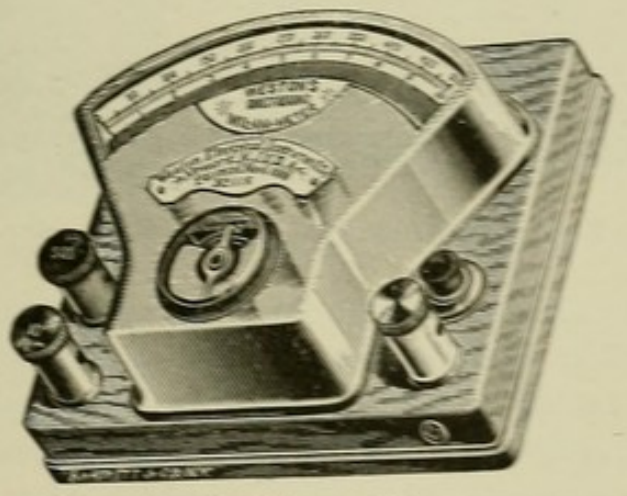


Fig. 26. The Weston Mil-am-meter.

The Weston mil-am-meter (Fig. 26), which is a standard meter, is a direct reading instrument, and all scale-readings begin at zero and extend by practical uniform increments to the maximum readings. The instrument is "dead beat," that is, the pointer comes to rest at once, thus reducing the time required for reading and preventing unnecessary wearing of the moving parts. The temperature correction is negligible, and the instrument can be kept in circuit any length of time without appreciable heat effects.

A one-quarter-size cut of this mil-am-meter is shown in Fig. 26. In the double-scale instrument, a change from one scale to the other is made by changing the connection on the left of the

instrument from one binding-post to the other, the scale used being of the same color as the binding-post to which the wire is connected.

The Vetter mil-am-meter is shown in Fig. 27. It is a direct reading instrument, and has the advantage of being vertical, which is useful in many cases.

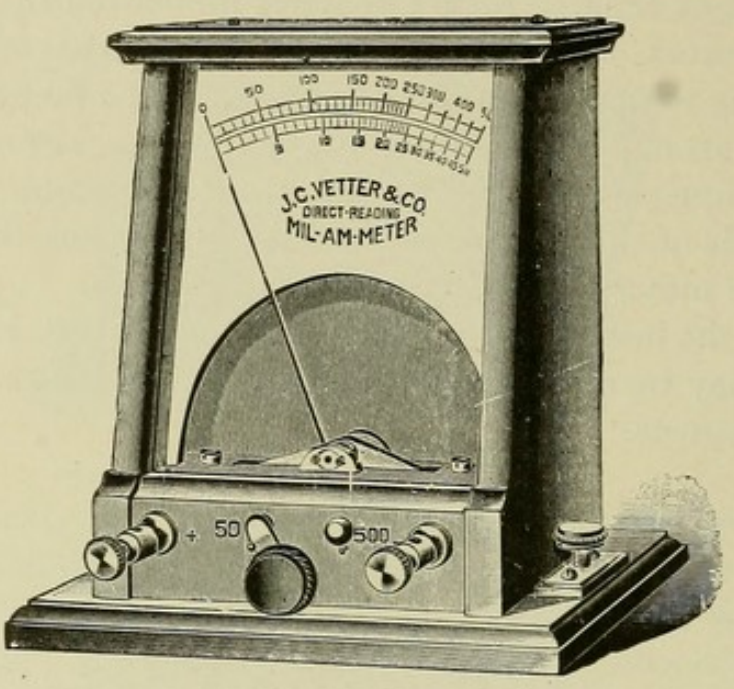


Fig. 27. The Upright Vetter Mil-am-meter.

The Committee on Meters of the American Electro-Therapeutic Association, in reporting the results of their examinations before the third annual meeting of the Association held at Chicago, Sept. 13, 1893, called attention to the necessity of using a meter that should be a standard instrument, which when registering five milliamperes in the hand of one person will not register six and even seven with another. Without such a standard, physiological experiments and clinic records lose much of their value as far as scientific accuracy is concerned.

The Committee made careful tests of eight of the most popular meters on the market, and reported that the Weston and Kennelly meters were the best of those which had been tested. Where another milliampere-meter is used, its accuracy should be tested by a meter of known standard and precision, and, if the variations are comparatively small, a scale should be made by means of which the records can be corrected. If these variations are too large or irregular, the meter had better be abandoned for a more accurate one.

This Committee (8) also reported favorably on the milliampere-meter made by Jerome Kidder. The instrument is a type similar to the Weston and Kennelly, and is practically unaffected by outside magnetism. By means of a proper "drag," the instrument may be practically made "dead beat." The scale is clear and convenient, and the instrument may be made either for horizontal or vertical use.

The McIntosh milliampere-meter was not found to be accurate in its reading, and in the upper part of the scale the difference was very great; it is readily affected by outside influences.

The D'Arsonval instrument, which is acknowledged to be of superior quality, was not submitted to this Committee for testing.

The *pole-changer switch* (Fig. 28) is used for reversing the cur-

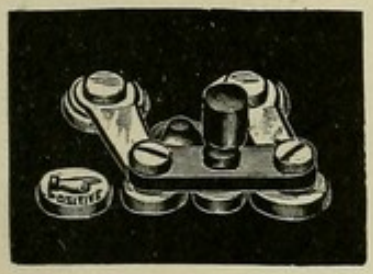


Fig. 28. Polarity Changer.

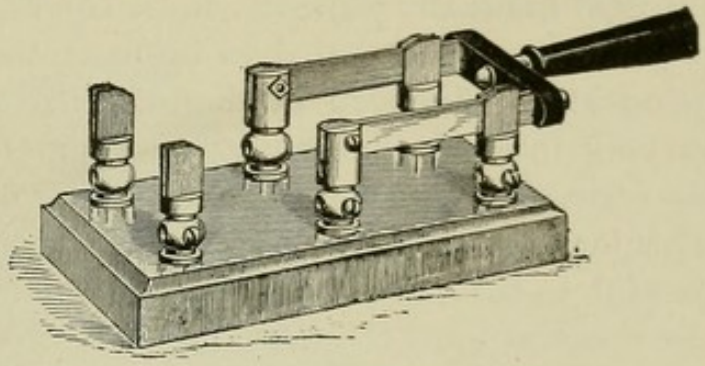


Fig. 29. Knife-Switch Polarity Changer.

rent, thus making the negative electrode the positive, and the positive the negative. It is sometimes used to make the breaks in the interrupted current, and when this is the case only mild currents should be used, to avoid shocking the patient.

A switch which may be used with the chemical battery is shown in Fig. 28. For the incandescent current, a switch (Fig. 29) made after the fashion of the knife-switch is necessary in order to prevent a short circuit in the act of changing the poles.

CHAPTER IV.

Method of Applying Galvanism.

WHEN a galvanic application is to be made, the electrodes which have first been moistened are applied, and the rheostat gradually adjusted until the meter indicates the number of milliamperes intended to be used, the strength of the current being also influenced by the tolerance of the patient. After a varying interval, the pointer of the meter will begin to move up the scale, showing that a larger number of milliamperes is passing. This increase of current is sometimes considerable and may prove painful to the patient. It is remedied by raising the carbon of the rheostat until the meter again indicates the required number of milliamperes.

As regards the cause of this increase in the current, a number of explanations has been given. Rockwell (6) does not believe this to be due to the increased blood supply to the part traversed by the electric current, from the passage of this current. No doubt, however, this has a certain influence, an important cause being the moisture from the electrodes penetrating the skin, and decreasing its resistance.

When the application is to be discontinued, the rheostat should be slowly returned to its starting-point, when the pointer of the meter should indicate zero. If this is not done by means of a rheostat, even a light application will shock the patient.

If, for instance, it is intended to administer a current of 10 milliamperes, and these are suddenly applied by means of a switch, the patient would receive a disagreeable shock, and a second shock would result from the sudden breaking of the current, due to the counter-electro-motive force of the broken circuit; if, however, the current is turned on gradually by a proper rheostat or cell selector and also reduced slowly, there should be entire absence of any shock.

INTERRUPTED GALVANIC CURRENT.

In certain cases the application of the interrupted galvanic current is indicated. Many electrode handles are supplied with an interrupter for this purpose, or this may be done by means of the starting switch by which the circuit is alternately opened and closed. Certain instruments called *rheotomes* have been devised, by means of which these interruptions may be made automatically. Generally speaking, only mild currents should be used in these cases, as the patient feels both the shock of the closing and of the opening of the circuit.

One of the instruments, by means of which these interruptions may be made automatically and with different degrees of rapidity,

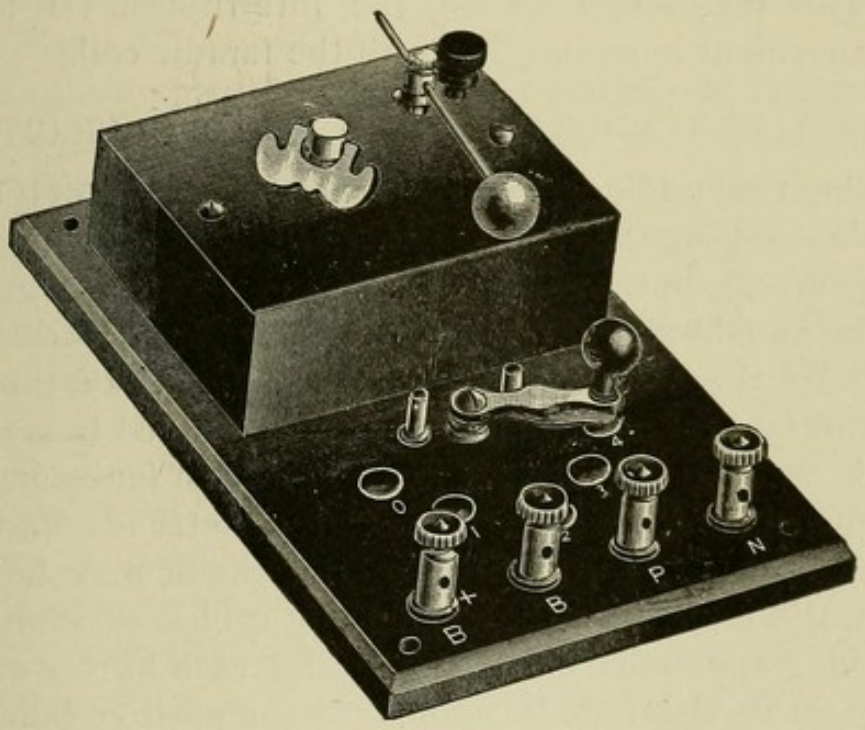


Fig. 30. Automatic Rheotome.

is shown in Fig. 30. This apparatus contains a spring which is wound up as in a clock, and which operates a pendulum, adjustable in length, by means of which the interruptions are effected. The rate of the interruptions is further regulated by a switch, so that the range of the instrument is from 6 to 660 interruptions per minute.

A method which I have found convenient and effective in making these interruptions, is by means of a small *electric motor;* an ordinary fan or drill motor, or one used for operating a static electric machine, will answer the purpose. A commutator, so made that one revolution of the shaft will give 5, 10 or other

number of contacts, is attached to the free end of the shaft of the motor. A small brush is placed against the commutator and connects with the positive wire of the galvanic circuit. Another brush is placed against the shaft, and the wire from this is connected with the positive binding-post of the table.

When the motor is set in operation, one revolution of the shaft will give as many interruptions as there are contacts in the commutator, and the number of contacts may be varied by increasing or decreasing the speed of the motor. By having two or three commutators on the shaft, the first with one, the second with ten, and the third with 50 contacts, on a sliding brush so arranged that it may be placed in contact with one or the other commutator, we will have an apparatus for effecting a wide range of interruptions. This method of making the interruptions, I have also found convenient in connection with the faradic coil.

TESTING THE GALVANIC AND FARADIC CIRCUITS.

In using the faradic coil, the existence of the current is indicated by the buzzing of the instrument. The silent discharge of the galvanic current, however, requires some other test. A milliampere-meter should always be in the circuit, and the working of this will indicate the existence, as also the strength of the current. Where this fails to indicate, it should be examined to see that the pointer is not restricted in its movements by a faulty levelling of the instrument or otherwise. Where the meter is found to be in good condition, the interruption of the circuit may be due to a defect in the electrodes, the conducting cables, or some point of the working apparatus, and these should each be tested in turn. If the negative electrode be applied to the positive binding-post, and the milliampere-meter indicates a current, the fault then lies in the binding cords or electrode of the positive side; if the fault is not there, the test should be applied to the negative binding cords and electrode; and this method should be continued until the fault is located. In making these tests, care should be taken that the current is not passed through the milliampere-meter without the resistance of the rheostat.

TESTS FOR POLARITY.

In all the applications of galvanism, electrolysis, cataphoresis and catalysis, it is important to determine the *negative* from the *positive pole*. The terms "positive" and "negative" are synony-

mous with *anode* and *cathode* respectively, these names being given by Faraday to the terminals by which a current enters and leaves an electrolytic cell; the anode being the terminal by which the current passes into the electrolyte, and the cathode by which the current passes from the electrolyte.

There is a number of methods for determining the polarity: Connect wires to each of the binding-posts, dip their ends into starch water containing iodide of potash in solution; the iodide of potash will be decomposed or electrolyzed, the iodine appearing at the positive pole and the potash at the negative. The nascent iodine combines with the starch, showing the characteristic blue color of this reaction. The wire at which the blue color appears is the positive, and the other the negative pole. When this has once been determined, the binding-posts should be marked *P* and *N* respectively.

A more convenient method of determining the polarity of the electrodes is as follows: Saturate a small piece of blotting-paper with a solution of iodide of potash. On touching the moistened blotting-paper with the electrodes, a brown spot will immediately appear under one of these electrodes, due to the liberation of iodine at this point. This is the positive and the other the negative pole.

ELECTRODES.

Electrodes may be either *active* or *dispersing*. The dispersing electrodes are used in the unipolar method of applications, and are made so large that the current will give rise to no irritation in passing through the skin. These electrodes are usually made of thin, pliable plates of lead, copper (Fig. 31) or zinc, preferably

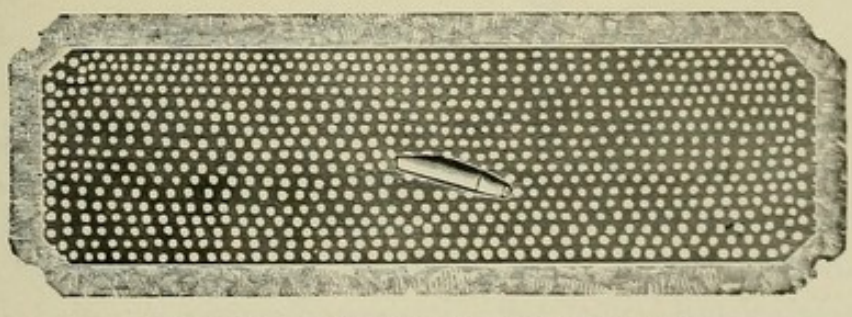


Fig. 31. Dispersive Copper Electrode.

perforated, and these are placed on the back, chest, neck (Fig. 32) or other part of the patient where there is sufficient space. They should be covered with a layer of absorbent cotton, which

should be moistened before use. As the active electrode is modified in size and form according to the purpose and location to which it is to be applied, a large number of these are in use.

The McIntosh carbon electrode (Fig. 33) has an attachment by which the cotton is held in position. This is also the case in the universal electrode (Fig. 34). The use of absorbent cotton

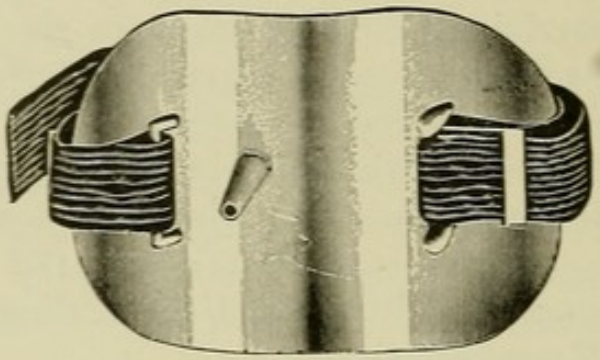


Fig. 32. Arm and Neck Band Electrode.

in this connection, has almost entirely supplanted the sponges and flannel cloths formerly recommended. The cotton is easily adjusted, and there is little difficulty in covering the electrode with a new piece for each patient, thus preventing him from speculating as to the cutaneous condition of the last patient on whom the electrode was used.

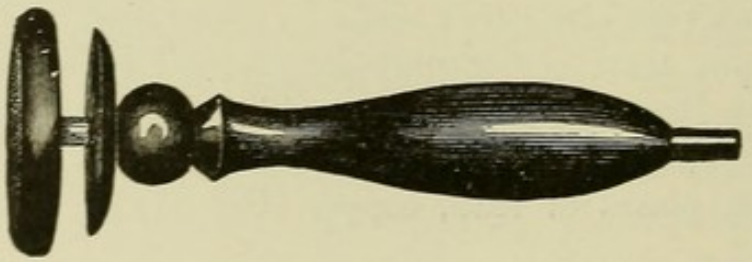


Fig. 33. McIntosh Carbon Electrode.

For the conducting surface of the dispersing electrode, the Committee of the American Electro-Therapeutic Association (9) recommends white sculptor's clay, one-half inch thick, moistened to the consistency of soft putty. It is desirable that the conducting material should part with its water only enough to moisten the epidermis, but not enough to wet the patient's clothes. This is the objection to absorbent cotton, sponge and punk. For application, the clay may be covered with a layer of absorbent gauze, and thus avoid soiling the skin or clothes of the patient.

The contact with the clay should be made with copper-wire gauze insulated with common table oilcloth.

When an electrode is applied without a sufficient moist surface to protect it, a considerable burning may be produced at this point, and, if continued, will result in an ulcer which is usually

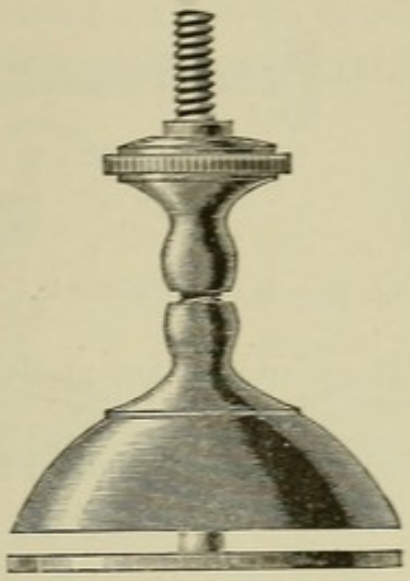


Fig. 34. Universal Electrode.

protracted in healing. The cause of the caustic action is a mixed one; it is partly due to the electric action of the current itself and to the chemical effects of the products of the chemical decompositions that have been effected. This chemical action is sometimes utilized as a local counter-irritant.

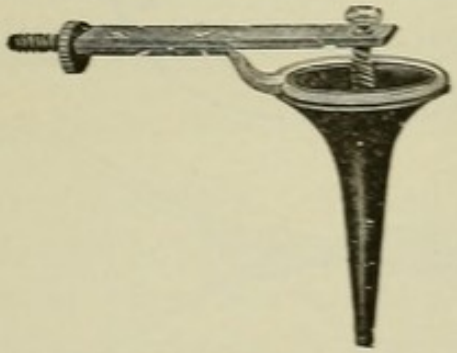


Fig. 35. Ear Electrode.

When salt is added to the water with which an electrode is moistened, it increases its conductivity. An electrolysis of the salt is also set up, which, in addition to the increased current, renders it more painful than when simple water is used.

Active electrodes are made in a great variety of forms, being especially adapted to the part for which they are to be used.

Fig. 35 represents an ear electrode consisting of a hard-rubber ear speculum with a brass rod for making electrical contact. When used, the auricular canal is filled with warm water for the application of galvanism or faradism, or with the solution to be used, if cataphoresis is to be applied. Fig. 36 shows a biaural

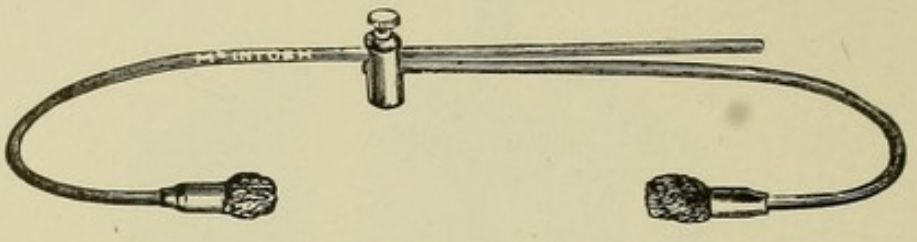


Fig. 36. Biaural Electrode.

electrode, with which the contacts are made by means of moistened cotton.

An internal laryngeal electrode is shown in Fig. 37, the curve, however, being too obtuse for ordinary use. The writer has de-

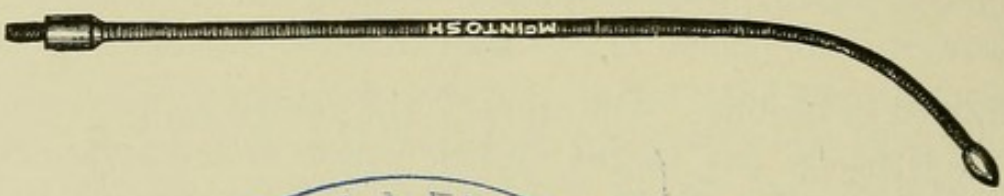


Fig. 37. Internal Laryngeal Electrode.

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vised a double external electrode (Fig. 38) especially adapted for galvanism and cataphoresis in goitre, and for external laryngeal applications, as in paralysis of the laryngeal muscles. It consists

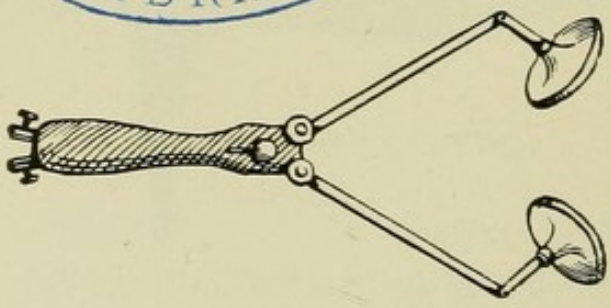


Fig. 38. Scheppegrell's Electrode for External Laryngeal Application.

of an insulated handle, from which project two brass rods, which are pivoted from the handle but which may be fixed in any position by thumb-screws. At the end of each rod is a brass disk which is also moved on a pivot. This arrangement allows the disk to be applied flat to any portion of the neck. There are three pairs of

disks, respectively one-half, seven-eighths and one-fourth inch in diameter, any pair of which may be adjusted to the instrument. When applied, the disk should be covered with moistened absorbent cotton; the handle is provided with an interrupter.

The pair of single electrodes (Fig. 39) may be used alone or together, as for external galvanism of the larynx or cataphoric applications for goitre. When used for this purpose, the elec-

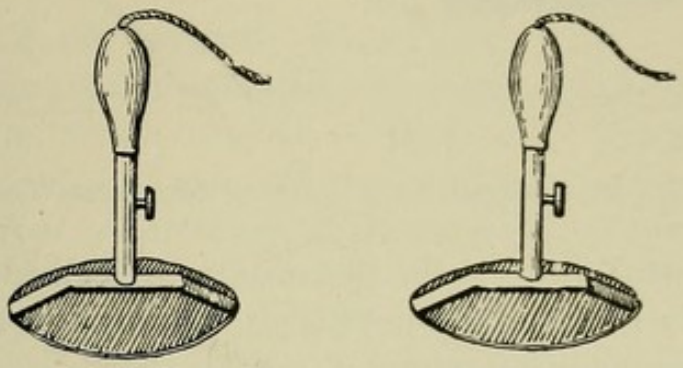


Fig 39. Scheppegrell's Single Electrodes.

trodes are applied to the goitre, and a band passes over the electrodes, under the loops and around the neck, the electrodes being thus held in position. They may also be used instead of the ordinary electrode.

An electrode which I have found useful in nasal applications is shown in Fig. 40. It consists of three and one-half inches of copper wire, threaded at one end and insulated by a thin rubber



Fig. 40. Nasal Electrode.

tube for three inches of its length. A small copper bulb may be attached to the end, or a small piece of absorbent cotton may be used for this purpose. It is attached to a universal handle.

A number of other electrodes is used in the treatment of pathologic conditions of the nose, throat and ear, but these will be described in the sections referring to these diseases.

The electrodes used with the *faradic* current are, in the main, similar to those used in the application of galvanism.

CONDUCTING CORDS.

The conducting cords of a battery are composed either of a single wire, or a bundle of fine wires, the latter being more useful

as they are more flexible. These wires should at all times be thoroughly insulated. The size of the wire will depend upon the character of the current and the object for which it is to be used.

A universal tip for conducting cords, which I have found very useful, is shown in Fig. 41. It is perforated, so that while the

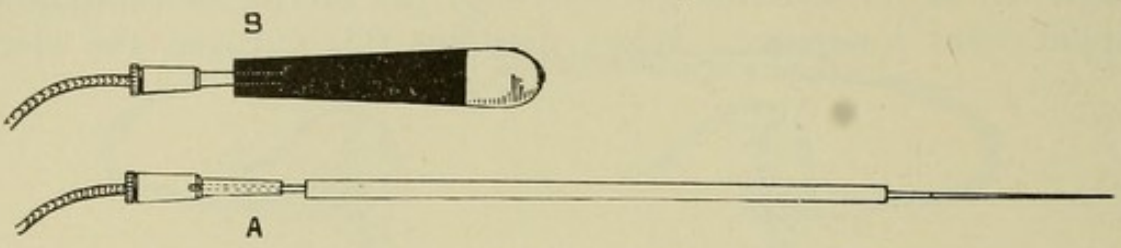


Fig. 41. Scheppegrell's Universal Attachment Tip.

exterior fits into openings in the ordinary electrode (B), needle electrodes may be inserted directly into the tip (A) so as to avoid more bulky means of attachment.

The current used for galvanism and faradism is of high tension and small quantity, and the connecting cords may be of small diameter. For the electro-cautery, however, where a low voltage

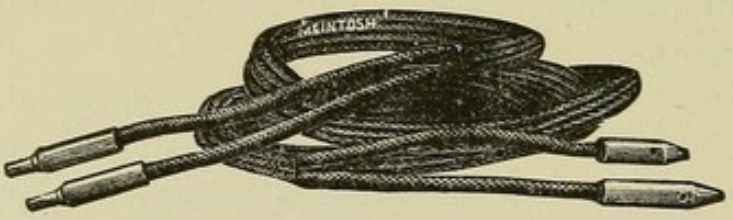


Fig. 42. Insulated Conducting Cords.

and a large quantity are used, the wire should be of large size (Fig. 42) so as to introduce no unnecessary resistance into the circuit. The best conductors are the metals. Of these, silver has the highest specific conductivity (100), the next being copper (77), zinc (27), iron (14), platinum (10) and lead (8).

CHAPTER V.

INDUCED CURRENTS.

THE use of the induced current dates back to the year 1832, when Faraday discovered that a galvanic current was capable of inducing other currents in wires near but not in contact with the conductor of the primary galvanic current. These currents are only of momentary duration, being present only when the circuit is closed and when it is opened ; the closing causes the *inverse* and the opening the *direct* current.

A common example of the induced current may be observed in the use of the commercial telephone, especially when this is used at night, where wires of an alternating electric-light current pass in proximity to the telephone wires. The alternations of the electric-light current develop induced currents in the telephone wires, which are transmitted to the ear in the form of a buzzing sound, which frequently interferes with the proper use of the telephone.

Induced currents may also be generated by a magnet, which is in conformity with Ampere's theory that a magnet is only a form of solenoid, and that each molecule of magnetic substance is traversed by a closed electric current.

FARADIC COIL.

The faradic coil is an apparatus for developing induced currents, which are generated by the action of an electric current whose circuit is alternately opened and closed. While made in a great variety of forms, they all consist essentially of a hollow cylinder in which is a bar of soft iron, or a bundle of wires, with two spiral coils around it, one called the *primary* coil, which is connected with the poles of a battery, the circuit of which is alternately opened and closed by an automatic arrangement called a *rheotome ;* and the other, a *secondary* coil, in which are developed the induced currents by the action of the galvanic current within the primary coil.

The working of the interrupter, or rheotome, depends upon the fact that when a current of electricity is passed through a coil of wire around a bar of soft iron, it magnetizes it, but as soon as the current is broken the iron loses its magnetic properties. When a current is passed through the interrupter, the magnetized iron bar attracts the hammer of the interrupter from the platinum point by means of which the circuit is closed. As this breaks the contact, the hammer is no longer attracted by the iron bar and falls back against the platinum point which again closes the circuit; and thus the process is continued automatically.

When the circuit is closed, the current passes through the primary coil which generates the inverse induced current in the secondary coil. When the circuit is opened, the direct current passes through the secondary coil. The terms "inverse" and "direct" refer to the directions of the current, the direct being in the same direction as the primary (galvanic) current, and the inverse in the opposite direction.

The strength of the induced current depends upon the position and arrangement of the coils and the iron core, and upon the relative length and thickness of the wires of the primary and secondary coils.

In the ordinary faradic coils, the induced current is much higher in potential than the current which generated it, and in some of the larger coils, as, for instance, in those used for generating the X-rays, the voltage of the induced current is frequently immense. The direct induced current is of short duration, but of high potential. The inverse current is of longer duration, but of lower potential. The electric phenomenon of this apparatus follows the law of the conservation of energy. While the current gains in intensity it loses proportionately in quantity.

On the other hand, the reverse may also be obtained, that is, the gain in quantity and the loss in potential, and this principle is used in the application of the alternating current for incandescent lighting. For this purpose, the current is passed through an outer coil of many turns and high resistance, the inner coil being of heavy wire and low resistance, and an induced current is generated which is of decreased intensity but of increased quantity. In this manner, a current of one ampere and one thousand volts may be passed through a converter and generate a current of approximately ten amperes and one hundred volts.

It has been found that it is commercially more economical to

carry a current of high potential, there being a great saving in the cost of the copper conduits, as much lighter wire may be used. The alternating current is conducted from place to place at a high voltage and by means of these converters transformed to the required potential wherever needed. This principle has been carried out on a large scale in harnessing the energy of Niagara Falls and conveying it in the form of an alternating current of high potential to the neighboring cities, to be there applied for illumination, operating electric-car systems etc.

The intensity of the induced current depends not only on the strength of the primary (inducing) current, but also on the length of the wires in the secondary coil, and upon the size of the iron core. By the increase in size of the secondary coil, a galvanic current of such a low voltage that it can scarcely be felt, may be

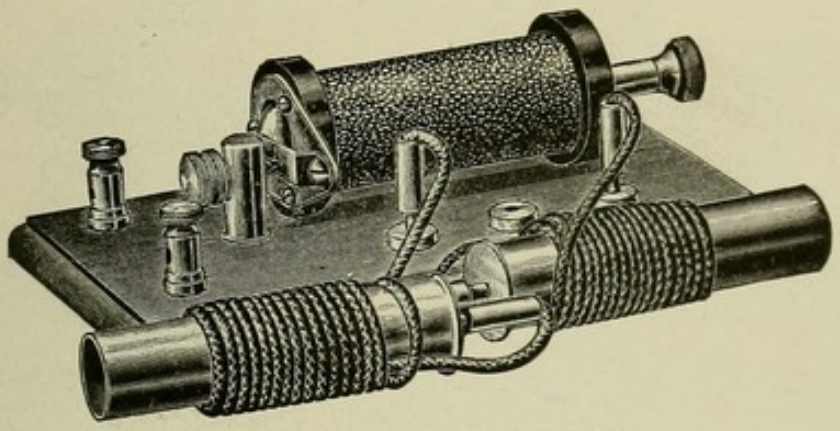


Fig. 43. Simple Faradic Coil.

made to generate an induced current of the most unbearable intensity. The strength of the induced current is lowered by withdrawing the iron core, and in the improved faradic coils also by withdrawing the secondary coil.

As the wire of the primary coil through which the current passes is short and thick, its resistance is very low, and the potential of the galvanic current for operating it should be correspondingly low. As, however, considerable quantity is required, the ordinary salammoniac battery should not be used, as it soon becomes polarized and the current from some form of battery, such as the Edison-Lalande, bichromate of potash, gravity etc., or a storage battery, should be used. The current from one cell (2 volts) of a storage battery, or an equivalent current from a constant chemical battery, will be sufficient to operate the faradic coils used in electro-therapeutics; and if a current from more cells is

used, it should be regulated by a wire rheostat. The effects of a stronger current can, of course, be counteracted by withdrawing the iron bar or secondary coil, but it is wasteful of the current and injurious to the platinum point of the interrupter.

When the faradic coil is operated from the mains of the Edison current, it should not be used by means of a shunt rheostat used for the electro-cautery, as this is unnecessarily wasteful of the current. In the K. A. P. Dynamic Apparatus, for instance, there is a shunt which consumes six or more amperes even when no current is passed through the cables for the cauteries. As a faradic coil is frequently applied for a considerable duration of time, a more economic method should be adopted.

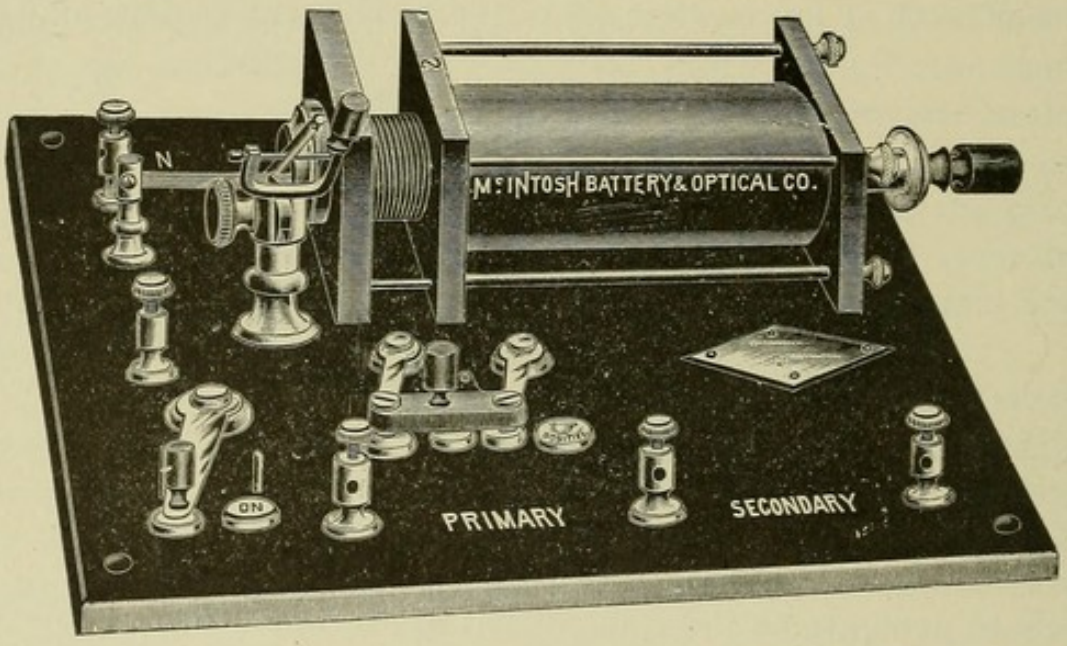


Fig. 44. McIntosh Faradic Coil with Adjustable Rheotome and Polarity Changer.

There is a large variety of *faradic coils* in use, most of which are more or less effective. Fig. 43 shows a simple form of faradic coil, which is sufficient in many cases of faradism. A more complete form of faradic coil is shown in Fig. 44, this having three secondary windings of different length and thickness of wire, pole-changer and adjustable rheotome for giving coarse or high-frequency interruptions, which will be found useful for the requirements of the majority of cases.

The Tripier induction apparatus is shown in Fig. 45. It is provided with a mechanism by means of which a variation from 50 to 3000 interruptions per minute can be effected. By means of a rack pinion (J), the secondary coil is moved backwards and

forwards over the primary; C is a pole-changer for reversing the current, and D is a contact button for arresting the current.

Another effective apparatus is the Dubois-Reymond coil shown in Fig. 46. It is provided with a slow and rapid current interrupter, a polarity changer, a calibrated scale by which the currents may be accurately registered, and a rack and pinion by which the current may be graduated. This faradic coil gives excellent results.

Some of the induction coils are so wound that, by placing simply a *lamp resistance*, as a 32- or 50-candle-power lamp, the coils may be very effectively worked in connection with the mains

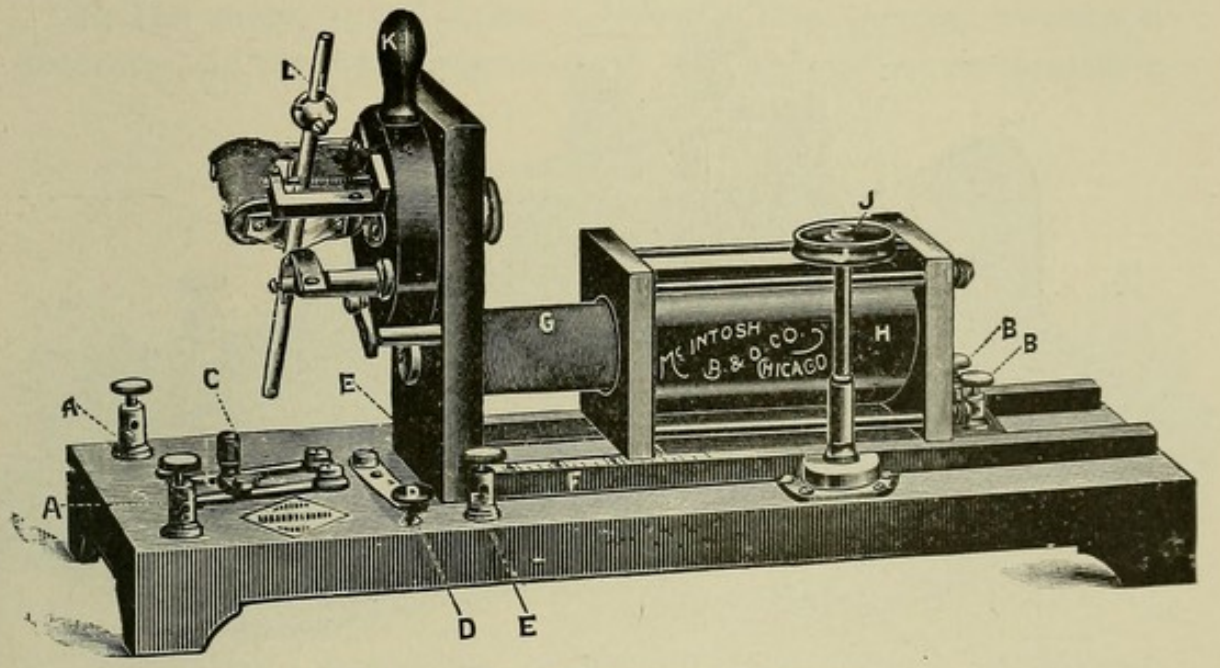


Fig. 45. Tripier Induction Apparatus.

of the Edison current, and with very little cost. With many of the coils, however, this method cannot be applied, as the break of a current of high intensity at the interrupter would cause a sparking in the rheotome, due to the counter-electromotive force of the broken circuit, which would soon destroy its usefulness. I have seen cases, thus connected with the incandescent light current, in which the platinum points had become fused and thus soldered to the opposite contact point.

This effect may be avoided in a simple manner, which I have used with complete success for several years. A coil of somewhat higher resistance than the primary coil of the inductorium is connected with the coil in such a way as to form a shunt. When the current is then obtained through a resistance of a 32- to 50-candle-

power lamp, the greater part of it passes through the primary coil of the faradic apparatus on account of its lesser resistance. When, however, the contact points are separated, the circuit is then not broken, as the current passes through the shunt and thus the sparking at the rheotome is avoided.

A very effective method of producing the slow and rapid interruptions for the faradic coil is by means of a *fan motor* or other motor to which a commutator is attached, as explained when describing the interrupted galvanic current. When this method of interruption is used, the platinum point of the rheotome of the coil is screwed up fast so as to prevent any interruptions at this point. The interruptions are then made by means of the com-

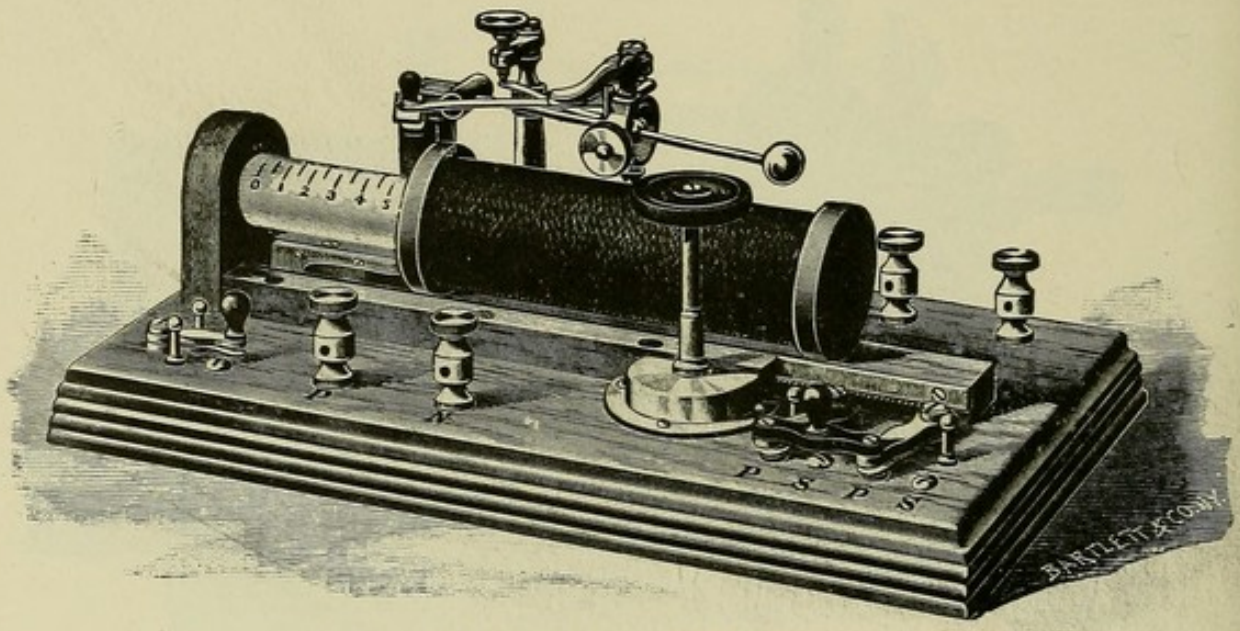


Fig. 46. Dubois-Reymond Faradic Coil.

mutator, through which the primary current is passed. The rate of the interruptions is regulated by the speed of the motor.

This method has been adopted in the " Edison Instantaneous Air-Break Wheel Apparatus " used with the Ruhmkorff coil for generating the X-rays.

Instead of adjusting the strength of the secondary current by means of the iron core or secondary coil, it may also be done by means of the rheostat, such as the water or carbon resistances used for the application of galvanism. The faradic coil is then allowed to produce a full induced current, which is regulated in its application to the patient by means of the rheostat, through which the induced current is allowed to pass.

In using the faradic coil, the principle of the instrument

should be remembered, and if the vibrations do not commence when the switch is closed, spontaneously or by starting the vibrations with the finger, the various points of the circuit should be examined for the defect. The principle of the rheotome demands that the platinum points come in contact to close the circuit, so that the magnetism induced will draw them apart, and if they do not come in contact, this should be remedied by the adjusting screw. Where every part of the circuit is in good condition, the fault may lie in the battery which operates the faradic coil. This should then be examined and, if necessary, renewed.

MAGNETO-INDUCTION CURRENT.

In the magneto-induction apparatus (Fig. 47), the current is generated by the rapid approaching and removal of an induction

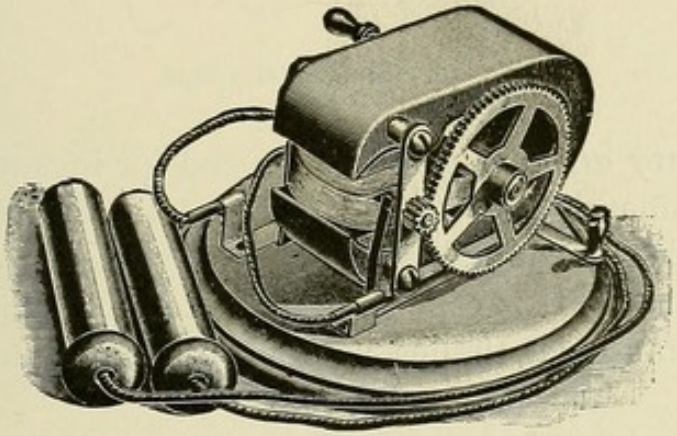


Fig. 47. Magneto-Electric Machine.

coil from a fixed magnet, or by the revolution of this magnet before the induction coil. Each new position of the magnet generates a current alternately inverse and direct. This principle was used in the magneto-induction apparatus, which were formerly much in vogue, but are now rarely seen. It has been entirely supplanted by the galvano-induction current.

STATIC INDUCED CURRENT.

The so-called *static induced*, whether developed from a frictional or an influence machine, is a current of an alternating discontinuity whereby currents of alternating directions commence and cease intermittently (Houston). It is characterized by a series of oscillations, and these may vary according to the size of the condenser, from a minimum of less than 1600 periods per second (or within the limits of audition) to 1,000,000 or more periods per second.

SINUSOIDAL CURRENT.

The sinusoidal current is an alternating current characterized by a successive rise and fall of potential, which is first in the positive and afterwards in the negative direction, both the rise and fall of potential not only corresponding in degree, but the expression of their variations forming what is mathematically known as a "sinsuoid" (Fig. 48).

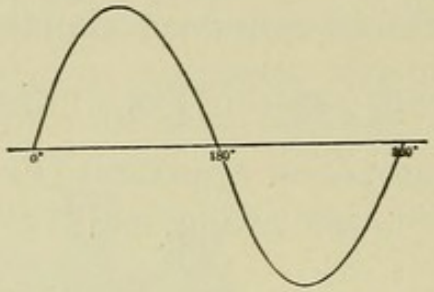


Fig. 48. Sinusoidal Curve.

The ordinary *alternating current* used for incandescent lighting, is approximately a curve of this character, and where it is applied, it should, of course, be adapted by means of a suitable current controller. It is especially indicated for exciting vigorous action of the muscular tissues, whether of the voluntary or invol-

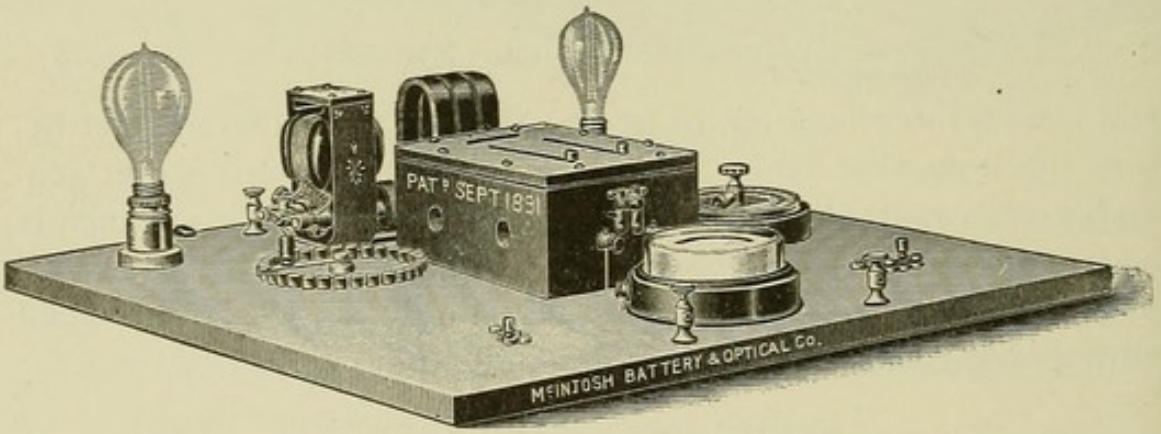


Fig. 49. McIntosh Sinusoidal Apparatus.

untary muscles. There seems to be a special property of this current in allaying pain, and Apostoli and others have used it with great benefit in the alleviation of pain in the pelvic organs.

The sinusoidal current, besides being almost painless, has great penetrating power, and, operated at a high rate of speed, the alternations are so rapid that polarization of the tissues is pre-

vented, consequently the maximum exciting effect is maintained. An improved apparatus for generating the sinusoidal current is shown in Fig. 49. It is operated by a motor wound for the 110-volt direct current, which together with the sinusoidal dynamo and the two rheostats (one for controlling the current for the sinusoidal dynamo, and the other for regulating the current to be applied to the patient) are attached to an insulated slate base.

This apparatus has also been so adapted that it may be operated by foot or water power, which is useful where the direct incandescent current is not available.

CHAPTER VI.

ILLUMINATION (93).

THE subject of lighting by electric incandescence has received much attention at the hands of many investigators, but it was Thomas A. Edison who first produced a commercial electric system of incandescent lighting. The success of his system depends upon two principal features: one being a lamp of high resistance by means of which any degree or sub-division of current is rendered possible, and the other a system of electric distribution by which the current is furnished as required to each lamp.

THE INCANDESCENT LAMP.

The incandescent lamp may be used in connection either with the alternating or the direct current. When used according to the Edison system of distribution, that is, a constancy of voltage (100 to 115) on the mains and the lamps in series with these, it is devoid of the danger to life of the high-potential currents which are generally used with the arc lamps.

In the incandescent lamps, light is evolved by the electric current which heats the filament to incandescence. In the original lamps, Edison employed platinum which was drawn to a very fine thread. When platinum becomes incandescent, however, it is very near its fusing point and a little addition of the current is sufficient to melt it. On this account, Edison afterwards adopted a fine filament of carbonized bamboo. In order to prevent this incandescent carbon from being consumed, the air is first exhausted from the bulb as far as practicable.

The filling of these globes with nitrogen, hydrogen and other gases, to the exclusion of oxygen, would likewise prevent the combustion of the carbon, but it has been found that when this is done, there is a loss of 50 per cent. per horse-power, which would make it commercially impracticable. The filament which yields the light is a carbonized strip of fibre of the size of a horse-hair. The diameter and length of this filament varies with the candle-power required and with the strength of the voltage current used

to operate the lamp. Originally the filament was given an oval shape, but recently the spiral form has been adopted, in order to obtain greater illuminating power without increasing too much the size of the bulb.

The incandescent lamp forms a convenient means of illumination for examining the ear, nose and throat. It gives a brilliant light with but comparatively small expenditure of heat; it is easily controlled, is not expensive, and does not give rise to the products of combustion, as with gas or oil lamps.

For ordinary examinations, a 32-candle-power lamp is sufficient, especially when the light is economized by some form of condenser or reflector. For special purposes, a 50-candle-power lamp may be required.

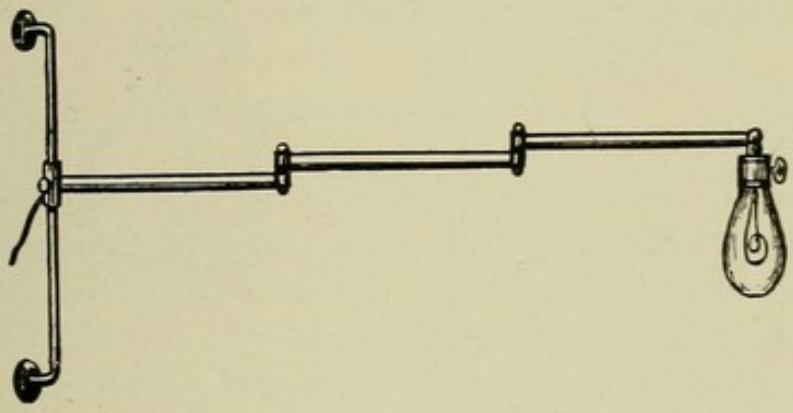


Fig. 50. Adjustable Incandescent Lamp.

When the rays from an ordinary incandescent lamp are focused by the head mirror, an inverted image of the incandescent filament is formed, which is sometimes annoying to the examiner. This has been remedied in the lamp devised by Delavan, in which an opal lens gives a concentration of light, but without the image of the incandescent filaments. The objection to this lamp is, however, that the opal lens absorbs so much light, that it loses much of its efficacy; but, by having this lens replaced by one of transparent glass, it may be made a very convenient source of light. One objection, however, is that the case soon becomes very much heated, and is liable to burn the operator in adjusting the lamp.

The incandescent lamp may be, for convenience, attached to an adjustable bracket, as shown in Fig. 50. A more convenient form, however, is the portable lamp devised by the author and shown in Fig. 51. This lamp is portable so that it can be attached to any incandescent-lamp plug, and by means of a cogged

arrangement it may be adjusted so that the lamp can be used at various elevations. Behind the lamp is a convex reflector, which not only projects the light forward, but prevents the light from illuminating the wall behind the lamp, which is objectionable. In front of the lamp is a powerful condenser for converging the rays of light, and, as the parts between the lens and the reflector are open, the lamp becomes but little heated. With this apparatus it

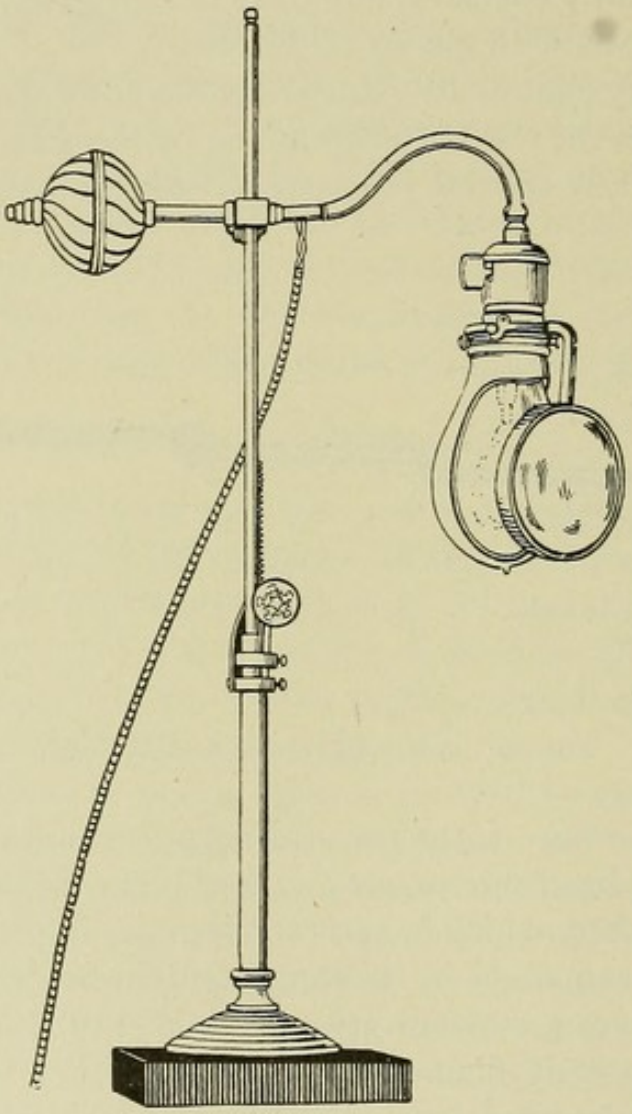


Fig. 51. Scheppegrell's Portable Laryngoscopic Lamp.

is possible to obtain from a 32-candle-power lamp more light than from an ordinary 100-candle-power lamp, and without the heat and expense of the larger lamp.

In referring to electricity as a means of illumination in laryngology, Chas. E. Sajous, of Philadelphia (2), calls attention to some of the inconveniences that are met with in using the incandescent light current, due to the irregularity of the current applied.

With the improvement in the incandescent-light system in the larger cities, these difficulties are now rarely met with. With a little understanding of the physics of electricity, many of the interruptions which are sometimes complained of are easily remedied. In several years' experience at the Eye, Ear, Nose and Throat Hospital, there was only one day that the electric lights could not be utilized, this being due to a large fire which had delayed the repair of the mains beyond the hours of the clinic. Occasionally an interruption of a few minutes was caused by a short circuit within the hospital, but this was soon remedied by removing the defective lamp or other source of the trouble, and by replacing the blown fuse, the location of each of which was thoroughly understood. This experience shows, however, the necessity of understanding the physics of electricity, even in those cases in which it is used only for its illuminating effects.

THE ELECTRIC ARC LAMP.

The arc lamp is rarely used in laryngoscopy. The light is so intense that close proximity to it, for any considerable length of time, would cause irritation and inflammation of the eyes. Sufficient illumination is also obtained from the safer incandescent lamps, so that the arc lamp is unnecessary in all but rare cases in which an intense degree of illumination is needed, and even in these cases the sunlight is a better substitute.

As already explained, when describing the systems used for electric lighting (*vide* Chapter II.), the arc lamps are generally used in connection with the high-voltage current, which is dangerous to life. They may also, however, be used with the 115-volt direct or alternating current, either by having two lamps in series, or by having a proper resistance when one arc lamp is used. When required in laryngoscopy or photography of the larynx, they should only be used in this manner.

The electric arc light has been applied for laryngoscopic purposes by E. Winckler, of Bremen (11). The lamp requires 60 to 80 volts and gives an illumination of 150 to 200 candle-power. As already explained, unless these lamps are supplied from an incandescent-light circuit, they present a grave element of danger. In the ordinary arc-light circuit, although the individual lamps require only 60 to 80 volts, the circuit itself may have an intensity of 2000 or more volts, the grounding or short-circuiting of which

would be dangerous to life. Even where this light is connected with the incandescent service, it gives a concentration of luminous rays from one point, which offers a very brilliant image, but is exceedingly irritating to the eyes. A number of cases have been reported in which inflammation of the eye of a serious nature has been set up by close proximity to these lights.

The recent introduction of the *enclosed* arc lamps, however, has rendered them practicable for many purposes for which they formerly could not be used. These lamps have also recently been made of smaller size, so that they can be used for many purposes for which the incandescent lamps were formerly applied. A lamp of this character (Fig. 52) has recently been introduced by the

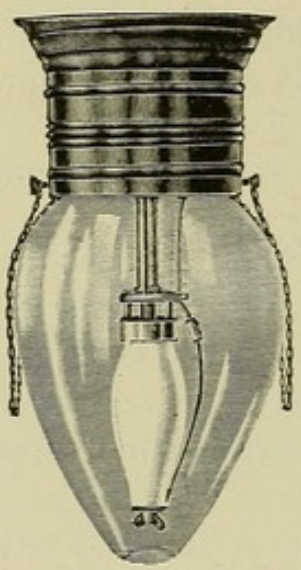


Fig. 52. Enclosed Arc Lamp.

Standard Thermometer and Electric Co., of Peabody, Mass., which is well adapted for laryngoscopic purposes. The enclosure of the arc gives a more diffused light, and does not give rise to the irritation caused by the unprotected arc.

THE PHOTO-LARYNGOSCOPE.

For photographic purposes, the arc lamp has decided advantage, and is used extensively in laryngeal photography.

Having had unsatisfactory results with the sunlight as the illuminating agent, T. R. French, of Brooklyn (12), has recently called to his aid the arc light, and with the most gratifying results not only with the larynx but also with the naso-pharynx and posterior nares.

The necessary outfit (Fig. 53) consists of a 2000-candle-power arc light partly enclosed in a metal box, the anterior face of which bears a condensing lens at a distance of nine inches from the box —the lens giving a focal distance of twenty inches. The lamp and accessories are fitted to a narrow board attached to a table with a device for raising and lowering the light. A shelf below

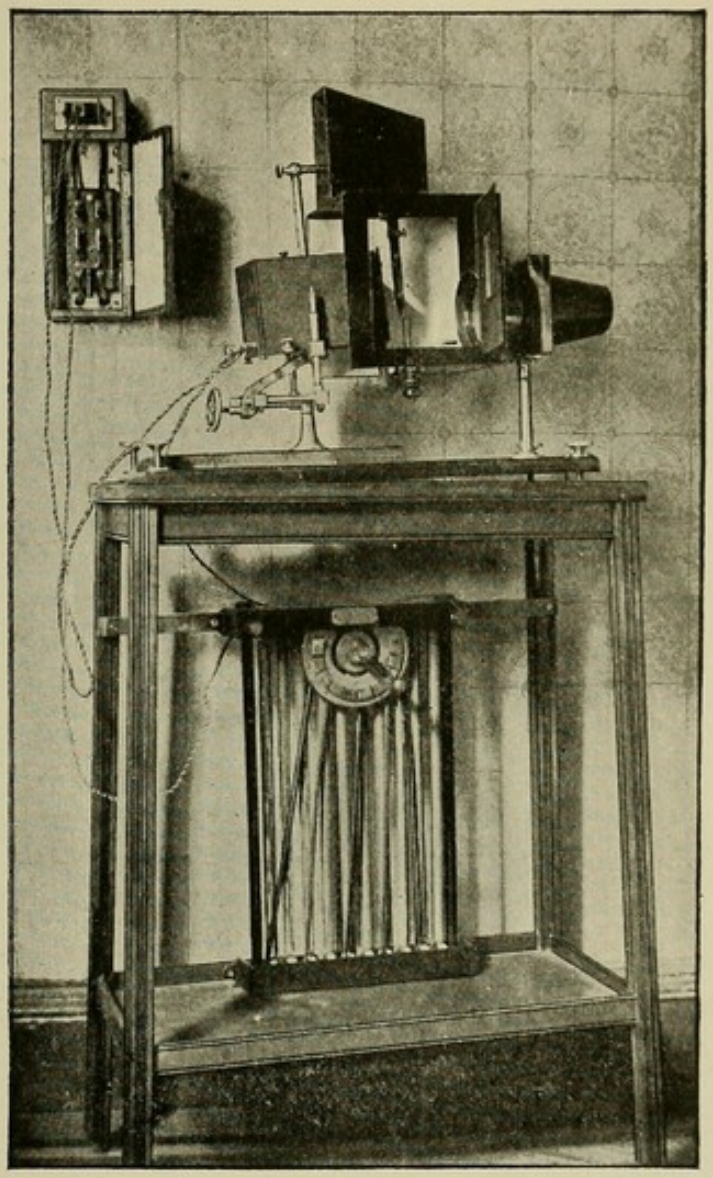


Fig. 53. Apparatus for Laryngeal and Postnasal Photography with the Aid of the Arc Light.

the table carries the rheostat, and the matter of technique is the same as with the sunlight condenser. A number of photographs obtained by this method is shown in Figs. 54, 55, 56.

The electric light has also been used by Stein, of Frankfurt, for making photographs of the interior of the eye, ear and larynx. Instead of the arc light, however, he has made use of the incan-

descent lamp. This light is much inferior to the arc light for photographic purposes, not only on account of its lesser brilliancy, but also because it does not contain all the elementary components of light, such as are present in the arc lamp.

Stein's photo-laryngoscope consists of a small camera which is placed on the handle of a "Nitze-Leiter" laryngoscope, which contains an incandescent lamp, as close to the mirror as possible.

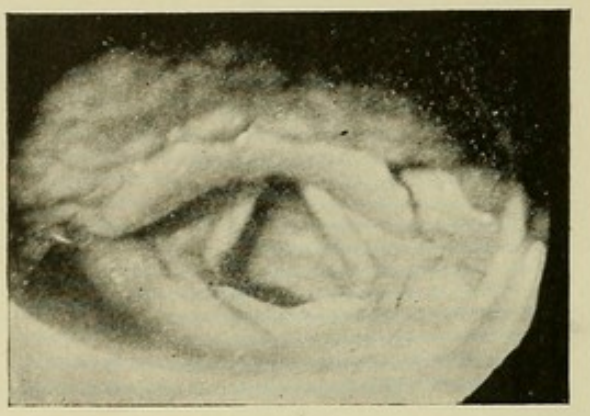


Fig. 54. Photograph of Larynx. (In Inspiration.)

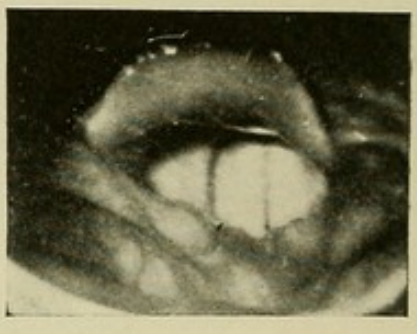


Fig. 55. Photograph of Larynx. (In Phonation.)

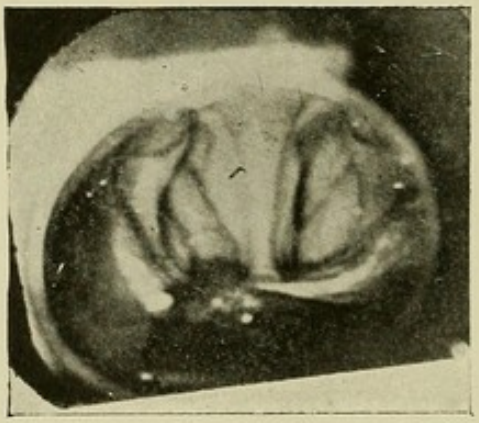


Fig. 56. Photograph of Nares.

The lens has a very short focus, and, by a fine adjustment, the image on the laryngeal mirror is sharply focused on the ground glass. Since the incandescent light is only about six centimeters from the larynx, it is well illuminated. When the ground glass falls back, a very sensitive dry plate is exposed. The exposure is made by means of a disk which rotates in front of the lens. A small bichromate immersion battery generates the current required for the lamp.

THE SCHUTT AND X-RAY LAMPS.

Another form of electric light was recently described by Schutt, of Jena (13), and called by him the Electrocapillary Light. This is also of much scientific interest, but whether it will be of practical and commercial value will depend upon future investigations.

When the discharge of an induction coil is sent through a narrow capillary tube about 0.05 millimeters ($\frac{1}{1500}$ inch) in diameter, provided with an aluminium or copper electrode and filled with air under ordinary pressure, an intense illumination of the threads of air is obtained—a luminosity which is far superior to that of the arc light, and one that would form an exceedingly brilliant source of light if it could be made continuous.

The narrow capillaries, however, deteriorate rapidly, are roughened inside, and are blown into a series of spherical enlargements. Wider tubes give less light, but are more permanent. At the same time, the bright lines in the continuous spectrum in the original light become more permanent. At a pressure of about one atmosphere, the phenomena are nearly the same, but the sparks pass with greater difficulty. At low pressure the light becomes less intense, the continuous spectrum fades and the bright lines shine out more distinctly. The kind of glass is immaterial. It is stated that tubes may be made 20 centimeters (8 inches) long.

The application of the X-rays for illumination has also been discussed, and at one time received considerable attention at the hands of our scientific and daily papers.

In this light, the effect of the X-rays on fluorescent salts is utilized, and the great advantage claimed is that it would furnish a light entirely without heat effects. The ordinary incandescent light has the advantage over gaslight in that it avoids filling the room with the products of combustion, but it, nevertheless, radiates considerable heat, as any one who has worked in the neighborhood of a 32- to 50- candle-power light can testify. The incandescent light is also objectionable in that the light emanates from a thin filament, which is irritating to the eye.

In the light produced by the action of the X-rays, there is not only the absence of the product of combustion, but also of the heat effects, and to such a degree that it has no influence on the most delicate methods of testing. An advantage of especial importance is that the light is not given off from a small point, as in

the arc lamp, or from a narrow filament, as in the incandescent lamp, but from the whole surface of the lamp, giving a soft and diffused light.

This lamp consists essentially of a Crookes' tube such as is used for generating the cathode rays, the glass condenser of which is coated with a fluorescent salt, such as tungstate of calcium or barium-platino-cyanid, which are also used as the agents for transforming the X-rays into luminous rays in the fluoroscope. The action of the X-rays on this salt has the effect of changing the character of the vibrations, so that instead of being invisible they become luminous and give rise to the peculiar white light that is seen in fluoroscopic examinations.

Theoretically, this is an ideal light because the energy is transformed into luminous rays without the loss of the energy involved in the generation of the caloric effects. Practically, it presents difficulties which at present appear almost insurmountable from a commercial standpoint. In the first place, the current required is of such high voltage that the ordinary methods of insulation would be entirely insufficient. This will easily be understood when we remember that the current used for the X-ray apparatus will spark three to ten inches or even more, according to the capacity of the coil and condenser. In the second place, the difficulty of obtaining and retaining the best degree of rarefication in the tube, which is met with in ordinary X-ray investigations and which it has been attempted to overcome by many contrivances more or less effective, will also be a great obstacle in making this light useful from a practical standpoint.

THE METHODS OF GENERATING THE INCANDESCENT LIGHT.

For the laryngoscopic lamps, the only effective means of generating a sufficiently strong and continued current is the incandescent street service, either alternating or direct. The various chemical and storage batteries, which have been recommended for this purpose, are so inconvenient and expensive, and require so much attention that they are but little used except where the street service is not available. For the smaller incandescent lamps, however, such as are used for the forehead illuminators, antrum lamps, etc., in which a lighter current is required, these may be illuminated by means of the Edison-Lalande or other constant chemical or storage battery, although these methods are

much inferior to the dynamic current of the incandescent system. The incandescent-light service may be used for these lamps either by some form of resistance, or by means of transformers.

The simplest apparatus for using these lamps with a resistance is shown in Fig. 57. It consists of a stand with two binding-posts and a lamp, the binding-post being so arranged that when the small lamp is used it will be *in series* with the incandescent lamp of the apparatus. The filament of this lamp is thus the resistance which prevents the burning out of the smaller lamp. As the resistance may be either of 15, 32, 50 or other candle-power, according to the requirements of the case, we will have here a changeable resistance, which, though somewhat inconvenient, is still a practical and economical method of using the smaller lamps.

In the ordinary antrum illuminator, a 32-candle-power lamp gives the proper resistance. It should be remembered that the

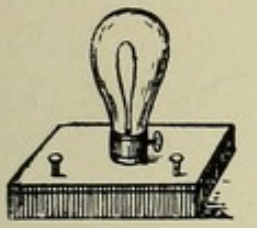


Fig. 57. Simple Lamp Resistance.

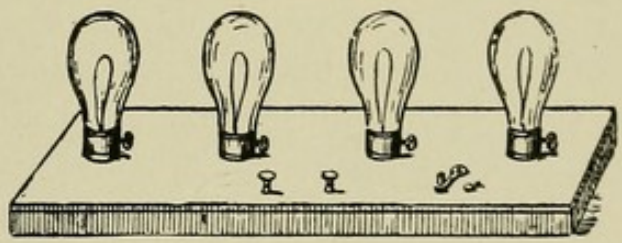


Fig. 58. Adjustable Lamp Resistance.

higher the candle-power of the lamp, the lower the resistance; thus a 16-candle-power lamp gives a resistance of 244 ohms, while a 32-candle-power lamp gives a resistance of 122 ohms, etc.

Should the resistance be made too small, the illuminator will burn out rapidly; if this be made too great, the lamp will not give sufficient light. The switch of the resistance lamp turns the current into both the lamp and the illuminator, and also shuts off the current from both. Where the light from the resistance lamp is an objection, it may be easily covered with a box, which is painted dark on the inside, or even with a dark cloth.

A more convenient arrangement for utilizing the incandescent current for these lamps is shown in Fig. 58. The lamps used are generally 16-candle-power, but larger or smaller ones may be used when necessary. When the cords of the illuminator are connected with the binding-post, one, two or all the lamps, which are connected in multiple-arc, may be switched into the circuit, each additional lamp admitting an increased current until the illuminator

gives the proper degree of light. After the light has been adjusted, the current may be turned off or on by the switch of the instrument.

The light from the resistance lamps is usually an objection, and they may, therefore, be covered with a box, as in the resistance lamp already described. When these lamps are used in a cabinet, the current may be controlled by a switch on the table and the lamps placed out of sight within the cabinet.

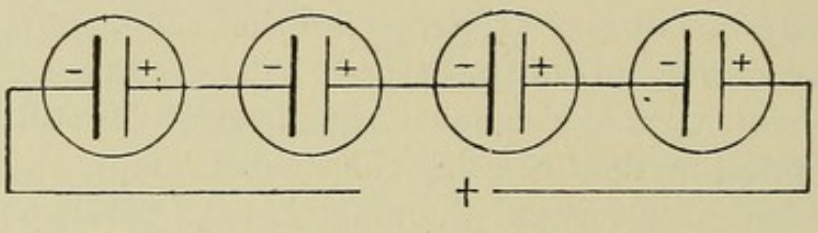


Fig. 59. Lamps Connected in Series.

In using the incandescent service for the antrum, forehead lamps etc., the possibility of grounding the current, as explained in the chapter on Galvanism, should not be forgotten. Although the two sides of the circuit are insulated from one another, they may not be well insulated from contact with the body of the physician or patient, and care should be taken, while these are used, to avoid coming in contact with gas- or water-pipes, which may ground the current.

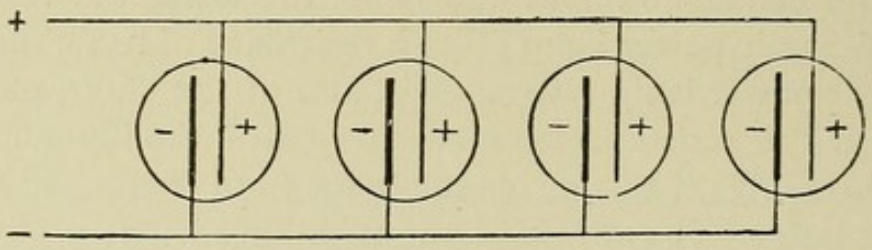


Fig. 60. Lamps Connected in Multiple-Arc.

The terms *multiple-arc* and *series*, when used in connection with an electric circuit, refer to the method in which the instruments or lamps are connected. Lamps are said to be arranged *in series* (Fig. 59) when they are so connected that the current passes through them successively. They are said to be arranged *in multiple-arc* (Fig. 60) when two or more are so connected as to form bridges or arcs between the two sides of the circuit.

In electric lighting, the incandescent-lamp system is an example of the first, and the arc lamps of the second.

The current adapted by means of a cautery rheostat, such as the McIntosh, Gish, K. A. P. dynamic apparatus etc., may also be used for the small incandescent lamps, although not as economically as in the methods above described, or when the transformers are used.

In electric transformers, the energy of a current of high potential and small quantity is transformed into one of lower voltage and greater amperage, thus making it a useful and economical method of applying the incandescent current for the small illuminators and the electro-cautery. These will be described more fully in the chapter on the Electro-Cautery.

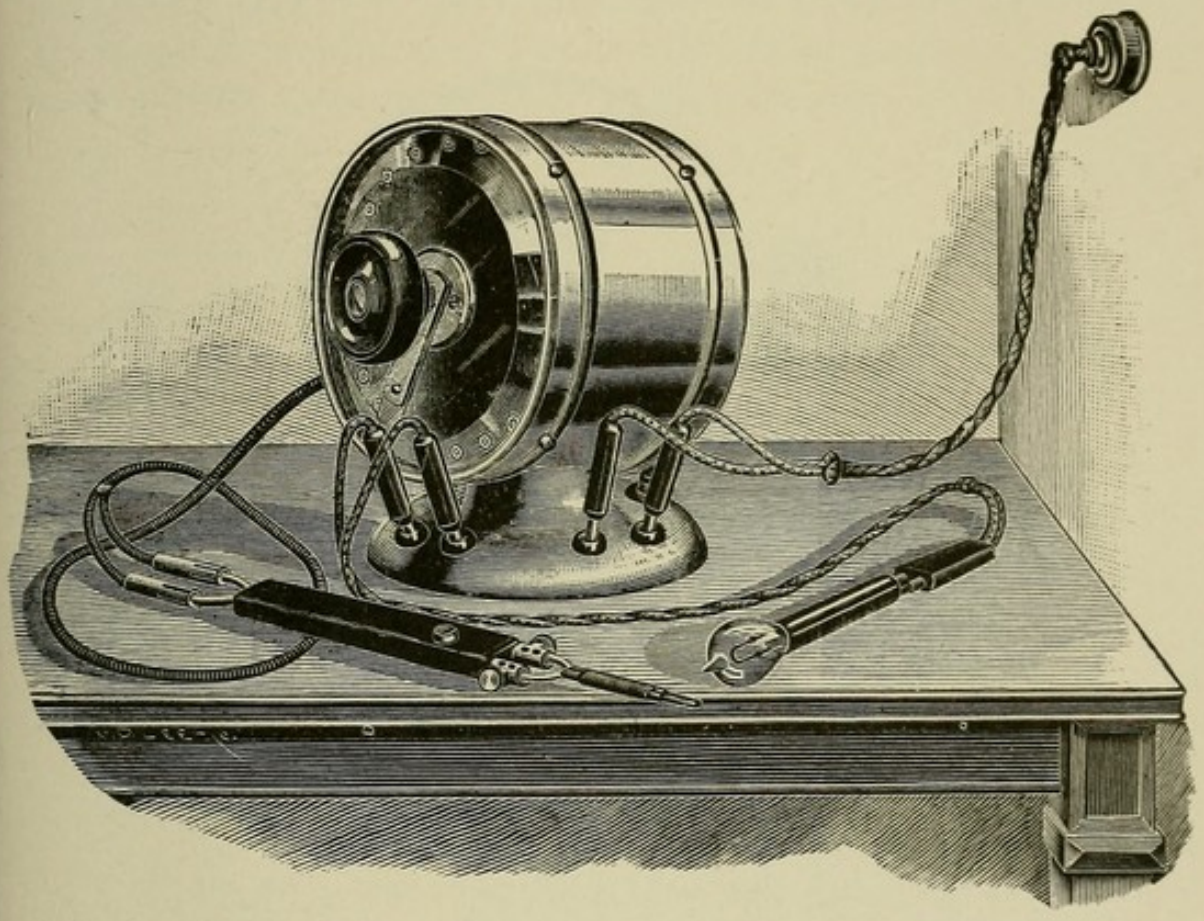


Fig. 61. The Carter Duplex Transformer.

The duplex transformer of the Carter Manufacturing Co. is shown in Fig. 61. It is used in connection with the alternating current, has separate regulators and separate connections for cauteries and lamps, thus enabling the physician to use either or both at the same time. The *motor-dynamo* or rotary transformer is shown in Fig. 84.

ELECTRIC FOREHEAD ILLUMINATORS.

The electric forehead illuminators (photophores) are praised by a number of writers, and it is claimed that they offer advantages in certain operations, as upon the drum and ossicles.

For general work, and in the majority of operations, the writer prefers the ordinary lamp and head mirror, as it is more convenient in many ways. One objection to the photophore is, that the rays of light, which are emitted from the lamp on the forehead or between the eyes, are not parallel with the line of

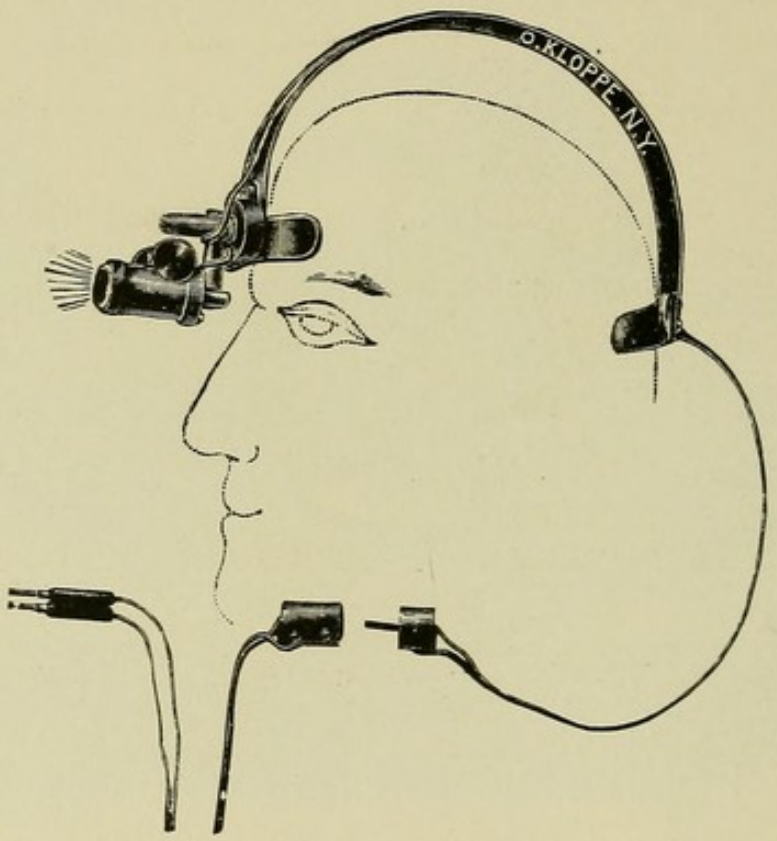


Fig. 62. Phillips' Head Lamp.

vision from either eye, so that in cases in which a mirror is used, occasional parts are within reach of the eye, but are not illuminated on account of the divergence between the visual and the projected light rays.

One advantage, however, of the incandescent electric light on the forehead, is that it can be used as well when the patient is in the recumbent position as when sitting upright.

The electric head illuminator devised by Wendell C. Phillips (14) is shown in Fig. 62. The incandescent lamp is held upon the forehead by means of a strong band of steel similiar to those

sometimes used with the ordinary head mirrors, and is lined throughout with fiber. By means of a thumb-screw at the side of the lamp cylinder, the focus may be regulated without removing the lamp from the head. This lamp is made incandescent by means of a storage cell or with the incandescent current and rheostat, in the same manner as the small incandescent lamps used for transillumination.

A lamp arranged in this manner was suggested by Samuel Sexton, of New York (15), who preferred it for the radical operation for chronic catarrh of the middle ear; he stated that this form of illumination enabled him to undertake more radical measures for aural surgery than the ordinary forehead mirror.

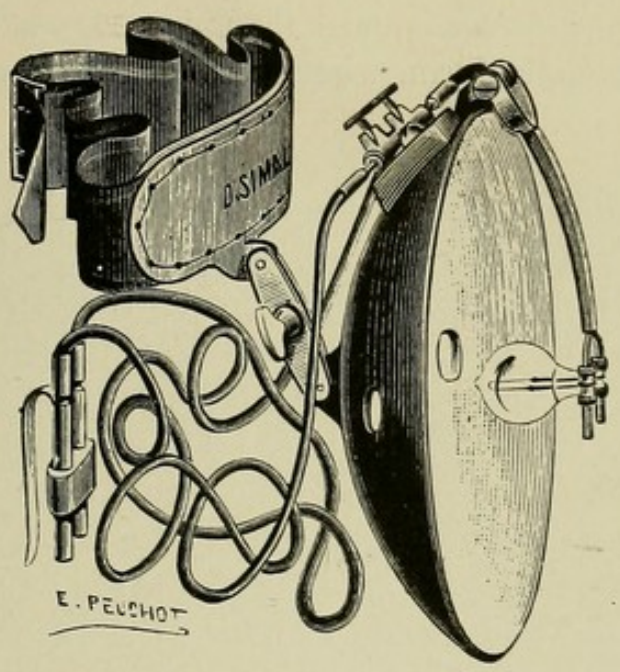


Fig. 63A. Head Mirror with Attached Incandescent Lamp.

A new electric forehead lamp has been devised by Th. Stein (16). It consists of two spectacle rings of vulcanite connected by an ivory insulating band which carries two small metal rods to which a light metal cylinder, containing an electric lamp, is attached. The spectacle rings can, if necessary, be fitted with lenses to correct any abnormality of vision in the observer. Each of the spectacle rings carries a black cylinder of stiff cardboard, which shades the eye of the observer from the glare of the light and from any extraneous light. It is operated by a battery and rheostat in the usual manner.

A new electric light, which is attached within the concave head

mirror, has been described by W. C. Jarvis (17). It is used as a substitute for the laryngoscopic lamp.

The weight, heat and inconvenience of these lamps attached to the head-band, and their inferiority to the ordinary laryngoscopic lamp, will probably prevent this method from becoming very popular. These lamps are especially objectionable when placed within the ordinary head mirror, as shown in Fig. 63A, as this is not a practical method of economizing the rays of light. When the rays are emitted from a lamp at some distance and are reflected by the head mirror, they are focused and give a concentration of light, but when the lamp is within the mirror, the rays are so divergent that they cannot be concentrated with the ordinary concave mirror, and the full effect of the light is not obtained. Where a mirror is used in connection with the lamp, it should be parabolic in form, when the full effects of the light will be obtained.

THERAPEUTIC EFFECTS OF THE ELECTRIC LIGHT.

The electric light has been used for its thermic effects in various ailments of the body. The experiments conducted at the Cornell University Agricultural Station, in 1889, have also demonstrated that the electric light may be used under certain conditions to make it fairly comparable to sunlight in its power to promote protoplasmic activity; that the electric light acts as a tonic to plants so that they are able to endure adverse conditions which would otherwise result in collapse; and that the electric light is a true vital stimulus, since the effect of its use at night upon plants is essentially the same as that of the longer days of the arctics upon plants growing in that region.

As a result of his experiments, it has been claimed by P. A. Khmelevsky, of St. Petersburg, that both the solar and the electric light undoubtedly have an inhibitory influence on the growth of microbes. Gatchkowski, of St. Petersburg, and Stanislaus Stein (545) report a number of cases in which they have used the electric light with success in controlling the pain due to neuralgia.

The effects of this light have also been tried in the treatment of goitre by Dawson Tyner, of London. He smeared the part with red iodide of mercury ointment and then exposed the surface to direct sunlight or electric light. He suggests that the effect is due to the power of the iodine to cut off the visible rays

of the spectrum. The fact that red iodide is the most efficacious points in this direction, for it would serve to transmit the heat rays only. In this way, the part is subjected to the full effect of the calorific rays without the vibration of its molecules being altered by the visible rays.

The thermic effect of the electric light has also been used by G. H. Kellogg, of Battle Creek, Mich. (546), in the form of the electric bath in a great variety of ailments, who finds it of great utility in applying heat to the body. He states that the incandescent lamps are safer and more efficacious than the arc lamps.

HEATING EFFECTS.

In the incandescent lamps there is a uniform generation of heat, and they would, no doubt, form an excellent substitute for the various methods now practised of applying dry heat to the

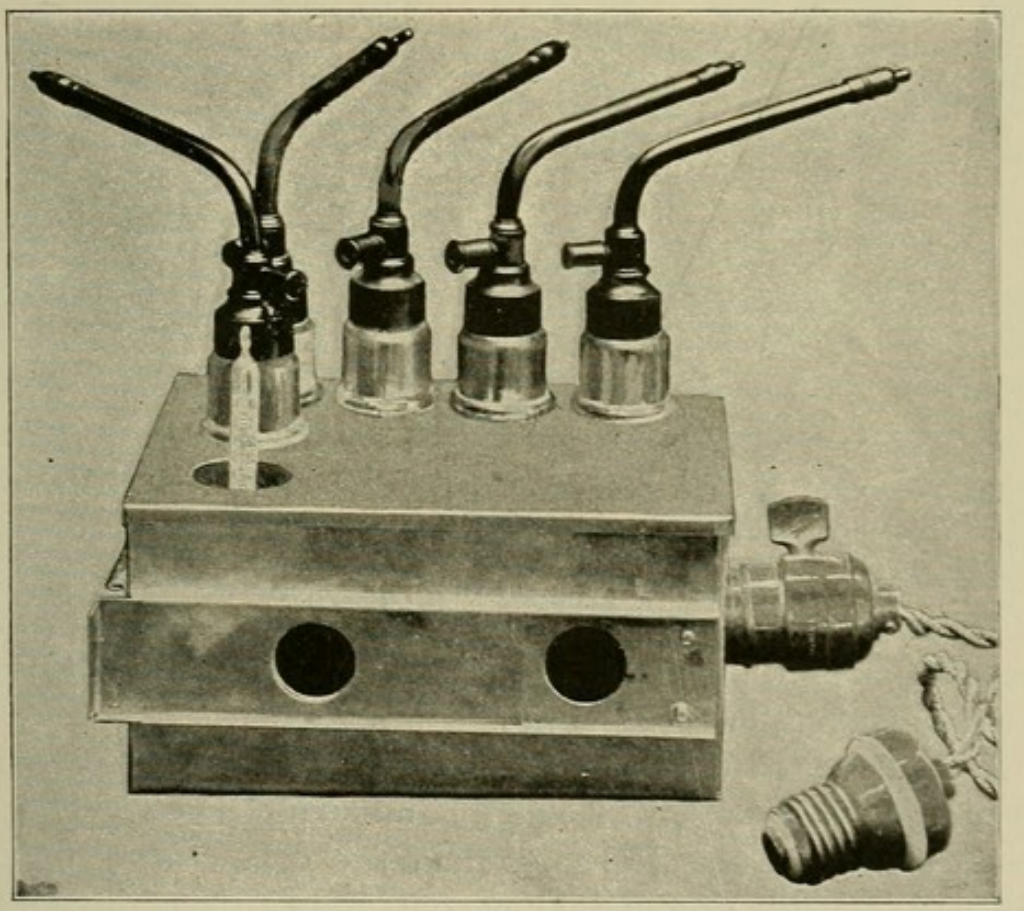


Fig. 63B. Electric Apparatus for Warming Sprays.

ear or mastoid cells. The extensive distribution of the electric-light system has now made this available in all hospitals and in a great number of private residences, and the uniformity of gener-

ating heat in the incandescent lamp should give it special advantages in this connection.

It should not be forgotten, however, that the incandescent lamp is capable of igniting combustible substances in continued close contact with it, a number of such cases having been reported by the Underwriters' Association. Where these lamps are used, therefore, they should first be covered with some non-combustible substance, such as asbestos.

An apparatus on the principle of the culinary vessels, in which

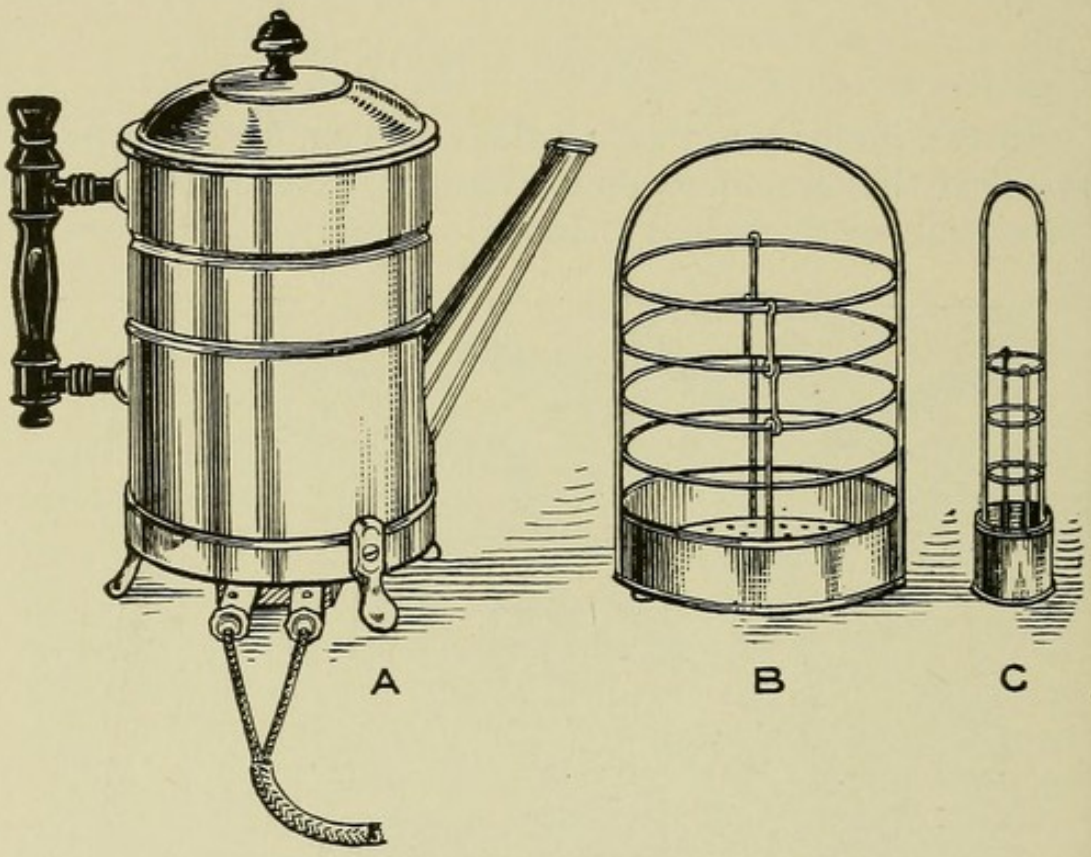


Fig. 64. Scheppegrell's Electric Sterilizer.

electricity is used for heating purposes, could also be adapted for its thermic effect in therapeutics.

An ingenious apparatus for warming sprays used for atomizers has been devised by L. C. Cline, of Indianapolis (518), who finds the warm spray more efficacious than the cold. The apparatus (Fig. 63B) consists of a metal box containing a 10-candle-power incandescent lamp which gives the necessary heat, the spray tubes being inserted into small cylinders projecting into the box. The heat may be controlled by means of dampers.

The employment of heat for boiling water and disinfecting instruments may be conveniently conducted by means of electricity.

As this method obviates the odor from the products of combustion from oil, gas and alcohol lamps, and the inconvenience of using these where there is a current of air, it has displaced all others in the office of the writer.

For this purpose, two vessels of two-quarts capacity are used, the heat being obtained from fine German-silver wire at the bottom of each vessel, as in the electric culinary utensils. In this way boiling water may be obtained in a few minutes.

In the second vessel (Fig. 64, A), which is used for sterilizing, a wire cage (B) containing the instruments is lowered into the vessel and left sufficiently long to become thoroughly sterilized. A smaller cage (C) is made for applicators. All metallic instruments used in the office are prepared in this manner and are therefore thoroughly aseptic.

In regard to the economy of this method, it has been shown by James S. Stevens and Burton S. Lanphear (547) that if electric energy can be furnished for 15 cents per kilowatt-hour, which is believed to be slightly in advance of the average rate, the use of the electric heater is about 30 per cent. cheaper than the commercial (95 per cent.) alcohol for the kind of work for which these heaters are designed.

The employment of incandescent lamps for the footlights of the theater should be recommended in all modern institutions of this kind, as the products of combustion of the illuminating gas are very irritating to the throat of actors, and especially of singers. Members of the theatrical profession, who have had the opportunity of acting under both conditions, speak very highly of the conservative influence on the voice of the incandescent lights. The source of danger due to the possibility of ignition of the draperies and clothing from the footlights is also avoided by the use of the incandescent lamp.

CHAPTER VII.

Examination of the Throat, Nose, Ear and Œsophagus.

IN examining the cavities of the nose, throat and ear, the light reflected by means of the head mirror is the most practical and the most useful method, and it is almost universally used. The incandescent light attached to the forehead is preferred by a number of physicians, and has its special applicability in certain cases.

Portable electric lights (Figs. 65, 66), attached to handles, are

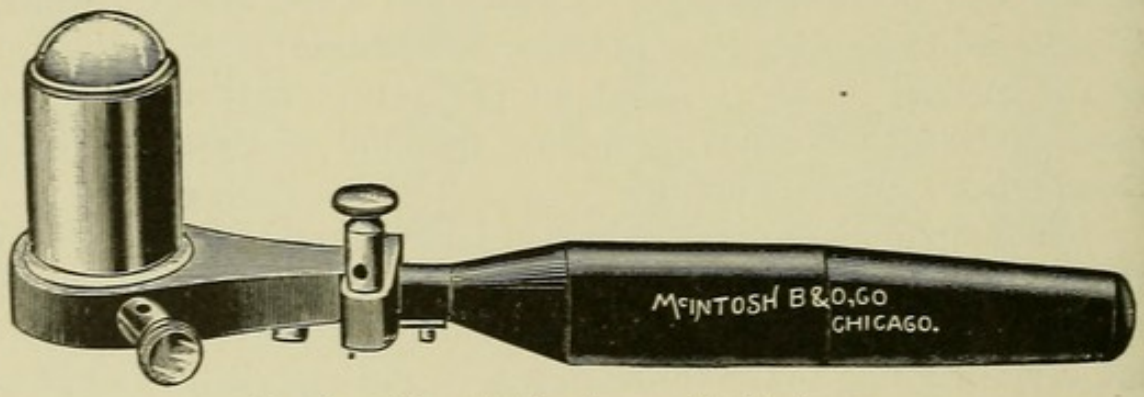


Fig. 65. Electric Illuminator with Condenser.

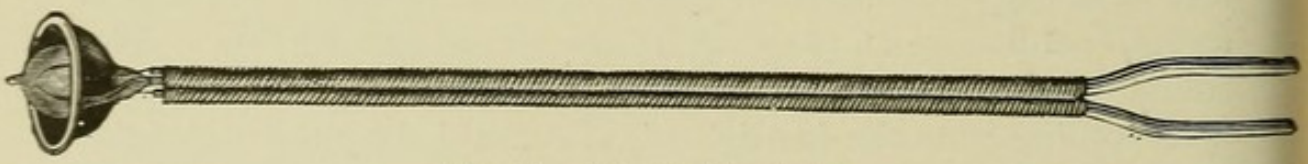


Fig. 66. Electric Illuminator.

also used, but are limited to the examination of the pharynx and oral cavity, and have no advantage even in this connection. The special objection to their application is, that they obstruct the vision of the examiner and require the use of the hand which may be needed for other purposes.

A tongue depressor and electric illuminator is shown in Fig. 67. In Fig. 68, a different form of the same instrument is shown, but is applied by means of the cautery handle. These have little value as compared to the routine methods of examining the

pharynx and oral cavity, but may be used in the method of trans-illumination of the maxillary sinuses.

An instrument which may be used for the various cavities of the human body is the Leiter *Pan-Electroscope* (Fig. 69). The current is admitted at *Le*, *Le* through the insulated handle, which is provided with an interrupter. The current causes incandescence in the lamp *L*, which is shown in the figure in dotted lines. The

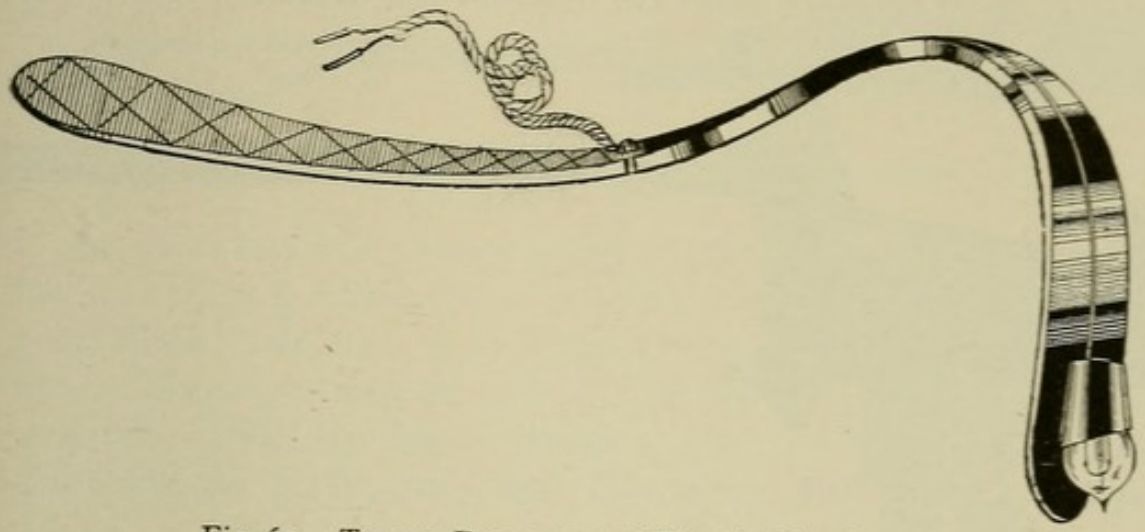


Fig. 67. Tongue Depressor and Electric Illuminator.

lamp is in the case *G'* and fixed by means of a screw, *S*. The case has a number of perforations for the circulation of air so as to prevent the metal from becoming too heated. In the upper part of the instrument *G*, there is a concave mirror 35 millimeters in diameter bent at such an angle that the rays of light are deflected and condensed directly into the funnel *T*. To this funnel are



Fig. 68. Mouth and Throat Illuminator.

attached various appliances according to the part to be examined, as the nose, ear, œsophagus etc. At *V* is a lens for enlarging the image or for correcting the vision of the examiner.

By means of this instrument, the light may be passed through a tube 5 millimeters in diameter and 10 centimeters in length, and of 14 millimeters in diameter and 50 centimeters in length, so that the object may not only be inspected, but especially constructed instruments may be passed for operative purposes when required.

While this instrument may be used for examining the ear, nose and throat, either directly or by being arranged in the form of a forehead lamp, its special adaptability in this department is for the examination of the œsophagus, in which it is of very valuable assistance. It is also used in connection with photographing the various cavities.

Several writers have described *laryngoscopic mirrors with electric lights attached* (Fig. 70) to avoid the necessity of the head

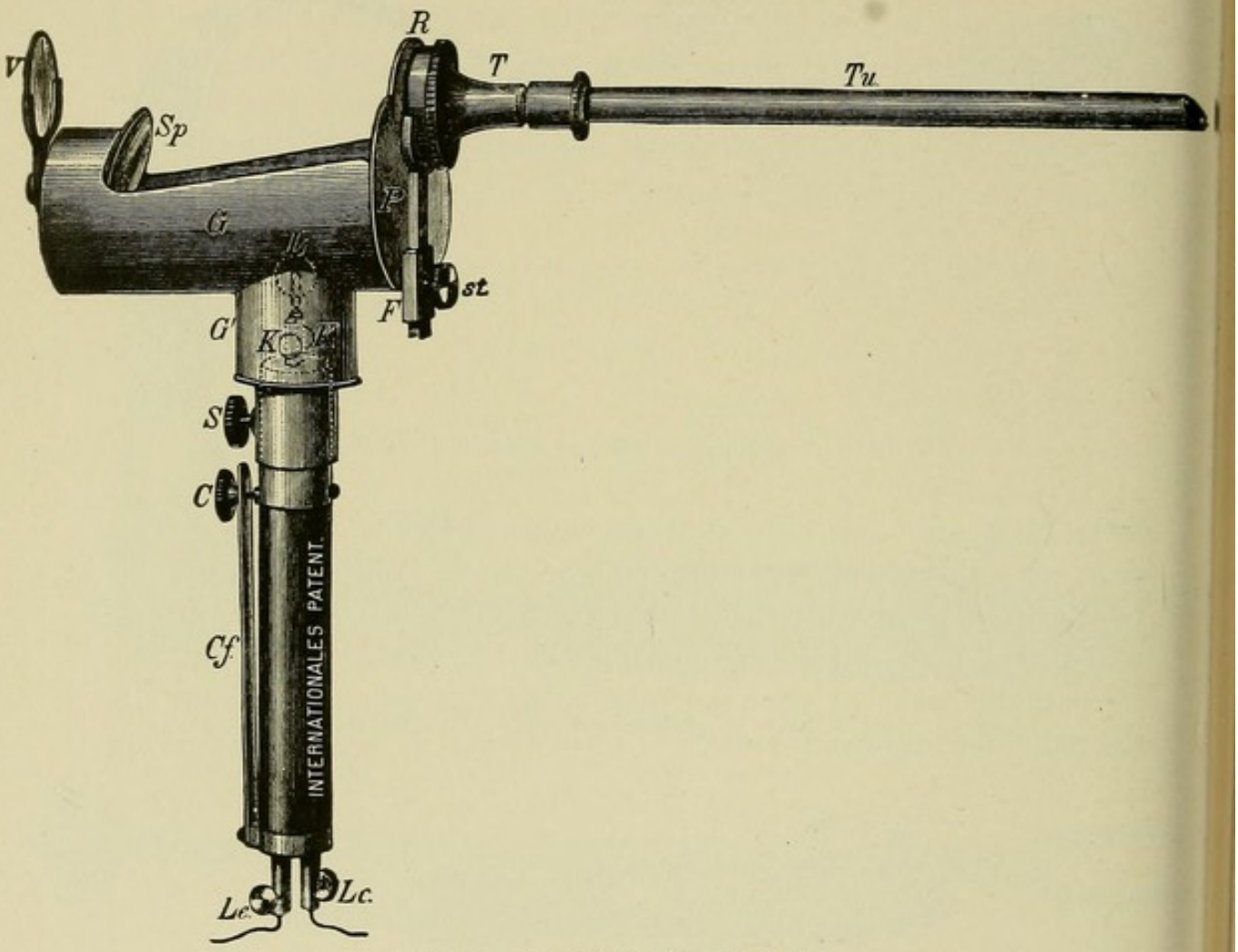


Fig. 69. Leiter's Pan-Electroscope.

mirror. This combined mirror and electric lamp is of use in dental work, but for laryngologic work it does not compare, from a practical standpoint, with the mirror and headlight ordinarily used, and this is the opinion of the majority of writers who have tried this instrument.

Such a mirror for direct illumination of the larynx has been described by Jno. McIntyre, of Glasgow (18), but Felix Semon (550) believes it to be of little practical use. J. Dionisio, of

Turin (19), also describes a laryngeal mirror with an electric lamp, of 3- to 4-candle-power intensity, attached to the free end of the mirror.

Aural specula with incandescent lamps attached for direct illumination have also been made, but these have little practical value and are now rarely used by aurists.

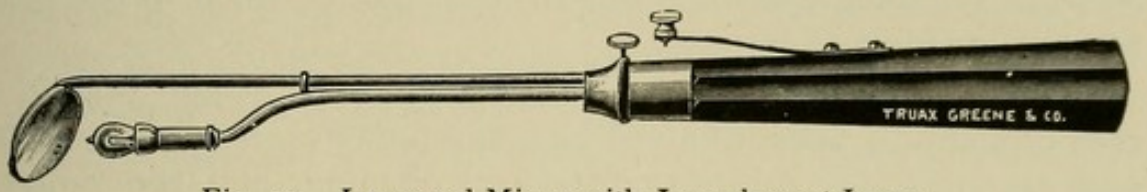


Fig. 70. Laryngeal Mirror with Incandescent Lamp.

In order to avoid the inversion of the laryngeal mirror, as is the case when a single mirror is used, a number of attempts has been made to devise a method by means of which an *upright picture of the larynx* can be seen. J. Hirschberg (20) described a method of effecting this by means of a mirror in connection with a rectangular glass prism, and Rosenberg, Rauchfuss, Lori and

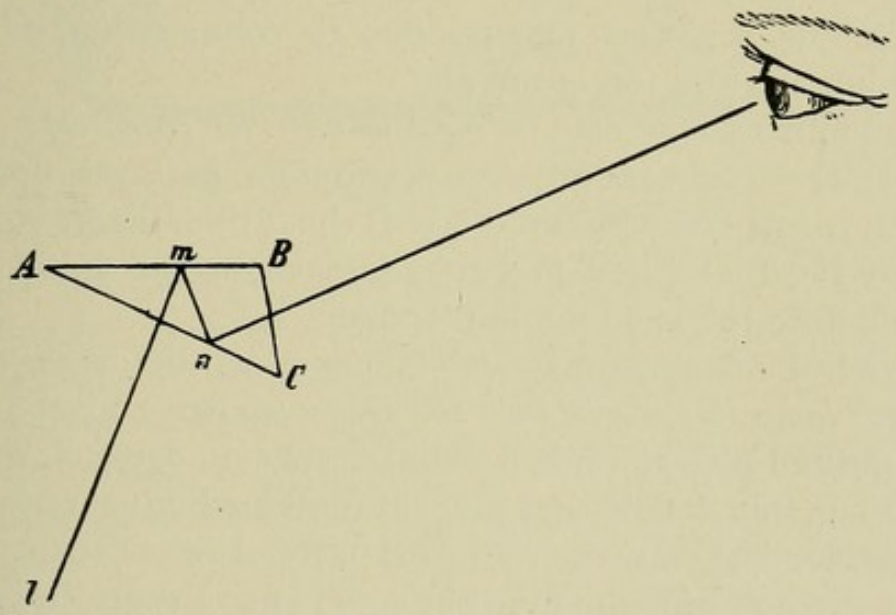


Fig. 71. Single Glass Prism for Obtaining Upright Image of the Larynx.

Unna applied this method either by means of two mirrors or by a mirror and a prism. Katzenstein, of Berlin (21), has recently described a method of obtaining an upright image, using for this purpose a single glass prism (Fig. 71) which gives an upright laryngeal image without the complication of two mirrors or a mirror and a prism combined. The prism is warmed and used in the same manner as the ordinary laryngeal mirror.

The *interior of the trachea* may also be inspected through the artificial opening made by tracheotomy. This opening may be enlarged by various dilators that have been suggested, one having been devised by Voltolini, which resembles an ear speculum with a lens attached. When the vocal bands are examined from below, they appear red and not the brilliant white as when seen from above. Pathologic changes in the lower part of the trachea may be seen in this manner.

This method has been applied by Weil, of Stuttgart (22), in a case of a child tracheotomized for papillomata. Small glass mirrors were introduced into the tracheal opening, and the tumors situated in the lower part of the larynx and trachea could be clearly inspected. The X-rays may form a useful method of inspecting this part of the respiratory tract.

Tracheoscopy in tracheotomized patients has also been advocated by Pieniazek, of Krakau (23), who found it of great value in the following conditions: In acute and chronic tracheal catarrh, in tracheo-bronchial croup, pathological changes caused by the presence of the canula, œdematous conditions following the irritation of the canula, scleroma, stenosis due to compression, non-malignant neoplasms and foreign bodies.

Small mirrors may also be used in *anterior rhinoscopy*. By introducing these mirrors into the vestibulum nasi, the upper portion of the nostril may be explored. If the turbinates are congested, they may be diminished in circumference by the application of cocaine before the examination is made.

The nasal chambers may also be examined by means of an *incandescent lamp introduced into the naso-pharynx* and the nostrils then inspected by means of an ordinary speculum, which will sometimes bring out details that are not obtained by anterior rhinoscopy, as, for instance, the posterior parts of the nostrils.

This method of examining the nasal chambers is described by Cozzolino (24), who claims priority for it. He first described this procedure at the Congress at Brussels, and has since published it in the Italian journals.

A nasal illuminator is described by J. A. Thompson, of New York (25). It consists of a small incandescent lamp attached to a metallic tube, the end of which is bent at an angle of 90 degrees. When this lamp is placed in the naso-pharyngeal cavity, and the nose examined by means of a good speculum, the nasal chambers are brilliantly illuminated and may be examined by varying the

position of the lamp. Where the view is not obstructed by marked deviations of the septum or hypertrophy of the mucous membrane, the sides and posterior walls of the naso-pharynx may be inspected by reversing the reflector of the lamp.

An electric light for illumination and examination of the anterior and posterior nasal cavities (Fig. 72) has also been devised by Braden B. Kyle, of Philadelphia (26). A small incandescent light is placed at the end of two light insulated copper wires, similar to the wires of the electro-cautery. In order to minimize the heat radiated from the lamp, an aluminum cap is placed over it, this cap having an opening to allow the escape of the rays of light, and the remainder of the cap acts as a reflector. This cap is reversible so that the light may be thrown in any direction. The light is placed in position in the same manner as the rhinoscopic mirror, and the patient then closes the mouth, holding the instrument firmly between the teeth. The examination is then made

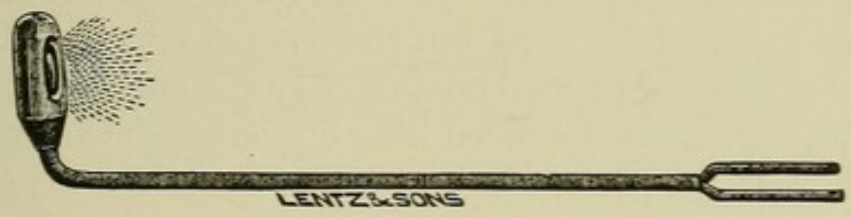


Fig. 72. Kyle's Post-Nasal Illuminator.

with an ordinary nasal speculum. An objection to this instrument is that, after 20 or 30 seconds, the aluminum cap becomes quite heated. This, however, could be avoided by surrounding the cap with a jacket of asbestos.

An instrument (Fig. 79), by means of which the light is carried to the naso-pharynx by a glass rod, has been devised by Chevalier Jackson, of Pittsburg. This instrument will be described in the chapter on Transillumination.

Among the cavities, which it would be desirable to inspect, is the *antrum of Highmore;* but thus far these attempts have not proved very satisfactory.

At the sixty-sixth congress of the German Naturalists and Physicians at Vienna, H. A. Wagner, of San Francisco (27), gave a demonstration of an instrument which he used for this purpose, and which he called the "antroscope."

He stated that it could be used to advantage in all obstinate diseases of the antrum of Highmore, but only after an alveolar open-

ing into this cavity had first been made. This instrument presents the advantage that it can be turned in different directions, of course only around one axis, so that the various parts of the cavity can be examined. It is lighted up by means of Renginer's pan-electroscope.

Special advantages from this instrument are claimed by Wagner (27) in the following cases: 1. He was able to determine that a drainage tube which had disappeared was present in the antrum. 2. A polypus could be localized in the hiatus semilunaris; this had kept up a sero-purulent discharge. 3. He was able to ascertain that a case of retention of pus was due to the presence of a bony septum. 4. He verified the differential diagnosis of an angioma in a case in which a severe hemorrhage suddenly developed in the antrum. 5. It facilitated the thorough curetting of the necrotic tissues by means of a bent curette.

For the *ear*, the head mirror and aural speculum form the best means of examination. Specula with small incandescent lamps attached are sometimes used, but these present no advantage over the ordinary method of examination. In certain operations, as in the mastoid cells, the forehead illuminator is convenient, as it is applicable with the patient in the recumbent position.

THE ŒSOPHAGUS.

The œsophagus does not present the same advantages for examination as the larynx, but several methods have been introduced to facilitate the inspection of this passage.

The first attempts in this direction were made by Semeleder and Karl Stoerk, who, shortly after the introduction of laryngoscopy, devised a special forceps, with which the œsophagus was dilated and then examined by means of the usual laryngoscopic method. More recently Waldenburg (28) attempted the examination of the œsophagus by passing a tube into the œsophagus, but this proved unsuccessful on account of the small caliber of the tube which he applied.

This method was developed on a practical basis by Karl Stoerk (29) by the introduction of a jointed tube (Fig. 73), which could be passed into the œsophagus closed and then extended by means of a special arrangement in the handle. The examination is effected either by means of the head mirror or an especially constructed lamp attached to a laryngoscopic mirror; the examination may also be conducted by means of the pan-electroscope of Leiter

(Fig. 69). While Hacker (30) and Rosenheim (31) made these examinations by placing the patient in the horizontal position with the head hanging down (Fig. 74), Stoerk places his patient in a sitting position on a low stool, with the head bent strongly backwards. The tube is then introduced by means of a shaft until the point of greatest resistance is met with; the shaft is then removed and the œsophagus examined.

On account of the irritation which is set up by the presence of the tube, the examination has to be made very rapidly. In order to facilitate this, a flexible tube is first inserted to ascertain the location of the part to be examined.

When a search is to be made for a foreign body, it may usually be detected by its difference of color from the deep red of the œsophagus. The removal may then be effected by passing a specially constructed forceps through the canula without diffi-

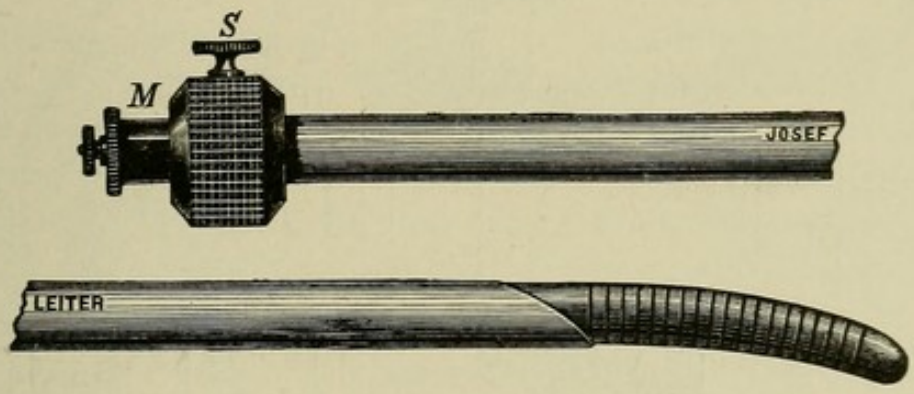


Fig. 73. Modified Œsophageal Tube.

culty. Stoerk makes use of this as a routine procedure in his clinic, and has had no great difficulty in the method. He has been able to locate foreign bodies, strictures and cases of carcinoma.

The advantage of œsophagoscopy is also advocated by E. Meyer (32). In a case of cicatricial stenosis, the bougie could be passed successfully only after it had been inserted by the assistance of the œsophagoscope. In a second case, an ulcerating tumor above the cardiac opening could be inspected, and in a third case, in which a foreign body had been swallowed, it could be shown by this instrument that the foreign body was no longer present, but that there was a superficial ulceration of the mucous membrane.

A modification of the œsophagoscope devised by Morell Mackenzie is described by Loewe, of Berlin (33). He has added a cap of soft rubber which can be opened when the instrument is

inserted, to prevent its filling with the secretions from the œsophagus.

A large number of examinations has been made by Von Hacker, of Vienna (34), with the Mickulicz-Leiter's electro-endoscope in the normal and diseased œsophagus with the following results: The normal œsophagus has a rosy color; its lumen differs in its various parts. Respiratory, pulsatory and peristaltic movements can be observed. In acute inflammations, the œsophagus is more red than normal; in chronic, it is pale and œdematous; after the extraction of foreign bodies little wounds can be seen in the mucous membrane; partial dilatation, compression and strictures can be detected by variations of the lumen.

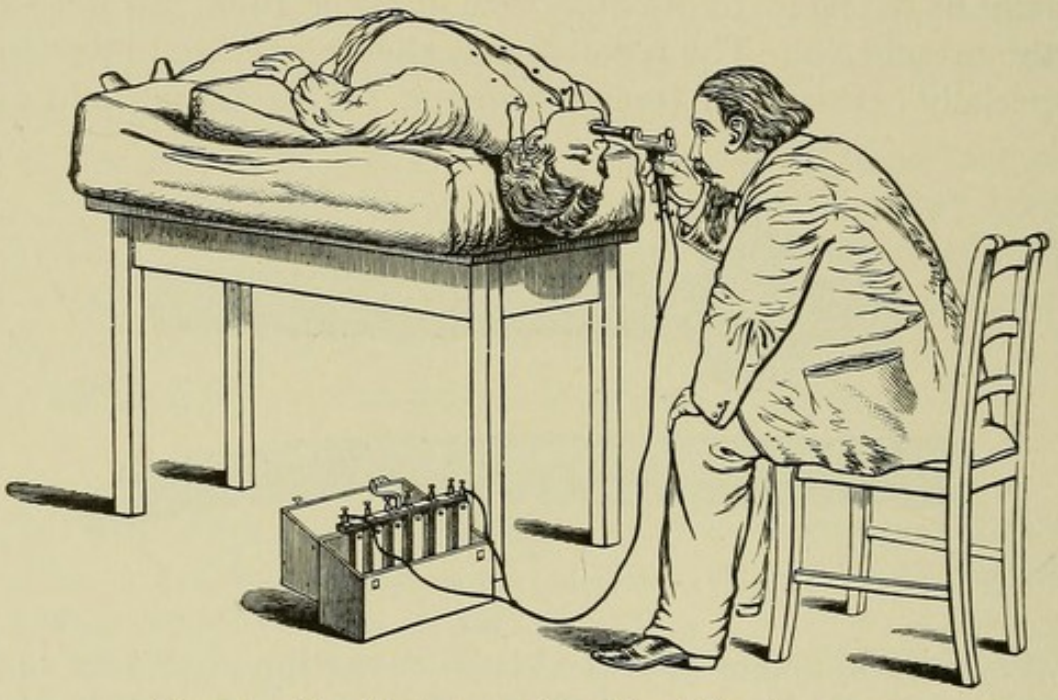


Fig. 74. Pan-Electroscope Used for Œsophagoscopy.

More than one hundred cases of cancer have been observed by Von Hacker, most of them being in the region of the bifurcation. In the early stages of the disease, the œsophagus shows protuberances, redness, stenosis of the lumen and thickening of the epithelium. In later stages, ulcerations can be seen. Usually it is possible to diagnose the cancer upon the first examination with certainty.

The most satisfactory effects are obtained in cases of foreign bodies. It is frequently possible to remove impacted substances, which cannot be done in any other manner. In healthy gullets the foreign body is usually retained at the region of the bifurcation. Von Hacker (34) was able to remove an impacted plate of

artificial teeth, an impacted bone which could not be extracted in Schroetter's clinic, two pieces of impacted bone, soft bodies which could not be pressed down by bougies, and in some cases pieces of meat or fruit stones.

In cases of strictures of the œsophagus, in which the strictured part is obturated by foreign bodies, gastrotomy and œsophagotomy may also be avoided. In a case of carcinoma of the œsophagus diagnosed by this method, Von Hacker (35) was able not only to locate the growth at the level of the diaphragm, but also to remove papillomatous granulations by means of a long pair of forceps by this method. Instead, however, of injecting morphine, as recommended by Mickulicz, Von Hacker (30) applies a 20 per cent. solution of cocaine, especially to the sinus pyriformis, and examines the patient in a horizontal dorsal position with the head hanging down (Fig. 74). He does not first wash out the stomach, but advises the patient to avoid taking food for some time before the examination. He rarely finds chloroform necessary, but, in those cases in which it is required, he carries it to the point of full narcosis. Von Hacker also describes in this connection a kind of articulated curette for the endo-œsophageal extraction of foreign bodies to be used with the œsophagoscope.

These diagnostic and practical results demonstrate the great value of the electric œsophagoscope. It is, therefore, to be regretted that this instrument is so little used and so rarely referred to in medical literature.

CHAPTER VIII.

Direct Laryngoscopy.

A RECENT addition to the methods of examining the larynx is *direct laryngoscopy* or *autoscopy*. The term autoscopy has been given by Kirstein to his method of examining the larynx and trachea without the assistance of a laryngeal mirror. As autoscopy is a word whose origin would lead us to infer that this method is intended for the examination of one's own larynx, and, as the word *auto-laryngoscopy* is commonly used with this definition, it would, perhaps, be better to call it "direct laryngoscopy" in this method, in contradistinction to the term "indirect laryngoscopy," in which the larynx is examined through the intervention of a mirror.

The whole principle of direct laryngoscopy is practically embodied in the following simple directions (36): "The patient bends his head slightly upward and opens his mouth; the physician presses the base of the patient's tongue forward with a spatula." These are the remarkably simple directions which may be deducted from the theoretical considerations concerning the possibility of autoscopy.

By Kirstein's method, we obtain a direct image of the intralaryngeal structures, and not a reflected image, such as is obtained by the ordinary laryngoscopic mirrors. In the description of the method, Kirstein recommends the use of the electric light attached to a forehead mirror, on account of its convenience, in that it follows the movements of the head, and the examiner need not adjust the laryngoscopic lamp to these movements.

Attention has already been called to the inferiority of this means of illumination as compared with the laryngoscopic lamp proper, but in this method the forehead lamp has certain advantages, although I generally use the light reflected from a laryngoscopic lamp in this as in the indirect method of examination.

In the forehead lamp described by Kirstein (Fig. 75), the rays issuing from a small incandescent lamp are condensed by means

of a convex lens and projected downward, and a small, plain mirror, placed at an angle of forty-five degrees to it, projects the rays directly forward. The mirror is perforated obliquely through its centre, for the eye of the observer.

Direct laryngoscopy may also be used with the assistance of the pan-electroscope (Fig. 74), an instrument originally devised by Casper for examining the urethra, certain modifications having been made by Kirstein to adapt it to this method.

In Kirstein's method (37), the pharynx and epiglottis of the patient is first cocainized, and he is then either placed on his back with the head hanging downwards, or is seated upright in a chair with the head forcibly bent back on his shoulders. The autoscope is then passed through the open mouth, the patient

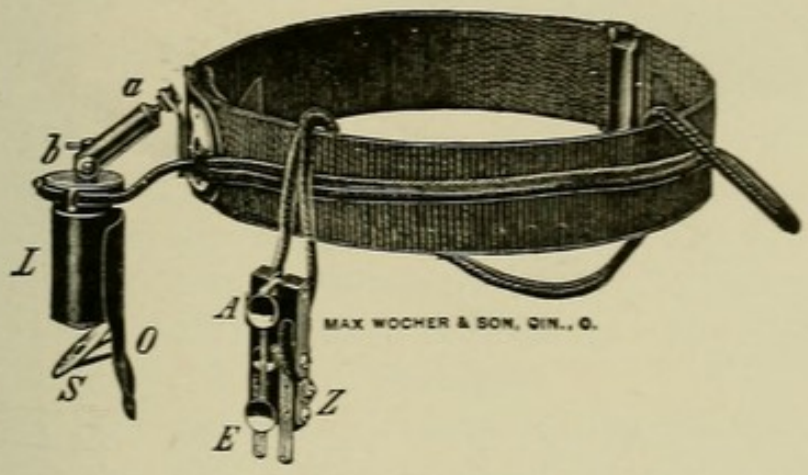


Fig. 75. Forehead Lamp for Direct Laryngoscopy.

having projected his tongue. This *autoscope* (Fig. 76) consists of three parts: a spatula, a hood and a handle. The spatula for adults is fourteen centimeters long; at the tip it is about two centimeters wide and one and a half centimeters where it passes the convexity of the tongue.

The intralaryngeal spatula forms a perfectly straight groove which ends anteriorly in a thin convex border. Both spatulas have lateral ribs to which the ends are attached. These hoods prevent the light and vision from being obstructed by the upper teeth or lip.

In a more recent form of the autoscope, the hood is dispensed with, and instead of it a simple plate is used, so that the lateral ribs of the autoscopic spatula are omitted, thus giving more room for surgical procedures. In the handle of the autoscope (Fig. 76) there is an incandescent lamp, the rays of which are collected

by a lens and deflected ninety degrees by a prism, after the manner of the electroscope. Where the forehead lamp is used, the electroscopic handle may be dispensed with and a plain metallic handle used.

The autoscope is held by the left hand, the end of the spatula being gently passed backwards to the height of the cartilage of Santorini. A strong lever movement is then made by which the tongue is pressed forward and the epiglottis elevated. The larynx and trachea may then be examined in the cases adapted to this method, and, by the assistance of the electric light, any

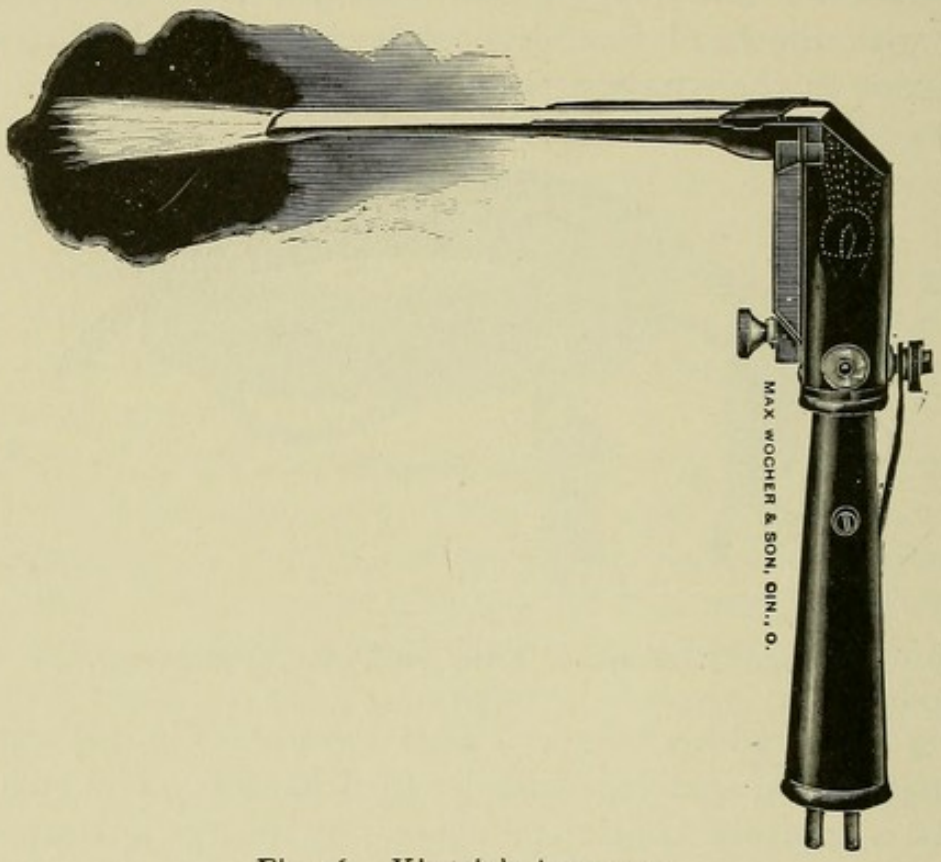


Fig. 76. Kirstein's Autoscope.

necessary operation may thus be performed. The autoscopic is far more distinct and natural than the usual laryngoscopic picture. It is, however, not applicable to every patient.

In the discussion of this method before the Berlin Laryngologic Society, B. Fränkel (61) expressed himself as much in favor of this method, and thought it especially applicable in laryngeal operations. A. Rosenberg (548), however, considered the method too violent to be used in diseased conditions of the throat, and Herzfeld thought this method had special advantages for small children.

In regard to the necessity of using cocaine in these cases, Flatau (549) does not think this a matter of indifference, as it may develop dangerous symptoms. The hanging position of the head is not desirable on account of the disturbance of circulation which it sets up. He also does not consider this method of value from a therapeutic standpoint, as it causes fixation of the larynx.

This method has been used by W. T. Wroblewski (38), who considers it of especial importance in the examination of the upper respiratory passages.

In regard to the applicability of this method, E. Meyer (32) reports that in only one-fifth of all the cases did he find autoscopy applicable, and in only one-twelfth of the cases could the whole larynx, including the anterior commissure, be inspected, and in twenty per cent. could the posterior two-thirds be seen with this method. In twelve per cent. of the cases this method was not at all applicable, it being disagreeable to the patient and sometimes the pressure on the base of the tongue even painful. Three times in three hundred cases, spasm of the glottis was caused.

This method is contraindicated by inflammatory processes of the tongue and epiglottis, and also in certain disturbances of circulation and in well-developed stenosis of the larynx and trachea. As the larynx is held in a fixed position in autoscopy, previous difficulties of respiration are aggravated.

This method is sometimes disagreeable for the examiner, as it easily causes coughing, which is not without its danger. For diagnostic purposes, it has undoubted advantages in diseases of the posterior laryngeal wall. For operative purposes, it has especial adaptability for processes of the posterior laryngeal wall, as in the method of treating laryngeal tuberculosis by cataphoresis (40).

Kirstein states that the autoscope gives us, in some instances, a perfect picture of the larynx and of the trachea; in others an incomplete picture, while still in others no view at all is obtainable. These results depend upon certain physical conditions of the patient to be examined; hence, while direct laryngoscopy is a valuable method in certain indications, and, in those cases in which it is applicable, superior to indirect laryngoscopy, still the laryngoscopic mirror can rarely ever be wholly dispensed with for a complete examination of the throat.

The inspection of the *under surface* of the vocal cords is also possible by this method. A small mirror eight millimeters in di-

ameter is used, the mirror being introduced through the autoscope beneath the glottis of the cocainized patient. The sub-glottic mirror is fastened to a very thin nickel-plated rod of copper, which may be bent to suit the requirements of the case. Thus the under surface of the vocal cords may be seen much more distinctly than by the method first described by Rauchfuss, in which the image is first reflected by the sub-glottic and afterwards by the laryngoscopic mirror.

Direct laryngoscopy is of special importance in *surgical operations*, especially where the site of the operation is in the posterior part of the larynx. For this purpose the instrument, instead of being bent downward, as in the ordinary laryngeal operating instrument, is straight as for nasal operations, but somewhat longer.

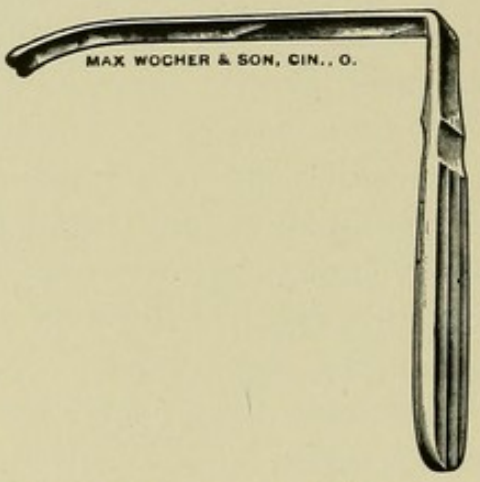


Fig. 77. Tongue Depressor for Direct Laryngoscopy.

The posterior wall of the larynx, the inter-arytenoid folds, which can be examined only with great difficulty by the aid of the laryngoscopic mirror, can be thoroughly inspected by means of Kirstein's method in those cases in which it is applicable.

Some modifications of this method have recently been published by Kirstein (41). He has found that for ordinary examinations a complicated appliance is not necessary; a tongue depressor, as shown in Fig. 77, being all that is necessary in most cases. The patient should be seated, lean slightly forward and tilt the head backward, and the physician stands before the patient. The spatula is then placed as far back as possible upon the tongue, and a firm pressure in a downward and forward direction is exercised upon the root of the tongue, whereby a deep and slanting groove is formed on the tongue, thus allowing the

rays of light from the forehead mirror to penetrate the parts to be examined. The extent of view depends upon the individuality of the patient. He also states that the ordinary forehead reflector may be used, but he evidently still prefers the electric forehead lamp. This simplified method, I make use of as a routine procedure in my practice.

Kirstein summarizes the description of direct laryngoscopy in the following words: "Autoscopy is the art of pressing on the tongue, with a minimal amount of irritation, a longitudinal groove reaching backward and downward as far as possible, and approximating in direction to the axis of the laryngo-tracheal tract."

The following is a résumé of the claims for this method (36):

1. The human larynx and trachea can be examined autoscopically; that is, they are accessible to direct inspection; the means to this end is pressure on the tongue.

2. The individual adaptability to autoscopy varies within wide limits, the reasons being of an anatomical nature.

3. Laryngoscopy is no longer the only method of examining the air-passages as hitherto; but it will continue to be the standard method and the one to be used above all others for the purpose of diagnosis.

4. Autoscopy is an important addition to laryngoscopy, especially for examining the posterior wall of the larynx and the trachea.

5. In the examination of children, autoscopy is indispensable in some cases; especially with the aid of chloroform anæsthesia, it can be carried out without any great difficulty.

6. In endolaryngeal and endotracheal surgery, autoscopy will take the front rank as the standard method; of course, within its anatomical limits.

7. The technique of laryngoscopic operations remains the same, and must continue to be used in those patients who are ill adapted to autoscopy.

When the tongue is an obstacle in the employment of this procedure, Kirstein believes that a little patience and even a certain amount of diplomacy will enable us to examine these parts without having recourse to cocaine. I have also found this the case, and in a number of patients now under treatment the previous application of cocaine is unnecessary.

This new method of examining the larynx and the trachea is considered by P. Bruns (42) as a very valuable addition to our

methods. He has given especial attention to autoscopy in order to ascertain its value in performing endolaryngeal operations, and is much gratified with his results. The cases which he reports are five tumors of the larynx and of the trachea and three of tracheal stenosis, three of the cases being in adults, and five in children.

As showing the value of direct laryngoscopy, Max Thorner, Cincinnati (43), reports a case in which a piece of bone was imbedded between the right ventricle and the right ary-epiglottic ligament, whose position was located by direct laryngoscopy without cocaine, and the foreign body was removed in a few seconds by means of a straight slender serrated forceps.

In a case exhibited by J. Solis-Cohen, Philadelphia (44), it was easy to see as far as the bifurcation of the trachea without any other illumination than the diffused daylight of the room. The observer stands in such a position before the sitting patient as enables him to look down upon the structures exposed by the manipulation of the tongue depressor; the patient's head being held backwards, much as the sword swallower holds his head when performing his feat. In many cases, this method may be used without preliminary cocainization.

The topical applications of the medicaments, and the operative manipulation with forceps and other instruments, can be as readily accomplished by a skilled operator as in ordinary methods of surgical operation. The anterior structures are fully and more readily inspected in the image of the mirror, while the posterior portions are infinitely better inspected directly without the mirror. Hence, the new method will be of great value in the recognition and treatment of tuberculous cases in which the lesions predominate posteriorly.

A method of direct examination of the naso-pharyngeal cavity has also been described by J. Katzenstein, of Berlin (45). The patient is placed in the dorsal position, with hanging head, the mouth opened, and the tongue drawn forward as for laryngoscopic examination. In this position, the naso-pharyngeal cavity lies downwards and the uvula directly upwards. A palatal retractor is now applied behind the uvula and slowly and firmly drawn forward. The following parts of the naso-pharyngeal cavity will then be seen directly with the eye: the posterior and upper pharyngeal wall, the Eustachian cushions, the tubal openings, the salpingo-palatine and the salpingo-pharyngeal folds and the Ro-

senmüller fossæ. The septum, choanæ and posterior extremities of the turbinals cannot be seen by this method.

For ordinary examinations, this method possesses little advantage over the older methods, but for certain operative procedures it is of advantage, especially as this position is indicated in cases of operations in the naso-pharyngeal cavity, in which there is danger of blood passing into the lower respiratory passages when the patient is in the upright position. This refers especially to prolonged operations. It is also useful in examining the naso-pharynx in children when this cannot be done by the ordinary methods.

CHAPTER IX.

Transillumination (109).

THE subject of transillumination is one of considerable interest. Its application, especially to the diagnosis of empyema of the maxillary sinuses, has received a great deal of attention, and since the method was first elaborated by Heryng in 1890, repeated references to this method are found in rhinologic literature, giving the arguments pro and con, and the experience of the various investigators as to the value of transillumination as a diagnostic measure.

The various methods of transillumination for investigating the nose and throat were first described in detail by Voltolini. He refers to the following methods:

1. A strong light is projected upon the exterior of the nose, and the nostril examined by means of a speculum from which all light is excluded as much as possible.

2. A strong light is projected into one nostril while the other nostril is examined by the speculum.

3. Introducing a mirror as in posterior rhinoscopy, and throwing a strong light upon it while the anterior nares are inspected.

4. Examining the nose while an electric light is placed in the mouth.

5. Introducing a small incandescent lamp in the naso-pharynx. The velum is thereby seen strongly illuminated, and the nares may be inspected by means of the nasal speculum.

6. Placing an incandescent lamp in the mouth and observing the transillumination of the antrum of Highmore and cheek. This method was afterwards elaborated by Heryng.

7. Projecting a light from an incandescent lamp upon the external part of the larynx and trachea, and inspecting the interior of the larynx with the laryngoscopic mirror.

In addition to these methods, transillumination may also be used in connection with the ear, the light from an incandescent

lamp being projected externally on the mastoid cells, and the auricular canal examined by means of an aural speculum.

ANTRUM OF HIGHMORE.

In order to appreciate the true value of transillumination in the diagnosis of empyema of the antrum of Highmore, it is important that the source of light should be of sufficient intensity, and that the room should be properly darkened.

After a careful test of the various antrum lamps sold by dealers for this purpose, it is not surprising that such diverse results have

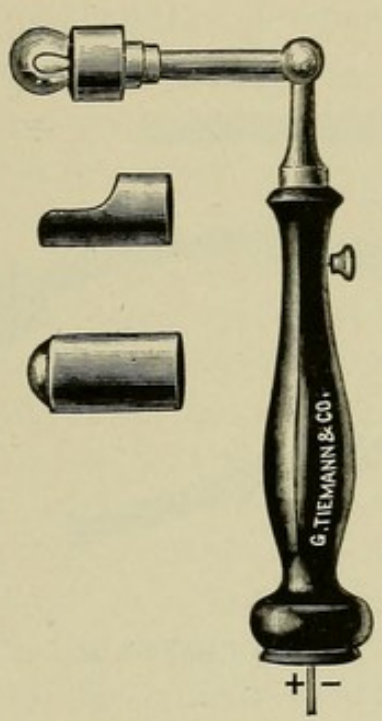


Fig. 78. Heryng's Antrum Lamp.

been obtained with this method. In addition to the false construction of the majority of the lamps examined, they did not give the requisite amount of illumination. The power of the lamp should be 5 candle-power; less than this will not give sufficient brilliancy except in rare cases, and a greater intensity will deprive this method of much of its delicacy.

In view of the different conformations of the bones of the face, as shown by the investigations of Zuckerkandl (564) and others, and their variations in density and thickness in different individuals, it can easily be understood that the same degree of light is not applicable in all cases, and it is, therefore, preferable that the amount of light be varied by means of a rheostat until the proper

degree of transillumination is obtained. By this means, the results are more definite and reliable.

For transillumination, an incandescent lamp attached to a tongue depressor, as shown in Figs. 67 and 68, may be used. A superior instrument is the one devised by Heryng (Fig. 78). In the original Heryng's lamp sent me by Tiemann & Co., the lamp did not have a sufficient capacity, so that the results obtained were unsatisfactory. By my suggestion, however, they have increased the capacity of the lamp, and it now gives very good results. I have also removed the interrupter from the handle, as this is liable to become deranged, and I use a foot-switch for completing the circuit, in the same manner as in the electro-cautery.

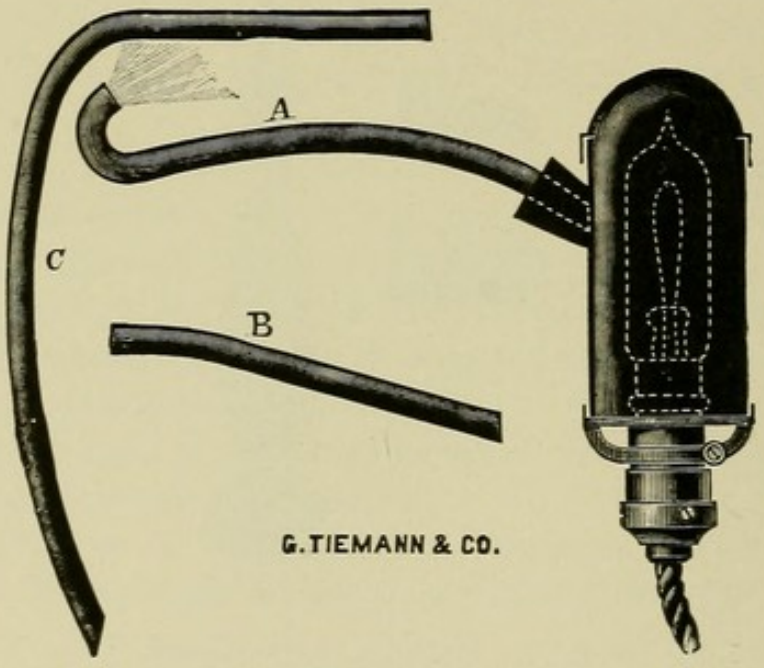


Fig. 79. Chevalier Jackson's Lamp for Transillumination.

In applying these instruments, the face of the patient should be tested with different degrees of light, as the diminished intensity sometimes brings out points of detail that are not observed with the brighter light.

The illuminator should be carefully placed in the mouth of the patient, the mouth closed, and the current turned into the illuminator. The lamp should not be left in position for more than half a minute, so as to prevent it from becoming so heated as to make it disagreeable or even painful to the patient. Where there is an artificial set of teeth, this should be removed before the test is made. Before removing the illuminator from the mouth, the cur-

rent should be turned off in order to avoid the possibility of burning the patient while removing the instrument.

Various experimenters have devised different forms of lamps for transillumination, but Heryng's is still the most useful. Chevalier Jackson, Pittsburg, however, has devised a transilluminator (Fig. 79), which has the advantage of a wide range of applicability. It consists of a German-silver lamp box polished within, blackened without, and containing a 50-candle-power incandescent lamp. Projecting from the side of the box is a metal neck, into which fits a perforated asbestos cork. Through this cork passes a glass rod (A), which is silvered all over except the ends, the silvering being protected by a layer of enamel. The brilliant light within the box is transmitted axially through this rod, without lateral radiation, and issues from the distal end with considerable intensity. A cloth skirt, not shown in the cut, hangs from the lower rim, preventing any radiation of light from the open air channel; and from the bottom of the lamp socket issues an ordinary flexible double cord, two meters in length, ending in an "attachment plug."

An incandescent lamp can be withdrawn from its socket and this "plug" substituted when the transilluminator is ready for use. When the slightly warmed distal end of the glass rod is passed up behind the palate, and the patient's lips closed, inspection through the anterior nares shows the nasal chambers to be brilliantly illuminated. A retractor should be used to draw the palate forward while the tip of the rod goes into place, after which it is removed, and the patient closes his lips around the shaft of the rod.

When the glass rod is placed on the tongue, the distal concavity forward, transillumination of the antrum is obtained. In this position the nasal cavities are also transilluminated, the outer wall under the overhanging inferior turbinate. The single curved rod (B) is used where its shape is more convenient. The distal end in one nostril illuminates the other nasal chamber; placed externally over the thyroid cartilage, the larynx may be seen with the laryngoscope with the light transmitted through the tissues. Thus can be executed the whole list of Voltolini's procedures, and many others. The room should be dark to obtain the best results.

The glass rod does not become heated, wherein is a great advantage. The lamp soon becomes hot, but if desired it can be made double-walled, with a layer of asbestos between, though this makes a more expensive instrument.

In the ordinary antrum illuminator, a 5-candle-power lamp gives the proper amount of illumination. Where this is used in connection with the incandescent street service, a resistance of one 50-candle-power lamp, or three 16-candle-power lamps is required. As explained in the chapter on Illumination, these lamps may also be used in connection with the shunt rheostats, storage batteries, motor-dynamos or the chemical batteries that are used to operate the electro-cautery.

An important point is that the room should be totally darkened. Where this is not feasible, a cloth such as the photographers use may be thrown over the head and shoulders of the examining physician and patient, which will usually give sufficient darkness for the examination.

The diagnosis of empyema of the *maxillary sinus* by transillumination may be considered under the following heads:

1. Opacity of the cheek of the affected side, or the method of Voltolini-Heryng.

2. Opacity of the pupil of the affected side, or the method of Davidsohn.

3. Absence of the luminous sensation of the diseased side, or the method of Garel.

Each of these methods may be modified by placing the lamp laterally in the mouth, that is, directly under the maxillary sinus and not under the nasal fossæ, according to the method of Ruault (46).

4. Examination of the antrum by retro-maxillary illumination, or the method of Escat.

5. Opacity of the nasal wall of the sinus observed by rhinoscopy, or the method of Robertson. This is difficult to prove and is rarely used.

VOLTOLINI–HERYNG'S METHOD.

In 1890, Theodor Heryng (47) succeeded in illuminating the antrum of Highmore by using a 5-volt incandescent lamp attached to a tongue depressor. In more than 30 cases he was able to diagnosticate latent empyema without exploratory puncture, the diagnosis being corroborated by the subsequent removal of pus. Since using this method he has been able to diagnosticate empyema of the antrum much more frequently than formerly, and he, therefore, gives great weight to transillumination.

When he first published this method, it was a distinct advance in the methods of diagnosing the various pathologic conditions of these parts; but, as usual, its value was overestimated, and the reaction caused the pendulum to swing in the opposite direction, and this procedure was soon much undervalued. The true state of the case is, that it is a valuable addition to our means of examination, and has the advantage of being quickly and readily applied. It must, however, be corroborated by other signs.

In considering the value of transillumination as a diagnostic measure in diseases of the maxillary sinuses, it will be interesting to note the objections which have been offered against it. Among these are the following:

1. When the pus has been evacuated, the diagnostic absence of transparency persists, indicating that this does not depend only upon the presence of the pus. 2. In healthy individuals, translucidity of the antrum is sometimes not obtained. 3. In some cases of unilateral empyema, both sides of the face are transparent, indicating that the presence of pus does not always influence the degree of transillumination.

From an examination of a number of cases of empyema of the maxillary sinus in Jurasz Clinic, Chancy, of Bristol (48), states that transillumination is not an absolutely sure means of diagnosis and cannot be relied upon in doubtful cases.

It is claimed by Gouguenheim (49) that transillumination is embarrassing, as it always leaves one in doubt. In a case in his practice, on finding a beautiful sub-orbital umbra, and then opening the maxillary sinus, he found no pus. Robertson (551) also found on opening an antrum containing much pus, and which gave a decided umbra on transillumination, that it exhibited the same umbra after thorough irrigation. This observation has also been referred to by Moreau Brown, of Chicago (552). The presence of an umbra, therefore, is not a decided indication of pus, but it may be a positive sign of some pathologic condition of the antral mucosa.

The articles published by Raulin, Wiebe, Schech, Walter, Heymann, Ziem and Srebrny also indicate that they accord but little value to transillumination as a means of diagnosis.

Transillumination is also considered of little diagnostic value by Lichtwitz (50) and Hartmann, because the luminous rays, projected into the sinus, originate not only from their direct

source, the mouth, but also indirectly from the nostrils. The cavity is thus illuminated from the nostrils and causes the antrum to appear translucent even when it contains a certain amount of pus.

The majority of writers, however, believe that this procedure has considerable merit, some even being enthusiastic in its praise. The illumination of these cavities by the mouth-lamp is believed by W. H. Fletcher, of Cincinnati (51), to be a most valuable adjunct to the diagnostic symptoms. The cases to which he refers in his article have all shown the diagnostic shadow. Freudenthal (523) also values transillumination as a diagnostic measure.

A large number of cases has been examined by means of transillumination by Schleicher (52), who considers this one of the best methods for the diagnosis of the presence or absence of pus in the antrum of Highmore, without, however, being applicable in all cases.

While not considering transillumination of the antrum entirely reliable, Moritz Schmidt (54) states that it recommends itself on account of its rapidity and simplicity. The unilateral darkening of the cheek may be due to a peculiar anatomical formation of the maxilla, obstruction of the nose with polypi or a pathologic condition of the maxilla. A serous exudate in the maxilla does not prevent transillumination. Sajous (55) also states that transillumination cannot be considered infallible, still methods of any kind possessing all the requirements for perfection are indeed few.

Heryng insists that the value of transillumination should not be underestimated, and states that the method has been criticised by persons who do not understand it, and who are not familiar with this procedure. He calls attention to certain sources of error and lays great stress upon the absolute darkening of the examination room.

Electrical illumination by transparence is, according to Garel, of Lyons (56), the best proof when we suspect the existence of empyema of the maxillary sinus from the ordinary symptoms complained of by the patient. He, therefore, attaches much value to transillumination in the diagnosis of empyema of the antrum. G. W. Caldwell (57) calls attention to the fact that, where a large number of mucous polypi is present in the nasal cavity, they may cause a concentration of light and increased brilliancy of the bones of the face, thus confusing the ordinary signs of transillumination.

DAVIDSOHN'S METHOD.

After a systematic investigation of the value of transillumination, as suggested by Heryng and Voltolini, H. Davidsohn (62) claims that the most important evidence is not the *transillumination* of the cheek, but of the *retina of the eye*, and he considers the latter the only reliable and valuable sign in the diagnosis of empyema of the antrum of Highmore. He claims that this method demonstrates with absolute certainty the absence or presence of an empyema of the antrum of Highmore without the necessity of an exploratory syringing, as recommended by Lichtwitz and Ziem.

When Davidsohn introduced an electric lamp into the mouth, he observed in normal subjects a red illumination of the retina, surrounded by a dark circulatory zone. He claimed that this was produced only when the maxillary sinus was free of pus, and that, on the other hand, this phenomenon was never present when the antrum was filled with purulent secretions; that the transillumination of the eye is prevented by even the smallest amount of pus in the antrum. The pupil is, at the same time, of medium size, occasionally even dilated to its maximum. The dark ring around the orbit is the shadow of the fat capsule surrounding the eye. If the eye remains darkened, this cannot be considered as absolutely indicating the presence of pus under all circumstances, because in abnormal conditions of the maxillary bone, the light cannot penetrate to the orbit.

In the discussion of this subject, Flatau (63) states that he does not believe in the accuracy of the observation that the pupil cannot be illuminated where pus is in the antrum, as he has seen the opposite result in his own observations. This has also been the experience of Heymann and Scheinmann who have likewise seen the persistence of the darkening of the pupil even months after the pus had disappeared from the cavity.

As a proof of this theory, however, Davidsohn (64) reported that he had filled a number of antra with milk, and had never found the illumination of the pupil present when this had been done.

The value of this method is denied by Ziem, of Dantzig (65), who shows at length how these luminous rays may penetrate from the diaphanoscope (antrum illuminator) into the orbit through the nasal cavities without first passing through the antrum, on account of the anatomical condition of these cavities in many cases.

He shows that, in the normal antrum, sufficient light does not penetrate through the nasal cavities into the orbit to cause the illumination of the retina, but in abnormal cases there would be little or no interception of the rays, even if the cavities were filled with a purulent secretion, so that this method, in these cases, would not only be without value, but would even lead us to suppose that a negative condition existed, whereas one or both the cavities might be filled with the result of a chronic suppurative inflammation.

Little value is also credited by Herzfeld (66) to Davidsohn's method of transillumination. B. Fränkel (553) warns that too much reliance should not be placed in the illumination of the cheek or eye, as it may lead to disagreeable results. In two cases in which, guided by this method, he had performed an exploratory puncture, he had had negative results. Davidsohn (67), however, supports his view of the value of transillumination of the pupil by the observation of thirteen cases, as showing the reliability of this sign, even when the smallest amount of pus is present in the antral cavity.

Attention has been called by Stevenson (68) to the fact that this illumination of the retina may be of value in *ophthalmology*, as it permits the fundus oculi to be seen without the simultaneous contraction of the pupil.

As regards the value of Davidsohn's method, this is subject to the same conditions which influence the value of the other forms of transillumination. As in these methods, it is of importance only in connection with other symptoms. If there is pus in the middle meatus of one side, or, with or without this, certain subjective symptoms are complained of that we associate with empyema of the antrum, and if, in addition to these symptoms, the affected side of the face is also darkened and the pupil in contrast with the opposite side of the face, we may consider this strong corroborative evidence, which would justify us in making an exploratory puncture in cases in which the normal opening (ostium maxillare) cannot be found and catheterized.

While Ziem (65) is correct in his statement that the actual syringing of the antrum is the only absolutely reliable method of diagnosing the presence or absence of empyema of this cavity, still this method, if carried out through the normal opening, requires considerable time, patience and skill, is unpleasant and even painful to the patient in spite of the application of cocaine, whose

effect must not be regarded entirely with indifference in these cases. In addition to this, there are many cases in which the finding of the natural opening is extremely difficult and even impossible, as has been maintained by Stoerk and other observers of the highest experience. An exploratory puncture for making the diagnostic syringing is an operation that is likely to be objected to by the patient, and requires the usual care and precaution incident to a minor operation. The puncture, therefore, should not be made unless the symptoms pointing to an empyema are fairly positive in character.

GAREL'S METHOD.

It has been observed by Garel (56) that the electric lamp in the mouth of a healthy subject, whose eyes are closed, causes the patient to perceive a *luminous impression* in the lower part of the retina, due to the transmission of light. In a number of cases affected with empyema, he found that this luminous perception was absent on the side of the face in which pus was in the antrum. Burger, of Amsterdam (69), while favoring Davidsohn's method of transillumination, contends that luminous sensations of the eyeball are far more delicate tests than illumination. Herzfeld (70), on the other hand, from the extensive experiments which he has made, states that unilateral light in the face or pupil does not exclude the possibility of pus in the antrum, and that both pupils may remain dark without being due to pus, as this also occurs in healthy subjects; that the lighting up of one pupil may serve as collateral evidence only when the symptoms point towards the presence of empyema.

This phenomenon has been extensively experimented with, as with other methods, the results showing that the value of this symptom is influenced by the same conditions which affect the usefulness of the methods described by Heryng, Voltolini and Davidsohn, in that it is influenced not only by the pathologic conditions of the antrum, but sometimes also by the anatomical peculiarities of the parts, regardless of the pathologic conditions of the antrum itself.

A modification of the method of transillumination, as practised after the Voltolini-Heryng method, has been suggested by A. Ruault at the meeting of the Paris Society of Laryngology (46), the author claiming that it presents advantages over the ordinary methods used.

RUAULT'S METHOD.

In healthy subjects, who possess normal translucidity without modifications due to anomalies of the conformation and thickness of the osseous walls, Ruault has observed a *certain number of zones* in the adult, which are more strongly illuminated than the neighboring parts. When the lower part of the face corresponding to the dental arches and the alveolar borders of the superior maxilla is very clearly illuminated, the middle part of the cheek is darker as far as the inferior orbital arch, and above this there is a zone more clear, in the form of a cross, answering to the lower eyelid. But when an electric lamp giving sufficient light is applied in a certain manner, there is, on each side at the level of the nasal bones, a clear zone irregularly oval, less bright than the neighboring palpebral region, but clearly distinct from the other darker parts.

These clear zones are often absent when the lamp is placed in the middle of the mouth on the median part of the back of the tongue, for, according as the subject has a narrow nose or tumefaction of the inferior turbinates, the illumination of the upper part of the nose is poor; the luminous rays, having traversed the palatine arch at the level of the floor of the nasal fossæ, are arrested by the projections formed by the turbinals, especially the inferior. But if care is taken to place the lamp in the mouth *laterally*, that is, below the lower wall of the maxillary sinus, and not below the floor of the nasal fossæ, the region in the bones of the nose is clearly illuminated, the luminous rays traversing the maxillary sinus and the anterior ethmoidal cells.

This fact has not yet been noticed, probably because observers have been directing their attention to the examination of the transparency of the cheeks and lower eyelids; but it is easy to see if a lamp of sufficient intensity is employed.

ESCAT'S METHOD.

A new method of examining the antrum by means of transillumination has recently been suggested by E. Escat, of Toulouse (434). Instead of placing the electric lamp in the mouth, he applies it in the retro-maxillary space (Fig. 80) and claims to have had good results from this method. He does not underestimate the value of Heryng's phenomenon, but claims that the method

of applying the lamp in the retro-maxillary space is indicated in all cases in which the positive results furnished by Heryng's

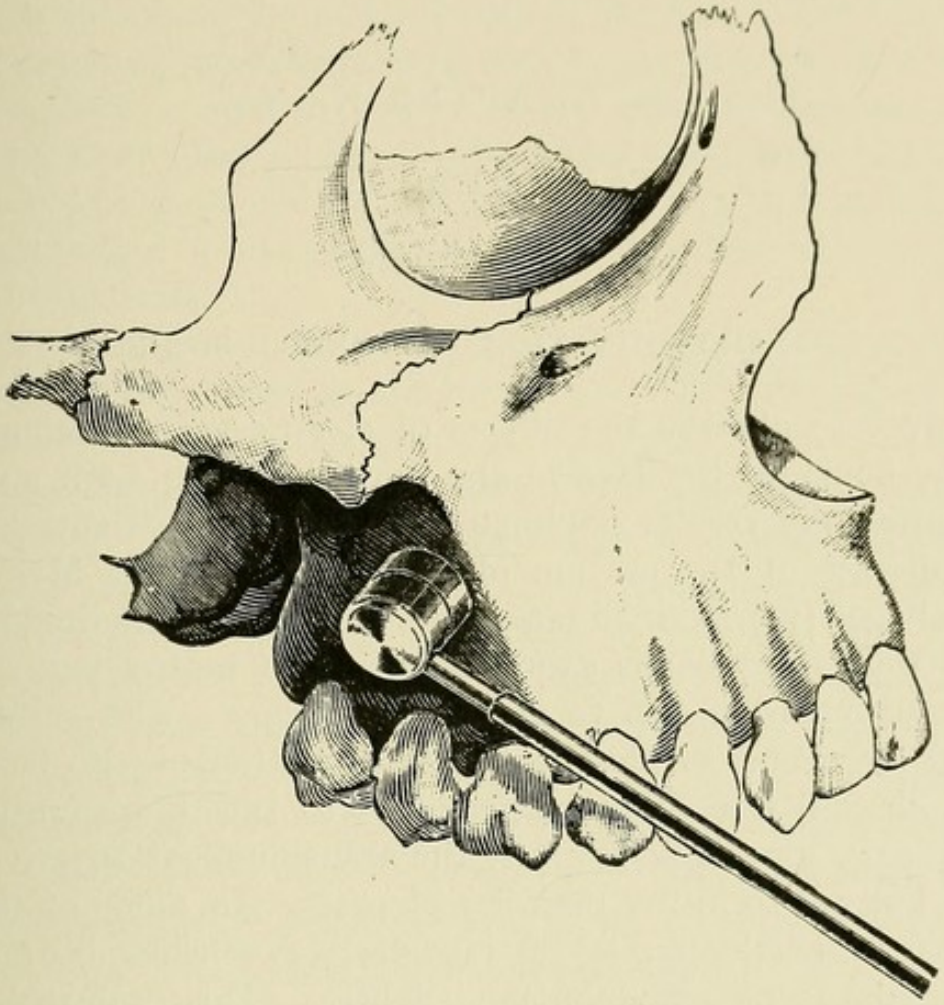


Fig. 80. Examination of Antrum by Retro-Maxillary Illumination.

method are rendered suspicious by pathologic alterations of the nasal walls of the sinus, and especially of the supraturbinal portion.

CHAPTER X.

TRANSILLUMINATION.

(*Concluded.*)

TRANSILLUMINATION IN NORMAL SUBJECTS.

IN order to observe the effects of electric transillumination of the bones of the face in the normal subject, with a view of comparing the results obtained with those of patients affected with disease of the antrum of Highmore, Holger Mygind, of Copenhagen (71), has made an examination of two hundred healthy individuals, the persons examined being of both sexes, and the ages varying from two to seventy-six years. The results observed by means of electric transillumination of the face were quite dissimilar in different persons. In the thin, slightly built individuals, especially females, the transillumination is very intense, but not so in the majority of cases. In many of the persons examined, the pupils remained dark. A considerable minority exhibited the phenomenon but slightly. This group consisted chiefly of strongly built men, principally of dark complexion, and of well-developed adipose tissue. In these cases, the pupils always remained dark.

In referring to the transillumination of the pupil, as described by Davidsohn (72), Mygind admits that this transillumination is principally produced by the light from the mouth penetrating through the floor and roof of the antrum, but believes that there is a possibility that some light penetrates from the nasal cavity into the orbit through its inner wall. This light is sometimes sufficient, when the bones and mucous membranes are thin, to illuminate the pupil even if no light penetrates the antrum, as would be the case if pus were present in that cavity. In many of the healthy individuals examined, the transillumination of the two pupils was unequal, and, in 4 per cent. of all the cases, one pupil was distinctly though slightly illuminated while the other remained perfectly dark.

In regard to the reliability of Davidsohn's phenomenon as a basis for the diagnosis of pus in the antrum, Mygind found that one-third of all the cases examined exhibited perfectly dark pupils under transillumination of the bones of the face. The lamp used was constructed by Vohsen (73), and it was brought to a bright incandescence, so that the failure of this phenomenon was apparently not due to any defect of light, but to anatomical conditions. In regard to sex, 30 per cent. of the females examined exhibited nonillumination of the pupils, while this was the case with 62 per cent. of the males.

This difference can be naturally explained by the variation of thickness of the bones in the two sexes. The effect of transillumination on the pupil is found to vary with the consistency of the mucous membrane of the palate, the thickness and structure of the bones of the face, the consistency of the mucous membrane of the antrum of Highmore, abnormality in the size and shape of the antrum, the consistency and extent of the fatty layer of the orbits, and even the physical condition of the bulbus oculi.

More favorable results, as regards the efficacy of transillumination in healthy persons, were obtained by J. A. Wilkens (74). From the examination of a large number of individuals, who were not affected with any nasal disease, this investigator found a complete transparency of the cheek in 51 per cent., a partial transparency in 37 per cent., and a complete opacity in only 9 per cent. of the cases. The pupils were illuminated in 74 per cent. of the cases, and the subjective perception of light existed on both sides in 97 per cent. of the persons examined.

In twenty-three cases of acute unilateral empyema of the maxillary sinus, the Heryng symptom existed in nineteen. In three cases, the corresponding cheek was not absolutely opaque, but less transparent than the cheek of the opposite side. In the last case, however, the two cheeks were equally transparent. The symptoms of Davidsohn and of Garel were present in each case of acute empyema without exception.

In sixteen cases of chronic empyema, the Heryng symptom was very marked in ten; that of Davidsohn, thirteen times, and that of Garel, thirteen times. The first of these symptoms was present, but less marked in two cases; the second in one, and the third in one case. In short, a complete absence was shown with the first method in four, in the second in two, and in the third in two cases.

In six cases of bilateral empyema, the symptom of Heryng was shown each time, as also that of Davidsohn. The symptom of Garel was absent four times.

These statistics prove that while the method of transillumination is not of absolute certainty, it is, nevertheless, in the majority of cases, a valuable diagnostic measure.

The absence of transparency in empyema of the maxillary sinus depends not only on the absence of pus, but also on hyperemia, infiltration and thickening of the wall. This explains

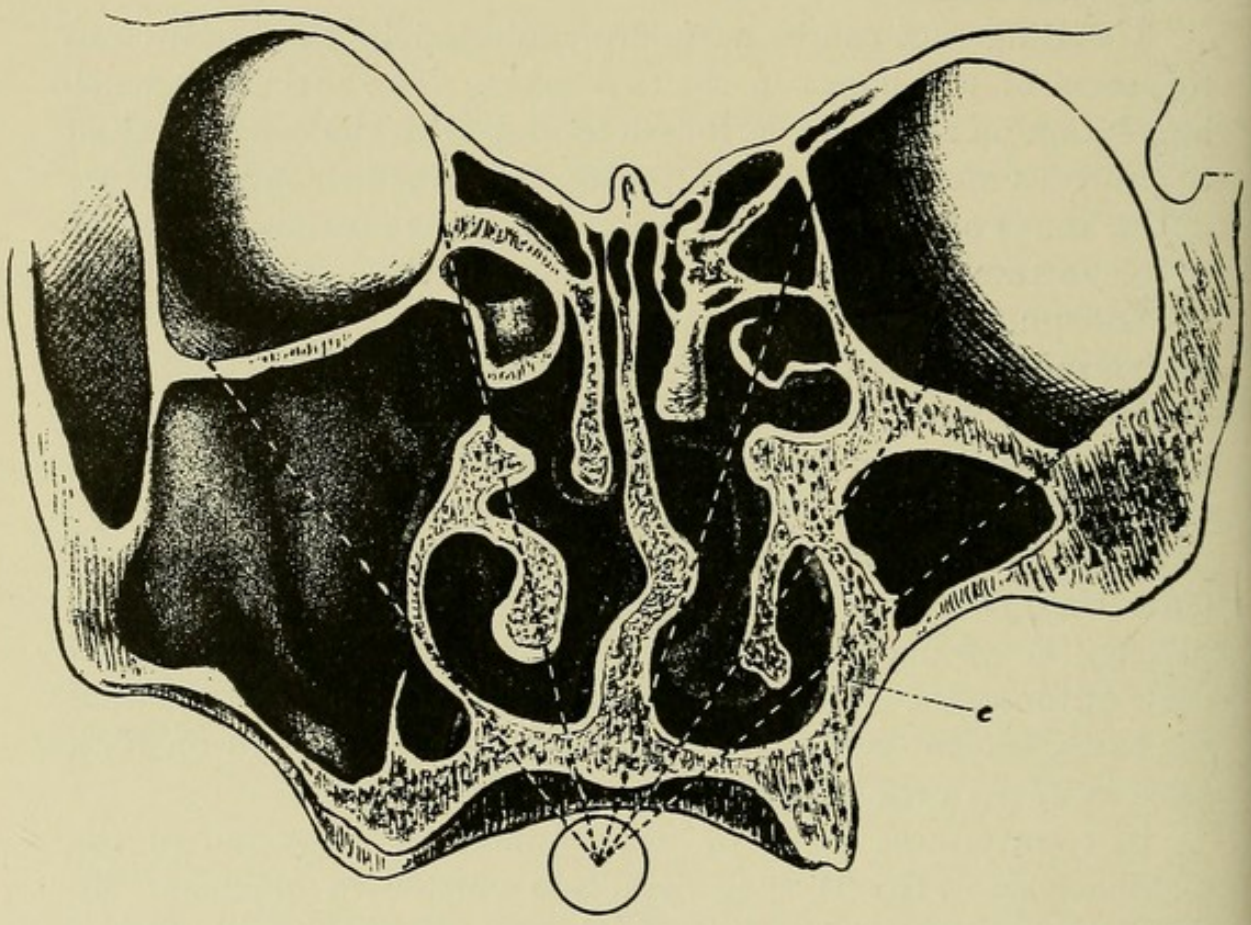


Fig. 81. Transillumination of the Antrum of Highmore.

one of the objections which have been brought against this method, that the opacity usually persists even after the injection and complete cleansing of the sinus. After the cure of empyema, the transparency reappears either fully or in part. If the opacity persists, the cure is doubtful. The exploratory puncture, which is followed by a positive result, has been considered as a certain diagnostic method, but if this gives a negative result, it is not absolutely conclusive that the sinus is healthy. The puncture should be used only when the other signs are insufficient to serve as a basis of diagnosis

The principle of transillumination is demonstrated in the section (Fig. 81). On the left side, the large size of the antrum and the corresponding thinness of its walls, and the fact that all the rays which reach the eye must first pass through this cavity, would make this an excellent case for the various methods of transillumination—Voltolini-Heryng's, Davidsohn's and Garel's.

If the sinus is free of secretion, this case would show transillumination of the cheek, illumination of the retina, and the subjective perception of light.

The other side of the section, however, would lead to embarrassing results from transillumination, as the small size of the cavity and the thickness of the surrounding wall would inhibit the various phenomena of transillumination. If this small sinus were filled with purulent secretion, it would not materially change the character of the results of transillumination on this side. Fortunately, however, this is an exceptional case, and there are comparatively only few cases which exhibit such a variation from the regular anatomical structure.

The value of transillumination would seem to depend upon the question as to whether pus in the antrum would always prevent the illumination of these cavities, or the illumination of the eye.

While these researches on the normal subject have shown that nonillumination may also take place, in a small percentage of cases, in subjects in whom the antrum of Highmore is not affected, still, if this were the only objection, it would nevertheless be of value if only in a negative capacity. This, however, is not always the case, and I have seen occasional subjects, in which transillumination was quite brilliant, while an exploratory puncture, or the catheterization of the normal opening, afterwards showed that the cavities were completely filled with pus.

On the other hand, as this method is so easily accomplished, and requires no special dexterity in the physician, or pain or inconvenience on the part of the patient, and, as the results obtained have certainly been valuable in a large number of cases, this method will, therefore, be useful, although not entirely reliable, in making the diagnosis of pus in the antrum of Highmore.

We should, therefore, not underestimate the value of the different methods of transillumination for the diagnosis of antral disease; every one who has made an extensive and impartial trial of these methods will admit that they have proved of great

assistance in many cases, although they may be occasionally misleading.

NASAL SEPTUM, FRONTAL SINUS, ETHMOIDAL AND MASTOID CELLS.

While the bulk of literature on transillumination in rhinologic practice has been expended on its value in the diagnosis of the maxillary sinuses, this method has also been applied, though to a limited extent, in the examination of the other accessory sinuses.

For the frontal sinus and ethmoidal cells, the Heryng lamp (Fig. 78) is also applicable, but the cylindrical cap should be attached instead of the tongue depressor. In order to avoid the possibility of giving the patient pain during the examination from the heat of the lamp or the cap, I attach a short rubber tube over the cap, and as only the rubber comes in contact with the face of the patient but little heat is transmitted. The rubber with the lamp inserted is then placed in the angle between the nose and the eyebrows and directed upward. In some cases, the frontal sinus will be sufficiently illuminated to show its whole dimension; in many cases, however, the results are unsatisfactory.

An electric lamp by means of which the thickening of the *nasal septum* may be estimated has been devised by J. H. Martindale (75) in order to avoid perforation in septal operations.

The *ethmoidal cells* are usually considered beyond the reach of the methods of transillumination, but Geo. W. Caldwell (57) claims that this region may also be reached by this method. A small lamp, such as is used for the mastoid cells, is applied to the orbital tissue between the pupil and the inner wall of the orbit, and the illumination of the ethmoidal cells and the superior meatus may then be seen through the naris. He claims that transillumination is one of our most valuable diagnostic methods. It is easy of application and causes no inconvenience to the patient.

Transillumination is also considered of importance in the diagnosis of empyema of the frontal sinus by Vohsen (73). The apparatus which he uses for this purpose is similar to the modified Heryng's lamp already described, and consists of a strong rubber tube 4 centimeters long attached to the end of the lamp container, the free end of the tube being applied to the base of the frontal sinus behind the supra-orbital border so that the light penetrates the frontal sinus.

Heryng has used transillumination of the frontal sinus through the nasal chambers, and of the mastoid process from the external auricular canal.

The disadvantage of examining the frontal sinus by transillumination is principally due to its anatomical conditions. In suppurative processes of the maxillary sinus, the opening, through which the secretion is discharged into the nasal chambers (ductus maxillaris), is at the upper part of the cavity, so that the sinus is almost filled with secretion when the head is in the upright position. The frontal sinus, however, under similar circumstances, is free of its discharge, as the point of drainage is in the lowest part of the cavity. This, of course, does not refer to obstructive lesions; the pain, pressure and general disturbance, due to this condition, are usually sufficiently plain without the assistance of transillumination. The interference with the transmitted light due to the presence of pus, which is found in empyema of the maxillary sinus, is, therefore, rarely seen in the frontal sinus.

In the method suggested by Heryng of examining the frontal sinus through the nasal passage, the objection is that the result may be vitiated not only by anatomical conditions of the frontal sinus, but also of the nasal chambers and ethmoidal cells, which may intercept the rays regardless of the condition of the frontal sinus.

The method of examining the antrum by placing the lamp laterally in the mouth as suggested by Ruault (46), is also useful in the diagnosis of suppurative processes in the ethmoidal cells and frontal sinus. In his opinion, the presence of the obscurity of the region of the nasal bones, in a subject presenting a purulent flow from the meatus of the same side, combined with translucidity of the corresponding maxillary sinus, is a diagnostic point of great value. It indicates suppuration in the region of the anterior ethmoidal cells, whether primary or secondary, and the inflammation of the frontal sinus. Ruault has found this sign present a number of times in patients with inflammation of the frontal and ethmoidal sinuses, and in those with syphilitic lesions of the same region. Although he does not attribute a pathognomonic value to this, he considers it a sign which should not be neglected.

Transillumination has also been used in the diagnosis of inflammatory processes in the *mastoid cells*. A lamp protected with a rubber tube (Fig. 78), such as is used for the frontal sinus, is applied to the mastoid cells, and the auricular canal is examined by

means of a speculum from which all light has been excluded as far as possible.

In cases in which the pneumatic cells of the mastoid are filled with pus, the transillumination may be entirely absent and is usually markedly diminished. Even in cases in which the lining membrane of the cells is thickened by hyperemia or inflammation, the full effect of transillumination is interfered with.

The results of transillumination in these cases are affected by anatomical peculiarities of the location and density of the cells to be examined, which influence the value of this method. In some cases, however, the comparison of the effects with those obtained in the opposite ear is of some diagnostic value, and should not be neglected in the differential diagnosis of cases in which inflammation of the mastoid cells is suspected.

Transillumination has also been tried by projecting a strong light into the auricular canal and examining the external mastoid cells in a darkened room. This method is of little value, however, and I have never been able to obtain satisfactory results from its application.

LARYNX.

The first reference to transillumination of the larynx was made by Czermak (94), this method being afterwards elaborated by Stoerk, Voltolini and others. As first practised, the source of illumination was either gas or sunlight, but the results were so unsatisfactory that the method was soon abandoned. Voltolini (77) was the first to apply the incandescent electric lamp for this purpose. He made use of an incandescent lamp, 4 centimeters in diameter, whose posterior surface was coated with mirror amalgam. In front of the lamp, a glass ball filled with cold water prevented the heating of the lamp, and, at the same time, answered the purpose of a biconvex lens. The larynx was then examined with the mirror in the usual manner, except that no light than what was transmitted through the tissues of the neck was used.

The advantage of this method of examining the internal structures of the larynx was pointed out by Voltolini, who demonstrated its effect in a number of normal and diseased individuals. He found it especially applicable in cases of neoplasms, situated far down in the trachea, and in granulations of the larynx, which are difficult to examine by the ordinary methods.

In order to illuminate the larynx, Roth made use of a lamp, the rays of which were conducted into the parts by means of a cylindrical rod of glass. This has the advantage that the glass does not become heated and that the illuminated area may be confined to any part of the larynx. Chevalier Jackson's transilluminator (Fig. 79) is also made on this principle, and may be used in a similar manner.

The most convenient instrument for examining the larynx by transillumination is the modification of Heryng's antrum illuminator (Fig. 78), the cylindrical piece with rubber tube protector being attached instead of the tongue depressor, as in the examination of the frontal sinus. The room is then thoroughly darkened and the larynx examined with a laryngoscopic mirror, as in ordinary laryngoscopy, the only light which is used being transmitted through the tissues of the larynx.

This method has been used by Heryng, who insists upon the total darkening of the examining chamber. Gottstein (78) states that the incandescent lamp gives the best results when applied to two points. First, in the region between the superior border of the *pomum Adami* and the hyoid bone, and second in the cricoid region. In the first position, the whole interior of the larynx is beautifully transilluminated and the epiglottis less so.

In some individuals, especially women, with upright larynxes, the light is projected upwards as far as the uvula and velum, so that there is a rosy appearance as soon as the mouth is opened. When the lamp is applied to the region of the cricoid cartilage, the trachea and the vocal cords appear a blood red, while the upper part of the larynx is dark. In order to illuminate the pyriform sinuses, the incandescent lamp should be applied to the right or to the left upper band of the thyroid cartilage.

In regard to the diagnostic value of transillumination of the larynx, it does not enable us to diagnosticate inflammatory processes, as the normal red and the inflammatory red appear of one color, and even anemic conditions are difficult to distinguish. Changes in the structures of the larynx, however, such as infiltrations, neoplasms etc., may be distinguished, but not as clearly as when the light is transmitted directly into the larynx.

Transillumination of the larynx, as advocated by Voltolini, has not been found very useful by Gottstein (79), who was not able to see more by this method than with ordinary methods of laryngoscopy—on the contrary usually much less. Seifert, of Würtzburg,

believes that the examination should be made from different parts of the larynx before it is abandoned, as advised by Schrötter.

A special advantage of transillumination of the larynx, and one which I have not seen referred to in the literature of this subject, is in the location of foreign bodies. When a 5-candle-power incandescent lamp is applied to the larynx in the manner already described, all the tissues of the parts take on a roseate hue, which reminds one of the setting sun. If now there be a foreign body in the larynx, its opacity at once distinguishes it from the surrounding tissues.

A case, in which I applied this method, was that of a young man who had inspired a collar button into his larynx. The location of this foreign body by the ordinary laryngoscopic mirror was exceedingly difficult on account of the neutral color of the foreign body and its location below the vocal cord. When the incandescent lamp was then applied to the external part of the thyroid cartilage and transillumination effected, the foreign body stood out as an opaque mass among the surrounding tissues, showing not only its location, but also its form. This foreign body was afterwards also located by means of the sun rays reflected into the larynx.

In regard to foreign bodies, the recent introduction of the X-ray method has furnished us with a useful means of diagnosis.

CHAPTER XI.

The Electro-Cautery.

THE surgical application of the electro-cautery in the last decade has been phenomenal, and not without reason. When we remember that the cautery point, attached to a wire of any shape, may be carried cold to locations in which the application is to be made, and even to parts, as in the larynx, in which we can follow the direction of the cautery point only by aid of the laryngeal mirror and reflected light—that the point may be instantly heated, the work accomplished, and the instrument withdrawn as cold and harmless as when it entered, it is not surprising that this agent has been so much utilized.

In the year 1885, cocaine was first brought prominently before the profession, and, by its property of causing local anæsthesia, largely stimulated the use—and also the abuse—of the electro-cautery.

At this time, the electric current used for heating the cautery was principally from chemical batteries, and the accumulators which were still imperfect were being first introduced.

The application of the electro-cautery in the upper respiratory passages has been much facilitated by Bruns, Hedinger and Voltolini. Schech (80) has also devised a number of useful instruments for this purpose.

In applying electricity to the electro-cautery for its thermic effect, a current of low potential but of large quantity is needed. On this account, the batteries used for galvanism are not applicable, as they are intended to generate a current of electricity of high potential, in order to overcome the resistance of the human body, but of small quantity. For the electro-cautery, the reverse of this is the case, a current of large quantity but low potential being needed. The electro-cautery itself, the handle and the conducting cords have a low electric resistance, which a current of low potential will overcome; as, however, we wish to develop a considerable degree of heat in the cautery point, a large quantity

of this current is required. Therefore, the chemical battery, storage cells or dynamo, intended for heating the electro-cautery, must have the capacity to furnish a large quantity of current, some cauteries requiring as much as 20 amperes, while the pressure need rarely be more than five volts.[1]

In order to produce the required thermic effect, the principal resistance in the circuit is placed in the wire points to be heated, which are, therefore, made comparatively light and usually of platinum, whose resistance is seven times as great as the copper

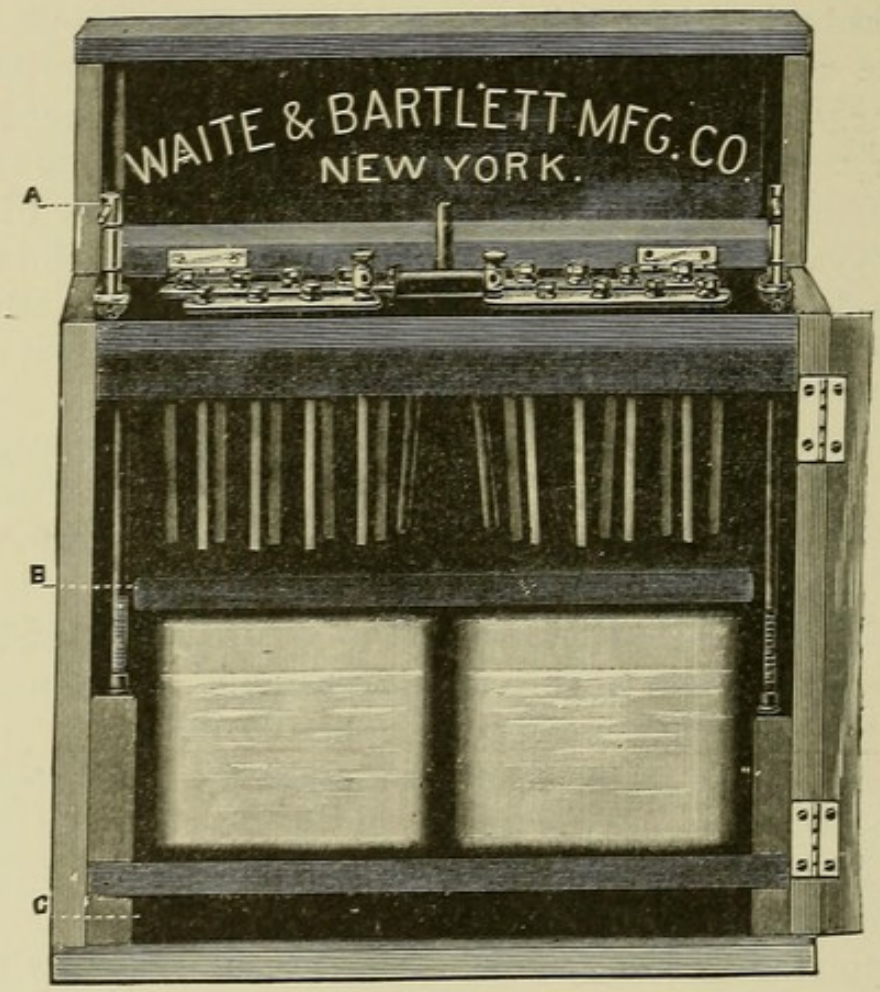


Fig. 82. Bichromate of Potash Cautery Battery.

of which the cables are made. Platinum also possesses the advantage of not being easily fused or oxidized. In France, iron cautery points have recently been introduced, and, while they

[1] If the electro-cautery handle and cable together have a resistance of 0.06 ohm, and if, for instance, the cells of a chemical battery should be found to have a small internal resistance of 0.06 ohm per cell, then two cells of 1.5 volts in series will be found sufficient to generate the required strength of current for the resistance, as shown by the following formula:

$$\frac{1.50 + 1.50 \text{ volts}}{0.06 + 0.12 \text{ ohms}} = \frac{3}{0.18} = 16.6 \text{ amperes.}$$

possess the advantage of cheapness, they are so rapidly destroyed by oxidation that they have to be frequently changed, and they will, therefore, probably not be very extensively used.

The current required for heating the electro-cauteries may be obtained by means of chemical batteries, storage cells or dynamos—the current supplied by the incandescent light companies coming under the third head.

Chemical batteries, whose composition and arrangement enable them to generate a current of large quantity, are applicable for heating the electro-cautery, and, where other methods are not available, they may be used for this purpose. The bichromate of

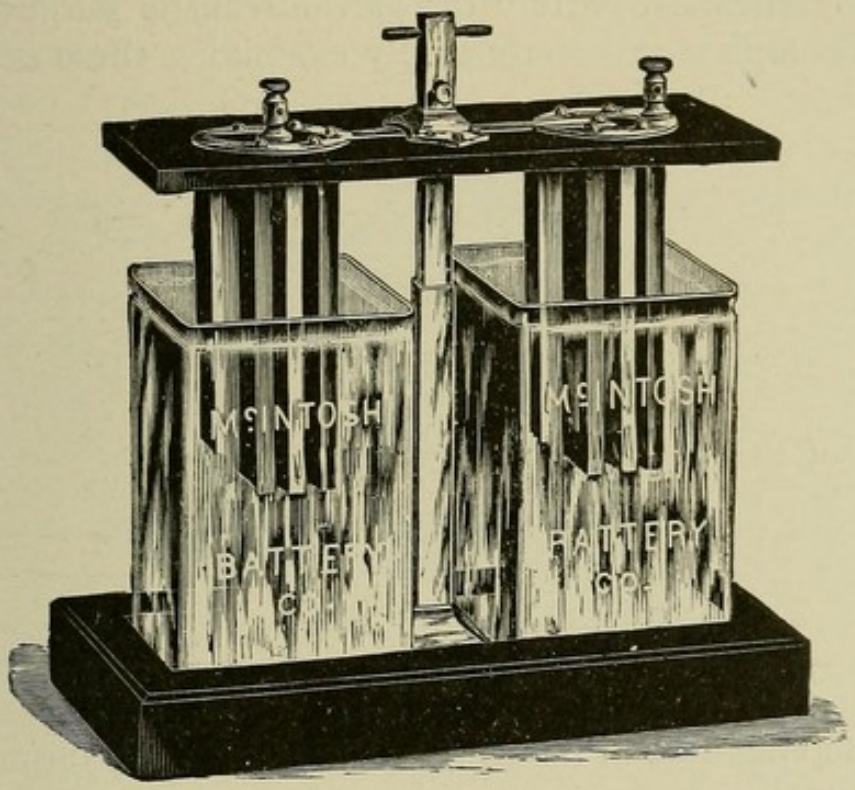


Fig. 83. Simple Cautery Battery.

potash battery (Fig. 82) was formerly much used for the electro-cautery. It consists of two or more large cells containing a solution of bichromate of potash, into which large plates of carbon and of amalgamated zinc are lowered by means of a special handle or crank, whence the name of "dip" or "plunge" batteries.

The objection to the bichromate of potash battery is the want of constancy of the current generated, the bulkiness of the battery, and that it requires special attention which the majority of physicians are unwilling or unable to give it. One of the advantages urged for the plunge battery is that it is "portable." If an

apparatus which weighs 25 to 50 pounds, and from which the solution is liable to spill to the detriment of the battery and the surroundings, may be called "portable," then it certainly has a right to this title.

Another bichromate of potash or plunge battery is shown in Fig. 83. It has the advantage of being inexpensive.

My personal experience with the Edison-Lalande battery for cautery work has been somewhat unfortunate. In spite of careful attention, it rapidly deteriorated, even when the battery was not in active use, and similar complaints have been made by others who have used this battery. On the other hand, it is difficult to obtain any chemical battery for galvano-caustic purposes which will give complete satisfaction. By examining these cells in the

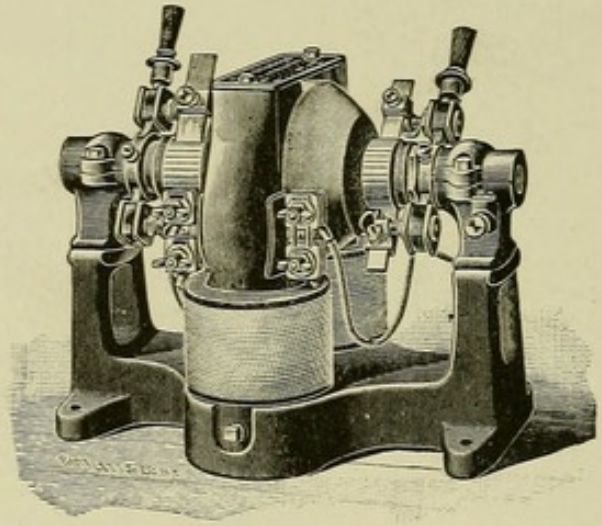


Fig. 84. Motor-Dynamo.

manner described when referring to their use in galvanism, the life of this battery may be much prolonged.

The introduction of *storage cells*, accumulators or secondary batteries, as they are also called, was a decided advance in the methods of obtaining an electric current for cautery purposes. They have the advantage over the bichromate batteries in that they are constant, that the plates need not be plunged in and out of the acid solution, and that they yield more than twice as many ampere-hours as a bichromate battery of the same size. On the other hand, storage batteries require charging at least every three months, even when not in use, and oftener in proportion to the extent to which they are used.

A storage battery may be charged from a dynamo of low voltage, as, for instance, a motor-dynamo (Fig. 84), or from the incan-

descent-light current by the introduction of a proper resistance, as a 100 candle-power lamp.

At the Eye, Ear, Nose and Throat Hospital, where for some years we used storage cells for heating the electro-cauteries, the battery was connected in series with all the lamps in the Treatment Room, and, as these were used for several hours daily, the storage cells were always kept charged for use. In order to avoid overcharging these cells, a switch was so arranged that the current could be either passed through the cells, or these could be left out of the circuit. In charging the storage cell, only the direct current can be used, as the alternating is impracticable for this purpose; its rapid alternations prevent the development of those chemical changes in the storage cells, whose reaction afterwards gives rise to a current of electricity.

Where the incandescent light current is not available, the storage cells may be charged by means of the ordinary cupric sulphate or gravity battery (Fig. 16). Four of these cells connected in series will suffice for each cell of the storage battery. It requires 24 to 48 hours to generate sufficient electro-motive force to begin with; after this the storage battery, when not in use, may remain connected with the primary cells and thus be always ready for use.

A battery of three storage and eleven charging cells is shown in the cabinet devised by J. M. Ray, Louisville, Ky. (Fig. 85). It is so constructed that the charging cells are easy of access. In most cases, it is preferable to place the charging cells in an adjoining room or closet.

Storage batteries form an efficient and safe source of electrical energy for heating cauteries. Each cell has a capacity of about two volts and 200 ampere-hours, so that two cells connected in series will answer the requirements of most cauteries in use. The low voltage of these batteries obviates all danger to the patient, as the arc formed by the breaking of the cautery point would be insignificant.

Care should be taken that the battery be not short-circuited, as by direct contact of the conducting cords, as the lead plates would be rapidly destroyed.

The objection to storage batteries is, that, after being used for a year or two, they become unsatisfactory, and the plates have to be renewed. At the Eye, Ear, Nose and Throat Hospital, where we employed these batteries for several years, we found that after about two years' use they could no longer be relied upon. Another

objection is the necessity of recharging, the batteries being frequently run down when needed by the physician, as this neglect would cause a delay which might be of considerable importance.

A storage battery is not practical where only occasional use of it is made, as it rapidly deteriorates when not used regularly, that is, systematically charged and discharged.

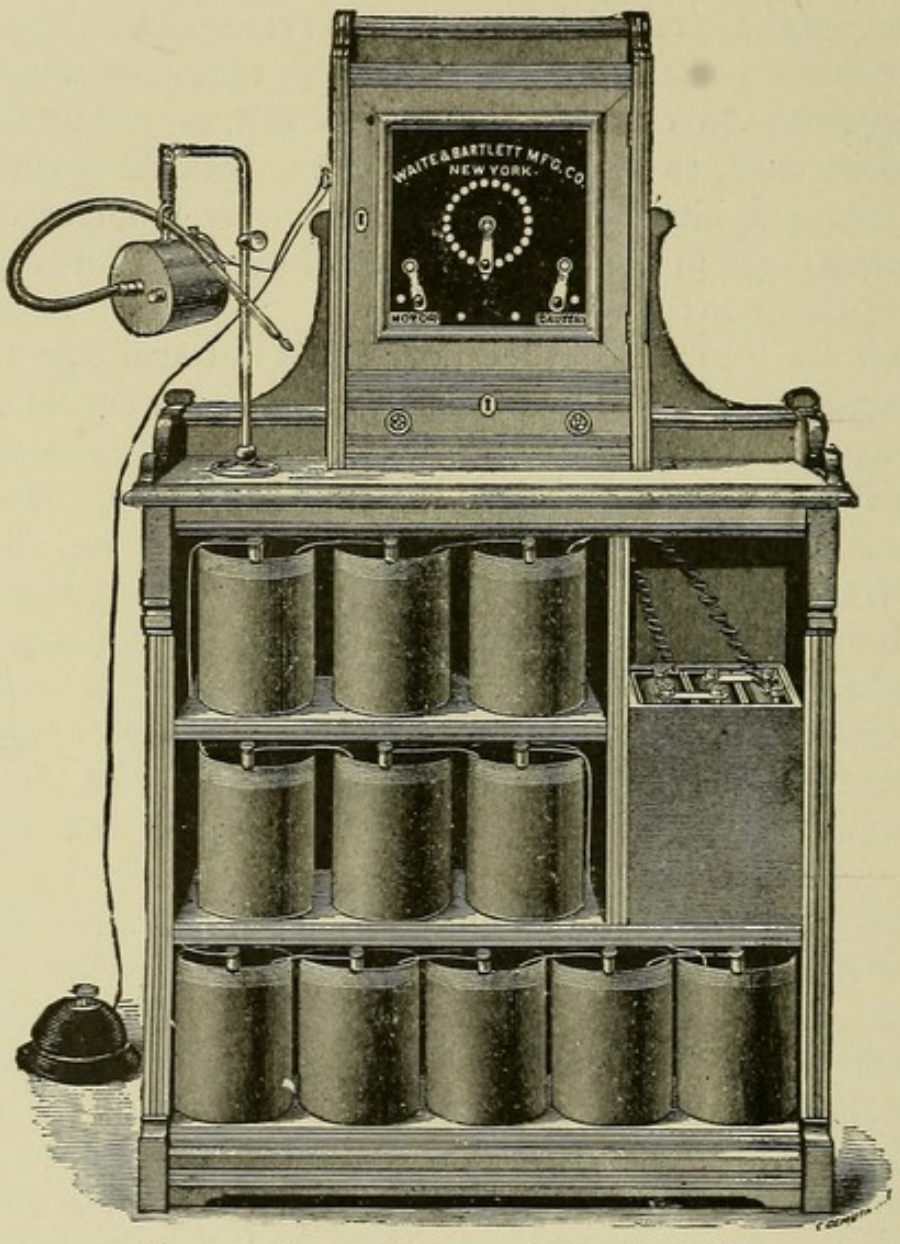


Fig. 85. Storage Battery and Charging Cells.

The storage batteries of the following manufacture were tested by the Committee of the American Electro-Therapeutic Association (8): The Franklin Electric Co., Electric Storage Battery Co., and Otto Flemming.

They found that these cells were well and favorably known in the electric field for their efficiency and strong mechanical struc-

ture, and that they were employed very extensively in electric light, launch and traction work. The outfits tested performed all that was claimed for them; they are well made, and with proper attention will serve a physician faithfully for at least five years without renewal of the plates.

The most convenient method of obtaining a current of electricity for cautery purposes is from a dynamo. This may be either from the incandescent light current, both the direct and the alternating being available for this purpose, or from a dynamo giving a current of low voltage and large amperage, as the motor dynamo shown in Fig. 84.

When the incandescent light current was first applied for cautery purposes, this was done without a shunt and simply by placing a sufficient resistance, as a bank of 100 candle-power lamps in series with the cautery, and in this way a current of sufficient amperage was obtained to heat the cautery point.

While a cautery requires a considerable quantity of electricity, the resistance is so low that a current of low voltage will suffice to overcome it, few cauteries requiring more than 8 volts. When, therefore, the 115 volt current was used, there was not only a great waste of power, but a heavy current at such a voltage possessed a dangerous amount of energy. This could be noted by observing the interrupter. Whenever the current was broken, it gave rise to a vivid arc on account of the large counter-electromotive force of the broken circuit. For this reason only a foot-switch was practical in these cases, as the lighter interrupter would have been burnt out.

This method also possesses a considerable element of danger. If, from excessive heat, the electro-cautery point becomes broken, or this effect is due to any other cause, the broken part of the electrode will cause an arcing due to the broken circuit, which will develop an enormous amount of heat.

In order to use a bank of lamps for cautery purposes, at least five 100 candle-power lamps are needed, as some of the cauteries require as much as 15 amperes in order to heat them. When this arrangement is used, the 15 amperes at 110 volts will give 1650 watts, which is nearly four times the energy expended in one of our street arc lamps. If such a current should form an arc from the breaking of the current in the electrode, there would be an expenditure of energy which would be exceedingly dangerous to the life of the patient on whom it is used.

In some cases instead of a lamp resistance, a rheostat of acidulated water is used for the same purpose, and quite recently in an estimate to a prominent hospital, a contract was seriously considered for adoption, in which this form of cautery resistance was specified. In spite of the danger of using the electro-cautery with a simple resistance to the incandescent mains, there are still some hospitals in which this dangerous method of using the electro-cautery is practiced.

In experiments which I have made with a view of testing these effects, the heat was sufficient when the point was broken to fuse the platinum into a ball at the end of the electrode. As the melting point of platinum is high, the amount of heat due to this would have been exceedingly dangerous, if this effect had taken place in the nose or throat of the patient. With the introduction of storage batteries, shunt rheostats and motor-dynamos, this danger, due to the employment of a current of high electromotive force, is entirely avoided.

In the *shunt rheostats*, the danger referred to in using the incandescent light current for the electro-cautery is entirely absent. In this instrument, the main current passes directly through the German-silver wire, or other material of which the coil is made, and the current which is tapped from this coil is of low voltage and considerable amperage. An apparatus made on the principle of the shunt rheostat is the K. A. P. Dynamic Cautery Apparatus, which is somewhat bulky, but still a useful and durable rheostat to use in connection with the incandescent circuit. The resistance in this apparatus consists of coils of German-silver wire imbedded in asbestos, the amount of current required for the cautery being shunted off by means of the crank at the upper part of the apparatus. The signal lamp above the switch is attached simply to show when the current is off or on, so that the operator will not forget to turn off the current after each operation.

A number of tests, which I have made with the volt-meter and ampere-meter with this apparatus, has given the following results:

No. on Scales.	Volts.	Amperes.
½	2	12
1	5	14½
1½	7	16
2	10	17
2½	12	17½
3	15	18

I have never had occasion to exceed No. 3 on the scales for heating the cauteries, or lighting up the small incandescent lamps for which this rheostat is also applicable, and it is rarely necessary to exceed No. 2.

An examination of the above table will show that this apparatus is adaptable to any cautery which is used in surgery, and that at no time is the voltage sufficient to be dangerous to human life, the maximum at the end of the scale of the instrument being 30 volts.

The objection that has been urged against the various shunt rheostats is that they are wasteful of the current, a large proportion passing over the shunt wires. While this is theoretically true, cauteries are used for such a short fraction of time that the question of the comparative expense need not be considered. When these rheostats are required for the incandescent lamps, however, which may be used for an indefinite time, the question of expense is an important one, and a more conservative method is therefore recommended for the forehead incandescent lamps for routine work. The antrum illuminators are required but for a short period of time, and these rheostats are therefore also applicable for this purpose.

The above consideration refers only to the electro-cautery in private practice. In hospitals where a large number of cauterizations may be required, and where the services of an intelligent electrician are available, the motor-dynamo is to be preferred. For electro-plating and other purposes in which a current of low voltage is required to be used for considerable lengths of time, the motor-dynamo is one of the most efficient of energy-saving devices.

The commercial *alternating current* used for incandescent lamps can also be utilized to heat electro-cauteries. The K. A. P. Cautery Apparatus and other shunt rheostats made on this principle are also suitable for this current. For the alternating current, *transformers* may be used for converting the energy of an alternating current of high tension and small quantity into one of large quantity and low tension. They are simply reversed induction coils and follow the physical laws of the faradic current.

A transformer is really the most economical arrangement for heating electro-cauteries, but it is available only with the alternating current, which cannot be used for the many purposes for which the direct (galvanic) current is applicable. A transformer

made on this principle is the Duplex Transformer (Fig. 61) made by the Carter Mfg. Co. This instrument is adapted to be used on any voltage alternating incandescent light circuit. It has separate regulators and separate connection for battery and lamp, thus enabling the physician to use either or both at the same time. There are 18 regulations on both the battery and the lamp circuit, making it possible to heat the smallest to the largest cauteries, and illuminate from two to ten candle-power exploring lamps.

A transformer, made by the Edison Mfg. Co. for utilizing the alternating current for cautery purposes is shown in Fig. 86.

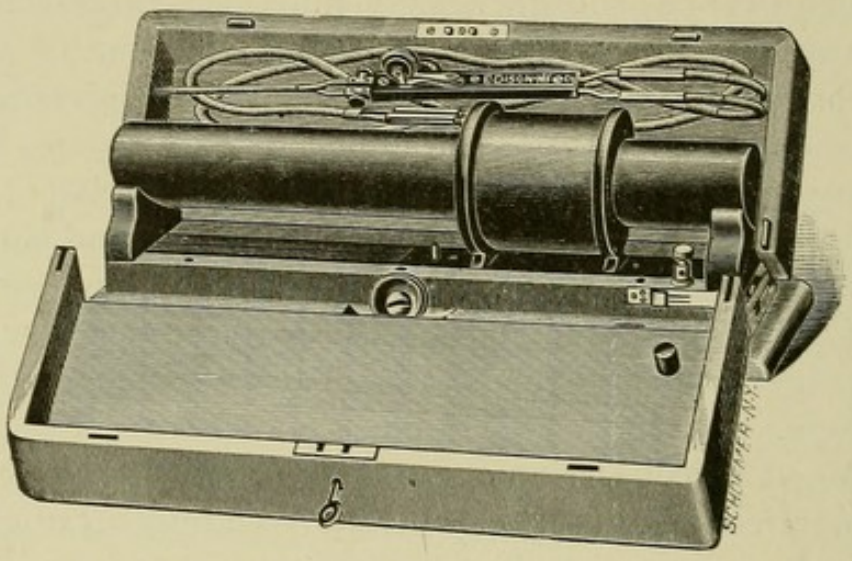


Fig. 86. Transformer for Alternating Current.

The same instrument combined with a motor-dynamo is shown in Fig. 87, in which the direct 110 volt current is transformed into an alternating current of the same voltage, this being passed through the transformer by which the voltage is reduced and the amperage correspondingly increased, so that it may be economically used for cautery purposes.

An apparatus made on the transformer principle for electro-cautery operations is also described by Arthur G. Hobbs, of Atlanta (81). The main current is passed through a coil, and, by the arrangement of the coil of the converter, any required voltage may be obtained. He states that, as the electro-motive force in actual use with this transformer is acquired by induction, and is not in direct contact with the initial current, there can be no possible danger to either the patient or the operator, even if the initial wire should by accident come in contact with more powerful wires.

Where this method is applied for reducing a high to a low voltage for incandescent lighting, it is not a rare occurrence that the tension of the primary current breaks through the insulation of the converter and thus destroys the converter itself. While the insulation of the transformer described may be sufficient for the 110-volt incandescent current for which it is intended, it is doubtful whether this would be sufficient, if by some accident a 2000-volt current should be passed through this transformer. On the other hand, this danger, although a possibility, is remote, and there is no doubt but that these converters form an excellent and convenient method for utilizing the alternating current for electro-cautery and incandescent-light work.

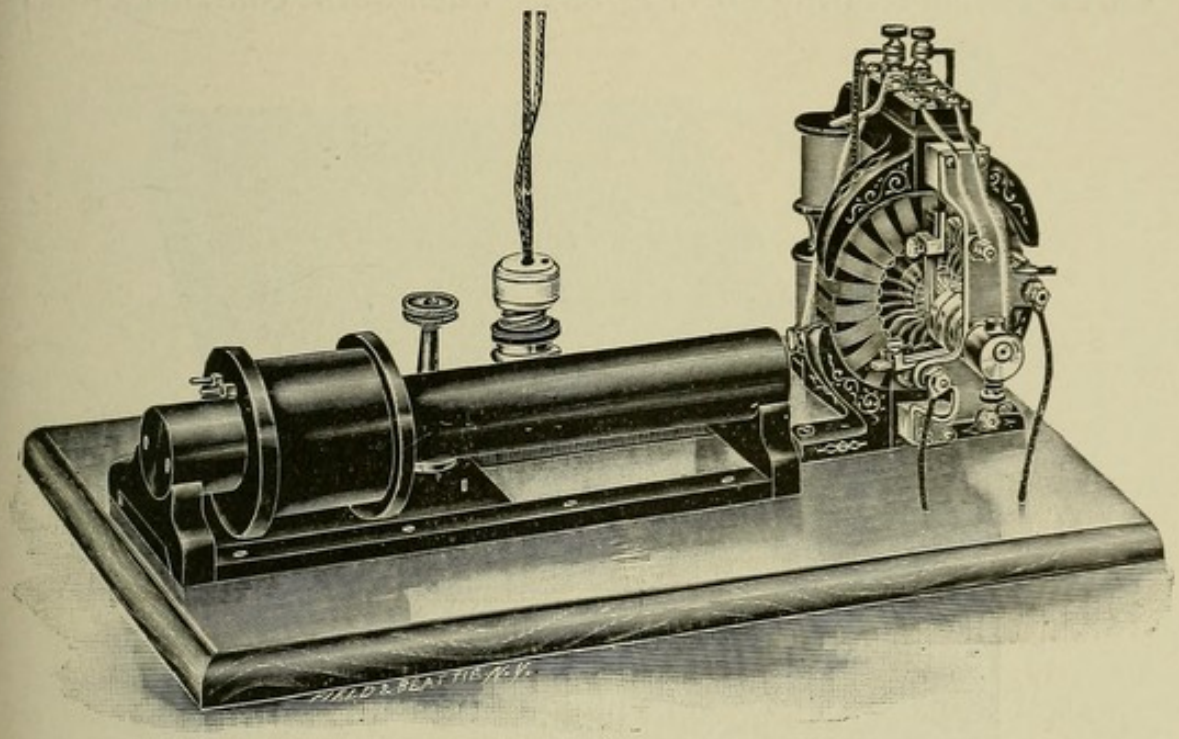


Fig. 87. Transformer with Motor-Dynamo.

A *motor-dynamo*, or rotary transformer, is a convenient and economical apparatus for transforming an available existing condition of direct electrical pressure and volume into the form of current required for heating electro-cauteries. They may also be conveniently used for operating the faradic coil, but, as the motor-dynamos for cautery purposes are usually adjusted to give a current of about five volts, the electric pressure is not sufficient for applying galvanism, for which 20 or more volts are required.

The motor-dynamo (Fig. 84) consists first of a motor which is operated by the available current, as the Edison incandescent-light current; the rotary motion of the armature of the motor is

transmitted to a shaft carrying another armature, enveloped by the same pair of field magnets as the motor; but the armature of the dynamo is so wound that the current generated has a pressure of only five volts, the remaining electric energy being transformed into volume of current. A current, for instance, of one ampere at 115 volts, which is equivalent to an energy of 115 watts, is transformed into a current of 23 amperes at 5 volts ($5 \times 23 = 115$ watts), with a loss of not more than 10 per cent., resulting from friction and self-induction. We can, therefore, utilize 90 per cent. of the supplied energy.

An excellent instrument made on this principle for utilizing the direct current for cautery and lamp purposes is devised by the Carter Manufacturing Co. (Fig. 88). Their outfit contains a rotary

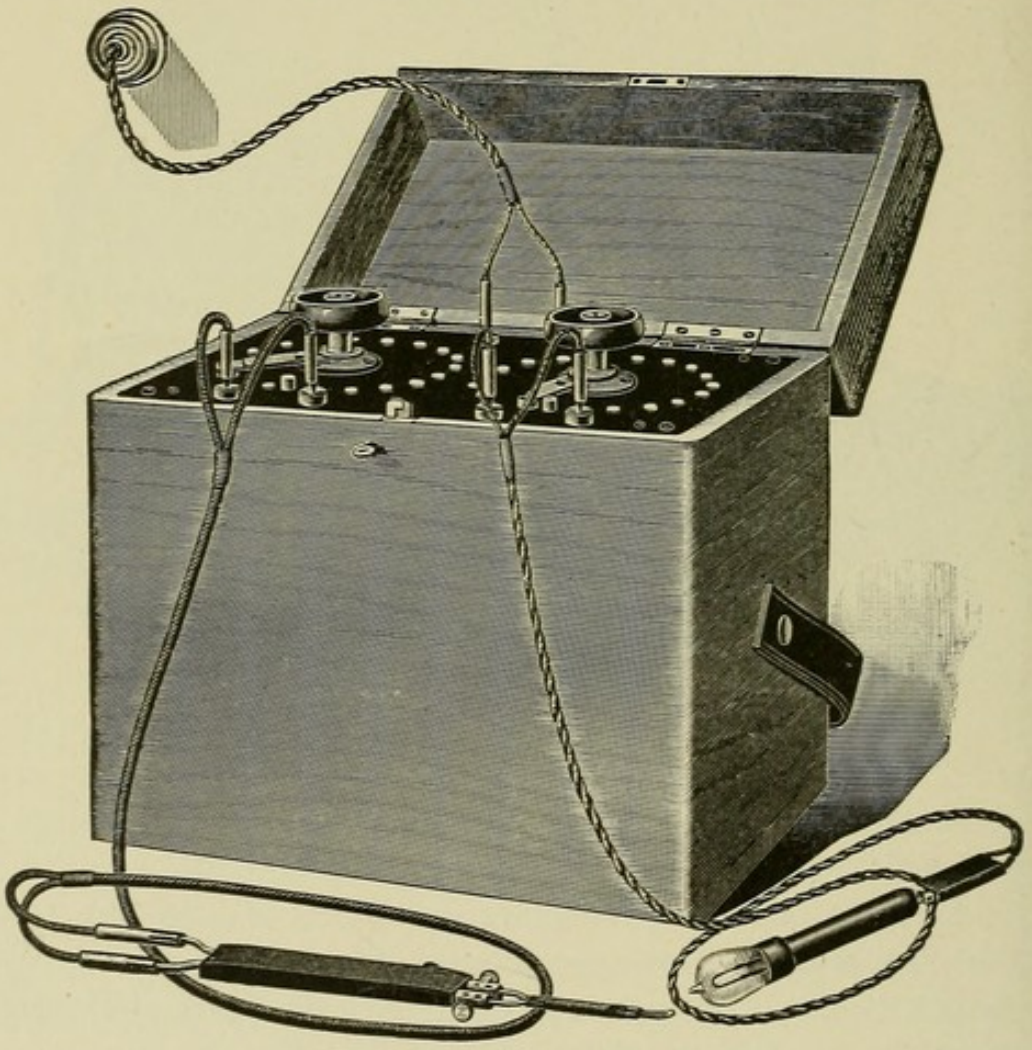


Fig. 88. Direct Current Transformer.

transformer or motor-dynamo, by which the 110-volt current is changed into one of low voltage and large quantity, this being a very economical method of utilizing the street current. The construction of their continuous-current cauterizer is as follows: a con-

tinuous current 110-volt motor with a special winding is used, and an alternating commutator in addition to the regular continuous-current motor commutator. This machine changes the current into an alternating current of 110 volts, which is transformed into one of lower voltage by means of a transformer similar to the one used in their duplex transformer (Fig. 61), that is, a transformer with two commutated secondary windings, one for the cauterizer and the other for the incandescent lamps. These secondary coils are wound on 19 sections, and each section connected with a contact point, thus enabling the operator to regulate the voltage of the current from one to ten volts on the cauterizer, and from two to twenty volts on the lamp regulator.

CHAPTER XII.

THE ELECTRO-CAUTERY.

(*Concluded.*)

ELECTRO-CAUTERY POINTS.

THE electro-cauteries are made of platinum soldered into copper wires of different lengths and shapes (Fig. 89), according to whether they are to be used for the nostrils, larynx, mouth etc.

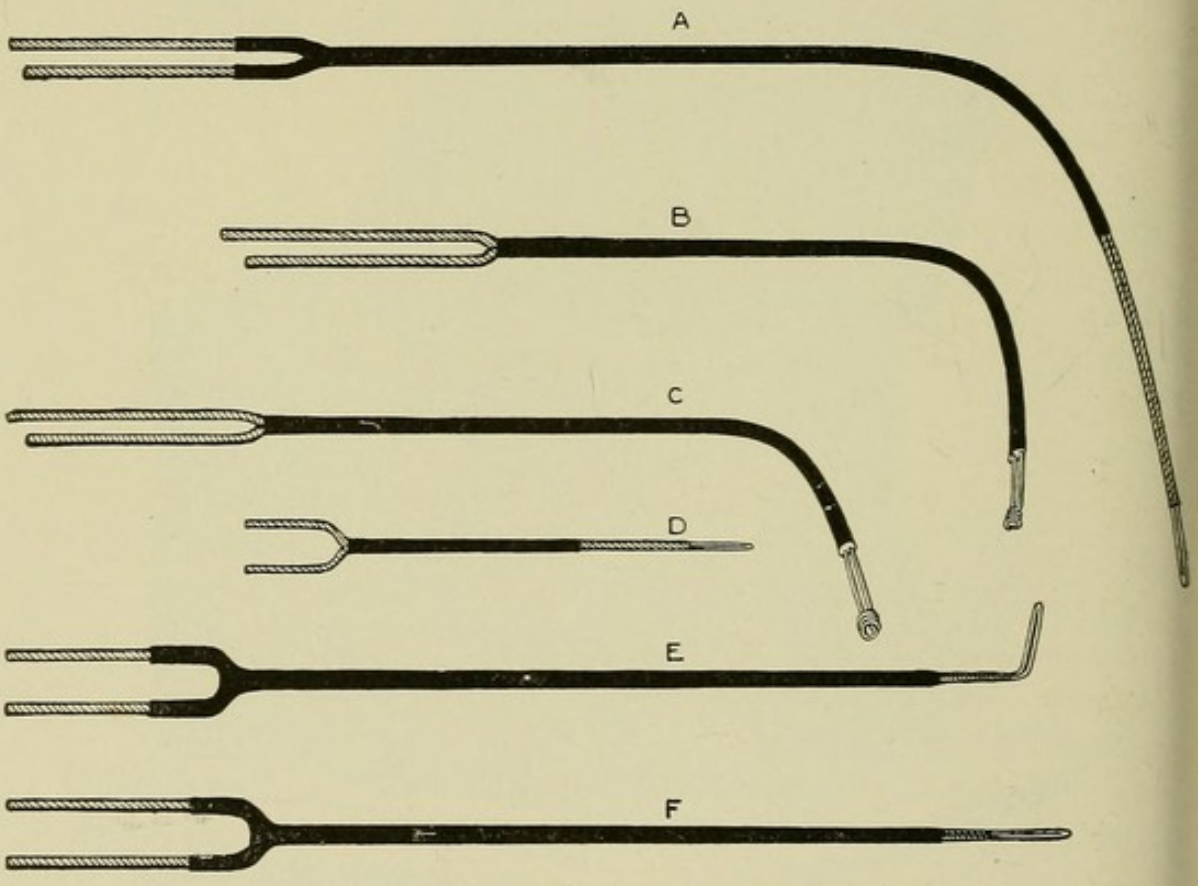


Fig. 89. Scheppegrell's Set of Electro-Cauteries.

The copper wires are insulated to prevent the short-circuiting of the current.

Many varieties of cauteries are figured in the various catalogues, but the majority of these are more or less impracticable. There are few operations in oto-laryngology which cannot be performed with two styles of cauteries—straight wire pointed and

rosette pointed. The cauteries made in the shape of a knife are usually too heavy and clumsy and radiate an excessive amount of heat. The same result is more easily obtained by means of a straight point which will cut as well as the knife-shaped cauteries while inflicting much less injury on the surrounding tissues. The lengths of the cauteries will depend, of course, upon the region in which they are to be used, the shorter cauteries being applicable for the nostrils and the longer for the larynx. When used in the naso-pharynx, base of tongue or larynx, the cautery is bent to the required angle.

The majority of cauteries are insulated with silk, but those which I have found the most useful are covered with an insulating material resembling gutta-percha, but, unlike this material, not affected by heat. The last mentioned have the advantage of being more easily sterilized. The cauteries which I have found sufficient for all work in oto-laryngology are shown in Fig. 89.

In selecting cauteries, they should be carefully examined to see that the insulation between the copper wires is good, and that these wires are not too light in proportion to the platinum point. If the insulation is not sufficient, the cautery will not become heated, and if the copper wires are too light, they will not only offer too much resistance to the current, but these may even become heated.

Some of the electro-cauteries which are sold are not sufficiently insulated, the conductors being separated only by two fittings of bone at each extremity. This construction makes them convenient for disinfection, but impracticable from an electrical standpoint. It is true that the two insulators are sufficient to prevent the short-circuiting of the current through the wires, and that the low potential, which is generally used, would remove any fear of sufficient current passing through the tissues to be disagreeable; but it should be remembered that in some hospitals they still use the direct 110-volt current with a simple lamp resistance, and not with a shunt rheostat, and that, if the platinum point of the electrode should be destroyed, the uninsulated condition of the wires would much increase the danger of arcing with this electrode.

An equally important matter is that, as these electrodes are frequently used in nasal operations, and, therefore, through a nasal speculum which is usually made of a metallic substance, the simultaneous contact of the two wires with the speculum would be sufficient to short-circuit the current, and thus prevent the

heating of the platinum wire. This is not a mere theoretical objection, as I have seen it in actual practice.

Another defect in many electrodes, and one which is unfortunately too common, is that the platinum wires are too large in proportion to the size of the copper conductors of the electrode. In order to obtain a red heat at the point of the electrode, these conductors become sufficiently hot to inflict injury on the tissues with which they come in contact. There is no necessity, moreover, for the platinum wires being so heavy, as they are never used with great force, and it would even be more economical if they were made lighter.

ELECTRO-CAUTERY HANDLES.

Electro-cautery handles are made in a variety of shapes and of some non-conducting material, usually of hard rubber. A variety of handles are here shown, some being round, and others square (Figs.

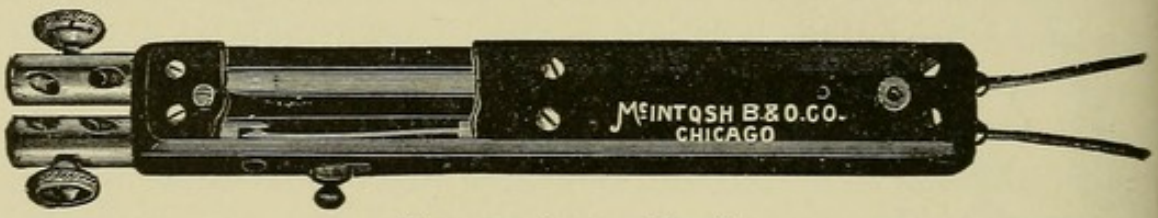


Fig. 90. Cautery Handle.

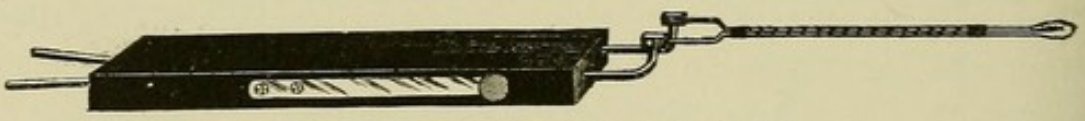


Fig. 91. Cautery Point and Handle.

90, 91, 93). A cautery handle, with wheel attachment for heating the wire loop, used as an écraseur, is shown in Fig. 92. This wheel attachment is an impracticable method of using the galvano-

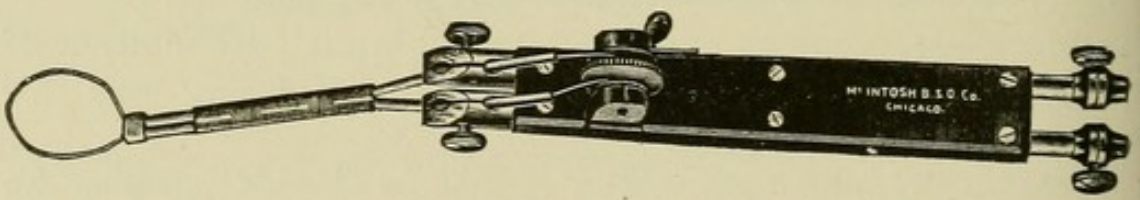


Fig. 92. Cautery Handle with Wheel Attachment.

caustic snare, and does not compare in efficacy with the snares made after the model of Schech (Fig. 98) and others.

A cautery handle (Fig. 93) which I have had made especially for my work, and which I have found most convenient, is made of hard rubber, corrugated on the outside, with a depression for

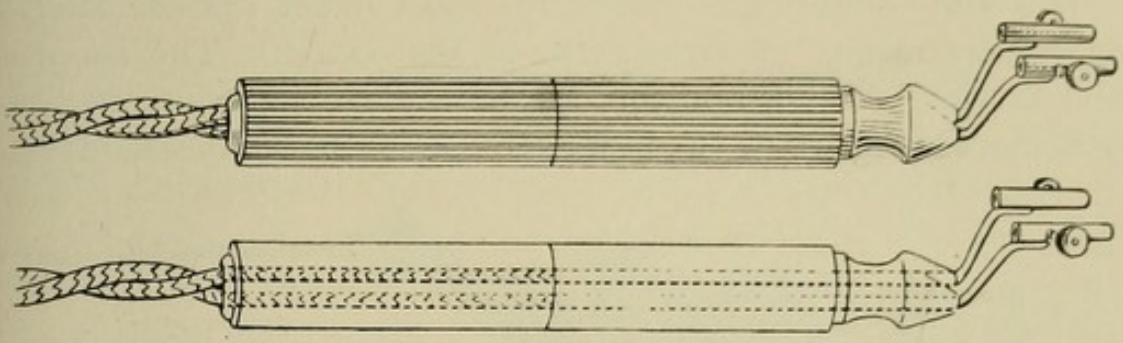


Fig. 93. Scheppegrell's Electro-Cautery Handle.

the fingers, and has the cables soldered within the handles. As the handle is hollow, it is exceedingly light and does not interfere with free manipulation.

An electro-cautery handle (Fig. 94), which has a lever attach-

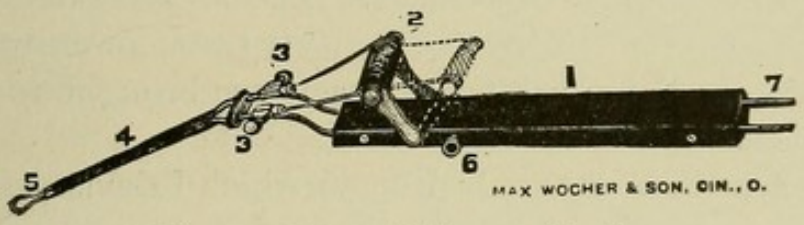


Fig. 94. Thorner's Cautery Handle.

ment so that it can be used for the snare, has been devised by Max Thorner, of Cincinnati (82).

CONNECTING CORDS.

The connecting cords for the electro-cauteries should be sufficiently heavy so as not to offer too much resistance to the passage of the current. Their resistance should not exceed 0.02 ohm. On the other hand, they should not be too heavy, as this would prevent the delicate manipulation of the cautery handle.

INTERRUPTERS.

In many of the electro-cautery handles, as in Fig. 95, the interrupter is controlled by the finger. I have always found this inconvenient and impracticable, as it requires the use of a finger and thus interferes with the delicacy of the manipulation of the cautery. The contact points of these interrupters also become easily oxidized, thus interfering with the use of the cautery.

They should never be used where the incandescent-light current is controlled by a simple resistance instead of a shunt rheostat, on account of the arc which would be formed.

It is more convenient to control the current for the electro-cautery by means of some form of foot-switch. The simplest form of this is a push-button, as shown in connection with the nasal motor (Fig. 102). A more convenient form consists of two

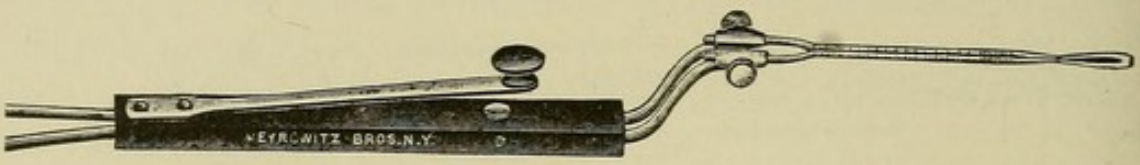


Fig. 95. Handle with Interrupter.

pieces of board, the upper adapted to the form of the foot, and balanced on a pivot attached to the upright band rising from the base-board (Figs. 105, 106). A spring attached between the two boards in advance of the median line presses the heel end of the foot-piece to the base-board. The contacts are placed near the front, so that when the foot, which rests comfortably on the upper board, is depressed, the contacts are brought together and the circuit closed.

The foot-switch, shown in Fig. 96, which I devised some years

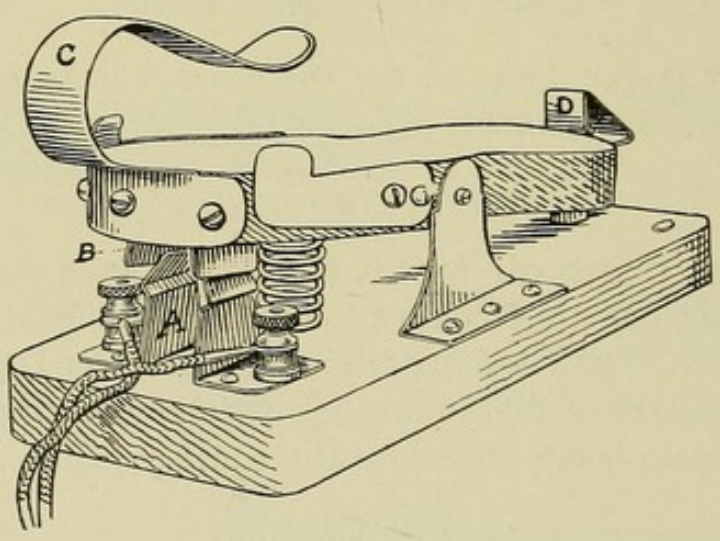


Fig. 96. Scheppegrell's Foot-Switch.

ago, has a feature which is sometimes useful. A slight pressure with the foot closes the circuit, and when this pressure is released a spring raises the upper plate and breaks the circuit. A heavier pressure with the foot, however, causes the switch to catch within another spring (Fig. 96, B), so that the circuit remains closed until

a slight pressure from the heel releases the spring. This arrangement is convenient in case we wish to use an interrupter in the handle, as in some forms of galvanic snares, antrum illuminators and for motors etc.

THE APPLICATION OF THE ELECTRO-CAUTERY.

Before being used, the cauteries should be examined to see that the copper wires are properly insulated, and that the metals do not touch in any part of their course, as this would short-circuit the current at the point of contact, and prevent the heating of the platinum wire.

When a cautery is too heavy for the capacity of the battery, the resistance may be increased by flattening the platinum wire, when it will become heated by a lighter current.

After a cautery has been used, it should be cleansed from organic matter, washed in an antiseptic solution and dried. Before being again used, it should be heated to a dull red for a moment, which will thoroughly disinfect it. The method sometimes adopted, of burning off the organic matter by heating the cautery, is efficacious only as far as the platinum point is concerned, and the high temperature needed for this purpose tends to destroy the usefulness of the cautery.

A cautery handle should be held like a pen, so as to allow delicate manipulation. When an application is to be made, the parts to be cauterized should be thoroughly illuminated, so that the process can be distinctly observed by the operator.

In applying the electro-cautery, the degree of heat is regulated by the nature of the tissue which it is intended to destroy. In general, this need not be more than a cherry red. Before making an application, the degree of heat should be tested in the air. This should not be done, however, in view of the patient, especially women who are easily frightened by the appearance of the heated point. Where it is to be used for tissues which contain a large amount of watery element, the degree of heat should be somewhat raised to allow for the cooling influence of these tissues.

Care should be taken in using the electro-cautery, that the circuit be not opened before the cautery is lifted from the tissues, as the eschar may be torn away, which would result in bleeding. The same effect is produced if the wire be too hot, because it then cuts like a knife. Too little heat is also objectionable, as

so much time is required that considerable heat is radiated into the surrounding tissues.

VALUE OF THE ELECTRO-CAUTERY.

The superiority of the electro-cautery over the chemical cauteries is admitted by the majority of writers. A few, however, still favor the use of chromic acid: Heryng, for instance, states his preference for this acid, and Maximillian Bresgen, of Frankfurt a. M. (83), also believes that, in narrow passages in which the hypertrophies are so marked that the space between the turbinal and the septum, or the floor of the nostril, has become so contracted that the finest sound cannot pass, chromic acid is more efficacious. In cases in which the electro-cautery cannot be applied, however, it is equally difficult to use the chromic acid. Such cases are preferably dealt with by electrolysis or the more radical surgical methods.

The electro-cautery is preferred by Fletcher Ingals, of Chicago (84), who finds that chromic acid causes much more pain than the electro-cautery, a more irritating discharge, and a sore which heals more slowly than that from the latter, and that its effects cannot be so accurately controlled.

The Paquelin cautery is rarely used in connection with diseases of the nose, throat and ear, and the more recent writers seldom refer to it in this connection. Krieg, of Stuttgart (85), however, prefers the Paquelin thermo-cautery to the electro-cautery for applications in the nose, naso-pharynx and throat. He has used it 690 (!) times in hypertrophic rhinitis, papillomata, epistaxis, pharyngeal granulations, destroying the base of polypi, reduction of the faucial and lingual tonsils, and also in pharyngomycosis leptothricia. He describes the various forms of burners which he uses for this purpose.

The fact that the electro-cautery may be applied cold and may be heated when *in situ* renders it much superior to the Paquelin cautery. The latter is also difficult to apply in cavities that are narrow, deep or anfractuous.

The thermo-cautery is compared with the electro-cautery by Dauchez (86), and, while he prefers both to tonsillotomy, he believes that the thermo-cautery is more efficient in causing the retraction and complete disappearance of the tonsil.

It is somewhat difficult to understand why the effects of the thermo- and electro-cautery should be compared, as both act by

the same agent—heat, the difference being only that in the Paquelin cautery the heat effect is maintained by the action of benzine vapor on a platinum point, and in the second, the platinum point is heated by the passage of an electric current. Presuming that both points are similar in size and form, and that the same degree of heat is maintained, the effects must necessarily be identical.

While the usefulness of the electro-cautery is admitted by most writers, its value is occasionally discredited. Thus F. H. Bosworth, New York (87), reports a case of a diffused round-cell sarcoma involving the posterior nares, vault of the pharynx, soft palate, pillar of the fauces, right tonsil and lower pharynx, which was cured by removal with the cold snare. He observed in this case that whenever the galvano-cautery was used, there was an aggravation of all the symptoms. As this occurred each time that the cautery was applied, he came to the conclusion that the galvano-cautery was responsible for it.

By snaring piece by piece with a cold écraseur, he finally removed the growth completely, which resulted in a cure of the patient. As a result of his experience, Bosworth inquires if the electro-cautery is not very much overestimated, and if it does not effect as much or even more evil than good. "All caustics," he states, "are an evil; sometimes, however, a necessary evil. When applied to destroy pathological tissue, there is always an inflammatory reaction of a more or less severe character in the neighboring tissues. The caustic whose effect is followed by the weakest reaction is therefore the best, and conversely, the one followed by the most severe reaction, the worst."

He thinks he is justified in the opinion that the potential cautery, whose action is dependent upon heat, calls forth a more severe reaction than the chemical agents. In the former case, we have added to the chemical effect that of heat, which is absent in the chemical agents. He is of the opinion that there is not a single indication for the use of the caustic which may not be obtained in a more active, reliable and mild manner, and with less after-effects, with simpler methods than with the electro-cautery.

This sweeping statement by so experienced an author as Bosworth necessarily carries considerable weight; but the question is whether the premises by which he arrives at his conclusions are properly substantiated.

The galvano-cautery when properly applied, being completely under control, may be conducted cold and harmless to the loca-

tion where it is to be used, and, after its work has been effected, which, by the way, may be stopped at any stage of the process, it may be removed as harmlessly as when it entered the cavity where the work was accomplished. The chemical cauteries, of which chromic acid may be accepted as a standard, are liable to have a destructive effect if the greatest care is not taken in reaching the part where the work is to be effected, and its action cannot be as clearly defined as with the galvano-cautery.

With the latter instrument, the destructive effect ceases as soon as the current is arrested; with the chemical cautery this is not the case. Its action will continue until those chemical changes have been effected which are produced by the combination of the acid with the tissues with which it is brought in contact. This may continue to some extent for a considerable time after the application, in spite of the use of alkalies, as I have had the opportunity of observing in a number of cases.

Where the electro-cautery is used in nasal operations with cocaine, the rule is that, when the anæsthesia has disappeared, pain is seldom complained of. With the chemical cauteries, and this more especially with chromic acid, the pain frequently continues for several hours after the application, and sometimes there is a violent reaction, which does not disappear until a day or two after the operation. With the electro-cautery, the reaction is usually so mild that the patient will frequently state that, had he not known that the cauterization had been done, he would not have realized it from any effect which he had experienced since the operation. This is rarely the case with the chemical cauteries. The possible toxic systemic effects of the chemical caustics are also impossible when the electro-cautery is used.

In the application of the electro-cautery in tumors, and especially in tumors of a malignant character, the repeated cauterization of a small area cannot but have an injurious effect on account of the reaction which is set up and repeated. The same rule applies here as with electrolysis, and the best results have been obtained with the latter where a powerful destructive effect has been produced in one or two sittings, whereas repeated sittings with currents of mild character would have aggravated the symptoms of the patient. This rule also applies to the cautery.

In a case of fibroid tumor of the naso-pharynx, under my care, the tumor was entirely destroyed by the electro-cautery, but in each case the application was continued until a very large mass of

the tumor had been destroyed, which would slough off a few days later. Where, however, the cold snare is used, as suggested by Bosworth, it is necessary, in order to avoid the hemorrhage following the interference with many of these tumors, that the snare be tightened so slowly that it causes considerable shock and depression to the patient. In one case in which this method was applied, and which afterwards came under my observation, it had required a two days' continuous application to remove a post-nasal fibroid by means of the cold snare.

On the other hand, Bosworth is not far from the truth when he states that the electro-cautery has been overestimated, or, perhaps more accurately speaking, too extensively used, especially in nasal surgery. But this need not prevent us from appreciating the true value of this instrument, which, of course, has its limitations, but in the cases where it is indicated, is incomparably superior to all chemical cauteries that may be used for the same purpose.

ELECTRO-CAUSTIC SNARE.

The principle of the electro-cautery has also been applied to certain instruments made for the same purpose as the écraseur, by means of which a steel or platinum wire is heated by the electric current and used for the bloodless removal of tumors and hypertrophic tissue. This principle was first applied by Middeldorf, Voltolini and Boekel.

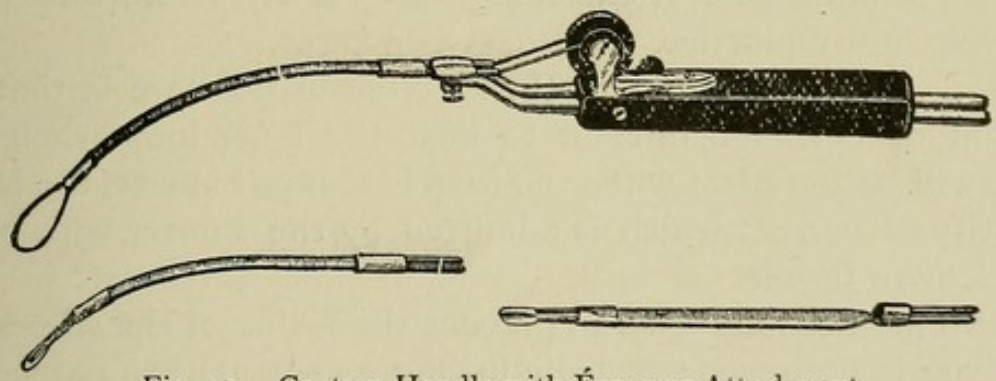


Fig. 97. Cautery Handle with Écraseur Attachment.

On account of the necessity of insulating the current used for this purpose, these instruments are made somewhat different from the ordinary cold snare.

Some of the cautery handles are so arranged that they may likewise be used for the electro-caustic snare. A handle of this description is shown in Fig. 97. Two tubes of copper insulated

from one another are inserted into the handle in the same manner as the cautery point, and the wire passed through the tubes is tightened by means of a wheel. A much superior instrument is shown in Fig. 98, being a modification of the electro-caustic snare

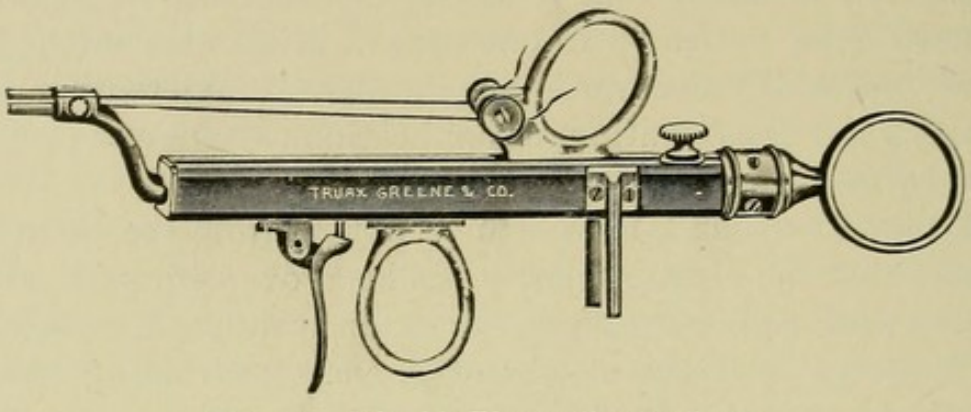


Fig. 98. Schech's Electro-Caustic Snare.

devised by Schech, and one which I have often used to advantage.

An electro-caustic snare has also been devised by Keimer, of Düsseldorf (88), the instrument being made on the model of the cold snare of Hartmann, for which he claims advantages over the ordinary snare.

The current required for the electro-caustic snare will, of course, depend upon the size of the snare to be used, five to ten amperes, however, being sufficient for all cases. Platinum wire was first used in these snares, but steel piano wire is not only cheaper but requires only about one-half of the current that will heat a platinum wire of the same size. It is therefore used exclusively in my practice.

One of the objections to the electro-caustic snare is that the amount of current sufficient to heat the large loop when first used, will be too great when the loop is reduced in size, the larger quantity of current which is admitted by the shorter wire being sufficient to fuse it.

Two methods are used to prevent the fusing of the wire when the snare is tightened: first, by having an assistant to reduce the current by means of a rheostat as the loop is tightened, and second, to effect this by rapidly interrupting the current. Both of these methods are inconvenient.

To overcome this difficulty, Schleicher, of Antwerp (89), has devised an electro-caustic snare with a compensatory resistance in the handle, so that the current is automatically reduced as the snare is tightened. This rheostat is so made that it can be at-

tached to most of the ordinary snare handles. The electro-caustic snare (Fig. 127) is also made on this principle.

For heating the platinum snare, the current is arranged as for the electro-cautery. After adjusting the current as for the cauteries, the circuit is closed by means of the trigger in the handle, or preferably by a foot-switch, and the loop tightened as in the cold snare. As a heated wire used in the snare is easily torn apart, it should be tightened with care.

CHAPTER XIII.

ELECTROLYSIS.

SURGICAL electrolysis, or the destruction of living tissue by the action of the electric current, was first used by Trippier and is now applied very extensively. It is superior to the electro-cautery for many purposes and may be adapted to certain conditions in which the electro-cautery is not applicable, as in the dilatation of strictures (108).

The process involved in electrolysis is more complicated than that of the electro-cautery and the principle is essentially different in character. In electrolysis, the current passes through the tissues, and the chemical changes which take place in these are directly due to the chemical effect of this current. In the electro-cautery, however, the electric current is used only for its thermic effect, and is preferred simply on account of the convenience of its application. Practically, the effects would be the same if the electrode were heated by an alcohol lamp to the proper degree of temperature.

By means of electricity, however, this heating effect may take place at any time by closing the circuit, which need not be done until the electrode is directly in contact with the tissues which it is intended to destroy. In this form of application, however, no part of the current passes into the tissues, as the current is entirely limited to the conducting wires of the electrode, whose resistance at the platinum point changes the electric energy into a heat effect. The " shock," which many people anticipate when the application of the electro-cautery is made, is therefore an impossibility with the proper working of the cautery.

In the electro-cautery, therefore, only the thermic effect of the electric current is utilized, and the apparatus is simpler and the technical knowledge required less than when electrolysis is made use of.

In surgical electrolysis, we utilize the chemical property of electric energy in reducing organic tissue, and this requires a more

delicate control of the current, a knowledge of the polarity of the electrodes and a definite means of measurement. On this account, electrolysis has not been used as extensively as the electro-cautery, and reference to it in oto-laryngologic literature is much less frequently met with.

In electrolysis, only the galvanic or direct current can be used, as the alternating and faradic possess little or no chemical or electrolytic effect, on account of the rapid alternations of polarity, which neutralize the electrolytic action. The static is also not applicable for this purpose.

The action of electrolysis on organic tissue may be more easily understood by testing this effect in water, which is the largest constituent in the tissues treated by this process.

If the wires from the negative and positive pole of a galvanic battery be dipped into water, the liquid will be decomposed, or electrolyzed, oxygen appearing at the positive pole and hydrogen at the negative. If the electrodes dipped into the water are made of platinum, both the hydrogen and oxygen will be liberated as bubbles of gas ; if, however, the points are of iron or other soluble metals, the hydrogen will appear as gas, but the nascent oxygen will combine with the iron, forming the oxide of iron. If a salt be added to the water, the solution will likewise be decomposed, oxygen and acids appearing at the positive and hydrogen and alkalies at the negative pole.

A similar decomposition takes place when the needles connected with the cords of a galvanic battery are passed into the human body. The tissues around each needle are decomposed, the extent of this effect depending upon the nature of the tissue in which the needles are imbedded, the strength of the current, and the length of time of the application.

There are two methods of using electrolysis—the monopolar and the bipolar. In the former, the needle or needles, introduced into the part to be electrolyzed, are connected with one pole, the circuit being completed by means of a dispersing electrode applied to some other part of the body. In the bipolar method, a needle is connected with the negative and positive pole respectively, both needles being passed into the part to be electrolyzed. In the bipolar method several needles may also be used, both for the negative and positive poles.

In applying electrolysis, the constant current should be used as for galvanism, the rheostat and milliampere-meter being in the

circuit. The current should be slowly turned on by means of the rheostat, the strength of the current being noted by the milliampere-meter.

It is of importance in the success of electrolysis, and especially in recording the effect for future comparison or reports, that the milliampere-meter should be a standard instrument, or that the variations in the meter used should be corrected by such an instrument. The inaccuracy of the majority of milliampere-meters is, no doubt, responsible for the great discrepancy in the reports of various authors as to the strength of the current used in electrolysis.

The same means of generating the galvanic current for galvanism are applicable for electrolysis, as in each case a current of sufficient intensity is required to overcome the resistance of the tissues. The various chemical batteries already described may, therefore, be used, and also the current from the direct incandescent-light service.

Storage cells are not usually practicable for this purpose. Occasionally, however, we note that an author refers to these as applicable in electrolysis. Thus Felix Semon, London (90), describes a storage battery which is charged by means of a chemical battery, and may be used 10 to 14 days after charging. He found this convenient for illuminating the various cavities of the body. By means of a special device, it may be attached to the laryngeal mirror. He also found this accumulator useful in faradization, as also in electrolytic operations. A battery of three or four accumulators was sufficient to heat the Schech's electro-caustic instrument.

While this accumulator, and others of its kind, may be advantageously used for the electro-cautery, illuminating small incandescent lamps, and for energizing the primary coil of an inductorium, its application for electrolytic purposes is impracticable unless 15 or more of these accumulators are connected in series. While the voltage capacity of the storage cells is not specified, still this rarely exceeds two volts even in the large batteries. If three or four of these accumulators were connected in series, the capacity would not be more than six or eight volts, a difference of potential inadequate for any electrolytic application.

In the small incandescent lamps, primary faradic coils and cauteries, the resistance is very low, for which a light voltage is sufficient, but in electrolytic operations in which the resistance of the tissues must be overcome, an intensity of less than 30 volts is

inadequate, and usually a much higher potential is necessary. The battery would, therefore, require 15 or more cells, which would be far more expensive and necessitate a great deal more care and attention than the simple chemical cells applicable for this purpose.

The polarity of the current in electrolysis is an important point for consideration, as the polar effect of the current varies at the negative and positive pole. At the positive, the application is followed by a drying coagulative effect, while at the negative it produces a softening, liquefying influence. The positive pole also gives a more retractile and the negative a more elastic cicatrix.

The success and rapidity of electrolysis will depend upon the nature of the tissue to be destroyed. Adenoid tissue is readily electrolyzed, fibroids and other more compact tissues less rapidly. Enchondromata are but slowly affected by electrolysis, and its influence on osteomata and bony tissue is so slow that the electrolytic effect is disputed by many writers.

A series of investigations upon the effect of electrolysis on animal tissue has been made by Althaus, the various stages of the experiment having been checked by microscopic observations. This investigator came to the conclusion that no animal tissue can resist the disintegrating effect of the galvanic current at the negative pole, and that the force and the rapidity with which this disintegration takes place are directly proportional to the softness and vascularity of the tissues acted upon, and the strength of the current employed.

The most practical needles for electrolysis are made of platinum, but steel needles may also be used, provided they are employed only in connection with the negative pole. I have not found gold-plated needles good substitutes for platinum, as they soon become corroded. The upper part of the needles should be insulated by a thin coating of shellac varnish, so that the skin or mucous membrane may be protected from the electrolytic process. These needles should be prepared with all precaution as regards asepsis, as in other surgical operations.

In electrolysis, it is important to avoid wounds upon the surface from the action of the needles employed. This may be effected by careful insulation of that part of the needle where it is in contact with the surface. After the operation has been completed, the points of entrance of the needles should be closed

with collodion and iodoform, so that the electrolyzed tissues may be protected against the entrance of pathogenic germs. These needles are attached to various handles, according to the location of the part to be operated.

In using the bipolar method, care should be taken that the needles do not come in contact within the tissues to be electrolyzed. In the monopolar method, the dispersing electrodes, which are similar to those used in galvanism (Figs. 31, 32) are applied to the nearest part of the body where there is sufficient surface, as the back, chest, cheek etc.

The influence of electrolysis on bacteria has been investigated by Apostoli, Laguerrier, Prochownik and Spaeth. They found for this purpose, that it was necessary to have a certain intensity of the current for the various bacteria. Sixty milliamperes for 15 minutes were fatal to the staphylococcus aureus, and 60 to 80 milliamperes to the staphylococcus pyogenes, while the bacillus of anthrax required 230 milliamperes applied for 30 to 60 minutes for its destruction.

The benefit of electrolysis is variously estimated by different writers. De Tymowski (91) gives the following résumé of his experience with electrolysis: In granular pharyngitis, the disappearance of the granulations is effected with this method without the trace of a cicatrix; in hypertrophy of the tonsils, the results are not as good. It is not effective in chronic ozena, but is useful for the destruction of adhesions, which sometimes follow the use of the electro-cautery. He has found it of use in laryngeal hemorrhage, and, by the application of the positive pole, he controlled a case of hemorrhage which had lasted three days and had resisted all other forms of treatment.

In the discussion of De Tymowski's paper, Heryng (555) stated that in angioma of the larynx, he had obtained (with positive pole) an excellent result when the electro-cautery had been followed by a serious hemorrhage. Negative electrolysis is indicated in fibromas and for the remains of polypi removed from the larynx. In tuberculosis it is more apt to be successful than any other form of cauterization.

In conclusion, Heryng stated that he considered electrolysis a difficult and painful procedure which occupied much time. He finds it much inferior to the electro-cautery in granular pharyngitis, though it appears to have given good results in thickenings of the septum.

A careful investigation of the effects of electrolysis in the surgery of the nose and larynx has also been made by Draispul, of St. Petersburg (92). He found that all patients could not tolerate the same strength of current. Some complained of pain when the current was only two milliamperes, while others bore 15 to 25 milliamperes without pain; no patient, however, could endure more than 35 milliamperes.

As the tolerance of the patient cannot be estimated beforehand, Draispul advises that a rheostat be used so that the strength of the current can be graduated very slowly. He prefers the bipolar electrodes of Groh. In cases of simple hypertrophic rhinitis, he obtained good results, but, where this had developed to a very marked extent, he found so many sittings necessary that it fatigued both the patient and the physician.

In a case of polypoid degeneration of the nasal mucosa, one side was removed with the electro-cautery, while the other was treated with electrolysis. Three weeks later recurrence took place in the part treated by the electro-cautery, while the other treated by electrolysis appeared in a normal condition. He believes this effect may be attributed to the fact that electrolysis is more penetrating in its action than the galvano-cautery. He also states that the effect of the electrolytic action can be increased by gently moving the needles within the tissues.

In a case of angio-sarcoma developing from the septum, the growth was twice removed, but recurred again in two to three months. Draispul then removed the tumor with the snare and treated the base with electrolysis. A healthy cicatrix developed without recurrence. He also used electrolysis in three cases of tuberculosis of the septum, after having removed the tubercular masses with the curette. This treatment was without effect in these cases. He also treated a case of ranula, a small angioma of the posterior pharyngeal wall and several cases of granular pharyngitis.

In the application of electrolysis for hypertrophy of the tonsils, 12 sittings were necessary in order to reduce them to one-half their former size. He found that the application of electrolysis to the larynx could be made only with great difficulty. It was necessary first to thoroughly cocainize the larynx, and, in spite of this, the electrode could not be tolerated for more than two to three minutes; in such a short sitting very little could be accomplished.

The conclusions arrived at by Draispul are as follows:

"Electrolysis in the surgery of the nose and larynx is a very slowly effective and not reliable method. In extensive malignant growths it can even be injurious, as the growth may be stimulated to progress while much valuable time is lost with electrolysis. Good results are obtained by electrolysis where small areas of tissues are to be destroyed. The effect of electrolysis in small malignant growths will require further observation."

While this article exhibits careful and painstaking investigation, it will bear considerable discussion. In regard to the fact that some patients cannot bear two milliamperes, while others can tolerate 15 to 25 without suffering, it would, perhaps, have been more proper to have stated that 15 to 25 milliamperes may be passed through certain portions of the body, whereas two milliamperes through other portions would give rise to serious disturbance. In treating a tumor, after cocainization, the reaction of the current will depend upon the distance between the two electrodes, and, if these are closely approximated, not only 15 to 25 milliamperes will be tolerated, but even 50 with but little pain. If, however, the electrodes are placed at a greater distance, a much smaller current will be disagreeable, on account of the distribution of the electric energy in more extensive waves between the two electrodes, and including in their course nerves of sensation of more distant areas.

In the unipolar method, where one needle is passed into the growth or tissue to be destroyed, and the dispersing electrode sometimes at a considerable distance, even one milliampere is often very painful on account of the wide distribution of the lines of electric force between the electrodes.

In the application of electrolysis, as in hypertrophic rhinitis, if both electrodes are placed together within one-fourth of an inch in the hypertrophied tissues, 10 milliamperes will frequently be borne without pain, provided the parts have been thoroughly cocainized. In the unipolar method, if one electrode be passed into the turbinal, and the dispersing electrode applied to the cheek as near as possible to the active electrode, three to five milliamperes will usually be borne without suffering; but if the dispersing electrode be applied to a more distant surface, as the back, chest or hands, even one to two milliamperes will develop not only pain but gustatory sensations, flashes of light and even vertigo, this being due to the extensive distribution of electric energy on account of the distance between the electrodes.

The milliampere-meter is not always a true indication of the amount of electric energy consumed; it simply states the fraction of an ampere which is passing in the circuit. The current required, however, varies directly as the resistance, and where the electrodes are placed near together and the current has but little resistance to overcome, the intensity of the current required is not very great; but where the electrodes are placed at a much greater distance, a much greater resistance has to be overcome, and a proportionately greater strength of current is necessary, although in each case the meter will show the same number of milliamperes.

Draispul's statement that electrolysis is useful in mild cases of hypertrophic rhinitis but not so in more advanced cases, differs from my experience, nor have I found a tedious number of sittings necessary for this purpose. Simple cases require one sitting and very few cases more than two or three.

As to the superiority of electrolysis in degeneration of the nasal mucosa, this has also been the experience of other surgeons. In the treatment of tuberculosis with electrolysis, the details are not given which would permit a fair analysis of the cause of the failure of these cases. Suffice it to state, however, that a number of authors speak very highly of the efficacy of electrolysis in selected cases of laryngeal tuberculosis. That 10 sittings were necessary for the partial reduction of a case of hypertrophic rhinitis, would indicate that the author had not used a current of sufficient strength for this purpose, and this, no doubt, also holds in his treatment of malignant growths. Unless a strong current is applied in these tumors—one of sufficient strength to effect the destructive dissolution of the diseased tissues rapidly and in a small number of sittings, the electrolytic method may not only be ineffective, but, by constantly irritating and stimulating the malignant tissues, may even aggravate the original condition.

In using electrolysis within the larynx, the application of two to three minutes with a sufficiently strong current and repeated often enough, will be effective in many conditions, as supported by the reports of other authors. On the whole, the experience of Draispul with small tumors and small diseased areas with light currents, would lead us to believe that he would have achieved as much success in more pronounced conditions had he employed proportionately stronger currents in the latter cases.

CHAPTER XIV.

Cataphoresis (554).

CATAPHORESIS is the property of electricity of diffusing fluids and substances through other fluids and substances. It is known under a variety of terms, many of which have been added since the adoption of the galvanic method of cocaine anæsthesia in dentistry. Among these names are "electric transportation," "electric transfer of particles and liquids," "anaphoresis," "anodal diffusion," "electric osmosis," and "electric medicamental diffusion."

Some writers explain cataphoresis on the principle of osmosis. In this process, when two liquids of different density are separated from each other by a porous septum, the fluid of the lesser passes to the fluid of the greater density. This is a slow process, the rapidity depending upon the difference of density of the two liquids and the thickness and character of the intervening septum. If, however, the positive pole of a galvanic battery be connected with the fluid of lesser density, and the negative to the other, this process is so rapidly increased that in a few moments it has advanced as far as it would have done in several hours in simple osmosis.

These writers claim that when we place on the outer surface of the skin or mucous membrane, a solution of greater density than the plasma within the tissue, the influence of the drug, which would be very slow or even imperceptible by the ordinary osmotic process, rapidly takes place, and in this manner we may impregnate the tissues with cocaine, iodine, guaiacol etc., according to the indications of the case.

The theory that cataphoresis is due to a purely physical action of the current, and that all medicaments must be placed at the positive pole of the direct current, is not accepted by many investigators, C. M. Haynes (5) and others holding the opinion that in all cases the medicaments are decomposed by the action of the current, the products of such decomposition moving towards that pole for which they have an affinity; and while it is true in elec-

tro-therapeutic work, that we nearly always place the medicament upon the positive pole, this is only because the great majority of substances, whose effect we wish to obtain, are electro-negative in character. This theory more fully explains the various phenomena of cataphoresis and corresponds with my investigations of this subject.

Faraday gave the name *anion* to the products of the decomposition which appear at the anode, or positive pole, and *cation* to those which appear at the cathode, or negative pole, the term *ions* being generic for both products. He believes that the anions are attracted by the positive pole because they are the same potential as the negative, and are therefore repelled, and that the cations are attracted by the negative pole because they are repelled by the positive, with which they are of the same potential.

This principle should be remembered in the application of cataphoresis. Iodine like oxygen is an anion, and has an affinity for the positive pole, and where iodide of potash and other iodine compounds are used in the treatment of goitre and the resolvent effect of the iodine be desired, they should be applied to the negative pole so that the iodine will be attracted towards the positive. If the iodide-of-potash solution is applied to the positive pole, the iodine will be liberated at this pole, so that we have the local and not the cataphoric effect of the iodine.

Morphine sulphate, quinine sulphate and cocaine muriate belong to the class of bases which are cations, and therefore have an affinity for the negative pole. When these, therefore, are used, they should be applied to the positive pole so that, in their passage towards the negative, we may obtain the effects of these medicaments. Where iodine is used on the positive electrode, its therapeutic effect is but little more than the local application of iodine.

Cataphoresis in the application of cocaine anæsthesia has recently been used extensively in dentistry. It must not be considered, however, as a newly discovered principle. Already in 1859, we find in the *Lancet* (Feb. 5th) the following report of the cataphoric application of an anæsthetic:

"Some interesting and important experiments have been commenced by B. W. Richardson, on the possibility of producing electro-chemical anæsthesia. A sponge impregnated with chloroform or tincture of aconite is applied in conjunction with the positive pole of the battery, and, a current being passed through the limb, it is found that the anæsthetic agent employed may be brought to bear in this way upon the deeper tissues, and profound anæsthesia produced. A public demonstration of this

method was given by Richardson at the Grosvenor Place School of Medicine, and the results were satisfactory as indicating the production of deep-seated anæsthesia; but the time occupied to effect insensibility was very inconveniently protracted. The further results of these experiments will be watched with interest."

In the *Medical News*, July, 1895, in an article entitled "Voltaic Narcotism," a report of the successful application of this method is also made, a molar tooth having been painlessly extracted after its cavity had been filled with a dossil of lint steeped in five minims each of tincture of aconite and chloroform, and a current of electricity passed through the part.

A number of experiments to illustrate the cataphoric effects of cocaine anæsthesia has been made by Frederick Peterson, New York (112), and may be easily repeated. In the first experiment, a 10 per cent. solution of cocaine was applied to the skin of the dorsal surface of the hand for 12 minutes by holding the open mouth of the bottle containing the solution against it. No anæsthesia of any kind was produced. In the second experiment, a large sponge-covered wire-netting cathode was applied to the palm of the same hand; 16 cells of a Grenet battery were applied for six minutes without cocaine. No anæsthesia whatever followed. In the third experiment, the same currents and electrodes were used, but with a 10 per cent. solution of cocaine applied to the anode. A contact for five minutes with the same strength of the battery caused complete anæsthesia to touch, pain and temperature, lasting over an hour in the surface which had been in contact with the anode.

It is known that the anode normally paralyzes the vasomotor nerves, producing congestion and edema, while cocaine has the opposite effect, contracting the capillaries, but when applied together, the normal electric effect outbalances that of the cocaine, and the part under the anode remains congested.

In the next experiment the last process was repeated, except that the cocaine solution was applied to the cathode; it was followed by no anæsthesia.

The following is a summary of Peterson's results:

"The galvanic current alone does not produce anæsthesia at either pole, although the anode has a soothing effect over painful foci. A watery solution of cocaine applied to the skin is not absorbed and does not produce anæsthesia, except, perhaps, after an indefinite and long period. The same is true of chloroform and of an alcoholic solution of aconite. A watery solution of cocaine is diffused through the skin and subcutaneous tissues by the *anode*, but not by the cathode. This is true of chlo-

roform, aconite, strychnine, potassium iodide, corrosive sublimate, tincture of iodine, and a number of other medicaments."

The anæsthesia produced by a 10 to 20 per cent. solution of cocaine on the anode is sufficient for small operations and affords relief for from four to 11 hours in cases of severe neuralgias in superficial nerves, and without any untoward constitutional effects having thus far been observed.

It has been shown by Arthur Harries (95) that the region covered by the negative electrode in the cataphoric application of cocaine, so far from being anæsthetized by the solution, was actually rendered hyperæsthetic, while the area covered by the positive electrode became insensible to the passage and action of a needle used to electrolyze the hair.

A number of experiments with the cataphoric application of guaiacol has been made by W. J. Morton (96), who has obtained satisfactory results, especially when the guaiacol was combined with cocaine. He found that guaiacol to which cocaine had been added enabled him to shorten the time ordinarily required to produce anæsthesia about two-thirds, and also permitted him to reduce the current strength of electricity almost two-thirds. Another important feature of guaiacol in soft tissue is that it appears to hold on chemically to the cocaine, and thus prevents quick absorption into the general circulation and consequent toxic effects. He gives the following formula for the use of guaiacol and cocaine combined, and of guaiacol alone:

℞—Guaiacol..... ʒ i ;
Cocaine hydrochl. anhyd.....gr. vi. M.

℞—Guaiacol..... ʒ i ;
Acid sulphur..... ...M i ;
Aq. dest.....M ij. M.
Sig.—Make emulsion.

Guaiacol is a non-conductor and cannot be used alone. Instead of using it as above, it may also be added to oil of pine, which removes, to a large extent, the unpleasant odor of guaiacol and improves its antiseptic properties. Creosote is a violent escharotic and is very irritating when used for cataphoresis, but guaiacol is creosote freed of the irritating hydroxyl.

Guaiacol possesses not only the property of anæsthesia, but is also a valuable disinfectant, and, in a number of experiments which I have made, it was successful not only in allaying the pain in tubercular laryngitis, but also of influencing, in a most favor-

able manner, the progress of this pathologic condition. In several cases, now under observation, the result has been so satisfactory that I have abandoned the method of curettement and lactic acid, as cataphoresis has given so much better results, and without the great discomfort to the patient from curettement. I have also made use of peroxide of hydrogen by this method. When this is used, a little phosphate of soda should be added to make it a good conductor; sodium chloride may also be used, but as the chlorine is liberated when the current is applied, it may cause considerable irritation.

Chloroform, which has also been recommended, should only be used for cataphoric purposes when, in addition to producing a local anæsthesia, it is desired for counter-irritation, as it causes a disagreeable dermatitis of considerable duration.

In many of the published reports of the cataphoric application of iodine, as, for instance, Hunter McGuire's in *Hare's System of Therapeutics*, the authors specify the application of tincture of iodine or iodide of potash to the *positive* electrode. As iodine is an anion, it is repelled by the negative pole, and will, therefore, remain at the positive pole when these medicaments are applied to the positive electrode, and the effects will be little more than the local application of iodine to the surface. It should, therefore, always be applied to the negative electrode when its resolvent effects are required.

As some writers claim to have received benefit from this method, C. S. Neiswanger (97) suggests that some beneficial result may possibly be obtained from the use of the iodine at the positive pole by what might be called "secondary reaction," which may be explained by the old experiment of the glass rod and pith ball; the rod having a positive charge of electricity will attract the pith ball because it is of opposite polarity or different potential. But after a while, or when the disturbed equilibrium is interrupted and the ball becomes the same potential as the glass rod, it is repelled. The same phenomenon may take place when we use the iodine at the positive pole. The iodine, being of different electric potential than the positive pole, is first drawn to it, but afterwards by secondary reaction, or when the difference of potential is restored, it is repelled and may penetrate the tissues to a certain depth; possibly this is the secret of the good results claimed by some operators when using iodine at the positive pole. According to the law of cataphoresis, as now understood,

the most penetrating effect of iodine preparations is obtained when they are applied to the negative electrode.

As showing the influence of the cataphoric application of iodine on micro-organisms, Burci and Fraseani (98) demonstrated that, with a current of 5 to 10 milliamperes for 15 to 30 minutes, the nascent iodine, liberated by electrolysis from the positive pole, killed both streptococci and staphylococci.

CHAPTER XV.

Interstitial Electrolysis.

INTERSTITIAL, or metallic electrolysis, is a combination of two processes—the electrolysis of the tissues and of the electrodes in contact with them, and the cataphoric diffusion of the chemical products, thus developed, into the surrounding tissues, according to the direction and intensity of the current.

In metallic electrolysis, the salt is not only dissolved from the metal, but by a further property of the current, it is forced into the tissues in a radiating direction around the metallic electrode. In this way, this method gives great advantages over topical applications.

Interstitial electrolysis has received considerable attention at the hands of Gautier, Morton, Cleves and others. When a soluble metallic needle, such as iron, copper, zinc etc., is used in electrolysis, the positive needle (anode) is acted upon by the oxygen and chlorine which are set free, and the metal is changed into a metallic salt. The negative pole (cathode), however, is not acted upon by the hydrogen and free alkali which are liberated, and the metal, therefore, retains its brightness.

When a copper needle is inserted into organic tissues and connected with the positive pole of an electric circuit, a chemical decomposition takes place, and a number of acids, such as hydrochloric, sulphuric etc., as well as oxygen, are liberated. These acids, principally hydrochloric, combine with the copper and form an oxychloride of copper in the nascent state. This salt is very diffusible, its effect being aided by the cataphoric action of the current, so that it is deposited not only in the tissues immediately around the needle, but also at some distance.

If two copper needles are inserted into a piece of meat, and the current applied, it will be found, after a time depending upon the strength of the current, that the copper needle connected with the positive pole has been entirely dissolved. If the meat is now cut, there will be found a green stain for a considerable

distance from the positive electrode, due to the oxychloride of copper, which is the result of the combination of the copper of the needle and the oxygen and chlorine from the meat. The colorization shows that the diffusion is proportional to the length of the application and intensity of the current. This chloride of copper has certain effects upon the tissue, which have been utilized in a variety of pathological conditions.

Instead of copper electrodes, other soluble metals have been used, as zinc, amalgamated zinc, silver, iron etc. These metals may be used either by means of needles inserted into the tissues, or with electrodes which are placed in contact with the tissues (Fig. 99). With zinc, the escharotic effects are much more severe

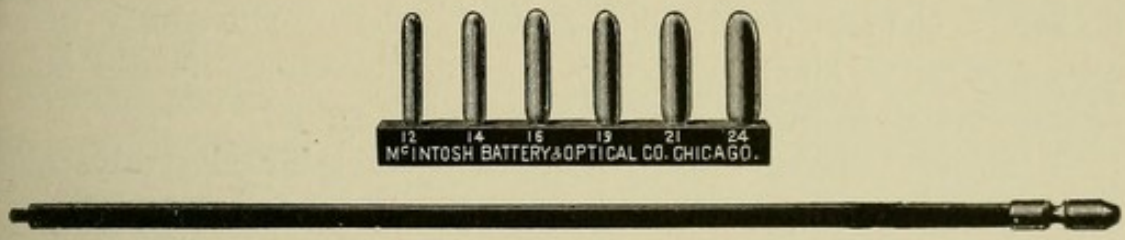


Fig. 99. Electrodes for Cupric Electrolysis.

than with copper. The oxychloride of copper, resulting from the electrolysis of copper, is a powerful antiseptic, having many times the germicidal effect of the current itself, and is therefore of great value in all pathologic conditions of microbic origin.

In using copper needles for metallic electrolysis, it is important that they should be made of pure copper, as the commercial article is more or less adulterated with zinc, whose salt, produced by the electrolytic action, exercises a very irritating effect on the tissues. After each application of metallic electrolysis, the electrode should be carefully rubbed with emery paper in order to secure an unoxidized surface for the next application.

In applying interstitial electrolysis, there is considerable tendency on the part of the electrode to become adherent to the tissues from a formation of an albumenoid salt of the metal used, this being present even when mild currents are applied. To avoid this, W. J. Morton (110) advises that the electrode should be kept in slow movement either longitudinal or rotary. If the needles inserted into the tissues or tumor become adherent in spite of this procedure, they may be loosened by reversing the polarity, a current of four to eight milliamperes being then used for a few minutes, until the needles are found to be loose.

The effects of the action of the direct current in electrolysis are summarized by C. M. Haynes (5) as follows:

"The galvanic current used to produce electrolysis on living tissue accomplishes its results by utilizing three properties of the current: First, the chemical property, into which the electricity is converted and manifests itself in the fluids and semi-fluids contiguous to the electrode (catalytic action); second, the physical properties, due to the disintegration of the electrodes, and the transference of substances through the tissues (cataphoric action); third, the physiologic properties of the galvanic current as it produces trophic changes in the tissues."

In metallic electrolysis, mild currents should be applied unless the escharotic effect in the treatment of neoplasms is required. There is no cauterization of the tissues, and it is, therefore, followed by no cicatrix. The application of zinc is of use in malignant growths on account of the escharotic property of the oxychloride of zinc. For this reason, therefore, its use is not recommended in ordinary pathologic conditions.

From an extensive experience with metallic electrolysis, W. J. Morton (110) offers the following conclusions:

1. The salts of many metals may be electrically dissolved from metallic electrodes, and at the same time be caused to permeate human tissue to a considerable depth. In the case of copper upon dead tissue, with the current usually applied to living tissue, this depth is visible as an apple-green color, in the radius about the electrode of from one-fourth to one-half of an inch; it probably extends invisibly much farther, shading off to a minimum.

2. The electrically formed and the electrically diffused metallic salts are not destructive to tissue in the sense that ordinary electrolysis is; the effect is rather by the presence of a partially insoluble salt and by the effect of a newly formed organo-metallic salt, denutritive or absorbing, upon diseased tissues.

3. It would seem to the writer that these electrically formed salts possess a selective affinity for diseased in preference to healthy tissue, or at least produce a more profound action upon the morbid tissue, causing a favorable alteration in the nutrition of the part.

4. Electric diffusion is greatly superior to topical applications, for the reason that the medicament is caused to penetrate the tissue acted upon.

In accordance with the experience of other investigators, Geo. Gautier, of Paris (99), also prefers copper for the anodal electrode,

and thinks it preferable to the zinc electrode, which presents certain disadvantages, especially that of causing pain. He believes that cupric electrolysis is one of the best treatments against hemorrhage.

Positive interstitial electrolysis is recommended by Miot (100) for extensive epistaxis occurring from erectile or varicose tissue. It is also of value in the treatment of hemorrhagic areas. Electrodes of copper or silver are preferable. He states that the intensity of the current should average from 16 to 20 milliamperes, and the length of the seance from 8 to 10 minutes, and that one or two applications are usually sufficient. In oto-laryngologic practice, however, a current of this strength is rarely required, and my personal experience has been that a current of 5 milliamperes need seldom be exceeded.

Zinc-mercuric applications are recommended by G. Betton Massey, of Philadelphia (401), who believes that this method is an important modification of the galvano-caustic applications in many muco-purulent and hemorrhagic conditions. He believes that the application of this method in incipient cancerous growths would seem to be radically indicated, for by it we may add to the tissue-destroying properties of a concentrated anode the additional effects of the nascent oxychloride of mercury and zinc, thus obtaining all that there is in the caustic treatment of cancer plus the electricity, and without the long-continued pain of the caustics as ordinarily applied.

The nascent caustic salts will also be carried into the tissues by the current, thus reaching the outlying ramifications of the cancer, particularly in those growths in which the cancerous structure is a better conductor than the surrounding healthy tissues. In this treatment, the monopolar method is, of course, essential, making it a distinctly different procedure from the Inglis-Parson plan of treating cancer, in which no special attempt is made to follow the malignant ramifications by current diffusion.

In order to successfully replace the knife, in the treatment of so grave a condition, it must partake of some of the elements of rapidity that distinguish that method of rapid removal; for the knife is to-day almost universally resorted to, in spite of the admission of its most eminent followers that it rarely cures and often makes the final condition of the patient more deplorable. To obtain rapid and effective results, heavy currents should be used.

Currents of a strength as high as 350 milliamperes have been used by Massey in his monopolar applications. While this current may perhaps be used with safety in gynæcologic work, on account of the fact that a large dispersing electrode may be applied over the abdomen, and the application thus limited to tissues which tolerate a heavy current, in the nose, throat and ear the proximity of the cerebrum and of many important nerves does not permit so heavy a current to be used by the monopolar method.

In bipolar interstitial electrolysis, in which the current passes directly through the growth, and is not distributed through a large area in reaching the dispersing electrode, a current of considerable strength is not contraindicated. It has been used successfully in the treatment of tumors in this region, as by Kaarsburg, of Copenhagen (111), who applied currents of 100 to 320 milliamperes in the treatment of post-nasal fibroids, and obtained rapid and permanent good results.

The bipolar method should, therefore, be preferred in these cases, or where circumstances favor the monopolar application, the current should not be increased beyond the limit of safety.

Massey believes that a chemical destruction and metallo-caustic impregnation of the diseased tissue to any extent may be employed, and that an active defense is aroused in the surrounding healthy tissue, which aids in limiting the further extension of the disease.

Catalysis is a process which takes place whenever an electric application is made, whether of galvanism, electrolysis, cataphoresis etc., but it may also take place independent of any destructive effect on the tissues to which the current is applied. When an application is made, not for its electrolytic or cataphoric, but for the more complex physical effects, this method has been given the name of catalysis. These effects are thus summed up by De Watteville (272):

1. The property of conveying liquids from pole to pole (cataphoresis and osmosis) through the tissues, whether cell-walls or intercellular material.

2. The property of inducing chemical changes in solutions through which it circulates (electrolysis).

3. The effect on the circulation of lymph and blood through the tissues. This effect is (a) direct (by excitation of the vessels themselves); (b) indirect (of vasomotor or sympathetic nerves); (c) reflex (of sensory nerves).

To which list may be added (4) the possible excitation of the trophic influence of nerves on tissues; and of their constituent cells themselves.

This method has been as yet but little used in the treatment of the nose, throat and ear, but with the greater conservatism, which is now being actively urged, this will probably find its place as a valuable remedial agent, as it deserves.

CHAPTER XVI.

Electro-Magnetic Appliances.

THE effects of *magnetism* in therapeutics have been investigated by Peterson and Kennelly, who have recently tried it with an exceedingly strong field, and have come to the conclusion that "the human organism is in no wise appreciably affected by the most powerful magnets known to science." A. E. Dolbear, of Boston (101), however, holds that it is not proved that magnetism is without any effect on the human body, but believes that the experiments, which have been made, simply show that magnetism, unlike electricity, does not produce the mechanical and chemical changes necessary to be appreciated by the subject.

THE TELEPHONE.

The telephone has been recommended in the education of deaf-mutes who still possess a fragment of hearing power. The essential part of the telephone (Fig. 100) consists of (1) a transmitter

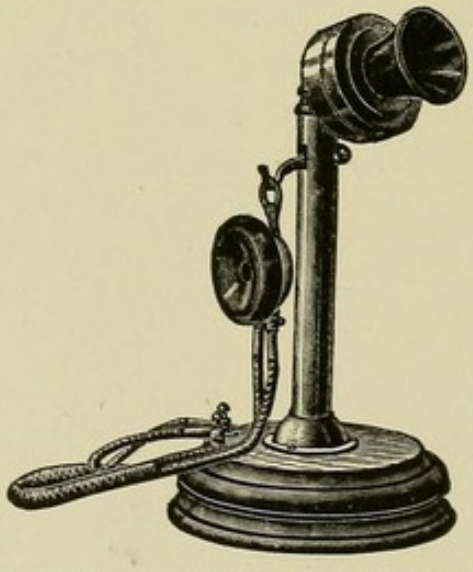


Fig. 100. Magneto Call Telephone.

in which a diaphragm, vibrating by sound, causes rapid alteration in the strength of an electric current, (2) a wire for conducting this current to a more or less distant point, and (3) a receiver in which the diaphragm is caused to vibrate by the current, the sound be-

ing thus reproduced. In the modern improvement of the telephone, it may be so arranged that the receiver may very largely augment the original vibrations of the sound receiver, and it is this principle which has been utilized in this method of instruction.

This form of telephone has been used experimentally by Bertram Thornton (102), medical officer of Margate Deaf and Dumb Asylum, with the charge of 300 deaf-mutes, to find out whether the instrument could be made of service in the education of the 10 to 20 per cent. of deaf-mute children, who are capable of hearing vowels or words and sentences with or without instrumental aid.

The advantage of the telephone over the most approved form of ear trumpet is that it is possible for the children to hear with the mouth of the speaker six to twelve inches from the mouthpiece of the transmitter, and they have, therefore, a full view of his facial expression and lip movements, and several children may be instructed at the same time, as the wires from a number of receivers can be coupled up to one transmitter. A case mentioned in illustration was that of a young woman with nerve deafness so extreme that it was necessary to speak as loud as possible, within two or three inches of the patient's ear, to enable her to hear, but with the telephone Thornton was able to converse in a subdued voice with his mouth 26 inches away from the transmitter.

An electro-acoumeter with a double tuning-fork and microphone has been described by Cheval (103), who has used it with success in testing the hearing.

ELECTRO-MAGNETIC LARYNGEAL TUBE EXTRACTORS.

The first effort in the application of the electro-magnet for laryngeal tube extractors was by John Bartlett, of Chicago. The body of the instrument was an ordinary electro-magnet, such as is used for the removal of pieces of iron from the eye, a long curved polar extension-piece projecting from the body of the magnet, and of sufficient length to reach the tube in the larynx. The laryngeal tubes were made of brass, but the heads were of iron, so that they could be attracted by the electro-magnet. As the capacity of this extractor was limited to a lifting power of only one-half pound, it was soon abandoned by its inventor.

An electro-magnetic tube extractor (Fig. 101) has been constructed by W. W. Wetherla, of Chicago (104), which embraces

the principle of the horse-shoe magnet, which possesses decided superiority over other forms of magnets. In this extractor, instead of the electro-magnet being in the hand-piece, it is at the working end of the extractor, so that the tube, which is to be lifted, comes in direct contact with the working end of the core of the magnet. The great mass of iron, which is magnetized by the electric current, is at the far end to which the handle is attached. It is ten centimeters long, and has the same curve as the O'Dwyer pattern, and is made entirely of soft pure iron instead of brass or German silver, as those in ordinary use. They are heavily nickel-plated, which has been found to be as serviceable as gold-plating. These tubes may be retained in the larynx a number of days without rusting.

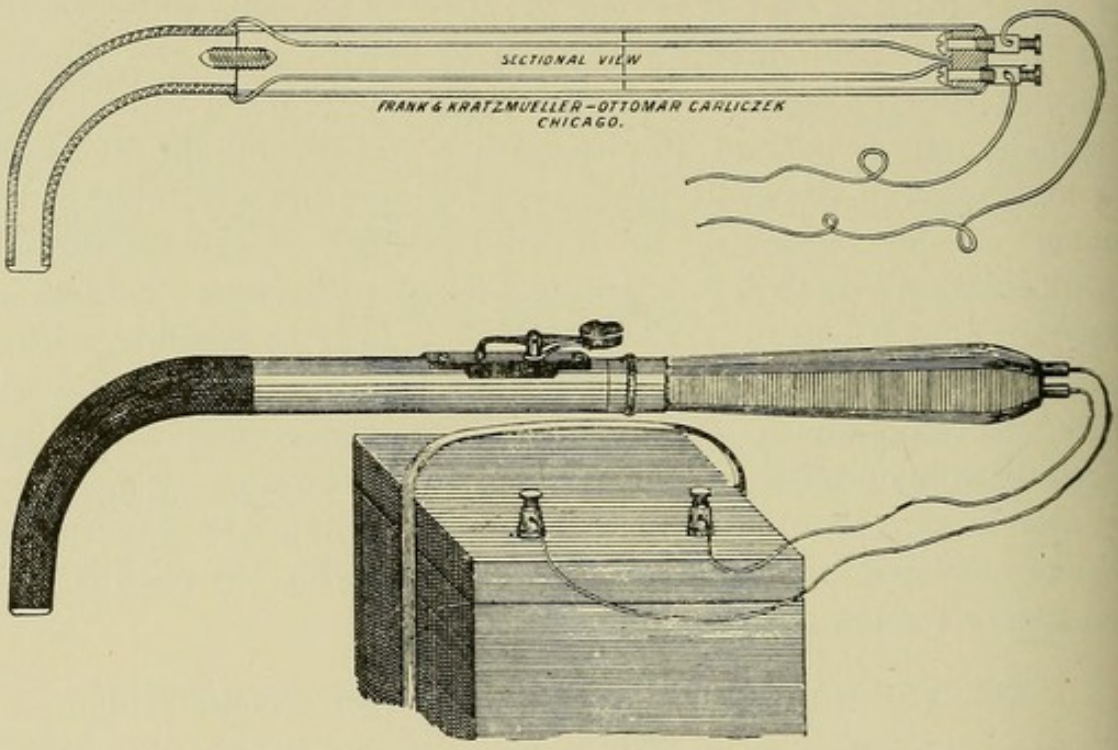


Fig. 101. Wetherla's Electro-Magnetic Tube Extractor.

Instead of tubes being made entirely of iron, they may also be made of brass with iron heads, as it is this part of the tube through which the magnetic lines will pass. When this extractor is excited by a storage or plunge battery of six volts, and applied to the head of the smallest-sized iron tube, the lifting power is two pounds; and when applied to the larger-sized children's tube, five pounds. This force is in excess of the strength that will be needed for the removal of the tubes from the larynx.

In the first instrument, which Wetherla constructed of this pattern, the interrupter was attached to the handle, but he found

this inconvenient, as the operator, in the excitement of the extraction, is liable to move the interrupter and cut off the current, thereby allowing the tube to lose its hold from the extractor and fall back into the œsophagus of the patient, an accident which has once happened in his practice. He therefore advises that the interrupter be connected with the battery and operated by an assistant.

The operation of the instrument is exceedingly simple and requires no special experience. The magnetized end of the extractor is brought in contact with the tube in the larynx, and will draw it out at any angle through the mouth. As an iron gag may interfere with the working of the magnetic tube extractor, one made of brass is preferable.

In a personal communication to the author, Wetherla states, that he has used this magnetic tube extractor about 50 times, and that it has never failed to bring out the tube; and even when it was used by the inexperienced, he has not seen it fail in the extraction. Instead of the nickel-plated tubes, he now has them enamelled, and some of these he has already used a dozen times without being affected by rust. Instead of using a plunge or storage battery, Wetherla has had a portable dynamo constructed, which is operated by the hand. In addition to its application for the electro-magnetic tube extractor, this dynamo will light an eight-volt incandescent lamp, and may be used for heating electro-cauteries.

ELECTRIC DRILL MOTORS.

The electric drill motor is used in operations for correcting deformities of the nasal septum, drilling through the alveolar process into the antrum of Highmore, mastoid operations, operating the nasal saw etc.

For these motors the same chemical, storage battery or adaptation of the incandescent current required for the cauteries, is applicable, and the circuit is also arranged as for the cautery. The current is regulated by means of a wire rheostat, and the circuit completed by depressing the floor-push, as for the electro-cautery.

A nasal motor with flexible shaft and hand-piece, stand and floor-push is shown in Fig. 102, and a number of *burrs* and *trephines* used in connection with the drill motor in Fig. 103. The Edison electric motor with rheostat is illustrated in Fig 104, and

a more complete outfit in Fig. 105. In the latter, the force is not transmitted directly from the motor, but by means of a flexible

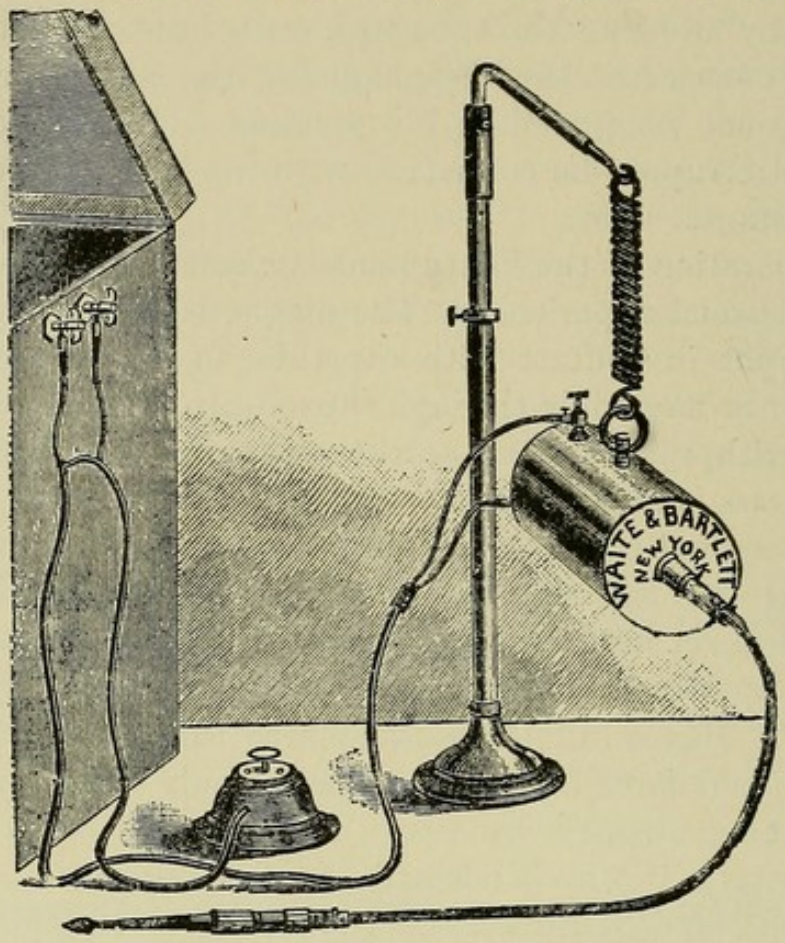


Fig. 102. Electric Motor and Floor-Push.

shaft, which allows greater range in the application. This motor has also a useful foot-switch.

A motor in combination with White's flexible arm is shown in Fig. 106. It is also combined with a rheostat and foot-switch.

In the ordinary drill motor, when the current is broken, the revolutions continue for some seconds, being kept up by the momentum. To remedy this, some form of brake may be attached to

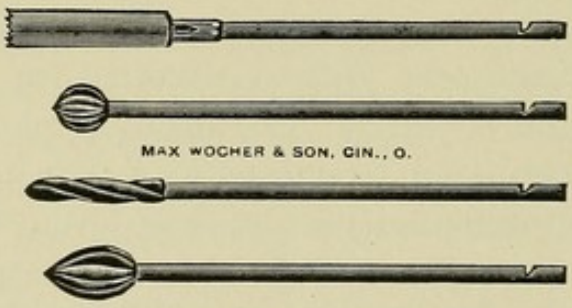


Fig. 103. Burrs and Trephines.

the motor, which will stop the revolutions instantly when the circuit is closed. In the apparatus described by A. W. de Roaldes

(192), the motor has an automatic brake-attachment by which the revolutions are stopped. When the circuit is broken by means of a foot-switch, the magnetic clutch which operates the flexible arm is released, thus arresting the revolutions.

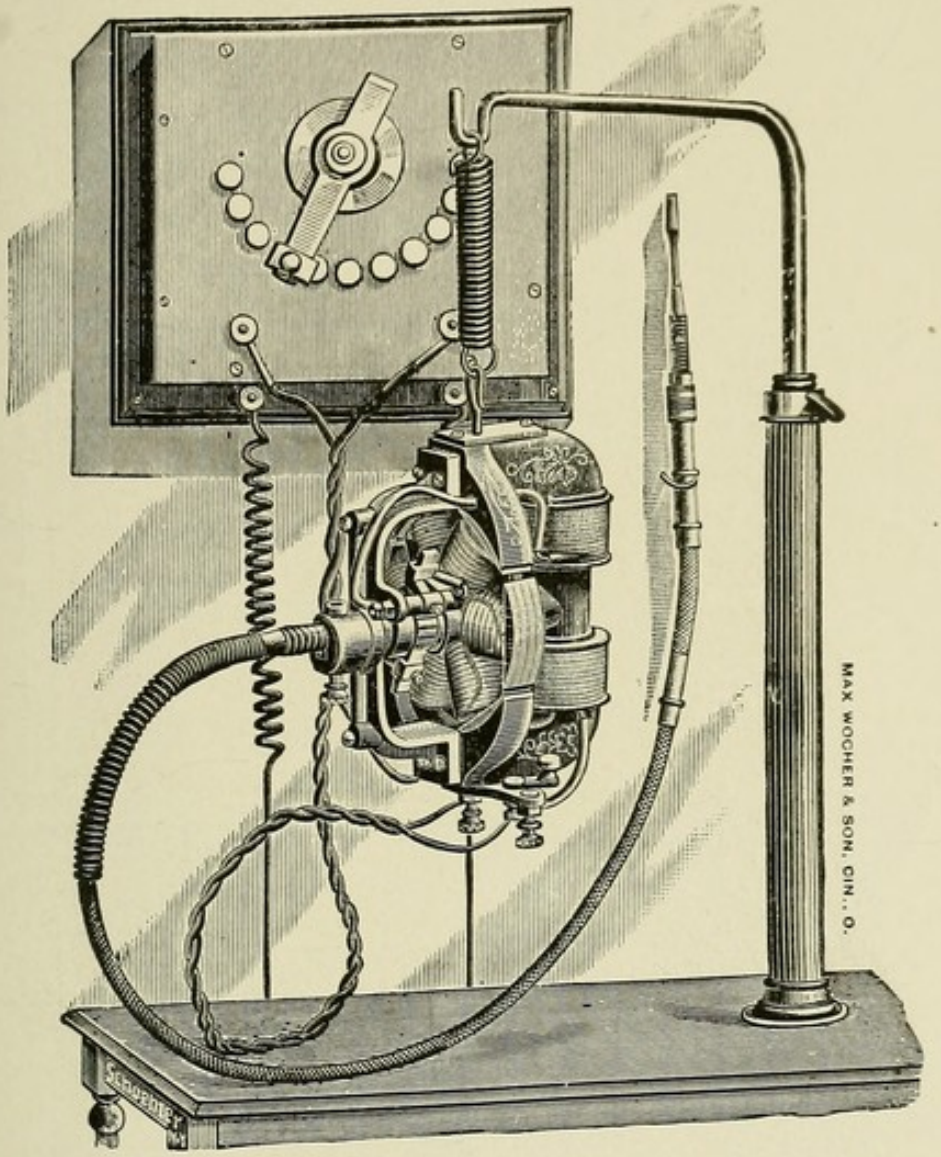


Fig. 104. Edison's Electric Motor with Rheostat.

The majority of motors which operate the burrs, trephines and mechanical saws, require some form of rheostat when used in connection with the incandescent-light current. In order to obviate this inconvenience, the motor should be so wound that it can be used directly with the street current. For this purpose, I have used an ordinary fan motor, by simply removing the fan, and having an attachment made so that the flexible shaft can be connected. Such a motor presents the advantage of enabling the operator to use it in any part of the hospital or other building where the incandescent service is used. The lamp is removed from an ordi-

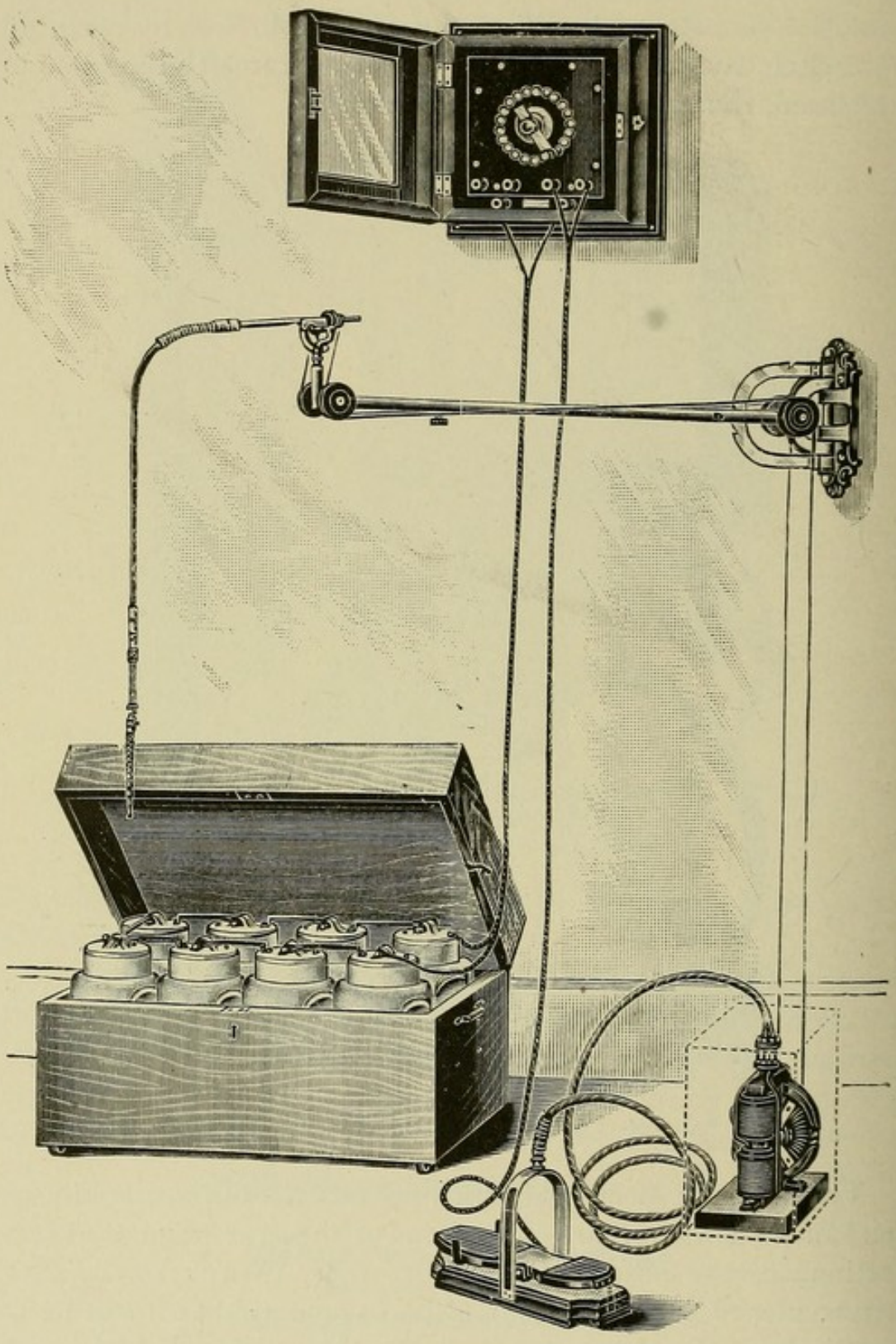


Fig. 105. Edison's Electric Motor with Foot-Switch.

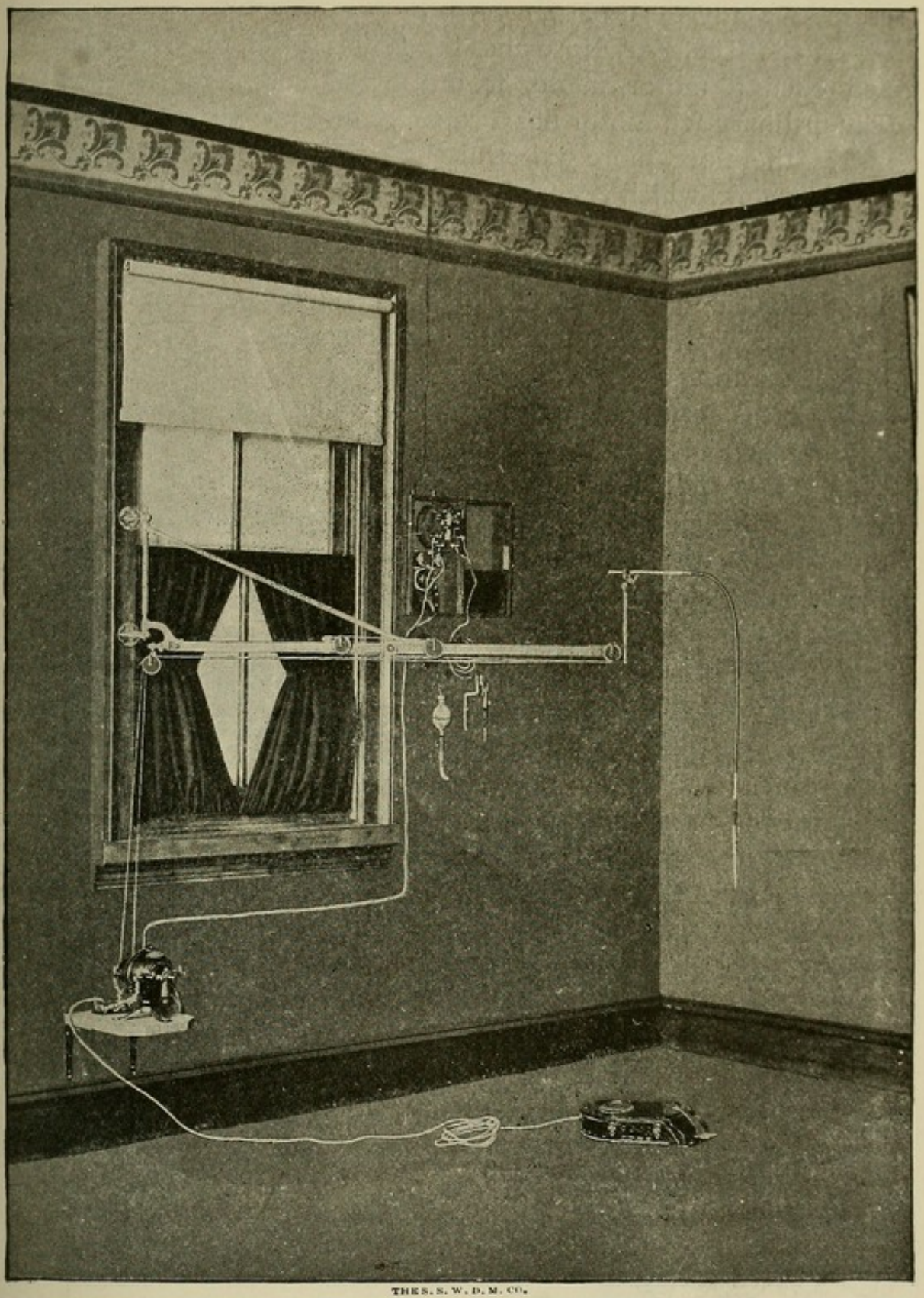


Fig. 106. Motor in Combination with White's Flexible Arm.

nary electric-light fixture, the connecting plug inserted, and the motor is ready for use.

At the Eye, Ear, Nose and Throat Hospital, for which I have had such a motor made, it has given complete satisfaction. The ordinary fan motor has a capacity of one-eighth horse power, and is, therefore, more powerful than the motors generally used for this work, which is an advantage, as it increases the operative power.

The speed of the motor is an important point to which sufficient attention is not usually given. Unless the burrs, trephines and other instruments for which these are used have a sufficient speed, a tearing and not a cutting movement is obtained, which is tedious and detrimental to good work. The speed should be from 2000 to 3000 revolutions per minute.

In many motor-dynamos, or rotary converters, which are used both for drilling and for generating the current for the cautery or illumination, the speed is not more than 1000 revolutions per minute, so that they frequently fail to give satisfactory results for motor work.

MECHANICAL NASAL SAWS.

In order to obviate the difficulty and fatigue of operating the nasal saw by hand, and to do this mechanically by some mechan-

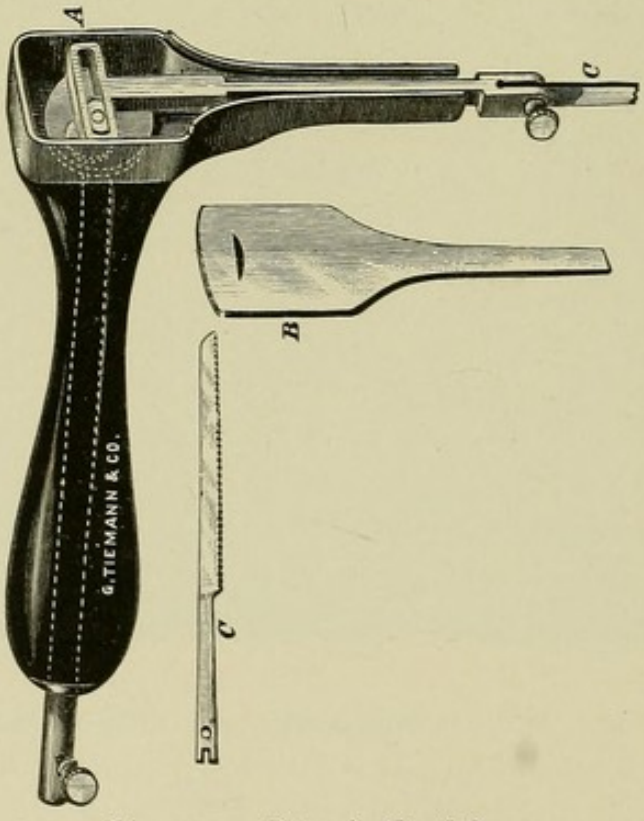


Fig. 107. Potter's Nasal Saw.

ism which will enable this to be done not only with less exertion, but also with greater rapidity and precision, various mechanical saws have been devised. These are usually operated by the electric dental motor.

In the mechanical saw described by F. H. Potter (105), the mechanism may be understood by reference to the illustration (Fig. 107). It consists of a handle through which runs a shaft capped with a disk which has a pin attached to one side. As this disk is made to revolve, it carries the saw-shaft backward and forward by means of the arrangement shown below the letter *A*. The saw *C* with the teeth either up or down is held firmly by a set-screw. The cover *B* fits securely upon the box *A*, and thus protects the running part from dust and injury. It is operated by means of a dental engine or electric motor, the flexible shaft of which is connected with the handle.

In the saw devised by M. R. Brown (Fig. 108), the flexible

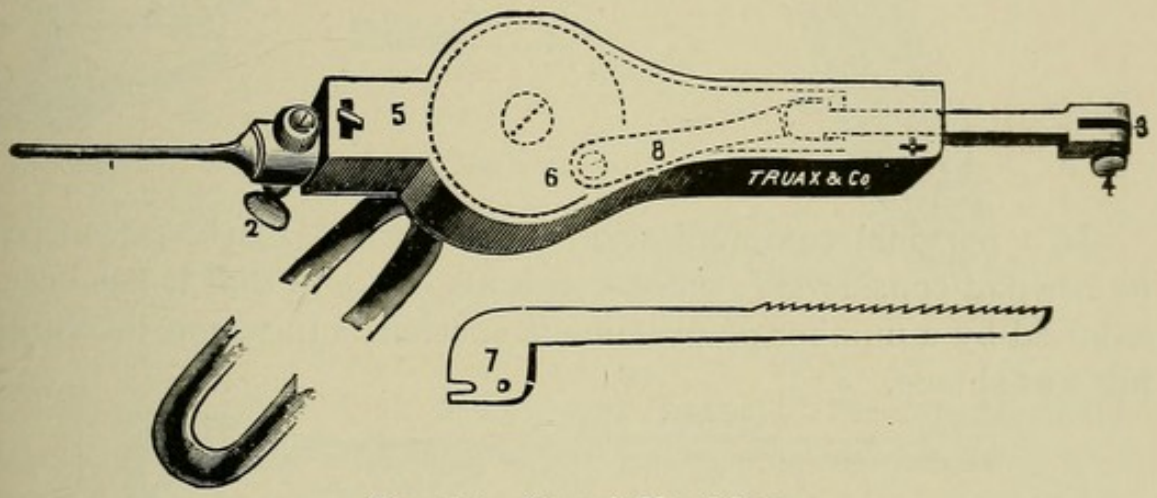


Fig. 108. Brown's Nasal Saw.

shaft is not connected through the handle, but behind the instrument, and the disk is vertical instead of horizontal.

The model of Roe's nasal saw (Fig. 109) is somewhat similar to that of M. R. Brown, but the flexible shaft is attached above instead of behind the handle.

G. Melville Black (53) has devised a saw (Fig. 110), which he claims to be more practicable than the instruments above described. He has found that in Potter's saw, the cam movement, with its enormous stroke, imparts to the instrument such vibrations that it is difficult to hold it in the hand, and the saw could be stopped by a little friction on the blade. He also found too much vibration in Roe's saw, and this could usually be stopped also. In Black's

saw, the rotary movement of the flexible shaft is converted into a forward and backward movement by means of a horizontal disk, as shown in the illustration (Fig. 110). The flexible shaft of the motor is attached within the handle.

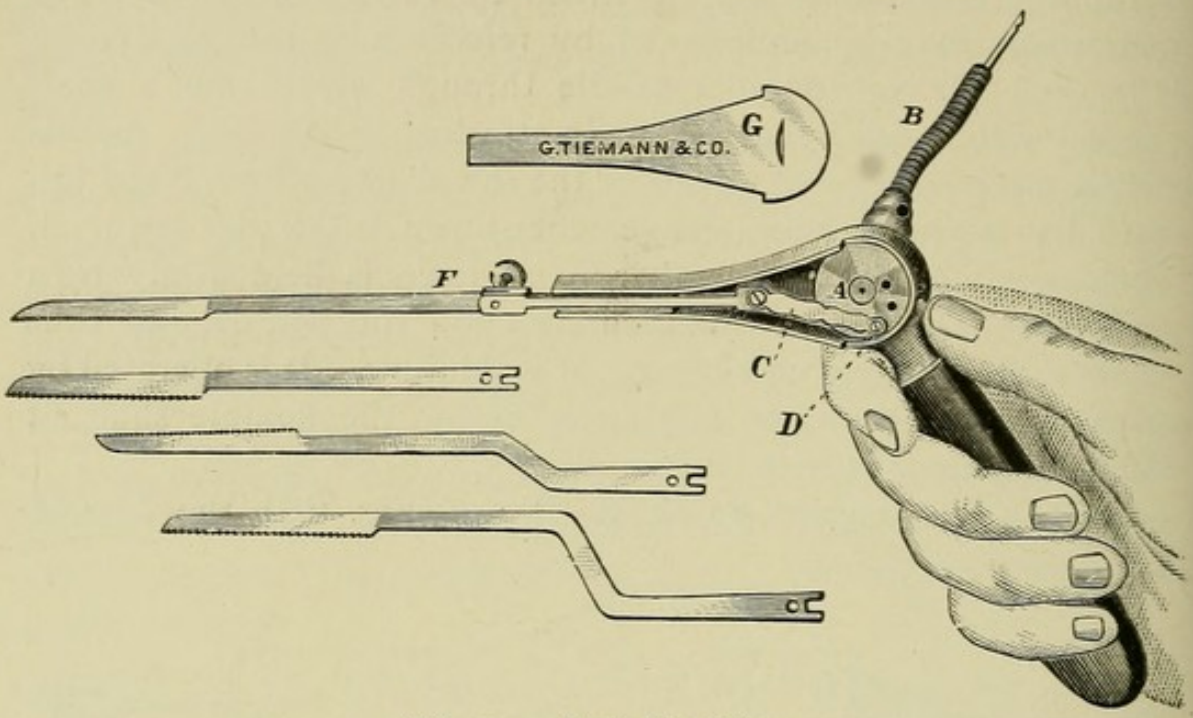


Fig. 109. Roe's Nasal Saw.

In a personal communication to the writer, Black states that he has had considerable success with his saw, and that it has been admired by a number of prominent specialists to whom its working was shown.

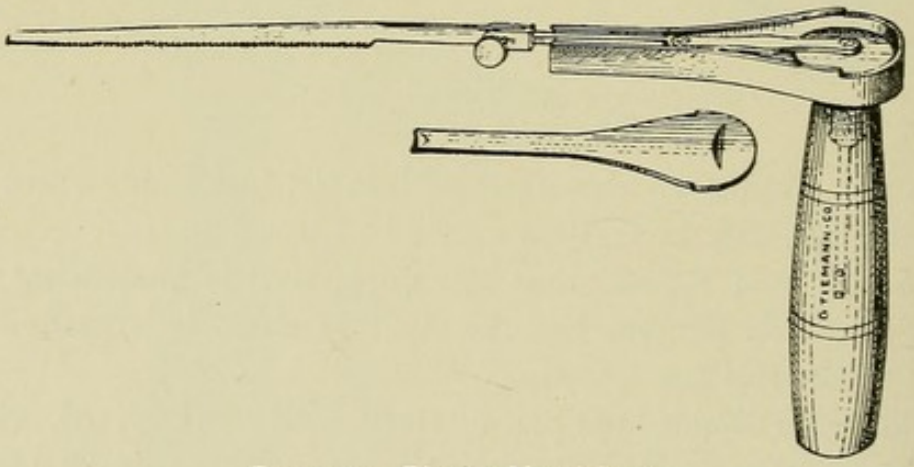


Fig. 110. Black's Nasal Saw.

In the mechanical saw (Fig. 111) devised by Andrew T. Veeder (106), another principle is involved—that of the band-saw. In the illustration, *d*, *d* represent the arms, which by the turning of the thumb-screw *b* can be placed at different distances from each

other; *a*, the screw, which by turning in opposite directions slides all the motive mechanism backward and forward, thus shortening or lengthening the endless chain-saw. This saw has small sharp teeth on the inside of each link, these teeth dropping into wheels of Babbitt metal having little depressions to keep them from being injured; *c* is the cable attachment for the electric motor.

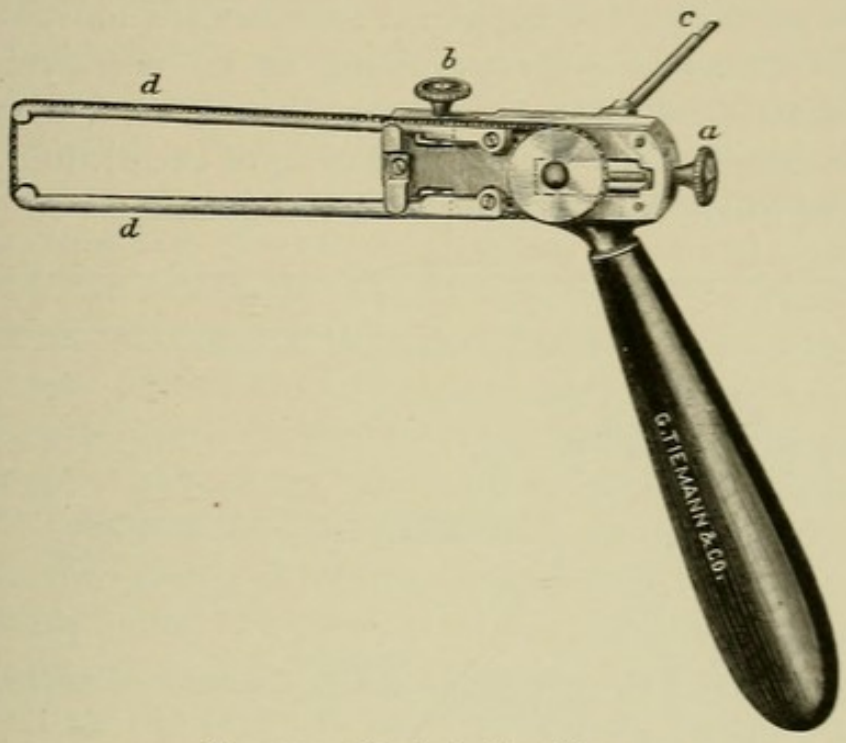


Fig. 111. Veeder's Nasal Saw.

While this saw is, no doubt, very ingenious in construction, it is inapplicable in many cases, and it appears to present a very serious objection in its application. In order to be effective, the band-saw must revolve at a great speed, and, as there is naturally considerable friction in an instrument of this construction, especially when sawing hard tissues, the band-saw is liable, therefore, to fly off or to break, and inflict injury on the patient or the operator.

Some years ago I endeavored to devise a saw for nasal operations, which would combine simplicity, effectiveness, ease in application, facility of control, and which would enable the operator to clearly follow the progress of the operation within the nasal cavity. After changing the model many times, so that the last bore scarcely any resemblance to the first, I finally constructed a saw which combines the important features enumerated above, and which has done me excellent service (203). This instrument may be attached to any of the dental motors now sold by dealers.

In this mechanical saw (Fig. 112), the handle, instead of being at right angles with the direction of the blade, is at an obtuse angle, thus giving it the shape which has been found the most convenient in the ordinary nasal saws, and which prevents the hand, holding the saw, from coming too near the face of the patient. In order to permit this position, the driving wheels used in the other mechanical saws, which have been described, cannot be used, and the backward and forward movement is obtained by means of a *ball* revolving at an eccentric *D*. The flexible shaft is attached within the handle *A*, and the obtuse angle also prevents the excessive bending of the flexible shaft and the friction which would result from this position.

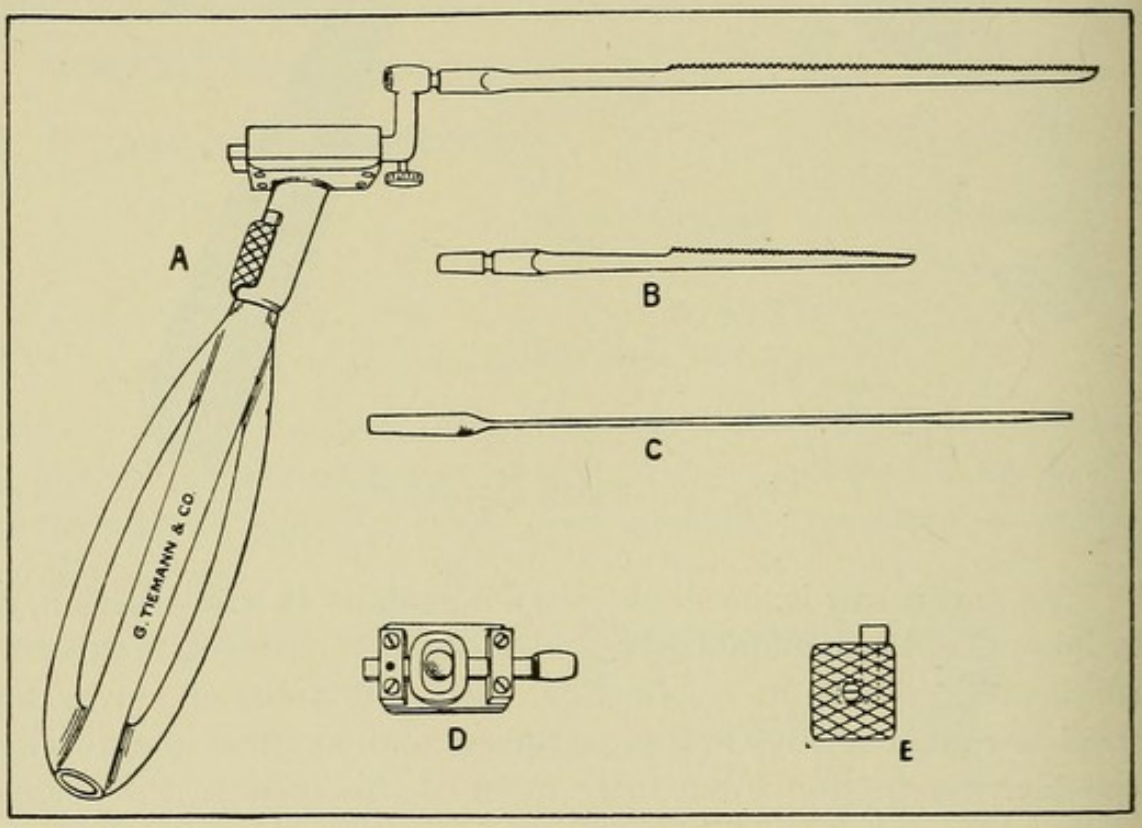


Fig. 112. Scheppegrell's Mechanical Saw.

The second advantage of this instrument is that the saw is at a higher plane than the transforming mechanism, so that it enables the operator to see more fully the work which is being done within the nasal cavity. The third advantage is that the arrangement, by which the saw blades are held in position, enables the blade to be used not only upwards and downwards, as in the mechanical saws which have been described, but also at any required angle. The fourth, and not least important, feature is that the movement of the saw may be instantly started or stopped by the

sliding thumb-piece *E* in the handle, and that its movement may likewise be increased from zero to a one-eighth-inch stroke without arresting the revolutions of the motor.

In this saw the whole mechanism is made of steel so as to combine strength with lightness. The handle is of brass, the central part being hollow for lightness and for the admission of the handle of the flexible shaft, and the whole instrument is nickel-plated. The movement of the saw is obtained by means of a steel ball which is attached to a shaft at an eccentric. This I believe is the first attempt to apply this principle to an instrument of this kind. The ball revolves within an oblong slot *D*, so arranged that it gives a backward and forward movement to the saw-holder, to which the saw is attached by means of a binding screw below the saw-holder and out of the line of vision. This mechanism is protected with a thin metallic cover which slides over the upper part of the instrument and is fixed by means of two small screws, thus protecting the mechanism from dust.

At the upper part of the handle, there is a sliding thumb-piece attached to a sleeve *E*, which raises or lowers the ball in or out of the slot, thus giving complete control over the movement of the saw and enabling the operator to start or stop it instantly.

The same mechanism which starts or stops the saw may be used to regulate the range of movement from zero to one-eighth inch, the full stroke of the saw. This is effected by gradually raising the thumb-piece, and the action of the saw commences as soon as the upper part of the ball enters the slot, and the full stroke is obtained when the ball is entirely within it. At the upper and lower ends of the slot respectively, there is a lateral extension by means of which the movements of the instrument may be continued without pressure of the thumb in the upper position, and may be prevented from starting automatically in the lower position.

The instrument is provided with two saws, one long and the other short, *B*. As these saws are reversible on the horizontal axis, they may be used either upwards or downwards.

This instrument may also be effectively used for massage work. The opening, into which the saw is inserted, will fit an ordinary Buck's applicator, and the mechanism is carried on in the same manner as for the saw. The applicator is armed at the end with a pledget of cotton well attached and flattened at its extremity. It is then dipped into the solution which is to be used, and the

massage may then be commenced, the length of the stroke being adjusted by means of a thumb-piece, which also enables the operator to start or stop the movements at will.

This saw was exhibited at the meeting of the Southern Section of the American Laryngological, Rhinological and Otological Society at New Orleans, 1897, at the meeting of all the Sections of this Society at Washington, 1897, and at other meetings of medical societies, and received much favorable comment.

CHAPTER XVII.

Electro-Magnetic Appliances.

(Continued.)

MASSAGE IN OTO-LARYNGOLOGY.

MASSAGE of the upper respiratory passages and ear have been fruitful in developing a number of electro-magnetic appliances to facilitate its application. Before describing the various means which have been devised for the mechanical application of this method, it would be well to consider the advantages that have been claimed for this by its supporters.

Massage in the treatment of the upper respiratory passages is recommended as a means of stimulating the normal physiological function of the organism, to produce a more active oxidation in the tissues, and to remove hyperemias and inflammation.

In order to obtain good results from massage of the mucous membrane, the process should be carried out in the most systematic manner, and Garnault (118) insists that it is an essential part of the method that the vibrations should be regular and of the same intensity, and that these two conditions are absolutely necessary in order to obtain good results; and that if they are not followed out, the inflammatory conditions are increased instead of diminished.

The effects of massage on the mucous membrane may be due directly to the increase of circulation, or indirectly to reflex stimulation. In this manner, massage may be useful not only for hypertrophic but also for atrophic conditions of the mucous membrane. Although this may appear contradictory, it has been proved in a great number of cases. In hypertrophies, the circulation is quickened and there is a more rapid excretion of the products from the hypertrophied tissue; while in atrophic conditions, the improved circulation carries a greater quantity of nourishment to the parts where it is most needed. If the theory is accepted that true hypertrophy and atrophy are different stages of the same pathologic condition, the usefulness of this method in both cases is easily understood.

The value of massage in diseases of the upper respiratory passages was first called to the attention of the profession by Michael Braun, of Trieste (119), who read an interesting paper on this subject before the International Medical Congress at Berlin. This method of treating the mucous membrane has also been recommended by a number of writers, as Karl Laker (120), W. Freudenthal (121), G. Melville Black (122), P. Garnault (123) and others.

After an extensive experience with this method, Braun (124) reports that he has cured many cases of ozena, 100 cases of chronic catarrh, 40 cases of asthma of nasal origin, 68 cases of reflex neuroses and 140 cases of hypertrophy of the Eustachian tube. He claims that the technique is very difficult; successful results with it requiring confidence, experience and skill.

Improvements in cases of ozena have also been reported by Löwenstein (125), but no cures. In 34 cases of atrophic rhinitis without fetor, he has had 18 cures, 13 improvements, and in three cases no change could be observed. He has also had success in hyperplastic rhinitis, and his best results have been in the treatment of hypersecretions.

Two principal forms of movement for massage of the mucous membrane of the nose, naso-pharynx, larynx and upper part of the trachea are recommended by Braun. These are stroking and vibration, and the two are combined in such a manner that each part of the mucous membrane is thoroughly massaged. For this purpose, he recommends probes of copper held between the thumb, index and middle finger like a pen, in such a way that the finger and fore-arm form a chain which transmits shorter or longer undulatory movements to the mucous membrane under treatment; these movements are produced by the contractions of the arm and fore-arm, and are transmitted through the curvature of the elbow. He uses three sizes of sounds; the thinnest for the nose and the Eustachian tube, the medium for the larynx and trachea, and the largest size for the naso- and oro-pharynx.

These probes are slightly roughened at their olivary termination in order to fix on more easily a pledget of antiseptic cotton, the size of which is adjusted according to the part under treatment. The cotton should extend two or three centimeters from the extremity of the probe and should have sufficient resistance and elasticity to give the required pressure.

The probe, thus prepared, is dipped into the solution or oint-

ment which it is desired to apply to the mucous membrane. A solution of 10 to 20 per cent. of cocaine is applied when required by the sensitiveness of the mucous membrane, and then an ointment of vaseline and 10 per cent. menthol or balsam of Peru, or a solution of sublimate (1 to 1000), or of alcohol, lanoline or iodide-glycerine (10 per cent.).

The duration of the vibration of each probe depends upon the individual resistance of the patient, and varies from four seconds to a minute. Braun uses about 14 probes for the same patient at each sitting. His treatment of chronic ozena is as follows: having carefully removed all crust and mucus, he commences the vibration of the mucous membrane with a probe, the cotton of which has been dipped into a 20-per-cent. solution of cocaine; then with another probe, whose tampon has been saturated with one of the above-named solutions, he "vibrates" the floor of the nose; with a third, the inferior meatus; with a fourth, the inferior turbinate; with a fifth, the middle meatus; with a sixth, the middle turbinate; with a seventh, the septum; with an eighth and ninth, the upper parts of each side of the nose; and finally with the tenth, the entire cavity. At the same time he continues the vibration of the naso-pharynx with two or three of the sounds. In the afternoon, the same process is repeated unless the reaction has been too strong. In no case should there be any pain or hemorrhage. Such symptoms indicate that the probe has not been applied by a skilled hand, or that too much violence has been used, and more harm than benefit is produced.

The large number of sounds recommended by Braun in this method has not been deemed essential by others who have practised this treatment, many of whom use simply one sound in each cavity.

The following advantages have been claimed by Braun for this method: the treatment is restricted and localized entirely to the diseased part, and the pressure required for each part can be directed by the fingers. The facility and rapidity, with which the flexible and elastic probe may be introduced into and removed from every point of the mucous membrane of the air passages, enable the patient to tolerate the operation with perfect tranquillity; the constant and perfect application gradually produces a greater physiological activity of the mucous membrane in its entirety, that is, of the epithelium, the connective tissues, vessels, nerves and muscles, so as to increase the activity of the entire

surface. The diminution of sensibility gives to the mucous membrane greater resistance against agents that might act on it harmfully.

This method has been employed by Braun for over seven years upon nearly 300 patients. In many cases he has obtained a complete cure, and in those in which other methods have not succeeded, he has obtained marked improvement.

He reports 62 cases of ozena as cured, the period of treatment varying from 4 to 250 sittings; also the cure or improvement of several hundred cases of chronic catarrh of the nose, pharynx and larynx; 35 cases of glossodynea, a case of hay-fever, 42 cases of nasal asthma, 178 cases of neuralgia of the trigeminal nerve, and 103 cases of catarrhal affections of the Eustachian tube. He also noted a remarkable diminution or the partial cessation in cases of tinnitus.

The following observations have been offered by Braun on this method:

"The technique of vibratory massage is decidedly difficult; in addition to an extraordinary amount of patience, it demands exact observations, innate and acquired ability with a disposition of great and natural perseverance. Success cannot be easily obtained; the operator must have the faith and firmness necessary to endure the process. When once the first difficulties have been overcome, there will be the satisfaction of seeing that a cure or encouraging improvement may be had in a variety of cases, many of which are considered incurable, and which render existence miserable or insupportable to the sufferers."

In the discussion of this communication before the Eleventh International Medical Congress at Rome, March 30, 1894, Garnault stated that it is important to determine whether vibratory massage has any action of its own, or if the results produced are due chiefly to the drugs employed. He believes that the results obtained are far superior to those procured from the local application of the drugs.

Some writers, however, believe that massage of the nose and throat gives but little promise, and this is the opinion expressed by Lennox Browne (126). He admits, however, that his experience is not sufficient to speak with authority on this subject. A similar opinion is expressed by Pierce (127), who has applied vibratory massage of the nose in a number of cases, and believes that the cleanliness of the parts, which is an important feature in this treatment, is responsible for many of the good effects obtained. He states that while the vibratory movements may be

useful on account of the stimulation of the lymph and circulatory system, they can have little or no effect on the regeneration of the tissues in atrophic diseases.

On the other hand, many writers are enthusiastic over the effects of vibratory massage, among whom may be mentioned Laker, of Graz (128). He often finds it superior to the electrocautery in simple hypertrophy of the tonsils. Numerous small polypi, as also the stumps of extirpated polypi, are effectually treated by this method. Cases of atrophic rhinitis associated with the formation of crust were markedly improved in five weeks. Patients with purulent rhinitis, acute rhinitis, rhinitis with reflex neurosis and aprosexia were cured by following out this method for a few weeks to several months. Chronic diseases of the naso-pharynx gave excellent results after the application of massage, as did also chronic pharyngitis and chronic affections of the Eustachian tube and opening. Paresis of the vocal cords, and chronic ulcerations of the larynx, even of a tubercular nature, were improved by this treatment.

The efficacy of massage of the mucous membrane of the nose and throat is also extolled by Carl Sahner (129), who gives precise directions as to its application (manual method).

While these authors are, perhaps, too sanguine of the efficacy of this method and of its capacity of preventing a tendency to recurrence, still they furnish some excellent proofs of its value as a therapeutic measure by the report of the cases which they have treated in this manner.

Good results are also reported by F. Felici (130), who has carefully examined into the merits of massage as applied to oto-laryngology, and is convinced that this method is destined to replace many of the older therapeutic measures in the most satisfactory manner. He has found massage useful in the hypertrophic period (?) of ozena, in chronic rhinitis, in extensive adenoid vegetations, in chronic granular catarrhal conditions of the larynx, and even in tubercular laryngitis with or without ulceration.

Improvements in the treatment of the various forms of rhinitis by this method are also reported by Atorch, of Copenhagen (131), who has succeeded in improving the condition of ozena by vibratory massage. He reports a case of anosmia, which was completely cured by this method. Bogdan, of Hungary (132), also states that he has had excellent results from the vibratory method in hyper-

trophic conditions of the nasal mucosa. Zwillinger, of Budapest (133), however, does not believe that this method is better than those already in vogue.

After a two years' experience with vibratory massage for the treatment of diseases of the respiratory passages according to the methods of Braun and Laker, O. Chiari, of Vienna (134), concludes that these vibrations are not more effective than ordinary medical applications continued for the same length of time. He does not think that more is obtained in ozena by this than with the methods formerly in vogue for the treatment of this disease. He believes that the nature of the medicaments, with which the cotton tampons are saturated, have an important bearing upon the effects of the treatment.

As opposed to this opinion, however, many authors have reported good results which they have obtained by this method. In addition to those already quoted may be mentioned the following: Hoffinger, Demme, Volpe, Massucci (135), Cederschiold (136), Herzfeld (137) and Lehmann (138). These have not only obtained excellent results, but found it superior to other methods in the cases in which they applied it.

In his more recent monograph, Laker (201) states specifically that, by control experiments, he has been able to ascertain that the effects of massage are little influenced by the nature of the medicaments applied to the tampon, but depend almost entirely upon the efficacy of the vibratory movements.

The fact that Chiari had no satisfactory result with this method, after a faithful attempt to use it, is accounted for by Braun as being due to the former's lack of experience in becoming master of the principles of this method, and not to any defect of the method itself. Garnault (139) also states that it is doubtful whether Chiari applied massage with the patience and perseverance necessary to give this method a fair trial.

The use of massage in the therapeutic management of atrophic rhinitis has also recently been advocated by Ralph W. Seiss, of Philadelphia (140), who states that it is one of the most important methods at our command for this disease. He ridicules, however, the great stress which many authors have laid on the elaborate directions for the number of vibrations and the special manner in which they should be made to secure favorable results. E. J. Moure, of Bordeaux (202), also gives preference to massage in the treatment of ozena.

The principle of massage is essentially a simple one, and depends upon the mechanical and vascular stimulation, which must never be carried to the point of causing inflammatory changes. In many cases it is undoubtedly of great advantage, and the technique is not difficult when applied by one of the various mechanical methods which have been suggested for this purpose.

CHAPTER XVIII.

Electro-Magnetic Appliances.

(Concluded.)

MASSAGE IN OTO-LARYNGOLOGY (*Concluded*).

MASSAGE of the mucous membrane of the upper respiratory passages is a process very difficult to carry out by the hand, and those who have had success with the manual method all claim that it requires weeks and months of careful training to obtain good results.

In order to avoid the fatigue resulting from the application of the manual method, and to apply it more systematically and with greater precision, a number of mechanical appliances has been devised. Braun, Laker, and others, who have had more experience with the manual, believe this to be far preferable to the mechanical method. Laker (201) gives an elaborate illustration showing that all the movements obtained mechanically may also by experience be reproduced by the manual method. This is, however, no argument in favor of the manual method. If the movements may be reproduced mechanically, it has the advantage of avoiding the fatigue and strain of the manual method, and, if it lacks a little in the delicacy of touch when the hand is used, it offers the advantage that the movements may be followed by the eye, which is not always possible in the manual method. Laker, for instance, advises the operator to stand at the right knee of the patient, and to be guided by the topography of the parts obtained by previous examination.

The most simple mechanical method is described by Hans Daae, of Christiana (141), who employed a hand machine, operated by the patient himself, which gave not only a vibratory but also a rotary movement.

Among the various devices for the mechanical application of massage is one described by G. M. Black (142). In this instrument (Fig. 113) the motive power, as in the majority of mechani-

cal devices for applying massage, is derived from an electric motor, to which is attached a White's dental shaft and hand-piece. To the latter is attached the probe-carrier, which slips over the hand by means of two rings which are held in place by a thumb-screw. The probe, made of copper and with a bulbous end, is inserted into a tube, which is soldered to the two rings and held fast by another thumb-screw. Introduced into the hand-piece is a shaft which carries a piece of leather; as the shaft revolves the leather strikes against the probe during each revolution and causes it to vibrate. Any number of vibrations up to seven thousand per minute can be obtained, according to the adjustment of the motor.

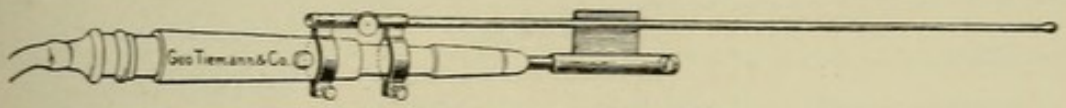


Fig. 113. Black's Intra-Nasal Vibrator.

In applying massage, Garnault uses an electric vibrator by which undulatory movements are given to the probe in both antero-posterior and lateral directions—that is, vibrations both transverse and axial. The frequency and precision obtained by this method are difficult to procure by hand even with the greatest experience.

One of the most practicable instruments for applying vibratory massage is described by W. Freudenthal (143). The mechanism of this instrument (Fig. 114), which is made on the principle of the magnetic hammer used in dentistry, is as follows: In the interior of the box are two iron bars around which insulated wire passes in manifold windings, thus constituting a pair of electro-magnets. Between these two electro-magnets is a rod which moves backwards and forwards by the alternating attraction of the magnetic poles; at its rear end an iron plate is fastened, and to this is attached a movable metal plate. To the front end of the rod is screwed a detachable probe, the button of which is movable. The index-finger slips into a holder, which is attached to the neck of the instrument, the box resting between the thumb and the index-finger of the operator. Two small screws at the lower part of the box are points of attachment for the electric wires. On the neck is placed a metal spring, which holds an ivory interrupter. When this button is pressed upon by the tip of the index-finger, the circuit is closed and the iron plate is drawn forward by the iron bar, which has become electro-magnetic, and the

rod holding the probe is drawn forward also. As soon as the iron plate has reached its foremost point, the contact is interrupted directly before the screw, and the iron plate falls into its original position by means of a spring. This again closes the circuit, and the mechanism repeats itself in the same manner as the automatic rheotome of the faradic coil. The quantity and quality of the vibrations can be regulated by a set of screws attached at the rear of the box.

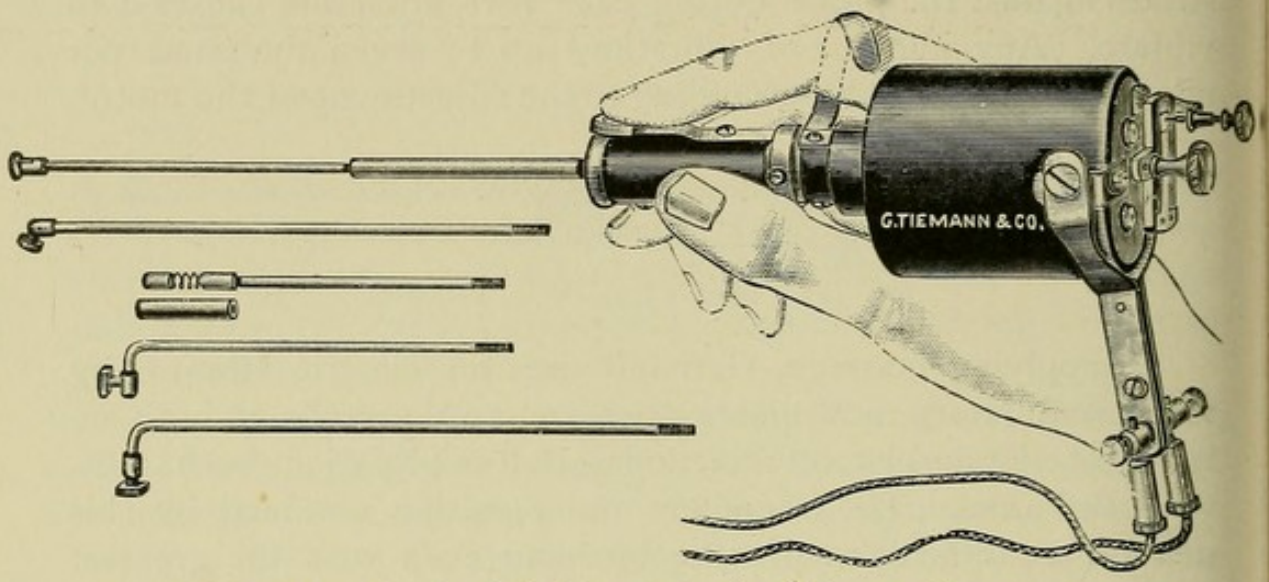


Fig. 114. Freudenthal's Instrument for Vibratory Massage.

This instrument has a capacity of 7920 vibrations to the minute, which is considerably more than can be obtained by the manual method. The *modus operandi* is very simple, and any one accustomed to using instruments can operate it at the first trial. The vibrations may be continued for five seconds or longer, according to the indications of the case. A five-per-cent. solution of cocaine is sufficient to produce insensibility of the parts for treatment. The applications are made from two to four times a week.

A large number of chronic catarrhal diseases has been treated by Freudenthal with this electric vibrator, and he concludes that vibratory massage is a remedy which will never disappear from our therapeutic armament.

The Scheppegrell mechanical saw (Fig. 112) also has an attachment by means of which massage may be applied to the mucous membrane, and several other mechanical saws which have been described may also be adapted for this purpose.

Believing that the therapeutic action of massage is more bene-

ficial in proportion to the frequency and regularity of the vibrations, Ignazio Dionisio, of Turin (144), has devised a method of applying vibrations not only to isolated points of the mucous membrane, but simultaneously to all or the greater portion of its extension.

The apparatus used for this method is composed of one part which transmits the vibrations, and another which generates them. The first consists of an india-rubber bag, which is introduced into the nasal cavity and inflated with air, so as to come in contact with a large portion of the mucous membrane, including parts ordinarily inaccessible to the probe. This bag is connected by means of a tube with the apparatus which generates the vibrations. This consists of a chamber of air, in which rapid increase and intermission of pressure is obtained by means of a cylinder and a piston. By arranging the latter, as many as 200 to 4000 oscillations per minute may be transmitted. The generator of the vibrations may be connected with various india-rubber bags, so that not only one but both nasal cavities may be treated, and even three or four patients at the same time.

The sensation experienced by the patient is that of a tremor, which in the larger vibrations extends to the whole head, and is not unpleasant or painful. The piston is operated by means of an electric motor, and the rapidity of the movements may be regulated not only by adjusting the speed of the motor, but also by changing the gear of the propelling wheels.

The following advantages have been claimed by Dionisio for this method :

1. The greater number and the quality of the vibrations acting on the mucous membrane, being homogeneous and not simply shocks.

2. The mildness of the applications, which are better tolerated, sparing the operator the disagreeable feature of being in the presence of the patients for hours, inhaling their unpleasant breath.

3. The economy of time and fatigue in being able to treat two or three patients at the same time.

This method has recently been advocated by L. Jaukau (522), who has had good results from its application.

Massage has also been applied in the treatment of *pathologic conditions of the ear*, and August Lucae (145) first applied this principle to the direct mechanical vibration of the membrana tym-

pani. A number of authors report good results from the use of this method. An instrument for applying this principle mechanically, by means of an electric motor, has been devised by Jno. C. Lester, of Brooklyn (146). When this instrument (Fig. 115A) is applied, the head of the patient is turned slightly toward the opposite side, as for an ordinary examination of the middle ear, and

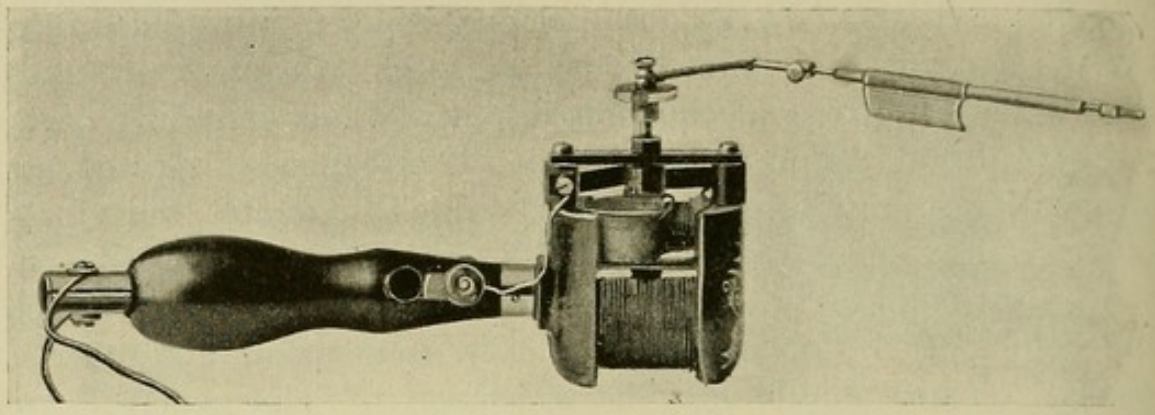


Fig. 115A. Lester's Mechanical Vibrator for the Ear.

fixed in this position. An ordinary round ear-speculum is introduced, and the canal illuminated in the usual manner. The speculum is omitted from the illustration in order to show more clearly the position of the sound as it enters the external auditory canal. The motor with pressure-sound attached is shown in Fig. 115B. The right hand grasps the handle of the motor, with the thumb resting on the button of the contact spring. The corrugated handle of the pressure-sound is firmly held between the thumb and the index-finger of the left hand. The tip of the little finger is made to rest gently on the head of the patient immediately behind the auricle, and the sound is introduced parallel to the anterior superior wall of the auditory canal, until the cylindrical extremity of the spiral end rests upon the base of the short process of the malleus, which is selected as the point of contact. When the contact is made with the pressure-button before referred to, vibrations ranging from 500 to 1500 or more per minute, judging from the note obtained from the revolutions of the armature, are produced. The extent or length of the vibrations is controlled by an eccentric throw and a binding screw, the range being from zero to half an inch.

A sound has also been devised by Lester which can be added to the motor above described for the treatment of pathologic conditions of the throat and nose.

In the cases so far treated, the best results have been obtained by a minimum length or extent of vibrations and a maximum number. It is seldom that the binding screw has been farther removed from the center of the eccentric throw than a sixteenth of an inch, and when this minimum length of stroke has been adhered to, in no case has the patient experienced pain.

The duration of treatment varies, the average being from three to 10 seconds at each sitting, and should be repeated from two to three times per week.

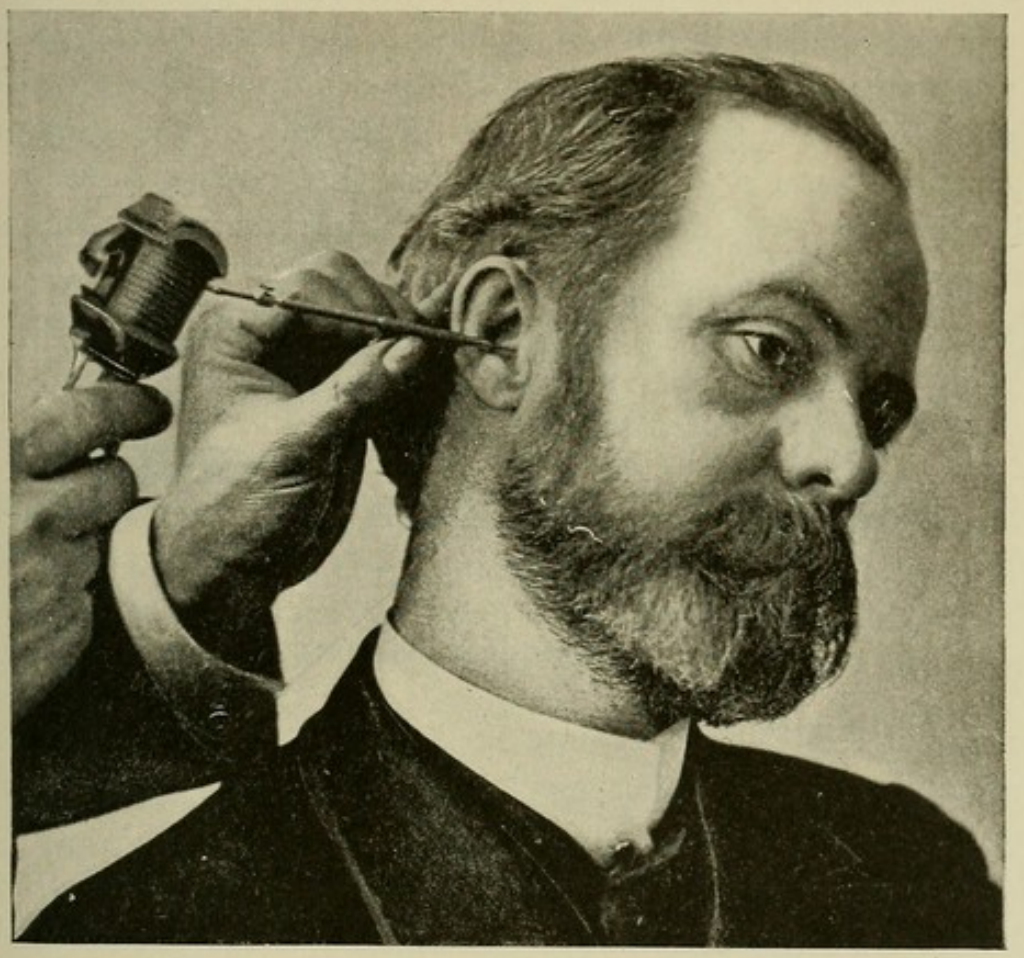


Fig. 115B. Method of Applying Vibrator to the Ear.

A *hand telephone* for vibratory massage of the middle ear is recommended by Wilson, of Detroit (147). The diaphragm of the telephone is set into powerful vibrations by the interrupted current from an ordinary faradic coil, which allows a great variety of sounds to be produced with this method by simply altering the rate of the interruptions of the current or varying its strength. The seances should last from five to 15 minutes, and vibrations of the highest intensity should be used where there is the greatest

impairment of hearing. In the five cases, which Wilson reported, there was diminution of the tinnitus in three cases, but no improvement of the hearing in any case.

A method of using the telephone in this connection is also described by E. J. Bissell (148). Instead of the faradic coil, however, he recommends a ribbon rheotome, by means of which he was enabled to obtain 60 to 20,000 interruptions per minute.

Good results from vibratory massage have been obtained by Gautier and Larat (149) in the treatment of Ménière's disease. A helmet, somewhat resembling the form employed to take the shape of the head by hatters, is applied to the head of the patient, and the many arms of which it is composed are made to vibrate by means of a small electric motor on the top of the apparatus. They report a number of cases where the vertigo rapidly disappeared after the commencement of the treatment, the cure remaining permanent.

An electric *tuning fork* (Fig. 116), which may be used for

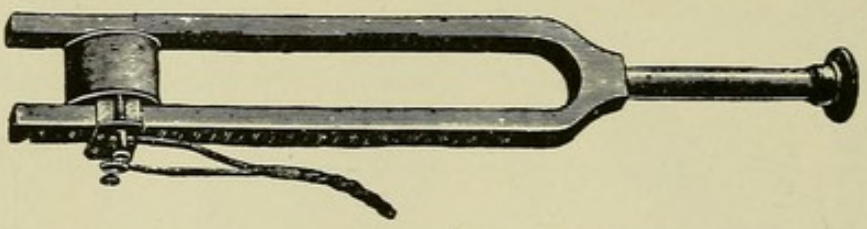


Fig. 116. Electric Tuning Fork.

carrying out Gellé's test, is described by Jouslain (150), who also recommends it for effecting mechanical vibrations after the manner of Charcot's helmet.

In view of the fact that direct pressure with probes in oto-massage, whether operated by hand or a special mechanism as advocated by Lucae and others, may be extremely painful and involve such risks of injury that it has been questioned whether it is advisable to subject the patient to them for the small amount of benefit claimed by the advocates of this method, Chevalier Jackson, of Pittsburg, Pa. (151), recommends the application of the mechanical method of massage by means of a column of confined air.

After referring to the various methods practised, such as manipulation by the fingers, Siegel's or Delstanche's masseur etc., he gives the preference to a well-constructed pneumatic masseur (Fig. 117) acting on the piston principle. He states that where

there is rigidity of the ossicular chain, passive motion must produce the best effect.

The necessity of using gentleness in this method is insisted upon by Jackson, and also the importance of starting on the exhaust stroke. He advises that the sittings should be of short duration, and not oftener than thrice weekly. The method should not be placed in the hands of the patient, who is certain to overdo it. He advises otologists not to subject the patient to serious operative measures until after pneumatic massage has been given a thorough trial.

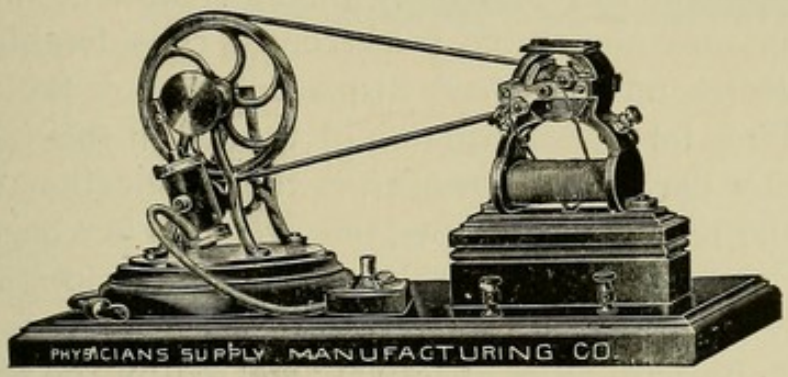


Fig. 117. Jackson's Pneumatic Masseur for the Ear.

Another form of massage for the ear is described by Thos. L. Shearer (152), who applied it by means of the "violin-vibrophone." In this instrument, the mechanism is based upon and is similar to the one first used by Garey, of Baltimore. The principle depends upon the formation of a series of sound waves which vary in pitch and intensity, and which are produced by the slow or rapid vibrations of a metallic revolving substance. These waves are sent against the membrana tympani with sufficient force to cause, in suitable cases, vibration of the drum and its chain of ossicles. The object of these vibrations is to remove and to render pliable the stiffened parts of the ossicular articulation where this condition exists. The column of vibrating air is conveyed by a rubber tube, which is bifurcated in order to allow its fitting accurately into each ear. The other end of this tube is attached to a rubber chamber, through the center of which is placed a diaphragm, thus dividing the space into a lower and upper section. The vibrations set up by the movement of the diaphragm are transmitted along the tube to the ears.

The violin-vibrophone is capable of developing slow, medium and rapid vibrations as well as two imitations of pathological sounds, namely, low buzzing and high singing notes. It is operated by three Edison cells or a storage battery of the same strength.

CHAPTER XIX.

Tumors of the Nose and Throat.

NASAL TUMORS.

THE application of electricity in the treatment of neoplasms of the nose and throat has received considerable attention, and the electric methods have displaced many of the other surgical procedures for the extirpation of tumors in this region.

A notable exception, however, is the application of the cold snare for the removal of tumors, but even this has been combined with the electric method, and the electrically heated wire is now extensively used instead of the cold wire.

Nasal polypi are more effectively treated by the snare, and, as the tendency of myxomatous growths to hemorrhage is insignificant, the simple method of the cold snare is the most practicable. Morell Mackenzie (113) recommended the *electro-cautery* for the removal of nasal polypi, using the heated point as a knife to cut through the pedicle. As the pedicle, in most cases, is concealed by the growth, and even where it is visible the cautery is difficult to apply, this method presents no advantages over the snare for this purpose. John M. Lefferts, of New York (114), also points out the advantages of the electro-cautery in the treatment of nasal polypi, but states that the snare should always be given the preference.

Where the polypi are very small, however, the electro-cautery may be used to advantage, and it is also indicated for destroying the tissues which form the base of the neoplasms.

A case of myxofibroma of the nose, successfully treated in this manner, is reported by V. Cozzolini, of Naples (115). In nasal tumors, which cannot be treated by the snare on account of their formation (very sessile), or on account of their disposition to bleed (angiomata), the electro-cautery may frequently be applied to advantage. Thus L. Gongora, of Barcelona (116), reports a case of varicose tumor of the posterior inferior part of the septum, which had given rise to repeated epistaxis, and which

for three years had caused the friends of the patient to believe that he suffered from hæmoptysis. This growth was destroyed by the electro-cautery and the hemorrhage did not recur.

A special modification of the electro-cautery for removing broad-based neoplasms of the turbinated bodies or of the septum has been devised by Walter Vulpius (117). This instrument (Fig. 118), which may be considered the connecting link between the

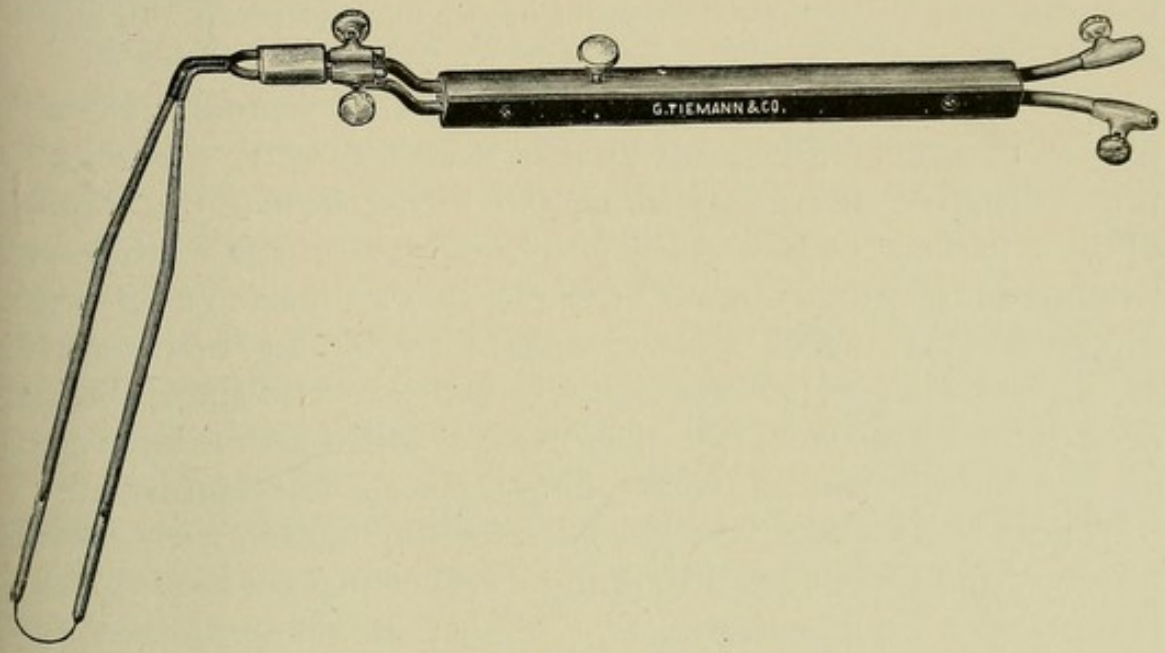


Fig. 118. Vulpius' Electro-Cautery.

electro-cautery and the electro-caustic snare, consists of two brass-wire shanks, four inches in length, diverging for the first half of their course, and then running, one inch apart, parallel to their blunt pointed ends, which are connected by a semicircular loop of platinum wire, stiffened by the addition of iridium. It is attached to an ordinary electro-cautery handle. The platinum wire is heated as in the ordinary electro-cautery.

Electrolysis has also been recommended in the treatment of nasal polypi, but this method presents no advantages over the snare in the treatment of simple myxomata. Electrolysis, however, may be used to advantage instead of the electro-cautery for destroying the base of these growths, the bipolar method being preferable. I now use cupric electrolysis in these cases, and the results from this method have given me more satisfaction than from other forms of treatment.

Among the authors who advocate electrolysis in nasal myxomata may be mentioned Sajous (153), who recommends that a

zinc or silver needle be connected with the positive pole of a moderately powerful galvanic battery and then introduced into the tumor, while the dispersing electrode is placed over the nose. As zinc and silver needles are both soluble in the electrolytic process and as they are connected with the positive pole, it would lead us to suppose that the author intended interstitial and not simple electrolysis. If the latter were intended, the needles should have been connected with the negative pole, or, if connected with the positive pole, the needles should have been of platinum, a non-soluble metal.

For angiomatous tumors of the nose, the treatment by electrolysis presents marked advantages over the other methods, as the destructive effects may be obtained with the least disturbance of the superficial parts which would favor hemorrhage. A case of a voluminous cavernous tumor of the septum is reported by Strazza, of Genes (154), which was successfully treated by this method, and in which a previous attempt to remove it with the snare had been followed by a violent hemorrhage, which necessitated tamponage and pressure to the bleeding surface for several hours.

These tumors have also been successfully treated with electrolysis by John Duncan, of Edinburgh (155), who gives the following indications for its application: 1. When the tumor is growing. 2. When it is important to avoid a scar. 3. When the subcutaneous parts are of considerable size in relation to the cutaneous development of the tumor.

A case of lipoma of the nose cured by electrolysis is described by R. W. St. Clair (156). Eight cases of angiomata treated by this method are reported by Kaarsburg, of Copenhagen (111). Among these were a subcutaneous cavernous angioma of the apex of the nose in a child of four months; another of the same region in a boy of eleven years, and a submucous buccal angioma in a girl of fifteen years. After a current of fifteen milliamperes had been passed through the angioma for five minutes, a shriveling of the tumor developed, and a cure followed within a few weeks.

Papillomata of the nasal cavities are of rare occurrence. Aysaguer, of Paris (253), states that they do not recur as persistently as papillomata of the larynx, and that this is due to the fact that they can be more radically removed by means of the electro-caustic snare and subsequent cauterizations than can be done in cases of papillomata of the larynx.

NASO-PHARYNGEAL TUMORS.

Fibroid tumors of the naso-pharynx form a pathologic condition which has demanded the earnest attention of the rhinologist, not only on account of the prominence of the symptoms developed by their presence, but also by their tendency to recurrence, which clinically gives them many of the characteristics of malignancy; and also from the fact that a malignant degeneration is not an infrequent occurrence.

While the majority of rhinologists are unanimous in preferring the snare in nasal tumors, there is a marked want of consensus of opinion as to the best surgical method of treating naso-pharyngeal tumors. The snare, either cold or electrically heated, is advocated by many writers, and condemned by others. The cautery has been successfully used in the hands of certain operators, while others have found it dangerous. Electrolysis has been advocated by many prominent authors, but condemned by others as being a slow, tedious and ineffective method of treating these neoplasms.

A careful study of the results which have been obtained by these various methods is therefore important, so that we may form a fair valuation of the merits, indications and limitations of the various surgical procedures.

Two cases of naso-pharyngeal polypi, in which marked benefit was obtained by simple electro-cautery applications, are reported by Bobone, of St. Remo (157). In the first case, the electro-caustic snare had been applied to the growth, but, in the act of tightening the snare, the wire broke and only a small surface was cauterized. This, however, was sufficient to cause a retrograde process in the growth, and it soon became so small that it caused no inconvenience.

In the second case, a few electro-caustic punctures were made in the growth, which resulted in a marked reduction of its size.

The electro-cautery is also highly recommended by R. Lincoln (158), who considers it superior to all other methods that have been heretofore used for naso-pharyngeal tumors.

A case of tumor of the naso-pharynx destroyed by the electro-cautery is reported by Jas. E. Logan, of Kansas City (511). There was no recurrence, although before this it had been removed eight or nine times. Three years later the patient died from sarcoma of the stomach.

The use of the *electro-caustic snare* for the removal of post-nasal

fibroids has many advocates, and is especially indicated on account of their proneness to hemorrhage. It is recommended by Michelson (512), Lincoln (513), and Schmidt (514), who report cases of naso-pharyngeal fibroma successfully treated by this method. It is also advocated by Hannau W. Loeb (159), who reports a case of fibroma which projected from the naso-pharynx, the vascularity of the growth being so great that it bled on the slightest provocation. This tumor was removed by means of the electro-caustic snare with a loss of but a few drops of blood.

The electro-caustic snare is preferred by Massei, of Naples (254), for the removal of fibroid tumors. In cases, however, where its application is difficult or impracticable, he also resorts to electrolysis. Cases of naso-pharyngeal tumor successfully removed by the electro-caustic snare are reported by H. B. Sands (160), and Felici describes a case of naso-pharyngeal fibroma which he successfully removed by this method.

For sessile tumors, McBride, of Edinburgh (161), prefers the cold snare, but first applies the electro-caustic snare for the purpose of furnishing a furrow, which enables the operator to obtain a firm grasp with the cold-wire snare. He does not believe that the cauterization of the base, credited to the electric snare, is performed in the majority of cases, as the actual base of the growth is rarely ever reached in such a way as to enable the operator to cauterize the point of junction between the healthy mucous membrane and the polypoid tissue. He further comes to the conclusion that the electric is much more painful than the cold-wire snare.

While the latter statement may be true, it must not be forgotten that the action of the electro-caustic snare is much more rapid than that of the cold-wire snare. When the latter is used, the contraction must be very slow and gradual in order to avoid hemorrhage, while the operation with the electro-caustic snare may be much more rapidly performed, as the action of the heated wire tends to prevent hemorrhage.

In a case of naso-pharyngeal tumor, which came under my observation, the cold snare had been applied, and, in order to prevent the violent hemorrhage which resulted from a former attempt to remove a part of this growth, the tumor was constricted so slowly that it required 24 hours to remove it, with the most agonizing pain to the patient. A recurrence of the tumor was afterwards removed by the electro-caustic snare in a few minutes, and with

but little pain compared to the protracted agony of the first application. The action of the cocaine, which was used in this case, could not be kept up in the former operation on account of its long duration, and morphine had lessened the pain but little.

The destruction of tumors by *electrolysis* was first advised by Gustav Crussell, in 1840, since which time this method has been extensively used. The advantages of electrolysis over the surgical methods in tumors are, (1) the avoidance of hemorrhage, which is of especial importance in erectile tumors, (2) the absence of suppuration when the rules of asepsis are well observed, (3) less danger of recurrence, and (4) the small degree of pain if the current is properly applied.

There are also many cases beyond the power of surgery, in which electrolysis can be used without danger, and sometimes with success. It is of especial importance that the strength of the current be gradually increased in commencing the application, and as gradually decreased at its termination. Except in special cases, there should be an interval of one week between each sitting.

In applying electrolysis for the dispersion of these tumors, the platinum needles may either be passed through the mouth by way of the naso-pharynx, the soft palate being drawn out of the way by means of a suitable palate retractor, or one or both needles may be passed through the nostrils. Care, of course, must be taken that the needles and their connections be well insulated, so that the electro-chemical energy may have its full effect within the tumor, and pain and irritation of other points be avoided. Special attention should be given that the points do not come in contact within the tumor, either before or during the application. If this takes place when the needles are inserted, there will be absolutely no electrolytic effect in the tissues, as the current will be short-circuited through the metallic points. If they are brought in contact during the application, however, the patient will sustain a severe shock from the sudden breaking of the circuit through the tissues, the current thus passing through the needles, the path of least resistance.

The application of electrolysis to fibroid tumors of the naso-pharynx was first practised by Nélaton (162), who reports a case successfully treated by this method. Voltolini (163) contributed much to bring this method before the profession.

A case of fibroid tumor of the naso-pharynx, which had been twice removed by a general surgeon, is reported by R. P. Lincoln

(164), as being successfully treated by electrolysis. The monopolar method was applied in this case, two needles, inserted into the tumor, being connected with the negative pole, and the positive pole connected with two large dispersing electrodes. Sixteen applications at intervals of four to six days were made, each seance occupying from 12 to 20 minutes.

The immediate effect of the electrolysis was a distension of the mass operated upon—resulting probably from the elimination of the gaseous products due to the electrolysis—and a change of color towards lividity; both of these conditions disappeared within 24 hours. At each succeeding seance, the mass was decidedly smaller than at the previous sitting. The only disagreeable symptom besides slight pain was a feeling of dizziness. This effect was probably due to the dispersion of the electric energy from the negative pole in its passage to the positive, which had been applied by means of sponge-covered electrodes to the chest and scapula, and could have been avoided by using the bipolar method.

Reports of cases of post-nasal fibroids cured by electrolysis are also published by P. Verdos, of Barcelona (165), Capart, of Brussells (166), Strazza (167), J. Normand (168), Kuttner (169), Gronbeeck (170), Michel, of Cologne (171), J. Solis-Cohen, of Philadelphia (172), A. S. Shipman, of Plattsmouth (173), and Kaarsburg (111).

Normand (168) states that while the cures by this method are not more than 62 per cent., it must be remembered that it has been used by operators not familiar with this form of manipulation or with the use of the currents required in these cases. He prefers the bipolar method.

A case in which the patient's health had been so undermined by frequent attacks of epistaxis, that surgical methods were contraindicated, is reported by Strazza (167). The unipolar method was applied, four sittings being sufficient to cause almost complete disappearance of the growth. A current of ten milliamperes was applied for 10 minutes at each sitting.

Of the cases of naso-pharyngeal fibroma reported by Gronbeeck (170), there were in 33 cases 19 cures, 11 improvements, and 3 cases not benefited. A large number of operations was required in the cases reported by Michel (171), 53, 47, 90 and 47 sittings respectively being necessary in the 4 cases which he reported. This is explained by the fact that he used very weak currents (2 to 6 Stöhrer cells), the sittings at first being several minutes and

later 40 to 80 minutes. He states that the large tumors required treatment by electrolysis for 6 to 9 months.

This duration of the applications and the large number required would be a serious disadvantage in the use of this method. The prolonged treatment is also objectionable on account of the continued irritation set up by these applications, strong currents and few sittings giving the most successful results.

In regard to the effects of electrolysis in fibroma, Rockwell (174) states that these tumors, being dense and comparatively dry, do not readily shrink under electrolysis, and that it is seldom that we can accomplish more than some slight diminution in bulk.

The opinion of this able electro-therapeutist, however, is opposed by many laryngologists who have treated fibroids of the naso-pharynx successfully by means of electrolysis. Not only have these applications been followed by continuous diminution in size, until a cure was permanently effected, but in certain cases where very strong currents were used, as in the case reported by Kaarsburg (111), tumors of even large size have been caused to disappear after one and two applications. The results in these cases should be considered as having marked weight, as the changes in these growths may be much more easily watched than in uterine tumors, which, no doubt, have been principally the subject of Rockwell's observations.

While electrolysis gives results which appear more favorable than those obtained by other methods in the treatment of this important pathologic condition, it is not without its *possibilities of danger*. Voltolini (175) refers to a case of meningitis following the application of electrolysis for the removal of a naso-pharyngeal tumor, a result which he attributes to the badly constructed needles used in the operation. With the improved instruments, there is very little danger of complications.

A case also came under my observation, in which a fibroid tumor, treated with electrolysis by a surgeon, afterwards took on the characteristics of malignancy. Whether this transformation was due to the irritation of the electrolytic method or whether it was a natural tendency of this growth, is not quite certain. The histologic examination, however, at first revealed simple fibroma, while the examination of a part, two months after this method had been commenced, proved it to be a fibro-sarcoma, and the case had a fatal termination. It is probable that more energetic treat-

ment, as advocated by Kaarsburg (111), might have given better results in this case.

Considerable success with this method was obtained by Voltolini (176), who protested against the statement that naso-pharyngeal tumors cannot be radically treated by electrolysis. In order to avoid the tediousness in the ordinary method of using electrolysis, he recommends a method which is somewhat analogous to the electro-caustic snare, but the electrolytic and not the thermic effects of the current are used. The wire of the snare is cut in the middle of the loop, and each end attached to an insulating knob of ivory. In case the proximity of the tumor to the pharyngeal walls would prevent this ivory knob from passing, Voltolini recommends that it be placed near one of the tubes, leaving the circumference of the loop quite smooth. In this case, the loop is shortened by contraction of the longer wire of the loop. This insulating knob prevents the closing of the circuit around the loop, and the current therefore passes through the tissues between the two parts of the loop, which are thus electrolyzed. The conducting tubes of this instrument must be well insulated, preferably with rubber or gutta-percha, as the insulation of the electro-caustic snare, for which a low voltage is used, is not sufficient for the electrolytic snare, for which a current of much higher voltage is required.

Voltolini also recommends that the electrolytic snare may be used by the monopolar method, the snare being connected with the negative pole of the battery, and the circuit closed by means of a dispersing electrode applied to some other portion of the body. This method is much less efficacious and gives rise to more disturbance than the bipolar method.

A pair of forceps which may be used in electrolysis has also been devised by Voltolini. On the inner side of the blades are fastened a number of platinum points, which penetrate and hold fast the surface of the growth. The blades are insulated with ivory, and the rest of the instrument is also properly insulated. The current is applied as with the ordinary electrolytic needles.

In the case reported by A. S. Shipman (173), zinc needles were found superior to the gold-plated ones, the former giving good results in a case of fibroma in an advanced stage, in which the gold-plated needles had proved unsuccessful.

This is somewhat difficult to understand, unless the zinc needles were connected with the positive pole, in which case its interstitial effects would be obtained. The fact that zinc needles

caused no discomfort, while the gold-plated ones gave rise to pain, is also an unusual experience.

The use of strong currents in fibromata is advocated by Kuttner (169), who found that 70 to 80 milliamperes could be used without injury to the patient, and with the effect of decreasing the time necessary for the treatment.

The most pronounced advocate of strong currents, however, is Kaarsburg (111), and his results prove the success of treating these tumors with strong currents.

There is no doubt that the repeated application of a weak current, instead of causing the disappearance of the growth, may so stimulate its vitality as to rapidly increase its volume. In fact, it is not impossible but that the prolonged irritation from the repeated application of mild currents may even cause a metamorphosis in the character of the growth, that may increase the seriousness of the case. As already stated, in a case which came under my observation, the early histologic examination showed simply fibroma, while after two months of ineffectual attempts to destroy the growth by repeated applications of a weak electrolytic current, the neoplasm was again examined and now showed a large number of spindle-shaped cells, indicating the presence of sarcomatous tissue.

In the following cases reported by Kaarsburg, in which heavy currents were used, the results seem to have been uniformly good:

1. A man of 47 years had a fibroid tumor of the size of a hazelnut in the left side of the naso-pharyngeal cavity. After chloroform narcosis, the negative electrolytic needle was passed through the nose into the growth, and the positive, a large dispersing electrode, was applied to the shoulders. Two hundred milliamperes were passed for seven minutes, and 250 milliamperes for seven minutes more. The tumor disappeared in seven days; no recurrence after two years.

2. In a young man of 18 years, a fibroid tumor had been previously removed by means of a snare and resection of the nose, without success. The tumor now again filled out the naso-pharyngeal cavity. Under chloroform narcosis, both electrodes were passed into the tumor; a current of 300 milliamperes being passed for 11 minutes, and afterwards, the length of the needles having been changed, 300 milliamperes were again passed for 15 minutes. The temperature fluctuated between 101 and 103 degrees after the operation. The tumor was very soft, partly gangrenous, and was removed by the forceps and scissors, trache-

otomy having been first performed. Three years later there had been no recurrence.

3. In a youth of 16 years, the posterior part of the left nasal cavity was filled with a fibroid tumor. After chloroform, the negative electrode was passed through the nose into the growth, the dispersing electrode being applied to the chest. One hundred and forty to 150 milliamperes were passed through the tumor for seven minutes. As this was not effective, a second application was made three weeks later under chloroform. The negative electrode was passed through the nose into the growth, and the positive, the dispersing electrode, being replaced by a needle, was passed into the tumor through an incision between the soft and the hard palate. Two hundred and forty milliamperes were passed for five minutes, and, after changing the electrode, 320 milliamperes for five minutes. This resulted in the disappearance of the tumor, and one year and a half afterwards there had been no recurrence.

In this connection, it would be well to state that the incision in the soft palate is not usually necessary in this operation. The tumor can easily be located by means of the rhinoscopic mirror and digital examination, and the needle may be passed directly through the tissues of the soft palate, the electrolytic effects on this part being prevented by insulating the portion of the needle in contact with these tissues, by means of a few layers of shellac varnish.

4. In a youth of 18 years, the left half of the naso-pharyngeal cavity was filled with a fibroid growth. Under chloroform, the needle electrodes were passed into the growth through the nose and from behind the palate. Two hundred milliamperes were passed for three minutes and then 340 milliamperes for four minutes. A shrinkage of the tumor followed this application, so that it was possible ten days later to remove a large piece with the snare. Two more electrolytic applications were made at intervals of ten and twenty days respectively, a current of 30 milliamperes being passed for seven minutes without chloroform. The tumor then disappeared and two years later had not recurred.

These cases show the importance of using strong currents so as to obtain rapidly their destructive electrolytic effects. Cocaine anæsthesia is usually not sufficient to prevent the pain from such currents, and general narcosis should be employed, as in the cases above reported.

CHAPTER XX.

TUMORS OF THE NOSE AND THROAT.

(Concluded.)

ORAL CAVITY.

THE various electric methods have also been extensively used in the oral cavity, although not to the extent as in the nose, as the ordinary surgical methods may be more easily carried out in this region. The same indications which govern the treatment of tumors in the naso-pharyngeal cavity are applicable here; the snare either cold or electrically heated being given the preference in tumors which are pediculated. Electrolysis also has special advantages in cases of angiomata.

The *electro-cautery* has been used to advantage in ranula, the fine cautery point *D* (Fig. 89) being the most preferable in these cases. In a case of ranula, in which the electro-cautery was unsuccessful, I have obtained a cure by using cupric cataphoresis after the electro cautery application had been made. In cases of leucoplakia of the cheek and tongue, or ichthyosis of the tongue, Fletcher Ingals, of Chicago (177), recommends the use of the electro-cautery. He believes that this will cure many cases if they come sufficiently early under treatment. He advises, however, that only a small area be treated at each sitting, and care be taken that the healthy tissue below the altered epithelium be not destroyed.

The *electro-caustic snare* has been successfully used for cancer of the tongue, and Erichsen (250) reports a number of successful operations with this method. He insists upon the necessity of slowly contracting the loop, so as to avoid hemorrhage from the operation.

A case of lymph-angioma of the right tonsil in a man 22 years of age is reported by Hubert D. Hamilton (180). The only symptom complained of by the patient was difficulty of breathing at night for two weeks preceding his visit. The tumor was three inches long, three-fourths of an inch wide, and one-half inch

thick, and was somewhat pear-shaped. It was removed by the electro-caustic snare.

A case of a vascular tumor at the angle of the mouth, treated by *metallic electrolysis*, is reported by W. J. Morton (178). A steel needle was thrust into the tumor, thus securing the styptic action of the oxychloride of iron upon its contents. In the first application a current of 15 milliamperes was passed for ten minutes, and in the second, 25 milliamperes for ten minutes. This resulted in the decrease of the tumor to one-third its former size. In the application, the needle became adherent within the tumor, but by reversing the current, it was effectually loosened so that it could be extracted.

The same author (179) also reports a case of a dermoid cyst, as large as an English walnut, cured by metallic electrolysis. A copper bulb electrode one-fourth of an inch long and one-sixteenth of an inch wide was used. During the course of treatment, one-third of this electrode was dissolved. Twenty-five milliamperes for 20 minutes were applied, and the inside lining of the cyst was so permeated with the oxychloride of copper, that it ceased its abnormal secretions, and, by the inflammation set up, the walls united. There was no recurrence.

THE LARYNX AND TRACHEA.

The application of the electro-cautery in the larynx is strongly advocated by many writers. The fact that it may be carried cold and harmless into the interior of the larynx, and the cautery point instantly heated when desired and as quickly cooled when the operation is completed, or when a contraction of the larynx makes this necessary, gives this method advantages over all other methods of cauterization in this region.

The application of the electro-cautery has been much facilitated since the introduction of local anæsthesia by means of cocaine.

In spite of these facts, however, some authors are still opposed to the use of the electro-cautery in the laryngeal cavity. Thus Gottstein (78) does not favor this method for the removal of neoplasms in the larynx. Lennox Browne (126) also makes the following statement:

"While without the electro-cautery in diseases of the nose, pharynx, mouth and tongue, I should feel deprived of at least one-half of my power to help the conditions for which I use it, I have a strong conviction that, were I to employ it to such re-

gions as the larynx below the epiglottis, to the pharynx below the same level, or to the œsophagus, I should introduce into my practice a new and grave element of danger."

In spite of this adverse statement, other laryngologists have had good results from the application of the electro-cautery in the larynx, and this has also been my experience with this method. I have used it successfully in several cases of neoplasms in the larynx, and at no time with unpleasant complications due to the use of the electro-cautery.

In a case of a necrosis of the left arytenoid cartilage, which I reported before the Société Française d'Otol., Laryng. et du Rhin. (181), an excessive amount of granulation tissue developed at the site from which the necrosed cartilage had been removed, and persistently recurred after removal with the snare and forceps. The electro-cautery was now applied and the diseased tissue carefully extirpated, which resulted in a permanent cure.

The electro-caustic snare for the removal of tumors from the laryngeal cavity was first successfully used by Voltolini (251), who was recognized for his great skill in manipulating the electro-cautery.

In using the electro-cautery in the larynx, it is of importance that the platinum point be very fine (*A*, Fig. 89) so that it may be instantly heated and as quickly cooled under the control of the operator. This is necessitated by the possibility of a laryngeal spasm, which may develop at any time in spite of careful cocainization. With such a cautery point, the current may be instantly cut off, so that its contact with the healthy tissues will not give rise to any injurious effect.

As an additional precaution to avoid injuring the healthy tissues in applying the electro-cautery for destroying neoplasms in the larynx, J. Solis-Cohen (182) has devised an instrument which he considers useful for this purpose. He attaches a thin layer of asbestos to one side of the platinum point and a thin plate of ivory over the asbestos, these being secured to the conducting wires. He also advises cauteries of a similar construction for cauterization in the mouth and nose.

I have found these additions objectionable, however, as they interfere with the distinct view of the parts to be cauterized, and because they cannot be used as thoroughly as when only the cautery point is applied, as for instance to the base of a tumor. I have therefore rarely used these protected cauteries in the nose

or larynx. In the mouth, in which they do not obstruct the view, they are seldom indicated.

The use of the cautery is advocated by Alexander W. McCoy (183), who states that it has now become possible to use this effectively in the larynx, as all the conditions are present for a successful result. By means of this instrument, he has seen the largest growth subside; not only did the papillomatous masses rapidly disappear, but the conditions of the tumor changed in regard to the usual tendency to rapid recurrence.

He claims that good results can only be obtained when the electrode is so applied that it enters into the base of the mass, so that it can effect the destruction of the nutritive and vascular elements of the papilloma. The electrode should be brought to a white heat. McCoy reports the clinical details of a case which was successfully cured by the electro-cautery, which had resisted all other measures, such as the guillotine, snare, forceps etc.

Two cases of benign tumors of the larynx, which were successfully treated by means of the electro-cautery, are reported by Rousseau, of Brussels (184). He believes that the electro-cautery is useful in the interior of the larynx, and that it is especially indicated for benign tumors in this region, for which the delicacy and precision of the electro-cautery give it an incontestable superiority.

A case of lupus of the face, nose, pharynx and larynx is reported by Semon (185), in which persistent punctures by the electro-cautery succeeded in curing the laryngeal affection, which had already developed to the extent of causing complete aphonia.

A case of a growth which filled the lumen of the trachea is reported by P. Pieniazek, of Krakau (186), this being cured by means of the electro-cautery which was passed through the tracheal opening. By means of a small mirror passed through this opening, the location of the growth was obtained, and repeated applications of the electro-cautery resulted in a cure, leaving a normal voice.

Electrolysis is a process too slow to be effectively applied in tumors of the larynx, and it has, therefore, rarely been used. Cupric electrolysis has given good results in growths of a tubercular character (*vide* Tubercular Laryngitis).

MALIGNANT TUMORS.

The most extensive discussions as to the value of electric

methods in rhino-laryngology have been in regard to the treatment of malignant tumors. While the majority of writers admit the superiority of electric methods in benign tumors of this region, in malignant tumors, however, the prevailing opinion is that more radical surgical measures should be adopted wherever possible in this dangerous condition. A number of operators, however, favor the application of electric methods in malignant tumors, and the comparatively favorable results, which they report, tend to give weight to their opinion.

In order to form a definite judgment as to the value of surgical methods based upon electric energy, it will be well to review the literature of this subject, which will assist us to decide as to their value in this connection.

Galvanism or *faradism* alone, by percutaneous application, as sometimes advocated, is not only useless in the treatment of true malignant disease, but may even cause aggravation of the condition. In order to extirpate such a disease, it is important to destroy each and every cell involved in the pathologic process, and this can be done electrically only by such methods as the electro-cautery and electrolysis.

In the discussion of a paper on sarcoma of the pharynx and the soft palate, reported by Bosworth at the meeting of the American Medical Association, at Washington, May 6 and 7, 1884 (187), Roe, Seiler and Mackenzie expressed themselves in favor of the *electro-cautery* in the treatment of these cases.

In cancer of the tonsil, Lennox Browne (126) suggests that temporary and even considerable relief may be had by the removal of portions of the tumor by means of the electro-cautery, but that there is no means of eradicating the disease or even of otherwise arresting its slow and certain march to a fatal issue. A case of sarcoma of the tonsil, however, is reported by A. H. Marvin (562), in which a malignant growth of the tonsil was successfully removed by means of the electro-cautery knife under cocaine anæsthesia. A microscopic examination showed it to be a spindle-celled sarcoma. Six months later there had been no recurrence.

A case of a pediculated fibro-sarcoma of the septum is reported by Calmettes and Chatellier, of Paris (188). This tumor, which was as large as a cherry-stone, was successfully removed by the electro-cautery, with permanent cure. The clinical history in this case, however, creates a doubt as to the accuracy of the diagnosis of fibro-sarcoma.

An interesting case of a melano-sarcoma of the nose, which was entirely cured by the electro-cautery, is reported by Lincoln, of Detroit (189). E. Schmiegelow, of Copenhagen (190), uses the cold snare followed by cauterization for malignant growths. In two cases which he reports, he has had good results. He admits, however, that there is always a tendency to recurrence in these cases.

A carcinoma of the right vocal cord the size of a bean, which was extirpated by the cautery loop, is reported by B. Fränkel (252). A year later it had recurred and was again extirpated. During the next three years there were three further recurrences and extirpations. A carcinomatous gland, which developed in the neck, was also removed. During the last two years there has been no recurrence of the neoplasm, and the voice is clear and loud.

The advisability of endolaryngeal operations, whenever practicable, is recommended by Schnitzler, of Vienna (191), who insists that resection of the larynx should be used only where this method is impracticable. He reports a case of epithelioma of the vocal cords which he successfully destroyed endolaryngeally with the electro-cautery, so that the patient was still alive 20 years after the operation. The same view is held by Rousseau (319), who reports a number of malignant growths with which he has had successful results by the use of the electro-cautery.

Electrolysis in the treatment of malignant tumors appears to have given better results than the electro-cautery, and is now more frequently used. Lennox Browne (126), however, states that electrolysis is strongly contraindicated in epithelioma, as it would only aggravate the intensity of the disease.

A somewhat more favorable opinion is held by A. D. Rockwell (174), who states that while the effects of the electrolytic method on malignant growths is but trifling, the pain is usually much alleviated. The best result in this class of cases has been obtained in epitheliomata. Verdos (193), on the other hand, has had good results in the treatment of malignant tumors of the nose by electrolysis, and considers it superior to all other methods. Hutchinson (194) also states that he has obtained good results in 16 cases of malignant tumors by this method, two of the cases being still living. One was a case of epithelioma of the lower lip, which was removed 14 years ago; there has been no return and the patient is in good health. He is convinced that carcinoma is curable by electrolysis.

An interesting case of epithelioma of the tongue, successfully treated by means of electrolysis, is reported by Draispul, of St. Petersburg (195). The patient had an ulcer 2.5 centimeters in length and one centimeter in breadth, with involvement of the cervical glands. A histologic examination showed the growth to be an epithelioma.

A cutting operation was refused on account of the tubercular history of the patient. Electrolysis was used in preference to the electro-cautery on account of the comparative painlessness of its application, its mild reaction, and its more permanent result. The monopolar method was used, 12 milliamperes being applied through the negative pole by means of a steel needle. At the end of six seances, the ulcer was completely destroyed, and three months later the tongue had healed entirely, leaving a thin cicatrix, and the enlarged glands had disappeared. A year later there had been no recurrence.

The disappearance of the enlarged glands was an especially gratifying feature, which shows the superiority of electrolysis over the electro-cautery in such cases. It is supposed that this is due to the catalytic effect of the current at a distance, attention having already been called to this by Groh, who reported the disappearance of enlarged glands after destroying an epithelioma of the lower lip by means of electrolysis.

As with other surgical methods, favorable results find their way more frequently into medical literature than the reverse, and this should always be considered in judging the value of such methods. The following cases, however, of the unsuccessful use of electric methods are also reported:

A case of excision by the cautery of the whole tongue, the left tonsil and one-half of the soft palate is reported by Kendal Franks, of Dublin (196), this being due to carcinoma. This operation was undertaken, in spite of the extensive development of the disease, on account of the intolerable pain of the patient. The extirpation was effected by means of the electro-and thermo-cautery. The patient was relieved of the pain, but died two months later from exhaustion. Before death, symptoms of recurrence in the mouth had already developed.

A case of an epithelioma which involved the tonsil, the soft palate and the base of the tongue is also reported by Berthod and Barbier, of Paris (197). After ligation of the linguals and the right external carotid, the diseased tissue was removed by the electro-

cautery. The operation was at once followed by hemiplegia of the left side. The malignant growth recurred, and, a month later, the patient died from a sudden hemorrhage.

A primary epithelioma of the tonsil is reported by F. Donaldson (198). A portion of the growth was destroyed by the electro-cautery, which prolonged the life of the patient, but did not prevent the ultimate fatal issue of the growth. A similar result is reported by G. Coupard (199), who describes a case of a pharyngo-laryngeal epithelioma which was extirpated by means of the electro-cautery snare, the whole growth being removed in two sittings. Four months later the growth again developed in the site of the wound and rapidly proved fatal.

The electro-cautery and electrolysis have been used in many cases, as in those above quoted, in which the condition was too aggravated, or too far advanced, for other surgical methods. This factor should not be forgotten in estimating the true value of electric methods in malignant tumors.

A modification of the electrolytic method (*metallic electrolysis*) of treating malignant tumors is reported by G. B. Massey, of Philadelphia (200), who publishes a case of sarcoma of the tonsil and soft palate cured by local electrolysis and zinc-amalgam cataphoresis. After the local application of cocaine, two treatments were given with a current of 200 to 250 milliamperes. After the eschar had separated with some pain, healing commenced, and, when concluded, only a small portion of the growth remained. A year later the patient returned for treatment, when he seemed to be doing well with the exception that the growth had increased to about a peach-stone in size. The zinc-amalgam cataphoresis was now employed, and the bipolar electrode carried deeply into the base of the growth, and treatment continued for six weeks, when the patient was discharged cured.

In a case in my own practice (206) in which there existed epithelioma of the larynx and of the base of the tongue, and in which there was extreme pain on deglutition from the latter growth, I applied zinc electrolysis with the result that in three weeks the growth on the tongue had almost entirely disappeared. On account of the irritability of the throat of the patient and the disturbance which the attempts caused, I was not able to apply the same treatment to the larynx. I was very much impressed, however, with the result of this application to the tumor of the tongue.

From a study of these cases, it would seem that the electro-cautery and electrolysis are not without merit in the treatment of malignant tumors, and that they are especially applicable in cases in which the condition of the patient does not permit of more radical measures. The important object in malignant tumors is the complete extirpation of all the diseased area, and its removal by means of the knife, or the cautery point used as a knife, is to be recommended. Where, however, such an operation is contra-indicated on account of the location or extension of the growth, or the condition of the patient, we see from the above cases that relief is sometimes afforded and that a fatal issue may occasion-ally be avoided by the scientific application of electric methods for the removal of these tumors.

CHAPTER XXI.

External Nose. Hypertrophic Rhinitis.

FROM the frequency with which reference is made to electric methods in rhinology, the extensive use which has been made of this method may be estimated. This bulk of literature is perhaps also a proof of the extreme to which these measures have been carried, and this is corroborated when the literature is more closely analyzed, the greater portion of this referring to destructive methods, such as the electro-cautery in nasal diseases. The milder and more conservative methods, such as catalysis, are rarely referred to.

A more attentive study of the physiology and pathology of this region will tend to develop more conservative methods, and will teach the aspiring rhinologist that, even if nasal congestion is an impediment to proper breathing, the establishment of freer respiration, at the expense of extensive destruction of the mucous membrane of the nose, may be a much more aggravated condition and one more difficult to remedy than the former.

EXTERNAL NOSE.

Electricity has been used in the treatment of the external nose, the galvanic current usually being selected for this purpose. Helbing, of Germany (204), has been successful in the use of electricity for frost-bitten noses. He applied the galvanic current, placing the anode upon one side and the cathode upon the other, the electrodes being "continually moved about." The patient's endurance should regulate the strength of the current—from five to eight cells. Should the patient be very sensitive to the current, the anode may be placed upon the zygoma and the nose gently stroked with the cathode. For 2 to 48 hours an intense redness will follow the application. On account of the excessive irritation, strong currents should be avoided. The seances should be repeated at intervals of two to three days, 10 to 30 applications being necessary to effect a cure.

Good effects from galvanism for external nasal applications have also been obtained by Mongardi, of Bologna (205). He has had successful results in three cases of extreme redness of the skin of the nose, two cases of seborrhea, and three cases of acne rosacea.

HYPERTROPHIC RHINITIS.

In the literature of nasal obstruction, a sufficient dividing line has not been drawn between true hypertrophy and simple swelling of the mucous membrane of the nasal passages, a condition to which the name "rhinitis intumescent" has been given by Fletcher Ingals, of Chicago.

While the former is an obstruction for which surgical measures are admissible, the latter may be a symptom of a disturbance in another part of the body. The turbinates of the nose are the *locus minoris resistentiæ*, perhaps even the safety valves, of functional disturbance in many other parts of the body. It is the scapegoat which exhibits the results of unhygienic surroundings, faulty diet, lack of exercise and intemperance, and forms a complication in most of the exanthemas and a large number of functional and organic derangements of other organs of the body.

The necessity of proper nasal respiration is often impressed upon the rhinologic student, without, however, sufficient importance being laid on the relation of this mucous membrane to other conditions of the body. The most direct method, therefore, of restoring free respiration appears to be the removal of the obstruction. Where this is due to a deviation or thickening of the septum, a tumor or a true hypertrophy, the principle is correct. In the majority of cases, however, the obstruction is simply a passive congestion or hyperemia, and the removal of this by the electro-cautery, or other means, gives simply temporary relief. The same conditions which produced the original lesion still exist and cause a prompt return of the obstructed breathing.

In regard to the use of the electro-cautery, Lennox Browne (126) states that if it be used scientifically in hypertrophic rhinitis, it should effect the reduction of superficial layers of the mucosa by the formation of a slough, and the shrinking of the underlying vascular tissues by the formation of inflammatory adhesions to the periosteum. For a large hypertrophied inferior turbinated body, he plunges a long and slender cautery point into the cavernous tissues in a direction close to, and as near as possible parallel

with, the inferior border of the bone. In moderate cases, one or two such procedures may suffice to secure the requisite reduction of the inferior turbinate swelling, but when the condition is very marked and little reducible under cocaine, he prefers the linear superficial cauterization also, especially along the inner and lower sides of the turbinated body.

The use of the electro-cautery for hypertrophic rhinitis is recommended by Eugen Fränkel (207). J. C. Mulhall, of St. Louis (208), has found the electro-cautery useful in hypertrophic rhinitis, adenoid vegetations, hypertrophies in the vault of the pharynx, granulations and simple hypertrophies in the pharynx, and in chronic follicular tonsillitis.

He has never seen such complications as erysipelas of the face (Cohen) or otitis media (Browne) or other unpleasant symptoms. He attaches importance to the removal of the cautery from the tissues while still in a heated condition—a good point to observe, as it prevents laceration of the tissues and removal of the eschar, which may result when the cautery is allowed to cool and then removed from the cauterized tissues. Where hemorrhage follows a nasal electro-cauterization, it is usually due to the non-observance of this rule.

The lack of success in many cases of cauterization is attributed by Jno. G. Taylor (209) to the fact that the operation was contra-indicated. In the acute state of hypertrophy of the nasal mucosa, he found a constitutional treatment, combined with the local application of astringents, quite sufficient for a cure. When other organs are affected, as the stomach, liver or kidneys, or where a rheumatic or gouty diathesis is present, these should not be neglected. Where, however, the hypertrophy is chronic, the most rapid and permanent cure is effected by means of the prompt application of the electro-cautery. In the last six years he has never seen a relapse. He limits the application to the hypertrophic tissue and never cauterizes as far as the bone. After the operation he applies an ointment of cocaine and vaseline.

Where a cautery application is indicated, it should be judiciously applied. T. A. de Blois (211), in reviewing this subject, states that there are two extremes which should be avoided: the first, in which the cauterizations are not made sufficiently, and in which the parts soon return to the original hypertrophic condition; and the second, in which it is overdone and the nostril is left full of cicatrices. He hopes that we will find a method

by which we can select a medium between this "Scylla and Charybdis."

Among the strong advocates of the electro-cautery in diseases of the upper respiratory passages and the ears is J. Sendziak, of Warsaw (212), who also recommends its application in laryngeal tuberculosis, and prefers it to all other methods.

The subject of the comparative value of the electro-cautery in the treatment of diseases of the nose and throat was introduced by Shurly at the sixth annual meeting of the American Laryngological Association, New York, May, 1894, but without decision of this important question, as both those who favored and opposed it held their ground firmly.

Eugen Fränkel, in commenting on this in the *Internationales Centralblatt für Laryngologie, 1885*, states that any one who has used the electro-cautery, especially in hypertrophies of the nasal mucosa and in tumors in the nasal and naso-pharyngeal cavities, will become an enthusiast in this method, which is far superior to the application of chemical preparations. He also prefers the electro-caustic to the cold-wire snare.

The linear method of cauterization is recommended for chronic rhinitis by Greville MacDonald (213). He finds it highly satisfactory when it is employed in the absence of subacute inflammation or a profuse discharge.

In regard to the slough which forms after the application of the electro-cautery in nasal operations, M. Schäffer, of Bremen (214), advises that it be removed if it does not fall off spontaneously in a few days, as this slough sometimes becomes organized and may cause adhesions between the turbinal and the septum. This proceeding, according to most authors, is contraindicated, as the slough instead of causing adhesions is one of the most efficacious means of preventing them.

In using the electro-cautery for hypertrophic rhinitis, Jacoby (521) applies a cautery protected by a flat piece from coming in contact with the septum. A similar instrument is advocated by Fletcher Ingals (84), who uses it to make two or more linear incisions the whole length of the turbinated body, and deep enough to just graze the bone in two or three places, one at each sitting, with sufficient interval for healing before the cauterization is repeated. These lines are usually made at the junction of the middle with the inferior or superior third of the lower turbinated body, and in from 10 to 15 days afterwards a similar cauterization

is made upon the other side. In a few cases, a single cauterization on each side is sufficient to effect a cure, but in the great majority of cases two upon each side are necessary, and, occasionally, three, four or even more will be required before the disease is checked. In using the electro-cautery, he employs a current sufficiently strong to heat the platinum wire to a white heat within two seconds after the circuit is closed.

The objection to the protector used in this method is that, in cases in which the space between the turbinal and the septum is very narrow, there is usually not sufficient room for its passage, and where the nasal chambers are more roomy, its use is unnecessary. While it may be applicable in special cases for routine work, most rhinologists prefer the simple cautery point, so that the manipulations may be followed more closely by the eye.

A novel method of reducing the tissues in hypertrophic rhinitis is recommended by G. Melville Black, of Denver, Col. (215), who advises the use of the nasal trephine for this purpose. The trephine is made two and a half inches long instead of the usual short size, so that it will not be easily obstructed by the tissues. The trephine operated by an electric motor is placed against the anterior and inferior portion of the hypertrophied turbinal, and a semicircular or circular piece of the tissues removed from the entire length of the body. If the hypertrophy is confined to a portion of the turbinated body, the trephine is limited to that portion.

The only objection that he finds in this method is the rather free hemorrhage, but he has never found this alarming. He claims for this method: 1. All clean-cut surfaces of the semicircular opening made at the inferior portion of the turbinated body fall together and heal by first intention, thereby at once restoring free nasal respiration. 2. There is but little secretion after the first twenty-four hours. 3. There is no perceptible cicatrix. The surface of the turbinated body is of normal shape. 4. It is extremely rare that more than one operation is required. 5. There is no danger of the adhesion of the turbinated body to the septum.

In this manner, Black has been able to relieve cases which resisted repeated applications of the electro-cautery. He states that this method cannot be used with the middle turbinate.

In *hyperesthetic rhinitis*, Sajous (153) recommends that each point of hypersensitiveness be destroyed by means of the electro-cautery, and he lays great stress on the fact that the platinum

should become white-hot immediately. He states that white heat, which cauterizes in an instant, destroys the nerve filaments before they have time to convey the sensation of pain to the nervous centers. Cherry heat causes some pain, while black heat is exceedingly painful.

The application of white heat, while undoubtedly more tolerable than a less degree of heat, is nevertheless painful, and most patients will object to it in this age of cocaine anæsthesia. I have obtained equally good results by noting the points of hypersensitiveness while applying cocaine with a small pledget of cotton. After anæsthesia has become established, these points are then cauterized, and this may be repeated at subsequent sittings.

COMPLICATIONS.

The application of the electro-cautery in the nasal chambers has been made so frequently that we are apt to forget that this method is not without a certain element of danger. As in chloroform anæsthesia, the experience of individuals is not always a reliable guide as to its safety, and the true realization of the physician's responsibility can be obtained only by a study of the mortality statistics of its use from all available quarters. So with the electro-cautery, we should survey the literature and use the results obtained by others as a lesson in our own practice.

Where an agent like the electro-cautery has been used so extensively, and in a region of such importance as the nose, it is not surprising that complications are sometimes met with, and it is even remarkable that unfavorable results do not follow more frequently. As in other forms of medical literature, we more often see the reports of the good results obtained by this method than the failure or bad results that follow its use. The following cases are therefore of special interest:

A case of meningitis following the cauterization of the middle turbinated body is reported by Wagner, of Halle (216). The electro-cautery had been applied to the anterior part of the lower border of the left turbinate. Three days afterwards there was a venous hemorrhage from the posterior nares and headache, but the bleeding was arrested by plugging. The temperature rose to 104° F. and the general symptoms became worse, death occurring 13 days after the operation. No autopsy was made, but the author concludes that the bleeding could not have been the direct

consequence of the operation, as the spot from which the blood came was not operated upon. He believes that thrombosis of the sinus occurred, which disturbed the nasal circulation.

A case of sinus thrombosis resulting from nasal cauterization is also reported by Victor Lange (249). A young man of 19 years suffered from occlusion of the right choana, this consisting partly of bone and partly of membrane. This obstruction was opened by means of the electro-cautery, the patient having first been chloroformed. Six days later the patient died as a result of sinus thrombosis.

A curious effect produced in a patient, in which an electro-caustic operation was followed by a neurotic symptom, is reported by Felix Semon, of London (217). In this case, the application relieved the patient of nervous asthma, but developed exophthalmos.

In the discussion of this subject before the Clinical Society of London, Brudenell Carter stated his belief that the development of the exophthalmos was simply a coincidence, and Havilland Hall suggested that the conclusion of the operation which had cured the first neurotic symptom might be instrumental in curing the second. Semon (218) afterwards reported that he had made the second application, but that this was followed by an increase of the pulse, which had heretofore been normal, to 100 to 110, which persisted for two months. Two months after the treatment had been concluded, the pulse had reduced to 90 and the exophthalmos had also somewhat diminished.

In this connection, it is interesting to note the report of B. Fränkel, of Berlin (219), who describes a case of goitre with rapid pulse, in which the application of the electro-cautery for the reduction of an hypertrophied turbinal of the left side was followed by a decrease of the goitre on the left side. A similar application of the cautery was then made to the right nostril, which was followed by a decrease of the goitre on the right side.

A pseudo-membranous inflammation of the faucial tonsils following nasal cauterization is occasionally observed, and Schöltz (220) has frequently seen angina of the pharyngeal tonsil from the same cause.

A not uncommon result of cauterization in the nasal chambers, and one which frequently causes annoying symptoms, is *synechia* between the turbinal and septum. It is especially apt to follow a cauterization of the turbinal when the radiated heat

or the direct contact of the cautery causes an ulceration of the septum opposite to the turbinal that is cauterized. An aggravated case is reported by Beregszaszy, of Vienna (221), who described a case of total adhesion of the soft palate with the posterior pharyngeal wall, resulting from repeated electro-cautery applications through the nose. Beregszaszy treated this case by separating the adherent tissue with the electro-cautery and packing the parts with iodoform gauze, and afterwards inserting a plate of hard rubber, which had to be retained permanently.

A case of severe hæmoptysis followed by rapid cavernization of the left lung, which occurred two weeks after the application of the cautery to the left inferior turbinal, is reported by W. C. Phillips (222). He believes, however, that this was simply a coincidence, and that the electro-cauterization was not connected with the cause of the hæmoptysis.

Ear complications occasionally follow the use of the electro-cautery in the nose. Chas. H. Burnett (223) advises caution in its application, as two cases of acute otitis media had been observed, which followed this application. G. Ferreri, of Rome (224), even reports a case of purulent mastoiditis, which followed 48 hours after the cauterization of the left inferior turbinate.

Epistaxis occasionally results either from the improper use of the electro-cautery or from the premature discharge of the slough. In a case of a plethoric man, in the practice of the writer, on whom the cautery had been used for hypertrophic rhinitis, the slough came away after a violent attack of sneezing about three days after the application. It was followed by a violent hemorrhage which a physician, to whom the patient applied, attempted to control by plugging the anterior nares with cotton, this simply causing the blood to flow backwards into the throat. A second physician syringed the nostril with a solution of perchloride of iron, which was also without effect, and the patient had lost considerable blood when he finally reached my office. The hemorrhage was arrested at once by a tampon of iodoform gauze.

Momentary delirium following slight surgical interference in the nose, is reported by Ziem, of Dantzig (225). Two of the patients were addicted to alcoholic liquors, and in the third the effect was produced after opening the maxillary sinus and its injection with a solution.

The author also reports a number of disturbances of vision following electro-cauterization of the turbinals, and believes that

these symptoms are developed through the sudden congestion of the meninges. In these cases, however, it is questionable how much of the effect in the two first cases was due to the alcoholic beverages which the patients had, no doubt, taken to prepare for the operation, and in all the cases, the systemic effects of the cocaine must be determined before the results can be ascribed to the operations.

As showing the influence of nasal irritation producing nervous disturbances, H. Schmeltz, of Dresden (248), gives the clinical history of two cases. In the first, in which the electro-cautery was used for a mild hypertrophy of the middle turbinal, there developed a severe reaction. The patient complained of great pain in the superior maxillary branch of the trigeminus, which was followed by epileptiform spasms, which disappeared with the healing of the cauterized area.

Two cases of anosmia, one of which was due to prolonged cauterization of the nostril, are reported by Luc, of Paris (226). Both of these cases were cured by the application of galvanism.

As an illustration of the serious effects of a trivial operation, the following case of W. W. Tompkins (227) is interesting. In this case, the removal of a part of the uvula was followed a few minutes later by the death of the patient. Tompkins states, however, that the patient had suffered no inconvenience from the operation, and that death, in this case, was due to heart-disease. The excitement incident to the operation, however, may have been one of the exciting causes.

CHAPTER XXII.

Hypertrophic Rhinitis.

(Concluded.)

ELECTROLYSIS.

AMONG the agents commonly used for the reduction of hypertrophic rhinitis are the electro-cautery, chromic and trichloracetic acids (228). Of these, the electro-cautery is, as has already been explained, the most practicable and efficient. One of the objections to chromic acid not usually referred to, and which I have frequently observed in my practice, is that it gives rise to considerable pain. If the parts are well anæsthetized with cocaine, there is of course no pain in the application of the caustic, but after the effects of the cocaine have passed off, patients frequently complain of pain, more or less severe, lasting from one to several hours, sometimes involving the whole side of the face and eye. This is, undoubtedly, due to the chromic acid, and occurs even when an alkaline solution is used afterwards to neutralize the acid. With the electro-cautery or electrolysis, pain is rarely complained of.

An objection, however, which applies alike to the electro-cautery, chromic and trichloracetic acids, is the formation of cicatricial tissue. In other parts of the body less important in their physiologic functions, the surgeon uses every device to avoid the formation of a scar, while many rhinologists boldly inflict one in the nose of every patient who is suffering from a hypertrophic or even only a congested condition of the mucous membrane. In fact, I have seen the cautery applied so recklessly in some of these cases that but little of the normal mucous membrane could be seen in the nostril.

In using electrolysis, the object is to reduce the hyperplasia and break up the network of dilated blood vessels, as with the electro-cautery, but to effect this by means of a submucous operation. Theoretically, this is of course the ideal operation in all cases,

although practically there are some in which we have to resort to other methods.

An experience of several years with electrolysis has convinced me that in those cases in which it can be carried out, especially by the bipolar method, the results are more satisfactory and more lasting than from any other procedure.

For electrolysis the galvanic current must be used, the faradic (induced) not possessing the required electro-chemical properties, as has already been shown. A current of 35 volts will answer the requirements, which may be obtained either from a chemical battery, as for instance 24 Law or Mesco cells, or from the wires of an incandescent-lamp circuit, using the Edison current of not more than 120 volts. The alternating current should never be used, because, like the faradic, it does not possess the required electrolytic properties.

In applying electrolysis, a milliampere-meter should be used, so that the strength of the current may be noted.

In the monopolar method, the platinum needle is passed into the hypertrophied tissues, while a dispersing electrode is applied to the face, the neck or chest. While the results of the monopolar method are, in the main, good, experience has shown that it is open to the following objections:

1. A burning sensation is frequently experienced at the dispersing electrode, which, to many patients, is very unpleasant. This objection could be overcome by the use of larger dispersing electrodes.

2. As the current must traverse a considerable portion of the face and head in passing from the needle to the dispersing electrode, disagreeable sensations reflected from these points are frequently felt.

3. On account of the great resistance which the distance between the active and the dispersing electrodes forms to the current, there is a great waste of electro-motive force, and the current has to be applied a considerable length of time to effect the electrolyzation of the tissues around the platinum needle.

With a view of obviating these objections in a method of treatment which had given me some excellent results, I commenced about three years ago to apply electrolysis by the bipolar method—that is, by using two needles in the hypertrophied tissues, one being connected with the positive and the other with the negative pole of the battery. The passage of a current

of electricity through these needles causes the electrolyzation, or chemical decomposition, of the tissues between them, hydrogen being eliminated at the negative needle and oxygen at the positive. As nascent oxygen combines rapidly with most metals, platinum or gold must be used for the positive side, but for greater convenience and to avoid testing the current each time that it is applied, I make use of platinum needles for both the positive and the negative sides.

On account of the proximity of the needles to each other, there is a great reduction in the resistance as compared to the monopolar method, so that a current of less strength will effect the same work, or the same current that was used in the monopolar method will act much more effectively. Not only is this the case, but, as both needles are imbedded in the tissues between them, the operation may be effected much more rapidly. While with the monopolar method, a case required 15 to 30 minutes, the same operation may now be performed by the bipolar method in from two to five minutes. Another advantage is that, as the current traverses only the tissues between the two needles, which can be thoroughly cocainized, the operation can be effected without pain.

The platinum needles should be fine and well pointed, and the greatest care be exercised that the uninsulated parts of the needles do not come in contact within the tissues or elsewhere. I have found eucaine preferable to cocaine in these cases.

The needle should be prepared with all the necessary details for asepsis, and all except one-half inch nearest to the point should be insulated with a coating of shellac varnish. This prevents the electrolytic action from taking place at the point of insertion in the mucous membrane, and thus leaving an opening for the entrance of pathogenic germs.

The needle (Fig. 119) which I use consists simply of a light but

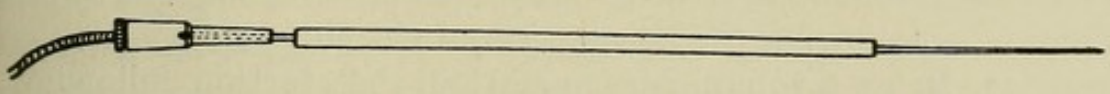


Fig. 119. Electrolytic Needle.

sufficiently strong piece of copper wire, to one end of which the platinum needle is soldered, the other end being connected with the flexible cord. The copper wire is covered with a thin piece of rubber tubing, which may be taken off for the proper disinfection of the instrument. The insulating cords attached

to the binding-posts should be as light as possible, as a very thin cable is sufficient to carry the current for this purpose, and is more convenient to handle. Instead of using these needles and holders separately, I have also devised a double electrolytic needle to be used with the bipolar method, as shown in Fig. 120.



Fig. 120. Scheppegrell's Double Electrolytic Needle.

The nostrils being thoroughly illuminated by the reflected light from the forehead mirror, and the ala well dilated by the nasal speculum, the first needle is passed into the upper part of the hypertrophy, and the second into the lower part. A current of sufficient strength is then gradually admitted by means of the rheostat. I have found that while a current of five milliamperes was painful when used by the monopolar, ten milliamperes could frequently be borne with the bipolar method. From two to five minutes is usually all the time required to effect the necessary electrolyzation of the tissues.

An experience of over 100 cases with the bipolar method of electrolyzation enables me to deduce the following points:

A. As compared with the unipolar method:
   1. It is more rapid in its application.
   2. Less painful to the patient.
   3. More definite in its action.

B. As compared with other methods:
   1. It is a more conservative operation, as it effects the reduction of the tissues without destroying the mucous membrane and its glandular elements.
   2. It is not more painful and but little more difficult to the skilled operator. It has not the disagreeable after-pain following the application of chromic acid.
   3. Being a submucous operation, the reaction following it is very slight, as the electrolyzed tissues are frequently absorbed instead of sloughing off as in other methods.
   4. The probabilities of a relapse are much less than in other methods. I have never yet seen a synechia formed in the nostril, due to the effects of electrolyzation.

Besides the direct effect due to the electrolyzation of the tissues, there is evidently some other beneficial influence in this

mode of applying electricity, which is not yet well understood. The electric force passing between two points extends across this distance not only in a straight line, but also in curves which extend in every direction between the two poles. The greater portion of the electro-motive force passes in a more direct line, causing the electro-chemical destruction of the intervening tissues, but the outside curves of electro-motive force, of moderate intensity, exercise a catalytic effect on the surrounding tissues, blood-vessels, and nerves, to which some of the good results of this operation must be attributed.

The cases in which the electrolytic method is not practicable may be summed up as follows:

A. As the operation is not performed as rapidly as by means of the electro-cautery, it is not so practicable in cases of young children or very nervous patients.

B. The physical conformation of some nostrils renders it difficult to properly insert the electrolytic needles, and in these cases some other method must be adopted.

Electrolysis in the treatment of hypertrophic rhinitis has also been used by Flatau, of Berlin (230), in a large number of cases, and he considers this method of special value, as the action of the current is submucous and spares the superficial layers of the mucous membrane, and is conservative of the acinous and muciparous glands, which are destroyed by the application of the electro-cautery.

The bipolar method is preferred by Flatau, who now uses this to the exclusion of the monopolar method. He states that a current of 40 milliamperes should not be exceeded, and that the application should be limited to four or five minutes. He has not seen any untoward results following these applications.

As to the relative value of electrolysis and the electro-cautery in the treatment of hypertrophic rhinitis, Scheimann, of Berlin, states that this depends upon whether it is advisable to conserve the superficial layer of the mucous membrane. As this point hardly admits of discussion, it is a decided approval of the method.

Electrolysis is preferred by Smithiusen Aachem in very narrow nostrils, especially in children, in order to avoid the danger of synechia. As electrolysis requires more detailed arrangement and a longer duration of application than the electro-cautery, I have rarely found it applicable in children, except with general narcosis.

Electrolysis has also been advocated for hypertrophies of the nasal mucosa by Voltolini, Kafemann, Kuttner, Cozzolino and Grünwald.

A systematic use of electrolysis in the reduction of hypertrophies of the posterior extremity of the turbinals, has been made by Helot (231), who prefers this to the electro-cautery and the cold snare.

He uses a current of from five to ten milliamperes for five to ten minutes. A strong steel needle is passed through each nostril into the tumefied portion of the turbinate. There is no bleeding, except at the positive electrode. With soft hypertrophy the results are rapid. Two applications with intervals of eight days are sufficient. Where the tissues are dense or hard, three or four applications are necessary, or a single application may be made and the operation finished with the cold snare without fear of hemorrhage. This method is not dangerous and removes the fear of severe reaction and hemorrhage.

In posterior hypertrophies, Lennox Browne (126) does not use the cautery on account of the proximity of the Eustachian tube, but prefers a snare which he passes through the inferior meatus and adjusts to the excrescence by the aid of a finger in the naso-pharynx. In some cases he has obtained excellent results from the entire removal of posterior overgrowths by the "spoke shave" of Carmalt Jones, though he notes that it is sometimes attended by rather brisk hemorrhage.

A posterior hypertrophy is difficult to reach effectively by means of the cautery through the nostrils, but by applying the cautery through the naso-pharynx, it may be readily reduced. After the soft palate has been cocainized, a White's palate-retractor is applied, and by means of a rhinoscopic mirror and a properly bent cautery with a rosette point, the hypertrophies may be effectively reduced, or the same end may be obtained by means of a bipolar electrolytic needle.

In a large number of these operations, I have not seen the hemorrhage which sometimes results from the application of the snare, and especially after the use of the "spoke shave." If the cautery point is small, the heat radiated is not sufficient to be injurious to the Eustachian orifice, and if the patient be directed to breathe gently through the nostrils during the application of the cautery, the products of the application will be expired through the nostrils. The hypertrophy of only one turbinal

should be reduced at a single sitting, when the reaction will be very slight. In one case, in which circumstances compelled me to make a more extensive cauterization, the reaction was somewhat severe.

As regards the application of the "spoke shave," I have used this several times, but would not apply it again except in an extreme case. In spite of the most careful application of cocaine, the pain is quite severe and the hemorrhage in one case was quite alarming. As the removal of parts with the "spoke shave" must be done with considerable force, it effects the scientific precision with which such an operation should be conducted, and may be the cause of considerable damage. It is a radical operation which should be limited to exceptional cases, and I have read with much surprise of the large number of cases treated with this method by several English writers.

The use of electrolysis for the destruction of hypertrophies of the turbinals and adenoid vegetations, is advocated by J. R. Briggs (232). The anode is connected with a sponge which the patient holds, and the cathode to an insulated gold-pointed needle, which is passed into the tissue to be destroyed. In some cases, he does not use the needle, but simply applies a nasal electrode to the parts which are to be reduced. He claims that this has been successful in his hands in cases in which other methods of reducing hypertrophies of the turbinals and adenoid vegetations of the vault of the pharynx have failed.

Metallic electrolysis has also been found useful in hypertrophic rhinitis, and Massey (233) has found that one application will often give relief for many days in nasal obstruction, and that a systematic treatment for six months will destroy the tendency of the patient to constantly "catch cold." Margaret A. Cleaves, of New York (234), also reports four cases of nasal stenosis which were treated by cupric electrolysis with good results. It is unfortunate that greater details are not given in these cases, so that a fair judgment might be formed.

Metallic electrolysis has been used by Clarence C. Rice, of New York (235), in a number of cases of hypertrophic rhinitis, and also in cases of hypersecretion of the nasal mucosa, in the irritative cough due to catarrh of the pharynx and larynx, and in hypertrophy of the turbinates. In the latter cases, the electrode consisted of a copper needle which was passed into the tissues. He also found this method useful in arresting the hemorrhage

from erosions of the septum. More than five to ten milliamperes were not needed in any of his cases. In the 20 cases which he treated, six were cured, while 75 per cent. of all were decidedly improved.

A case of *purulent rhinitis* treated by interstitial electrolysis, is reported by William L. Jackson, of Boston (236). He used a current of eight milliamperes with a copper positive electrode applied to the nasal mucous membrane, and the negative, a large sponge electrode, applied to the cheek. In order to destroy the sensibility, a solution of cocaine was used before the application. A slow but positive cure followed. The purulent discharge ceased, the amount of water diminished, respiration became easier, and the sense of smell returned.

Vibratory massage has been highly recommended by writers who are familiar with this method, and who claim that it has advantages over other modes of treatment. As massage is used without any destruction of the mucous membrane and its important structures, it would seem to be especially indicated and should always be given a fair trial before more severe methods are undertaken. This subject has already been fully discussed in Chapters XVII. and XVIII.

Of the various methods which have been here described, each no doubt has its special indication, and each is therefore useful in selected cases. The more conservative methods should always be given the preference, and if these do not bring about the desired results, the other methods may then be used according to the judgment of the physician. The influence of the general health and of constitutional dyscrasias in such cases should not be overlooked, as otherwise a relapse will be developed by the same causes which produced the original affection.

CHAPTER XXIII.

Ozena (Fetid Atrophic Rhinitis).

Of the ordinary diseases of the nose, there is none which is more disagreeable in its effects and more resistant to treatment than ozena or fetid atrophic rhinitis. Not only has the treatment of this disease been the subject of many long discussions, but even the pathology involved, many claiming that all forms of atrophic rhinitis, whether fetid or nonfetid, are the later stages of hypertrophic rhinitis, while others claim that ozena is a distinct disease entirely dissociated from previous hypertrophy.

While pathology does not form a part of the subject of this work, I would state that my investigations have led me to believe that fetid atrophic rhinitis is a distinct disease of microbic origin, entirely independent of any previous hypertrophy and quite distinct from the nonfetid variety, or the dry rhinitis of adults, which is a later stage of hypertrophic rhinitis. This view of the subject is strengthened by the fact that ozena usually originates in early life, when true hypertrophy is rarely met with.

Many methods have been advocated in the treatment of ozena. Thorough cleanliness is a necessary feature in each of these, and the importance of this should be impressed upon the patient. A

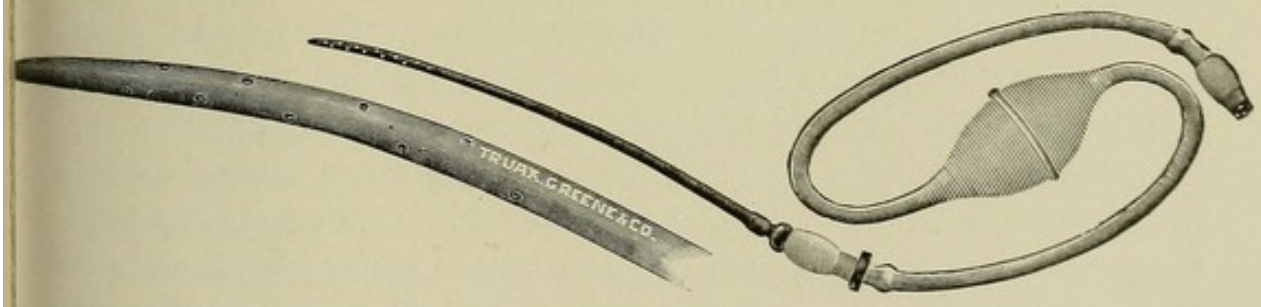


Fig. 120B. Scheppegrell's Nasal Syringe.

useful syringe for this purpose is shown in Fig. 120B. It consists of an ordinary Davidson's syringe to which is attached a perforated soft-rubber catheter.

Galvanism was one of the first of the electric methods used in the treatment of this disease. In view of the good results which they had already obtained by galvanization in the treatment of Eustachian catarrh, Garrigou-Desarènes and Mercié, of Paris (237), advise the same treatment in ozena. They report five cases treated in this manner, in which the nasal mucosa was much improved and the secretion appeared to return to its normal consistency.

This method is also recommended by Bryson Delevan, of New York (238), as follows: The positive (dispersing) electrode is placed on the nape of the neck, while the negative is wrapped in absorbent cotton and applied directly to the nasal mucous membrane. The strength of the current is from four to seven milliamperes, and the duration of the application from seven to fifteen minutes, or until a moderate watery secretion is induced. Delevan secured excellent results from this plan of treatment.

In the application of galvanism in ozena, it is preferable, however, to apply the *positive* electrode to the mucous membrane. This is substantiated by the investigations of Apostoli and Laquerriere (239), who demonstrated that even where the thermal action of the current is excluded, the virulence of bacteria is diminished or destroyed, and that this action is present to a large degree only at the positive pole. Therefore, when the galvanic current is applied in the treatment of ozena, the positive electrode should be passed over the mucous membrane.

The stimulating effect of galvanism in atrophic rhinitis is well illustrated by a case which was treated by an assistant at the Eye, Ear, Nose and Throat Hospital, in which the sittings were continued beyond the necessary point, and a patulous atrophic nostril changed into one resembling rhinitis intumescent.

Galvanization in atrophic rhinitis is also advocated by J. H. Hartman, of Baltimore (240). Shurly, of Detroit (241), recommends galvanism in atrophic conditions of the nasal cavities and the pharynx, and reports that he has had more lasting effects than from any other form of treatment. He applied one metallic electrode through the nasal passage, and the other, also a metallic electrode, to the posterior and lateral wall of the pharynx; the application was made by the labile method—that is, by passing the electrode over the surface to be treated. Taking into consideration the strength of the battery described and the normal resistance of the part, a very light current was evidently used,

and the gagging of which the patient complained was probably due to mechanical irritation.

Faradism has also been used in atrophic rhinitis, many authors reporting good results. J. B. Garrison, of New York (242), advises the thorough and persistent trial of the faradic current for the purpose of establishing better circulation in the atrophied parts of the nasal mucosa, and thus building up new tissue by means of the pabulum which the arterial blood supplies. After the nostrils have been thoroughly cleansed in the usual manner, a flexible electrode, about two inches long, the end of which has been covered with moistened cotton, is attached to one cord of the battery, the patient holding a sponge electrode in one hand. The secondary coil of fine wire should be used, and the vibration should be rapid. The current should be very mild, and the treatment given every day.

The faradic current has been recommended by Ralph W. Seiss (244) in all grades of sclerosis and atrophy of the nose and throat. He uses a straight nasal electrode connected with the positive pole, long enough to reach the pharyngeal wall when introduced through the nose. The tip of the electrode is well wrapped in cotton and dipped in an alkaline solution. The dispersing electrode is applied to the hand or to the maxillary or laryngeal region of the patient. The seances should not exceed ten minutes. In a later publication (245), the same author again describes the advantages of faradism, but states his preference for massage as a routine practice in such cases.

Vibratory massage has been recommended in atrophic rhinitis, and the results obtained by those who are proficient in this method entitle it to a high position as a remedial agent in this obdurate disease. This subject has already been fully discussed in Chapters XVII. and XVIII., and the results therein stated show that in atrophic rhinitis vibratory massage has its most useful field. In a recent monograph on this subject, E. J. Moure (246) places this method in the front rank in the treatment of ozena.

Massage has also been so combined with the electric method that both may be applied at the same time. Garnault (247) has modified the vibratory massage as described by Braun, so that the sound which is used for massage also serves for applying the galvanic current. He applies the dispersing electrode to the back, while the other pole is connected with the sound by means

of which the vibrations are made. The point of the sound is provided with a pledget of cotton saturated with salt water and dipped into lanoline. With this method he has achieved good results in the treatment of ozena, asthma of reflex origin, and chronic naso-pharyngeal catarrh.

In ozena, in which atrophy is the predominating symptom, any destructive remedy would seem to be strongly contraindicated. The *electro-cautery* should therefore not be used in this disease, as its devitalizing effect tends to aggravate the already hampered condition of the nostril. Several authors have nevertheless recommended the electro-cautery in atrophic rhinitis, and even Sajous (153) states that in the treatment of this disease he uses the method recommended by Fränkel of applying the flat surface of the electro-cautery to each suppurative area.

All operative procedures in atrophic nostrils should be undertaken with much caution on account of the unhealthy secretion, which is not aseptic as in the normal nostril, and because the lower vitality of the tissues causes slower efforts at repair than in the normal mucous membrane.

A case is reported by Abeille (255), in which a boy of 15 years, who had suffered from his infancy from ozena which had resisted every form of treatment, was cured by the application of the electro-cautery to the turbinated bodies of both sides. The application was followed by febrile reaction, but 15 months after the treatment there had been no recurrence of the ozena. The description of this case is so vague, however, that it would indicate the lack of familiarity of the author with rhinoscopic work, so that no conclusions can be drawn from this experience.

The treatment which is now attracting most attention and which seems to have given more permanent results than others which have been used in this disease, is the method of *cupric electrolysis*. The oxychloride of copper, which is generated in the tissues in a nascent condition by this procedure, has energetic antiseptic properties. This salt may be generated either by means of a cylindrical rod of pure copper, which is passed into the nasal chambers and is connected with the positive electrode, or more effectively by means of a copper needle which is passed directly into the tissues to be treated.

This method is recommended by Jouslain (256), who passes the copper rod into one nostril, the negative electrode in the shape of a moistened tampon of absorbent cotton being applied to the

other nostril. In a later publication, Jouslain (257) again states that he has had most satisfactory results in the treatment of atrophic rhinitis by means of interstitial electrolysis. He attributes the results obtained to the strong microbicidal action of the oxychloride of copper on the saprogenous microbes in the glands and epithelial cells of the mucous membrane, which he believes to be the important factor in the production of ozena. He uses two cylinders, twelve *cm* long by six *cm* thick, of pure copper, which are inserted into the nostrils, which have previously been thoroughly cleansed, and a galvanic current of five milliamperes is passed for five minutes, the current then reversed and applied for five minutes more. With each application the electrodes are applied to a different portion of the mucous membrane.

The treatment of ozena by interstitial electrolysis was described by Cheval at the annual meeting of the Belgian Otologists and Laryngologists, June 16, 1895. He prefers the bipolar method. A silver or copper needle is introduced into the middle turbinate, either into its substance or within its cavity. A steel needle is inserted into the inferior turbinate of the same side, having, if possible, pierced both bone and mucous membrane. As the interstitial effect of the copper or silver needle is desired, this should be connected with the positive pole, while the steel needle is connected with the negative.

The intensity of the current should be governed by the sensitiveness of the patient. Cheval (258) states that he uses 18 to 20 milliamperes, the length of the seances being from 7 to 15 minutes. The sitting should be separated by intervals of from eight to fifteen days, and to avoid irritation both nostrils should not be treated at the same sitting. Cheval frequently employs electrolysis by a method which he calls "en cascade," two, three, four or even twelve ozenic patients being connected in the circuit of one battery.

The simultaneous treatment of several patients, however, is not to be recommended, as the tolerance to the electric current varies considerably in different patients and also according to the location of the needles imbedded in the tissues. It is therefore not advisable to treat even two patients in the same circuit. I have also not found it necessary to use a strength of current greater than ten milliamperes in these cases.

Cheval states that cocainization usually renders the passage of

the needle painless. In the cases in which he applied this method, the fetor disappeared from the nostril of the patient a few days after the application; the mucous membrane of the middle turbinate and meatus appeared a bluish-green color, due to the presence of oxychloride of copper. In grave cases the mucosa remained slightly atrophic, but showed the sign of regeneration.

An author who is enthusiastic in the electrolytic treatment of ozena and who has had unusually good results with this method, is Copart (259). This writer states that vibratory massage by hand or by the electric motor has proved disappointing in the treatment of ozena, and that none of the methods, which have been advocated, can compare with electrolysis, especially the bipolar method.

He believes that 90 per cent. of all cases of ozena may be cured, and that one sitting is sometimes sufficient. A current of 20 milliamperes should be used for 20 minutes at each sitting. If the patient cannot tolerate the bipolar method, the unipolar may be applied with the negative pole to the arm, thigh etc. In children chloroform may be used, and Copart, in more than 300 cases, has never seen an accident from this treatment.

In the discussion of this subject before the Belgian Society of Otology and Laryngology, Bayer (260) stated that he had found few patients who could tolerate more than six to seven milliamperes, and even this caused severe pain in the ear of the same side. Its success in many cases, however, was striking, the odor and crust disappearing rapidly. He calls attention to the possibility of danger in this method and relates a case in which, a few days after electrolysis, the patient developed a hemorrhagic otitis media, then a meningitis which proved fatal.

Cupric electrolysis has been used by Rosseaux in about 40 cases and without accident. He advises that the needle be passed into the middle turbinal from below upwards, then turned and driven backwards. If this were done accidents would be impossible.

The results obtained by Bayer (260) are as follows: In seven cases of ozena there were six with marked improvement, but two were attacked with otitis after the operation, of which one died 20 days after the operation in a meningitic coma, as already stated. In one case, one sitting of electrolysis was sufficient to modify the secretion and to cause the odor to disappear. In another

case, the ozena gave place to a chronic catarrhal condition, but without fetor. Sometimes the action of electrolysis was not limited to the side on which the application was made, but extended to the nasal fossa and even to the naso-pharyngeal cavity.

In regard to the bacteriology of ozena, Bayer considers it a tropho-neurosis with abnormal secretion which forms a suitable medium for the culture of the cocco-bacillus of Loewenberg and Abel. He considers interstitial electrolysis, which is almost specific but not free of danger, the best treatment. It should be applied only with the consent of the patient, who should be informed of the possible danger. Two or more sittings are necessary, and weak currents of six to eight milliamperes should be used.

Cupric electrolysis has also been found useful in the treatment of ozena by W. J. Morton (110), who applied copper bulbs instead of needles. He also found this method useful in pathologic conditions of the nose and pharynx in which there was excessive secretion.

Ozone, which may be obtained by the action of induced electricity of high potential on a current of air, has also been used with success in the treatment of this disease. This method will be referred to in the chapter on Diseases of the Accessory Sinuses.

CHAPTER XXIV.

Epistaxis—Anosmia—Reflex Neuroses of Nasal Origin.

EPISTAXIS.

THE electro-cautery is a valuable method of controlling epistaxis where the hemorrhage is not the result of some constitutional dyscrasia, and when the bleeding point can be seen, which is often the case, the most common site being the anterior inferior part of the nasal septum. Attention has already been called to this fact by Michael (261), Lefferts, Littel, Hartmann, Chiari and others. A 20-per-cent. solution of cocaine should be firmly applied to the bleeding point by means of a pledget of cotton and applicator; this will control the hemorrhage for the time being and will also anæsthetize the part so that the cautery may be applied. The cautery point in this application should be heated somewhat more than is required in ordinary operations, as the blood has a tendency to cool the heated platinum below the degree at which its application would be effective.

Not only is this method useful in passive hemorrhage, but also in hemorrhage of arterial origin. In a case occurring in my practice, in which a septal operation had been performed and the slough, which had formed over the exposed area, had been removed by the patient in an effort to blow the nostril strongly, a violent hemorrhage took place, which on rhinoscopic examination was found to be of arterial origin, the blood spurting in interrupted jets completely across the nasal chamber. In this case, the cocainized cotton was held firmly to the bleeding point for five minutes, as described above, and then a fine platinum electrode, heated to a bright red, was quickly applied to the bleeding point, successfully and permanently controlling the hemorrhage.

In five cases reported by Calmettes, of Paris (262), the application of the electro-cautery was followed by healing in each case. In a sixth case reported by this author, the hemorrhage was due to a raspberry-like excrescence in the middle meatus, which was also cured by the application of the electro-cautery.

Hemorrhage due to a cavernous tumor of the septum, cured by the electro-cautery, is also reported by Voltolini and Rischawy (263).

The use of the electro-cautery for epistaxis was recommended by Voltolini (264) as a sovereign method. He stated that the cautery should be only bright red, otherwise it is too penetrating in its action. In a case of hemorrhage from diapedesis, which he reported, a cure was effected by the general application of a flat cautery to the mucous membrane of the inferior turbinal.

This method is also recommended by E. F. Ingals, of Chicago (266), and Baumgarten, of Budapest (267). The latter advises, where the bleeding point cannot be found, the insertion of a tampon of strips of iodoform gauze, as is now very often done in these cases. The unpleasantness and discomfort of having the nostril packed with gauze should make it a remedy to be used only where the first method is not practicable.

The use of packing in the nostril, while not as dangerous as when used in the post-nasal space, is still occasionally followed by unpleasant complications. Gellé (268) reports a case of epistaxis in which the tampon was used for arresting it, which was followed by bilateral purulent otitis media. Baratoux has seen a similar case.

While this is a valuable method for controlling epistaxis where the bleeding point cannot be otherwise located, it should be used with due precautions and the gauze not allowed to remain in the nostril more than 12 to 24 hours.

Electrolysis has also been used in these cases, and C. C. Rice, of New York (269), reports three cases of epistaxis from septal erosions which were controlled by metallic electrolysis. He prefers this method to the electro-cautery.

ANOSMIA.

In anosmia due to the atrophy of the mucous membrane, the treatment should of course be directed to the improvement of this condition. In those cases in which it is functional and not dependent upon atrophy or sclerosis, electricity is of benefit, the *galvanic* being preferable to the faradic current. The dispersing electrode should be applied to the nape of the neck, and a nasal electrode, the point of which has been covered with absorbent cotton, should be connected with the negative pole and applied to

the upper region of each nostril, and a mild current passed daily. Where the irritability of the mucous membrane makes this application painful, the parts should first be anæsthetized by a five-per-cent. solution of eucaine hydrochlorate.

The influence of the electric current on the organ of smell is shown by the investigations of Aronsohn, of Berlin-Ems (270), who reports the results of his experiments on the perception of odor by electricity. The experiment was made with 12 persons, in 10 of whom a peculiar odor was perceived when the olfactory nerve was stimulated by a galvanic current. It is of special interest to note that a girl of 12 years, suffering from atrophic rhinitis, in whom the normal sense of smell was very defective, perceived a strong odor during the electric irritation of the olfactory nerve.

The effect of the galvanic current on the mucous membrane of the nose has also been tested by Rockwell (6). When he applied the negative pole of a strong current to his own nostril, it caused, in certain sensitive localities, an odor much resembling sulphuretted hydrogen. This effect was not produced when the static or faradic current was used. The same author reports a case of anosmia cured by the application of galvanism.

The peculiar odor when the galvanic current is applied to the mucous membrane of the nose, is attributed by Schoenbein to the ozone which is generated by the current. But there is no reason for supposing otherwise than that the olfactory nerve reacts to the galvanic current and carries an olfactory sensation to the brain in the same manner as we note the reaction of the auditory, optic and gustatory nerves.

The *faradic* current has also been recommended in the treatment of anosmia, although the majority of electro-therapeutists agree in giving the preference to galvanism in such cases. Sajous (153), however, recommends faradism, a moderate current being passed from the intra-orbital space to the occiput, the negative pole being placed over the former.

In the two following cases, in which both the faradic and galvanic currents were used, the effect was probably due to the former. These were two cases of anosmia following the electro-cauterization of the hypertrophied mucous membrane of the turbinals, reported by Luc (271). They were treated by the application of the galvanic and faradic currents to the mucous membrane of the nose. One electrode was placed in the nasal chamber, and the other to the bridge of the nose, and the current

rapidly increased and decreased, but not exceeding a limit of three milliamperes. Afterwards the faradic current was used, the application being made for ten minutes to each side of the nose. The treatment was followed by a complete cure.

REFLEX NEUROSES OF NASAL ORIGIN.

Reflex neurosis of nasal origin has been the subject of many of the most animated discussions among rhinologists. Its importance has been admitted by all, although it probably has been overestimated by many of its more enthusiastic advocates.

The various organs of the body are so interdependent upon one another, that it is easily understood that the disturbance or defect of one organ may react on the others. At the same time, the rhinologist should avoid being narrow in his views and limiting his observations to what is seen through the nasal speculum. The fact that the nostrils have been somewhat overestimated in recent years is perhaps only a slight compensation for the complete neglect which has been shown this important organ in previous years.

One of the earliest reports of a reflex neurosis of nasal origin was made by Voltolini (264), who described a case of asthma due to the existence of nasal polypi, as shown by the fact that the asthma promptly disappeared on the removal of the nasal growth.

The *electro-cautery* should be used in these cases with extreme caution. A number of favorable results, however, has been reported. Sommerbrodt, of Breslau (273), describes four cases of asthma of nasal origin, which were cured by the application of the electro-cautery. The first was a woman of 43 years. Electro-cauterization of the right nostril was sufficient to effect a cure. The second, a man of 38 years, who suffered from sneezing, watery discharge from the nose, and asthma which he referred especially to the left side of the chest. A thickening of the middle turbinal was removed, which caused improvement in the patient, but afterwards, a relapse taking place, the left inferior turbinal was cauterized, which resulted in a cure.

The third was a young lady of 20 years. A thickening of the middle turbinal was removed, which resulted in improvement, but a relapse took place which the patient referred to the left portion of the lung. A cauterization of the left inferior turbinal resulted in a cure. The last was a patient who had suffered

ten years from asthma, which disappeared after cauterization of the left nostril.

The author calls attention to the asthma in these cases being referred to the side on which the nasal affection existed. He also reports a case of a convulsive cough in a five-year-old boy, which was cured by cauterization of the inferior turbinates.

A case of a woman, 45 years of age, who had suffered for four years from severe attacks of asthma, and who was cured by the removal of nasal polypi by means of the electro-cautery, is reported by Adolph Klein, of Vienna (274).

Reflex neuroses of nasal origin formed the subject of discussion of the Laryngological Section of the Eighth International Medical Congress at Copenhagen (275). B. Fränkel, who opened the discussion, stated that he did not believe in the theory of Hack, that the hypertrophy of the turbinals is an important link in the chain of reflex disturbances, but that these reflex neuroses may originate from the irritation of various points. He called attention to the fact that the nasal chambers may be the location of these irritations much more frequently than has been heretofore accepted. Where this is the case, he advised careful treatment of the nasal chambers, but admonished care in the use of the electro-cautery application. In some cases, the cure does not develop until months after the treatment. He stated that we must wait in all cases until the results of the cauterizations in the nose have healed. The effect of age in the prognosis is also noted. In older patients the results are rarely as satisfactory as in youthful subjects.

In the discussion of this subject (275), Semon, Krause, Bresgen, Heryng, Catti, Boecher, Bosworth, Daly, Chiari, Roe and Reichert expressed the opinion that there was considerable truth in the theory of Hack, but that it had, nevertheless, been much exaggerated. Gottstein, however, was quite skeptical in his views of this subject.

It was shown that an affection not only of the inferior turbinals, but also of other parts of the nasal chambers, may be instrumental in developing these neuroses, and that there are many other conditions, such as fatty degeneration of the heart etc., which may originate these symptoms. It is advisable to be cautious in the prognosis of these conditions, as the neuroses may continue in spite of the treatment of the nose. They all agreed, however, that the electro-cautery was too extensively used in

these cases, and that too much reliance should not be placed on it in this condition.

A case is reported by Cresswell Baber, of Brighton (276), in which a 19-year-old girl, otherwise healthy, suffered from a spasmodic cough which could be developed by the application of a sound to the mucous membrane of the left inferior turbinal. Electro-caustic treatment of the irritable portions of the nostrils resulted in a complete cure.

This reflex cough, following the irritation of the nostrils and ear, is frequently met with, and many cases have been reported. A case similar to Baber's was reported by the author (277), in which the cough was also cured by a mild cauterization of the inferior turbinal.

B. Fränkel, of Berlin (278), reports a case of a woman, 45 years old, suffering from spasms of the left facial nerve, which had existed for four years and had resisted all ordinary treatment. Although no symptoms of a nasal affection were present, still, as the application of a sound to the mucous membrane of the nose could develop the spasm, Fränkel cauterized the several sensitive areas with the electro-cautery, which resulted in a complete cure.

Reflex neuroses originating from the nose have been successfully treated by the electro-cautery by Roth, of Vienna (279). Julius Sommerbrodt, of Breslau (280), has treated 138 patients with the electro-cautery on account of reflex disturbances, only eight of whom had ascribed their affection to nasal origin. The neuroses were as follows:

1. Vasomotor neuroses of the bronchial mucous membrane without asthma, 20 cases; 13 cured, 1 improved. 2. Migraine, 14 cases; 8 cured, 1 improved. 3. Asthma, 52 cases; 18 cured, 12 improved, 5 not cured, 8 still under treatment, and 9, result unknown. 4. Reflex disturbances of the pharynx and larynx, 22 cases; 16 cured, 2 improved. 5. Attacks of sneezing, 6 cured. 6. Cough of nasal origin, all cured. 7. Neuralgia of the trigeminus, 3 cases; 2 cured. Instead of using the flat cautery for superficial application, he thoroughly destroys the affected erectile tissue with a spiral platinum cautery.

Two cases of hay fever, one complicated with asthma, which were cured by the application of the electro-cautery, are reported by K. Köhler, of Posen (281). Beschorner, of Dresden (282), also advises the electro-cautery in the treatment of hay fever, but warns against the promiscuous cauterization of the tissues. He

very properly insists upon the treatment of the nervous predisposition of this affection.

The intelligent application of the electro-cautery to the mucous membrane of the inferior turbinal is recommended by F. de Havilland Hall, of London (283), in cases of paroxysmal sneezing, and he reports a number of cases as proof of this statement.

The electro-cautery is recommended by J. C. Mulhall, of St. Louis (284), for removing the points of irritability in the nasal chambers, so as to make it impossible for the reflexes to start from this source. E. Fletcher Ingals (285) also advises this method, and claims that it will cure nine out of ten of such cases; a very sanguine estimate of the benefit of this method.

In the treatment of reflex neuroses, Sajous (286) recommends that the sensitive areas in the nostril be searched for by means of a probe and cauterized. He has had considerable success with this procedure. The same method is advocated by Thos. L. Shearer (210), who also confines the cautery to the sensitive nasal areas. The method of Sajous is also recommended by Greville MacDonald (213). In a later publication, Sajous states his preference for glacial acetic acid to the electro-cautery in the treatment of hay fever. He affirms that the proportion of permanent cures has been greater, and the relief afforded in uncured cases more marked, since he has adopted this method. He attributes this to the great affinity of glacial acetic acid for epithelial cells, the acid destroying the terminal filaments which furnish the parts with sensation. The electro-cautery produces the same superficial action, but does not affect the deeper portions of the epithelial layer unless pressure is exerted.

In asthma not due to nasal irritation, galvanization of the pneumogastric is sometimes effective. Neftel (107), while admitting that many forms of *asthma* cannot be radically cured, states that his experience has convinced him that the asthmatic paroxysms can be kept off for an indefinite time, and that the attacks may often be checked. Success with this method has also been obtained by Brenner (288).

The following general rules in the treatment of asthma by galvanization of the pneumogastric are given by Neftel: By means of the polar method he endeavors to call forth a catelectrotonic or anelectrotonic condition of the vagus, according to the character of the asthma. The current intensity is controlled by means of a

suitable rheostat, so that large fluctuations are avoided. He commences with a very weak current, gradually increasing its intensity until the severity of the attack has abated, when he reduces the current very gradually until it is almost imperceptibly discontinued. The duration of the seance is from two to ten minutes, the treatment being at first repeated daily, and afterwards three times and twice a week. The patient must be cautioned not to discontinue the treatment abruptly, but to continue it at some intervals.

Three cases are reported in detail by Neftel in which the galvanization of the pneumogastric was followed by complete recovery.

Hay fever has also been treated by a galvanic application to the pneumogastric nerve, the positive electrode being applied at the insertion of the sterno-cleido-mastoid muscle. Only mild currents should be used, as strong currents have been known to cause marked disturbance and even syncope.

The application of the induced current for asthma has been advocated by Schmitz, who has found it useful in selected cases. He applied the electrode at the inner border of the sterno-cleido-mastoid muscle, the seances lasting from ten to fifteen minutes.

CHAPTER XXV.

Deformities of the Nasal Septum. Nasal Synechia. Simple Ulcer of the Nasal Septum. Foreign Bodies.

DEFORMITIES OF THE NASAL SEPTUM.

WHILE a perfect septum forms the exception in the examination of the nasal chambers, still it is only in cases in which an obstruction inhibits the respiratory function of the nose or sets up reflex disturbances that it calls for surgical interference. When the deformity consists simply of a deviation, the most useful operation is one in which it is replaced in its normal position with as little loss of substance as possible. Where, however, there is a marked thickening, spur or ridge, which interferes with free breathing or gives rise to irritation, this should be removed.

MECHANICAL METHODS.

A number of methods has been advocated for removing this form of obstruction. The nasal saw is a useful instrument which has long been used by rhinologists and is still considered of value in these cases. The methods of operating this by means of the electric motor, as in the various mechanical saws that have been described (Figs. 107, 108, 109, 110, 111, 112), have added much to the usefulness and precision of this method, and have also decreased the time and fatigue of the operation.

The nasal trephine, applied by a motor in septal operations, was first recommended by H. Holbrook Curtis (289). He claimed for it the following advantages:

1. Greater rapidity may be obtained than by any other method.

2. The tissues in the neighborhood of the deviations are not torn; a clean opening is made and the operator is not annoyed with hemorrhages.

3. Even if the position of the posterior plate of a deflected septum is not visible, an exploratory canal may be made.

4. The greater part of the nervous shock in using a nasal saw is absent. The bone may be removed with less force and with greater accuracy than with any other method.

The trephine is a useful adjunct in those cases of septal operations in which it is difficult to apply the saw, as, for instance, where the septal thickening is very near the floor of the nostril. In these cases a furrow made by the trephine gives the space necessary for the insertion of the saw. Lennox Browne (126) refers with much enthusiasm to these trephines, and states that there is no innovation in modern rhinologic practice, for the relief of nasal obstructions, to which he is so much indebted as to these instruments.

These trephines are also useful where a very small spur is to be removed. For larger obstructions, however, it does not compare in accuracy, speed and in the results obtained with the method of the nasal saw, especially where this is mechanically operated by means of a motor.

The removal of septal obstruction by the successive application of the trephine is apt to leave a roughened surface, which tends to the formation of crust, and which may prove of great irritation after the operation.

In regard to the statement that this method is more conservative of the tissues in the neighborhood of the part to be operated, it is a curious coincidence that the two most severe cases of post-operative synechia which I have treated, were those in which the patients had been operated on by means of the trephine in the hands of experienced rhinologists. The trephine has now, however, its most useful field in operations on the antrum of Highmore and mastoid cells. In these cases, especially in perforating the antrum through the alveolar process, it is a most valuable instrument.

ELECTRO-CAUTERY AND ELECTROLYSIS.

In certain forms of cartilaginous thickenings, the electro-cautery is sometimes applicable. In recent years, however, it has been to a large extent displaced by the method of electrolysis, which has attracted a great deal of attention as a bloodless method of treating spurs and thickenings of the nasal septum. Among the earliest writers who advocated electrolysis in septal operations are Miot (290), Garel (291), Moure, Botey (293), L. Tilly (294) and J. Rosenthal (295).

Among the first to use electrolysis in these cases was Miot (243), who introduced one or more platinum needles into the base of the projecting cartilage, and connected these with the negative pole of a battery, the dispersing electrode, covered with a sheet of chamois moistened with salt water, being applied to a distant part of the body, as the arm, nape of the neck or sternum.

The objection to placing the dispersing at such a distance from the active electrode has already been referred to, in that it causes the lines of electric force to disperse so widely that it sets up irritation in important nerves and structures through which they pass, and this causes the flashes of light, gustatory sensations, vertigo and other disagreeable symptoms that have been complained of. These effects may be prevented by the bipolar method.

Electrolysis has also been used in a large number of cases by Moure and Bergonié (296), who suggest the following rules: In the monopolar method of galvano-puncture, it is advisable to use a large dispersing electrode having an area of 200 *cms.* (10 x 20) and steel needles for electrolyzing the cartilage. The needles should have a diameter of 0.8 to 1.5 *mms.* and a length of 8 to 11 *cms.* Steel needles are preferable to gold or platinum needles and should be attached to the negative pole, a battery of 30 volts being sufficient. The current should be gradually turned on by means of a rheostat, and two minutes should be consumed in carrying the current to the maximum to be used. The breaking of the circuit should be done in the same gradual manner. In this way, painful effects may be avoided. A current of 20 to 30 milliamperes should be applied.

In the bipolar method, both the positive and negative needles are inserted into the part, 20 volts being sufficient for this purpose, and a current of 12 to 15 milliamperes applied. From a clinical standpoint, the bipolar method is preferable. A useful electrode for this purpose is shown in Fig. 121.

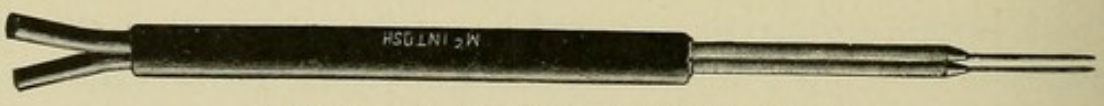


Fig. 121. Electrode for Bipolar Electrolysis.

The unfavorable results sometimes following the application of the monopolar method is shown by a case reported by Peyrissac (297). The sitting lasted 25 minutes, 20 milliamperes being applied by the monopolar method for about five minutes, and the

current afterwards increased to 40 milliamperes. After the treatment, the patient complained of toothache, which continued for eight days, especially in the region of the incisors. A similar report is made by Shearer (210), who has often found severe intranasal pain produced by the insertion of the needle, while the increased strength of the current was followed by pain in the incisor teeth.

The possibility of perichondritis developing from the application of electrolysis in nasal spurs is suggested by Sajous (515). In a case reported by Heryng (360), a long perforation developed in the septum after the application of electrolysis. He confesses, however, that his experience with this method has not been of sufficient extent to enable him to form a just opinion of its merits.

Electrolysis is also advocated by R. Botey, of Barcelona (298), whose results compare favorably with those of Garel, Miot, and Moure. Meyer, of Berlin (299), prefers electrolysis to the electrocautery in the treatment of spurs of the nasal septum, on account of the mild action and the absence of any necessity for after-treatment.

The treatment of thickenings of the nasal septum by electrolysis is advocated by Moritz Schmidt, of Frankfurt a. M. (300). In the discussion of this subject before the *XII. Congress f. innere Medicin*, Bresgen stated his preference for the electrocautery and the use of the sharp chisel for the reduction of bony spurs. In a more recent communication, Bresgen (301) also recommends electrolysis where mild measures must be used, as in delicate persons and when more radical measures have been refused. The procedure is absolutely painless, reaction very mild, but the process is very slow. In the discussion, Hajek, Stork, Heymann and Chiari stated that they had found electrolysis to be a tedious method and not always without pain, and preferred other methods of removing the conditions for which electrolysis is used.

The advisability of using the bipolar method is insisted upon by Bergonié and Moure (302) on account of the liability of perforation of the septum due to the dispersion of the electrolytic current when the monopolar method is used. The concentration of the current within the growth, as obtained by the bipolar method, is desirable not only to avoid the destructive action of dispersion, but also to prevent the greater pain which is felt by the patient in the application of the monopolar method.

This method is also advocated by Sajous (303), who, however, warns not only against the danger of perforation of the septum but also of perichondritis. Rosenfeldt prefers the electro-cautery for cartilaginous thickenings, but advocates the use of electrolysis in cases of bony thickenings. Ruault has also had good results.

Electrolysis has been used by Ed. Meyer, of Berlin (304), in 23 cases of cartilaginous thickenings, the number of sittings ranging from one to twelve. He used a double needle electrode with a platino-iridium point, and a current of 14 milliamperes, afterwards increasing this to 30. In those cases in which the latter strength of current was used, there were two cases of perforation of the septum, and, as the result of this experience, Meyer advises that the current be limited to 15 to 20 milliamperes, and the length of the sittings five to ten minutes. There were no subjective inconveniences in these cases.

The reduction of nasal spurs by electrolysis is also recommended by Boland, of Verviers (305). Moritz Schmidt, of Frankfurt (306), and Newcomb, of New York (307), have used electrolysis, but believe that the trephine achieves the same results more quickly. Strazza (308) has used the bipolar method of electrolysis in 28 cases, but the results did not encourage him to adopt this in preference to the surgical methods. He limits the operation to the treatment of faint-hearted patients, who are afraid of the more radical procedures.

In this connection, Sajous (309) suggests that, as the majority of patients are faint-hearted, this operation will probably continue to gain ground in the future. Scheinmann, of Berlin (310), reports a case in which electrolysis was followed by caries of the bone. This unfortunate result was probably due to the use of too strong a current, or a too protracted application.

Electrolysis has also been recommended by Karl Hess, of Falkenstein (311), and by Draispul (312). P. Hélat (313) finds this a mild method of correcting thickenings of the nasal septum, and one which causes the patient very little inconvenience. He considers it decidedly superior to the electro-cautery.

Sixteen cases have been treated by this method by W. E. Casselberry, of Chicago (314), who reports one small perforation. From his experience with these cases, Casselberry states as follows:

1. Strictly cartilaginous spurs can be thoroughly removed by electrolysis; one, two or even three operative sittings being

required. It is more tedious and less brilliant than the surgical method, but it is not accompanied by liability to hemorrhage. It is not to be indorsed as a universal substitute for the surgical method in even this limited class, but it is a serviceable measure for exceptional cases: (1) for quite small spurs and thickened areas; (2) for patients of delicate physique and those of highly sensitive and uncontrollable organization; (3) for "bleeders"; (4) for those who decline the surgical method.

2. Electrolysis will not thoroughly remove spurs which belong to the large class of mixed cartilaginous and bony substance, but it will reduce them in size. The majority of such cases would therefore better be treated surgically, as being the more thorough method; but instances will arise, as above indicated, in which the surgical method being inexpedient, benefit may accrue from the use of electrolysis.

3. Large spurs composed mainly of hard bone cannot be successfully treated by electrolysis, for the reason that needles cannot be caused to penetrate properly, and further, it is doubtful if the process is adequate, even if the needles should penetrate, to the resolution of hard and dense bone *en masse*.

4. Electrolysis is powerless to correct deviated septa of any form.

Electrolysis has, of course, not been advocated for deviations. It is a destructive method in which superfluous tissue is removed. In regard to the action of electrolysis on bony tissue, it has been shown by Althaus that no animal tissue can resist the disintegrating effect of the galvanic current at the negative pole. In these investigations, the various stages of the experiment were checked by microscopic observations. At the same time, the action of such currents on osseous tissue in the nostrils is so slow in its effects, that it should only be used in exceptional cases. The more radical measures, such as the mechanical saw, give more rapid and satisfactory results in the majority of cases.

Even this conservative operation is not to be recommended in "bleeders," as puncture with the electrolytic needle may produce a severe hemorrhage, but especially on account of the possibility of a secondary hemorrhage developing on the liberation of the slough.

It has been shown by William L. Ballenger (315) that in electrolysis, the primary and secondary action is to be taken into account. By primary electrolysis is meant the chemical dissolu-

tion of the elements composing the tissues. Secondary electrolysis refers to those changes which occur owing to the presence of the chemicals liberated by the current. The primary action takes place during the time when the current is passing through the tissues, while the secondary occurs so long as the newly liberated chemicals, hydrogen and alkalies or oxygen and acids, remain free in the tissues. In some cases, this may continue active for several days, and should be taken into account in the after-treatment.

In regard to the strength of the current and the duration of the applications, it is impossible to fix any limit, unless the size of the thickening and its character be first known. While a current of 20 milliamperes may be used with impunity in a large enchondromatous thickening, provided the needles are not brought too near the opposite edge of the septum, the same current would develop a perforation in a less prominent cartilage, unless the application be made of very short duration.

The strength of the current is also influenced by the method which is used, a much stronger current being tolerated in the bipolar method, in which the electric energy is expended within a very small area, than in the unipolar, in which the current has to traverse a considerable amount of tissue, and may thus set up subjective sensations of a very disagreeable character.

The bipolar method should be used wherever practicable, especially where the growth is of considerable size. Where the unipolar method is used, the negative electrode should be inserted into the growth, a large dispersing electrode being applied to the cheek of the same side, a small intensity of current used, and the application should be of longer duration on account of the weakness of the current.

Most authors advise that the dispersing electrode be applied to the back, but an extensive experience has shown that the nearer the dispersing electrode is to the active, the more direct is the passage of the current through the tissues, while, if they are separated by a considerable distance, the waves of electric force will pass in extensive curves, which may include the cerebrum and important nerves, and develop subjective symptoms, such as gustatory sensations, flashes of light and vertigo. Where, therefore, for any reason the bipolar method cannot be used, the dispersing electrode should be applied to the face or neck as near as possible to the active electrode.

NASAL SYNECHIA.

Nasal synechiæ, or adhesions between opposite parts of the nostril, as of the turbinal and septum, are much more frequently met with since the use of the electro-cautery, and often result from septal operations in the hands of inexperienced rhinologists. These adhesions are sometimes corrected by the electric methods. The electro-cautery has frequently been used for this purpose, but it should be limited to mild cases in which the adhesions are not of an extensive character.

Electrolysis for synechia is advocated by Moritz Schmidt (54), who hopes that this will be of valuable assistance in relieving this condition. Hugo Hecht, of Heidelberg (516), has also had some success with electrolysis in these cases. This method, however, does not seem to present any advantage in this condition, and in fact would easily tend to aggravate the extent of the synechia. I have found that the most successful and conservative method of remedying this condition, where the adhesion is extensive, is to pass a cold snare around the synechia, cut through the bands by tightening the snare, and prevent the adhesion from re-forming by the insertion of a thin piece of celluloid.

SIMPLE ULCER OF THE NASAL SEPTUM.

The simple ulcer of the septum, which is formed most frequently at the inferior anterior part of the quadrangular cartilage, is a troublesome condition and sometimes leads to perforation. The electro-cautery in these cases is not advisable, as it causes further loss of tissue. The method which I have found the most useful in treating these ulcers is the application of cupric electrolysis, a mild current being used. In this procedure, there is no destruction of tissue, and the oxychloride of copper, which is deposited, stimulates the sluggish circulation to a healthy reaction and destroys any microbes which may exist in the tissues. These applications are made at intervals of three days, an ointment of one grain of yellow oxide of mercury to two drams of vaseline being applied twice daily.

In cases in which there is a dry atrophic spot on the septum, but without the ulcer, I have found this treatment efficacious. In syphilitic lesions, this is also, where applicable, a most useful form of local treatment, constitutional remedies and cleansing washes being also of the first importance.

In tubercular ulcers and in lupus of the nasal mucous membrane, the electro-cautery is sometimes efficacious. Cozzolino, of Naples (467), has successfully used the electro-cautery in the latter condition, destroying the exuberant granulations by repeated applications, the resulting wound being treated on general antiseptic principles. Cupric electrolysis would seem to offer the best results in both of these conditions in the same manner that it is useful in tubercular affections of the larynx.

FOREIGN BODIES.

Electricity may also be used for locating foreign bodies of a metallic character in the nostrils and other parts of the respiratory tract as well as in other regions of the body. A telephone receiver and a small battery is used for this purpose, a dispersing electrode being placed in the hand or other available part of the patient. When the metallic sound, connected with the battery circuit, comes in contact with the metallic body, it is indicated by the sound in the receiver.

The usefulness of this method is limited in this region, but where a bullet is imbedded in the tissues or has fallen into one of the accessory sinuses, it is a useful diagnostic measure. The Roentgen rays now form a useful method of locating these metallic bodies.

Electricity has also been used for a novel purpose by Voltolini (477), who, from a number of experiments on small animals, advises its application for the removal of larvæ from the nasal passages. He found that these insects were numbed by a moderate constant or faradic current and were killed after its long application. He states that when the direct current with the interruptions is applied, the larvæ begin to move about rapidly and to creep away, usually against the direction of the current. He does not find it necessary that the electrodes should come in contact with the larvæ.

This method is not to be recommended on account of the fact that the mucous membrane of the nose is very sensitive to electric excitation, and also the neighborhood of the important nerves and the brain. From personal experiments, I have found that larvæ and insects generally resist the action of currents which are quite painful to human beings.

CHAPTER XXVI.

Diseases of the Accessory Sinuses.

In the treatment of the antrum, the trephine operated by the electric motor has been extensively used. The location of the opening varies according to the views of the individual operator. Lennox Browne (126) and others prefer the perforation of the cavity through the socket of a lost tooth, or the removal of a decayed one which is thought to be the cause of the empyema. Other operators have selected the canine fossa, inferior meatus etc. Each of these locations has its special indications, but Cooper's operation should be given the preference where there is a sufficient space in the alveolar process or a decayed tooth which can be removed to facilitate the operation. This procedure may be done quickly and with but little pain, and it does not prevent more radical measures where indicated.

The electro-cautery has also been used for making an opening in the maxillary sinus, and Bayer, of Brussels (317), recommends this method. He enlarges the normal opening in the *hiatus semilunaris* by the electro-cautery, and he reports a case of empyema of the antrum of Highmore which was thus cured in a short time.

This procedure, however, is not to be recommended; first, because it is more difficult than the other methods of puncture, and secondly, because the cicatrix, due to the cauterization of the normal opening, will leave a tendency to a stenosis of the *ostium maxillare*, which might prove more embarrassing than the empyema for which the puncture was made.

The treatment of empyema of the accessory sinuses by the electro-chemical method is advocated by G. Spiess, of Frankfurt a. M. (318). A hard-rubber tube is inserted through the artificial opening into the antrum. The cavity is then filled with a solution of common salt (ClNa), and the head leaned towards the affected side so that the natural opening of the cavity will be at the upper part. A copper wire is inserted through the hard-rubber tube, which is thus placed in contact with the salt solution. The posi-

tive pole of the current is connected with this wire, and the negative pole, a dispersing electrode, is applied to the outer walls of the cavity. Instead of the copper wire being passed through the rubber tube, the tube itself may be made of copper properly insulated on the outside. The copper is gradually absorbed by the electrolytic action of the current. Spiess recommends a current of 10 to 15 milliamperes to be used in this method.

The results which he has obtained thus far are not sufficient to allow him to give a positive opinion of this method, but still they are sufficiently satisfactory to lead him to believe that this method has a useful influence in this disease.

I have recently treated suppurative diseases of the accessory cavities and of the ear by means of *ozone* (229). The most economical and practical method of generating ozone for this purpose is the ozonizer first described by Siemens. A sort of Leyden jar is prepared by coating the interior of a long glass tube with tinfoil, and passing over this a second, wider tube, also coated with tinfoil on its outer surface. Between the two tubes a current of oxygen is passed, which becomes electrified by induction, the inner and outer coatings of tinfoil respectively being connected with the terminals of a strong induction coil. By this means it is possible to convert 10 to 15 per cent. of oxygen passed through the ozonizer into ozone.

Pure ozone is a powerful oxidizing agent; it possesses strong bleaching and disinfecting properties, and attacks cork, rubber and other organic substances.

The simplest test for ozone is to moisten a piece of blotting paper with a solution of iodide of potash, and the exposure to the ozone liberates the iodine, which shows its characteristic brown color. Ozone is a rapidly oxidizing agent, and in sufficient degree of concentration is very irritating to the mucous membrane of the respiratory passages.

In my first experiments with ozone for its therapeutic effects, the ozone was generated directly from oxygen and then diluted sufficiently for local application to the affected regions.

The ozone in this degree of concentration, however, proved difficult to handle on account of its rapid oxidizing effect, especially as it quickly attacked rubber. I then concluded to prepare the ozone directly from the oxygen found in the atmosphere. This was not only more economical, but the ozone could be used directly, as it was prepared in the required degree of dilution.

In order to eliminate the nitrogen products, developed by this procedure, I at first passed the ozone through an U-tube containing a small quantity of caustic potash. In testing the results, however, I found that the nitrogen products were so infinitesimal in character that they could be neglected. I therefore dispensed with the U-tube and alkali.

In applying ozone in the treatment of the nose, accessory sinuses or the ear, the apparatus is arranged as follows (Fig. 122): the ozonizer is connected with the induction coil, for which the

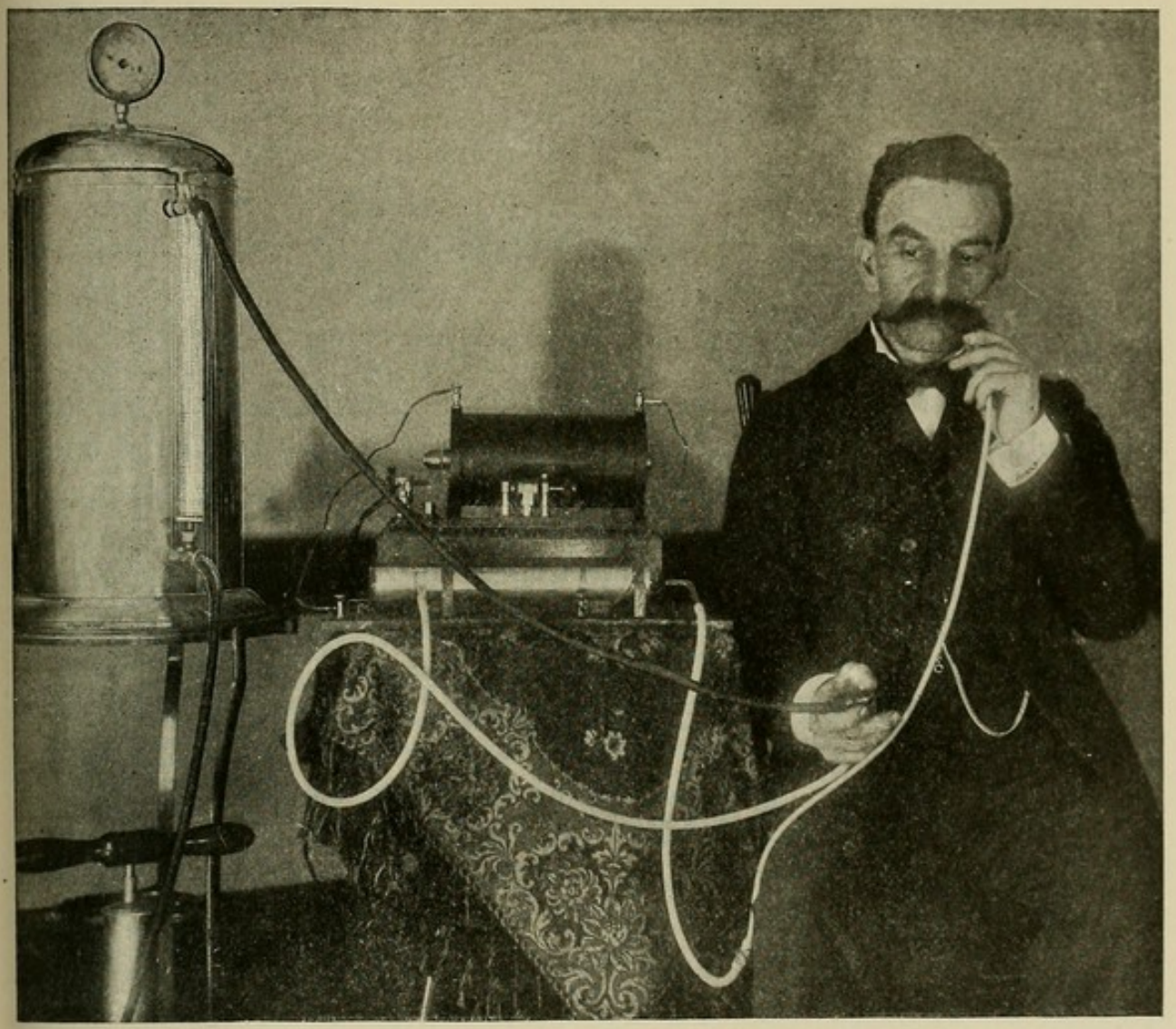


Fig. 122. Apparatus for the Generation and Application of Ozone.

inductorium used in generating the X-rays is especially adapted, although a smaller coil, as, for instance, one which will give a two-inch spark, is of sufficient strength for the ozonizer. The compressed-air reservoir is then connected with the inlet tube of the ozonizer in such a manner that the patient can control the cut-off which supplies air to the apparatus (Fig. 122). By means of a

rubber tube, the special canula for applying the ozone to the nose, ear or sinus is connected to the outlet tube.

The canulæ which are used for applying ozone to the various regions are shown in Fig. 123. *A* is the canula for the frontal

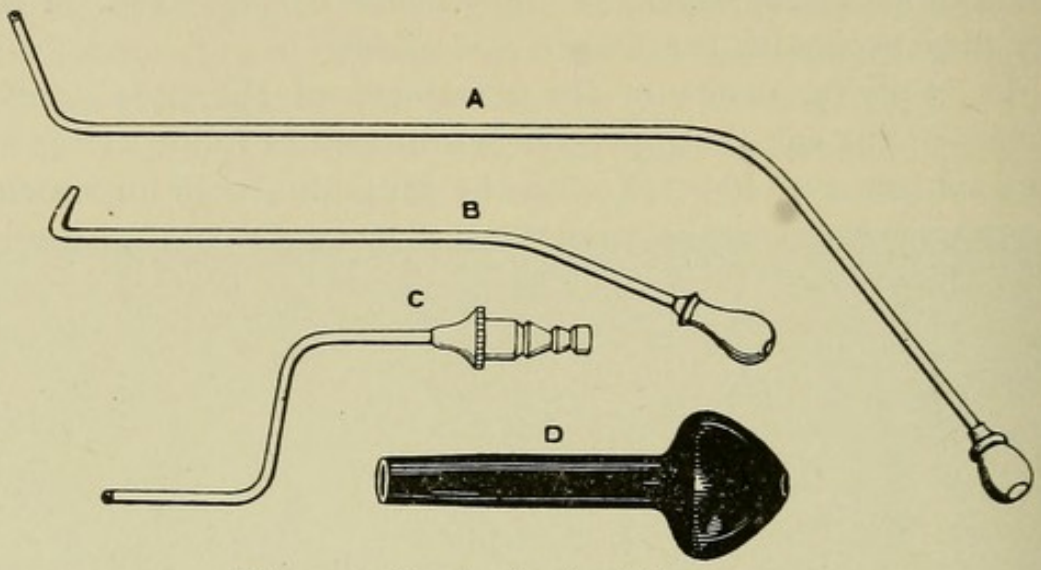


Fig. 123. Canulæ for Applying Ozone.

sinus; *C*, for the alveolar opening of the maxillary sinus; *B*, for the normal opening of the maxillary sinus (ductus maxillaris), and *D*, the nasal tip for ozena. The canula *C* is also the most practicable instrument for applying ozone to the ear.

In some cases it is advisable to heat the ozonized air before applying it to the desired region, and this is easily effected by passing it through a bent tube inserted into a bowl of hot water. The ozone should be heated only to the normal temperature of the body, as a much higher temperature causes a breaking up of the atomic arrangement of the ozone.

Great care should be taken in properly adjusting the valve of the condenser, so that only a mild current of air is passed into the ozonizer. If too strong a pressure is used, an excess of air is admitted and the ozone is diluted too much. Where the object is to diminish the proportion of ozone, I have found it more practicable to do this by regulating the induction coil than by increasing the amount of air.

In applying ozone to the nose or accessory cavities, care should be taken that the patient does not inhale the ozone. This may be avoided by allowing the vapor, which is under the control of the patient, to pass only during the acts of expiration, the cut-off being closed during inspiration. The applications need not be made for more than 10 to 20 minutes, and should be repeated not oftener than two or three times a week. As regards the consti-

tutional effects, I have noticed, in some cases, headaches which persisted for several hours after the treatment, but in each of the cases in which this occurred, it could always be traced to the fact that the patient had not controlled the cut-off properly, and had inhaled a considerable amount of ozone. Where the method was carried out correctly, no bad effects were ever complained of.

The local effects of this treatment are not only good, but frequently striking. In a case of antral disease, in which the discharge had been profuse and purulent, after the second application the discharge almost entirely lost its purulent character and diminished very much in quantity. After 14 treatments, during a period of ten weeks, the case appeared cured, and the artificial opening in the alveolus was allowed to close.

In a case of maxillary sinusitis combined with empyema of the frontal sinus, which had been treated by oxygen without success, a similar change in the quantity and character of the secretion took place, and the treatment resulted in a cure. In five cases of chronic suppurative otitis media, which have been treated by this method, in three the suppuration has ceased entirely, in the fourth there is still an occasional discharge, and in the fifth case the character of the discharge has improved very much, although the treatment has not been continued sufficiently long to give definite results.

I have also used ozone in five cases of ozena, and the results thus far have been encouraging. This, however, is a pathologic condition of such a chronic character, that I abstain from comparing the results obtained with those following other methods until I have had them under observation for a longer time.

As regards the bacteriologic investigation of this subject, I find that ozone not only inhibits the development of the cultures from the micrococci pyogenes aureus and albus, and other microorganisms, but also destroys these germs in the culture medium. Where the ozone is present in sufficient quantities, even the culture medium is attacked and oxidized.

Ozone is a most useful agent in the treatment of suppurative diseases of the nose and ear, but it should be used with the precautions that are required with other agents of this kind. Bichloride of mercury has powerful corrosive properties, but this does not debar us from using it in its diluted solutions for its excellent antiseptic qualities, and the same principle refers to ozone. When used as described, I have seen only good results from its application.

CHAPTER XXVII.

Diseases of the Pharyngeal, Faucial and Lingual Tonsils.

PHARYNGEAL TONSIL.

THE electro-cautery and other electric methods have been extensively used in the treatment of the pharyngeal, faucial and lingual tonsils. For the removal of the pharyngeal tonsil, the various cutting methods, such as with the curette of Gottstein or its modifications, the Schuetz's lymphatome more recently suggested, and the many other forms of curettes, are the most rapid and efficacious for removing these hypertrophies.

The electro-cautery is sometimes used as a bloodless method of destroying the tonsil, as a whole or any part remaining after cutting operations, in patients who have sufficient self-control to permit this manipulation. This method is not approved of by Fletcher Ingals (84), as he considers it painful, tedious and not altogether satisfactory. It is also objected to by Lennox Browne (126), because, even in skilled hands, it not infrequently leads to acute inflammation of the Eustachian tube and tympanum.

This method is not practicable in children on account of the difficulty of keeping them in the proper position, but in certain cases in which the adenoids are so spread out as to make it difficult to eradicate them with the ordinary curettes, and where a cutting operation is refused, I have used this method with advantage and without untoward results. The inflammatory complications of the Eustachian tube and tympanum are not limited to the electro-cautery applications, and many cases have been reported in which this has followed the use of the finger or curette, and, no doubt, there are many more cases of this complication which have not been reported.

For post-nasal cauterization, in order to diminish the risk of accidentally burning the velum in withdrawing the cautery, or to avoid injuring other parts, MacDonald (213) has devised an instrument in which the electro-cautery point is protected with an

ivory shield. This is hinged to the conducting rods, its termination projecting below the hinge in such a manner that it can be protruded from its shield by a lever extending to the handle of the instrument. This lever is operated by means of a trigger, which at the same time approximates the point to the posterior wall and closes the circuit, thus heating the point. As has been stated in referring to the protected nasal cauteries, this instrument has a limited usefulness and its additional safety is more than overbalanced by the inconvenience of its application.

An electric curette has been devised by L. Rousseau, of Brussels (319). In this instrument, which is made of various sizes, the cutting edge is replaced by a wire which is electrically heated, thus burning through the tissues instead of cutting as with the ordinary curette. Rousseau (320) believes that the operation of adenoid growths with these curettes is the safest method against all complications in this region, such as hemorrhage, septic infection etc., and he regrets that this method is not more extensively used. He also believes that, as it is a bloodless operation, it is less apprehended by the patient.

Where a bursa giving rise to a post-nasal secretion is found in the naso-pharyngeal cavity, it should be thoroughly curetted and cauterized by the electro-cautery. This subject has received considerable attention from L. G. Tornwaldt, of Dantzig (287), who ascribes great importance to this as an etiologic factor in catarrhal diseases, and who advises its treatment by the electro-cautery.

FAUCIAL TONSILS.

The faucial tonsils have received a large share of attention, and the various methods of treating them form a considerable part of laryngologic literature. Even at the recent meetings of the laryngological societies (321, 322, 323), this subject was discussed at considerable length without any great unanimity as to the methods advocated.

The electric methods used in hypertrophy of the faucial tonsils are the electro-cautery, electrolysis and the galvano-caustic snare; electricity has also been utilized in the tonsillotome so as to make the electrically heated wire the cutting edge.

From the result of his experience in tonsillotomy, Felix Semon, of London (324), states the following conclusions:

1. If the patient is under 20 years of age and the tonsil projects prominently, he prefers the cutting operation. Under

similar circumstances when the patient is over this age, he lets him select between amputation and the electro-cautery application, after having explained the advantages, the after-effects and dangers of both methods.

2. If the tonsils are markedly hypertrophied and almost or entirely covered by the pillars, he prefers the tedious but safe method of the electro-cautery.

He states in conclusion that full enucleation of the glands is not only dangerous, but also superfluous, and it is usually sufficient to reduce them to their normal size.

The electro-cautery is advocated by Auspenski (325), not only in adults but even in children. Quenu (326) is of the same opinion. Chas. M. Shields (327) warns against the use of the tonsillotome in adults, especially in cases in which the tissue is of a hard, fibrous nature. He has seen a dangerous hemorrhage only once in 500 cases, but this is quite sufficient to make us lay aside the tonsillotome in these cases for a more safe method—the electro-cautery.

The cutting method for the removal of hypertrophied tonsils has been abandoned by J. B. Kellogg (328) in favor of the electro-cautery. He states that in tonsillotomy the stump will sooner or later develop the original growth, as the gland is rarely removed in its entirety, while this is not the case when the cautery is used. Every one of large experience, however, has seen many cases in which the tonsils were removed with the tonsillotome, in which there was no recurrence, and, on the other hand, cases are not infrequent in which the tonsils have been reduced by means of the electro-cautery in which recurrence has taken place.

The indications for galvano-puncture for hypertrophy of the tonsils are pointed out by Chas. H. Knight (329), who limits it to the four following conditions: (1) when an anomaly of the blood-vessels is observed; (2) when the tonsils are deep-seated, diffused and, perhaps, even adherent to the pillars so that they cannot be well reached with the tonsillotome; (3) in hemophilia, and (4) where the patient absolutely refuses a cutting operation.

He advises as few sittings as possible, providing the patient tolerates a number of punctures at one sitting. He also recommends the galvano-caustic snare, if the patient is willing to stand the greater pain of this operation.

In an elaborate paper on this subject, Desiré (330) compares the results of tonsillotomy with those of the electro-cautery. He

favors the former and believes that the dangers resulting from tonsillotomy have been much overestimated. On the other hand, B. Robinson (331) warns against the too extensive use of the tonsillotome, and describes the untoward results which may follow its application. He advises the electro-cautery for the extirpation of crypts filled with caseous secretions, and considers this a more rational method than total or partial extirpation.

In using the electro-cautery in hypertrophies of the tonsils, the cautery point is inserted well into the lacunæ and the cautery then heated for a few seconds. After the cauterization of each lacuna, a flat cautery electrode is passed over the surface of the tonsil. The slough is discharged during the following week, and the tonsil reaches its maximum shrinkage in about four weeks. Where the patient tolerates this procedure, which may be rendered painless by cocaine, a repetition is needed only in exceptional cases.

This method is also advocated by Edwin Kuh, of Chicago (332), and by T. P. Hudnut, of Needham (333), who states that he has used galvano-puncture at least 500 times for hypertrophied tonsils and that it has never given rise to pain or caused bleeding, and he has found a solution of cocaine of from four to ten per cent. sufficient in all cases.

In view of the hemorrhage which he has seen follow the removal of the tonsils, which had to be seized with vulsellum forceps and drawn into the tonsillotome for excision, E. Fletcher Ingals, of Chicago (334), prefers the electro-cautery. A few applications will reduce such a tonsil to one-half its size, which will remove the great tendency to recurrent inflammation. He uses a platinum point about one-half inch in length, the current being regulated to heat it red in about a second. He presses the full length of the point into the tonsils and makes two or three cauterizations at each sitting. In the removal of these glands, he cauterizes without reference to follicles, but where they are larger, the platinum point is introduced into the follicles and moved about so as to completely destroy them.

Where the tonsils are adherent to the pillars so that they cannot be separated by a bent probe, Carl Seiler (335) recommends the electro-cautery knife. This method has been further developed by Pynchon, of Chicago (336), who not only dissects the tonsils from the pillars by the electro-cautery, but also uses it for removing all the diseased tissue which is to be extirpated. In anæsthe-

tizing the tonsils, he prefers a hypodermic injection of cocaine into the mucous membrane of the pillars by means of a special syringe, but the ordinary syringe with the special point for tonsillar injection is usually sufficient. Adhesions between the tonsils and the pillars of the palate are first destroyed by the cautery, and then the top of the tonsil seized with a tenaculum and drawn towards the median line and its separation completed by repeated applications of the cautery knife. He recommends that one tonsil should be removed at a time.

In a later article, Pynchon (337) describes a variety of cautery points bent at angles from the shaft varying from 30 to 90 degrees, with the bend either vertical or lateral from the line of the handle (Fig. 124), and as these are reversible, the former can be

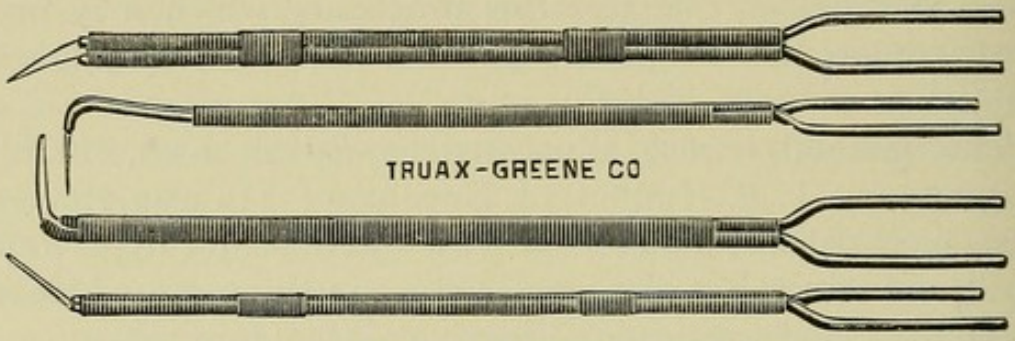


Fig. 124. Pynchon's Electro-Cautery Points.

directed either up or down, and the latter either to the right or left. The cauteries five and a half inches in length have been found the most convenient.

In a personal communication to the author, Pynchon states that he has now somewhat modified this operation, in order to avoid the hemorrhage which sometimes follows the application of this method. By applying a 25- to 50-per-cent. solution of argentic nitrate, hemorrhage rarely develops. Secondary hemorrhage is avoided by the internal administration of iron and by making the patient sleep in a semi-recumbent posture for two or three nights after the operation. To prevent severe reaction, the operation is sometimes divided into two or more stages at intervals of one week, only a part of the tonsil being removed at each sitting. With these modifications he has rarely seen complications develop.

Cautery dissection is also advocated, with some modifications, by J. Holmer Coulter (338), who prefers this to all other methods. He dissects out one-half of the tonsil and applies a strong solution of nitrate of silver, and within a week or ten days the other portion of the tonsil is removed in the same manner.

An instrument which is of deserved value in the treatment of hypertrophies of the faucial tonsils is the *electro-caustic snare.* With this we are able to remove an hypertrophied tonsil almost as rapidly as with the usual cutting instruments, without the danger of hemorrhage which may result from the latter. In using the snare, the wire should first be tightened so that when the heat is applied it will not radiate or come in contact with the extra-tonsillar tissue. Were this point always observed, we would have little complaint of the pain following this operation.

In young children where the tissues are soft and retractile, the ordinary tonsillotome is, in the majority of cases, the most useful instrument. Where the tissues are more dense, as in older children and in adults, the possibility of hemorrhage should not be overlooked, and the more conservative methods, the electro-cautery and electro-caustic snare, should be given the preference, the latter having the advantage of being more rapid and radical in its operation.

The galvano-caustic snare is advocated by Knight (339), Loeb (340), M. Schmidt (54), Garel (342), Heryng (343), Sendziak (344), Lichtwitz (345), Hélot (346) and others. In 400 operations with the galvano-caustic snare, both in children and in adults, L. Lichtwitz, of Bordeaux (345), has never seen more than a trifling amount of hemorrhage. Hannau W. Loeb (347) has had 300 tonsillotomies with the electro-caustic snare, with practically no bleeding.

A modified electro-caustic snare for tonsillotomy has been devised by Chas. H. Knight, of New York (348). This instrument (Fig. 125) is so constructed that the snare may be applied to the



Fig. 125. Knight's Electro-Caustic Tonsil Snare.

hypertrophied growth with great facility. It consists of a double canula attached to, and insulated from, a steel shaft terminating in a ring. The ring is intended to go over the tonsil, and carries with it the loop of wire attached to it by a thread. This ring answers the double purpose of facilitating the application of the snare and also protecting the surrounding tissues from the heat radiated by the wire. In manipulating the instrument, the

ring should lie to the outside so as to push away the tongue and the palatal folds. The loop should be pulled down upon the tonsil as close as possible before the current is turned on. Knight prefers electro-puncture when the tonsils are flat and adherent to the pillars, but the electro-caustic snare when they are protuberant.

Another modification of the electro-caustic snare has been made by K. Dusseldorf (341), in which instead of the contact being made by pressure on a trigger, as in the instrument first made by Schech, this is made automatically whenever pressure is applied to the thumb-ring in drawing up the snare. The model is similar to that of A. Hartmann's snare, with the necessary alterations for using it with the electric current.

The use of the electro-cautery is advised by Huguenin (349) in all cases of tonsillar hypertrophy: (1) when they are pediculated, with the electro-cautery snare; (2) when deep-seated, cauterization with the electro-cautery or thermo-cautery according to the age of the child, and (3) when they are pseudo-hypertrophic, discissions with a sharp galvanic hook.

The electro-caustic snare is also recommended by Sendziak (351) for the removal of hypertrophied tonsils, and he has never had unpleasant sequelæ.

This instrument is also considered by Lichtwitz (350) the best and safest method for reducing hypertrophied tonsils. He uses a steel wire, the electric current being furnished by a battery of accumulators. By this means the largest tonsils can be excised in two to four seconds, and in 400 operations there have never been complications. This author (352) states that, if the tonsil is pediculated, he tightens the snare before the application of the current; if, however, it has a broad base, he applies the current before tightening it so that the wire will burn a ridge in the surface of the tonsil. The operation should be completed in two to four seconds. If done too rapidly, it will not be effective in arresting hemorrhage, and if too slowly, it will injure the deep-seated structures from radiation of the heat.

This method is also preferred by Mounier (353), who finds that it has the advantage of rapid operation and complete hematosis. It is also recommended by J. M. Gleitsmann (354), who uses for his loop a wire of platinum and iridium—five to ten per cent. of the latter.

In order to determine the danger of tonsillotomy, Wright (355) has made a thorough research of the records of the past twenty-

five years in the Library of the Surgeon General at Washington, and succeeded in finding the report of thirty-one cases of hemorrhage. Of these, one-third were controlled by simple means, while several proved severe and two fatal. There is undoubtedly a considerable number of such cases, which have not found their way into medical literature.

A galvano-caustic tonsillotome has been devised by Wright, the model of which is similar to Mackenzie's tonsillotome, but the steel cutting blade is replaced by a platinum wire, which is connected with the circuit of a cautery battery. When this wire is heated, the tonsil is slowly cut through by means of the heat generated from the platinum wire, and thus the hemorrhage resulting from the ordinary method is avoided.

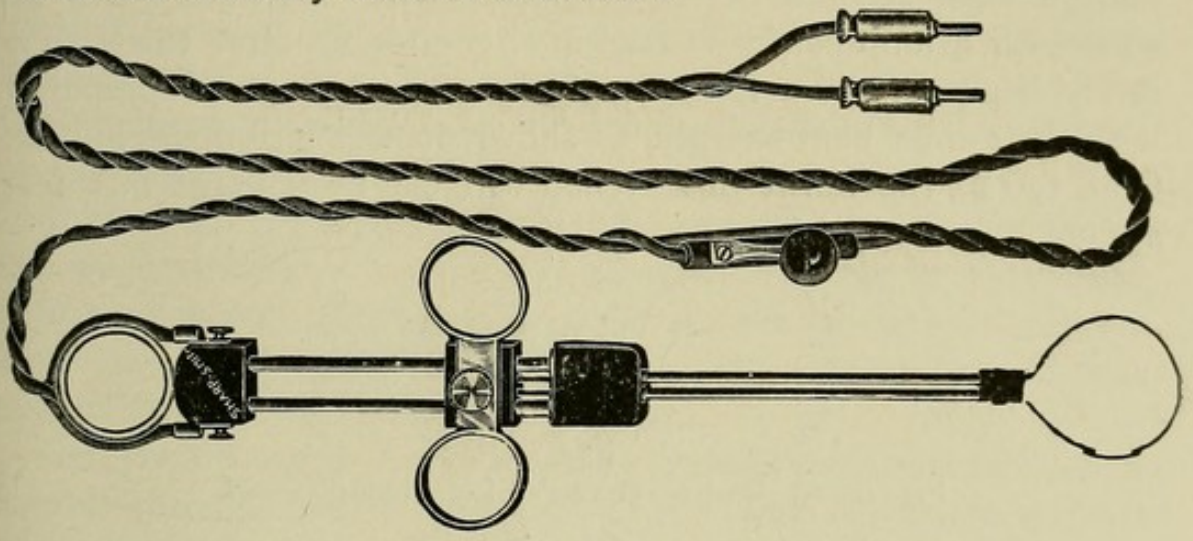


Fig. 126A. Gradle's Electro-Caustic Snare for Tonsillotomy.

Theoretically, this is an ideal instrument. An objection, however, is that it cuts more slowly than the electro-caustic snare, as the burning process takes place only at one side instead of the whole circumference of the tonsil. Another objection is that if the platinum wire becomes softened by heat and stretches, it will prevent the complete excision of the tonsil. A number of these tonsillotomes is also required, whereas with the electro-caustic snare one instrument is suitable for all operations.

An electro-caustic tonsillotome made on this principle has also been devised by Lichtwitz, in which the platinum wire has been substituted for the cutting blade of an ordinary Fahnenstock tonsillotome.

Among the useful electro-caustic snares which have recently been introduced is that of Henry Gradle (565), in which the loss of time incurred in wiring the snare in ordinary use is avoided. This

instrument (Fig. 126 A) consists of two parallel brass bars, 11 *cms.* long, mounted in rubber blocks at both ends. A third rubber block slides along the bars when guided by the fingers inserted through the rings on the block, while the thumb rests in the ring at the rear end of the handle. The sliding block holds two insulating steel stylets, which, when pushed forward, protrude through the two canulæ in front of the handle just far enough to allow a wire to be slipped through the eye in each stylet. The two canulæ, 9 *cms.* long and 2.5 *mms.* thick, are insulated by separation along their length and by a soft rubber tube slipped over the end, while their ends are strengthened by wire wound around the rubber insulation. Steel (piano) wire is a better material for the loop than platinum on account of its stiffness. The instrument can be used with a loop nearly 11 *cms.* in circumference, but this size is rarely required. If a few suitable lengths of wire are prepared with their ends bent sharply, as shown in the accompanying cut (Fig. 126 B), the burnt or softened wire can be replaced in a few seconds.

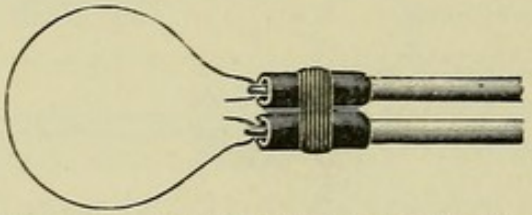


Fig. 126 B. Loop for Gradle's Electro-Caustic Snare.

This electro-caustic snare is certainly an improvement over the ordinary instrument in that it avoids the delay and inconvenience of passing the wire through the canulæ to the handle, as in the old instruments. The key for establishing the circuit, which Gradle has placed in the cable, is inconvenient, however, and does not compare, from a practical standpoint, with the foot-switch which has already been described.

One of the objections to the electro-caustic snare is the fact that when the length of the wire is shortened, the resistance to the current is decreased and the same quantity of current, which in its first adjustment brought it to a cherry red, which gives the best results for this purpose, is sufficient to make it white to the point of incandescence, and frequently the heat is so great that the metal is melted. When the wire becomes too hot it then acts like the knife and has no effect in preventing hemorrhage, which is one of the objects of this method. If the wire should fuse from the excessive heat, there is danger not only

directly from this, but also from the arc due to the counter-electromotive force of the broken circuit, although this is insignificant if a current of low voltage is used. While this may effect no material injury, the operator is compelled to readjust the snare, which is sometimes, as in the case of post-nasal fibroids, quite a difficult undertaking.

To prevent this effect, an assistant is needed to operate the rheostat so as to diminish the current in proportion to the shortening of the galvanic loop, and this is usually difficult when the loop is buried in the tissues. Another method is to rapidly make and break the circuit with the switch, which is even more difficult than the above.

To obviate this danger and to regulate the amount of current passing through the snare, W. Schleicher, of Antwerp (356), has devised a galvano-caustic snare in which a rheostat is placed in the handle of the instrument, which is so adjusted that the strength of the current is reduced in the same ratio as the snare is contracted, thus avoiding the overheating of the snare. Schleicher also suggests that, to avoid the great friction due to the passing of the wires through tubes, the wires should be exposed, all that is necessary being three rings on each side to keep them in their proper direction and to prevent contact.

An electro-caustic snare, which I have devised and which acts on this principle, is shown in Fig. 127. The resistance consists of German-silver wire which is coiled around a sheet of mica the same size as the handle of the snare, so that the rheostat adds but little to the size and weight of the instrument. The contact of the sliding piece is made through this wire, and, as the resistance of the loop is decreased, it is offset by the increase of the resistance of this coil, so that the heat of the snare is not materially increased. This rheostat may be added to the ordinary electro-caustic snare.

The wire loop écraseur for the removal of tonsils when very large is preferred by Lennox Browne (126), and especially when they grow down along the side wall of the pharynx, in which case it is difficult to apply the tonsillotome. He has applied the electro-cautery loop in one instance of this kind, and found that it possessed no advantage over the ordinary écraseur, and the after-pain of the eschar was much greater. He therefore does not recommend this procedure.

The cold snare, when applied in this condition, is a much slower

procedure and gives rise to considerable pain in spite of the application of cocaine. The galvano-caustic snare, however, when the wire loop is raised to the proper degree of heat, is so rapid in its operation that the pain is of short duration, and, after a considerable experience with this method, I have not found the pain of the eschar more severe than that following the cold snare.

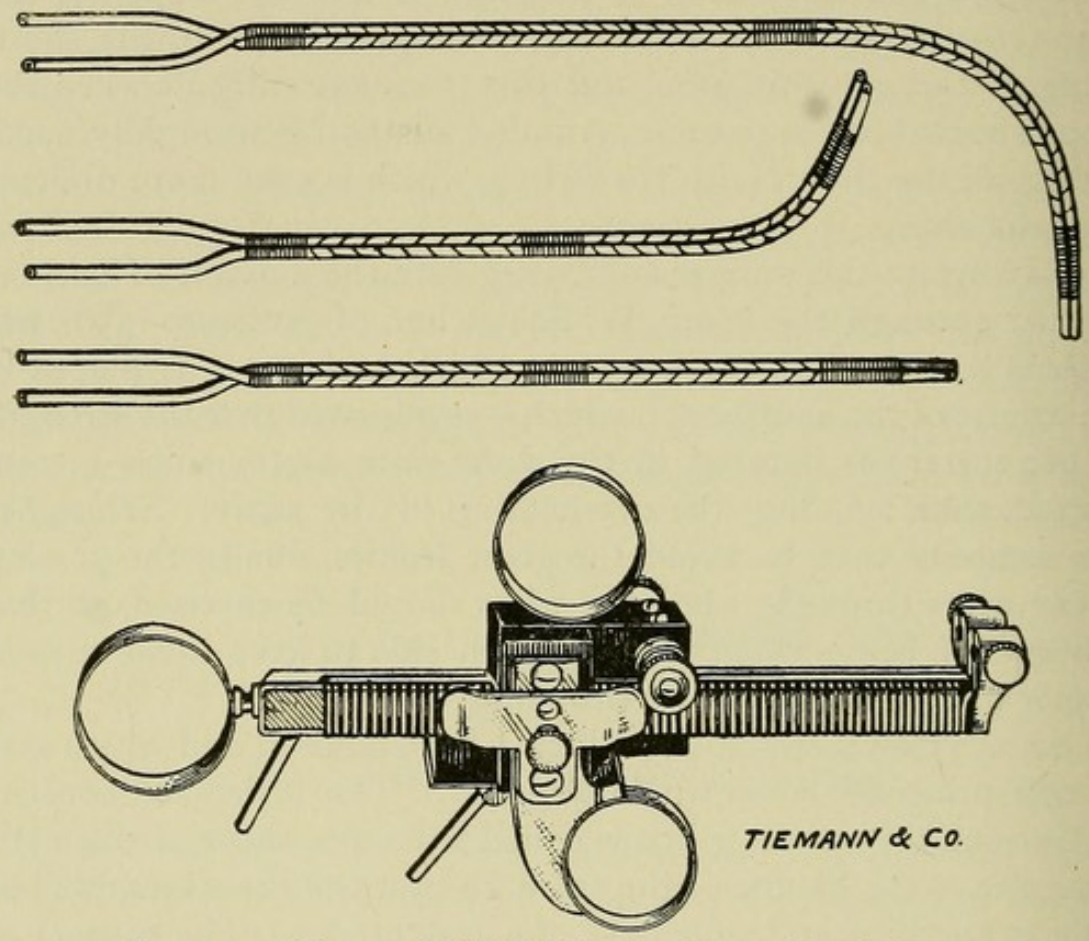


Fig. 127. Scheppegrell's Self-Adjusting Electro-Caustic Snare.

In order to obtain good results with the galvano-caustic snare, experience is necessary to apply the proper degree of heat and to use the correct pressure in tightening the loop. If the wire is allowed to become too hot, and the loop slowly tightened, the radiation of the heat causes a considerable destruction of tissue, which takes longer to heal and gives rise to much reaction. If however the loop is rapidly tightened, the effects of the radiated heat will be less, but the hemostatic effect of the cautery is not obtained.

On the other hand, if the heat is not sufficient, the contraction of the snare is so slow that the extended duration of time allows considerable radiation of heat into the surrounding tissues, which may cause marked reaction. When the proper degree of heat,

however, has been obtained, the wire cuts through smoothly and rapidly, and without hemorrhage.

Electrolysis has also been used in the treatment of hypertrophied tonsils, although to much less extent than the electro-cautery and electro-caustic snare. This is probably due to the fact that the method is more complicated and is slower in its effects than those which have already been described. Baumgarten, of Budapest (358), however, believes that electrolysis will be the method of the future in the treatment of these conditions.

A special electrode to be used in hypertrophy of the faucial tonsils has been described by Henry L. Coit, of Newark (359). The electrode consists of a shaft of steel insulated throughout its entire length with a movable hard-rubber sheath. The bifurcated needle is curved so as to include the tonsillar tissue in its grasp. It is made of platinum and is insulated to within a centimeter of the ends. The points are separated by pushing the steel shaft through the insulated sheath, and, by means of a thumb-screw, they are made to approximate each other and thereby caused to pierce the mucous tissue of the tonsil. The continuous current is used, the electrode being attached to the negative pole and the positive connected with the dispersing electrode.

Electrolysis has also been used by Heryng (360) for hypertrophied faucial tonsils, but he found the process so tedious that he discontinued it.

For the *hemorrhage* which sometimes follows tonsillotomy, the electro-cautery is one of the best expedients to be used, although the Paquelin cautery is of special value in these cases, as it presents a larger surface and is more easily transported. In two cases of hemorrhage after tonsillotomy, Fletcher Ingals (84) applied the electro-cautery, once with perfect success, but in the second case he had to resort to other means. He has also found the electro-cautery useful in tubercular ulceration of the tonsils. After the parts have been cocainized, the tubercular masses are each touched with the electro-cautery point, four or five being treated at each sitting, and the process repeated once in four or five days until the growths have all been destroyed. He states that there is but little tendency to recurrence of any of the masses which have been thoroughly treated by the electro-cautery.

The electro-cautery has been advised by R. A. Stirling, of Melbourne (510), in condyloma and deep syphilitic ulcerations of the tonsils.

Electro-cautery puncture in obstinate cases of *acute tonsillitis* is recommended by Fletcher Ingals (84). In carrying out this treatment, he advises that two or three punctures should be made at each sitting, and repeated at intervals of two or three days.

The treatment of follicular tonsillitis by *metallic electrolysis* is recommended by W. J. Morton (361). He reports two cases in which the tonsils were enlarged and covered with the characteristic grayish-white spots. Electric diffusion from a copper bulb was applied to each spot, one application being sufficient to effect a cure in both cases.

A somewhat similar report is made by Emily A. Bruce, of Boston (362), in which equal parts of tincture of iodine and fluid extract of belladonna were applied to the positive electrode.

The indiscriminate use of the tonsillotome is dangerous, as shown by the records of this operation. In 1890, 31 cases of severe hemorrhage following tonsillotomy were collated by J. Wright (508), two of the cases having proved fatal, the first being an adult and the second a child of eight and a half years.

In 1892, Heryng (509) also collated the available reports of this complication, numbering 59 cases. When it is remembered that the successful cases are more apt to find their way into literature than the unsuccessful ones, it will be easily understood that this method is not without its danger. It has been statistically proved that the danger from chloroform narcosis is not greater than one in 6000, still this has been considered by the majority of surgeons sufficient to abandon it for the safer method of ether narcosis.

The accessibility of the faucial tonsils enables us to treat them effectively by any of the described procedures, and the selection of the method should be governed by the indication of the individual case.

In children who have taken an anæsthetic and in whom rapidity of operation is essential and danger of hemorrhage slight, the tonsillotome is the most effective method, unless there is a hemophilic diathesis or other contraindication. In adults in whom the possibility of hemorrhage is not so remote, and in cases in which the tonsils are spread out or adherent to the pillars, which would make an operation with the tonsillotome ineffective or even dangerous, one of the other methods must be selected.

In patients over 15 years, when the tonsils are so formed that they may easily be caught in the loop, the electro-caustic snare is an effectual method, and the pain and reaction described by some authors who have used it may be avoided if proper care is exercised. After the wire snare has been passed around the tonsil and is in its proper position, it should be tightened as much as possible before the closing of the electric circuit. When the wires are well imbedded in the tissues, so that there is no danger from the radiation of heat to the pillars or other adjoining parts, the circuit should be closed and the snare firmly and steadily tightened. The heat of the wire should be adjusted before the operation so that a bright red is obtained, as a too intense heat would tend to melt and break the wire, while if this is not sufficient it would be too slow in its action and would allow too great a radiation of heat to the surrounding tissues. As the wires become shorter they tend to become more heated, which should be checked by an assistant controlling the rheostat, by rapidly breaking the circuit with a foot-switch or, preferably, by a compensatory rheostat in the handle (Fig. 127), which has already been described.

A steel piano wire of proper thickness has been found to answer every indication for the snare, while it is less expensive than the platinum or iridio-platinum wire which is sometimes used.

In cases in which neither the tonsillotome nor electro-caustic snare is admissible, we have the choice of the electro-cautery or electrolysis. In some cases the combination of the two methods is preferable. Where the tonsil is of considerable size, the double-needle electrode connected with the negative and positive pole respectively should be inserted into the growth, and a current of 10 to 20 milliamperes applied for five minutes, the points of the needles being about one-fourth of an inch apart, and the application repeated to the various parts of one tonsil at the same sitting. In this manner the tonsil may be rapidly reduced. After the parts have healed, I usually apply the electro-cautery to the points of the tonsils that have been left irregular by the electrolysis, so that a smooth surface is obtained. This is one of the advantages of the electro-cautery, in that it enables us to obtain smooth and uniform results, and I frequently apply it even in cases that have been previously treated with the tonsillotome or snare. The reduction of the tonsils by means of cautery dissection is also a useful expedient.

LINGUAL TONSILS.

The lymphoid tissue at the base of the tongue, which is sometimes developed to such an extent as to set up reflex disturbances, frequently demands local treatment. A number of methods has been suggested, such as the electro-cautery, electro-caustic snare, cutting operation, and chemical caustics, but the first is probably the most extensively used. It does not create the danger of hemorrhage which may develop with the cutting operation, and is more exact in its application than the chemical caustics.

The snare, either galvanic or cold, is useful, but the growth is rarely sufficiently developed to make it applicable. In the varicose condition of the vessels, which is sometimes found at the base of the tongue, Lennox Browne (126) also advises the use of the electro-cautery.

CHAPTER XXVIII.

Diseases of the Pharynx.

In follicular pharyngitis, two methods of applying the electro-cautery have been suggested. In the first, the destruction of the follicles with the heated point, which is recommended by Michael, Riesenfeld, Mackenzie, Stoker (363), Sajous (153) and others, Sajous recommends that six or seven follicles be cauterized at each sitting, while Seiss (364) limits the number to four or five.

The important part of the treatment, on the other hand, is believed by Lennox Browne (126) to lie in the destruction of the enlarged vessels which supply blood to the hypertrophic lymphoid granules, which constitute the so-called granulations. When these vessels are divided and obliterated by means of a fine electro-cautery point, he has seen the prominences shrivel and disappear in a very short time. He believes that this method is superior to the destruction of the granules themselves by the cautery.

A combination of both methods is recommended by Seiss (364) in cases where the superficial vessels are large and show evidences of varicosity, in which case he advises that the larger ones should be cauterized.

Electrolysis has its supporters in the treatment of follicular pharyngitis on account of its greater safety and the fact that the resulting cicatrix is more apt to be absorbed. De Tymososki, of Nice (365), prefers electrolysis not only in granular pharyngitis, but also in hypertrophy of the tonsils, chronic rhinitis and in many laryngeal conditions. Cupric electrolysis has also been used, and this is probably the most serviceable method, as it combines the advantage of direct electrolysis and the stimulating effects of the copper salts which are deposited in the tissues.

Electrolysis is preferred by Grünwald (366), who uses a current of 15 milliamperes for ten seconds, an intensity which I have never found necessary in this condition. He states that this

treatment gave relief in cases which had been previously treated with the electro-cautery and with chromic acid without success. The indication for this treatment, according to this author, is not the hypertrophy, but the severity of the reflex disturbances. He gives a record of 20 cases treated in this manner, and also considers this treatment the best for chronic obstructive rhinitis.

Chronic pharyngitis is usually the result of some abnormal condition of the nasal chambers, and the most efficacious treatment in such cases is directed to the nostrils. As a means of hastening the reparative process after the nasal passages have been treated, and in cases in which the nostrils have been permanently incapacitated for their respiratory function, as in the later stages of atrophic rhinitis, galvanism has proved more useful in my hands than other methods.

The application of galvanism in certain forms of pharyngitis is also recommended by E. L. Shurly, of Detroit (367). He believes that certain conditions of the pharynx, such as chronic hypertrophy, hypersecretions etc., are only the local expression of the disturbance of some other organ, as the stomach, intestinal canal etc., and warns against too energetic treatment of these as well as of other affections of these parts. He states that he has had the best results in the therapeusis of these conditions from galvanism, and recommends the following method: The mucous membrane is first cleansed, a four- to five-per-cent. solution of cocaine being used, and the electrodes applied for five minutes, one through the nasal passages and the other to the posterior and lateral walls of the pharynx, both being gently but firmly applied to the parts. He commences with a very mild current which is gradually increased in intensity.

While this method cannot cause the restoration of the tissues already destroyed, he believes that it has a beneficial effect on the mucous membrane so that it can perform its functions in a more normal manner.

To avoid the irritation from the direct application of the electrode to the throat, Sajous (2) utilizes water as a conductor, an ordinary bent electrode being used to make electric contact with the water. This allows such an equal distribution of electric energy, that cocaine is not necessary in this application. As the tissues are not touched directly by the electrodes, the benefit of the current is obtained by the mucous surfaces without involving any undesirable results of actual contact with the instruments.

The method is as follows:

"The patient having taken what is usually called a mouthful of water, in reality about an ounce, he is told to throw his head backward and open his mouth. The first movement of deglutition causes the water to fill the pharyngeal cavity. Light being thrown in, a Mackenzie electrode is introduced and simply immersed in the water, the external electrode, thoroughly wetted to secure penetration through the skin, being placed over the thyroid region. The current being then closed by pressing the button of the electrode, it is allowed to flow as long as the patient can hold his breath. The mouth electrode being then taken out, he can either by closing his mouth and bowing his head forward bring the water forward and take a few breaths through the nose, then renew the first movement, throwing the head backward, etc., or take another mouthful of water, after ridding himself of the first draught."

While this method is useful in a general application of electricity to the throat, it has the disadvantage of not limiting the treatment to any particular point, the tongue and other adjacent tissue, in contact with the water, receiving a portion of the application.

In tertiary syphilitic ulceration of the pharynx, Lennox Browne (126) has met with such marked success, both as to rapidity of cure and freedom from recurrence, from the employment of the electro-cautery, that this measure has largely superseded the use of mineral caustics in his practice. He calls attention to the necessity of the thorough cleansing of the parts of all coatings of secretion over the ulcerations before the local remedy is applied.

In specific ulceration of the nose, he has also had two cases in which the threatened destruction of this organ was arrested by means of the electro-cautery when other measures proved useless.

In view of the results which may be obtained in the treatment of chronic ulcers by the use of galvanism, I have been encouraged to use it in the treatment of indolent mucous patches which resisted the usual constitutional treatment.

The positive pole is applied to the back of the neck as the dispersing electrode, and the negative pole adjusted to an insulated wire to the end of which is attached a pledget of cotton saturated with a strong solution of salt water. In this case, we have not only the stimulation of the galvanic current, but also of the decomposed chloride of sodium.

In a case of mucous patches which had resisted the effects of large doses of mercury, iodine, and the combination of both, for several months, the patches disappeared after five applications, by the method above described, at intervals of three days each.

The parts were first anæsthetized with a five-per-cent. solution of cocaine.

In cases in which this application does not effect a cure, as in tertiary ulcerations, I apply spherical bulbs of pure copper attached to the positive pole instead of the negative, which seems to be more efficacious than the former method.

In *mycosis* of the throat in which the fungoid growths develop with a special predilection for the crypts of the faucial and lingual tonsils, the destruction of the parasite is usually effected by the application of the electro-cautery point to the crypts or other parts which form the site of the fungoid growth. This method is recommended by Heryng (368), Ingals (369) and others.

Cupric electrolysis would seem to be especially indicated in these cases. When the copper electrode, connected with the positive pole, is applied to the crypts, the electrolysis and the oxychloride of copper, which is developed around the needle, will destroy these growths, and the passage of the salt into the surrounding tissues will set up a reaction which is preventive against recurrence.

In a case of mycosis of the lingual tonsils, which had existed for several months in spite of various local applications, the part was first anæsthetized by a ten-per-cent. solution of cocaine, and a bent needle of pure copper, attached to the positive wire, was inserted into each growth successively, a current of three milliamperes being passed from two to five minutes into each of the affected spots.

Although this is a mild current, sufficient electrolytic action takes place around the needle to destroy the fungoid growth, and the oxychloride of copper, which is generated, furthers this action and also tends to restore a healthy tone to the affected area. The first application was successful in reducing all but three of the mycotic spots, and the cure was completed by the second application. Occasionally the needle becomes adherent at its point of insertion, and, where it is not easily loosened, it may be released by reversing the current for a few minutes.

The electro-cautery may also be used instead of the knife or scissors in operations on the *uvula*. It is of special benefit where there is a disposition to bleed, and in some cases it is better tolerated where the patient fears the sight of the cutting instrument. F. A. DeBlois, of Boston (370), states that the pain and reaction from this are less than with other methods.

In *paralysis of the palate*, which is a frequent sequela of diphtheria, electricity is of use in the diagnosis as well as in the treatment. When the paralysis is of central origin, the application of the induced current will cause contraction of the muscles, which will not be the case if atrophy of the muscles has already developed.

In testing the electric reaction of the palate as well as of other muscular structures, the important considerations are the degree of contractibility, the amount of sensibility, and the amount of resistance. In testing the reaction of a muscle, the current may be either from the periphery to the center, or from the center to the periphery. The direction of the current materially affects the result. At the negative pole, there is an increase of excitability, while at the positive there is a diminution. With the negative the closing gives the maximum effect, while in the opening, the maximum is at the positive.

In testing the effects of the closing and opening of the circuit, this should be of a decided character, and by a metallic interrupter and not by means of the rheostat. This should first be adjusted so as to admit a light current, and then the opening and closing made by means of the metallic button. The results given by the slower method of the rheostat are of a different character from those already stated and they may be entirely absent.

The galvanic and faradic current may be used for differentiating between central and peripheral lesions of nerves, in determining the existence, decrease or increase of pathologic excitability, and in the detection of simulation.

Galvanism is valuable in the treatment of paralysis of the pharynx, and a useful method is the one suggested by Sajous (2), which has already been described in the treatment of chronic pharyngitis. It is also favored by Gessler, of Stuttgart (371), who reports a case of paresis of the velum palati of six months' duration, which developed after an apoplectic attack. The right half of the tongue and of the palate were anæsthetic. This case was treated by galvanism (17 sittings) for two months, and resulted in a cure.

Faradism is also recommended in paralysis of the palate by Seiss (364), who uses the negative pole for the local application. The electrode is either applied directly to the parts, or by means of water held in the mouth, as in the method of Sajous.

In paralysis of the muscles of deglutition, Schech (80) advocates the use of electricity. He applies a laryngeal electrode, connected with the negative pole, directly to the paralyzed muscles and the dispersing electrode to the walls of the neck.

Where it is desired to stimulate the gustatory nerve, this may be done by applying a piece of zinc to the upper part of the tongue and a piece of silver to the lower. When these two metals are brought in contact, the action of the saliva on the metals develops a mild galvanic current, which gives rise to an acid taste under the zinc plate and a slight alkaline taste under the silver.

The same effect may be produced by applying two electrodes to the tongue, and, in some cases, even when these applications are made at a distant point, this gustatory effect being frequently observed when the applications are made to the ear. This metallic taste persists as long as the galvanic circuit is closed, and occasionally for some time afterwards. When the faradic current is applied, this effect is usually absent, although it is occasionally noticed by some persons, but to a very mild degree.

This subject has been carefully investigated by L. Hermann (460), who found that the gustatory sensation developed by the galvanic current increased very gradually with the strength of the current; is acid with the increasing current, alkaline with the decreasing and less acute than the acid. With medium and strongly increasing currents, there is developed in the parts adjoining the palate and tongue a countertaste (*gegengeschmack*).

The susceptibility to the electric taste in various individuals and in the same individual at various times, is different. The reaction of the organ of taste to the galvanic current is incomparably higher than that of any other organ of sense. Induced currents are only efficacious in producing this reaction when they are very strong, and then only an acid taste is perceived. Variations in the constant current weaken the effects; the acid taste of the increasing current is distinctly observed with the other taste, but not the alkaline with the decreasing current.

Cocaine weakens the gustatory reaction, or may even cause it to disappear entirely. The electric taste is also present in the epiglottis. The portions of the tissues in which these variations are produced are in the extreme periphery. The electric taste is due exclusively to the nerve endings in the mucous membrane.

CHAPTER XXIX.

Neuroses of the Larynx. Diphtheria.

THE use of electricity in diseases of the larynx has a wide range of applicability, and the various methods, such as the electro-cautery, electrolysis, cataphoresis and vibratory massage, have all been used in this region. The electro-cautery and electrolysis are of special value in neoplasms of the larynx, a subject that has already been discussed in a previous chapter.

The motive power of electricity has also been utilized for diagnostic purposes in the laryngo-stroboscope (Fig. 128) devised by Gust. Spiess (563), by means of which the movements of the vocal cords during phonation may be observed. This effect is obtained by interrupting the view of the vocal cords so that these appear to remain in the same position. As soon as there is the slightest difference between the number of vibrations and interruptions of the instrument, the vocal cords will be found a little farther on their path after each interruption, so that the vibrations will apparently be made so slowly that they can be distinctly followed by the eye, and any variation from the normal observed. The number of vibrations is regulated by means of a siren, and the interruptions varied by adjustment of a motor, which operates the instrument by means of a flexible shaft.

The effect of *galvanism* on the muscles of the larynx has been investigated by Rossbach (372), who found that the adductors especially respond to this application. He states that the location in which a constant effect is observed, is on the plate of the thyroid cartilage, as also in the middle between the cricoid cartilage and sternum on the median edge of the sterno-cleido-mastoid muscle. The electrodes are applied to these points, and a current of one-half to three milliamperes passed. The effect of the cathodal closure (K. S.) is the closing of the glottis followed at once by the separation of the vocal cords; for the anodal-opening (A. O.) reaction, a somewhat stronger current is required, the effect of this being the raising of the pitch of the voice.

This subject has also been investigated by Gerhardt (373), who limits his experiments to the faradic current. He applied the electrode to the cornu of the thyroid cartilage, and noted, as the effect of this application, a vibratory movement and a periodic separation of the vocal cords after the enunciation of vowels, which had before taken place in the normal manner. The opening of the glottis was also affected by this application, as this reached only one-half or three-fourths of its usual respiratory space.

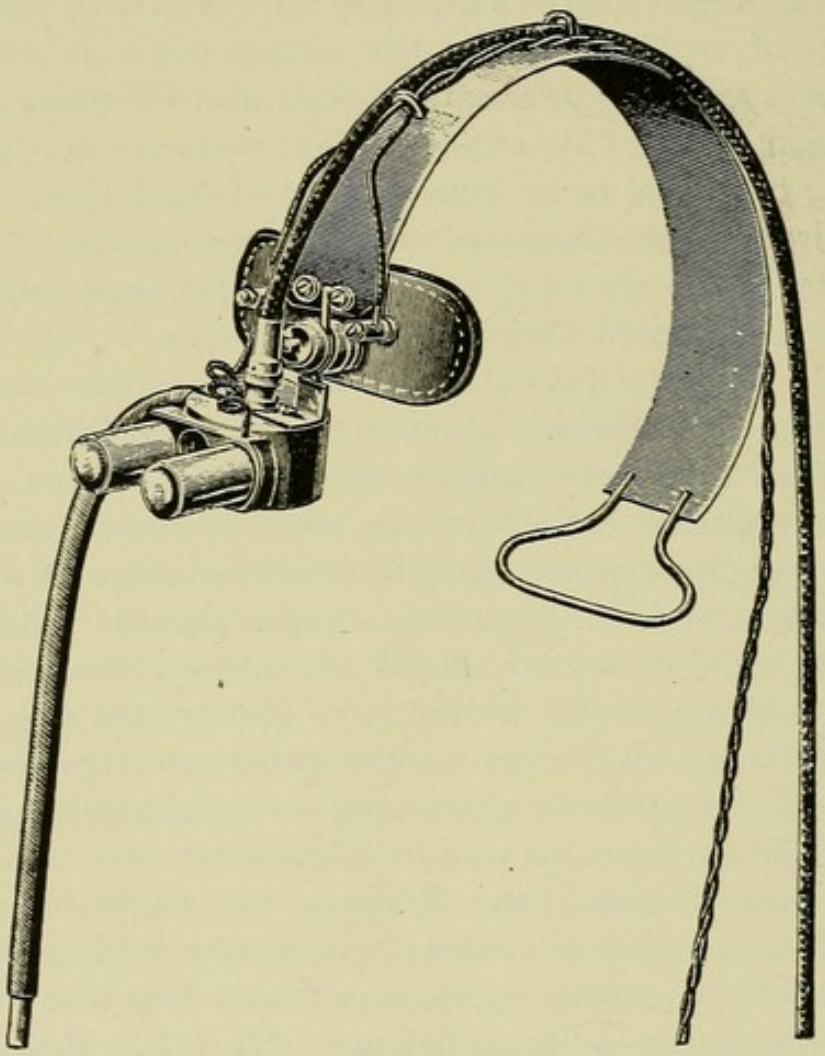


Fig. 128. Laryngo-Stroboscope.

In the diagnosis of *neuroses* of the larynx, the test with the galvanic and faradic currents is also of special value. Von Ziemssen (374) used the galvanic current for this purpose, and obtained much better results than with the laryngeal probe.

In making electrical application to the larynx three methods may be used: the bipolar, in which a double electrode is applied to the affected area, a method which is preferred by Von Ziems-

sen, as the action of the current may be more definitely localized than with the single electrode; the monopolar, in which one electrode is applied to the diseased part and the other pole, a large dispersing electrode, applied externally; and the external method, in which both electrodes are applied externally by means of two electrodes or a double external electrode (Fig. 38).

The various muscles of the larynx may be stimulated by direct application with the endolaryngeal electrode, but this can rarely be done without the use of cocaine. In most cases it is advisable to try first the external method. While this is inferior to the internal, it possesses the advantage of creating but little irritation and is, therefore, easily tolerated by the patient. The current may also be of greater intensity and applied longer than in the internal method.

As regards the intensity of the current, however, it should be remembered that the object of the application is for its stimulating effect, and too strong a current may not only defeat this object, but aggravate the existing conditions by overstimulation and irritation. Where the external method is unsuccessful, the endolaryngeal method should then be tried.

The faradic current is used most frequently in these cases, but the galvanic is the more serviceable and gives better results. Where simply the catalytic effect is required, the current is applied without interruption, but where stimulation is desired, the interrupted galvanic current should be used so that we have both the catalytic and mechanical effects. Mild currents only should be used with the interrupted current.

When endolaryngeal applications are made, the electrode should be applied to the *motor points*, at which locations the muscles react best to the electrical applications. Von Ziemssen (375) has investigated this subject and has described the motor points from which the laryngeal muscles may be stimulated.

In using the monopolar method, he advises that the positive pole be connected with the dispersing electrode at the neck, and the negative to the laryngeal electrode, which is applied to the larynx which has been previously cocainized.

The motor point for the arytenoideus transversus and obliquus is in the inter-arytenoid commissure and the posterior wall of the arytenoid cartilage. When the circuit is closed, the arytenoids approach the median line, and it is important when this takes place, that the electrode be held firmly in position, so that it

is not dislodged by the approximation of the cartilages (Fig. 129, *A*).

The motor point of the crico-arytenoideus posticus lies deep in the lateral wall of the plate of the cricoid cartilage. The electrode should be passed over the posterior surface of the arytenoid cartilage (*B*).

The motor point of the crico-arytenoideus lateralis is in the posterior part of the pyriform sinus (*D*) at the border of the plate of the cricoid cartilage (*C*).

The motor point of the thyreo-arytenoideus externus and internus muscles is in the central part of the pyriform sinus. The thyreo-arytenoideus internus may also be stimulated by applying the current to the vocal cords (*E*, *E*), but this is usually very irritating to the patient.

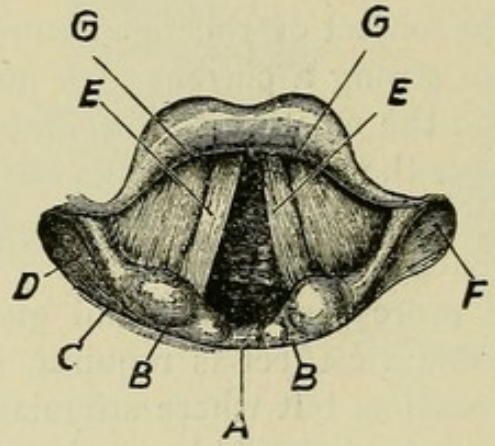


Fig. 129. Intra-Laryngeal Motor Points.

The superior laryngeal nerve may be reached by placing the electrode to the anterior part of the sinus pyriformis (*F*), or externally to the neck at the upper end of the large cornu of the thyroid at its point of union with the hyo-thyroid membrane.

The muscles of the epiglottis, the ary- and thyreo-epiglotticus, may be stimulated at the free end of the laryngeal part of the epiglottis, or by means of the superior laryngeal nerve in the pyriform sinus (*G*).

In front of the neck between the thyroid and cricoid cartilages are the motor points for the crico-thyroideus muscles, by the contraction of which the cricoid cartilage is raised against the thyroid cartilage.

Von Ziemssen states that it is difficult to stimulate the recurrent laryngeal nerve from the skin. In lean necks, it is sometimes possible to reach this by pressing an oblong electrode

between the trachea and the œsophagus, but in the majority of cases it is impossible, especially in muscular or strumous necks.

A different opinion is held by William H. King (377), who believes that the recurrent laryngeal nerve can be stimulated in almost all cases. He states that Mackenzie did not have success with the external applications on account of his faulty understanding of the use of electricity in muscular development. The current which King prefers is the interrupted galvanic, and he advises the following method:

The small-size Erb electrode, preferably of oval shape, should be selected. The first motor point is reached by placing the electrode along the posterior border of the thyroid cartilage, about one-eighth of an inch above the line drawn directly backward from the *pomum Adami*. The second point is located by carrying the finger back along the side of the cricoid cartilage until the point of articulation with the inferior cornu of the thyroid cartilage is reached. Just back of this point, the distinct beats of the carotid artery will be felt. The electrodes should be firmly pressed between these two points and the inferior laryngeal will at once respond.

He recommends this treatment in the following conditions: general weakness of the laryngeal muscles, atrophy of the muscles from over-use, so frequently observed in professional singers, and also those conditions in which a passive congestion of the vocal cords and the surrounding tissues is observed. The recurrent laryngeal nerve may also be reached by passing an electrode into the upper part of the œsophagus, and by firmly pressing the electrode anteriorly.

Other nerves in this region, which it is sometimes necessary to stimulate, are the facial, pneumogastric and phrenic nerves. The facial nerve may be stimulated at its exit from the stylo-mastoid foramen between the mastoid process and the angle of the lower jaw, or at the opening of the external auditory canal; the pneumogastric nerve at the lower and anterior part of the neck between the common carotid artery and the jugular vein; the inferior laryngeal nerve between the œsophagus and the trachea near the ganglia of the sympathetic.

The phrenic nerve may be stimulated at the outer border of the sterno-cleido-mastoid muscle near the anterior border of the scalenus anticus near the omo-hyoid muscle.

PARALYSIS OF THE LARYNX.

In the treatment of paralysis of the laryngeal muscles, laryngologists differ as to the most efficacious method of applying electricity, some claiming that only the endolaryngeal method is of service, while others believe that the same effect may be obtained by the external method. Morell Mackenzie (376) was of the former opinion and believed that electricity applied externally to the larynx acts as a local tonic which might be useful in allaying irritation, but that it is of no effect in developing muscles, for which purpose the endolaryngeal electrodes should be used.

The internal method is recommended by Seiss (364), who uses the *faradic* current. The laryngeal electrode (Fig. 37) is connected with the negative pole of the battery, and its extremity introduced into the larynx, while the positive pole is connected with a dispersing electrode placed externally over the larynx. Both electrodes should be covered with moistened absorbent cotton, the application being made as directly to the paralyzed muscle as possible. As in other laryngeal manipulations, the presence of the instrument at first causes considerable irritation, but after a number of operations tolerance is usually obtained, and cocaine may be used if required. The application should be but for a few seconds, and repeated several times at short intervals. The seances should be daily if practicable.

Faradization has also been found useful by W. Oltuszewski, of Warsaw (378), in a patient suffering from unilateral laryngeal paralysis complicated with paralysis of the inferior branches of the facial nerve and paresis of the tongue and palate, and disturbances of the function of the sympathethic nerve. Although the examination with the galvanic current showed the reaction of degeneration of the muscles supplied by the facial and hypoglossus nerves, a decided improvement was obtained.

The internal application of faradism is also recommended by Sajous (153), the negative pole being attached to the laryngeal electrode, and the positive, a sponge electrode, being applied externally over the larynx.

Although it has been demonstrated by electro-therapeutists that the *galvanic* current is a more useful agent in the treatment of paralyzed muscles, it is surprising to note that the majority of writers have used the faradic current in the treatment of motor paralysis of the larynx. The only explanation of this fact is that it is easier of application, as the effect of the galvanic current

is undoubtedly far superior to the faradic, although the latter is occasionally useful.

Among the few writers who refer to galvanism in this condition is F. I. Knight, of Boston (379), who reports a case of complete paralysis of one recurrent laryngeal nerve and partial paralysis of the other, which was benefited by the galvanic current applied locally.

When paralysis of the vocal cords is due to pressure on the recurrent laryngeal nerve from any cause, the treatment by electric applications cannot, of course, be successful in curing it unless the cause be removed, but the persistent application of a mild galvanic current nevertheless tends to prevent the degeneration of the muscular tissue of the larynx following the paralysis.

Vibratory massage has also been used in laryngeal paralysis. Massucci (380) reports a number of cases in which he has had perfect cures, and without relapse, from the application of this method.

In the treatment of *hysterical aphonia*, the administration of arsenic, strychnia, valerian or the bromides should be carried out according to the indications of the case, and the possibility of ovarian or uterine disease should not be overlooked. A different treatment is required for acute and chronic cases. In acute cases, I have found the following method the most efficacious: the patient is directed to count from one to ten while the current is passing through the neck, the electrodes being applied to both sides of the larynx. While the patient is counting, the faradic current causes contraction of the laryngeal muscles, which will restore the confidence of the patient in the power of these parts, and, after a few attempts, a sound is heard above the whisper used by aphonic persons. This treatment should be followed each day until the voice is permanently restored; one sitting is sometimes sufficient.

In chronic cases, the faradic application should be made as described above, but, in addition to this, the galvanic current should also be applied on account of its tonic effect on the muscles which have been weakened by disuse. If external galvanism is ineffective, the endolaryngeal method should be used, the negative electrode being applied within the larynx, and the positive externally.

A remarkable case of hysterical aphonia was referred to me by Dr. William Brickell, of New Orleans, the case being of unusual interest in that the aphonia was combined with spasmodic

contraction of the adductors, so that death appeared imminent from dyspnœa.

This case was treated by central galvanization, with complete success, the aphonia afterwards being treated by the method already described. In a previous attack of this kind, which had taken place in another city, the symptoms so alarmed the attending physician that a tracheotomy was performed.

External faradization for aphonia is also recommended by Rockwell (6). L. Réthi (381), however, reports two cases in which internal and external laryngeal applications were without benefit, but when the electrode was applied to the temples, so that the faradic current passed for a few seconds through the brain, the voice was recovered. Réthi calls attention to the circumstance that, according to the investigations of Krause, electric irritation of the *gyrus prefrontalis* caused closure of the glottis and of the vestibule of the larynx.

A more rational explanation of the result of this procedure, however, is that it was due to suggestion. This probably also applies to the method of Moura-Bourouillou (382), who states that from his study of anastomosis of the laryngeal nerve, he advises that in hysterical aphonia one of the electrodes should be applied to the lingual surface of the epiglottis so that the circuit may include the superior laryngeal nerve.

The fact that it is not specified whether the positive or negative electrode should be used in this procedure, or whether the galvanic or faradic current is to be applied, would lead us to believe that the results in these cases are due rather to suggestion than to any effect of the electric current. This is supported by the report of a case made by Moore (383), in which the simple application of the laryngoscopic mirror was sufficient to restore the voice either for a short time or permanently.

Cases of aphonia successfully treated by electricity have been reported by E. Jacob, of Leeds (384), Rockwell (6), L. Krom, of Dünaburg (385), T. D. Savill, of London (386), P. Massucci, of Naples (387), Moure, of Bordeaux (388), J. C. Mulhall (389), R. Daniel (390) and others.

INFLUENCE OF ELECTRICITY ON THE VOICE.

The possibility of the development of the higher vocal register by electricity is advocated by William H. King (391). He advises the strengthening of the laryngeal muscles by applying the

interrupted galvanic current to the superior laryngeal and inferior laryngeal nerves. He finds this far superior to the application of the current directly to the muscles, as advocated by Mackenzie and others.

In view of the difficulty of locating the motor points within the larynx, King applies the electrodes externally. He locates the motor point of the external laryngeal nerve, which supplies the crico-thyroid muscle, along the posterior border of the thyroid cartilage about one-eighth of an inch from the line drawn directly backward from the *pomum Adami*. The inferior laryngeal nerve, which supplies the arytenoideus and the crico-arytenoidei laterales, passes under the lower border of the inferior constrictor muscles just in front of the carotid, and into the larynx at the point of articulation of the inferior cornu of the thyroid cartilage with the cricoid. It is just as it dips under the inferior constrictor muscle that it is most easily reached. The operator should first locate the point by carrying his finger back along the side of the cricoid cartilage until he reaches the point of articulation with its inferior cornu. Just back of this point, the distinct beats of the carotid will be felt. The electrodes should be firmly pressed between these two points, and the nerve will at once respond. The small-size Erb electrode can be used for this purpose, though one made of the same diameter but more oval in shape is preferable.

King finds this method useful not only in general weakness of the laryngeal muscles, but especially in cases where the muscles are of unequal strength on different sides of the larynx, which results in the vocal cords being put in unequal tension. The usefulness of this method is claimed to be due not only to the increase of nutrition, by the active exercise of the muscles, but also to the catalytic action, which has been described by Remak and by Erb.

These two forces acting together are capable of developing the muscle to a very high degree, and placing it at the same time in a condition to be trained by physical exercise up to the very highest degree. This line of investigation has also been followed by J. B. Garrison (392), who has had good results from its use.

The influence of the static current on the voice of singers has been investigated by A. Moutier and J. Granier (316), who found it to give good results in cases not due to pathologic changes in the vocal organs.

The patient is seated on an insulated chair connected with the

negative pole of a static machine, an electric brush being drawn near the face of the patient. The seances should last from 10 to 30 minutes, according to the condition of the patient, and be repeated two or three times weekly. After a number of treatments with this method, the patients experience a greater resistance to fatigue and improvement in the quality and intensity of the voice, and in some cases even the register is increased. The authors give in detail a number of cases treated by this method.

Electricity is also sometimes of value in the treatment of stammering, the operation being either general, as by the method of central galvanization or general faradization, or local, the stimulation being applied to the nerves governing the defective muscles.

Good results from the application of galvanism are claimed by M. Crispino, of Naples (519), the patient being a man of 21 years who had suffered from stammering since infancy. Daily applications of galvanism were made to the hypoglossal and facial nerves for 40 days, with permanent good results.

DIPHTHERIA.

There has been such a radical change during recent years in the treatment of diphtheria, since the introduction of the serum therapy, that the application of electricity in these cases is now rarely referred to. Without being extensively used at any time, it is alluded to by a number of authors who claim to have had good results from its application.

A special *electro-cautery* apparatus has been devised by Blochbaum, of Coblenz (393), which he considers of great importance in the treatment of diphtheria. In a later communication (394), this author states that the electro-cautery may be effectively used in diphtheria, if applied early in the disease before the bacilli have developed to a marked degree. After cauterization, he advises that the cauterized areas be powdered with dermatol, which will insure rapid healing.

This method has also been used by Hagedorn (395), who applied it in 24 cases, only one of which died, and is also advocated by P. Cogo (396). In the discussion of this subject, Waitz (397) advises that this treatment be limited only to the most severe cases, and recommends for milder ones the treatment with ice. Aly (398) states that the application of the electro-cautery to certain points, as the posterior part of the soft palate, is impracticable and the technique especially difficult in children.

While the antiseptic and microbicidal effects which are claimed for this method, cannot be denied, still this object may be obtained by so many more simple and harmless means that the application of the electro-cautery in this disease is not to be recommended.

Electrolysis has been used in a case of pseudo-membranous laryngitis by F. E. Waxham (399), the case being interesting as showing the result of electrolysis in this condition. The patient was an eight-year-old child suffering from pseudo-membranous croup, and was in the last stage of asphyxia. Electrolysis was applied, not in the expectation that the galvanic current would have much effect on the pseudo-membranes, but in the hope that it would decrease the congestion and swelling of the tissues. The intubation canula was used as the negative electrode, and was connected by means of a platinum wire with 12 cells of a battery. The positive pole was connected with an ordinary sponge electrode which was applied externally to the larynx. A current of six to ten elements was used. Only a few sittings were made, further treatment being prevented by the condition of the little patient, who died as a result of pneumonia and exhaustion.

Contrary to the expectation of the author, electrolysis had a decided influence on the loosening and dissolution of the membrane. Another feature was also noted. Instead of diminishing the inflammatory reaction, an increase of swelling and congestion of the tissues followed the application, so that really the opposite effect to what was expected was obtained.

CHAPTER XXX.

Tubercular Laryngitis.

ONE of the gravest diseases that demands the attention of the laryngologist is tuberculosis of the larynx (400). The gravity of this affection lies not only in the fact that the disease itself is intrinsically of a most serious nature, but also that it is usually a complication of pulmonary tuberculosis; the patient has, therefore, little of the vital resistance necessary to battle against the encroachment of the tubercular disease in the larynx, this condition being aggravated by the fact that the parts are continually reinfected by the tubercular expectorations from the lungs.

Primary laryngeal tuberculosis is exceedingly rare; in fact, many authors have even disputed its existence. Statistics, however, prove that while it is of infrequent occurrence, it sometimes exists without disease of the lungs that can be detected by the most scrutinizing methods of examination. *Prima facie*, it is not impossible that the tubercular disease in the system may develop primarily in the tissues of the larynx as well as in the tissues of the lungs, although the latter, for many reasons, is the usual location for the tubercular infection.

The treatment of this grave affection has long claimed the attention of laryngologists, especially since the means of laryngoscopic examinations have been perfected; but in most cases, the prognosis was so grave that but little hope of a cure has been entertained in the majority of patients. The methods of treatment, both medical and operative, are large in number, and this very fact would seem to indicate the lack of confidence in any individual method.

The treatment of tubercular laryngitis by curettement and the application of lactic acid has been advocated by Heryng, of Warsaw, and the results which he published, while the percentage of cures was small, were more favorable than those obtained by any method previously tried. The objections to this

method are that it is difficult to apply in many cases, the reaction which follows, but more especially that the surgical removal of the diseased areas exposes the unprotected tissues to constant reinfection from the tubercular sputum—for, as already stated, primary tuberculosis of the larynx is an extremely rare disease. Heryng does not recommend curettement for all cases, and he advises *electrolysis* (402) in tubercular laryngitis when there are hard neoplastic infiltrations of the ventricular band, especially when their extirpation with the curette is liable to be followed by a dangerous hemorrhage. He also advises electrolysis in tubercular choroiditis with or without the formation of tubercular ulcers.

Electrolysis has also been used by Moritz Schmidt (406), who applied it to an edematous vocal cord in a case of tubercular laryngitis with good results. He was able to use as much as 15 milliamperes in this case. Usually, however, a much weaker current is advisable. Schrötter believes that electrolysis is of no service in the larynx.

The *electro-cautery* has also had its advocates in the treatment of tubercular laryngitis. It was favored by Voltolini (403) as it destroyed not only the diseased tissue, but at the same time the bacillus. A case of tuberculosis of the larynx treated with the electro-cautery is reported by E. Schmiegelow, of Copenhagen (404). The patient, a man of 50 years, had tubercular infiltration of both ventricular bands and suffered from great pain. A thorough cauterization of the affected area diminished the infiltration to a great degree, and caused the disappearance of the pain.

The electro-cautery has also been recommended in this disease by Srebrny (405), who has treated 11 cases of tubercular laryngitis and reports the following results: In four cases the result was satisfactory for one to three months, the further course of the disease being unknown. Four cases ended fatally after six and ten months. The fifth and tenth cases belonged to the most severe form of tuberculosis of the larynx and the lungs. In the first three cases there was a recurrence of the disease in the larynx. Of five cases, in the first the cure was still present two and one-half years after the operation; in the second, two years; in the third, fifteen months; in the fourth, nine months; in the fifth, twenty months. Srebrny states that the pain after the operation is slight, as also the reaction.

In comparing the surgical and electro-cautery treatments in

this condition, Srebrny believes that the second is usually as efficacious as the first. He reaches this conclusion from the following premises: The number of operations necessary for the electro-cautery treatment is not greater than that required by the surgical method; the pain after the electro-cautery applications is not marked in any case, while in two cases in which Heryng's curette was used, and in one in which Krauze's double curette was applied, the pain was quite violent. Srebrny has not seen edema follow this application, as noted by Heryng. In the electro-cautery treatment there is no possibility of hemorrhage when it is properly applied, while in the surgical method this takes place quite frequently—a very important point in a patient already suffering from a debilitating disease. Srebrny, however, does not advocate the electro-cautery in infiltrations of the aryepiglottic ligaments, on account of the possibility of edema consecutive to the application.

The electro-cautery has also been recommended by Gouguenheim, of Paris (408). He makes punctated applications to the edematous epiglottis and the aryepiglottic folds, and advises that the polypoid vegetations, which are so often present in certain forms of tuberculosis, be cauterized. He has never seen the application of the electro-cautery followed by acute edema of the glottis, as reported by other authors.

A case of tubercular laryngitis benefited by the electro-cautery is reported by Cahn (409). The patient also suffered from pulmonary tuberculosis and had a marked hypertrophy in the arytenoid and subglottic regions, complete aphonia and difficulty of breathing. The application of the electro-cautery was followed by a pronounced diminution of the hypertrophies to the extent of enabling the vocal cords to be seen, diminution of the aphonia and improvement of the general condition of the patient. The author is somewhat vague in describing his method of using the electro-cautery in this case, but insists that the improvement was due to its application.

The application of the electro-cautery to the larynx requires great manipulative skill, and some of the most prominent writers have advised against its application in this region. While this is not my individual opinion, having frequently had satisfactory results from its use in the larynx, still I fully appreciate the difficulty attending its application.

In seeking a treatment for laryngeal tuberculosis, my desire

has been to select a method which would be conservative, not especially difficult to carry out and, if possible, applicable in all cases of this disease; it should not be painful, be followed by little or no reaction, be devoid of hemorrhage and should not expose the parts to reinfection from the tubercular expectorations.

The application of electricity for the passage of medicaments into the tissues, or *cataphoresis*, has already been explained in the chapter on Cataphoresis. In this procedure we have a method of saturating the diseased tissues with such medicaments as will neutralize the infectious character of the disease, and which will, at the same time, stimulate the tissues to a healthy reaction.

In my investigations of the treatment of laryngeal tuberculosis by cataphoresis, I have tried a variety of substances, especially creosote, guaiacol, iodine, chloride of zinc and the oxychloride of copper. Creosote was abandoned after a few trials, as it proved to be too irritating to the tissues and caused too much pain and reaction after the application. Iodine is useful, but not as efficacious as the oxychloride of copper; and guaiacol, which is really creosote deprived of its irritating properties, was found to be very useful and especially applicable in cases in which there was considerable pain, as its application was usually followed by marked diminution of the pain, and this effect frequently lasted 24 hours. I therefore still make use of guaiacol when the relief of pain is the principal object. Cocaine may also be used in this connection, but its effects are too transient and the systemic effects are not well tolerated by the tubercular patient.

In the oxychloride of copper we have a salt possessing marked germicidal properties, while exerting at the same time a stimulating effect on the pathologic tissues, which is superior to any other medicament which I have used in this treatment. Its microbicidal properties are not as strong as those of the chloride of zinc, but the latter was found to be too corrosive and irritating to be recommended in this disease, although it is of special value in the application of cataphoresis to malignant neoplasms of the larynx and other regions.

It has already been explained that when pure copper is applied to the tissues and connected with the positive electrode, the reaction between the needle and the tissues gives rise to the formation of the oxychloride of copper. This salt, formed at the positive pole, is repelled by this and is driven into the tissues in its passage to the opposite pole.

In the application of cupric electrolysis for laryngeal tuberculosis, I found it difficult and impracticable to use the needles, not only because the movement of the larynx might cause the loosening of the needles and laceration of the tissues, but also because the puncture made by the needles opened the portals for further entry of pathogenic microbes. I therefore selected spherical electrodes of pure copper, one-eighth to one-fourth inch in diameter (Fig. 130), applied to the diseased areas by means of an insulated handle, and have found these efficient for the cataphoric process, and, when properly applied, without giving rise to pain, irritation

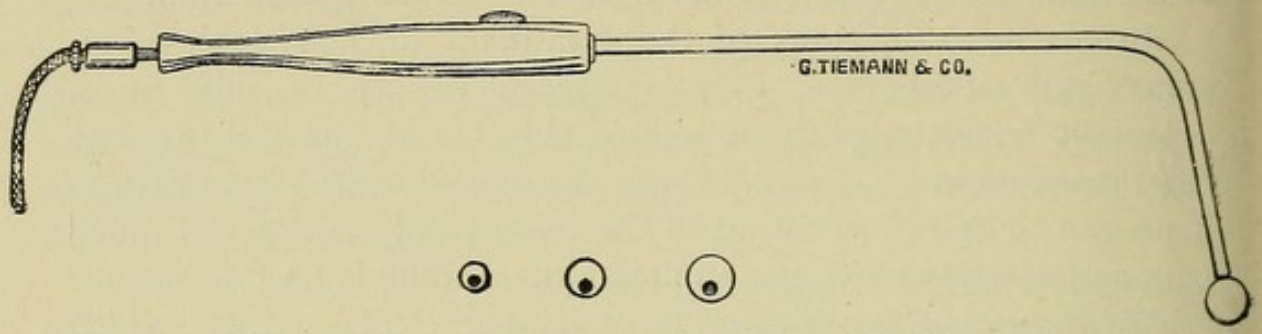


Fig. 130. Scheppegrell's Laryngeal Electrode and Handle for Cupric Electrolysis.

or reaction after the application. It is of great importance that only pure copper should be used in this method; commercial copper contains zinc in its composition, and I found this to be especially irritating in this treatment. Pure copper obtained by electrolysis is to be preferred.

The galvanic current only can be used in this method, as the faradic and alternating currents possess no cataphoric properties. Weak currents should be used at all times, and I have rarely found more than five milliamperes necessary, and have frequently used much less. A rheostat should always be used, so that the current may be admitted and reduced without pain. The copper electrode must be connected with the positive pole, and the negative connected with a large dispersing electrode applied to the nape of the neck.

The throat should first be sprayed with a five-per-cent. solution of cocaine or eucaine, although I have found in several of my cases that, after a few applications had been made, the anæsthetic was no longer necessary. The applications should be made every second day, as a rule, although the physician must be governed by the strength of the patient and other circumstances in the number and interval of the applications. These should be continued until the parts resume their normal condition, or until the weak-

ness of the patient no longer justifies the exertion necessary for the application.

I have found the use of direct laryngoscopy or the autoscopy of Kirstein (36) of special value in this treatment. This method, which has already been described, is of special value in this disease, as the pathologic process of laryngeal tuberculosis is usually in the posterior part of the larynx, which is the most easily seen and reached by this procedure. This method very much facilitates the cataphoric treatment of tubercular laryngitis.

When direct laryngoscopy is used, the electrode, instead of being bent in the usual angle for the larynx (Fig. 130), is straight with a slight downward flexion only at the end of the electrode (Fig. 131). The applications are then made directly without the aid of the laryngeal mirror.

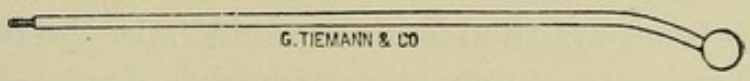


Fig. 131. Electrode for Direct Laryngoscopy.

When the copper electrodes are applied to the tissues, the decomposition of the copper takes place, giving rise to the oxychloride of copper, which passes into the tissues toward the dispersing electrode. It is important, when the applications are made, that the electrode be slightly rotated or moved about, so as to avoid the adhesion of the electrode to the tissues, which would give rise to an abrasion which it is desirable to avoid. Should, however, an adhesion take place, the circuit should be slowly broken with the rheostat, the current reversed by means of a polarity changer, and a light current passed in the opposite direction for a few minutes. The electrode may then be easily removed without laceration of the tissues.

The advantages which I have found in the method of applying cupric electrolysis in the treatment of laryngeal tuberculosis are as follows:

1. There is no real destruction of the tissues, and there are no lacerations of the surfaces, which might form a point of entrance for new pathogenic germs for reinfection, as is the case with the method of curettement, and, to a certain extent, also with the electro-cautery and with simple electrolysis. The cure is effected by the healthy reaction of the tissues in the same manner in which we often see specific lesions heal when the system is under the influence of mercurials.

2. In the cases which I have treated with this method there has been absolutely no reaction or hemorrhage following the application—a point of great importance with tubercular patients.

3. It does not demand the high degree of manipulative skill required for curettement, or for the manipulation of the electrocautery in the larynx, and is especially simple when direct laryngoscopy can be used.

4. This method is applicable in all cases of laryngeal tuberculosis.

While cupric electrolysis is applicable in all cases, it is not to be recommended where the pulmonary disease has advanced so far that the extra exertion of the patient for this treatment would be injurious, and in some cases the irritability of the throat is so great as to make it difficult or impossible to apply.

The following three cases will illustrate the method of applying this treatment and the results obtained: In the first case, the patient suffered from tubercular laryngitis complicating tuberculosis of the lung. There was marked infiltration of the arytenoid region, with incipient ulceration of the interarytenoid commissure. In this case, the cataphoric treatment was at once instituted, and, after seven applications at intervals of three days, the case had improved so much that the patient was permitted to go to the mountains for the benefit of his pulmonary disease. The infiltration had very much diminished, especially over the left arytenoid where only a small amount was still visible. After six weeks' absence the patient returned, with the tubercular disease of the lungs much aggravated; the laryngeal condition, however, was but slightly changed, in that the infiltration was somewhat more noticeable, but there were no ulcerations visible in any part. The patient subsequently succumbed to tuberculosis of the lungs, but the treatment had relieved him of all the pain and irritation attending the progress of the laryngeal complication.

In the second case, also complicated with severe pulmonary tuberculosis, the tubercular lesions were more decided in character, the ulcerations having extended over a considerable portion of the right ventricular band, both vocal cords being involved. In this case, the granulations were reduced, the ulcerations healed and the infiltration was somewhat diminished, when the application had to be discontinued on account of the weakness of the patient, who subsequently succumbed to tuberculosis of the lungs.

The third patient had suffered for seven months from tubercular laryngitis, but tuberculosis of the lung was either entirely absent or it could not be detected by the most careful physical examination. The sputum showed the tubercle bacilli, which were found only after repeated examinations. The patient weighed 110 pounds, was so weak that he could walk only when supported, suffered from constant irritation of the throat which gave rise to a hacking cough and deglutition was so painful that he could swallow only with the greatest difficulty. There was no history of any specific infection, nor were there any physical evidences of such a condition.

The arytenoid region was much infiltrated, with extensive ulceration of the interarytenoid fold, which extended to the left over the ventricular band. The epiglottis was tumefied, with an ulceration of the left anterior portion. The anemia, infiltration and ulceration presented a typical image of laryngeal tuberculosis. The patient could speak only in whispers, and the pain in deglutition was so severe that he subsisted only on liquids, and even these he could now swallow only with difficulty. The patient had been treated by several physicians without success, one of whom had used antiphthisin but with no apparent benefit.

The cataphoric treatment was at once commenced, at first being applied every third day and afterward twice weekly. Improvement was noted after the third application, and after the ninth, the ulcerations had healed so far that the patient could swallow semisolid food with but little pain. After the eleventh application, the ulcerations had entirely healed, so that the patient could now take solid food without pain or difficulty, and he at once improved in strength and in appearance. The applications were continued twice weekly, and the infiltration gradually receded, and eight weeks later had entirely disappeared. The voice, which at first had been entirely lost, gradually improved and at the end of the treatment was restored, only a huskiness persisting. His weight had advanced to 136 pounds, and he was able to resume his regular business occupation. I saw this patient six months after the treatment, and his larynx showed no return of the laryngeal disease and his health was excellent.

Percutaneous galvanism has also been recommended in the treatment of tubercular laryngitis. This subject has been investigated by De Renzi, of Naples (410), who advises its application by means of large electrodes so as to avoid local irritation. It is

interesting to note that this author has also used this method in the treatment of pulmonary tuberculosis, and has given elaborate reports of its application. A current of sufficient tension is used to overcome the body resistance, and to permit long and numerous applications. The object of the treatment is to bring about destruction or attenuation of the morbid principle by means of strong currents without inducing general or local irritation.

In a case of tubercular pleuritis, the disappearance of the exudate followed this treatment, and De Renzi states that in all the tubercular cases in which it was applied there was a marked increase in weight and diminution and even cessation of fever, while the bacilli were diminished in number.

Faradization has also been used in the treatment of tuberculosis. Soupinsky, of St. Petersburg (411), reports a case of a woman of 28 years, with tubercular infiltration of both apices, pleuritic effusion, hemoptysis, night sweats, and bacilli in the sputum, who was treated for three months with daily applications of faradism of ten minutes each. At the end of this time the dyspnœa, night sweats and râles had disappeared and there were few bacilli in the sputum. The treatment resulted in a complete cure, which still existed at the time of the report, two and one-half years later.

Our experience with electricity in other pathologic conditions would lead us to give the preference to galvanism over faradism in the treatment of tubercular affections. The faradic current properly applied is, no doubt, useful in these cases from its influence on the circulation and in increasing the metabolic processes; but with galvanism we may not only obtain these effects, but also its powerful stimulating action, its germicidal effects and the resolvent influence of the catalytic processes, which result from the application of this current. This subject certainly demands further investigation.

CHAPTER XXXI.

Diseases of the Trachea and Œsophagus.

TRACHEA.

THE operation of tracheotomy is sometimes performed by means of the electro-cautery knife with a view of preventing hemorrhage. It does not compare from a surgical standpoint, however, with the usual method of performing this operation, and is therefore not frequently used. In hemophilic patients, however, where this operation is required, the electro-cautery or Paquelin knife is useful on account of its hemostatic effect.

The *electro-cautery* is sometimes useful in the trachea for the removal of granulations due to the pressure of the tracheal canula. A case of granuloma is reported by Basler (412), which was successfully removed by the electro-cautery followed by the application of a 30-per-cent. solution of chromic acid. A similar case is reported by Zwicke (413), in which the granulations were also removed in the same manner.

Catalysis is reported by Laman (414) to have been of benefit in the treatment of two cases of stricture of the trachea. In the first case there was a decided improvement, and in the second, the lumen of the trachea was entirely restored. The author claims that in the latter case the current was so weak and the intervals so long that the effects could not have been due to the electrolytic action of the current. There was no recurrence.

A branchial fistula of the neck cured by *electrolysis* is reported by Lichtwitz (415). The fistula was situated about two *cms.* to the left of the middle line between the hyoid bone and the thyroid cartilage. A whalebone probe was passed upward and inward for six and a half centimeters behind the cornu to the hyoid, and could be felt by the patient at the level of the right tonsil. Treatment was called for on account of the discharge which involved the continuous wearing of a dressing, but a cutting operation was refused.

Electrolysis was carried out by means of a fine electrode, one

millimeter in thickness and covered with rubber two centimeters from its extremity. This was attached to the negative pole, and after cocainization a current of from two to three milliamperes was applied. Seventeen applications were made at intervals of from one week to a fortnight. The fistula then closed, and no recurrence had taken place at the end of ten months.

A case of congenital serous cyst of the neck successfully treated by electrolysis is reported by Gavaert (520).

ŒSOPHAGEAL STRICTURE.

The treatment of stricture of the œsophagus by *electrolysis* is a method which has received considerable attention, and has given good results in the hands of physicians familiar with the application of electricity. It should be used with extreme caution, not only on account of the possibility of producing an ulceration in the walls of the œsophagus or causing irritation of the pneumogastric nerve, but also because the simple passage of a sound into the œsophagus is a procedure which is not always free of danger. This, however, is much less than in the surgical methods, and the application of this procedure is much simpler in the hands of one familiar with electro-therapeutics than the surgical method for relieving this condition. Its effects are more rapid than the method of dilatation, and the force required for the latter is the source of more danger than the application of a mild electric current.

A careful diagnosis should first be made, so as to eliminate the possibility of a malignant growth, which might so weaken the walls of the œsophagus as to favor perforation. The exact site of the stricture should also be located. The œsophagoscope (Fig. 74) is a useful instrument for determining the character of the stricture or obstruction, and should not be neglected in the treatment of such cases. Rosenheim (482) gives the clinical history of 18 cases of carcinoma of the œsophagus, which were diagnosticated by means of this instrument.

Auscultation is also valuable in this connection, and, being entirely free of danger, should form the first means of examination in all cases of stricture or obstruction of the œsophagus.

Electrolysis should be limited to the treatment of fibrous strictures, as for instance those of traumatic origin. Strictures of a spasmodic character should not be treated by electrolysis, although a mild application of galvanism is sometimes useful in these cases.

The principles of electrolysis have already been explained. The electrodes which are used in the treatment of stricture of the œsophagus resemble those in ordinary use, but the stem is an insulated conductor, and the olive points, which are made of various sizes, are metallic so as to conduct the electricity into the tissues. A modification of these olive tips has been suggested by W. H. King (416), the object being that the electrodes can be withdrawn from the stricture with less resistance than with the ordinary tips in use.

The œsophageal electrode (Fig. 132) should be connected with the negative pole, it having been shown by Althaus that the dis-

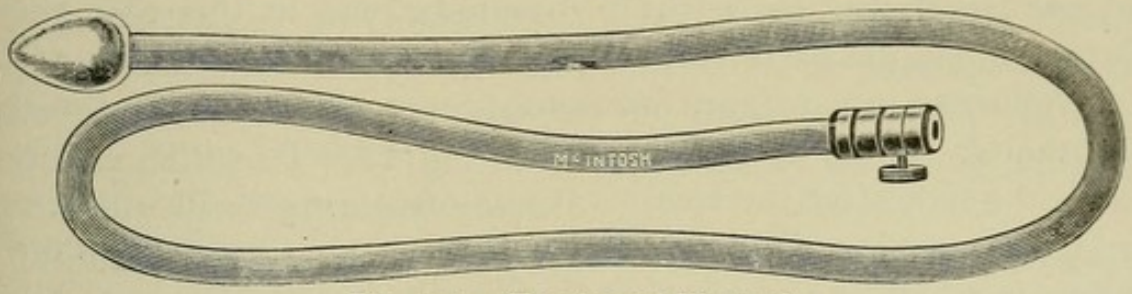


Fig. 132. Œsophageal Electrode.

integrating effect of the galvanic current is most powerful at this pole. William J. Morton (425) has also shown that the negative pole has a special "resorptive" effect in dilating strictures. The positive pole should be connected with a large dispersing electrode placed over the chest or back of the patient. The current is then gradually admitted by means of the rheostat, and should not exceed five milliamperes at any time, while two or three are sufficient in most cases. The size of the electrodes should be gradually increased in the same way as when the ordinary bougies are used. The electrodes should be inserted gradually into the stricture, and the force which is required for the ordinary method of dilatation is not necessary and should not be used.

A combination of electrolysis and dilatation is favored by A. Fort (417), who considers electrolysis a mild method, painless and free of danger. The patient, whose case he reports, had been in a pitiable condition from an œsophageal stricture produced by swallowing a potash solution. A cure was effected by the above method within two months.

A case of traumatic stricture of the œsophagus is also reported by Wolff (418), which was satisfactorily dilated by the daily employment of metallic bougies with a galvanic current of five to ten milliamperes.

This treatment is recommended by W. H. King (416), who does not limit it to simple strictures of the œsophagus, but finds it useful even in cancerous conditions, as it frequently results in increasing the caliber of the canal and allows the patient to take nourishment. He states that in strictures of a fibrous character the prognosis is good, but where they are spasmodic, due to some general outside cause, the treatment by electricity does not permanently relieve.

Of six cases of stricture reported by King, one was cancerous, and the treatment enabled the patient to swallow liquids and thin gruels readily, which he had been unable to do before. The second was largely but not entirely spasmodic, and in this case the treatment was unsatisfactory. The third was cicatricial, due to the swallowing of a mixture of sulphuric acid. This case improved continuously under treatment, and was practically cured. One year and a half after the treatment was discontinued, the patient could still swallow food without difficulty. Three cases were fibrous, in which the results were uniformly successful.

While the result of this application in cancer of the œsophagus appears to have been satisfactory as a palliative measure, it should be used only with the greatest caution on account of the danger of perforating the weakened walls of the œsophagus with the electrode.

Cases of œsophageal stricture treated by electrolysis are reported by W. T. Watson (419) and A. J. Baker (420), in which both had good results.

A case of impermeable stricture of the œsophagus, due to drinking lye-water, was presented at the Meeting of the Norwegian Physicians by Johann Hjort, of Christiania (421). After the preliminary performing of gastrotomy on the patient, who was 14 years old, the stricture was successfully treated by electrolysis.

In consequence of this report, Ström, of Christiania (422), undertook a series of clinical and experimental work in order to ascertain the value of the electrolytic treatment of strictures. As a result of this investigation, Ström criticises this method and calls attention to the fact that the electrolytic treatment of strictures may imperil the life of the patient, as a current of electricity of too great intensity may cause a cauterization of the mucous membrane and perforation.

He states that electrolysis should not be undertaken until it

has first been ascertained, by means of a guiding sound, that the electrolytic sound will enter the right passage. He shows the importance of this advice by the report of a case of œsophageal stricture, in which, after successive attempts, it was found that the electrolytic sound had formed a false passage, and could be felt at the anterior edge of the sterno-cleido-mastoid muscle and the trachea, at the level of the cricoid cartilage.

In a second case of stricture of the œsophagus, which could only be passed by a No. 9 Charrière, after an electrolytic sound had been applied for an hour and a half, a No. 11 could be passed and the dilatation increased until a No. 22 was used without difficulty.

As a result of his clinical experience, Ström states that there is no doubt that electrolysis will enable us to pass through a stricture, but that this is done by the cauterizing effect of the negative pole, and that this cauterization may be strong enough to destroy the mucous membrane.

If this is the case, then he thinks that this method loses its principal benefit, on account of the cicatrix resulting from the cauterization, which will leave a tendency to recurrence of the stricture. He, therefore, considers the electrolytic method as unreliable, dangerous, and not safe against recurrence, especially when the current is not well regulated. A strength of four milliamperes should not be exceeded.

The investigations of Ström are useful as pointing out the necessity of using proper caution in the application of electrolysis. The precautionary measures which he presents should not be neglected, and strong currents should never be used. When, however, the procedure is properly carried out, there is no more danger than in the application of other methods for the relief of œsophageal strictures, and even less than in many which have been suggested.

While applying electrolysis in stricture of the œsophagus, A. Fort (517) made a number of experiments to ascertain the influence of the continuous electric current on the pneumogastric nerve. A small platinum negative electrode being within the stricture, and the positive electrode on the left side of the abdomen, a current of 11 milliamperes passed for two minutes increased the pulse rate from 70 to 90, and excited some contraction of the facial muscles near the nose. A current of 30 milliamperes increased the pulse rate from 84 to 120, and produced similar contractions of the facial muscles.

On another occasion, the œsophageal electrode being more deeply situated, there was but little effect on the pulse; but the withdrawal of the electrodes produced intense pain in the chest, radiating to both ears.

These experiments are interesting as showing the influence of galvanism on the pneumogastric nerve, although all the effects described cannot be attributed directly to the influence of the galvanic current on this nerve, as a current of 11 to 30 milliamperes is quite painful, and some of the effects may be due to other reflex disturbances from this irritation. As already stated, a current of five milliamperes is sufficient for operations of this kind and stronger currents may be positively injurious.

The application of the *faradic* current for the removal of an impaction from the œsophagus has been found useful by J. R. Sowers, of Warrenton, Va. (423). In this case, the impaction consisted of a large piece of meat. One electrode was placed over the stomach and the other as near as possible to the point of obstruction. After some strong and rather painful contractions, the obstruction disappeared.

This method is not advisable where the foreign body has sharp cutting edges, or where the obstructing body has remained in the œsophagus long enough to produce ulceration, as the severe contraction due to this method may be followed by serious injury to the walls of the œsophagus.

CHAPTER XXXII.

Diseases of the Thyroid Gland.

GOITRE.

ELECTRICITY has been applied in the treatment of goitres directly by means of galvanism and faradism, and indirectly by electrolysis and cataphoresis. As regards the use of galvanism and faradism, the former is undoubtedly the more useful, although a few authors report benefit from the application of faradism.

Electrolysis is of special value in cystic and fibrous goitres, while the cataphoric application of iodine is claimed by many to have given excellent results. The prognosis in the application of electricity to these cases naturally depends upon the chronicity of the affection. Cases of recent development usually react promptly, while those of long standing are sometimes very resistant to treatment.

Where *galvanism* is used for goitre, large dispersing electrodes should be placed on both sides of the hypertrophied gland, and a current of five to ten milliamperes applied for ten to twenty minutes at intervals of two or three days, care being taken to avoid ulceration at the point of application. If a large electrode is adapted to the whole surface of the enlarged gland, a dispersing electrode being applied to the back, a current of 25 to 50 milliamperes is usually tolerated by the patient, and this method of applying galvanism externally is frequently the most rapid and successful.

Some authors advise a much stronger current, as Charles R. Dickson, of Toronto (407), who states that the strength of the current should be gradually increased until it reaches 100 to 150 milliamperes, while in exceptional cases 200 may be used. To avoid the irritating effects of the application, he applies the positive electrode, consisting of Goelet's modification of the Apostoli clay pad, used in gynecologic practice, to the back between the shoulders; and, for the negative electrode, a thinner clay pad of sufficient size to enclose the whole surface of the

tumor. Fifteen to twenty milliamperes are used at the first application, but the strength is gradually increased until the amount stated is reached. Strong currents for a short time are considered preferable by Dickson to weaker ones for a longer period. This strength of current is in excess of what is recommended by most writers, and my personal experience is that 50 milliamperes need be exceeded only in exceptional instances.

Where the cases resist the application of external galvanism, other methods should be tried, as cataphoresis and electrolysis. The principles of *cataphoresis* have already been explained; we make use of the galvanic current as a means of depositing certain medicaments directly into the tissues.

The administration of iodine by this method has been advocated by Hunter McGuire (424), who states that he has used cataphoresis successfully in the treatment of goitre. He uses a cup-shaped electrode, in which is placed some absorbent cotton, which has been first dipped into water and squeezed as dry as possible; on this cotton 10 or 15 drops of tincture of iodine are poured. The electrode, thus prepared, is placed over the most prominent part of the goitre, and the negative electrode on the back of the neck. A galvanic current of six to eight milliamperes is passed daily for ten minutes over a period of several weeks.

In the cataphoric application of iodine to goitre, I have found a saturated solution of iodide of potash to be more useful than the tincture; also that the preparation should be applied to the negative instead of the positive electrode, otherwise the local and not the cataphoric effects are obtained. When the galvanic current is now applied, the iodide of potash is decomposed and the iodine, which is liberated, is passed into the tissues and is more efficacious than the iodine from the tincture, as it is in a nascent condition.

A study of the statistics of the reported cases treated by cataphoresis would be interesting, but, in the majority of cases, it is not stated whether the medicaments were applied to the positive or to the negative electrode, or the reports are defective in some other important particular, which vitiates their value for statistic purposes. My personal experience with the cataphoric application of iodine has been satisfactory, with the exception of cases of a cystic or fibrous character, in which the electrolytic method is more useful.

In the application of *electrolysis* to goitre, the same rules are

followed as in the electrolytic treatment of tumors. As in these cases, the bipolar or unipolar method may be used. In the bipolar method, both needles, which should be of platinum, are passed into the growth and the hypertrophied tissues reduced by means of the galvanic current, while in the unipolar, a dispersing electrode is applied to the back or the neck and one or more needles inserted into the growth. The electrolytic method is of special value in cystic and fibrous goitres.

Percutaneous galvanism is considered by A. Juettner (426) as only of transient value, for in all of his cases the former conditions again developed. In a case which he had treated by electrolysis, he has not observed this tendency to recurrence, and he considers this method one of permanent value.

The bipolar method is recommended by Thomas, of Marseilles (427), for vascular and parenchymatous goitres. After the skin has been antiseptically prepared, both electrodes are passed one-half to two centimeters into the tissues, the needles being one-half a centimeter apart. The current is gradually increased to the tolerance of the patient. He applies the current for ten minutes and then reverses it to obtain the hemostatic effects at both poles.

In cystic goitre, E. Fletcher Ingals (428) has had good results by introducing one needle into the sac, and placing the opposite pole over the tumor, passing through it a current of six to ten Leclanché cells; the seance was repeated four times, when the sac did not refill. Three years later the parts were in the same condition. In the second case, the platinum needle was passed into the cyst, which had been previously tapped, and the current passed for 20 minutes; four seances were sufficient to insure a permanent cure.

A cystic goitre of large size has been successfully treated by Massey (429) by means of electro-puncture, the negative needle being applied to the cyst and a current of 35 to 40 milliamperes passed; afterwards free incision followed by the application of a positive gold bulb electrode to the inner wall of the tumor, a current of 50 milliamperes being applied and then 100.

Electrolysis was also used by Chas. M. Shields (430) in four cases of fibro-cystic goitre which had resisted the usual method of treatment. Three of these cases were cured and the fourth improved. He applied a current (galvanic) of 15 to 30 Leclanché cells, each sitting lasting from 20 to 30 minutes, which was repeated every two to six days, the treatment being continued for

six weeks to six months. He believes that this is the most efficacious method of treating the fibro-cystic forms of goitre, but does not think it of value in ordinary enlargement of the thyroid gland.

A special method of applying electrolysis to goitres is recommended by Charles R. Dickson, of Toronto (431). He first injects a solution of five per cent. cocaine and six per cent. antipyrin into the part of the growth which is to be treated. A steel needle, insulated to within an inch of its point and attached to the negative pole, is introduced through the isthmus into the lobe which is most hypertrophied, and the current slowly admitted by means of the rheostat. Ten milliamperes for ten minutes are applied at first, and increased at each sitting until fifty or more are used. The subsequent punctures may be made, as a rule, through the same opening used in the previous treatment, the needle being thrust into the different parts of the lobe. The operation is repeated weekly until the desired result is obtained, the wound being dressed after each treatment with iodoform and boracic acid.

The best results are obtained in cystic goitres. For these cases, an aspirating needle, insulated to within an inch of its tip, is first used to evacuate the contents of the cyst and then for refilling the cavity with a solution of chloride of sodium. The same needle is then used as an electrode, being connected with the negative pole, and a current of 30 milliamperes applied for 15 to 20 minutes. The sac is then emptied and the wound dressed as in the cases already described. Two or three sittings are sometimes sufficient to effect a cure.

In a later communication (432), Dickson recommends that 50 to 150 milliamperes for eight to ten minutes should be applied in these cases. Reversal of the polarity and using ten milliamperes for five minutes, before withdrawal of the needle, lessens the tendency to hemorrhage, which however is readily checked by pressure. Care should be exercised in puncturing the thyroid and in turning the current on and off so as to avoid pain, dizziness and other reactions. As these effects are especially liable to be produced by heavy currents, I have rarely found it advisable to use more than 50 milliamperes in these cases.

EXOPHTHALMIC GOITRE (Basedow's Disease).

In cases suffering from Basedow's disease, it has been noted by Payton and Noir (433) that, when the *static spark* is applied,

it leaves a white livid bloodless point surrounded by a reddish-yellow areola. They claim that the decrease of this phenomenon will be observed with the improvement of the patient's condition.

Attention has been called by Charcot to the fact that in cases of exophthalmic goitre, the *electric resistance* of the body is decidedly reduced. These observations have been corroborated by Vigouroux, who likewise noted this phenomenon in certain cases of heart disease.

In order to test the value of this sign, Wolfenden (435) took the electric resistance in a number of healthy persons, and found this to be 4000 to 5000 ohms. In 8 cases of well-developed Basedow's disease, this resistance was found to be only 500 to 700 ohms, and in 12 other cases, in which the uncertain signs of the early stages of this disease were present, the resistance was 1000 to 1300 ohms. He believes that this observation of Charcot will be of marked service in the diagnosis of the early stages of the disease, when the symptoms are yet of an indefinite nature.

In ordinary goitre, Wolfenden did not find that the electric resistance was reduced, nor was this the case in a patient suffering from malignant disease of this gland. He found the electric resistance reduced in hemiplegia, epilepsy, softening of the brain, paraplegia, general paralysis and hystero-epilepsy. He believes that this circumstance is associated with the dilatation of the capillaries of the skin, which saturate it with moisture and reduce the resistance of the epidermis to a minimum.

The diminution of electric resistance has also been noted by Kahler, of Vienna, and Prager (436), but these authors believe this to be due to the great tendency to perspiration in these cases, which causes a marked saturation of the skin even where there is no evidence of coarse perspiration to be seen. This is also the opinion of H. W. D. Cardew, of London (437), who finds this condition of the skin present not only in Basedow's disease, but in a number of other conditions in which there is considerable moisture of the skin, so that this symptom has really no value in this connection.

Electricity has been used extensively in the treatment of Basedow's disease, and a number of methods have been applied. Both galvanism and faradism have been used, with preference however for the former, which has been applied by the method of central galvanization, directly to the hypertrophied gland, to the pneumogastric nerve etc.

The application of electricity for Basedow's disease was considered a useful method by Charcot (438). Pelzer, of Mühlheim, (439), reports a case of this disease in a woman of 42 years, which was cured by the *galvanic* current.

A case of exophthalmic goitre, of one year's standing, is reported by A. D. Rockwell (6). In this case the palpitation and exophthalmus disappeared after 15 applications of galvanism, and the goitre was reduced to one-third its former size. This author (440) also reports 45 cases of exophthalmic goitre, 27 of which were benefited and 14 fully or approximately cured. Both galvanism and faradism were used in these cases.

Faradism has also been used in exophthalmic goitre by A. F. Plicque (441), who gives a minute description of the operative technique for this treatment. He has found the improvement from this method to be prompt, but six months, a year or even longer treatment is required before all the symptoms disappear.

The external application of the galvanic current has been successfully used by Massey (442), who has cured four cases out of six of exophthalmic goitre by this method. It is also recommended by Jaccoud (443), who combines with galvanization of the neck faradization of the precordial region, as recommended by Vigouroux.

Instead of applying the galvanic current to the thyroid gland, Leslie Phillips, of Birmingham (444), suggests that it be applied below the ears of the patient, and reports a case in which there was marked palpitation, a pulse frequency of 160 to 180, and hypertrophy of the thyroid gland, which was cured by this method. A current of seven milliamperes was applied for ten minutes. Within one month the frequency of the pulse had decreased to 90, the palpitations had decidedly improved, and a complete cure was obtained. The author very properly advises caution in applying a current of this strength in the neighborhood of the ears, on account of the vertigo and other disagreeable nervous effects which are likely to be produced.

The electro-therapeutic treatment of Basedow's disease is strongly advocated by H. W. D. Cardew (445). He has found galvanism superior to faradism, and a very weak current strength (two to three milliamperes) sufficient for this method. The applications should continue for six minutes, and be made three or more times daily. He advises that the anode (positive pole) be applied to the back of the neck, so that the middle of the inferior

border covers the *processus spinosus* of the seventh cervical vertebra. The cathode should be passed up and down the neck (labile) as far as the mastoid process, so that the important nerves may be reached.

The effect of this treatment is the reduction of the frequency and the strength of the cardiac beats. The treatment must be continued in the most careful manner for several months, and, in cases adapted to this method, there is usually a gradual cessation of all the symptoms.

Cardew advises that the patient be carefully instructed in this method so that it may be used at home, on account of the frequent applications which are necessary. He reports several cases in which this method has been used with success.

This method is also recommended by Spencer, of Grand Rapids, Mich. (446), who has found it of marked benefit in Basedow's disease. He elaborates the statement made by Cardew that we have in electricity an agent powerful for good in the majority of cases of Basedow's disease, and reports six cases showing the benefits of electro-therapeutic treatment in this condition.

The galvanic current is also advocated by Robt. Newman (447), but he advises that the negative pole be applied to the eye, the vagus and the sympathicus. In regard to the strength of the application, he does not give any fixed rule, as this is regulated by the conditions of each case, but he advises that long sittings and strong currents be avoided. A similar method is recommended by Regnier (448).

On account of the danger of applying the electric current to the eye, it is preferable to omit this in the treatment of these cases. In applying this to the pneumogastric and sympathetic nerves, extreme caution should be used on account of reflex disturbances which may be produced.

Several authors have advised the treatment of Basedow's disease by galvanization of the sympathetic nerve, and good effects from this method are reported by Dusch (449), Eulenburg and Guttmann (450).

The *galvanization* of the *sympathetic nerve* was introduced by Remak, and probably presents great possibilities in electro-therapeutics. This is easily explained when the large number of vaso-motor nerves under its control is considered, and the great influence of the circulation upon the function of an organ.

This method is advocated by Neftel (107), who warns that the

sympathetic must be very cautiously galvanized with a weak current and no longer than one-half minute, on account of the danger of producing cerebral symptoms, as vertigo, congestion etc., especially if the electrode be applied to the fossa auriculo-maxillaris. These effects, according to Remak (452), are due to the change of equilibrium between the two parts of the cerebellum, caused by the excitation of some of the fasciculi of the superior ganglion of the cervical sympathetic of one side. In galvanizing the sympathetic, one electrode should be applied under the articulation of the jaw at the inner edge of the sterno-mastoid muscle, and the other electrode in the situation of the lower part of the common carotid.

Galvanization of the *pneumogastric* has also been advocated in this disease, the positive electrode being placed at the lower and anterior part of the neck between the common carotid artery and the jugular vein, and the negative to the solar plexus, a current of five to ten milliamperes being applied for ten to fifteen minutes daily.

In my own investigations of this subject, I have found faradism of but little benefit, but have obtained good results from the use of galvanism. Central galvanization, which has already been described, has been found to be the fundamental treatment in the majority of cases. In addition to this, mild currents were applied to the hypertrophied gland two or three times weekly; where this treatment was not efficacious, it was combined with galvanization of the pneumogastric or the sympathetic, and in some cases with both alternately. In patients who resisted all the ordinary forms of treatment, this method was sometimes successful. The general condition of the patient should, of course, not be neglected, and tonics, healthy outdoor exercise and, in some cases, also hydro-therapy, are important measures which should not be overlooked.

Under no circumstances should strong currents be applied; partly as they may overstimulate and irritate, and also because they unfavorably impress the patients, who are almost always of a neurotic type. Electro-therapy in these cases is a most useful treatment, but it should be scientifically and judiciously applied.

CHAPTER XXXIII.

Application of Electricity to the Ear. Reaction of the Acoustic Nerve to Electric Excitation.

APPLICATION OF ELECTRICITY TO THE EAR.

THE ear has not been neglected by electro-therapeutists, although our knowledge of this subject is still in an unsettled condition. The brilliant investigations of Remak, Brenner and others gave a strong impetus to the application of electricity to the ear, but their researches were not followed up by subsequent observers, and many of the later writers on otology have entirely neglected this subject, in spite of its great possibilities.

For examination of the ear, electricity is of value especially in connection with the head mirror, by means of which the rays from an incandescent lamp are projected into the aural speculum. Various forms of ear speculums with electric light combined have been introduced, and are used in a limited capacity, but the head mirror is so universally applicable that it is still used in a very large majority of cases.

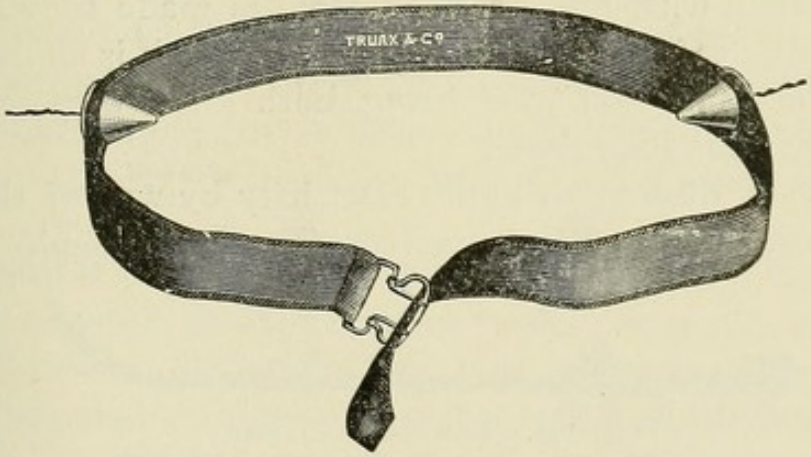


Fig. 133. Bishop's Double Ear Electrode.

A number of aural electrodes has already been described in Chapter III. A double ear electrode (Fig. 133) has also been devised by Seth S. Bishop, of Chicago (453). It consists of two

metal cones covered with chamois skin and held in position for treatment by an elastic ribbon buckled around the head. The tips of the electrodes are moistened before insertion into the auditory meatus. He has found this a useful method in applying electricity in diseases of the ear.



Fig. 134. Scheppegrell's External Ear Electrode.

An external electrode (Fig. 134), which I have found most useful, consists of a copper bulb which fits into the concha, the handle being of hard rubber. When used, the copper should be covered with a layer of moistened absorbent cotton or flannel. The canal of the ear is first filled with warm water, the head of the patient being supported on the table with the affected ear upwards, and the electrode then inserted. In this manner, the contact extends over a large surface, thus avoiding the irritation which results from the applications being made to a smaller area. This electrode may also be used without filling the canal of the ear, and is applicable for both galvanism and faradism.

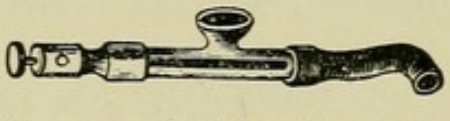


Fig. 135. Liel's Ear Electrode.

An ear electrode has also been devised by Liel, in which the electric contact with the auricular canal is made by water only. It consists of a soft-rubber tube (Fig. 135), which is applied to the ear, and the canal and tube being both filled with water, the electric contact is thus made.

When it is desired to apply electricity by way of the Eustachian orifice, a Eustachian electrode (Fig. 136) should be used.

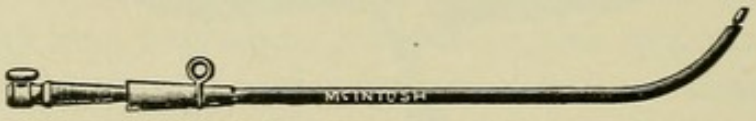


Fig. 136. Eustachian Electrode.

This consists of a hard-rubber catheter or an insulated silver catheter through which a metallic wire with an oval end is introduced. When used, a pledget of moistened cotton is applied to the tip of the electrode. The advantage of this arrangement is

that the Politzer bag may be used in order to ascertain, by the sounds of inflation, whether the electrode is in the proper position.

REACTION OF THE ACOUSTIC NERVE TO ELECTRIC EXCITATION.

The experiments of the effect of the galvanic current on the auditory nerve date back to Volta (454), who introduced a metallic electrode into each ear and connected these with a pile of 30 or 40 pairs which he had constructed. On closing the circuit and during its continuance, a peculiar acoustic sensation was experienced, which resembled the boiling of a viscid fluid. This experiment was not repeated, as the cerebral symptoms which accompanied it were of a disagreeable nature.

The electric test of the acoustic nerve was not only repeated by Ritter (455), but he also conducted it by means of a current from a battery of 100 to 200 cells. In this case, also, there was a disagreeable acoustic sensation on closing and opening the circuit and during the continuance of the current. This experiment, conducted with a battery of such strength, must have been not only disagreeable but even dangerous, and the cerebral disturbances, which accompanied it, are therefore easily understood.

After these investigations were published, reference to this subject was only made at long intervals. Grapengiesser and Ermann, 1812, referred casually to the application of electricity to the ear, and R. Wagner, 1843, E. H. Wever, 1846, E. Harless, 1853, and Longet, 1850, simply called attention to the fact that the subjective sensation of sound could be produced by the electric current. This subject was also investigated by Schiff, 1858, Ludwig, 1858, Fick, 1860, and E. R. Weber, but these differ from the former writers in explaining the origin of the sounds, and, instead of attributing this to the acoustic nerve, they believed that the sound sensations were the effects of the current on the sound-conducting apparatus.

This subject was also investigated by Duchenne, of Boulogne (456), who however made use of the faradic current. He used an electrode in which the conducting cord is insulated by a kind of ear speculum made of ivory. One ear was then filled with warm water, and the circuit closed by placing the other electrode over the mastoid process. As will be explained later, this is not a good method of exciting the acoustic nerve, it being better effected when the dispersing electrode is at a more distant point. On account of the higher potential of the faradic current, the location of

the dispersing electrode on the mastoid process does not interfere as seriously with the stimulation of the acoustic nerve as when the galvanic current is applied.

In using the faradic current in this manner, Duchenne perceived, at the moment when the current was broken, a dry sound resembling the crackling of parchment, which he traced to the external auditory canal. When the intermittances occurred with extreme rapidity, the sounds then resembled the beating of a fly's wings between a pane of glass and a curtain, and these sounds increased directly with the strength of the current. After a certain time of excitation and a decrease of the tension of the current, a tickling of the right side of the tongue was perceived. When the force of the current was increased, this sensation progressed towards the point of the tongue and a numbness and a disagreeable prickling was noticed, but this did not go as far as actual pain.

The stimulation of the auditory apparatus is not an easy matter on account of its somewhat inaccessible position. In attempting to stimulate it, other nerves are frequently excited, such as the optic, gustatory and facial, and even the brain itself may be disagreeably affected by the application of the current. The perception of sound, which is characteristic of acoustic reaction, also differs in various individuals, and is more easily produced in some persons than in others.

The reaction of the auditory nerve, however, is more easily produced in certain pathologic conditions, when excitation may sometimes be accomplished by comparatively light currents.

The first systematic treatise on the subject of the reaction of the acoustic nerve to galvanic excitation was made by R. Brenner (457), who in 1868 published his investigations on the subject of electro-otiatrics. He made a series of investigations on this subject, and stated that the reaction of the acoustic nerve is more easily demonstrated than that of any other motor or sensory nerve, and that this reaction is of great importance not only from a diagnostic, but also from a therapeutic standpoint.

Great importance was attached by Brenner to the proper location of the electrodes, and he believed that faulty applications would not only vitiate the results, but would also cause unpleasant cerebral symptoms. If, for instance, the galvanic application to the ear is made in the manner that is usually described, that is, by applying one electrode to the auditory canal and the other over the adjoining region, as the face or mastoid process, even a mild

current will give rise to disagreeable effects. This application not only causes pain, but is accompanied by muscular contraction of the region controlled by the facial nerves and the motor branches of the fifth pair, and is frequently accompanied by vertigo.

When, however, the electrodes are so applied that a supposed line connecting them is parallel to the plane passing through the antero-posterior diameter of the head, it is claimed by Brenner (457) and also by Neftel (107) that this vertigo never appears. They believe that vertigo will follow when the line connecting the electrodes forms an angle with this plane, and that this symptom will vary according to the strength of the current and the angle which is formed, the most disagreeable effect being obtained when this is a right angle.

While I fully agree with these writers as to locating the dispersing electrode at a distance from the ear, it is not in my experience an invariable rule that there is no vertigo when the imaginary line connecting the electrodes is parallel to the antero-posterior diameter of the head. This frequently depends upon the nervous condition of the patient and his susceptibility to the electric current, and I have frequently been compelled to discontinue even mild currents on account of the vertigo which was produced.

It is of special importance, however, in stimulating the auditory nerve that the dispersing electrode be placed at a distant point, as, for instance, the hand, the principal factor being a sufficient distance without relation to the antero-posterior diameter of the head.

If the dispersing electrode be applied to the mastoid or other neighboring region, the tendency of the current is to reach the opposite electrode through the tissues by the most direct route. Therefore a greater portion of the current passes through the external tissues and very little to the auditory nerve. By applying the dispersing electrode to the hand or other distant region, a much greater portion of the current reaches the auditory nerve.

In spite of every precaution, galvanization of the ear is sometimes followed by flashes of light, due to excitation of the optic nerve, cough, gustatory sensations etc. A delicate rheostat and a mild current minimize these effects, but do not always prevent them.

It is advised by Neftel (107) that instead of introducing the electrode into the meatus, a button-shaped electrode be applied to the tragus, pressing it inward so as to occlude the auricular

canal. With this method, however, it is difficult to avoid ulceration from a prolonged use of the galvanic current.

On account of the amount of cartilage and bone around the auricular canal, its conducting capacity is small and an ulceration is easily produced. To avoid this effect, it is my practice to fill the canal with warm water and apply the ear electrode (Fig. 134) covered with moistened cotton to the whole cavity of the concha. In this manner the entire auricular canal and part of the auricle form a conducting medium, so that the irritating effects are minimized.

In his investigations on the acoustic nerve, Brenner states that if the negative electrode be applied to the ear and the positive to the neck or other distant part, the closure of the circuit, by means of the interrupter, causes a prickling, burning sensation to be felt at first. On increasing the strength of the current, a sound is perceived usually of a distinct metallic character. This acoustic perception is most noticeable at the closing of the circuit, but disappears in a few seconds and does not reappear even when the circuit is broken. On changing the polarity and connecting the positive pole with the ear electrode, or effecting this by means of the pole-changer, no acoustic sensation is perceived at the closing of the circuit or during its continuance. When the circuit is interrupted, however, a sound similar to the cathodal closure is heard, but more feeble in character and of less duration. The intensity of these phenomena may be strengthened by increasing the force of the current, but their appearance always follows the same rule regardless of the intensity.

These observations were utilized by Brenner to institute certain formulas, which are of interest as being the first attempt to establish rules for the electric diagnosis of the acoustic nerve.

Where the opening and closing of the current is used in testing the reaction of the acoustic nerve, only very mild applications should be made, on account of the irritating symptoms which may be developed by a stronger current. Unfortunately, however, the reactions are not always developed by means of currents sufficiently mild not to be unpleasant.

That the phenomenon produced in these cases is due to the action of the current, was demonstrated by Neftel (107) by means of the following experiments: He introduced two needles into the semicircular canal of the labyrinth in the dead subject, and connected them with the wires of a galvanometer. When one

electrode was applied to the meatus and the other to the neck, the galvanometer at once showed a distinct current. When, however, the second electrode was applied nearer to the ear, a larger strength of current was required to produce the same degree of deflection of the galvanometer needle, and when the electrodes were nearly approximate, the limit of the battery did not produce any effect. This experiment proves not only that the acoustic nerve is traversed by the electric current, but also the inefficiency of the method, so often advised, of applying the dispersing electrode to the mastoid region.

It has been shown by Brenner that the resistance to the penetration of the current applied to the acoustic nerve is less from points surrounding the lower portion of the ear than those about the upper part, and also less from the anterior side than the posterior.

The results of the action of the galvanic current upon the acoustic nerve, in a normal condition, is summarized by Neftel (107) as follows:

1. The continuous galvanic current can call forth the specific energy of the acoustic nerve in a certain characteristic manner.

2. This normal reaction of the acoustic nerve consists of an acoustic sensation, which is felt under the influence of the cathode at the closing, and for a short time during the closure of the circuit; and, under the influence of the anode, only at the opening of the circuit. The cathodic opening and the anodic closing are not followed by an acoustic sensation.

3. The cathodic reaction, which appears almost at its full strength at the closing of the circuit, soon decreases and disappears altogether. The anodic opening reaction appears gradually, and requires that the preceding anodic closure should be of considerable duration; otherwise the anodic opening will not call forth an acoustic sensation.

4. After the cathodic opening, the acoustic nerve, being in the electrotonic state with increased irritability, reacts at subsequent cathodic closings to smaller current intensities than before. The same takes place in a still higher degree after reversing the current direction.

5. The acoustic reaction is called forth not only by the closing and breaking of the circuit, but also by sudden and large fluctuations during the uninterrupted flow of the current. Fluctuations with increasing intensity have the same effect as the closing; and

those with diminishing intensity, the same as the opening of the circuit.

6. The acoustic sensations, produced by the galvanic current, are different in various persons, though always identical in the same. They resemble buzzing, hissing, rolling, whistling, ringing etc., and in their highest development, pure, pleasant, musical notes of various tones in different persons. Very often the murmurs correspond to lower current intensities, and the metallic ringing and musical sounds to the higher intensities.

7. On increasing the current intensity, the sound becomes higher when the acoustic nerve is under the influence of the cathode, and lower when under the influence of the anode.

The normal reaction of the acoustic nerve is variously affected by different pathologic conditions. The resistance is abnormally lessened by suppurative and ulcerative processes, and a perforation of the tympanic membrane, scarcely noticeable by inspection, will give a galvanic reaction of unusual severity with a very weak current intensity; while in atresia of the external meatus, or its occlusion by hardened cerumen, a comparatively heavy current may be insufficient to excite it.

The reaction of the auditory nerve has been the subject of considerable discussion, some claiming that the symptoms experienced are not due to its excitation, but to contraction of the small muscles of the ear, this opinion being held by Wreden, of St. Petersburg. Rockwell (6), however, believes this opinion untenable for the following reasons:

1. The reaction of the galvanic current, when applied to the ear, is frequently similar to some of the sounds of tinnitus aurium.

2. The differential polar effects of the galvanic current on the ear, which are very easy of demonstration, cannot be explained by any theory of muscular contraction.

3. Some of the reactions are produced by the steady flow of the galvanic current without any interruptions, and with a strength not sufficient to produce muscular contraction.

4. A reaction of the auditory nerve, similar to certain forms of tinnitus, can be obtained in some sensitive cases, not only by the galvanization of the ear, but of other parts of the head and even the trunk.

Although he admits that it may be of value in special cases, Bürkner (451) attaches little importance to the application of the galvanic current as a method of diagnosis in diseases of the ear.

D. B. St. John Roosa, in his earlier edition on diseases of the ear, gave considerable space to this subject; in a later edition (458), however, he states that he does not think it has yet been demonstrated that we can determine the situation or character of the lesion in the ear by means of electricity. He advises the student of aural diseases not to concern himself with the various theories on this subject! Roosa believes that the value of electricity in the treatment of aural diseases has been much overrated, and that little can be done by this method which cannot be effected as well by the catheter, Politzerization and applications to the pharynx.

The treatment of diseases of the internal ear with galvanism is not indorsed by Politzer (506), as he has seen permanent improvement of the hearing in very few of the cases which he has treated in this manner, and he believes that the complete disappearance of tinnitus is of great rarity; not seldom, however, after a shorter or longer treatment, the intensity of the subjective sounds diminishes for a considerable time. He has, however, had marked benefit in many of the accompanying symptoms of disease of the ear, such as oppression, vertigo etc., which he has been able to cure entirely or improved to a marked degree.

An author who has had considerable experience with electrical methods, and who has carefully investigated this subject, is Gradenigo (459). He considers galvanism an important method in the diagnosis and prognosis of aural diseases. In his opinion, the electric method of examination of the acoustic nerve is a much more delicate proof than the functional examination. If the external tests with currents of eight to ten milliamperes be employed, the pain is moderate and the results satisfactory. He has observed the following electric reactions of the acoustic nerve:

1. In normal conditions there is no electrical reactions in the acoustic nerve. In order to obtain any reaction, the auditory parts must be diseased.

2. There is an acoustic reaction in all cases of disease connected with hyperemia. There is never a reaction without hyperemia.

3. There is a reaction in the initial stages of neuritis.

4. The reaction of the acoustic nerve is exactly like that of any other nerve.

5. The character and duration of the sound evoked by the passage of the current are influenced by the nature of the

morbid affection, by the remedies employed and by individual idiosyncrasies.

6. The acoustic reaction is attributable to the nerve rather than to the labyrinth.

While agreeing with the latter statements made by Gradenigo, the first observation, that there is no electric reaction of the acoustic nerve in the normal condition, and that this occurs only when the auditory parts are diseased, has not been my experience or that of many others who have investigated this subject. Schwartze, as the result of his observations, states that in healthy persons, as a rule, a current of six milliamperes will bring forth the reaction of the acoustic nerve. In certain irritable conditions, such as hyperemia and inflammations, which affect the acoustic nerve either directly or indirectly, a reaction is often produced by interrupting a current of one milliampere. The easy reaction of the acoustic nerve (with currents of one to three milliamperes) is therefore indicative of an irritable condition of the internal ear or the acoustic nerve, when the objective examination enables us to exclude inflammatory alteration of the middle ear.

This more easily produced reaction is not attributed by Schwartze to the decrease of the resistance of the ear, as is believed by Pollak, Gartner (461), Benedikt (462) and Bernhardt (463), but to the actual increase of electric excitability of the acoustic nerve.

The electric reaction of the auditory apparatus is attributed by most writers on electro-otiatrics to the auditory nerve only, who claim that the reaction is not due to any effect of the current on the labyrinth. The qualitative effects, however, which I have been able to obtain by varying the current have convinced me that the latter takes an active part in this reaction.

The electric examination of the acoustic apparatus is a delicate means of diagnosis and is as important as the functional examination. The proper use of the electric method enables us to detect slight changes in the acoustic nerve, which the functional examination may have failed to exhibit, and Schwartze calls attention to its importance in the involvement of the nerve with certain intracranial processes, as tabes dorsalis, hysteria with acoustic anæsthesia and in *sclérose en plaques.*

A series of experiments have been conducted by H. Beauregard and E. Duprey (464), with a view of determining the presence of an electric current in the auditory nerve, and to ascertain the

limits of auditory sensation in animals. They employed for this purpose the galvanometer of D'Arsonval with a micrometer scale, which permits very feeble currents to be recognized. These experiments were made on frogs.

The acoustic nerve having been exposed, it was divided and an electrode applied to the section and another to the tympanum. The electrodes were attached by a thread of copper to the galvanometer. The action of the nerve gave rise to a perceptible current, which was accentuated by noises when these were made near the ear. Shrill noises had more effect than those of a lower pitch. These experiments were verified in other animals.

CHAPTER XXXIV.

Electricity in Diseases of the Ear.

GALVANISM.

THE value of electricity in diseases of the ear has been extensively discussed, many believing it to be of great importance and others affirming that they have had no results from this method of treatment. When it is considered that we are frequently unable to differentiate precisely the pathologic conditions present in the labyrinth or auditory nerve, and when we remember that this agent has been employed by many aurists who are unfamiliar with the application of electricity, the contradictory results which have been reported are easily understood.

It is of the utmost importance that the physician should be thoroughly familiar with the application of electricity before attempting to apply it to such a delicate organ as the human ear. In many cases, for instance, in which the application of the positive pole would be of benefit, the use of the negative would not only be disagreeable but even injurious. In other cases where a mild galvanic current may relieve tinnitus, a stronger current will not only fail to do this, but will even aggravate this distressing symptom.

Generally speaking, the positive pole is more sedative and the negative more stimulating. This has been found to be the case in other portions of the body, and it also applies to the auditory nerve.

On account of the influence of electricity in stimulating defective action of the nerves and its general tonic effects, galvanism should be conscientiously tried in such forms of deafness in children, when due to some obscure condition of the internal ear, before these cases are considered hopeless.

The reaction of the auditory nerve under electric excitation in hyperesthesia and other conditions of this nerve has been care-

fully investigated by Brenner (288), who presents the following formulas:

1. In simple hyperesthesia, the auditory nerve reacts under electric currents very much weaker than those required to produce a corresponding excitation in the normal auditory nerve. The continuance of the reaction during cathodal duration (Ka D) and anodal opening (A O) is much longer, and during a moderate current the cathodal duration (Ka D) does not terminate before the opening of the current.

2. In hyperesthesia with qualitative alteration of the formula, the electric excitation manifests itself not only by an easy excitability, but also by a change in its mode of occurrence. Thus, with cathodal closure (Ka S), cathodal duration (Ka D) and anodal opening (A O), there is a subjective ringing, and with anodal closure (A S), anodal duration (A D) and cathodal opening (Ka O), there is hissing.

3. In simple hyperesthesia, there is an inversion of the formula, and the disappearance of the normal formula in presence of the pathologic can be very striking. The normal may be characterized by the lower notes of the scale and distinguished from the pathologic reactions by shortness of duration. With weak currents, this condition does not manifest itself.

4. Hyperesthesia of the auditory nerve, with the paradoxical formula in the ear opposite that to which the diagnostic application is made, is of frequent occurrence, but Brenner has found this curious phenomenon present only in very chronic cases of ear diseases. These cases are characterized by the circumstance that during the application of electricity to one ear, not only the auditory nerve of that side, but also that of the other ear, responds, but in an inverse manner, so that, in the ear not under treatment, the perception of sound occurs at those moments of excitation during which the nerve of the ear immediately under treatment is silent. The ear not treated reacts as if it were under the influence of the other electrode.

These tests of the auditory nerve are of much importance, and it is to be regretted that so little reference to this subject is found in the majority of text-books on diseases of the ear. These and other electric tests of the ear should be as necessary a part in making a diagnosis of diseases of this organ as the tuning-fork, Galton's whistle etc.

As showing the correctness of this test, and that it is due to

the acoustic nerve and not to the labyrinth, Unverricht (465) reports a case of multiple paralysis of the cranial nerves with rapid diminution of the capacity for hearing, in which a galvanic hyperesthesia of the acoustic nerve could be demonstrated, and it was afterwards shown in the autopsy that the labyrinth was intact, but that the gustatory nerve was compressed by a cerebral tumor. Gradenigo (466) also reports a case in which the lesion of the acoustic nerve, diagnosed by the galvanic current, was corroborated in the autopsy.

It has also been shown by Brenner (457) and Hagen (468) that the galvanic current is indicated not only in those cases where no morbid changes can be diagnosticated, but also in all cases, however complicated, in which the abnormal reaction to the current shows that the nerve participates in the disease. The galvanic treatment may also aid in the absorption of the morbid deposits.

A disagreeable symptom in which electricity has been found useful is tinnitus. This, however, is due to an irritation of the auditory apparatus depending upon so many pathologic conditions that it is not surprising that the application of electricity does not permanently cure, or even give relief, in many cases. Many patients however are temporarily relieved by the proper application of galvanism, and, in some cases, its continued use gives permanent relief. The cases of tinnitus, which are most benefited by this treatment, appear to be those in which it is associated with hyperesthesia or qualitative galvanic changes.

The method of making galvanic applications in these cases is as follows: the ear electrode (Fig. 134), covered with moistened cotton, is connected with the positive pole and placed over the external meatus, the dispersing electrode being applied at a considerable distance, as to the hand. By means of the rheostat, the current is now gradually admitted until a point is reached at which the noises have disappeared. This should not be more than three milliamperes at any time. The current is then allowed to pass for three to five minutes and is gradually reduced by means of the rheostat.

Where relief is experienced from this application, it usually continues for at least several hours and frequently for many days. Even in cases in which the tinnitus returns, it is sometimes of a milder form and much less disagreeable to the patient.

Where this method fails to give relief, a light current (one milliampere or less) should be applied, and the positive electrode

suddenly reversed by means of the polarity changer. Where a prolonged and permanent effect is necessary, Neftel (107) advises the following method:

The current is closed with the cathode at so low an intensity as not to excite the acoustic nerve, and the rheostat is gradually adjusted until a certain intensity is reached, when suddenly the current is reversed to the anode by means of the polarity changer. The acoustic nerve is kept under the influence of the anode for about a minute or more, and then the current intensity is slowly diminished by means of the rheostat. The object of this slow diminution of the current is to avoid the reaction of the anodal opening. He states that where the tinnitus is due simply to hyperesthesia, this method is usually followed by complete success.

A different method of application is advised by Erb (478), who closes the circuit with the full strength of the current to be used, instead of admitting it with the rheostat as in the ordinary method. After applying the current for five to fifteen minutes, he reduces it by means of the rheostat.

The following case in my practice will illustrate the advantage of using galvanism in these cases: a young lady of 24 years, who had had non-suppurative otitis media for several years, suffered from tinnitus to such an extent that it prevented her from following her occupation. At the time of her visit, this had become so aggravated that it almost bewildered her. As this case showed marked evidence of hyperesthesia, the positive pole was applied to the left ear, to which the patient attributed the tinnitus, and a large dispersing electrode to the wrist. The rheostat was then adjusted so that a current of one milliampere was passed, which was continued for ten minutes.

Before the end of the sitting, the patient stated that the noises had disappeared. After the application there was some vertigo, which, however, passed off in a few minutes. A week later, the patient reported that the tinnitus had been entirely absent for six hours following the application and had then returned to a slight degree, but the noises had since been noticeable only mornings and evenings, and then not to an extent to be disagreeable. An application of one milliampere was then made for ten minutes, and this repeated five times at intervals of one week, when the patient stated that, although she still occasionally heard the noises, they caused her but little or no inconvenience.

The advantage of the galvanic current in tinnitus is admitted

by Schwartze (470), who states that its good effects are specially noticeable in that category of tinnitus which disappears or diminishes on the application of the positive pole. In traumatic lesions of the labyrinth, however, he states that galvanization of the acoustic nerve is not to be recommended, and in subacute cases is absolutely contraindicated.

Two cases of tinnitus aurium are reported by F. M. Rumboldt, of St. Louis (471), these having been benefited by the application of galvanism.

Galvanism has been found useful by W. C. Baxter (472) for the relief of tinnitus and improvement of the hearing in some very chronic cases of middle-ear disease, which had been treated by the usual method without benefit. He fills the ear of the patient with warm water and applies a current by means of a small wire insulated to within two millimeters of its point. A current of five to ten milliamperes is then passed, and "retaining the electrodes in position, the poles are changed two or three times a minute."

The sudden interruption of a current of this strength, when the polarity is reversed, is exceedingly irritating to the auditory and cranial nerves and even to the brain. In hyperesthesia it is distinctly contraindicated, while in other conditions a current of less strength is to be recommended.

The galvanic treatment of tinnitus aurium is advised by Lewis Jones, of London (473). He applies the current by means of a bifurcated or divided electrode, the extremities of which are placed in front of the tragus and kept in position by means of an elastic band or spring. The dispersing electrode is placed to the back of the neck, the positive pole being applied to the aural electrode. The current is slowly increased to ten milliamperes. He does not find the prognosis of the electric treatment favorable in progressive sclerosis.

I would again caution against the application of strong currents to the ear. Ten milliamperes are likely not only to produce the symptoms already referred to, but even to cause ulceration at the point of application of the electrode to the ear.

Instead of using the external auricular canal for the electrode, the Eustachian opening is recommended by H. Campbell (474), who reports a number of cases in which he has used the galvanic current successfully for the treatment of catarrhal otitis media. He first introduces a Eustachian catheter in the usual manner,

through which he injects a little warm water, and then passes a metal wire through the catheter and applies a mild current of electricity. He states that the influence on the mucous membrane, in this treatment, decreases the liability to relapse.

The great danger of producing ulceration and subsequent stenosis of the canal, from the application of galvanism by means of so small an electrode as a metallic wire, which is passed through the catheter, should not be overlooked in the application of these methods.

A similar method for the conditions of atrophy or sclerosis is recommended by Fred Whiting, of New York (475). He advises that the Eustachian electrode be applied to the negative pole on account of the congesting effect of this pole on the mucous membrane, which may thus antagonize the atrophic process. This method has also been found useful by Weber-Liel, of Berlin (476), who claims that in this manner the muscular structures of the Eustachian tube, and perhaps those of the middle ear (tensor tympani and stapedius), come under the direct influence of the galvanic current. He claims that the auditory nerve is not irritated in this way.

The result of the scientific application of the galvanic current to diseases of the ear is shown by the reports of Brenner (457), who gives the clinical history of 11 cases treated :

In a case of thickening of the drum, the current caused absorption.

The tinnitus was cured in a case of hyperesthesia with tinnitus aurium and pathologic changes in the middle ear.

There was recovery in a case of hyperesthesia following the use of quinine.

The tinnitus was cured in a case of hyperesthesia with tinnitus aurium and catarrh of the middle ear.

There was improvement in one case of obstinate subjective symptoms of various kinds, under great difficulties of application.

There was amelioration in a case of noises in the head and ears of ten years' standing, with important pathologic changes in the ear.

Of deafness, two cases were improved, one much benefited and one cured. The case which recovered was one of facial paralysis, with anomalous reaction of the auditory nerves. In all the cases there were pathologic changes. In some, the treatment was quite persistent.

those with diminishing intensity, the same as the opening of the circuit.

6. The acoustic sensations, produced by the galvanic current, are different in various persons, though always identical in the same. They resemble buzzing, hissing, rolling, whistling, ringing etc., and in their highest development, pure, pleasant, musical notes of various tones in different persons. Very often the murmurs correspond to lower current intensities, and the metallic ringing and musical sounds to the higher intensities.

7. On increasing the current intensity, the sound becomes higher when the acoustic nerve is under the influence of the cathode, and lower when under the influence of the anode.

The normal reaction of the acoustic nerve is variously affected by different pathologic conditions. The resistance is abnormally lessened by suppurative and ulcerative processes, and a perforation of the tympanic membrane, scarcely noticeable by inspection, will give a galvanic reaction of unusual severity with a very weak current intensity; while in atresia of the external meatus, or its occlusion by hardened cerumen, a comparatively heavy current may be insufficient to excite it.

The reaction of the auditory nerve has been the subject of considerable discussion, some claiming that the symptoms experienced are not due to its excitation, but to contraction of the small muscles of the ear, this opinion being held by Wreden, of St. Petersburg. Rockwell (6), however, believes this opinion untenable for the following reasons:

1. The reaction of the galvanic current, when applied to the ear, is frequently similar to some of the sounds of tinnitus aurium.

2. The differential polar effects of the galvanic current on the ear, which are very easy of demonstration, cannot be explained by any theory of muscular contraction.

3. Some of the reactions are produced by the steady flow of the galvanic current without any interruptions, and with a strength not sufficient to produce muscular contraction.

4. A reaction of the auditory nerve, similar to certain forms of tinnitus, can be obtained in some sensitive cases, not only by the galvanization of the ear, but of other parts of the head and even the trunk.

Although he admits that it may be of value in special cases, Bürkner (451) attaches little importance to the application of the galvanic current as a method of diagnosis in diseases of the ear.

D. B. St. John Roosa, in his earlier edition on diseases of the ear, gave considerable space to this subject; in a later edition (458), however, he states that he does not think it has yet been demonstrated that we can determine the situation or character of the lesion in the ear by means of electricity. He advises the student of aural diseases not to concern himself with the various theories on this subject! Roosa believes that the value of electricity in the treatment of aural diseases has been much overrated, and that little can be done by this method which cannot be effected as well by the catheter, Politzerization and applications to the pharynx.

The treatment of diseases of the internal ear with galvanism is not indorsed by Politzer (506), as he has seen permanent improvement of the hearing in very few of the cases which he has treated in this manner, and he believes that the complete disappearance of tinnitus is of great rarity; not seldom, however, after a shorter or longer treatment, the intensity of the subjective sounds diminishes for a considerable time. He has, however, had marked benefit in many of the accompanying symptoms of disease of the ear, such as oppression, vertigo etc., which he has been able to cure entirely or improved to a marked degree.

An author who has had considerable experience with electrical methods, and who has carefully investigated this subject, is Gradenigo (459). He considers galvanism an important method in the diagnosis and prognosis of aural diseases. In his opinion, the electric method of examination of the acoustic nerve is a much more delicate proof than the functional examination. If the external tests with currents of eight to ten milliamperes be employed, the pain is moderate and the results satisfactory. He has observed the following electric reactions of the acoustic nerve:

1. In normal conditions there is no electrical reactions in the acoustic nerve. In order to obtain any reaction, the auditory parts must be diseased.

2. There is an acoustic reaction in all cases of disease connected with hyperemia. There is never a reaction without hyperemia.

3. There is a reaction in the initial stages of neuritis.

4. The reaction of the acoustic nerve is exactly like that of any other nerve.

5. The character and duration of the sound evoked by the passage of the current are influenced by the nature of the

A current of three to four milliamperes is used for three to four minutes. The application of strong faradic currents is very properly condemned.

FARADISM.

Faradism has also been used in the treatment of diseases of the middle ear, but not to the extent of galvanism. The latter is undoubtedly the more efficacious in these cases, although there are some indications in which the former is useful.

In applying faradism, the electrodes are used in the same manner as in galvanism. The polarity of the electrodes, however, is of little importance in this method, as this alternates, so that the extreme care, which should be necessarily exercised in selecting the proper pole for galvanism, may be ordinarily dispensed with when faradism is used.

Some writers have supposed that the beneficial effects of faradism are due to the shaking or loosening of the rigid ossicular chain, which is thought to be one of the effects of this treatment. This theory, however, is opposed by Barr (486), who has used this method and claims to have had better results from the faradic than from the constant current. Rockwell (6) believes that when faradism is used in subacute and chronic inflammation of the middle ear, the results are due to the mechanical action of this current on the adhesions within the middle ear.

It is advocated by Duchenne (487) that the therapeutic action of the process of faradization is chiefly due to the undulations of the labyrinthine liquid produced by the movement of the little chain of bones, and consequently of the fenestra ovali.

In the later stages of acute attacks of ear disease, Mounier, of Paris (488), states that electricity has the widest field, and believes that the time necessary for the recovery of the ear to its normal power, if this takes place, is much shortened by this treatment. He prefers the faradic current for the following reasons: 1. The weakness of the hearing power is associated with the weakness of the muscles of the middle ear. 2. This form of electricity is better tolerated by the patient. 3. The instruments and methods of use are simple.

In making these applications, Mounier uses a simple faradic battery, one electrode of copper in the hand of the patient, and the other, a carbon olive electrode, covered with moistened chamois leather, fitted into the external auricular canal, but

not in contact with the tympanic membrane. He attaches no importance to the polarity, and commences with a weak current which is gradually increased, but never to the extent of causing pain. The sittings should last from five to six minutes, being repeated every three or five days.

In experimenting with the faradic current, Lawrence Turnbull (489) has applied it to his own ear, and has also used it on numerous patients. There was never much pain, and the sensation was not more than a feeling of warmth in the ear with more or less noise resembling the buzzing of an insect.

Good results have been obtained by Duchenne (490) from faradization of the ear in certain forms of nerve deafness, especially in hysteria, cinchonism, typhus and in the exanthemas. He attributes these effects to stimulation of the chorda tympani and the connective tissue of the ear.

This author used faradism successfully in a child deaf and dumb since its birth, and his experience in this case encouraged him to use it in other similar cases where the deafness was of nervous origin. While successful in some cases, he failed in the larger number, but believes that this method will be of importance in these cases, which have proved so refractory to other methods. He applied the current to the external ear, which had previously been filled with warm water, a dispersing electrode being applied to the neck.

Successful results from faradization of the ear in tinnitus and deafness have been obtained by Urbantschitsch (491) and Wraden (492), who have also had favorable results in otalgia and in neurosis of the mastoid process. For acute inflammatory processes of the auricular canal and middle ear, they advise a strong faradic current for three to five minutes, and have noted favorable effects on the hearing and the inflammation.

As illustrating the effects of the faradic current, Urbantschitsch (557) reports a case of a patient suffering from Basedow's disease who had developed deafness, tinnitus and vertigo, these symptoms being cured by the application of the faradic current, one electrode being applied to the tragus, and the other to the region of the inferior cervical ganglion. The galvanic current was previously used in this case without effect.

In cases of inflammation of the tympanum resulting from a tropho-neurosis, the electric treatment has also been successfully used. The author just quoted (557) reports the case of a boy

who had received a blow on the ear and who developed on the following day a throbbing in the ears and marked difficulty of hearing. The history and clinical examination showed that the symptoms were the result of a tropho-neurosis. The symptoms disappeared rapidly under the application of the induced current.

The advantage of the faradic current is also illustrated by Bezold (558), who reports a case of a patient who had previously had cerebro-spinal meningitis and who suffered from vertigo, tinnitus and deafness, who was successfully treated by this current.

In the treatment of tinnitus, Geo. P. Field (493) has had marked benefit from faradization, and reports a number of cases not only improved, but even cured. He ascribes the results to the stimulation of the intrinsic muscles of the ear to the performance of their function. In certain cases of tinnitus, the stapes remains fixed within the foramen ovale, and the continued pressure upon the fluid within the internal ear cannot but tend to induce a constant formation of false sounds. The partial withdrawal of the stapes through the contraction of the stapedius muscle would be followed by a reduction or temporary cessation of such sounds, and Field believes that electric stimulation, by restoring to the relaxed muscle its lost tonicity, enables it to re-exert its proper influence on the auditory function. He states that several of the patients who had been relieved by faradization returned again, but have been cured by the same treatment.

Where deafness results from a disturbance of the nervous apparatus of the ear, the probability is that the best results will be attained by means of the galvanic current. Where, however, the deafness is due to a muscular defect, faradization may be useful on account of the passive exercise and tonic contraction which are obtained by this means. But even in these cases, the interrupted galvanic current would be preferable, as the catalytic influence of the current on the muscles and the nerves which supply them would undoubtedly prove more beneficial than the faradic in the treatment of these conditions.

STATIC ELECTRICITY.

Static electricity has been recommended in the treatment of diseases of the ear by Charcot, Benedikt and others. Its use has evidently been very much limited, as this subject is but rarely referred to in otologic literature.

In his work on diseases of the ear, Turnbull (489) states that when static electricity is applied to the ear, it causes muscular contraction of the tensor and laxor muscles. Good results from the application of static electricity have been obtained by Henry C. Houghton (494), who states that the application of this form of electricity in cases of diseases of the middle ear has given him results surpassing those obtained by galvanism. In the restoration of muscular tonicity and modification of the nutrition of the middle ear, and in the amelioration of subjective noises, faradism and static electricity have given him better results than galvanism, and of the two former, he prefers the latter.

CATAPHORESIS.

Cataphoresis is a useful method of applying cocaine anæsthesia to the external auricular canal. This cavity is very slow in absorbing this solution and frequently the anæsthetic effect is not very pronounced even after the solution has remained in contact for a considerable time. In some cases, cocaine, introduced cataphorically by means of a mild galvanic current, is a useful and rapid method of anæsthetizing this canal, as for the opening of a furuncle, for scarifying the canal or for incising the membrana tympani.

For anæsthetizing the drum or an extensive portion of the canal, a five-per-cent. solution of cocaine is instilled into the meatus, and the positive electrode placed in contact with the solution, the dispersing electrode being applied to some other part of the body. A current of one-fourth to one-half milliampere is quite sufficient for this purpose, the time required being five to ten minutes. Where a small area is to be anæsthetized, as for a furuncle, cotton saturated with a ten-per-cent. solution is applied to this site, and the method carried out in the manner already described.

Cataphoresis has also been used by Masini (495), who obtained excellent results from its application for anæsthesia of the membrana tympani. In applying this method to the healthy ear, he found that a two-per-cent. solution of cocaine applied for fifteen minutes entirely abolished the sensibility of the membrane. Anæsthesia could be more rapidly produced when stronger solutions were used. Solutions of five, eight and ten per cent., when the current was continued for 25, 15 and 10 minutes, al-

lowed him to perforate the membrana tympani without pain. Solutions of from five to ten per cent., with very weak currents applied for five minutes, were sufficient to arrest otalgia, the same effect being obtained with morphine, but to a weaker degree.

Other chemicals have also been used in diseases of the ear by this method. Cagney, of London (496), employed iodine and iodide of potassium solutions cataphorically for labyrinthine deafness. This method has been but rarely used in diseases of the ear, still it undoubtedly offers considerable possibilities in treating certain chronic conditions, which are resistant to the ordinary methods.

In a case of chronic eczema of the auricular canal, in my practice, which had resisted treatment for over a year, a cure was effected within three weeks by a two-per-cent. solution of guaiacol in pine oil, which was cataphorically applied.

CHAPTER XXXV.

Electrolysis, Electro-Cautery and Electric Massage in Ear Diseases.

STRICTURE OF THE EXTERNAL AUDITORY CANAL.

STRICTURES of the external auditory canal are usually due to ulcerative processes or to traumatism. The result of this condition is not only the effect on the hearing, but it tends to prevent the free drainage of the canal when suppuration from the tympanic cavity is present, so that the suppurative process is liable to invade the mastoid cells or other important parts, thus developing the most serious complications.

A number of methods has been suggested to correct this condition of the external auditory canal. As in other parts of the body, there is always more or less tendency to recurrence.

These strictures may be due to connective tissue, but may also consist of bony structure. In the latter, the trephine applied by means of an electric engine is most useful, and this instrument is now also used in operations on the mastoid cells, for which it has special advantages. A useful motor for this work is shown in Fig. 137.

A case of bony stricture operated with the trephine is reported by Robt. Barclay (497), in which there was an ivory-like exostosis which almost completely occluded the auditory canal of a patient who suffered from otorrhea, the result of the operation being satisfactory.

For the connective-tissue strictures of the external auditory canal, electrolysis has proved a useful method. The procedure is similar to electrolysis for stricture of the œsophagus, although milder currents are indicated for the auditory canal. Irritation of the auditory nerve may be best avoided by applying the dispersing electrode over the mastoid process, the negative pole being attached to the ear electrode and the positive pole to the dispersing. In some cases, it is preferable to insert two needles

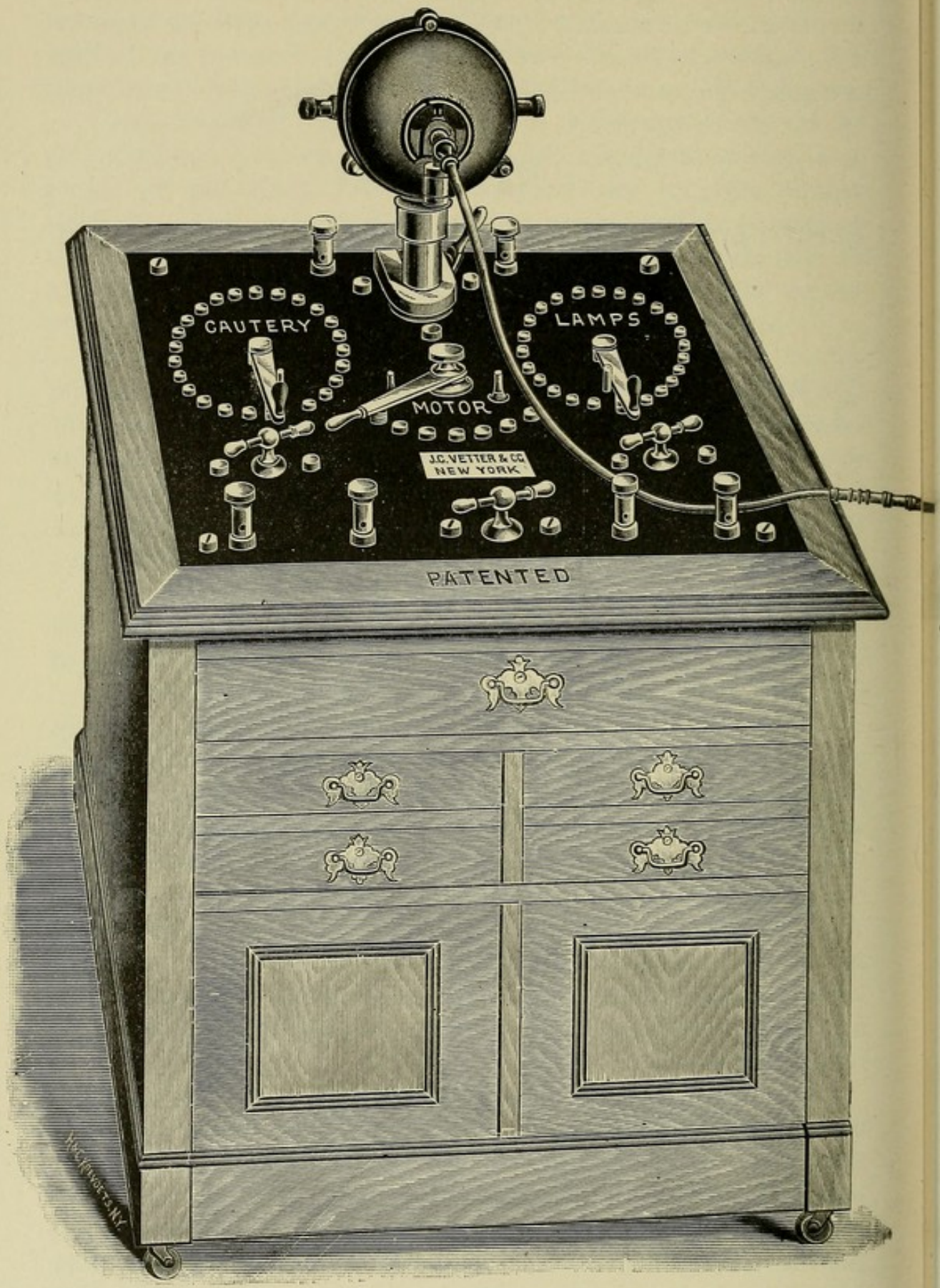


Fig. 137. Vetter Motor and Dynamo Apparatus.

directly into the obstructing tissue, and by this bipolar method irritation of the auditory apparatus is most effectively avoided.

I have also used the bipolar method by means of a sound electrode, the portion to be inserted into the growth having first been cut longitudinally into two parts and insulated by means of a strip of hard rubber, one-half of the electrode thus serving for the positive and the other half for the negative electrode.

A case of stricture of the external auditory canal successfully treated by electrolysis is reported by Ostmann (498). The canal was so contracted that it admitted only the passage of a small sound, and the suppurating middle ear could not be freed of its fetid secretion. After thorough disinfection, two needles were thrust through the upper part of the base of the stricture, and a current of five milliamperes passed for five minutes. In the three following seances, which were made at intervals of eight to ten days, the other parts of the stricture were destroyed. After each application, iodoform powder and gauze were introduced. The pain was quite severe (as no anæsthetic was used), which could probably have been prevented by the injection of a weak solution of cocaine. The reaction was slight, this being one of the special features of this operation, as severe inflammatory reactions tend to the formation of new tissue and thus to the re-formation of the stricture.

STRICTURE OF THE EUSTACHIAN TUBE.

Electrolysis has also been used in dilating the Eustachian tube. For this purpose an ordinary Eustachian catheter of hard rubber is first introduced, and the ear inflated, if possible, in order to ascertain whether the point of the catheter is in the Eustachian orifice. A fine flexible bougie of celluloid is now passed through the catheter, and, when this has effected a passage into the Eustachian tube, a fine silver bougie with a round point is substituted for the celluloid and connected with the negative pole of a galvanic battery, and a small dispersing electrode applied over the mastoid cells or neck. The current should be exceedingly mild (one to three milliamperes), otherwise ulceration may develop and aggravate the original condition. This method is somewhat difficult to apply and should be used only with the greatest caution.

Electrolysis has been applied by Mercié (499), who made use

of fine silver threads doubled upon themselves to render them harmless to the soft tissues. As soon as the threads are found to pass with difficulty or are obstructed by the tissues, a current is passed. The silver wire is attached to the positive pole and the negative to an olive-shaped silver electrode inserted into the external auditory meatus. Stevenson and Cumberbatch also report good results from this method. The insertion of the electrode into the external auditory meatus, however, is apt to prove irritating and offers no advantage over the application of the dispersing electrode to the mastoid process or the neck. It will also be found a useful rule to connect the electrolytic sound with the negative and not the positive pole.

This method has recently been advocated by Arthur Duel, of New York (500). He uses four copper bougies varying from No. 3 to No. 6 (French scale), securely mounted on No. 5 piano wire, and these are passed through small insulated pure silver catheters and drawn back until the bulging portion of the bougie fits tightly into the mouth of the catheter. These catheters are the ordinary instruments, insulated by drawing thin rubber tubing over them or by winding with silk and afterwards coating them with shellac. He does not find the hard-rubber catheters as useful in these cases.

This catheter (Fig. 138) is connected with the negative pole of

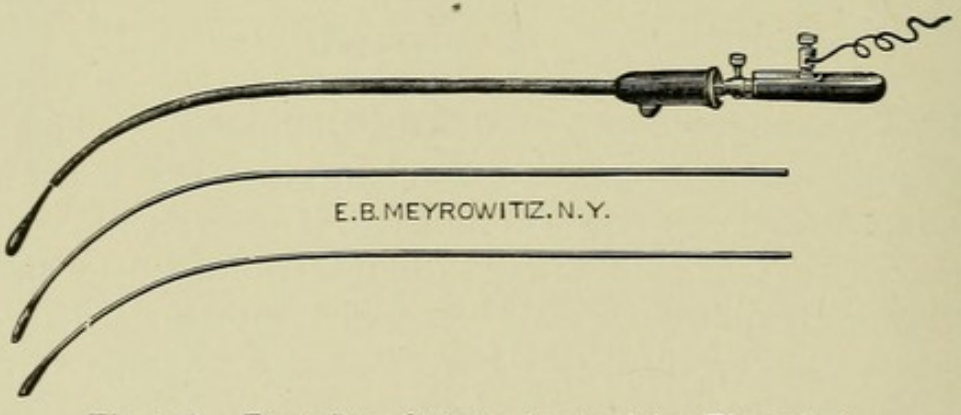


Fig. 138. Eustachian Catheter for Applying Electrolysis.

the battery and the positive with a dispersing electrode in the hand of the patient. When the tube is felt to be within the obstruction, the current is slowly turned on until four to five milliamperes are used. After an application of from two to five minutes, the bougie is felt to pass through the softened stricture with a slight pressure. Duel reports in detail a number of cases treated in this manner.

ELECTRO-CAUTERY.

The electro-cautery has not been used as extensively in diseases of the ear as in diseases of the nose and throat. Where its use is indicated, a fine electrode (Fig. 89, D) should be applied so as to avoid too much radiation of heat to the adjoining parts.

The electro-cautery has been used for making an opening into the tympanic membrane, a method first practised by Voltolini. It has the advantage that the perforation may be kept open for a much longer time than with the usual method of incision, and thus affords more permanent drainage. In old perforations also it has been successfully used for cauterizing the edges so as to develop a healthy reaction for the closure of the perforation.

In granulations, which develop as a result of chronic suppuration of the middle ear, a fine electro-cautery point is a most useful instrument, and it is also recommended by Adam Politzer (501) in granulations of the drum (myringitis granulosa). He states that it is less painful than other methods and more rapidly effective.

This method has also been recommended in the treatment of furunculosis and other inflammatory conditions of the external auditory canal. Löwenberg (502) advises this procedure, and uses for this purpose an electrode which has a lateral action.

For the removal of foreign bodies from the external auricular canal, the electro-cautery has been advised by Voltolini. In certain tightly impacted bodies, as a bean, for instance, it may thus be used to diminish the bulk by the partial destruction of its substance. The electro-cautery has also been used for making incisions in operations on the mastoid cells. Ménière (503) and Lacoarret (504) advise punctiformed cauterization of the superficial areas of the mastoid process, in the same manner that these were used at one time as a counter-irritant for neuralgia.

ELECTRIC MASSAGE.

The subject of vibratory massage in the treatment of diseases of the ear has already been described in Chapters XVII. and XVIII., and the various methods of producing these vibrations and the indications for which they are used pointed out. This method has been recommended, in diseases of the ear, for the purpose of modifying any rigidity in the mechanism of sound transmission into the ear, absorption of inflammatory products, improvement

in the circulation, and increase in the tonicity of the muscles involved in hearing.

The subject of vibratory massage has been investigated by Thos. L. Shearer (152), who applied the violin-vibrophone for this purpose. He states that this method should not be used when acute inflammatory conditions or pain about the ear are present, and that the character of the vibrations should be carefully selected in people of nervous temperament, as a marked increase of the nervous shock may be produced when the vibrations are coarse and of a loud variety. He obtained the best results where a moderate catarrhal condition of the Eustachian tube existed, but the effects were not satisfactory in cases of long-standing hypertrophy or very marked atrophy of the parts. He reports a number of cases in which he has had good results from direct mechanical vibration.

The use of the pneumo-massage apparatus in non-purulent diseases of the middle ear has already been discussed (Chapter XVIII.). Chevalier Jackson (151), who has devised a special apparatus (Fig. 117) for this purpose, states that he has obtained benefit from this method in about 65 per cent. of cases of chronic catarrhal otitis media. In those cases in which a cure is not established, it frequently arrests the onward march of the progressive difficulty of hearing. It has the advantage of being easy to apply, and is harmless in those cases in which it is not beneficial, and is not objected to by the patient. It does not interfere with the application of other methods, such as Politzerization, nasal treatment etc.

In regard to applying pneumo-massage to the drum and ossicular chain, the difficulty in the application of these methods is that where there are adhesions and anchyloses, the influence of the rarefication and condensation is expended on the more flaccid parts of the drum, which yield more readily, and but little influence is exerted on the points which form the real object of the manipulation.

The successful reports, however, which have been made by a number of otologists would indicate that there is some value in the method described, and it should be given a careful trial in selected cases.

The combination of massage and electricity in non-suppurative processes of the middle ear is recommended by W. H. King, New York (559). The massage is applied by means of one of

the forms of pneumatic vibrators already described, a mild galvanic current being used simultaneously. He reports three cases which were apparently benefited by this treatment.

Vibratory massage has also been used as a means of cleansing and drying the middle-ear cavities in cases of suppuration. Louis J. Lautenbach (507), who advocates this method, states that the ear is first cleansed and Politzerized in the usual manner, and then a pneumo-massage apparatus of medium strength and gradual increase of suction is applied. In this way, all the discharge which may have adhered to the crypts and along the walls of the middle ear are drawn into the meatus and about the perforation. These are dried with cotton and the instrument again applied, and, after drying, an astringent antiseptic powder is inflated.

CHAPTER XXXVI.

The X-Rays.

THE latest important addition to our methods of examination is due to the discovery of the X-rays by Prof. Roentgen. When the description of this method was first published to the world, it captivated the public fancy and the most marvelous and absurd results were expected from this new form of radiation. Even in the medical profession, the possibilities of the X-rays were overestimated, and much that was expected from their use has not been realized. This subject, however, is still in its infancy and it has, no doubt, an important future.

With the improved appliances, we have already been enabled to distinguish parts and organs of the human body which at first could not be traced by this method, and the time may not be far distant when we shall have discovered some means of making these invisible rays so perceptible to the eye, that it will give us immense advantages over other methods now in vogue.

The X-rays differ from ordinary light not only in their power of penetration of substances opaque to the light, but also by the absorption of these rays by glass and other crystalline substances which are pervious to light. The softer tissues of the body are easily penetrated by the X-rays, as also cartilage, but bone absorbs the rays to the extent of causing a distinct shadow when surrounded by the softer tissues. Metals are opaque but of different degrees, aluminum being more transparent to these rays than glass, and platinum much more opaque than either.

In the department of the nose, throat and ear, the new radiation has thus far accomplished much less than has been the case in the other branches of medicine. In general surgery, it has furnished most decided results, and in obstetrics and gynecology, it is already considered an important addition to the diagnostic methods.

The appliances required in using the X-rays are simple: (1) a Crookes' or vacuum tube; (2) a large induction coil to excite

it, and (3) a source of electric energy to actuate the coil. Instead of the induction coil, a strong static machine may also be used.

If this method is intended to be applied for skiagraphy, an ordinary sensitized plate and holder, such as are obtained at the photograph supplies' stores, are needed. Especially prepared sensitized films and covers are also made, which may be applied directly to the parts to be skiagraphed. If direct vision is to be employed, a fluoroscope will be required.

When a Crookes' tube is excited by a proper induction coil, it is filled with a beautiful fluorescence due to the cathode rays, which in turn give rise to the X-rays. These cathode rays are developed only in a very high vacuum, and they leave the cathode in straight lines independent of the position of the anode. It has been shown that these rays may be deflected from their course by a magnet exactly as if they were an electric current passing along a conductor.

Crookes believes that the cathode rays are due to the streams of electrified particles of residual matter in the tube, which are shot off in straight lines. The projection of these particles upon the sides of the tube or other obstacles in their path, gives rise to the X-rays, which represent a portion of the energy expended.

Various theories have been presented to explain the phenomena of the X-rays, and the most satisfactory is that they are some form of wave motion; that these wave lengths are so short that they cannot be taken up by the retina of the human eye, and that, by impinging upon certain fluorescent substances, they are lengthened so that they become visible. The defraction and interference phenomena, which are characteristic of wave motion, have not, however, been positively obtained with the X-rays.

The explanation that the phenomena are due to streams of material particles has been supported by a number of physicists, but this fails to explain many of the phenomena which are present, and the majority of investigators now favor the wave theory. It has been suggested by J. J. Thompson (524) and others, that the X-rays may not all be of one kind.

A Crookes' tube is a closed glass vessel, in which the contained air is in a state of high rarefaction, having been exhausted to one-millionth part. In the two ends of the tube are soldered platinum terminals called electrodes. If now the terminals of a large induction coil or static machine be attached to the two electrodes, the enclosed air is brightened to a vivid state of incan-

descence. The point at which the current enters is the positive or anode, and the other, the negative or cathode. From the cathode a faint violet cone of rays is emitted, which appears to fill the whole tube. Crookes thought that this luminosity was due to radiant matter, but Hertz and Lenard came to the conclusion that it was not matter of any kind, but "Processes of the Ether," that is, vibrations analogous to the ultraviolet light.

The X-rays, a name given by Roentgen because *X* is the algebraic symbol of an unknown quantity, are not identical with the cathode rays, which appear in the excited Crookes' tube as a bright luminosity. Without dwelling too long upon their points of distinction, suffice it to state that Roentgen believes them to be distinct, and that the X-rays are generated by the cathode rays at the glass wall of the discharging apparatus.

X-RAY INDUCTION COIL.

The induction coil which is used for exciting the Crookes' tube is simply a large form of the faradic coil with a condenser

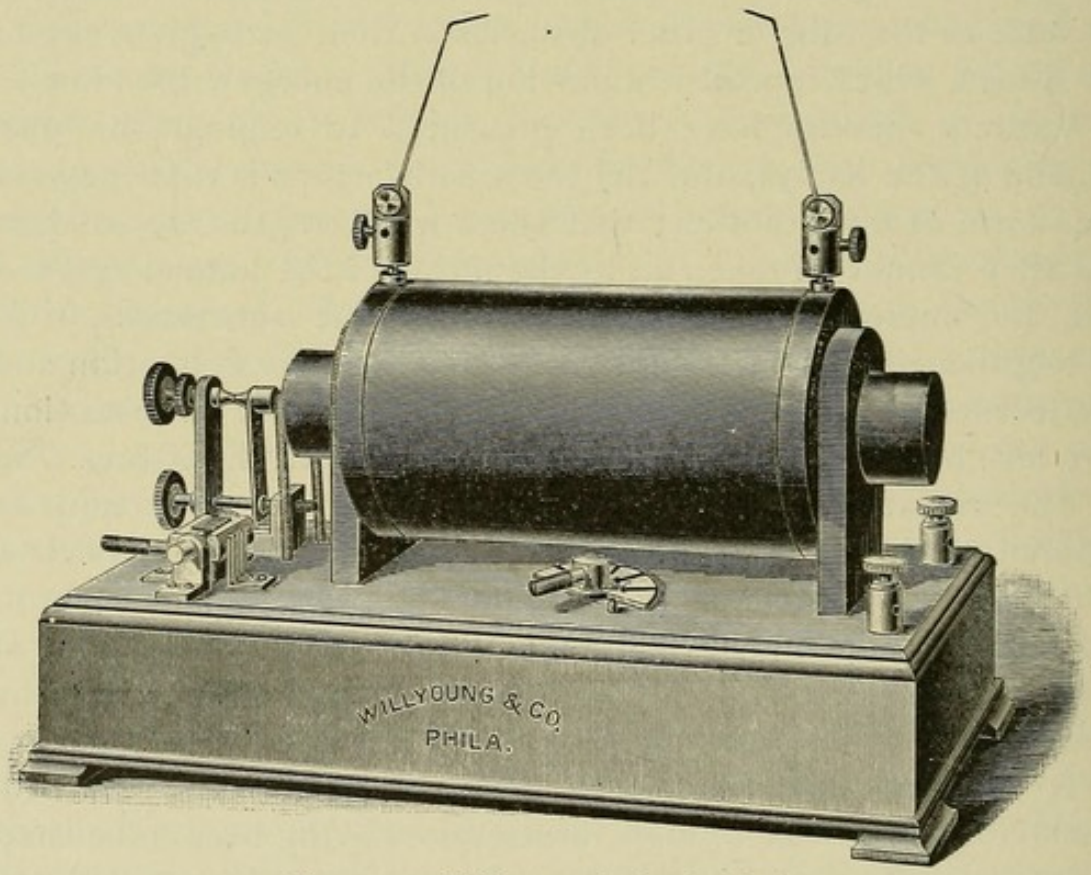


Fig. 139. Willyoung Induction Coil.

in its base for accumulating electric energy, as in the Leyden jar. In the Willyoung induction coil (Fig. 139) there is an adjustable

condenser, in which the capacity may be varied by means of a switch that cuts off more or less capacity as required.

In the secondary coil there is an immense number of turns for the purpose of generating an induced current of great electromotive force. Thus a current of 12 volts passing through a pri-

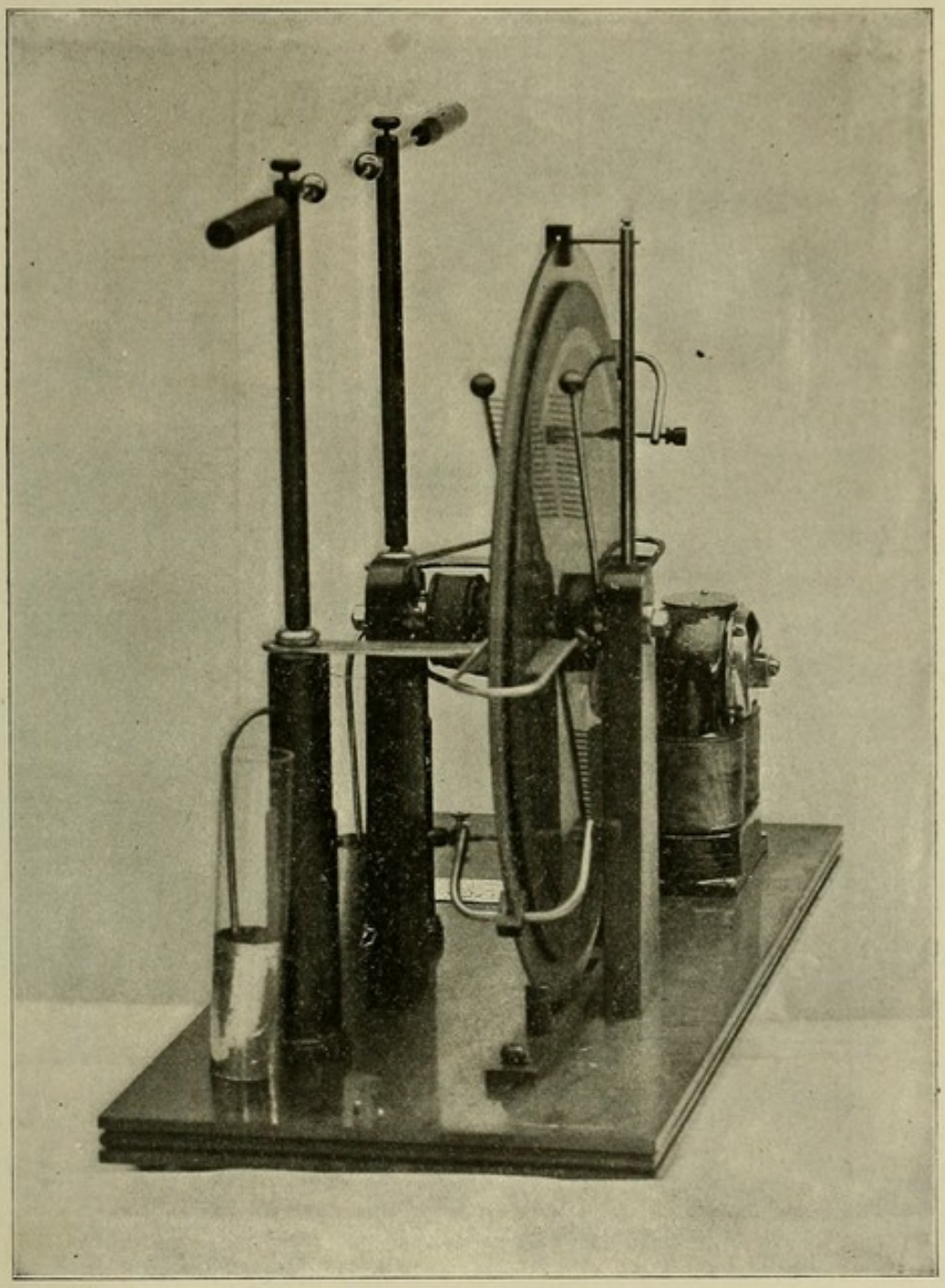


Fig. 140. Static Apparatus for Operating X-Ray Tubes.

mary coil in such an apparatus, will generate in the secondary a current with a voltage of 100,000 or more. The induction apparatus which are used in this method, will give a spark of two to twelve inches in the open air. A high-tension current is necessary to

overcome the resistance of the Crookes' tube, and it has been found by Trowbridge (525) that the lowest voltage that will produce satisfactory Roentgen rays is about 100,000. He also found that electro-static polarization is largely instrumental in the generation of the X-rays.

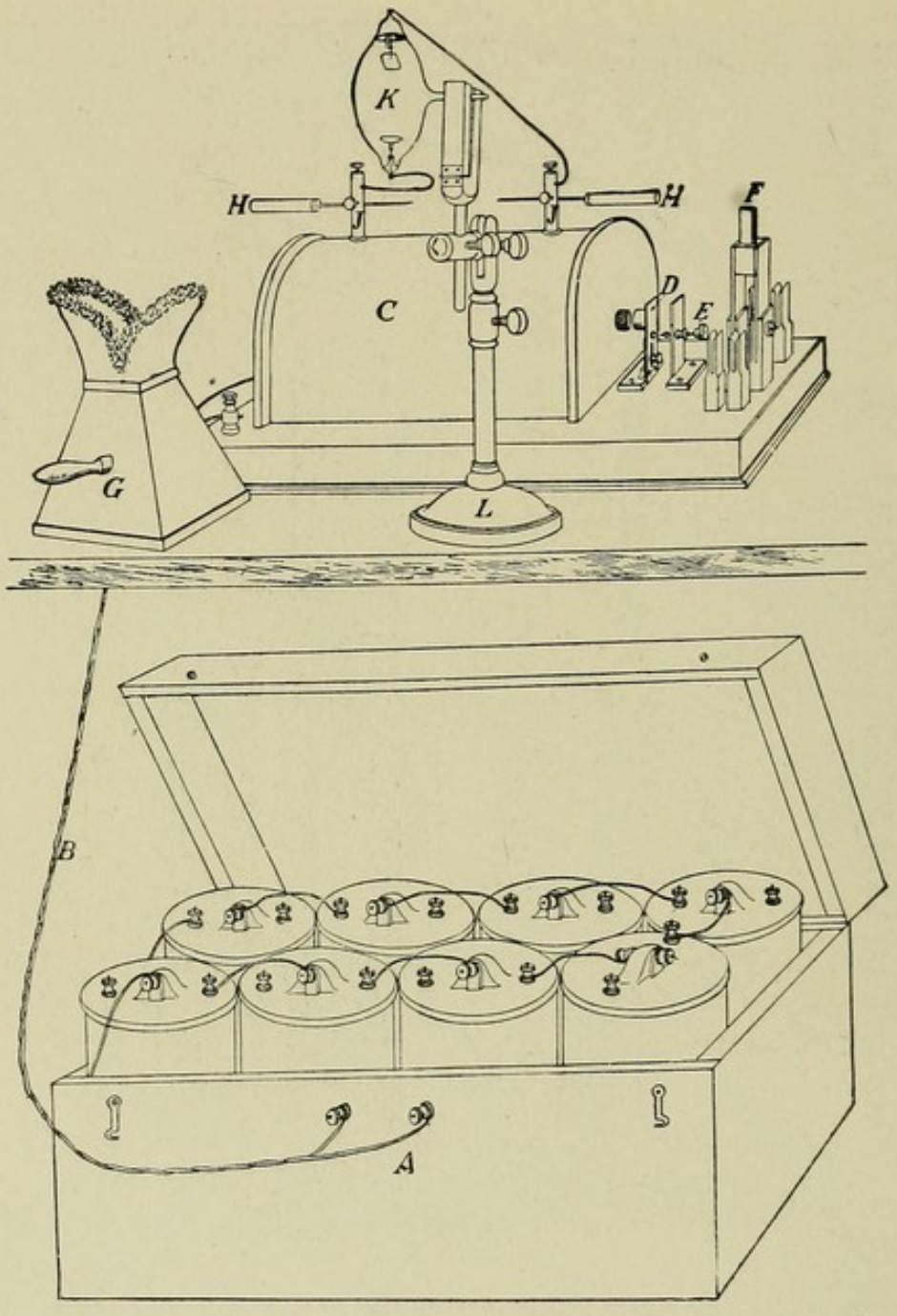


Fig. 141. X-Ray Apparatus with Edison-Lalande Cells.

In the induction coil used for the X-rays, the core should be of specially annealed wire, each wire being covered with a thin coating of shellac. The core, which lies inside the primary coil, should be enclosed within a hard-rubber tube of sufficient length to prevent sparking from the secondary to the primary core. The

secondary coil should be wound in a large number of small sections, each thoroughly insulated from its neighbors, and the coil, as a whole, insulated in such a manner that the air is excluded as completely as possible. Where this is not done, the coil should be immersed in oil to prevent the heating of the solid dielectric by bombardment and the consequent softening and breaking down of the insulation.

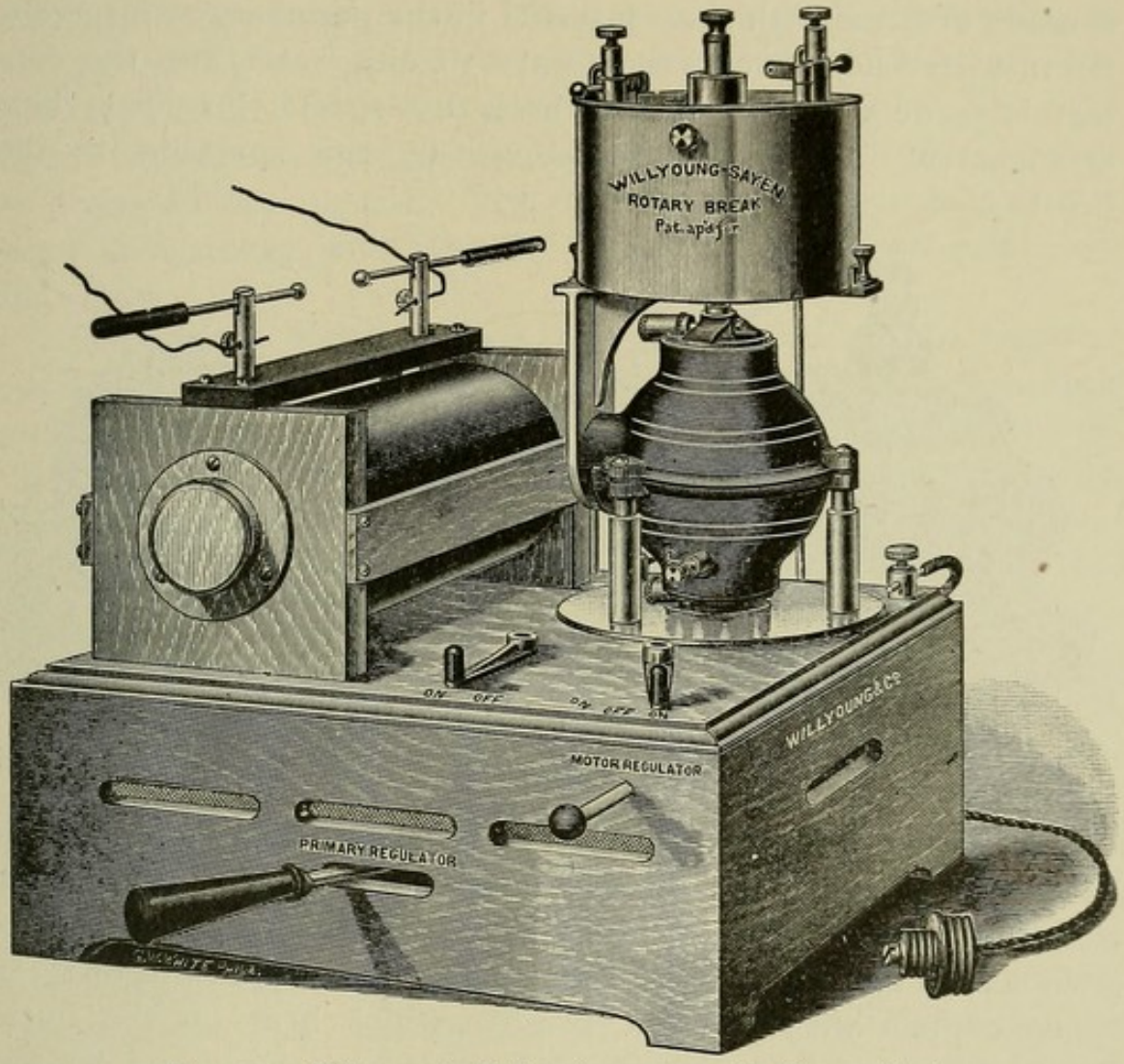


Fig. 142. Willyoung's X-Ray Apparatus with Rotary Break.

A Crookes' tube may be excited by a *static electric machine* (Fig. 140), or by means of *Tesla's transformer* which utilizes oscillatory electric currents.

The induction coil for the X-rays may be operated by means of chemical cells or storage batteries. Six cells of a storage battery, each having an electro-motive force of two volts, will actuate the primary coil, or preferably a motor-dynamo with a voltage of about 12; or a primary chemical battery consisting of eight Edison-Lalande cells (Fig. 141) may be used.

The direct and alternating incandescent-light currents are now generally used for this purpose, but require a special apparatus for controlling them. For the direct current, the Willyoung-Sayen Rotary Break (Fig. 142) may be used. As shown in the illustration, this break consists essentially of an electric motor mounted on a vertical shaft, to which is attached a break-wheel rotating in a copper vessel filled with distilled water. The wheel is made of brass with slate inserted in the periphery at intervals. An insulated lid prevents the escape of any water, and the contact is made with the break-wheels by special brushes. This arrangement is effective in preventing the sparking at the brushes.

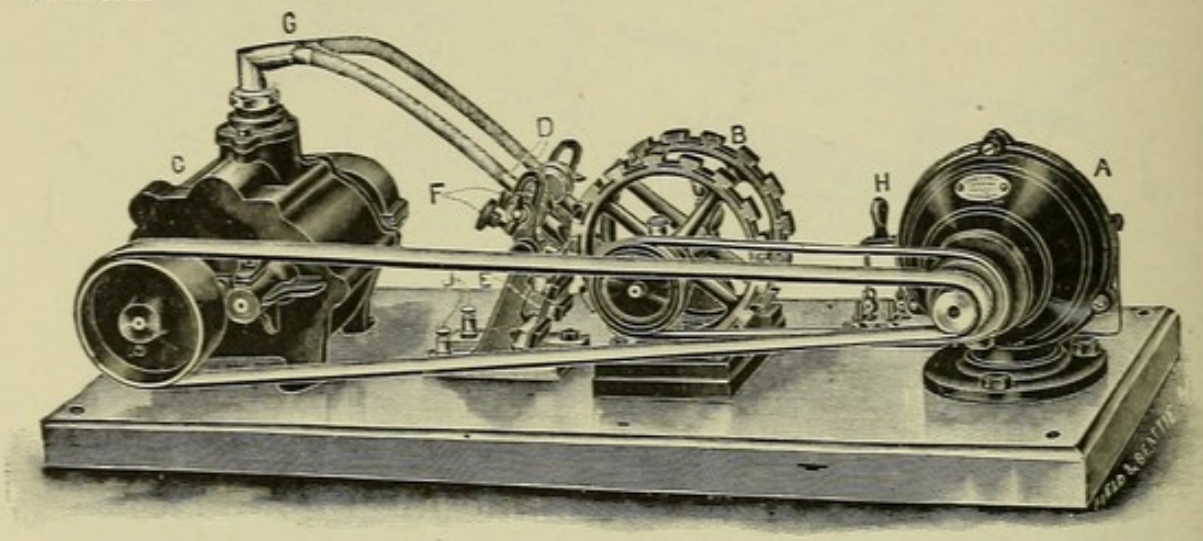


Fig. 143. Edison's Instantaneous Air-Break-Wheel.

Another apparatus for using the direct incandescent current is the Instantaneous Air-Break-Wheel shown in Fig. 143, which takes the place of the ordinary vibrator. This device consists of two wheels mounted on the same shaft. The projections or teeth make contact with two flat brushes, which bear on the outer peripheries, and by which the current is brought in and let out again. These wheels are rotated at a very high speed by a small direct-current motor, which also runs a pressure blower. The air blast from this blower enters a bifurcated tube, and is conducted to two flat nozzles immediately over the contact brushes.

When this apparatus is set in operation, by starting the motor and connecting the primary of the induction coil in series with the binding-posts (attached to the break-wheels) provided for this purpose, the spark formed at the contact brushes, when the coil is energized, is instantaneously blown out by the air blast at the moment of formation. This greatly increases the rapidity

of change in the magnetic circuit, and consequently augments the electro-motive force in the secondary coil.

The motor, break-wheel and pressure blower are mounted on a hard-wood base, provided with binding-posts for connecting with the 120-volt direct current.

In the Tesla transformer (526), the induced current of the secondary coil is used to charge the condenser instead of being carried directly to the tube. The two coatings of the condenser are joined by the primary to the second induction coil, the primary coil of which is interrupted by a spark gap. Thus the condensers are charged by the induced current from the first coil to a very high potential. The discharging of the condensers is done disruptively, and gives rise to oscillations at an extremely high rate.

The primary of the second coil is thus energized by an alternating current of extremely high frequency and of very high voltage, so that the secondary of the second coil also produces an alternating current of excessively high frequency and greatly magnified voltage. This induced voltage is so high that the second coil must be placed in an oil bath to avoid flaming discharges and brushes, which would otherwise emerge from every point of the second coil.

An apparatus which has given excellent results in the hands of the author, is the high-frequency coil of the L. E. Knott Apparatus Co. shown in Fig. 144. The Tesla phenomenon is utilized in this coil, and a current of high frequency and high voltage with low amperage is furnished. With a consumption of about 2 amperes and 110 volts, a voltage of about 2,500,000 with a frequency of approximately 400,000 is obtained. A uniform discharge is made by the mechanism shown in the illustration, so that the operator may regulate the potential of the discharge and produce a continuous uniform fluorescence in the tube.

This apparatus is made for the alternating current. By means of an alternator attached to the motor, the direct current may also be used, being first changed into an alternating one, the same induction coil being utilized in both instances.

When the Crookes' tube is connected, a portion of the current usually passes through the air between the poles of the condenser, making a disagreeable sound. To avoid this, W. J. Morton (527) suggests to enclose the spark gap in a cylindrical drum of ebonite or hard rubber, having closed ends.

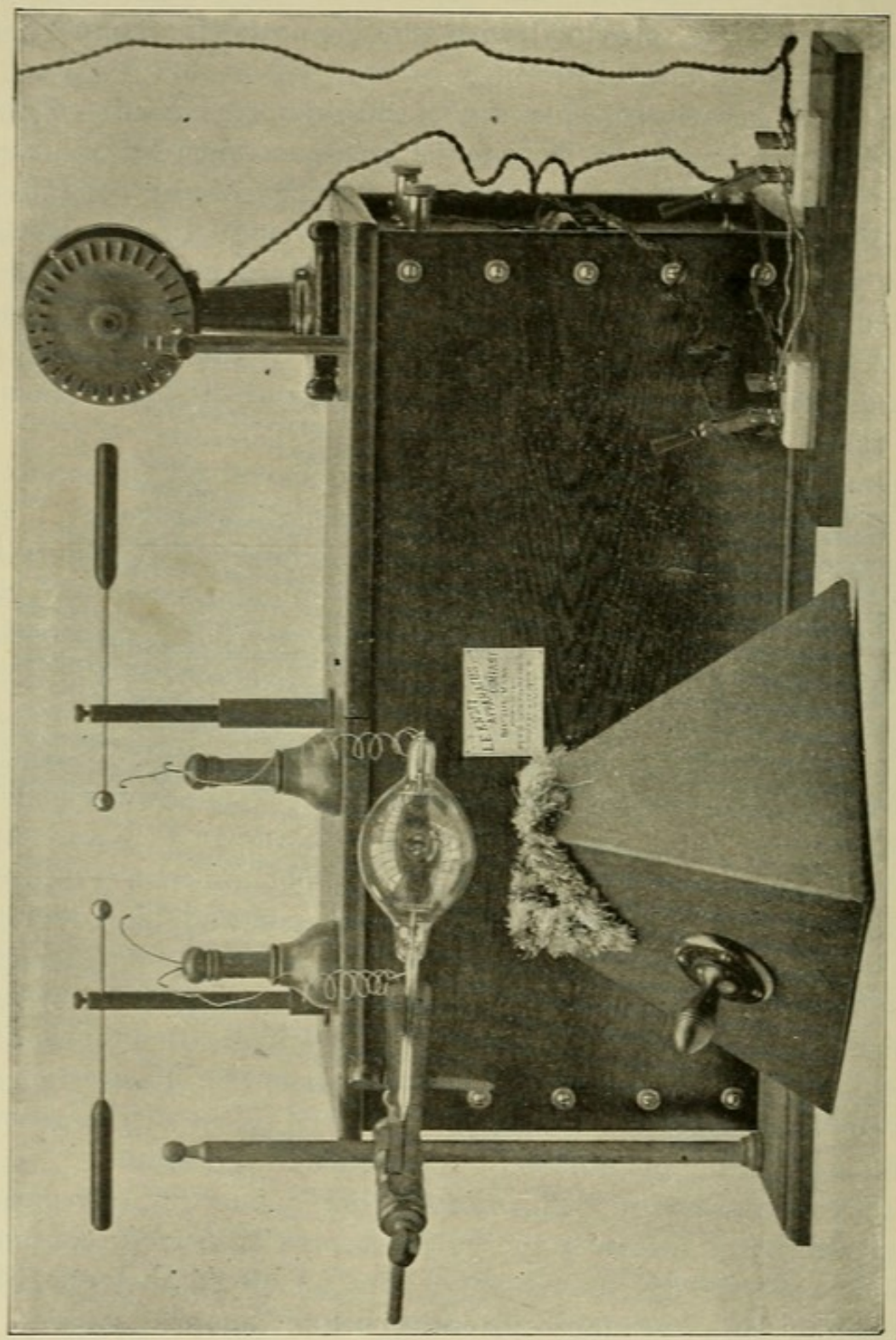


Fig. 144. The Knott X-Ray Apparatus.

X-RAY TUBES.

Since the discovery of the X-rays, investigators have experimented with various forms of Crookes' tubes with a view of devising one which will be permanent in character and which will give the best results. More or less success has attended their efforts, but the tube is still a subject of much inconvenience in the application of this method. By means of special contrivances, the lifetime of the tube has been considerably prolonged, and it is to be hoped that eventually the tube may be so perfected as to avoid many of the complications which now attend its use.

The X-ray tube should be selected according to the capacity of the induction coil. The resistance, however, varies within considerable limits in the ordinary Crookes' tube, on account of the tendency to an increase of the rarefication of the air contained in the tube. Many attempts have been made to overcome this difficulty. In the Bowdoin X-ray tube (Fig. 145), for instance, the

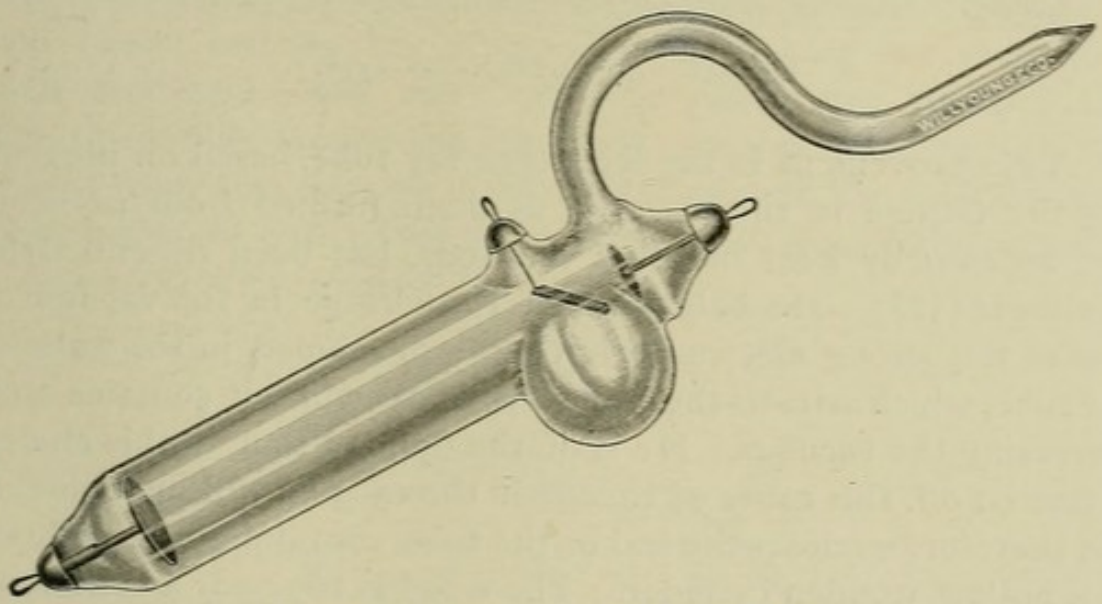


Fig. 145. Bowdoin X-Ray Focus Tube.

difficulty of obtaining the most suitable vacuum is overcome by means of a fluorescent material fused inside of the bulb opposite to the reflector. The inventors claim that the action of the rays upon this material is sufficient to release enough gas in the tube to compensate for that which disappears in its normal working. This tube is not intended for use with the Tesla or other coils of exceedingly high voltage or frequency, an inductorium which will produce a two- to six-inch spark giving the best results.

In the X-ray tube shown in Fig. 146, a uniform vacuum is

maintained by means of a salt which is placed in the diverticulum of the tube. When the vacuum is increased above the point at which the best results are obtained, it is only necessary to apply heat to this salt by means of an alcohol lamp until the correct vacuum is again established. This X-ray tube is especially adapted to the high-frequency and high-voltage apparatus.

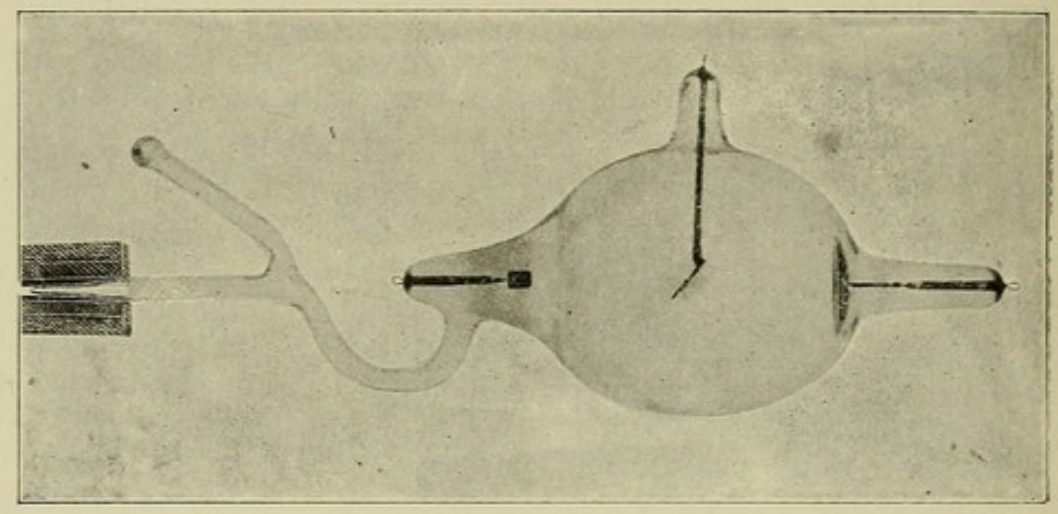


Fig. 146. Adjustable X-Ray Tube.

An improvement in the Roentgen ray tube, based on preventing the change in the vacuum, as distinguished from reducing the vacuum by heat or other methods, has been described by Berlinger (528). He believes that the change in the vacuum is due to the strong electro-static charge developed in the walls of the tube, which attracts the molecules of gas which it contains, thus increasing the vacuum. He is of the opinion that if this charge is carried off, this cause of change in the vacuum will be removed. He therefore encloses the end of the tube containing the cathode in a hollow wooden cylinder. The wood is too poor a conductor to give rise to sparking, and yet, sufficient to lead off the charge.

With this arrangement, he also finds that the tube can be operated with an appreciably lower voltage. To prevent the wood from becoming too dry, he suggests moistening it with glycerine, as this absorbs moisture from the air.

In order to obtain the best results, different arrangements of the cathode have been suggested. For ordinary purposes the various forms of focus tubes are the most effective. In these tubes (Fig. 147), the cathode is of a concave, circular form, and the anode consists of a square, flat piece of aluminum placed exactly opposite the cathode at an angle of 45 degrees. In this tube,

the cathode rays are concentrated to a point in the flat platinum anode, from which point issues a powerful stream of X-rays, as shown by the arrows in the illustration (Fig. 148). It has been

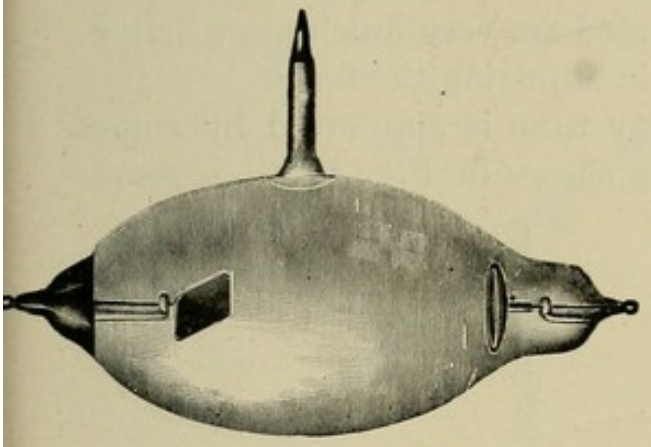


Fig. 147. X-Ray Tube.

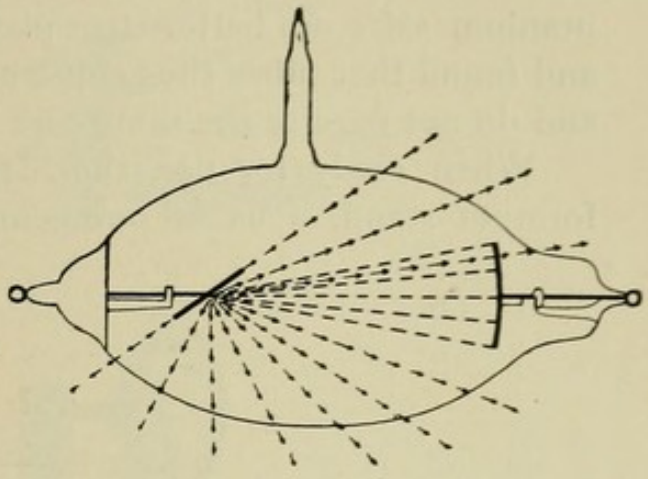


Fig. 148. X-Ray Tube. (Diagrammatic.)

found that the shadows are more sharply defined when using these focus tubes, and the time of exposure for making the skiagraph much shortened. Still more powerful effects are obtained by using the double focus tube (Fig. 149). In this tube, the cathode rays (c) from two concave disks connected with the cathodes are projected upon a platinum plate, from which a powerful stream of X-rays (x) are projected.

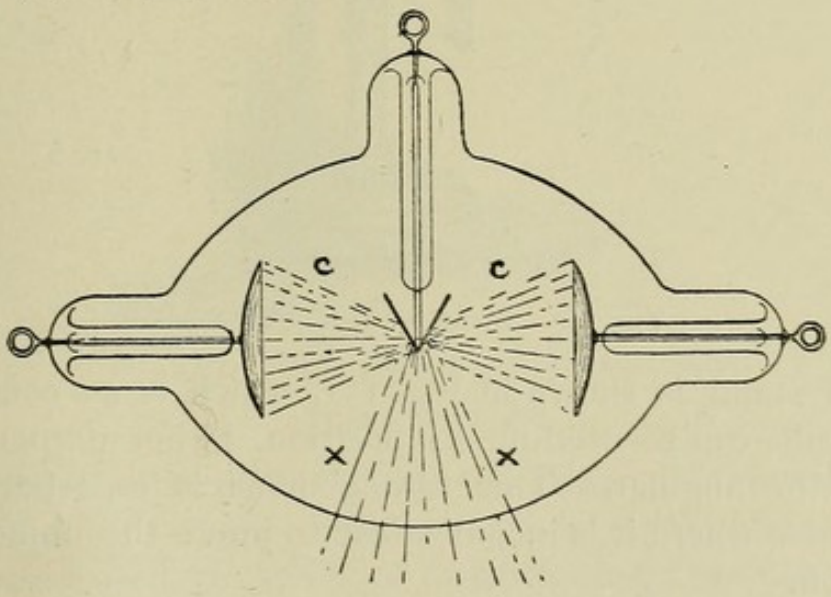


Fig. 149. Double X-Ray Tube. (Diagrammatic.)

It has been found, however, that the double X-ray tube does not give as satisfactory results or as clear definition as when the rays from only one cathode are focused (Fig. 146).

Instead of using platinum for the anti-cathode, other substances have been tried. Langer (529) showed that the property of generating the X-rays increases with the molecular weight of the substances from which the rays are propagated, and that, therefore, uranium salts are better than platinum. He made comparisons and found that tubes thus constructed are very much more active and do not require the same care in adjusting the focus.

When ready for use, the X-ray tube is supported by some form of stand, a useful one being shown in Fig. 150. A more

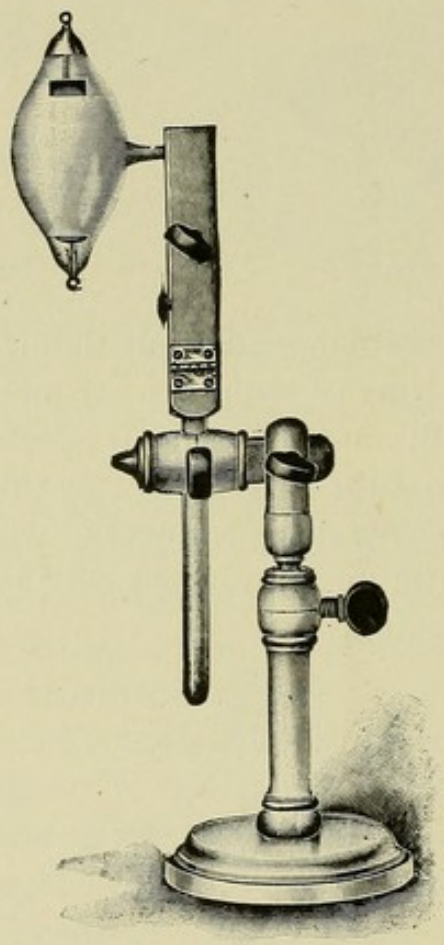


Fig. 150. Stand for X-Ray Tube.

convenient stand is shown in Fig. 151, which is so constructed that the tube can be used in any position, either perpendicular, horizontal or angular. This arrangement is especially applicable in cases where it is inconvenient to move the object under examination.

An important consideration in applying the X-rays for skiagraphy or the fluoroscope, is the distance of the object to be examined from the tube. If the object is too near, the diverging rays give a tendency to distort the image, whereas if the distance is too great, the efficacy of the rays may be lost. One of the ad-

vantages of a strong X-ray tube is that the object may be examined at a greater distance, thus giving better definition. The greater distance also prevents the tendency to irritation when the X-rays are projected upon the skin.

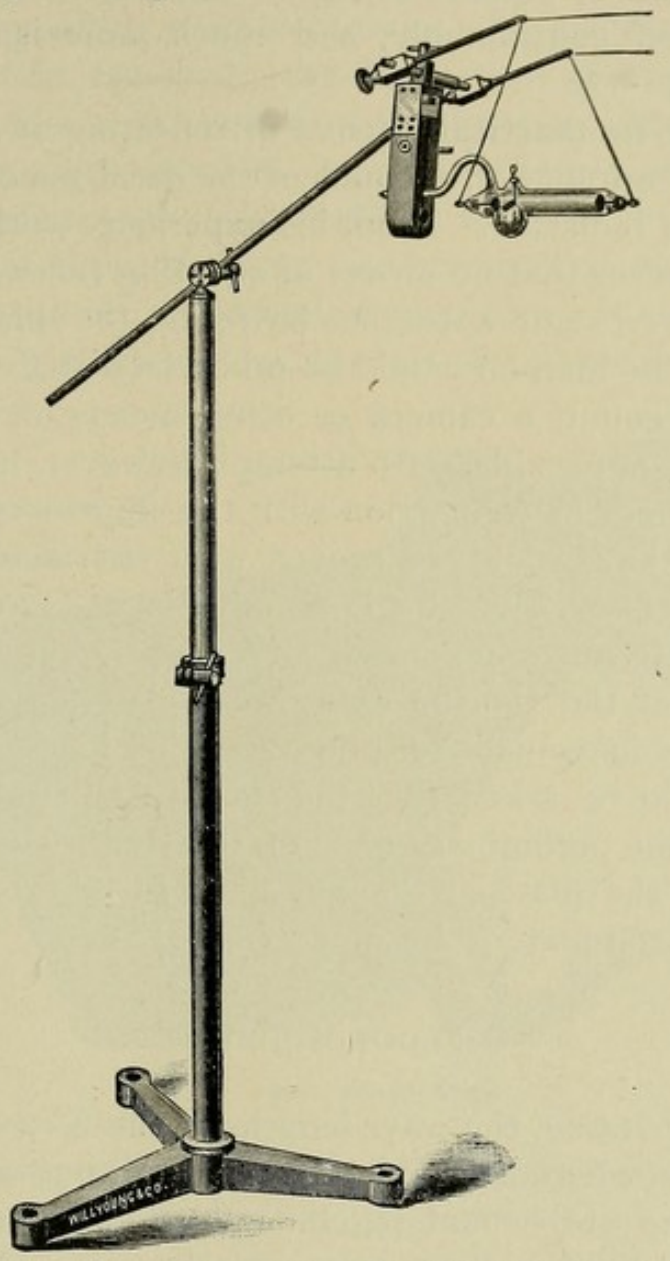


Fig. 151. X-Ray Tube with Adjustable Stand.

SKIAGRAPHY.

The application of the X-rays for skiagraphic purposes is extremely simple, a highly sensitized photographic plate in a plate-holder being used, the cover of which protects the plate from the action of the ordinary luminous rays, but is transparent to the X-rays. A skiagraph may therefore be taken in ordinary daylight.

The object to be skiagraphed is placed upon the plate, or as near as possible to it, in order to obtain good definition. The Crookes' tube is then adjusted at the proper distance. This,

as also the length of time of exposure, varies with different tubes and with the same tube at different times, and can only be learned by practice. The duration of time required was one of the important obstacles to the use of this method, but this has already been shortened considerably, and much more is hoped for in this direction.

At present, no practical method of reflecting or refracting the X-rays has been found on account of the great penetrating power of this form of radiation. From his experience with the X-rays, Roentgen believes that no means of effecting this will be devised. Should, however, some substance be found for this purpose, the usefulness of the method would be much increased.

On this account, a camera or other means of concentrating the rays is not applicable. An attempt, however, has been made to use the camera in connection with the fluorescent screen, but these results have not yet proved of a satisfactory character. This method is advocated by J. Mount Bleyer (530), who claims that this contrivance possesses advantage over the ordinary method in that the time of exposure is materially lessened, and that it is more convenient for photographing inaccessible parts.

Care should be taken that the sensitized plate is not in the room during the preliminary tests of the fluoroscope, as the rays will penetrate the plate-covering at a considerable distance, causing the sensitized plate to become "fogged."

FLUOROSCOPY.

As already stated, the wave-lengths of the X-rays are so short that they cannot be taken up by the retina of the human eye. On account of the absence of regular reflection and refraction, the greatest difficulty has been met with in measuring the wave-lengths, and the only available method was found to be diffraction. By this means, L. Fomm (531) found the wave-lengths 0.000014 of a millimeter, which is about one-fifteenth of that of the shortest ultraviolet waves that have as yet been accurately measured.

In examining objects with the X-rays, therefore, some form of apparatus is necessary to lengthen the wave-lengths so as to make them visible. For this purpose, the fluoroscope has been devised (Fig. 152).

Fluoroscopy is a rapid method of examination, but lacks the

delicacy of skiagraphy, and leaves no record for future use as in the latter. A stronger source of radiation is necessary for the fluoroscope, while in skiagraphy a source of much less strength is sufficient, the lack of intensity being compensated for by a longer exposure of the plate to the rays. In the examination of the bones of the face, especially, the fluoroscope gives but unsatisfactory results, while, with a sufficient exposure, we obtain results with the skiagraph which may be studied at leisure, and which may bring out a delicacy of detail invisible with the fluoroscope. On the other hand, fluoroscopy is a rapid method of making an examination, and requires no special preparation. It also renders this method more interesting by causing the phenomena to be visible to the eye.

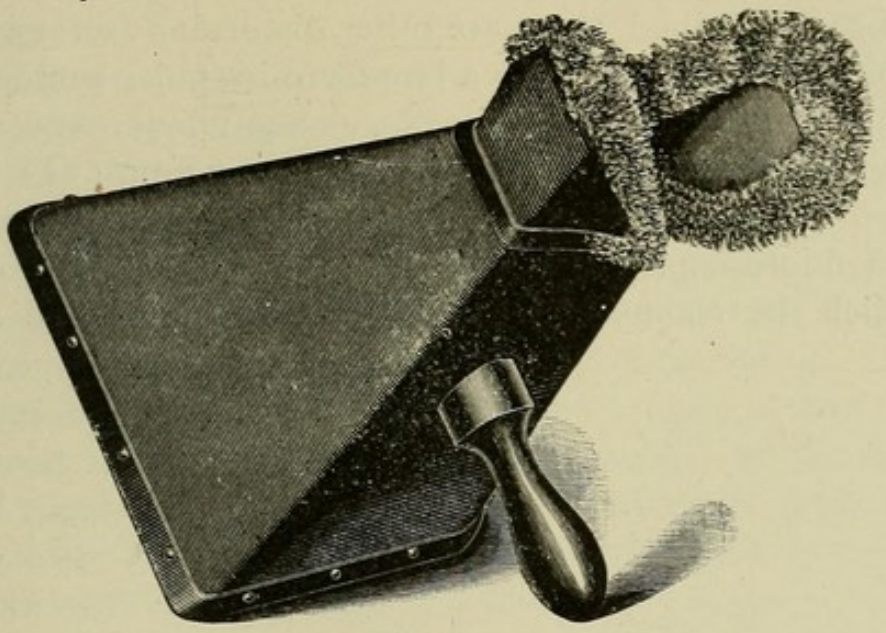


Fig. 152. Fluoroscope.

The *fluoroscope* is simply a box (Fig. 152), somewhat similar to the stereoscope, the front of the apparatus being covered on the inner side with tungstate of calcium or barium-platino-cyanide. These salts are fluorescent, and when the X-rays impinge upon the particles of this coating they become visible to the eye. As the X-rays are absorbed to a different degree by the various structures of the body, the fluoroscope enables us to note these effects with the eye.

In using the fluoroscope, the object to be examined is held between the instrument and the Crookes' tube. The X-rays will project a skiagraph of the object upon the coated surface of the fluoroscope, and the invisible X-rays, being transformed through the fluorescent properties of the tungstate of calcium, or

barium-platino-cyanide, into luminous rays, the skiagraph becomes visible to the eye.

The fluorescent salt first used by Roentgen was the potassium-platino-cyanide. The tungstate of calcium was suggested by Edison, but the preparation used by Roentgen is still preferred by many experimenters, who find that it gives a better definition than the former.

By employing a large screen on which the crystals are coarser than those previously used and the thickness much increased, John Macintyre, of London (532), obtained much better results with the deep structures of the body than with the ordinary method.

Besides the disadvantages of the fluoroscope, which have already been described, there are other disturbing factors, such as the action of stray rays due to a large and irregular source, and a persistence of the fluorescent image, as a previous exposure will frequently reduce the intensity of the shadow until the fluorescence from the exposure has worn off. In order to obviate these defects, a fluoroscope has been devised by George T. Hanchett (533) which he claims will overcome these defects to a great extent.

CHAPTER XXXVII.

The X-Rays in Oto-Laryngology.

ALTHOUGH the X-rays for diagnostic purposes have not given the results in oto-laryngology that they have in general surgery, still a number of investigators has experimented in this branch of medicine, some of whom have furnished interesting results.

The X-rays naturally give the best effects where tissues apparently opaque to the rays, such as bone, are imbedded in softer tissues. On this account, the examination of the limbs gives the most satisfactory results. In the thorax, where the rays pass through two layers of bone and where there is also considerable soft tissue, there is so much absorption of the rays that the results here obtained are not as satisfactory in character.

In the head, however, which consists largely of bone and in which most of the soft tissues are surrounded by bone, the results are decidedly less marked. In the antrum of Highmore, for instance, a cavity in which the means of examination now practised are not altogether satisfactory, the test of the X-rays would be of the utmost importance. In this case, however, the bony sides of the sinus absorb most of the rays, so that there is but little effect in the skiagraph and still less in the fluoroscope, even if the interior were filled with a polypoid mass or other soft tissue transparent to the rays. A bony tumor, however, could be recognized, and a foreign body, especially of a metallic character, located without difficulty.

It must be remembered that the value of the X-rays for diagnostic purposes does not depend simply upon their penetrative power, but upon the property of differential absorption by the various tissues through which they pass. In making a skiagraph of the head, the outlines of the sinuses are sometimes clearly defined, as the bones surrounding these cavities are thinner and absorb the rays to a less degree. A thickening of the walls or a foreign object, by their greater absorption of the rays, would be

noticeable, which is not the case with the softer tissues whether normal or pathologic.

Repeated reference has been made as to the differentiation of the normal from the pathologic tissue by the examination with the X-rays. This very desirable result does not, however, seem to be within reach or even probable at the present time. The penetrating property of the X-rays is so great that the difference of absorption between normal and diseased tissues for the same volume cannot be determined, unless there is a decided greater density of the growth to be examined.

The contrast between metallic objects and the tissues, and even bone, is quite noticeable. A probe passed into the nostrils or a sound into the naso-pharynx or larynx is easily discernible with the fluoroscope and usually gives a well-defined skiagraph.

In experimenting with this subject, Scheier (534) found that while metallic substances and beads within the nostrils could be distinguished, the stones of fruit were almost invisible. This author also noted the root of a tooth, which was revealed as a well-marked projection within the antrum of Highmore. Tuberculous glands surrounding the larynx and trachea were also plainly visible.

After a five minutes' exposure to the X-rays, Waggett (535) succeeded in obtaining clear shadowed images of coins and fish bones attached to the surface of the larynx. He found the larynx so transparent that the skiagraph was projected on charts representing the image of the structures of the neck. By a more delicate adjustment of the Crookes' tube, however, the cartilaginous larynx could have been distinguished from the softer tissues.

This subject has also been carefully investigated by John Macintyre, of London (536), who succeeded in skiagraphing the larynx of a human subject, the pictures obtained showing the base of the tongue, hyoid bone, thyroid and cricoid cartilages, and the epiglottis. He also skiagraphed the bones of the face in a case showing destruction of the upper jaw, this being the result of malignant disease. In the case of a patient who had swallowed a half-penny six months before, the round black shadow of the coin could be seen at the level of the third dorsal vertebra. This was especially interesting, as the patient referred the pain to the cardiac orifice of the stomach.

In experimenting with this method on the antrum of Highmore, Macintyre has used small tubes in the mouth and also large

tubes applied from the outside. In regard to the former, aside from the fact that it would be difficult to obtain effective tubes of such small size, it would also be dangerous to apply them on account of the high-potential current used in this method. In most cases, the connections in the tubes will give a spark from a distance of several inches.

Laryngo-cryptoscopic mirrors have also been passed into the mouth, in connection with a Crookes' tube on the outside, by Macintyre. On account of the small amount of rays penetrating through the bones of the jaw, little result can be expected from this procedure. Probably the only method by which satisfactory effects can be obtained is by placing the tube on the outside and a sensitized film, properly protected from the light, in the interior of the mouth to receive the rays which pass through the bones of the maxilla. In this manner, the absorption of the light by means of the bone may be offset by the longer exposure of the film. Even this method gives uncertain results, unless the bone is involved in the diseased process. Mucous polypi, granulations and morbid secretions are so transparent that they would leave little or no impression in the skiagraph, although a larger mass, such as a fibroid tumor, would give a perceptible shadow.

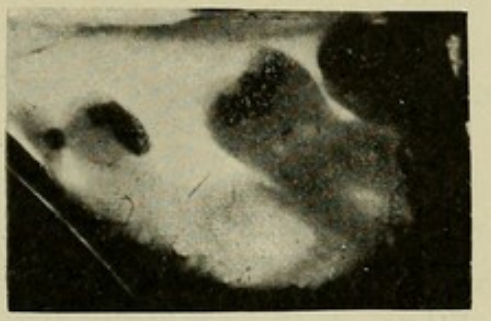


Fig. 153. Skiagraph of Section of Lower Jaw.

As showing the value of skiagraphy in dentistry, Edmund Kells, of New Orleans, has made a number of skiagraphs showing the teeth in the bony tissues. These are more distinctly shown in the lower jaw (Fig. 153), in which the rays penetrate a smaller mass of bony tissue, the results being therefore more decided in character. In this skiagraph, the bifurcated root of a lower molar is plainly outlined, a metallic filling in the crown being shown by the black spot, while the brighter portion in the body of the tooth indicates the pulp cavity.

The roots of the teeth being enclosed in the alveolus, their

shadows projected by the X-rays do not show the contrast which may be obtained of the bones of the body surrounded by the softer and more transparent tissues, this referring especially to the upper maxilla.

In making a skiagraph of the antrum, a method similar to that used in dental work is applicable. The sensitized film protected by a covering of aluminum foil is inserted into the mouth under the sinus, being held in position by a temporary rubber plate, and the X-rays from a Crookes' tube about 12 inches from the face then projected through the cavity to the film.

The skiagraphs shown in Figs. 154A and B were prepared by

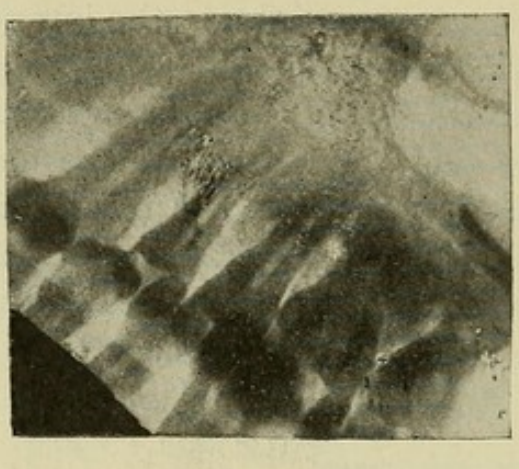


Fig. 154A. Skiagraph of Antrum Showing Foreign Body.



Fig. 154B. Skiagraph of Antrum (Negative).

me in this manner. In the former, the antrum is outlined with a fair amount of distinctness, as also the teeth, the pulp cavities being clearly defined. The dark line to the right side of the cut shows the broken end of a Buck's applicator which was left in the cavity, and illustrates the effect which may be obtained with this method in diagnosticating foreign bodies in the antrum, especially if these are of a metallic character.

A skiagraph (negative) of the same antrum after the foreign body was removed is shown in Fig. 154B. The dark area in the upper part of the cut represents a portion of the antrum of Highmore, but the delicate gradations of color in the skiagraph of this case have been lost in the process of electrotyping.

The application of the X-rays in the examination of the soft tissues of the antrum of Highmore has thus far been without satisfactory results. This is due to the fact that the antrum is surrounded on each side by an osseous wall whose absorption of

the rays is so much greater than that of the soft lining tissues of the cavity, that the latter gives no perceptible shadow in the skiagraph. Where this is made of the superior maxilla, even the difference between the teeth and the bone of the jaw is not always clearly defined, although sometimes sufficient to be of assistance to the dentist in determining the formation of the roots of the teeth, as has already been shown. This method may also be useful in locating a diseased tooth which has caused infection of the antrum.

Where, however, it is a question of the difference of the soft tissues of the interior of the antrum, or a purulent secretion, the results obtained thus far have given little encouragement that this method will be a successful aid in the diagnosis of antral disease, and it has as yet given me no better results than those obtained with the older method of transillumination.

Although thus far the X-rays have been of little value in determining the presence, absence or character of the inflammatory process within the antrum, they are not, however, without their use in this connection. In cases of osseous tumors, as, for instance, an osteo-sarcoma of the antrum, and especially in the case of foreign bodies, where these have a higher resistance to the rays than the bone, as a metallic substance, this method is undoubtedly of great assistance.

A tooth in this cavity could be distinguished by means of a skiagraph, and a bullet and a piece of copper wire, which were placed through the artificial opening into the antrum through the alveolar process, were easily distinguished in the skiagraph, but with no degree of certainty with the fluoroscope.

The appearance of the accessory cavities of the nose is shown in the skiagraph of the head (Fig. 155) made for me by Prof. A. W. Goodspeed, of Philadelphia. In this, the frontal sinus and the antrum of Highmore are clearly defined. In the latter, however, the two sinuses are projected one over the other, which would prove confusing if the condition of each cavity is to be diagnosticated. By applying the film, properly protected, into the upper part of the mouth, as has already been described, and projecting the rays downward from a Crookes' tube at a proper distance from the side of the face, the single antrum can be skiagraphed.

Improvement in the application of the X-rays has extended to such a point that the location of coins or other metallic substances

in the œsophagus has become an easy matter. Skiagraphy in these cases is of great advantage, as it shows the exact location of the object, thus facilitating the operation for its extraction. A jack-

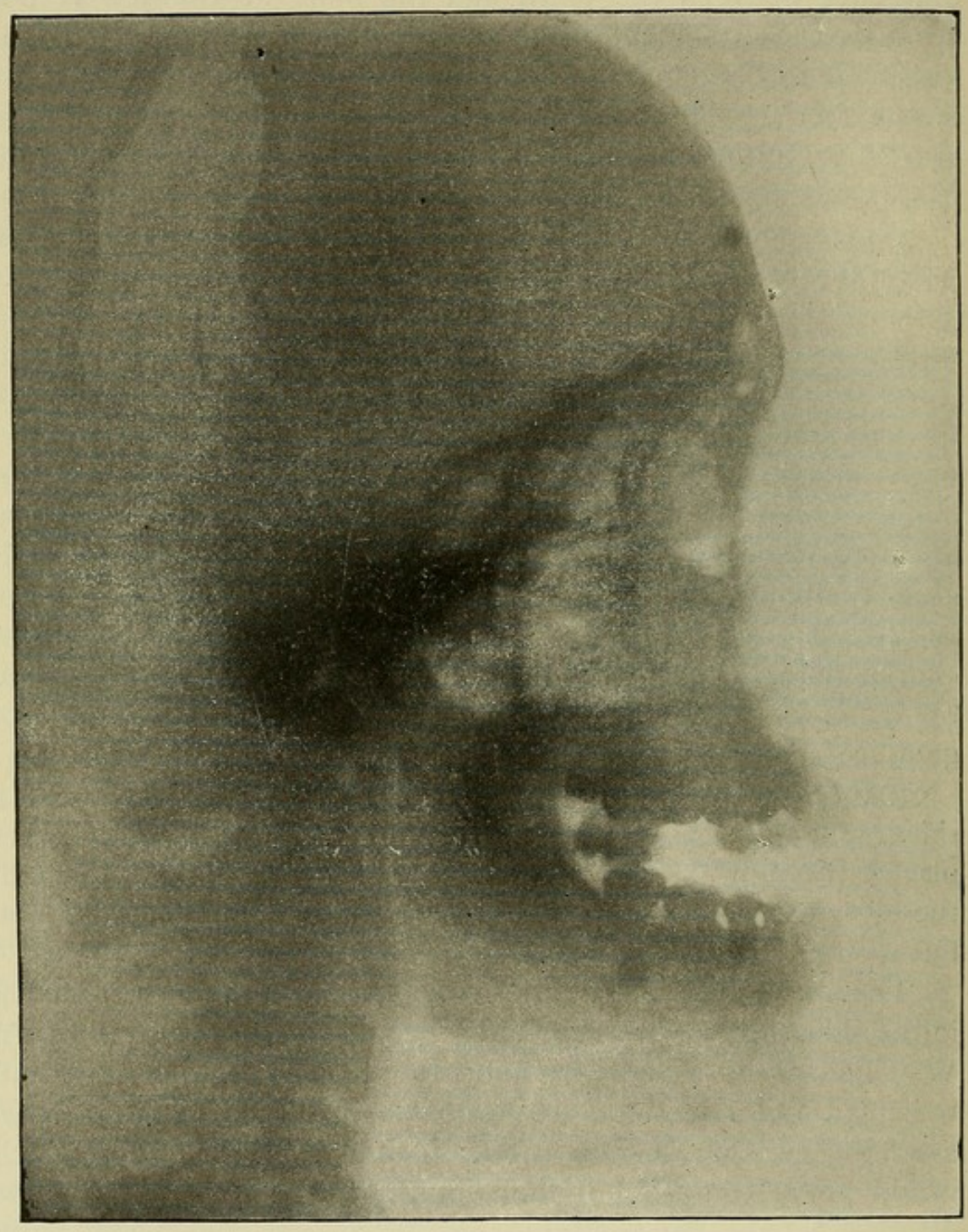


Fig. 155. Skiagraph of the Head.

stone in the œsophagus is reported by A. C. Wood, of Philadelphia (537), the foreign body being located by the fluoroscope and removed after performing gastrotomy.

The fluoroscope does not give as clear results in these cases

as skiagraphy, but was necessitated in this instance, as the child was too unmanageable to allow the skiagraph to be taken.

A similar case is reported by W. H. Price (538), in which a skiagraph was successfully made. A number of cases are on record in which a portion of a tracheotomy tube was lost, leaving a doubt as to whether or not it had passed into the trachea or bronchus. In these cases, the X-rays promise to be of the greatest utility.

In order to test the value of the X-rays in the location of foreign bodies in the chest, Nathan Raw (539) inserted a brass key as far as possible into the right bronchus of the cadaver of a boy through an opening in the trachea. A Crookes' tube was then applied and the skiagraph, which was taken, gave a clear shadow of a watch key pointing downward and outward near the right of the median line and opposite the third and fourth ribs. The outlines of the viscera could also be distinguished.

By means of a suitable X-ray apparatus, the heart and other parts of the body may now be outlined and many pathologic processes detected. In the lungs, areas of consolidation may be located, and the X-rays promise to be of great importance in the examination of cases of supposed tuberculosis. We may soon be able by this method to discriminate in many cases in which the older means of physical exploration leave the observer in doubt. For this purpose, an induction coil of not less than an eighth-inch spark should be used. The appearance is at first uncertain, but after practice the eye soon learns to appreciate the finer differences of shades and outlines.

This method has been used by Philip M. Jones, of San Francisco (540), who obtained successful results, and also by J. Edward Stubbert, of Liberty, N. Y. (541). The latter gives a series of 73 cases in which the comparative diagnosis in pulmonary tuberculosis by the Roentgen rays is shown. He gives the following summary of the results of his investigations:

1. Slight haziness indicates the beginning of tuberculous infiltration, and may or may not be accompanied by dullness.

2. Decided shadows indicate consolidation, the extent of which is in direct relation to the comparative density of the shadow thrown on the fluoroscope.

3. Circumscribed spots of bright reflex, surrounded by narrow dark shadow rings or located in the midst of an area of dense shadow, indicate cavities.

4. Intense darkness, especially at the lower portion of the lung, indicates pleuritic thickenings over consolidated lung tissue.

In applying the X-rays, certain precautions should be taken, as the constant and continued exposure of the rays tends to produce inflammation of the skin, which in some of the cases reported has been followed by falling out of the hair and nails, and occasionally blistering. The effect on the skin was found by Reid (542) not to be limited to the point at which the rays enter the body, but also developed to a certain extent where these rays pass out of the body. This effect is not considered by Tesla as due to the rays directly, but to the ozone which is generated by them in contact with the skin, and he suggests the coating of the parts exposed to the rays with oil, to prevent this irritation.

The effects of the X-rays, however, are probably similar to those of the sun's rays, and this is the opinion of Kaposi (543). There is at first an active filling of the blood-vessels of the exposed region and this is followed by their paralysis. These disturbances of the circulation lead to an inflammation of the skin, which in turn causes a falling out of the hair. After the skin has resumed its normal appearance and function, the hair grows out again. These radiating effects may be avoided by using a strong Crookes' tube, which enables the object to be examined to be placed at a considerable distance, thus avoiding the concentrated effects of the rays.

The application of the X-rays to therapeutics has been experimented with on account of their supposed germicidal properties. In spite of the publication of certain results, which have been obtained in test tubes, there have been thus far no satisfactory developments which would lead us to believe that this force of radiant energy has any germicidal effect on microbes in the human body.

A number of experiments on the effects of the X-rays in tuberculosis has been made by Lortet and Genoud (544), who believe that these rays are capable of modifying this condition. In the experiment, eight guinea-pigs of good health and of about the same age were inoculated with bouillon containing triturate of the spleen of another guinea-pig, manifestly tuberculous. Three were exposed to the Roentgen rays for at least an hour daily for nearly two months, while the others were used for control purposes. In the former, the inguinal glands were enlarged, indurated and circumscribed, while in the latter, softening of the glands had taken place with suppuration and spontaneous evacuation.

Although these experiments were incomplete, they believe that it would indicate the benefit of exposing tuberculous processes to the Roentgen rays. For purposes of observation, some form of superficial tuberculosis would seem the most appropriate in testing the value of this experiment.

While these tests appear encouraging, other observers have had negative results. Adolph Gehrmann, of Chicago (10), has made a careful investigation of the germicidal properties of the X-rays, and found, after a long exposure, that the various kinds of bacteria examined were apparently unaffected by exposure to these rays, and their multiplication did not seem to be retarded.

The effects of the X-rays in other pathologic conditions have also been investigated. A case of cancer is reported by V. Despeigues (560) in which the X-rays appeared to have had good effects. The patient had a small epithelioma of the mouth starting from the lingual fold, with an enlarged gland in the maxillary region. The application of the X-rays was followed by marked diminution of pain, so that morphine could be discontinued. The patient, however, died but was apparently much relieved by this application.

In lupus, in which Hicguet (561) applied this form of energy, the results appeared to have been more satisfactory. In two cases of lupus of the nose, the X-rays seem to have given marked benefit. In the first case, a youth of 18 years who had suffered for two years from nasal irritation, a diagnosis of lupus could be easily demonstrated. The sittings lasted for five minutes, at first every day but later at irregular intervals. After the twelfth sitting great improvement was noted. An abundant secretion from the nose followed each application. Eventually the nose no longer showed any trace of ulceration, and only a mild infiltration was left.

In the second case, a girl of 12 years, lupous nodules were spread over the extremity of the nose and left side of the face. The nasal cavity showed ulceration and an extensive perforation. The patient was treated by the X-rays, which was followed by a most distinct amelioration, the ulceration cicatrizing and the lupous nodules disappearing. Altogether, there have been 50 sittings, each lasting five minutes. The author has also applied this method in the treatment of lupus of the larynx, but thus far without appreciable effect.

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