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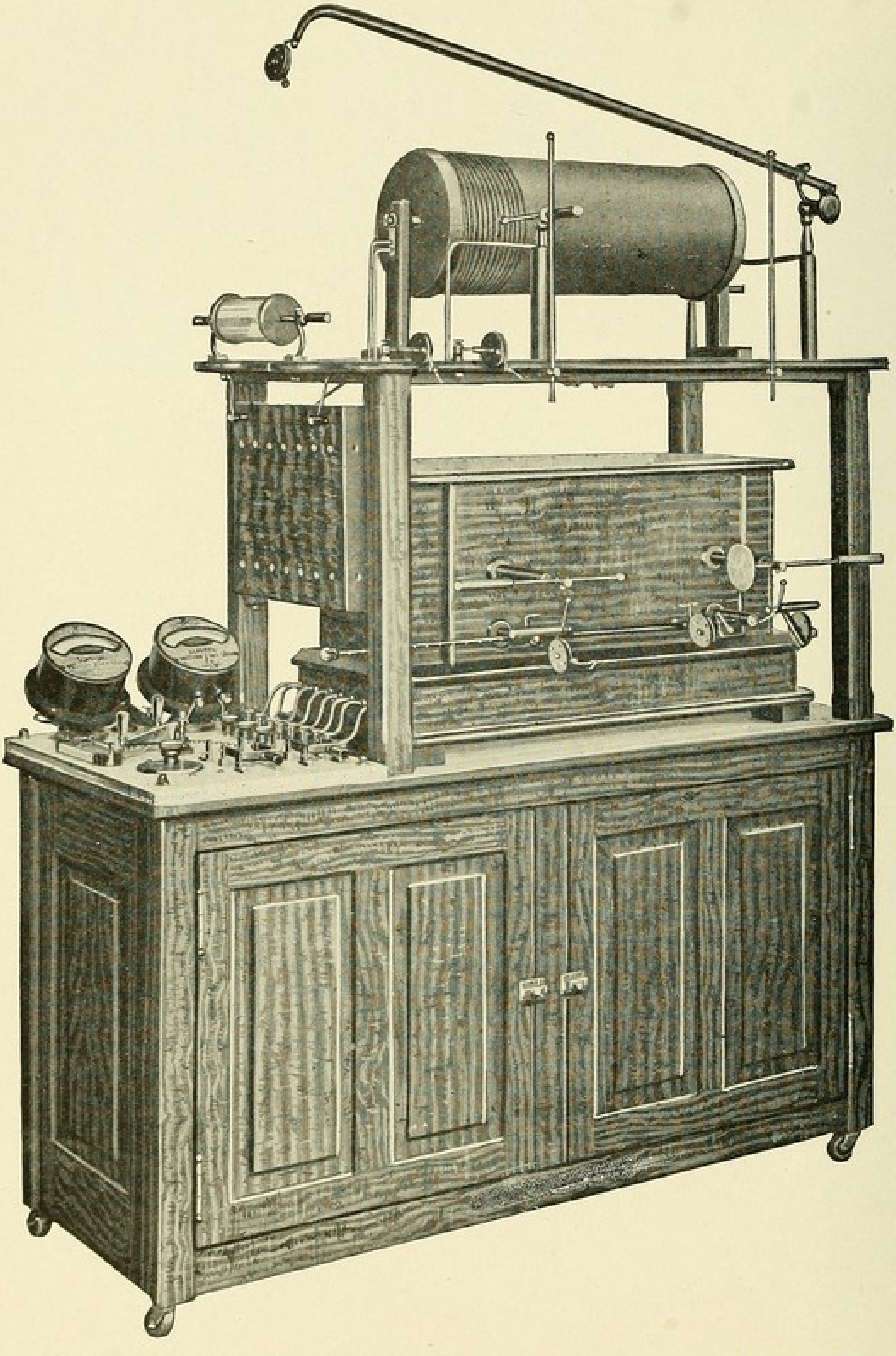
PRACTICAL ELECTRO-THERAPEUTICS AND X-RAY THERAPY



COMBINATION RADIOGRAPHIC X-RAY AND HIGH-FREQUENCY APPARATUS FOR ALTERNATING OR DIRECT CURRENT.

PRACTICAL ELECTRO-THERAPEUTICS AND X-RAY THERAPY

WITH CHAPTERS ON PHOTOTHERAPY, X-RAY IN EYE SURGERY, X-RAY IN DENTISTRY, AND MEDICO-LEGAL ASPECT OF THE X-RAY

BY

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PREFACE.

This book has been written for the student and general practitioner. It has been the object of the author to introduce only such features of the diagnostic and therapeutic work as will be of practical value to a large class of busy physicians who desire to gain an intelligent understanding of the specialty, but have not the time to devote to a more extended study of the subject.

Technicalities have been avoided. No attempt has been made to illustrate or describe the many excellent machines now on the market. Those described represent a type to which they belong, and what is said of them may be applied to all machines of the same type.

The photographs and skiagraphs are from the author's private collection, and are introduced as practical examples of the efficiency of the methods described.

Electric and x-ray methods have proven their worth. They are receiving merited recognition as diagnostic and therapeutic agents in medicine and surgery, and the physician who disregards these methods may be accused of neglect.

It is hoped that this volume will awaken a deeper interest among its readers in the use of electricity and x-ray by showing what may be done by a thorough study and careful application of the methods presented. No attempt has been made to treat any subject exhaustively, but sufficient matter has been presented to convince the most skeptical.

In the preparation of this volume frequent reference has been made to the writings of Kassabian, Tousey, Snow, Massey, Strong, Pusey, Allen, Guilleminot, Belot, Freund, and others, and the author takes occasion to acknowledge his indebtedness for important information to these pioneers in this line of work.

If this volume will be the means of adding to the physician's knowledge, and helps him, in the least way, to better serve the sick and injured who may seek his aid, the object of the author will have been accomplished.

J. M. Martin.

Dallas, Texas, January, 1912.

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INTRODUCTION.

The "electron theory," as now advanced, goes back to the very foundation of matter, and attempts are made to have it account for all electric phenomena through "ether waves." These waves, it is believed, are caused solely by the vibration or rotation of the electrons of which all matter is composed. The electron is thought to be the unit of all substances and the "center of negative electricity." All matter is composed of molecules, and each molecule is made up of two or more atoms. In the normal state these atoms do not exist alone, and are separated from their fellows only by a chemical process, which leaves them free to form different combinations. In this way new molecules and new substances are formed.

For the electron theory it is claimed that the atom is made up of a certain definite number of electrons (negative elements) floating or suspended in a sphere of positive electricity. The electron being the real substance of the atom, the nature and atomic weight of the different chemical elements will naturally depend upon the number of electrons in each atom. It is also believed that a limited number of electrons may exist independent of the atom for a short time, or that they may be passed from one atom to another, and that an electric current is the result of the passage of a stream of these independent electrons through a conductor. This statement is contrary to our former belief and teaching, which was to the effect that the current was positive and left the positive terminal of the negative element. According to the electron theory, positive electricity can not have an independent existence. It is always associated with the negative electrons in the atom.

The unit of positive electricity is the "positive ion," and consists of an atom with an excess of positive electricity. In a neutral body the electric charges are balanced. There is an equal amount of positive and negative electricity in each atom of which the body is composed. If, however, a few of the electrons are withdrawn from a neutral body, there will be an inequality between the charges; the positive being the greater, the body will, therefore, be positively charged. If, on the other hand, electrons be added to a neutral body, it will possess an excess of negative charge.

Atoms that have an excess of positive electricity are called positive ions, and atoms having an excess of negative electricity are called negative ions. Atoms of the metals and bases have the property of becoming deprived of one or more electrons, and in this way becoming positive ions, while, on the other hand, atoms of acid-forming elements have the property of taking on one or more extra electrons, and in this way they become negative ions.

It will be seen from the above statement that chemical action can not take place between two substances short of "ionization." There must be an inequality between the electric charges on the two substances or elements before a current can pass between them. In order to bring about ionization between two or more substances, it is necessary to increase the rate of vibration between the atoms of which the substances are composed. This is produced by the application of some external vibratory force, transmitted in the form of "ether waves" or "radiant electric energy."

Ether is supposed to be an "elastic medium" filling all space, interatomic and interelectrotonic, as well as all other space of which we have any knowledge. When ether is disturbed, it produces waves or vibrations, resulting in a motion known as "radiant energy." It is believed that these ether waves are produced solely by the periodic vibration or rotation of electrons.

Ordinary motion of matter, in mass, produces only mechanical movements, and does not produce radiant energy in the ether; while, on the other hand, a lighted taper disturbs the electrons in the flame, producing a rate of vibration that causes ether waves of both light and heat, yet there is no mechanical disturbance.

Each substance has its own specific atom. The electrons of these atoms have their own rate of vibration, and they therefore produce ether waves of different lengths and frequencies. In the spark discharge of a Leyden jar we have the slowest and longest ether waves with which we are acquainted. These waves are called "Hertz waves." A little higher up the scale, where the electrons are made to vibrate faster, we have the "heat waves." Here we have a chemical combination resulting from friction caused by the colliding of the moving masses. Farther up the scale, where the electrons vibrate still faster, we have a disturbance in ether known as light waves. Here we have electrical discharges, producing combustion and illumination. Light vibrations occur between 350,000,000 (red) and 450,000,000 (violet light). Vibrations below and above this rate do not produce phenomena that can be seen by the human eye. That there are rays far above these rates of vibration is proven by their power to affect photographic plates. Under their influence certain chemicals, as willemite, calcium, and tungstate, are made to fluoresce.

The Röntgen x-rays are the result of the most rapid ether vibrations of which we have any knowledge. The phenomena is produced by the sudden stopping of a stream of rapid-moving free electrons in a tube having a vacuum of one-millionth of an atmosphere. These invisible x-rays have the power of penetrating very dense objects, affecting photographic plates and making substances fluorescent. Animal tissue, when exposed to the x-ray, undergoes many changes, depending upon the length of exposure, kind of tube, distance from the parts, and strength of the current, as well as the resistance of the tissue.

From the foregoing opinions regarding the electron theory we come to the conclusion that in the passage of an electric current there is an actual rapid movement along the conductor of electrons (negative elements), which in turn produces ether waves, causing what we understand to be electric energy. The quantity of electrons allowed to pass over a conductor, together with the rate of their vibration, determines the strength of an electric current.

In passing along a conductor, the electrons pass through the substance of the conductor, going from atom to atom. This passage of free electrons through a substance disturbs the residual electrons in each atom of which the conductor is composed in proportion to the size of the conductor and the number of electrons being forced through it, together with the rate at which they travel. If the conductor is small and the atoms of which it is composed contain a large number of electrons to the atom, the stream of electrons passing through will crowd the residual electrons, and cause a considerable amount of vibration and friction, which will heat the conductor in proportion to its density and the strength and size of the current.

The electrons of which an atom is composed are never still, but are continually vibrating, producing ether waves of different lengths necessary to maintain certain phenomena for which nature has particularly designed them. When this rate of vibration is disturbed, there is a change in the ether waves and a corresponding change in the phenomena produced.

If the electron theory is correct, we have a rather clear idea of what electricity really is, how it acts, and why. Considering the human body as a conductor, we have a variable mass composed of liquid, muscle, nerve, tendon, skin, and bone, each with its own specific resistance and rate of electrotonic vibration, and corresponding ether disturbance. Any distinct variation from the normal electrotonic vibration in any of these tissues will change the ether waves and interfere with the normal functions of the parts disturbed.

Those who have made a study of electricity in its broadest sense, while far from knowing all there is to be known or all that we would like to know, do know that animate or inanimate matter can not exist as such without the constant passage of electric currents through the substances of which it is composed. Summing up the electron theory, we have learned that the atomic weight of a substance is determined by the number of electrons to the atom; that the electron is the unit of negative electricity; that free electrons passing through a substance constitute an electric current; that an atom may be negative or positive, and in either case it is called an ion; that in liquid and semi-liquid conductors the electrons mainly travel with the atoms through the substance instead of from atom to atom.

From the conclusions reached we are able to get a clear understanding of what takes place during the passage of an electric current through animal tissues. To the novice in electro-therapeutics the great number of currents is confusing, but, when once understood, the whole system becomes very simple. The galvanic, faradic, static, sinusoidal, and high and low-frequency currents are separate and distinct methods, and are particularly useful in certain cases. In these currents the electricity is the same, the difference being in the direction; the quantity and the pressure cause a distinct rate of vibration of the electrons, with certain ether waves and a definite physiological effect upon animal tissues.

There is a vast difference in the tissues of which the human body is composed. It is reasonable to suppose that the normal rates of vibration of the electrons of the various tissues are widely different, and when overtaken by disease it is believed that the normal rates of vibration are greatly interfered with.

If electricity is to be of value as a therapeutic agent, we must be so thoroughly conversant with our currents and their physiological effects as to be able to supply the particular current or currents in such a way as to relieve the abnormal condition. This is not so hard as it appears on first thought. Electricity, as a therapeutic agent, will probably reach its acme in the treatment of diseases of the nervous system.

It is the aim and ambition of the author to so present the subject in this volume that the student who really wants to master the subject of this young but important specialty may thoroughly grasp the basic principles, and be able to apply electricity as a powerful weapon against the many diseases and human infirmities from which our people are continually suffering.

PRACTICAL ELECTRO-THERAPEUTICS AND X-RAY THERAPY

CHAPTER I.

DIRECT ELECTRIC CURRENTS.

What is Electricity?—The question, "What is electricity?" is always the first to be asked by those who oppose electric methods, and, because no very clear answer or definition can be given, they at once condemn the whole system without an investigation. Mystery and superstition have always surrounded every department of electrical science.

The commercial world was quick to realize the possibilities of electromotive force, and has studied it from every standpoint, with the result that it has been developed into the most gigantic and powerful factor in not only the production of human necessities, but of the majority of luxuries as well. If electricity in all of its many branches were taken from us now, we would suddenly drop backward in the scale of human progress two hundred years. To name the uses to which electricity is daily put would require a large volume. So important has it become that we can not think of doing without it for a single day.

As many of our scientific physicians are interesting themselves in the therapeutic uses of electricity, it is being rapidly placed upon the same high level as a therapeutic agent that it now enjoys as a commercial power. For years electrical methods were in the hands of the quacks and fakes—men who used any kind of method, or worthless apparatus, to beguile those who knew no better.

The electron theory, though but a theory, comes more nearly to a solution of electric phenomena than any other with which the author is acquainted, and until something better is brought forward he is willing to accept it. If the electrons (primary elements of matter and the unit of negative electricity) are capable of existing alone in the form of an electric current, which passes through solid conductors, going from atom to atom and starting a rate of vibration in the residual electrons in each atom, resulting in ether waves, that act upon surrounding objects as electrical manifestations—or, as we commonly say, electrical currents—we are not far from a solution of electricity, and can therefore venture a definition. The mere passage of electrons through a substance disturbs only the kindred electrons of the atoms, and the resulting radiant energy—ether vibrations—produces an external force or electric energy. Electricity is, therefore, the result of ether waves, caused by the passage of electrons from one substance to another having a positive charge.

The statement advanced some time ago that electricity is not a form of matter, but a mere condition or manifestation, was not so far wrong. Whatever electricity really is, no one doubts that it is a manifestation of nature—a natural condition that exists in great abundance everywhere, and a condition that is absolutely essential to the existence of all matter in any state, either animate or inanimate. Though we are unable to define electricity or analyze its properties, we are able to start a current, carry it in any quantity to any place, high or low, and completely control it at all times and under all conditions.

Because of long usage, electrical manifestations will be referred to as electric currents, though they must not be literally understood to be such.

Electric Units.—Since electricity is probably only a manifestation of certain states of matter, and can be neither increased nor decreased, we are interested in knowing only how it can be made manifest—how the current is started, conducted, measured, and controlled. Electricity is naturally a property of all matter, in which it exists in an equal amount of negative and positive charge, or in what is known as a neutral state. External manifestations are never discernible in neutral bodies, but, when two unequally charged substances are brought together, either by actual contact or by means of extra conductors, a current will be established by the passage of electrons from the negative to the positive body. The current will cease as soon as the two bodies are equally charged or become neutral.

Electricity is a natural phenomenon, but nature has not supplied us with a storehouse from which to draw at will. When we wish to use electric currents, we are compelled to produce a difference in potential between two objects in order to obtain a pressure. This is accomplished in several ways, but in this work the student will study only the chemical and mechanical methods, which will be described in detail in another chapter.

Electromotive Force.—The pressure or force in an electric current is called an electromotive force. A stream of water passing through a pipe is, for example, used to represent an electric current. When pressure in a current of water is required, it is necessary to raise the source of supply to the necessary height. The higher the source, the greater will be the pressure. In order to start an electric current, it is necessary to produce a pressure or a difference in potential, which means that we must store up electrons in such a quantity as will be required to produce a given current in a conductor. The electromotive force in any generator is its capacity for producing electric pressure. The unit of this pressure is called the volt. The volt is the pressure necessary to force one ampere through a resistance of one ohm. In a conductor of constant resistance the current strength may be varied by changing the pressure—i. e., the current strength varies with the pressure.

Ampere.—The ampere is the unit rate of current flow, and is the amount of current forced through a resistance of one ohm by a pressure of one volt. An ampere is too strong for general application to the human body. It has, therefore, been divided into one thousand parts, each of which is called a milliampere.

Ohm.—It is noticed that electricity does not pass with the same ease through all substances. Some materials offer a great deal more resistance than others. Every substance offers some resistance, and every substance will conduct some current. Materials that offer little resistance to the passage of an electric current are called good conductors, while those that conduct but little current are known as poor conductors, or insulators. Pure silver is probably the best conductor and pure copper comes next. Most other metals, carbon, and acidulated water are good conductors. The human body, cotton, dry wood, marble, and paper are among the poor conductors. Oils, porcelain, wool, rubber, guttapercha, shellac, paraffin, glass, etc., are excellent insulators.

Since each substance has its own specific resistance, it becomes necessary to select a standard by which the resistance of all materials can be measured. For this purpose a column of mercury of a certain length and cross sectional area, with a temperature at the freezing point of water, is chosen. In dimensions this column of mercury measures 41.7323 inches long with a cross sectional area of .00155 square inches. The resistance offered to the passage of a current through this column of mercury is taken as the unit and is called the ohm. One ohm is nearly equal to the resistance offered by 200 feet of No. 20 copper wire.

The resistance of a conductor increases as its length and temperature increases, and decreases as its cross sectional area increases. In metallic conductors the resistance remains the same (constant) during the passage of a current, no matter what its strength may be, provided the temperature is unchanged. This will not hold good in semi-liquid conductors, as, for example, the animal tissues.

In applying electric currents to animal tissue, it is noticed that the resistance decreases up to a certain point.

Ohm's Law.—In a conductor of constant resistance the current strength is directly proportional to the pressure. In a conductor where the pressure is constant the current strength varies inversely with the resistance. Therefore the current strength varies directly with the electromotive force and inversely with the resistance. Stating this law in the form of equations, we have the following:

(1) Current strength in amperes $= \dfrac{\text{electromotive force in volts.}}{\text{resistance in ohms.}}$

(2) Resistance in ohms $= \dfrac{\text{electromotive force in volts.}}{\text{current strength in amperes.}}$

(3) Electromotive force in volts equals current strength in amperes multiplied by the resistance in ohms.

From a study of this law we learn that, to increase the current strength in a conductor, we must either increase the electromotive force in volts or decrease the resistance in ohms; while, on the other hand, if we wish to decrease the current strength in amperes, we must either increase the resistance in ohms or decrease the electromotive force in volts.

The following abbreviations, or characters, will be used in expressing electric formulas:

(1) C or A—current strength or ampere.
(2) V or EMF—volt or electromotive force.
(3) R—resistance or ohm.
(4) Ma—Milliampere ($1/_{1000}$ of an ampere).

Simplifying Ohm's law, the following formulas will be easily remembered:

$$(1)\ C = \frac{EMF}{R} \qquad (2)\ R = \frac{EMF}{C} \qquad (3)\ EMF = R \times C.$$

In order to fix the above rules in the student's mind, the following practical problems will be of service:

Example.—During the therapeutic application of the direct current the voltage is 110, and according to the reading of the milliamperemeter the current strength is 10 milliamperes ($\frac{1}{100}$ A). What is the resistance in ohms offered by the patient?

Applying the formula that the resistance is equal to the electromotive force divided by the current strength, we have the following statement according to formula No. 2.

$$\frac{EMF}{C} = \frac{110\ V}{10\ Ma} = \frac{110\ V}{\frac{1}{100}\ A} = 11{,}000 \text{ ohms, the resistance offered by the tissue of the patient.}$$

Example.—During the therapeutic application of the direct current the voltage is 110, and according to the milliamperemeter the current strength is 20 milliamperes ($\frac{1}{50}$ A). What is the resistance offered by the patient's tissues?

$$\frac{EMF}{C} = \frac{110\ V}{20\ Ma} = \frac{110\ V}{\frac{1}{50}\ A} = 5{,}500 \text{ ohms, the resistance offered by the tissue of the patient.}$$

Many other problems could be given to illustrate the application of the above rules, but we believe that every man who is qualified to take up this work will grasp the meaning of Ohm's law, and will be able to make a practical application when necessary.

CHAPTER II.

METHODS OF CREATING AN ELECTROMOTIVE FORCE.

From what has been said in Chapter I it is clear that before a current can be made to pass along a conductor it is necessary to create a pressure, or EMF. There are a number of methods for creating this pressure, but only a few are of any importance to us as electro-therapeutists.

We will limit our studies principally to the production of an EMF by means of chemical action—as the galvanic, primary, and secondary cells—and by means of mechanical energy, as the dynamo-electric machine and the electro-static induction machine. There are other methods of starting an EMF, such as radiant energy (light and heat), animals, and plants. These methods, while intensely interesting to the student, can not be discussed here.

PRIMARY AND SECONDARY CELLS.

Simple Cell.—The voltaic is the simplest form of cell, and will be used in describing the chemical changes that take place within the electrolyte. This experiment can be easily and quickly made by the student or physician in his home or office.

Procure the following articles: wide-mouth, flat-bottom tumbler; strip of zinc and copper, each ½ inch wide and 6 inches long; and a piece of copper wire 6 or 8 inches long. Fill the tumbler two-thirds full of water, to which add 5 percent of sulphuric acid. This solution will hereafter be known as the electrolyte. Now place the zinc strip in the electrolyte, and some bubbles will be seen to form around the strip and rise to the surface of the solution. Then place the copper strip in the electrolyte in such a position that it will not come in contact with the zinc. No action is visible about the copper. The outer ends of the copper and zinc strips, which will hereafter be known as the elements, are now connected by means of the copper wire. An increased activity will be noticed about the zinc element. The copper element becomes active, and the bubbles around it are much more numerous than around the zinc element. The greater number of these bubbles are seen to rise to the surface of the solution and disappear as gas. The question will be asked by the investigating student, What causes this phenomena?

Fig. 1 represents a simple or voltaic cell. It is filled to the point *A* with a 5-percent solution of sulphuric acid, which constitutes the electrolyte. *Z* and *C* are the elements. The bubbles that form

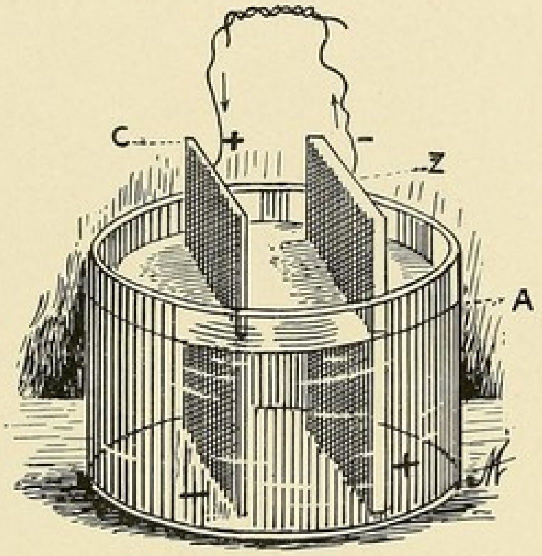


Fig. 1.—Simple cell.

around the zinc before the elements are connected are due to what is called a local action or short currents within the zinc, due to the presence in the zinc itself of impurities, as iron, arsenic, etc. If the zinc is perfectly pure, no bubbles will come from it when disconnected.

To explain the action that takes place in a voltaic cell, it is necessary to understand the interaction between the electrolyte and the elements. The electrolyte is composed of a compound substance in solution. The water seems to so destroy the natural chemical affinity existing between the atoms of some compounds as to allow them a freedom of action when influenced by an external controlling force. Every electrolyte is a watery solution of some compound, and every compound is made up of elements of different polarity. It must be understood that in every electrolyte there will be atoms carrying a negative and atoms carrying a positive charge, and that these atoms may be moving in opposite directions.

On account of the action of the water on the compound, the dissimilar atoms are unable to combine with each other and are mixed up in the solution in a promiscuous way.

It should be remembered that fluids do not conduct electric currents in the same way as solids. In solids it is believed that the electrons travel through the substance, going from atom to atom, while in solutions the electrons travel with the atom. When an electric current is passed through a liquid, the charged atoms do not pass rapidly through the solution. The attraction and repulsion is not exerted through any great distance. The range of attraction is said to be about one-ten-millionth of a millimeter and is called the molecular range. When the atoms within this range have been attracted, other like atoms will take their place, and so continue until all of the atoms of the electrolyte have been attracted in this manner, the elements destroyed, or the cell is polarized.

OPERATION OF A VOLTAIC CELL ACCORDING TO THE ELECTRON THEORY.

An ion is an atom carrying an electric charge, and may be either negative or positive. If a neutral atom has had a few of the electrons removed from it, it is a positive ion; if, on the other hand, the atom has had a few electrons added to it, it becomes negatively charged and is a negative ion.

Before elements can combine chemically they must ionize—i. e., the natural electric attraction existing between the elements of a molecule in a compound must be broken up, so that new molecules, and consequently new compounds, can be formed.

When the zinc and copper elements are placed in the electrolyte in a voltaic cell and short-circuited by connecting their outer ends, ionization between the zinc and electrolyte takes place. The acid elements are usually negative ions (possessed of negative charges), while the metallic zinc is made up of positive ions. Ionization at the positive pole (zinc element) causes a dissolution of the zinc. The negative sulfion (SO_4) and oxygen elements of the electrolyte (H_2SO_4, H_2O) enter into new molecular combinations with the zinc, forming zinc sulphate and setting free a vast amount of electrons (negative elements). The external circuit of the cell, being of low resistance, offers a far better means of conduction than the solution (electrolyte) in the cell, and on this account the free electrons rush around the external circuit, coming back to the copper element.

The stream of active electrons (electrically negative and chemically acid) enter the positive terminal of the copper element, and here combine with and neutralize the alkaline and electro-positive hydrogen elements. This neutralizing process produces an effervescence, resulting in the liberation of hydrogen gas, which rises to the surface of the electrolyte in the form of bubbles. When a sufficient amount of electrons is allowed to return to the electrolyte through the copper element, the positive ions or alkaline hydrogen elements are neutralized, but if, on account of the resistance in the external circuit, but few electrons are returned to the electrolyte, the unneutralized hydrogen elements accumulate about the negative pole or copper element, forming a dense film and stopping the action of the cell, when it is said to be polarized. This theory accounts for the physiological action of the two poles, and explains why one is acid and the other alkaline, and why one is destroyed and the other is unaffected.

The molecular range or ionization between the electrolyte and the zinc element takes place through a very short space, but the freeing of the electrons is very rapid—so rapid that there is no apparent intermission between them. The stream going to the external circuit appears to be absolutely continuous. In this way a difference of potential is constantly maintained, and the current is said to be continuous—i. e., the galvanic current.

USE OF SIMPLE CELLS.

The physician living in the country districts and the smaller towns, where the commercial street current is not available, will be compelled to use batteries for operating the galvanic, faradic, light, and cautery apparatus.

There are many kinds of liquid and dry cells on the market, most of which are very good when properly cared for. The liquid cells in general use are known as the acid, or bichromate, and the salammoniac. In the former the electrolyte is a solution of sulphuric acid, bichromate of potash, and bisulphate of mercury, while in the latter the electrolyte consists of a solution of chlorid of ammonia. The elements are the same in either case.

Dry cells, so called, are not really dry. The electrolyte is made up of a semi-solid compound, sealed up so that it can not spill out. They are very valuable in many cases, and can be depended upon for all broken currents, such as the faradic. Secondary cells, or storage batteries, are now very little used in the physician's office, and will not be discussed here.

To successfully operate the galvanic current (wall plate) for therapeutic purposes, it will be necessary to have at least forty cells similar to the cell shown in Fig. 2. They are to be filled two-thirds full of rain water, to which have been added 4 ounces of chlorid of ammonia for each cell.

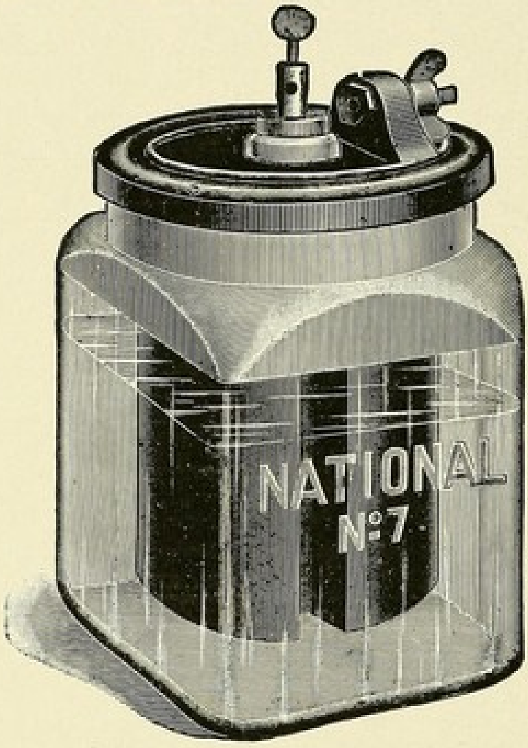


Fig. 2.—Chlorid ammonia cell.

It will be noted that forty cells will take up a good deal of space. It is customary to put them in some out-of-the-way place, as in another room, or they may be placed in the basement. They may, however, be put in a neat cabinet, and allowed to remain in the same room with the other apparatus. In connecting up the cells for use with a wall plate, they are arranged in series—i. e., carbon to zinc. The carbon of one cell is fastened to the zinc of another by short pieces of copper wire. When all the cells are connected, it will be found that there is a free zinc (negative element) at one end and a free carbon (positive element) at the other. Long copper wires attached to these free terminals and carried to their respective poles on the wall plate will complete the battery connection, and the apparatus is ready for use. Dry cells, if used, should be connected in the same manner, but they are not suited for closed circuit or continuous work.

CARE OF BATTERIES.

A battery of salammoniac cells will need but very little attention for some time—say, two to four months. As the water evaporates from the cells, more must be added. After a time the zincs will be destroyed, or the electrolyte will be exhausted. When the cells stop work after long use, they should be emptied and cleaned; new elements and new electrolyte will make them again operative. When cleaning up an old battery, be sure to see that all of the brass and copper connections are perfectly bright and clean. Sand paper, emery paper, or a file may be used to brighten up the parts. The insulation must be removed from the ends of all wires before connecting the cells together. The thinnest piece of tissue paper or other substance will prevent the passage of the galvanic current.

ARRANGEMENT OF CELLS.

It has been stated that the quantity of electricity used in making a therapeutic application is usually very small, and therefore the necessity of dividing the ampere into one thousand parts, or milliamperes. On account of the great resistance of the human

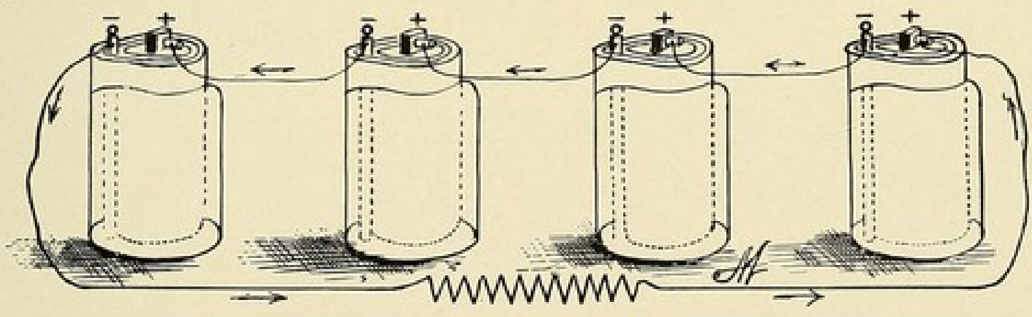


Fig. 3.—Cells in series.

body as a whole, it is necessary to have a high EMF. When using the wall plate—or, more definitely speaking, the galvanic current—we need a strong electromotive force with a low amperage—seldom more than half an ampere. In order to get this high pressure and low current strength, the cells are connected as in Fig. 3. When the cells are thus connected, they are said to be in series—i. e., carbon to zinc.

Each salammoniac cell is supposed to have a pressure (EMF) of 1½ volts and a current strength of ½ ampere. By connecting the cells in series, the pressure is increased to the amount of 1½ volts every time a cell is added. A battery of forty cells in series would deliver ½ ampere, with a pressure of 60 volts.

At first thought this statement appears confusing. It must be remembered that the load or amperage is not increased by the addition of cells in series, while the pressure is increased in proportion to the number of cells in use. The following lesson in hydraulics will serve to make plain what is meant:

Imagine a single force pump carrying a 1-inch stream of water. When this pump is operated at a certain rate, it will deliver a 1-inch stream of water with a certain definite pressure. Now, if this same stream of water is carried through another pump of the same capacity and working at the same rate, the stream will not be increased in size, but it will receive the pressure of the second pump, which will be added to that of the first. The size of the stream of water can not change, but the pressure or force given to the stream is increased as the pumps are increased.

The analogy is a happy one, for it enables the student to grasp the thought and to plainly understand the operation of the cells when thus connected (Fig. 3). Occasionally it is necessary to reduce the voltage and increase the amperage or rate of current flow. This may be accomplished by connecting the cells in parallel or parallel series. Fig. 4 shows the arrangement of the cells in parallel. It will be seen that all like elements are connected together—i. e., all of the zincs are connected on one side and all of the carbons on the other. With this arrangement of the cells, the current strength is increased as the cells are increased, while the voltage remains that of one cell. Going back to hydraulics by way of analogy, this principle is easily explained. If one pump delivers a stream of water 1 inch in diameter into a common pipe, the water will be definite in quantity and of a definite pressure. If a second pump is made to deliver the same sized stream with the same pressure into the common pipe, it will be seen at once that the stream of water in the common pipe is increased in size, but the force of the stream is not affected, and is that of only one pump. It makes no difference how many pumps are added and made to throw their streams into the common pipe; the stream will be increased in size as the pumps are added, but the pressure in the stream is unchanged. In this arrangement the stream of water does not go through each pump, but each pump delivers a separate stream into the common pipe. What is true

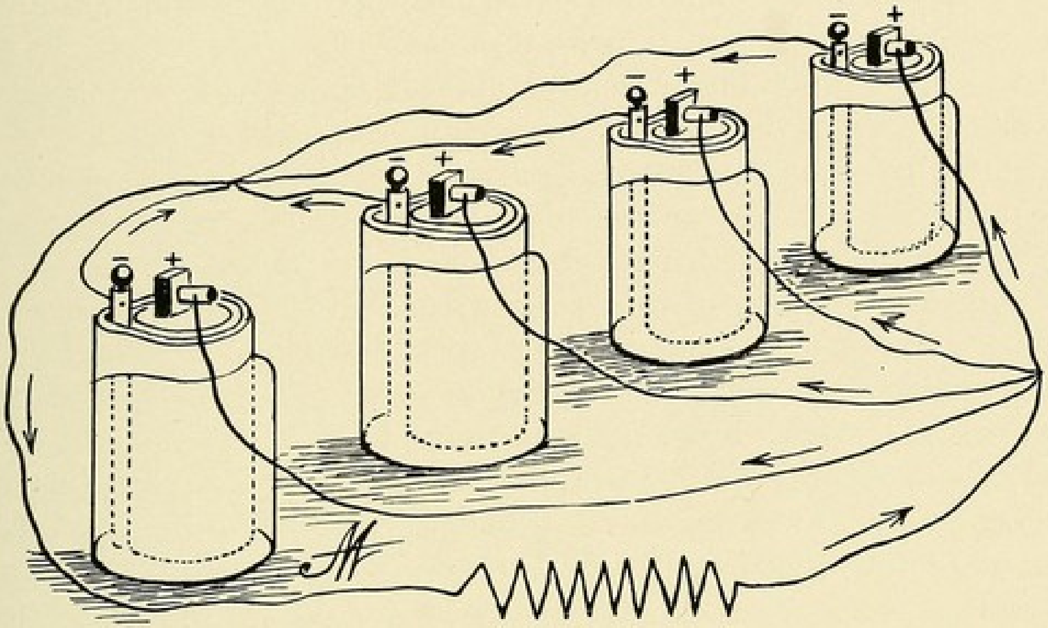


Fig. 4.—Cells in parallel.

of the pump is true of electric cells. A current of this kind could be used only where the resistance is very low, and in this arrangement such currents could be used for cautery purposes. By arranging some of the cells in series and some of them in parallel, any voltage or amperage may be had.

KINDS OF ELECTROMOTIVE FORCE.

It has been said that there is only one kind of electricity, but there are several kinds of EMF, or several ways in which a current is delivered to the conductors. The various methods of producing an electromotive force are alike in that they are capable of starting an electric current, but each apparatus differs widely from the other in many respects. Primary batteries and direct current dynamos produce an electromotive force continuous in direction and nearly constant in strength. Induction coils and alternators produce an electromotive force varying in both strength and direction.

Direct Current.—The galvanic or direct current has a continuous pressure or EMF, and can be likened to a stream of water continually flowing in one direction. There is no rise or fall in pressure or variation in current strength.

Intermittent Current.—An intermittent current is a direct current, with a sudden break or stop in the current strength, and finds its analogy in the force pump working with a single piston—as the piston rises, a stream of water is delivered to the pile, but as the piston falls the current ceases to flow. The current taken from the galvanic side of the wall plate and interrupted with the rheotome will deliver a unidirectional intermittent current.

Pulsating Current.—A pulsating current is not intermittent or interrupted, but rises and falls in volume without changing direction. The direct current may be made pulsating by increasing or decreasing the resistance through the rheostat, or by increasing or decreasing the EMF at the source of current supply. A similar result may be produced in a stream of water delivered from a rotary pump producing a continuous stream; as, for example, a fire engine—if the pump is made to run first fast and then slow, the stream of water flowing from the hose, though continuous, will rise and fall with the speed of the pump.

Alternating Current.—Alternating currents differ from simple direct interrupted currents in the fact that they rise and fall above and below the zero line. In speaking of the EMF of alternating currents, we say that they "constantly change in magnitude and periodically change in direction." Its hydraulic analogy would be in two rubber bulbs connected by a rubber tube. If one of the bulbs is filled with water and the bulbs are compressed alternately, the water will flow through the tube first one way and then the other. When the alternating current is used in therapeutics, it is spoken of as a sinusoidal current. In making the alternations, the current rises and falls a certain distance above and below the zero line. If this rise and fall is equal, the current is called symmetrical; if, however, the rise and fall is unequal, the current is called dissymmetrical. This rise and fall, taken together, is called a cycle or period, and constitutes both a negative and positive wave. The number of complete cycles occurring in one second is called the frequency.

Commercial lighting plants are operated by both the 110-V direct and the 110-V 60- to 133-cycle alternating. The 110-V direct current is ideal for the galvanic side of the wall plate; the 60- to 133-cycle alternating for the sinusoidal and electrocautery. The faradic coil is best energized by cells. Rectifying valves are not a very great success at present.

The x-ray coil may be operated on the alternating current, in which case it is necessary to use an electrolytic interrupter. The tube can not be controlled as well with this interrupter, especially when weak currents are wanted, as when using the mercury interrupter and the 110-V direct current. The author is probably prejudiced in favor of the 110-V direct current because he uses nothing else, but he would not discourage any one from using the alternating currents where the 110-V direct current can not be had.

The current to be used in operating the machinery to be installed by the physician should be determined before any electrical apparatus is purchased, as a direct current motor can not be operated with an alternating current. Each piece of apparatus must be operated on the particular current for which it is designed. A careful study should be made by the physician of each piece of machinery—learning how it is constructed, how operated, and how kept in repair—as every physician should be his own mechanic as far as possible. By the physician doing such minor mechanical work as may become necessary, he will save much expense and valuable time, and will have the satisfaction of not being subject to such delays as may otherwise occur.

CHAPTER III.

MAGNETISM AND ELECTROMAGNETISM.

Magnetism and electricity, though differing in many respects, must have the same properties in common. In an unelectrified body the negative and positive ions balance—i. e., the charges are equal. In a magnetized body it appears that the charges are separated. There is an excess of electrons at one end, making it strongly negative, while the other end is positive. The property of becoming magnetized is possessed by only a few metals. Iron and steel make the most powerful magnets. Soft iron is easily magnetized, and remains a strong magnet as long as it is under the influence of the magnetizing body, but quickly loses its magnetism as soon as removed from under the magnetizing influence.

Soft iron is much less dense than steel, and the electrons are in a less stable condition, being free to move from and return to their normal positions. A strong magnet or electrical influence placed at one end of a bar of soft iron will attract the electrons to that end of the bar, but as soon as the influence ceases they will return to their normal positions, and the bar is no longer a magnet. If a bar of steel is substituted for the soft iron, it will be noticed that a stronger magnetic influence is required to move the electrons and magnetize the bar. It will also be noticed that the electrons do not return to their old positions as in the bar of soft iron. In this way the steel remains a permanent magnet.

METHODS OF MAKING A MAGNET.

A piece of steel may be magnetized and demagnetized any number of times. A permanent magnet has a north and south pole (Fig. 5). Its magnetism does not change so long as its physical properties are not changed. Lines of magnetic force are continually passing around the bar, entering at the south pole and emerging from the north. This action is continuous—not ceasing so long as the bar is a magnet. The truth of this statement may be tested by placing a compass near the bar. When the compass is brought near the north pole of the bar, the south pole of the compass will point to the north pole of the bar. If the compass is now moved around to the other end of the bar, it will change poles, allowing the north pole of the compass to point to the south pole of the bar. By placing the bar under a piece of white paper on which have

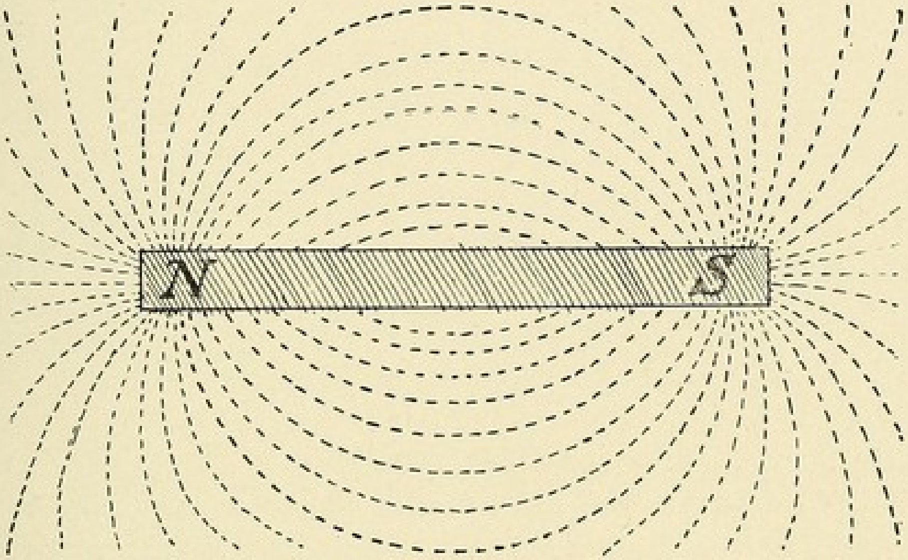


Fig. 5.—Bar magnet. N, north pole; S, south pole.

been sifted some iron filings, it will be noticed that the filings will arrange themselves in curved lines extending from pole to pole. These imaginary lines about a magnet constitute what is known as a magnetic field, throughout which the magnetic influence is manifest at all times during the life of the magnet. The strength of this influence decreases as the square of the distance increases until a point is reached where the influence is lost.

REACTION BETWEEN MAGNETS.

All magnets possess one property in common—namely, that of attraction and repulsion. Magnetism obeys the same laws that govern and control electricity—i. e., like poles repel and unlike poles attract. An interesting experiment may be performed by magnetizing two ordinary cambric needles and placing them on a smooth pane of glass. When placed with unlike poles together, they will hold each other, as it were, in a tight embrace, but when the poles are reversed they actually push each other apart.

One piece of steel may be magnetized by a magnet no larger than itself, both having the same magnetic strength. To do this the unmagnetized bar is stroked from center to end with one end of the magnet placed at right angles to the steel bar. After several strokes the bar is turned over and ends reversed, and with the other end of the magnet the stroking is continued as before. The steel bar will now be found to be magnetized, and

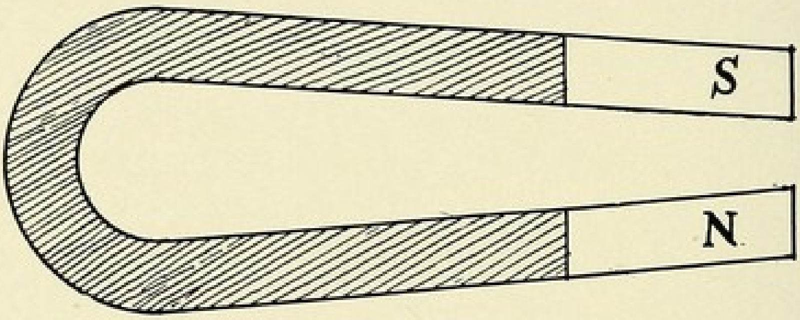


Fig. 6.—Horseshoe magnet. N, north pole; S, south pole.

will attract metallic objects the same as the magnet that magnetized it. To increase the influence of a bar magnet, it should be bent into the shape of a horseshoe, as shown in Fig. 6. In the horseshoe magnet the distance between the poles is much shorter and the resistance offered by the air is not so great; therefore the magnetic field between the poles is much stronger.

ELECTROMAGNETISM.

While an electric current is going through a conductor, another influence is put in motion which passes in circles around the conductor and at right angles to it. This external force or manifestation is called electromagnetism, and its strength depends upon the strength of the current in the conductor. Fig. 7 illustrates the lines of magnetic force about a conductor. The presence of this external force may be proven by placing a galvanometer either above or below a wire carrying a current. The needle will be deflected in proportion to the strength of the current in the conductor. If the current is sufficiently strong, the needle will take a position at right angles to the conductor. The north pole of the needle is always pointing in the direction in which the lines of force are traveling. In looking along a conductor, if the current is going away from the observer, the lines of force will be going around the conductor from left to right, or in the direction of the hands of a watch. Thus it will be seen that it is an easy matter

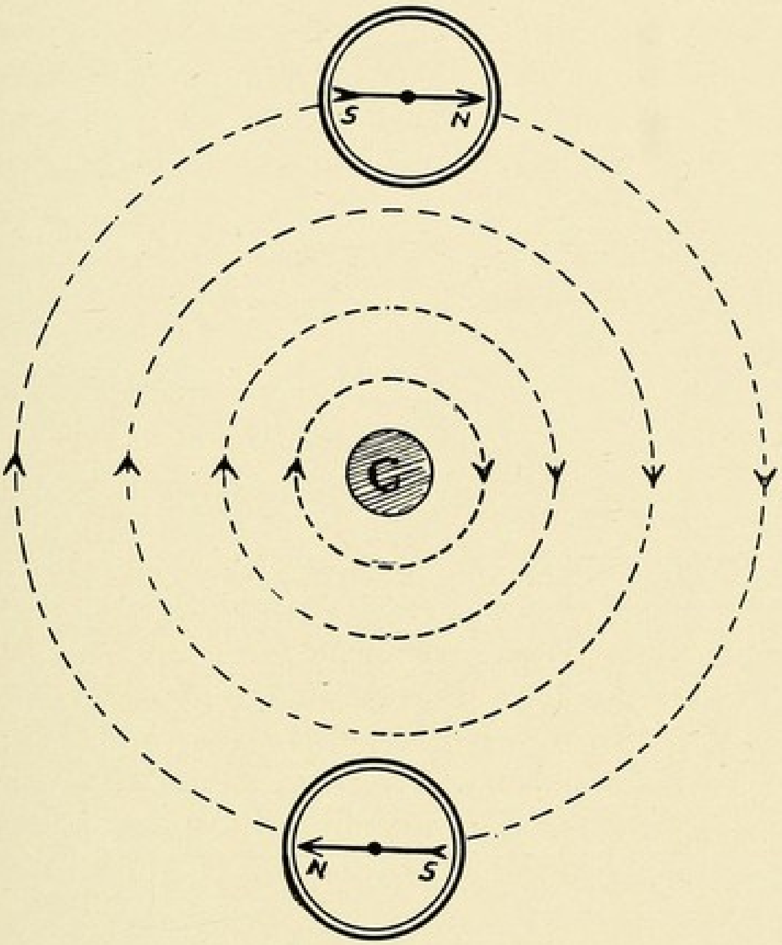


Fig. 7.—Waves of electromagnetic force. N, north pole of needle; S, south pole of needle.

to test the current in a wire or conductor, and determine its current as well as the direction of its magnetic influence.

INTERACTION BETWEEN CONDUCTORS.

The interaction between conductors is the same as that between magnets. Lines of magnetic force travel in the same direction, and, like magnets, like poles repel and unlike poles attract. In parallel conductors, if the lines of magnetic force are going in the same direction, there is a blending together of the lines of force of the conductors, or an attraction of one for the other, or a tendency to pull the conductors together. If, however, the lines of magnetic force should be going in different directions in parallel conductors, there will be a repulsion between the conductors the same as when like poles of magnetic needles are placed together. Fig. 8 illustrates the action of lines of magnetic force about a conductor carrying an electric current. If one turn in the wire pro-

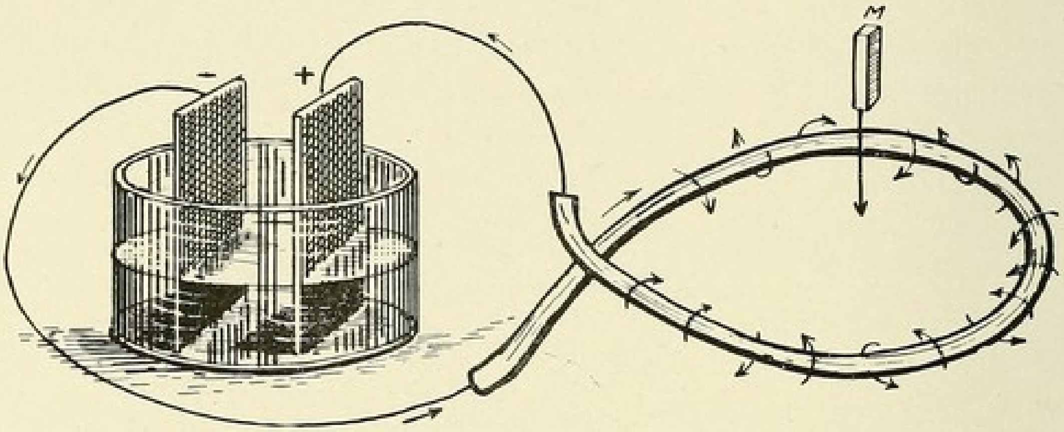


Fig. 8.—Lines of magnetic force about a conductor.

duces a certain magnetic influence, two turns of the same wire with an interaction of the lines of force will double the magnetic influence, and so on as the turns are added.

A bar of steel may be magnetized by an electric current by winding around it a coil of insulated copper wire and passing a

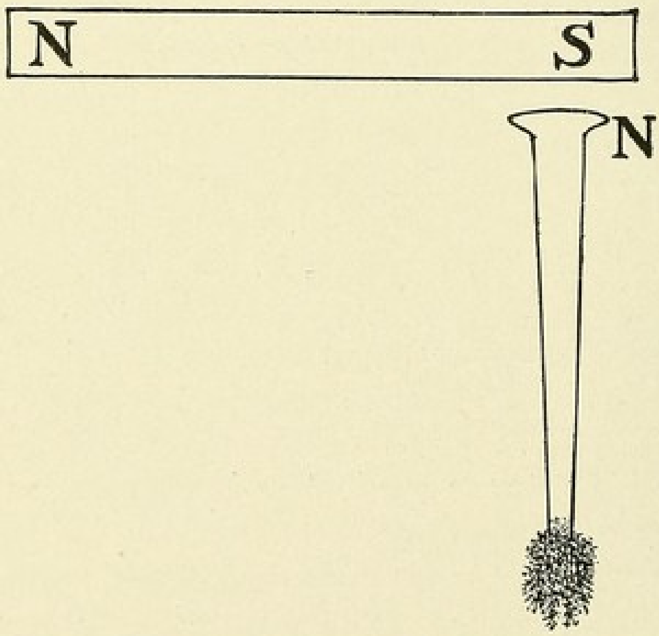


Fig. 9.—Inductive influence of a magnet. N, north pole; S, south pole.

current through the wire for a short time. When the bar is tested, it will be found to be magnetized, having a north and south pole. When the current is discontinued, the bar will retain its magnetism unless demagnetized as hereinafter described. Should the bar be of soft iron instead of steel, as soon as the battery current is broken the electrons in the bar will quickly return to their normal positions, and the bar will be neutral as before. This property of soft iron to instantly receive and lose a magnetic influence is of the greatest possible value in the construction and operation of the induction coil. The influence that a magnet or active coil has over a piece of steel or another coil is called induction. It is not necessary for an object to come in contact with a magnet to become affected by its influence. In Fig. 9 it will be noticed that the magnet is 1/8 inch from the nail, yet the nail is so influenced by the magnet that it attracts and holds the iron filings. If the magnet is now moved to a point where it loses its influence over the nail, the filings will quickly drop away.

STARTING AN ELECTRIC CURRENT BY MAGNETIC INFLUENCE.

It has been demonstrated that magnetic influences may be produced by electric currents. It is now to be seen how a magnetic influence can be made to start an electric current. Each coil of wire in a helix carrying an electric current sends out lines of magnetic force, each blending with its fellow to increase the strength of the magnetic field about the helix. If a coil of wire (helix) will give out lines of magnetic force while carrying an electric current, it stands to reason that the same coil will take up lines of magnetic force when placed in a magnetic field and start an electric current in the coil. To illustrate, in Fig. 10 *a* is a coil of insulated copper wire, so made that the permanent magnet *b* can be passed into the coil. The two ends of the coil *c* and *d* are fastened together and made to pass several times around the galvanometer *e*. When the magnet *b* is passed into the coil *a*, the needle in the galvanometer will be deflected to one side, and when the magnet is removed the needle will be deflected to the other side, proving that the lines of force thrown out by the magnet are taken up by the coils of wire and carried out through the conductors around the galvanometer, where they produce lines of magnetic force that affect the magnetic needle in the galvanometer. When the magnet remains stationary in the coil, no current passes through the conductors *c* and *d*. It is only when the magnet is moved in and out of the coil, allowing the lines of magnetic force from the magnet to cut across the coils of wire, that any influence is noticed in the galvanometer. To start an electric current with a magnet, it is necessary to move the magnet in the coil, or to move the coil over the magnet, or to make some other provision by which the lines of magnetic force may be made to pass to and fro over the coils of wire. This moving of the magnet, coil, or field will produce an alternating current, which will flow first in one direction and then in another, making it first negative and then positive at the poles—i. e., producing alternately an acid and alka-

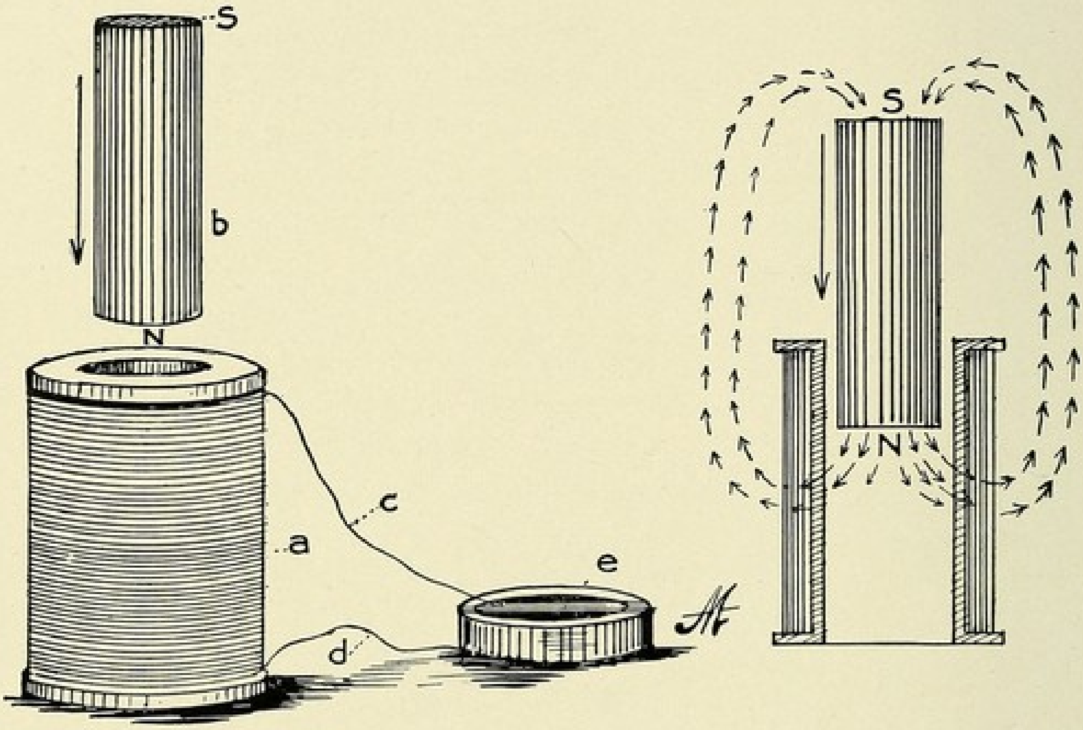


Fig. 10.—Method of starting an electric current with a magnet.

line reaction in the tissues, though the current flow itself is always negative.

From starting a current with a permanent magnet, it is only a step forward and upward to the starting of an electric current with an electromagnet. Fig. 11 represents a galvanic battery, a primary and a secondary coil. Coil *a* and galvanometer *e* are the same as used in Fig. 10. In the place of a permanent magnet, the small coil *1*, or primary coil, is placed inside of coil *a*. The terminals of coil *1* are connected to the poles of the battery *2*. So long as the current remains unbroken or the coils remain stationary, no change is noted in the galvanometer *e*. If, however, the battery current is broken, the needle in the galvanometer will be deflected to one side, and when the battery circuit is closed the galvanometer needle will be deflected to the other side. The distance that the galvanometer needle is deflected will depend upon the strength of the battery current and the number of turns of wire on the two coils. The change in the direction of the needle at the breaking of the current is caused by the change in the direction of the lines of force around the conductors *c* and *d*. The electromagnetic influence of the primary coil *1* on the secondary coil *a* is responsible for the current delivered to conductors *c* and *d*. This electromagnetic method of

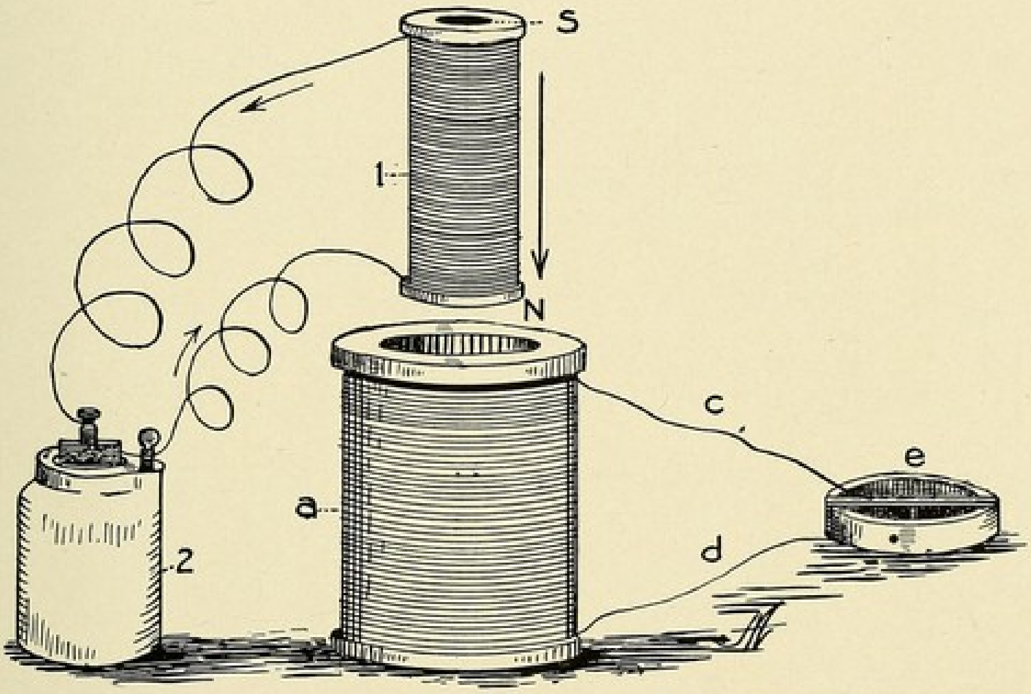


Fig. 11.—Starting an electric current with electromagnetism.

starting an electric current is the foundation principle of the faradic coil as well as of all motors and dynamos.

On account of the sudden magnetizing and demagnetizing property of soft iron, it is possible to construct a faradic coil in such a manner as to automatically change the magnetic field of the primary coil by rapidly interrupting the battery current. Before proceeding farther, a thorough understanding should be had of what has been said on the subject of magnetism and electromagnetism.

The effect produced on the galvanometer by moving the permanent magnet in and out of the coil, as illustrated in Fig. 10, has been observed and a similar effect has been observed by making and breaking the battery current in Fig. 11. In either case a current is started in the secondary coil, but the method is too clumsy to be of any practical use. By making use of the rapid magnetizing and demagnetizing properties of soft iron, it is possible to make the interrupter a part of the apparatus and to so construct it as to work automatically.

Fig. 12 is a simple faradic coil, and will be easily understood if the description is carefully followed. The current leaves battery *A* over conductor *1*, up through screw post *2*, through the screw,

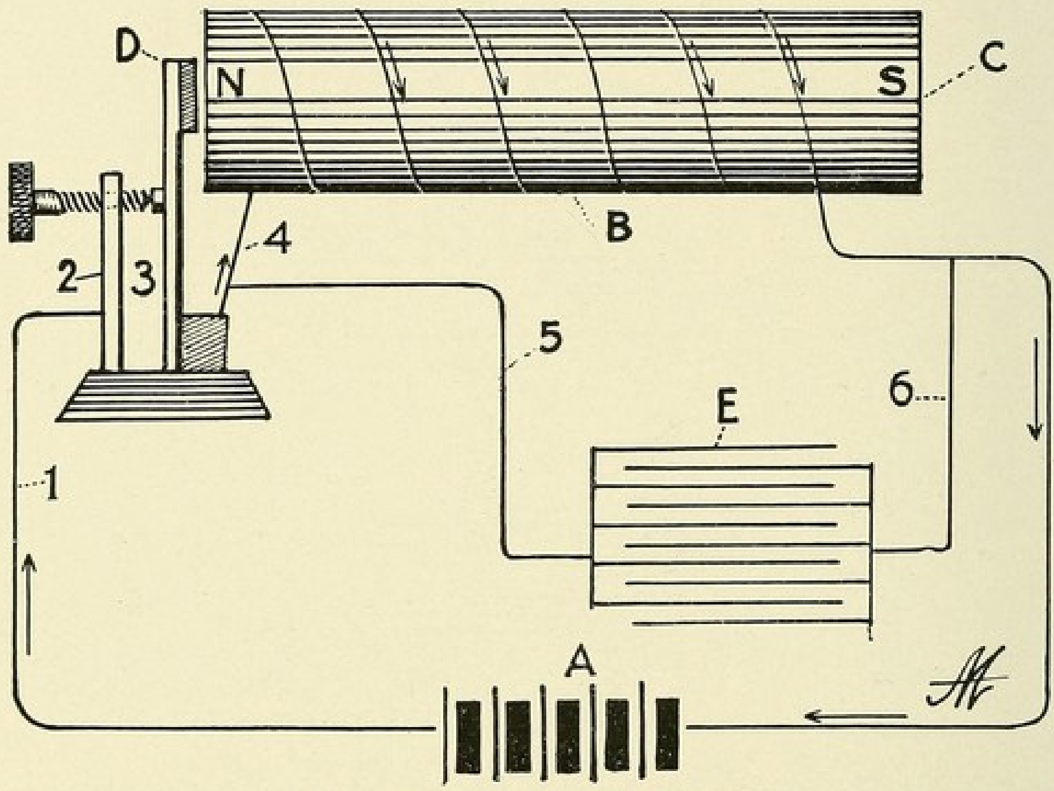


Fig. 12.—Simple faradic coil, with condenser.

and down through spring *3*, and on through conducting wires *4* to the coil. When the current reaches the primary coil *B*, the magnetic lines of force thrown out by the turns of wire magnetize the soft iron core *C*, which attracts the armature *D* on spring *3*, instantly pulling it up against the end of the core and away from the end of the screw, thus breaking the battery circuit and stopping the current in the primary coil. When the current ceases in the primary coil, the iron core *C* loses its magnetism by the electrons returning to their normal positions in the core. This return of the electrons toward the south pole of the core produces magnetic lines of force, which act on the primary coil by starting a current in the opposite direction. This current, strengthened by the closing in of the lines of force about the primary coil, is a high voltage current and readily bridges across the air gap between the screw and spring *3* by means of a broad spark, which prevents the abrupt breaking of the circuit and demagnetization of the core. This is overcome by placing a condenser *E* with conductors *5* and *6*, connecting it with the terminals of the primary coil.

Fig. 13 illustrates the method of building a condenser. It consists of a number of pieces of tin foil cut to the desired size, *A* and *B*, between which are inserted pieces of waxed paper *C*. Sheets

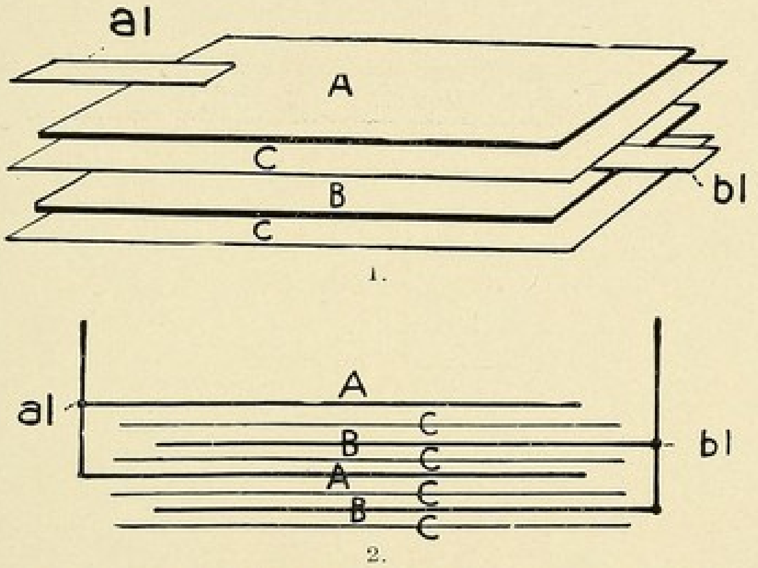


Fig. 13.—Method of making a condenser for faradic coil.

A have narrow prolongations at *a1,* and sheets *B* similar extensions *b1.* All the prolongations at *A* are joined together, and those at *B* are similarly joined. Wire *5* in Fig. 12 is connected to *a1* and wire *6* to *b1.* When in use, one set of sheets is negative and the other is positive, and the charges are prevented from uniting by means of the waxed paper. When the condenser is used, the current is offered a path of much less resistance, and, instead of jumping across the air gap at the contact between the screw and spring *3*, it goes into the condenser. The condenser not only provides an open path for the extra current, but furnishes a reverse current that effectively demagnetizes the coil core. All faradic coils intended for physician's use should be provided with well-built condensers. One or more secondary coils may be operated from around a primary.

The faradic coil usually found in the physician's office consists of a primary winding of about 250 feet of No. 20 copper wire, which is covered by a secondary of about 4,500 feet of No. 36 copper wire, the latter being tapped at 1,500 and 3,000 feet. These different lengths are connected with a selective switch in such a manner that they may be used separately and independently.

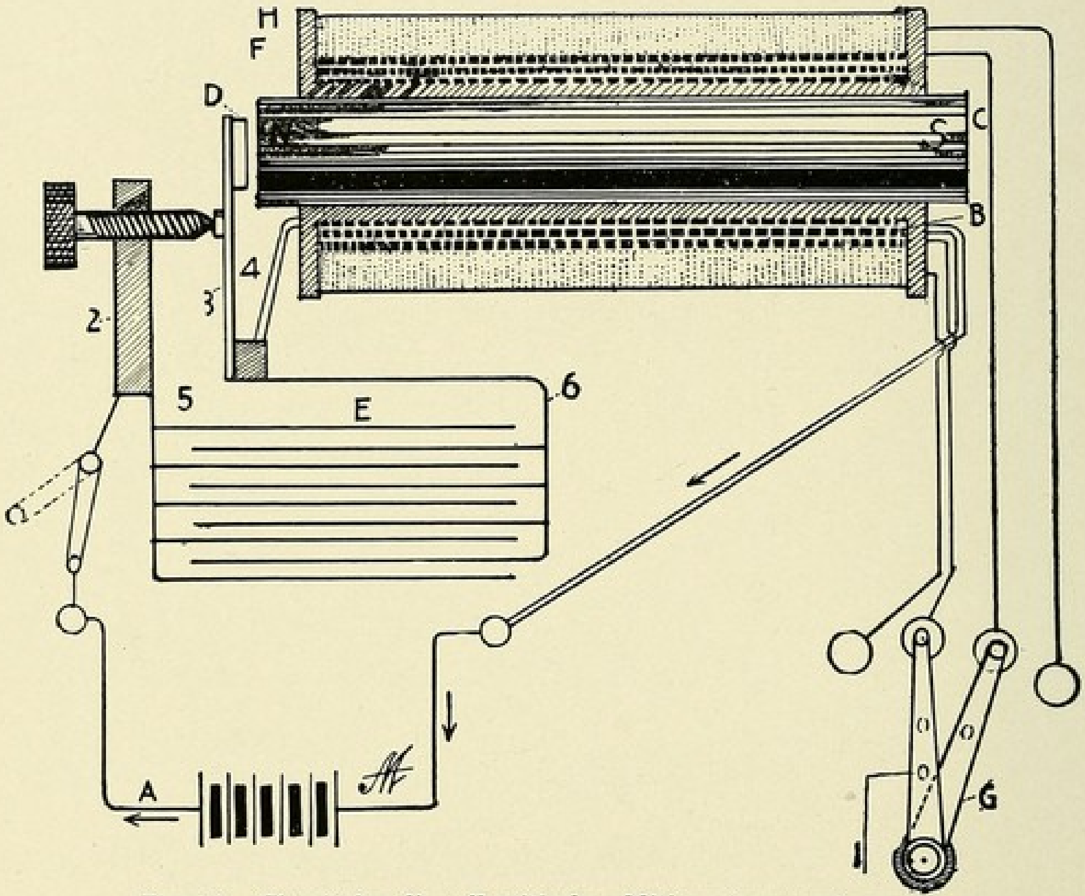


Fig. 14.—Simple faradic coil, with the addition of a secondary coil.

Fig. 14 is a reproduction of the coil in Fig. 12, with the addition of two secondary coils *F* and *H*. The various lengths of this coil are controlled by the selective switch *G*. The necessity for the different lengths of the secondary becomes obvious when it is understood that in the action of the coil each additional coil of wire increases the voltage of the secondary current. By constructing a secondary, so that several different lengths of wire may be used, the particular tension necessary in a given case may be selected at will. The physiological effects of these coils differ widely. The longer the wire, the higher the tension and the more marked the sedative effect, while the current from the short thick wire of the primary coil is stimulating and nutritional. This subject will be discussed at length under therapeutics of the faradic coil.

CHAPTER IV.

ELECTROSTATICS.

Thus far electricity in motion, or electric currents, has been considered. In this chapter will be presented the earliest electric phenomenon known to man—**static electricity.** History tells us that Thales, a Greek philosopher, about 2,600 years ago discovered that pieces of polished amber, when rubbed with articles of clothing, could be made to attract light objects. The ancients made no farther electrical discoveries for more than one thousand years. About 1600, Gilbert, physician to Queen Elizabeth, discovered that many other substances could be given the same property when rubbed in the same manner as the amber. The evolution of the science of electricity through those early periods of superstition and fanaticism reads like a fairy story.

Benjamin Franklin brought the first static machine to this country. His ideas, though wrong in part, were right in the main, and were far in advance of his day. With a kite he proved that static charges could be drawn from the clouds, and that these charges were the same as those artificially produced by his static machine.

The word **static** means stationary, or at rest. Static electricity, strictly speaking, would be worthless as a therapeutic agent. To go into a thorough discussion of electrostatics would require a larger volume than this.

Static induction and magnetomotive force are very closely related, if, in fact, they are not one and the same thing. By rubbing a glass or ebonite rod with a piece of silk, flannel, or cat's fur, and holding it near an electroscope, as shown in Fig. 15, the leaves will close, or converge, owing to the difference of the charge on the electroscope and the rod. The same test is made by bringing the same rod near a suspended pith ball, as shown in Fig. 16. The ball will swing toward the rod as soon as it comes within its field of influence. This influence, when acting across an air gap, is called electrostatic induction.

Friction between two substances produces heat and a consequent disturbance of the electrons. While in this heated state one of the substances takes on a preponderance of electrons and becomes negative, while the other gives up a part of its normal elec-

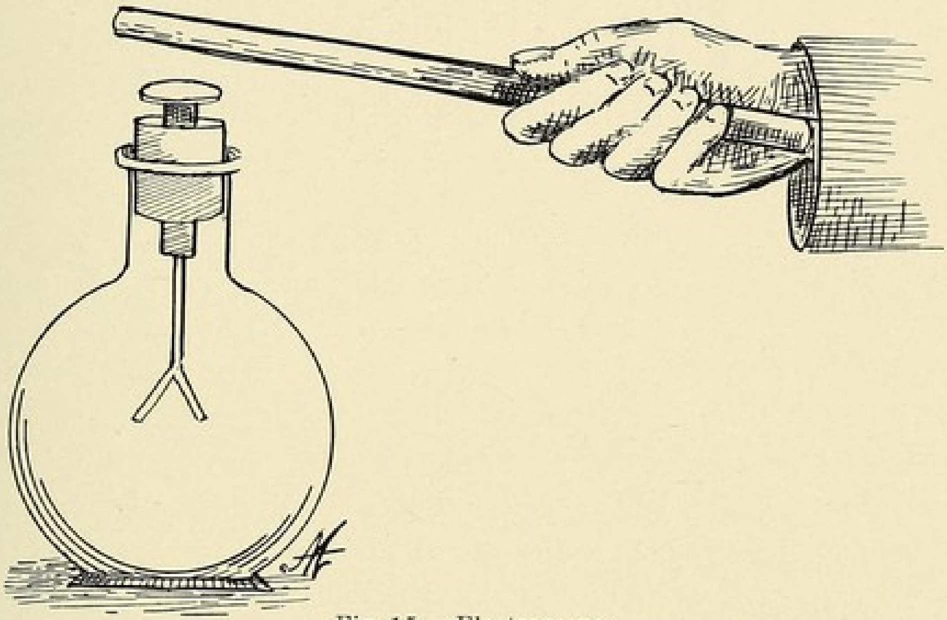


Fig. 15.—Electroscope.

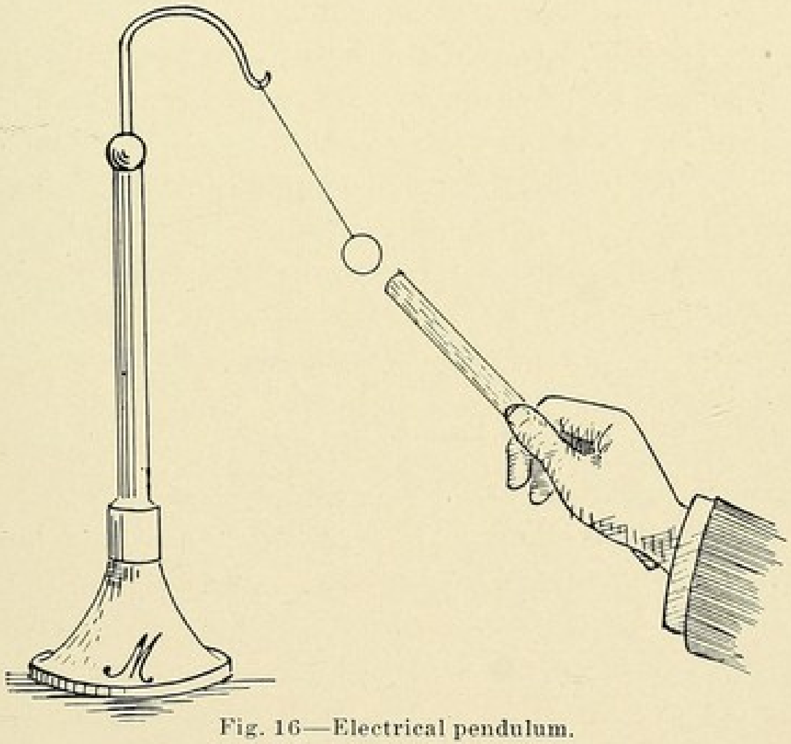


Fig. 16—Electrical pendulum.

trons and becomes positive. The gold leaf electroscope may be used to determine the charges. The electroscope is given a known charge by touching its disk with a charged body. If a glass rod is rubbed with a piece of silk, it becomes positively charged. If the disk of the electroscope is touched with this rod, the gold leaves will become positively charged and will repel each other. The distance that the leaves are separated will depend upon the strength of the charge.

The electroscope is now ready for use. If a positively charged body is brought near the disk of the electroscope, the leaves will diverge still further, while, if the body is negatively charged, the leaves will come together. This influence takes place through the air (ether), and is called induction. A thorough understanding of this influence will enable one to grasp the principles involved in the static machine.

CHARGING A BODY BY INDUCTION.

By rubbing an ebonite rod, it is given a specific charge. By the influence of the charged rod through a certain air space, it is possible to give an insulated brass ball an opposite charge. The experiment is conducted as shown in Fig. 17. The brass ball is

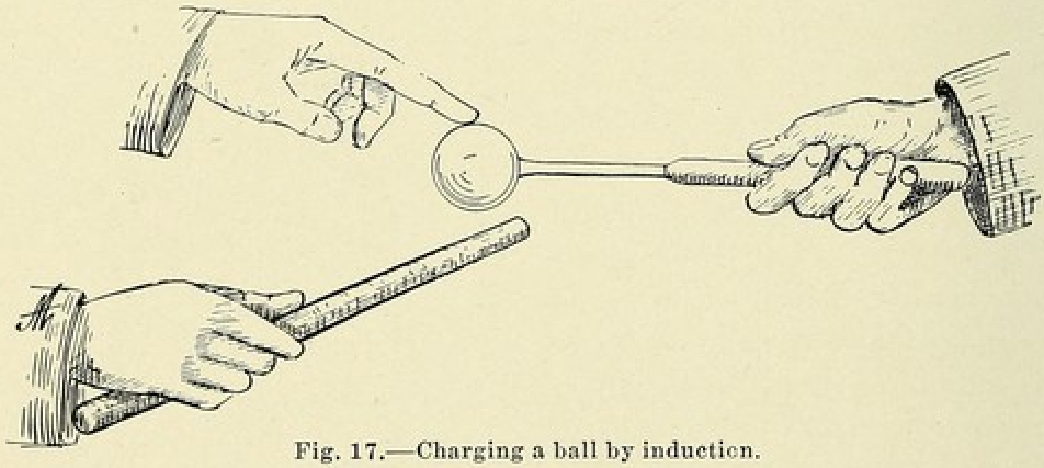


Fig. 17.—Charging a ball by induction.

neutral to start with. The charged ebonite rod is held a short distance below the ball, and at the same time the operator slightly touches the ball on the upper side with his finger. If the rod is negatively charged, it will drive the electrons, or a considerable portion of them, to the upper side of the ball, and at the instant it is touched with the finger they are by repulsion and attraction carried away to the operator's body, and the ball left with a positive charge. If, however, the rod is positive, the electrons will be attracted to the side next to the rod, and when the upper side of the ball is touched with the finger more electrons pass from the operator's body into the ball, giving it a negative charge.

Electrostatic charges remain only on the outside of the conductor. If a deep metal cup is heavily charged on the outside, and an insulated brass ball is placed on the inside of the cup and allowed to touch the sides, no charges will be imparted to the ball, as evidenced by the electroscope; but if the same ball be brought in contact with the outside of the cup and brought near the electroscope, the ball will be found to be charged.

DENSITY OF CHARGE ON DIFFERENT SURFACES.

It is a known fact that spheres retain static charges better than points or angles. Bring a charged ball near enough to the electroscope to affect it; now hold an insulated needle against the ball, pointing it toward the disk of the electroscope, and it will be found that the electroscope will be affected through a longer distance than when no needle is used.

CONDENSERS.

The simplest form of electrical condenser is the Leyden jar. This consists of a glass jar (Fig. 18), coated on the inner and outer side to a certain height with tin-foil. The inside coating is connected to a metallic rod that passes through the cork and terminates in a ball about three inches above the cork. Such a jar may be charged by grounding the outside coating and connecting the ball and inner coating to the prime conductor of an active static machine. If the jar is removed and the outside and inside coatings are brought near together by means of a wire or discharge rod, a series of sparks will pass between the discharge wire and the ball.

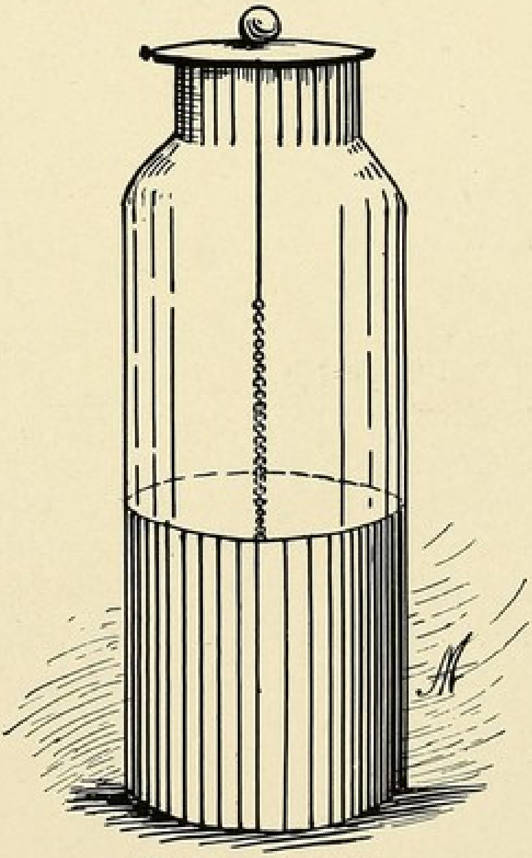


Fig. 18.—Leyden jar.

ELECTRICAL GENERATORS.

Electrophorus.—This simple form of electric generator (Fig. 19) will well illustrate the principles underlying the action of the static machine. It will be seen that the process is one of both friction and induction. *A* is either a hard rubber plate, or a disk made of resin and shellac and well rubbed with fur or flannel. *B* is a metal plate with an insulated handle. When *B* is placed in contact with *A* and the upper surface touched with the finger and

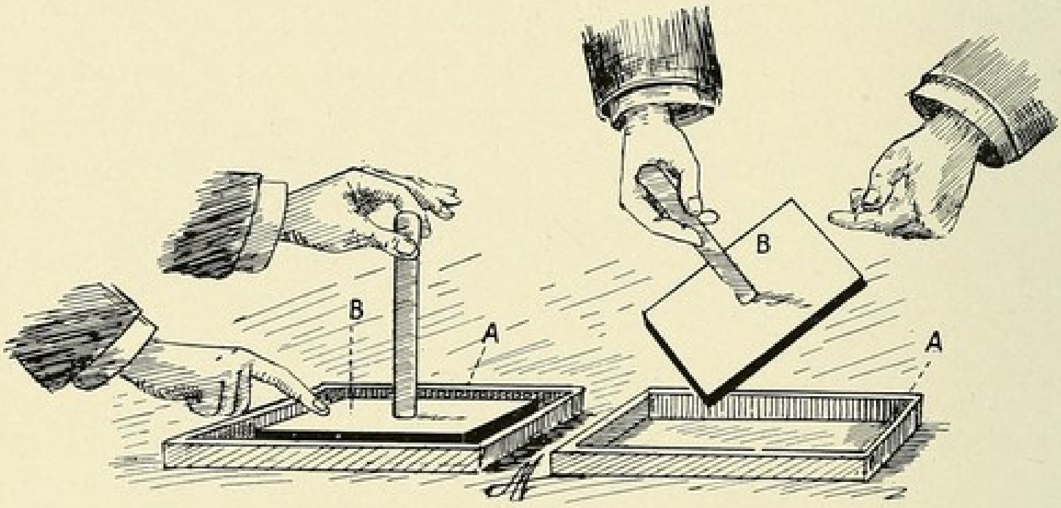


Fig. 19.—Electrophorus.

removed, *B* will be found to be charged, and, if the weather is dry, a short spark may be drawn from it. *B* may be charged in the same manner any number of times without in any way weakening the charge on *A*. By the electroscope the charges on *A* and *B* are found to be opposite. This proves that *B* has been charged by induction and not by contact, for, if such were the case, the charges on *A* and *B* would be the same.

Static Machine.—If the lesson in induction has been understood, the operation of the static machine will not be difficult to comprehend. The static machine is nothing more than a continuously charging and discharging electrophorus. The current from a static machine is unidirectional and continuous, having a high voltage and low amperage. There are three types of the static machine in general use: the Toepler, or friction machine; Holtz, or induction machine; and the compound, or a combination of the friction and induction types, called the Toepler-Holtz.

For demonstrating purposes a two-plate Toepler machine (Fig. 20) will be used. The machine consists of one stationary and one revolving plate, and what is true of two plates is true of many more, arranged in series. The average static machine has from eight

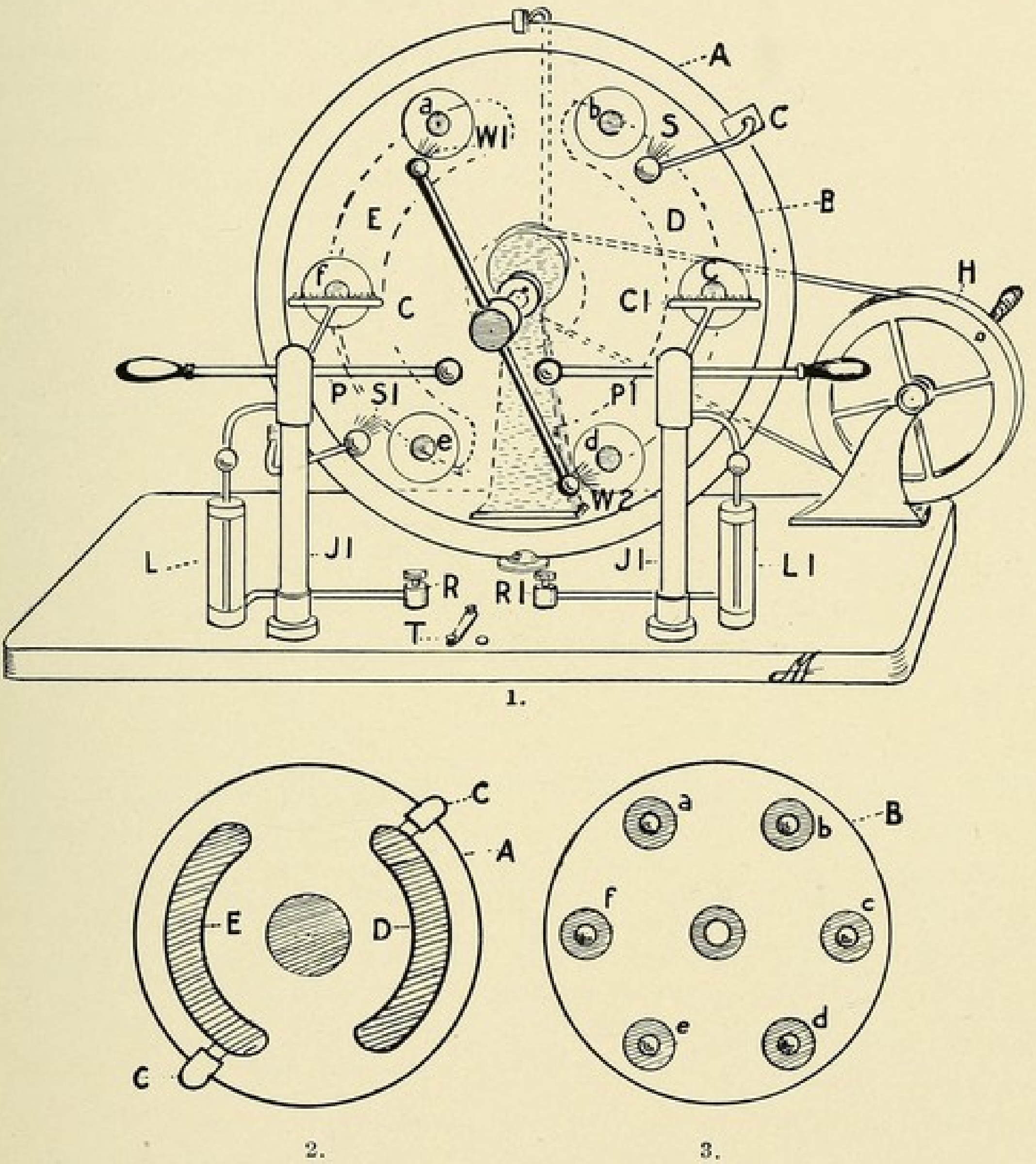


Fig. 20.—Elements of the static machine. 1, static machine; 2, back of stationary plate A; 3, front of revolving plate B.

to twelve revolving plates and as many stationary plates. Very few men who may be using the static machine continuously have a clear understanding of what takes place in the machine when it is in action. It will be noted that A (1) is the larger and is the stationary plate, while B (1) is the revolving plate, and should be placed as close to *A* as possible without touching it. On the back of *A*, as indicated by *D* and *E* (2), are glued two paper segments, called sectors or field plates. On the back of the stationary plate *A* is bolted a piece of metal *C*, which is connected by means of a narrow piece of tin-foil with a similar strip of tin-foil running lengthwise through the middle of the paper sectors *D* and *E* (2). To each piece of metal *C* just described is fastened a rod bent so as to come in front of the revolving plate and support a metallic brush *S* and *S1*. Placed at right angles to these rods is an arm extending across the plate, and supporting a brush on either end, *W1* and *W2*. On the front of the revolving plate *B* are fastened six metallic disks, *a, b, c, d, e, f* (3), equal distance apart, called carriers. The insulated posts *J* and *J1* support two brass combs *C* and *C1*, which are fixed about ¼ inch in front of the disks on the revolving plate. Through the tops of the posts *J* and *J1* pass two sliding rods *P* and *P1*, called the prime conductors. In metallic contact with the prime conductors and the collecting combs *C* and *C1* are the Leyden jars *L* and *L1*, the outer coats of which are connected to the binding posts *R* and *R1*. Switch *T* may be used to connect the outer coatings of the jars. *H* is a cranked pulley for operating the machine.

METHOD OF GENERATING A STATIC CURRENT.

The sectors or field plates are nonconductors, and will temporarily hold a static charge. When plate *B* is made to revolve rapidly, friction is produced between the carriers *a, b, c, d, e, f,* and the brushes *S* and *S1*. When carrier *a* reaches brush *S*, it gives off a few electrons to the field plate or paper sector, making it more negative, leaving the carrier with a positive charge until it reaches the neutralizing brush *W1*, where the positive charge is neutralized by the electrons from the other end of the rod *W2* and carrier *d*. Carrier *a* now goes on as a neutral body under the influence of the positive paper sector *E*, which binds the electrons on the back of the carrier, leaving the front positively charged. When carrier *a* comes under collecting comb *C*, a few electrons jump from the comb to *a* as it rushes on to brush *S1*, where it receives more electrons from the field plate *E* by conduction and is neutralized at *W2*. Carrier *a* is now under the inductive influence of the negative sector *D*, which repels the negative charges on the carrier. When *a* reaches the collecting comb *C1,* some of the electrons on *a* are forced off on the comb, and *a* continues on to *S,* where a quantity of electrons again enter the field plate *E,* and the carrier *a* goes on as a positively charged body until the neutralizing brush *W1* is again reached. Each carrier with each revolution repeats what *a* is described to have done, and will continue as long as the plate is rotated. As the negative charge accumulates on *C1* and *P1,* and the negative charge is withdrawn from *C* and *P,* there is a strong attraction between *P1* and *P,* and as soon as the potential is sufficiently high on *P1* it will seek to bridge across the air gap between *P1* and *P* in the form of a spark. By closing the air space between *R* and *R1* and charging the Leyden jars, the spark may be made to bridge across a much wider space, the Leyden jars acting as storage batteries. It has been stated that all static machines are primarily friction machines. When the field plates have once been charged, the action is purely inductive. All Holtz machines have a small friction machine in one end of the case to charge the field plates when they lose their charge, which they often do in damp weather. The Toepler-Holtz is self-exciting, and when well made is an excellent type of machine. All non-conductors must be perfectly dry in order to hold a static charge. If the field plates become damp, they will not hold their charge and the machine refuses to work. Moisture is the great enemy to the static machine, and there is no type exempt. There is not a machine on the market but that will cause trouble in damp, warm weather unless properly handled. Many methods have been recommended to keep the inside of the case and plates dry, and all have their disadvantages. After thoroughly trying fused calcium chlorid, lime, C. P. sulphuric acid, and caustic potash, the author has come to the conclusion that potash is least injurious to the working parts of the machine, and as a hygroscopic agent it is far superior to any other. It is cheap, easy to handle, and should be tried by all users of static machines. If used in the following manner, it will never disappoint the most exacting:

Procure four or six one-pint glass bowls, and after drying thoroughly dip the top about 1 inch into melted paraffin; when the paraffin has become hard put half a can of pure potash into each bowl, and quickly place one in each corner of the machine; close the door and let the machine alone for three or four hours, when it will be found to be dry and ready for use. As soon as the potash liquefies, which may require several months, depending on the time of the year and the closeness of the case, it should be removed.

When a static machine is working well, never open the doors for any purpose whatever. Most of our American firms make good static machines, but every machine should be thoroughly tested before it is accepted. The case should be as nearly air-tight as possible. There seems to be no ground for the statement that a machine should be frequently opened up and aired. The author never opens his machine for any purpose except to change the potash, which is not oftener than once in six months, and it is always in perfect order. The outside parts of a static machine should be kept free from dust and the metal parts carefully polished. Where the case is allowed to become very dusty, much of the current in damp weather will be conducted away, and it will be a difficult matter to get a sufficient current from the prime conductors.

STATIC MODALITIES.

This is not the place for a detailed outline of the proper static technic to be employed in the treatment of the many diseases amenable to static influence, and the therapeutic indications will be thoroughly discussed in another chapter.

To prevent a repetition, the seven static modalities in common use will be presented and studied in the following manner:

(1) General electrification or charge.
(2) Spray or breeze.
(3) Indirect sparks.
(4) Direct sparks.
(5) Static induced current.
(6) Potential alternation.
(7) Morton wave current.

(1) **General Electrification or Charge.**—This modality consists of the simplest method of electrifying the patient either negatively or positively. Fig. 21 is a diagrammatic illustration of the method of insulating the patient and placing him in the static circuit. The prime conductors of the machine are represented by *B* and *A*, which are respectively negatively and positively charged, as indicated by the plus and minus signs. *P* is the static platform, supported by glass legs *L* for the purpose of insulation. *M* represents the patient seated on the platform and connected by means

of the metallic rod (shepherd's crook) *R* to the positive prime conductor. The other prime conductor is grounded by means of a wire or chain *C* connected to the gas or water pipe. When the patient is connected to the negative prime conductor, he is made negative by having electrons forced into his body, but, when connected to the positive prime conductor, he is made positive by having electrons extracted or withdrawn from his body. The patient takes the position of the inside coating of a Leyden jar, the walls of the room are the outer coating, and the air is the dialectric. If the air were a perfect dialectric, the patient, when connected to the negative prime conductor, would become thoroughly charged,

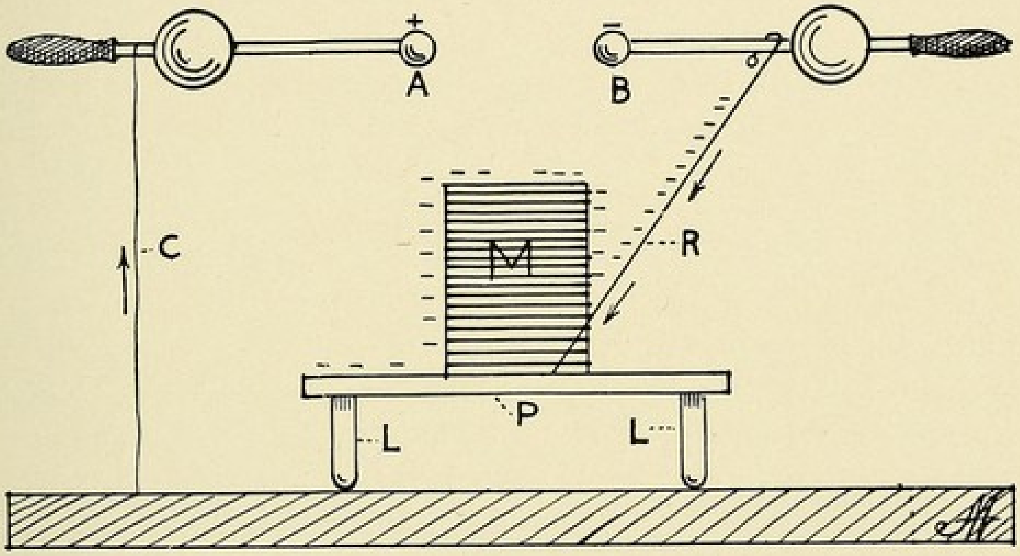


Fig. 21.—Method for static insulation.

and no more current (electrons) could be carried to him; while, on the other hand, if he were connected to the positive prime conductor, the electrons would be taken from him until a point is reached where no more could be made to pass. Since the air is not a perfect insulator, the electrons will leak off or onto the patient in either case, and the current is continuous. When giving this modality, it is noticed that the hair stands on end, and, if the patient presents his hand toward another person, a hissing sound will be heard, caused by the passing of electrons to or from the patient. Because of this leakage a constant current is kept up through the patient's body during the treatment.

(2) **Spray or Breeze.**—This modality is simply an increased or concentrated leaking at some desired point arranged by the opera-

tor. Fig. 22 illustrates the arrangement of the machine, patient, and electrode. The breeze or spray is always negative, and, when the patient is connected with the negative side of the machine, the electrons pass from the patient through the air space to the electrode *E* and on through wire *d* to the ground. When the patient *M* is connected to the positive side of the machine, the electrons will flow through the ground wire *d* to the electrode *E* and across the air space to the patient *M*. The patient *M* may be made negative or positive, but the current itself is always negative. The **electron theory** teaches that an atom is made negative by adding more than the normal amount of electrons to it, while it is made positive by taking from it a number of its normal electrons. If

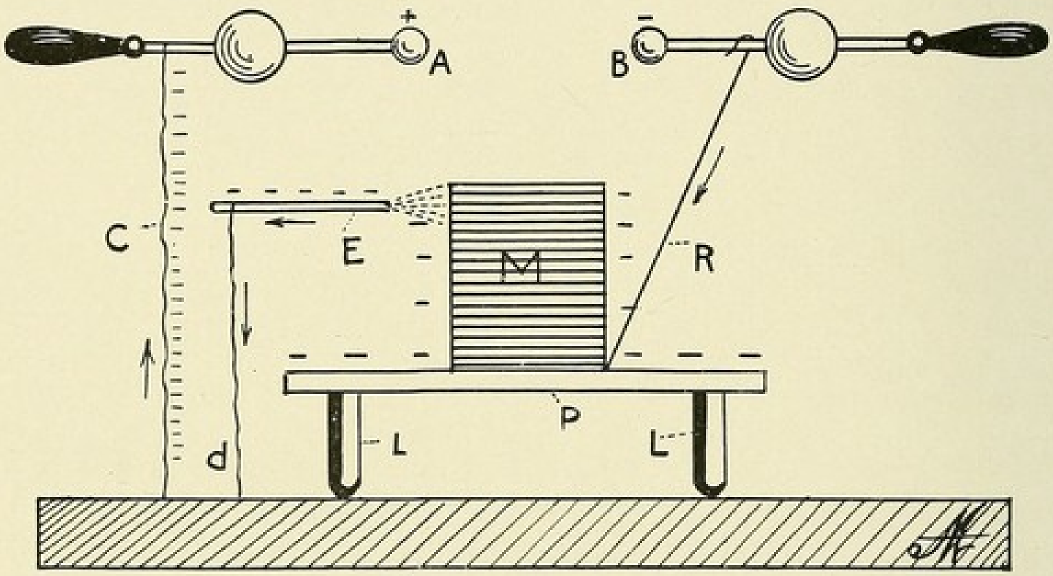


Fig. 22.—Method of arrangement for the static spray. Patient negative.

this is true of an atom, it must be true of a group of atoms, or molecules or groups of molecules, or mass, no matter how great.

Fig. 23 shows the patient connected to the positive side of the machine, and he becomes positive by having the electrons withdrawn from him by the action of the machine in making the prime conductor positive, and, since it is in metallic contact with the patient *M*, he will be made positive by conduction. In either case the patient *M* must be insulated by placing him on a platform *P*.

(3) **Indirect Sparks.**—The arrangement for the indirect spark is the same as for the static spray, with the exception that in the indirect spark the electrode is a ball instead of a point. Figs. 24

and 25 show the arrangement of the machine, electrode, and patient for the indirect static spark, negative and positive. A good-sized spark will pass between the patient *M* and the electrode *E*. Like

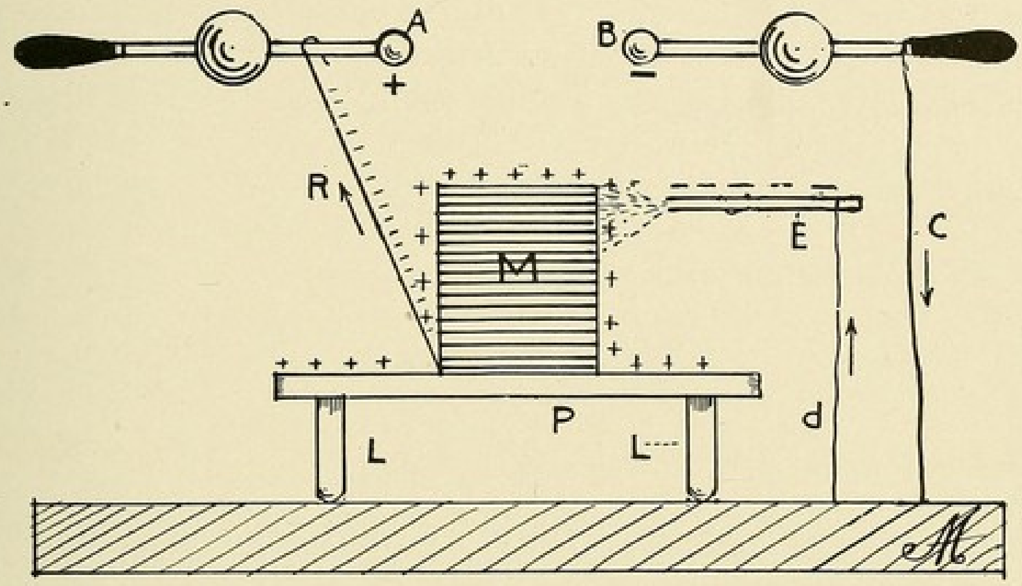


Fig. 23.—Arrangement for the static spray. Patient positive.

the spray, the spark or current is always negative. It leaves the patient *M* for the electrode when the patient is negative and leaves the electrode for the patient when the patient is positive. The elec-

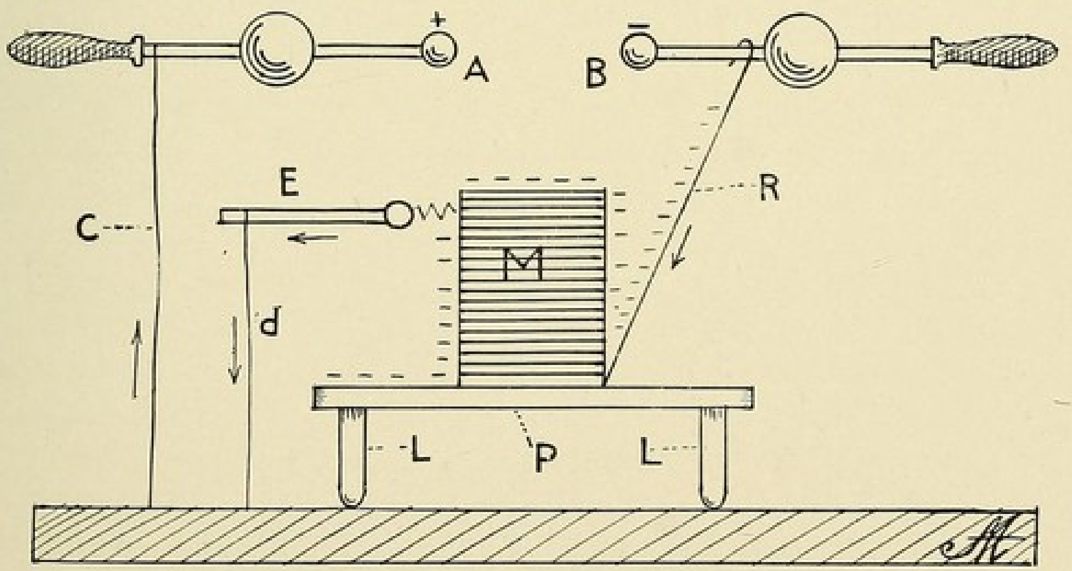


Fig. 24.—Arrangement for the indirect static spark. Patient negative.

trode is grounded, as in static sprays. One can not speak of a negative and positive spark any more than a negative and positive breeze. The size and strength of the spark is determined by the speed of the machine and the size of the ball on the end of the electrode. This is an active, energetic current, and is used to great advantage in the treatment of some of the most intractable cases of rheumatism, etc. This modality requires considerable skill in order to produce the best results. The electrode should be handled quickly and regularly, allowing only a single spark to pass between the elec-

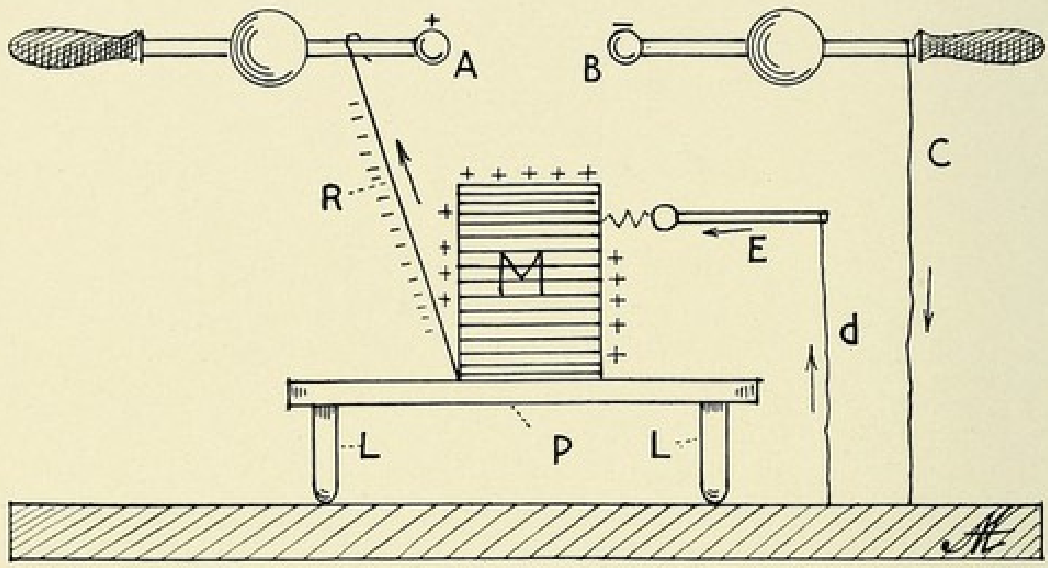


Fig. 25.—Arrangement for the indirect static spark. Patient positive.

trode and the patient at each motion of the electrode. The large fat sparks are, as a rule, not painful, though most timid patients are at first frightened by them. By operating the machine quite slowly, beginning with a small electrode, the size of the electrode may be increased as well as the speed of the machine until the patient is brought to bear the strongest sparks without protest.

(4) **Direct Sparks.**—In giving the direct spark, neither the electrode nor the prime conductor is grounded. In this modality the patient may be made either negative or positive, as in the foregoing methods.

In Fig. 26, 1 and 2 illustrate the arrangement of the static machine and patient for the direct static spark. The patient may be connected with either side of the machine, as before stated, the same laws holding good in either case. This modality is thought to furnish a more vigorous spark, but the author is unable to see any advantage over the indirect spark method; in fact, he uses the indirect spark exclusively and finds no need for the direct method. The Leyden jars are seldom used when giving any of the modalities mentioned. Should the machine not be working well and the current very weak, the Leyden jars may be used to strengthen the current.

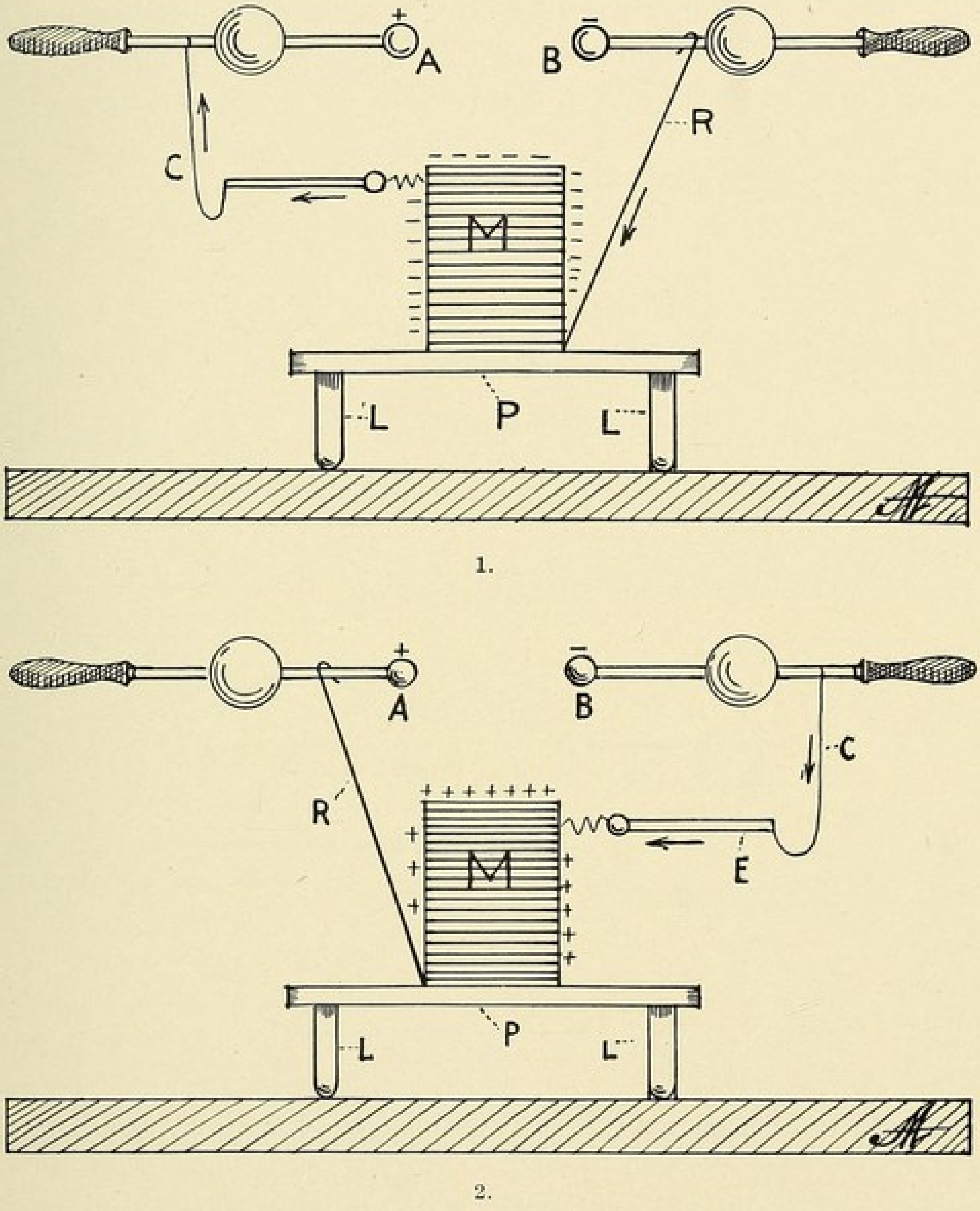


Fig. 26.—Arrangement for the direct static spark. 1, patient negative; 2, patient positive.

(5) **Static Induced Current.**—This current was first described by Doctor W. J. Morton in 1880. The prime conductors are connected with the inside coating of the Leyden jars and the patient with the outside coatings by means of two conducting cords and

electrodes. Fig. 27 represents this arrangement. *A* and *B* are the prime conductors, *L1* and *L2* are the Leyden jars, *E1* and *E2* are the binding posts connected to the outside coatings of the jars, *G1* and *G2* are the conducting cords, *H1* and *H2* are the electrodes, and *M* is the patient. It is not necessary to place the patient on the insulated platform. When the machine is started, electrons flow from the negative prime conductor *B* into Leyden jar *L2,* making it strongly negative. Electrons are forced away from the outside coating of this jar through conducting cord *G2* and electrode *H2* to the patient *M.* The electrons leave the patient through electrode *H1,* conductor *G1,* and binding post *E1,*

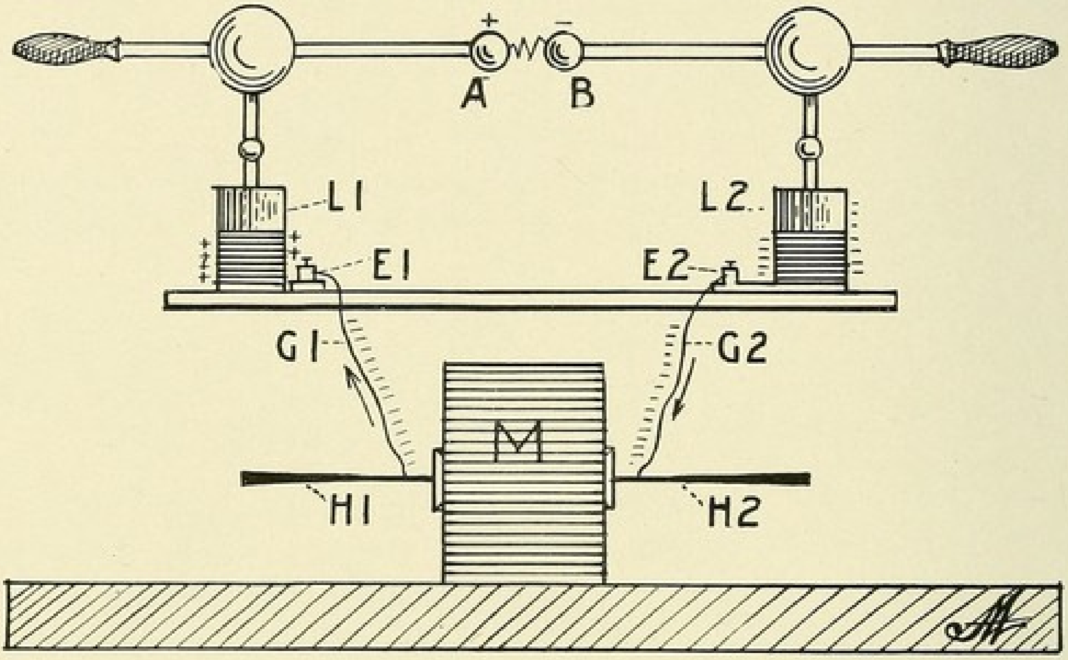


Fig. 27.—Static induced current.

and to the outside coating of Leyden jar *L1,* making it strongly negative. The action of the static machine, already explained, takes the electrons from the prime conductor *A* and the inside coating of Leyden jar *L1,* making them strongly positive. The strength of this current is controlled by the speed of the revolving plates and size of the Leyden jars. This current is oscillating in character, playing backward and forward through the patient between the outer coatings of the Leyden jars. When a spark jumps across the air gap from *B* to *A,* the positive charge on *A* is momentarily neutralized by an addition of negative charges and a like momentarily weakening of the negative charges on *B.* The increase of the negative charges on *A* increases the negative charge on the inside coat of Leyden jar *L1*, while the discharge of *B* weakens the negative charges on the inside coating of Leyden jar *L2*. At this instant the electrons that have collected in considerable numbers on the outside coating of Leyden jar *L1* will return through the conducting cord *G1*, electrode *H1*, the patient *M*, electrode *H2*, conducting cord *G2*, and back to the outside coating of Leyden jar *L2*, to be forced away again as soon as the jar *L2* has its inner coating negatively charged. The whole process takes only the smallest possible fraction of a second, and because of its rapid change in direction the current is a truly interrupted current, simulating closely the faradic current and used mainly for the same class of cases. It is claimed that the oscillations in the current are from 200,000 to 300,000 per second.

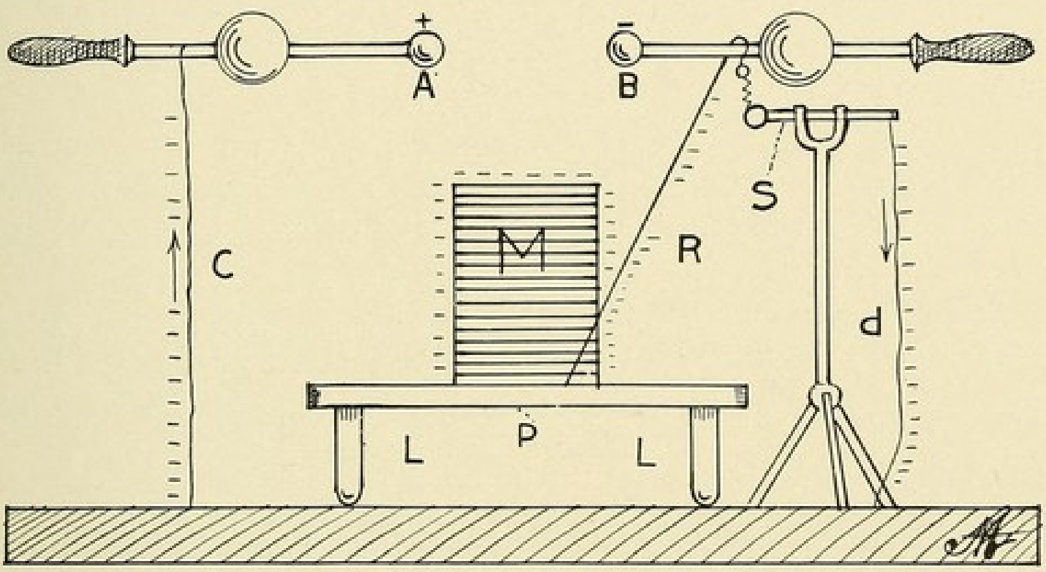


Fig. 28.—Arrangement for potential alternation. Patient negative.

(6) **Potential Alternation.**—This particular arrangement of static machine, patient, and electrode was first suggested by Doctor S. H. Monell in 1893. It differs very little from the Morton wave current, to be described, and has no advantage over it in the treatment of any case. It is seldom used, but is here described because sometimes spoken of in papers and text-books.

Fig. 28 shows the arrangement of static machine, electrode, and patient to produce the effect known as potential alternation. It differs mainly from the Morton wave in the spark gap, which, instead of being between the prime conductors, is between the stationary electrode and the ball on the shepherd's crook on the prime conductor *B*. In this arrangement the overcharge on the patient *M* overflows to the stationary electrode *S* and on to the ground through conducting wire *d*. This condition is true when the patient is connected to the negative side of the machine. When the patient is connected to the positive side of the machine, the condition is reversed, and, in place of the current overflowing to the stationary electrode, it flows from the stationary electrode from the ground to the patient *M* and the prime conductor *B*. It will be noticed that the opposite prime conductor is grounded.

(7) **Morton Wave Current.**—This current was suggested by W. J. Morton, M. D., in 1899, and produces the same effect as, and is

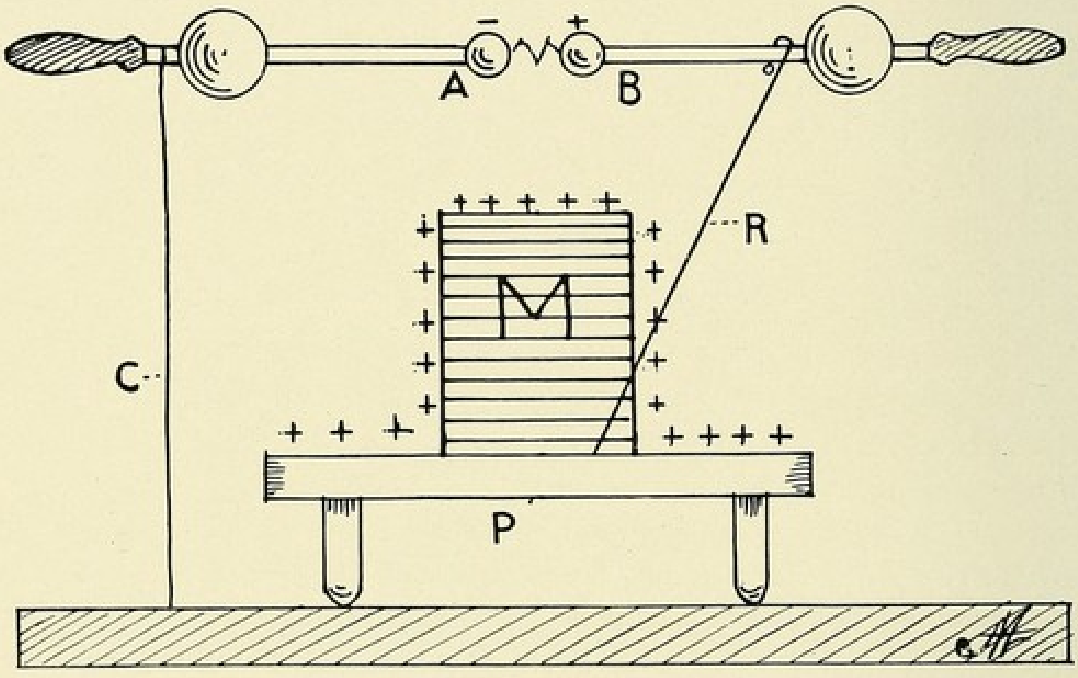


Fig. 29.—Arrangement for Morton wave. Patient positive.

much simpler than, the potential alternation of Monell. Fig. 29 illustrates the static connections for this current, which, it will be noticed, is the same as the arrangement for the general electrification, the difference being in bringing the prime conductors near enough together to allow a spark to pass between them. This oscillating action between the prime conductors causes a surging effect in the patient, which is quite marked. This is probably the most valuable of all the static modalities, and will be used more often than any other. It may be applied to the whole body or to any particular part. When given to the whole body, the patient *M* is seated on the insulated platform *P*, with shoes off and feet on a piece of sheet copper or zinc. One of the prime conductors is connected by means of the shepherd's crook *R* to the metal plate (12 by 14 inches) on the platform. The machine is started with the prime conductors close together, which should afterward be gradually separated as the patient's tolerance increases. When applying this modality to any particular part of the body, a piece of block tin or tin-foil may be used to cover or surround the part in question, and this connected to the prime conductor by means of a chain or wire. These metal electrodes must be in close contact with the skin to prevent sparking and burning. When small electrodes are used, weak currents and short spark gaps are employed. Swollen joints may be wrapped in tin-foil and treated in the same way. The therapeutic application of this current will be explained in another chapter.

High-Frequency Currents.—The frequency of electric currents is probably less understood than any other term used in electro-therapeutics. All currents are not high-frequency currents, and the therapeutic effects produced by low- and high-frequency currents differ widely. When speaking of frequency in currents, we mean the number of cycles that an alternating current will make in a second. Currents of low frequency may be very painful, while high-frequency currents may be sent through the body with only a mild sensation. This is explained by the fact that the sensory nerves are unable to respond to the rapid oscillations of the current. Currents of high frequency may be comfortably borne, while currents of low frequency of the same quantity would be serious. The senses do not seem to perceive the effects of high-frequency currents and they appear harmless.

PRODUCTION OF HIGH-FREQUENCY CURRENTS.

High-frequency currents may be obtained either from the static machine or coil. In either case a pair of Leyden jars are connected with the prime conductors, while the outer coatings of the jars are connected to the solenoid. The static machine may be used for low-frequency modalities as well as high. For high-frequency modalities the coil will be found far superior to the static machine.

Fig. 30 is a diagrammatic illustration of an induction coil, Leyden jars, and high-frequency solenoid. *I* represents the coil; *a* and *b* are the battery or feed wires from the mains going to the primary of the coil; *c* and *d* are the supports for the prime conductors *e* and *f*, and are also connected to the terminals of the secondary coil *I* and the wires *g* and *h*, going to the inside coatings of the Leyden jars *A* and *B*; *C* is the spark gap between the prime conductors *e* and *f*. The solenoid *H* is a coil of thick wire, the terminals of which are connected to the outside coatings of the Leyden jars at *i* and *j*. The reader is here referred to what has been said about the action of the Leyden jars under Static Induction (page 58).

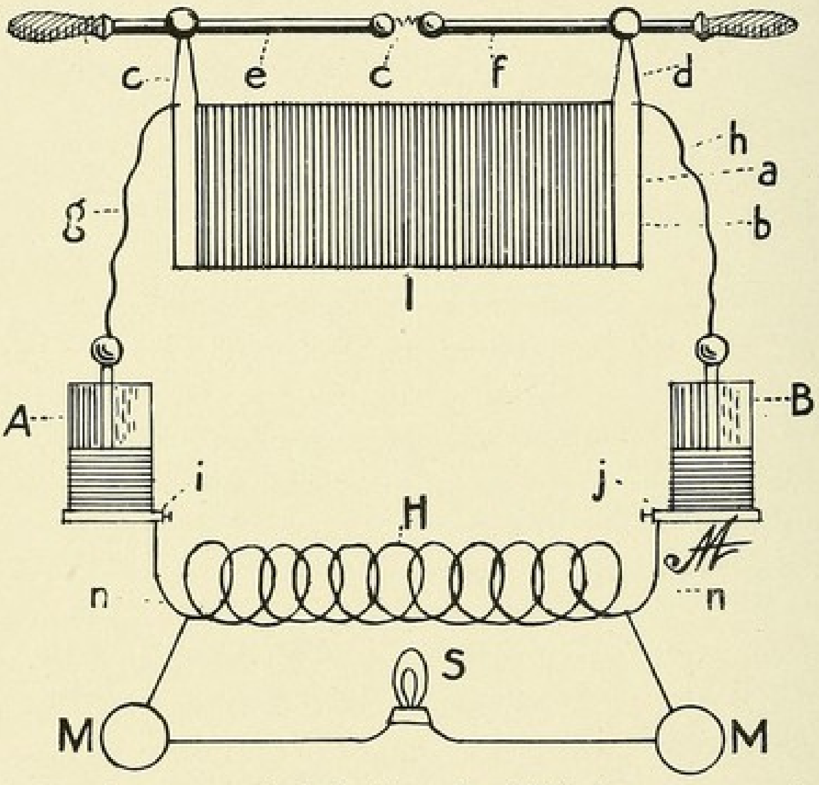


Fig. 30.—Arrangement for induction coil and high-frequency resonator.

Fig. 30 illustrates the D'Arsonval-Hertz apparatus. The solenoid *H* is made up of a number of turns of heavy copper wire, the number of which depends upon the capacity of the Leyden jars. When a spark bridges across the air gap between the prime conductors at *C*, an electric resonance takes place between the jars *A* and *B* and coil *H*. This resonance is the result of several thousand oscillations per second through the coil from jar to jar, producing what is known as a high-frequency current.

If two persons *M* and *M* are connected by wire to the terminals of coil H at *n* and *n*, and then connected by means of a wire supporting a light bulb S, the filament will glow to full incandescence, while the persons so connected will feel no sensation whatever. High-frequency currents carrying 15 amperes have been passed through the human body without doing the least harm. The frequency of these currents is from 500,000 to 1,000,000 per second. If the frequency of such currents were reduced to 50 or 100 per second, death would probably follow every application to the human body. This is explained by supposing that the frequencies are so high and pass with such rapidity that the tissues are not affected thereby. The D'Arsonval apparatus, as illustrated in Fig. 30, delivers a current of high frequency, large amperage, and relatively low voltage, and the therapeutic effects are general rather than local. Tesla devised an apparatus that produces a current of high frequency and high potential (high voltage). His therapeutic results were so brilliant that it soon took the place of all other high-frequency apparatus, and is given to us to-day in what is known as the Oudin resonator (Fig. 31, which is a schematic drawing). The same letters are used here as in Fig. 31, which will help to greatly simplify it and make it easily understood. A and B are two good-sized Leyden jars placed on a shelf in a small table. The inside coatings of the jars are connected with two small spark rods or prime conductors e and f, which are connected to the terminals of a Ruhmkorff coil. T is a wooden drum, the lower end of which is wound with a number of turns of heavy copper wire H. The rest of the drum is wound with a small-sized copper wire; the lower end of the small wire is soldered to the upper end of the large wire and the upper end of the small wire is fastened to a binding post $N1$. The lower end of the heavy wire coil is connected to the outside coating of one of the Leyden jars and the outside coating of the other jar is connected by wire i to a movable shoe K. This shoe is so arranged that it can be raised or lowered, and in this way is made to come into metallic contact with either turn of the winding of the large coil H. By this method of increasing and decreasing the number of turns of the large coil in the circuit the resonance in the coil L can be perfectly controlled. When a wire conductor P is connected to the binding post $N1$ and to a vacuum electrode O, the electrode will fluoresce or glow in proportion to the number of large coils of wires in the circuit and the vacuum of the electrode. When this apparatus is operated in a dark room, a blue spray or effluve will be seen about the wind-

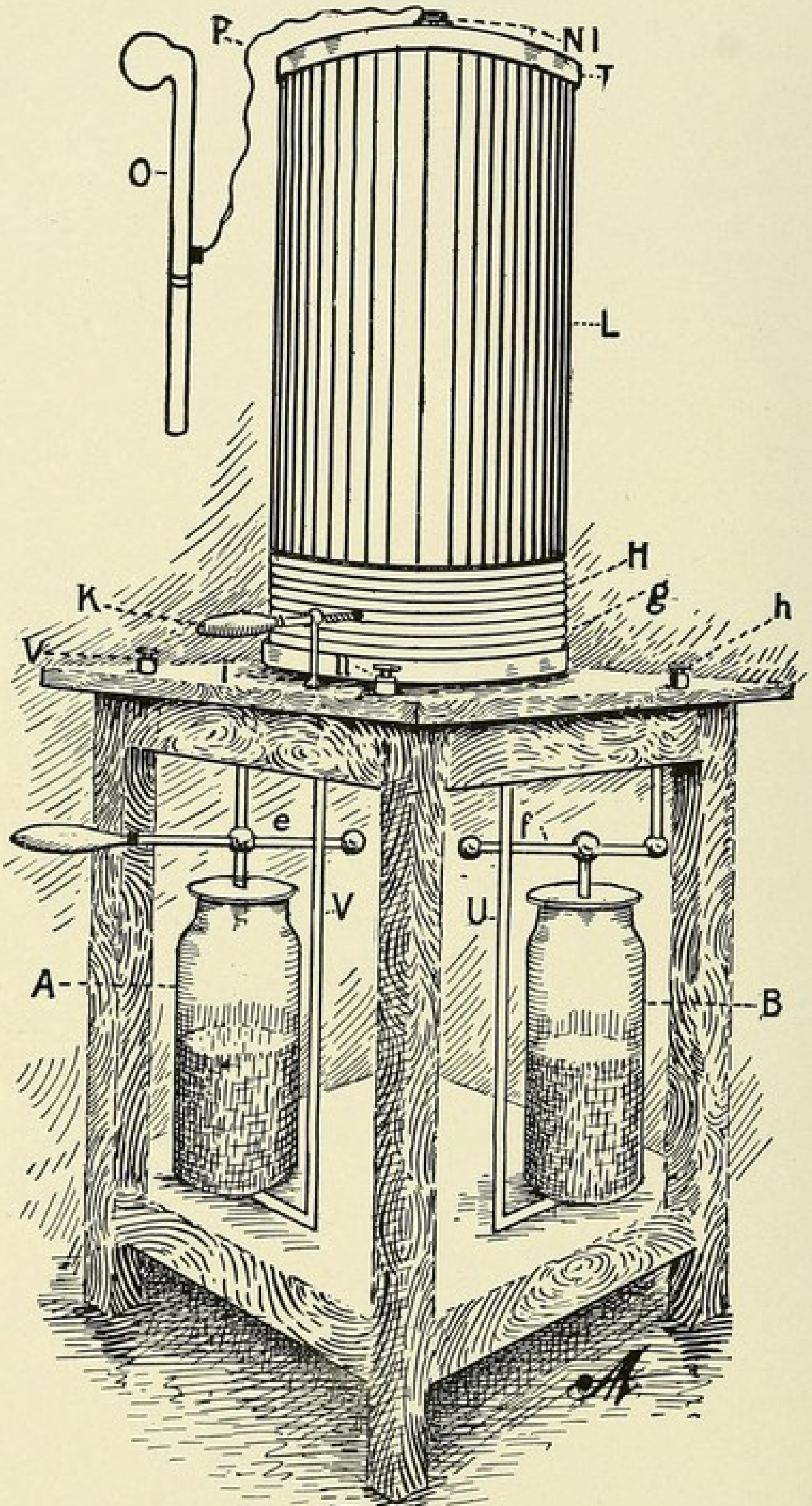


Fig. 31.—Oudin resonator.

ings of the coil *L,* and, if the hand or other objects are brought near the upper terminal of the coil, sprays or sparks will pass between the terminal and the object so presented.

High-frequency currents are used through a vacuum electrode directly to the surface of the body, or through an autocondensation couch or an autoconduction cage. Fig. 32 shows the arrangement for giving the autocondensation couch treatment. A heavy cushion of a good insulating material is placed upon a large zinc plate *A,* which is connected to binding post *U* in Fig. 31. When

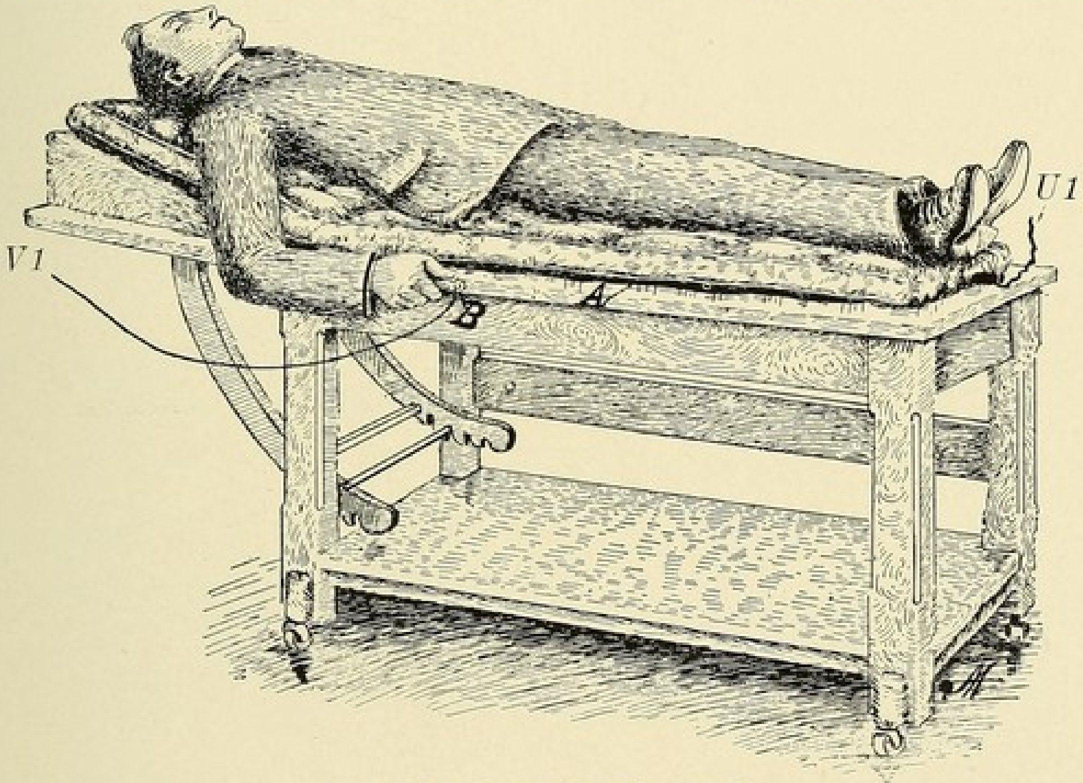
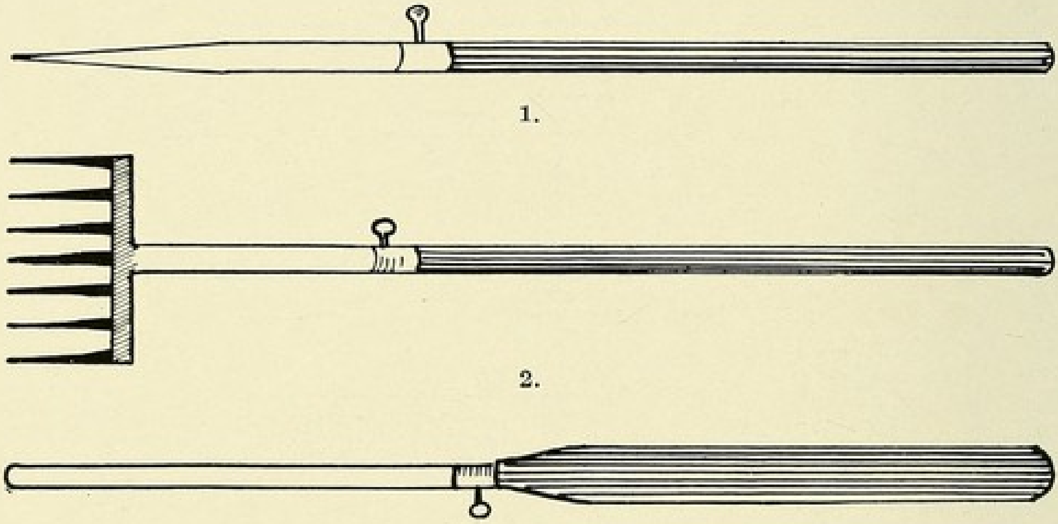


Fig. 32.—Autocondensation couch.

the patient is placed upon the cushion, he is told to grasp the metallic supports *B*, which are connected to binding post *V*. This arrangement produces the D'Arsonval current, as shown in Fig. 30. The current is regulated by the adjustable shoe *K* on *H* and the spark gap between *e* and *f*. *V* and *U* (Fig. 31) are connected by wire to *V1* and *U1* (Fig. 32). These two conductors connect the outside coatings of the Leyden jars *A* and *B* to the two ends of the heavy wire coil *H* on drum *T*. In using the autocondensation couch, care must be had that no sparks are allowed to pass between the patient and the metallic plate *A*. Should this occur, painful sensations will be produced. From the Oudin type resonator several high-frequency modalities may be obtained, and the effluve is taken from several kinds of electrodes. The single brass point, the multiple point, and the carbon point constitute the most important electrodes in general use, and Fig. 33 illustrates these electrodes. They are made with insulated handles, the same as regular static electrodes, and are connected by chain or wire conductor to *N1* in Fig. 31. They are not allowed to come in contact with the body, but are held at a distance of from 2 to 8 inches, allowing a series of very fine sprays to pass between the electrode and the parts treated. The operator should avoid bringing the electrode close enough to the patient to allow an arc to pass. Such an accident would burn and greatly frighten a nervous patient, and cause him to view the whole



1.

2.

3.

Fig. 33.—Metallic high-frequency electrodes. 1, single brass point; 2, multiple brass point; 3, carbon electrode.

matter with distrust. The machine should always be started with the electrode some distance from the patient, and it should be carefully brought closer and closer until a bluish fox-tail spray or effluve passes between the electrode and the part treated. Sparks may be obtained from the resonator by using a ball electrode and lengthening the gap between the spark rods *e* and *f* of the resonator. The sparks are seldom used from the resonator on account of the danger of arcing.

Hollow glass electrodes, exhausted to a low vacuum, are used universally for the administration of high-frequency currents to the surface and various cavities of the body. These electrodes are of two general varieties—plain and insulated. The plain electrodes, as shown in Fig. 34, are designed to fit the particular parts for which they are intended, and consist of a single wall of glass. The current enters the electrode from the metal thimble on the universal handle, and passes through its vacuum and into the patient throughout the contact of the electrode. The varieties in general use are: 1, body; 2, vaginal; 3, rectal; 4, laryngeal;

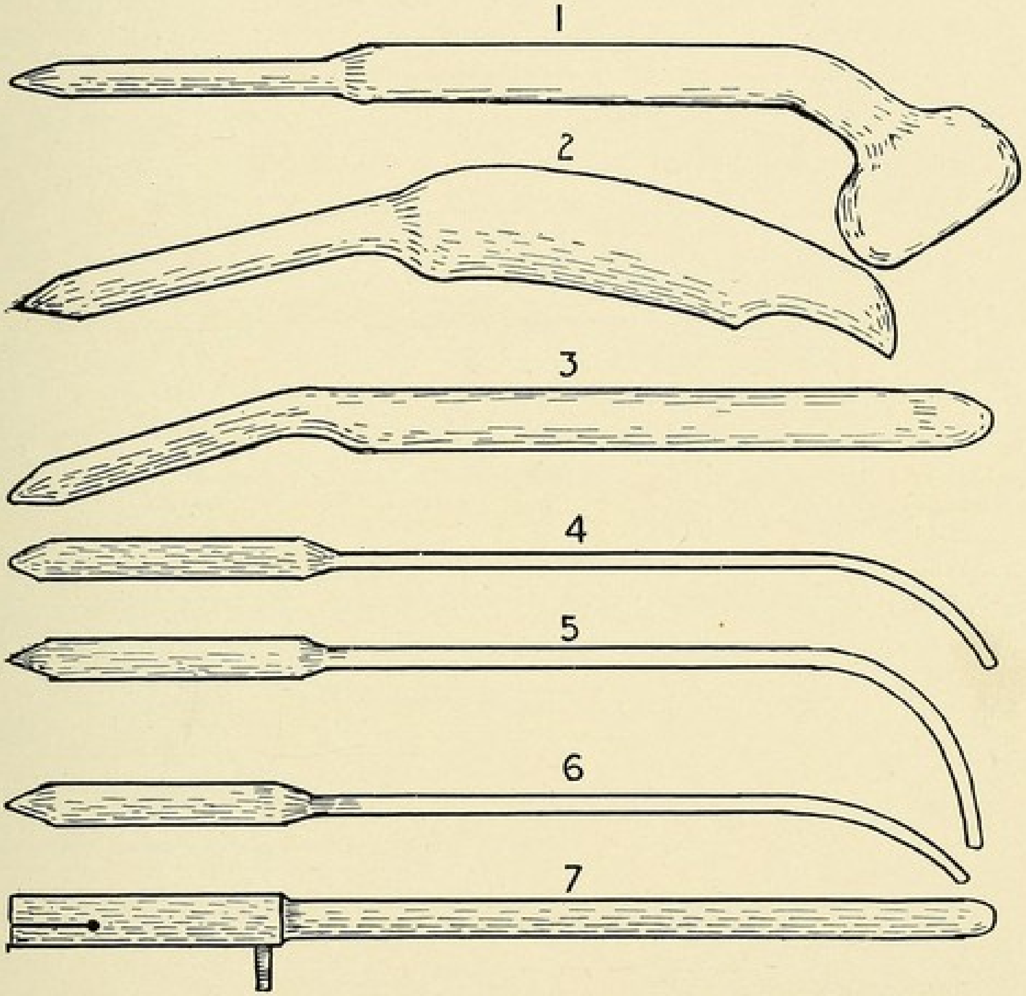


Fig. 34.—High-frequency glass vacuum electrodes. 1, body; 2, vaginal; 3, rectal; 4, laryngeal; 5, urethral; 6, nasal; 7, universal handle.

5, urethral; 6, nasal; 7, universal handle. The insulated variety has a decided advantage over the plain in that the high-frequency discharges are carried directly to the particular parts to be treated, and are not dissipated throughout the whole length of the electrode.

Fig. 35 represents the vaginal and rectal of the insulated variety. It is practically two tubes, the inner one of which is exhausted, while the outer one is at the pressure of the atmosphere. The high-frequency discharges are carried to the distal end *A*, where they enter the tissues of the patient as in the plain variety. On account of the delicate structure of the insulated vacuum electrodes,

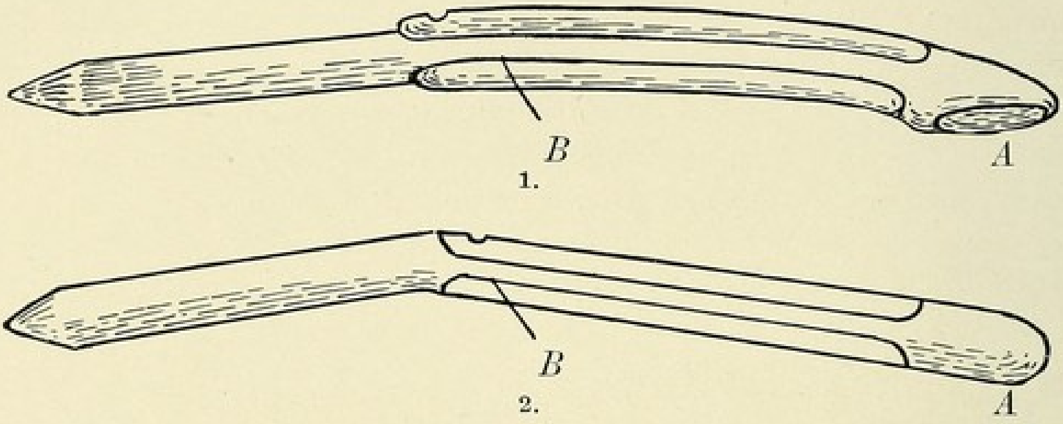


Fig. 35.—Insulated glass vacuum electrodes. 1, vaginal,; 2, rectal.

they are frequently broken at *B* when using heavy currents. When these electrodes are new, they should be used for some time with very weak currents until the glass becomes annealed and capable of carrying stronger currents.

The body condenser electrode is a glass vacuum electrode, with a pole or disk sealed in the wall, as shown in Fig. 36. This elec-

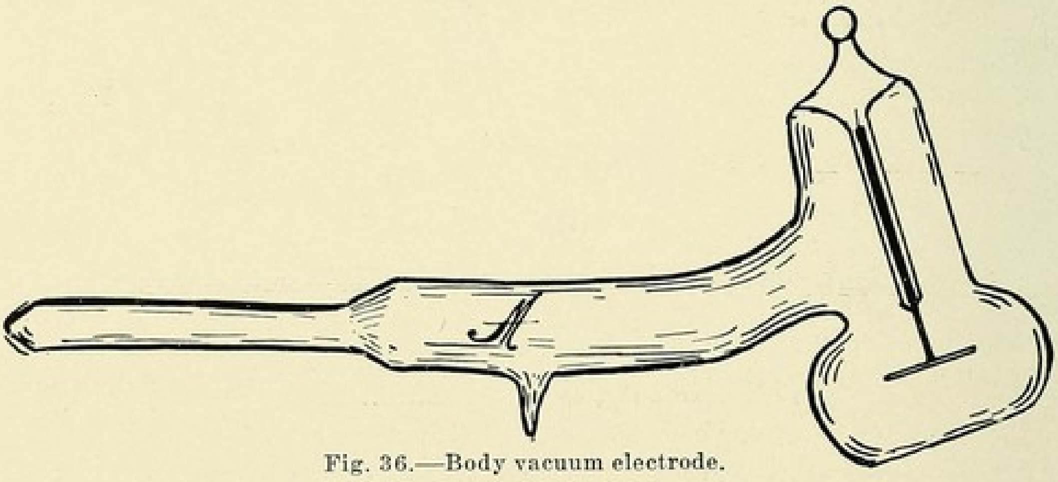


Fig. 36.—Body vacuum electrode.

trode is made in sets of three, the first having a low red vacuum, the second a white vacuum, and the third an x-ray vacuum. The low vacuum is indicated where a current of a sedative nature is required—the relief of acute congestion, inflammation, pain, and an increase of nutrition. The second is indicated in low chronic conditions, where the vital resistance is below normal, including several forms of nervous and skin diseases. The third, or high vacuum tube, combines the destructive effects of the x-ray with the active stimulating effects of the Tesla currents, and may be most effectively used in the treatment of the various forms of malignant disease. The vacuum electrodes may be used with the static machine as well as with the induction coil. They may be connected directly with the prime conductor by means of a wire or chain, or some form of resonator or coil may be used to increase the frequency. When the electrodes are connected directly with the prime conductor of the static machine, it would be called a low-frequency modality. While comparatively high, it would be low indeed when compared with the discharge from the Oudin reso-

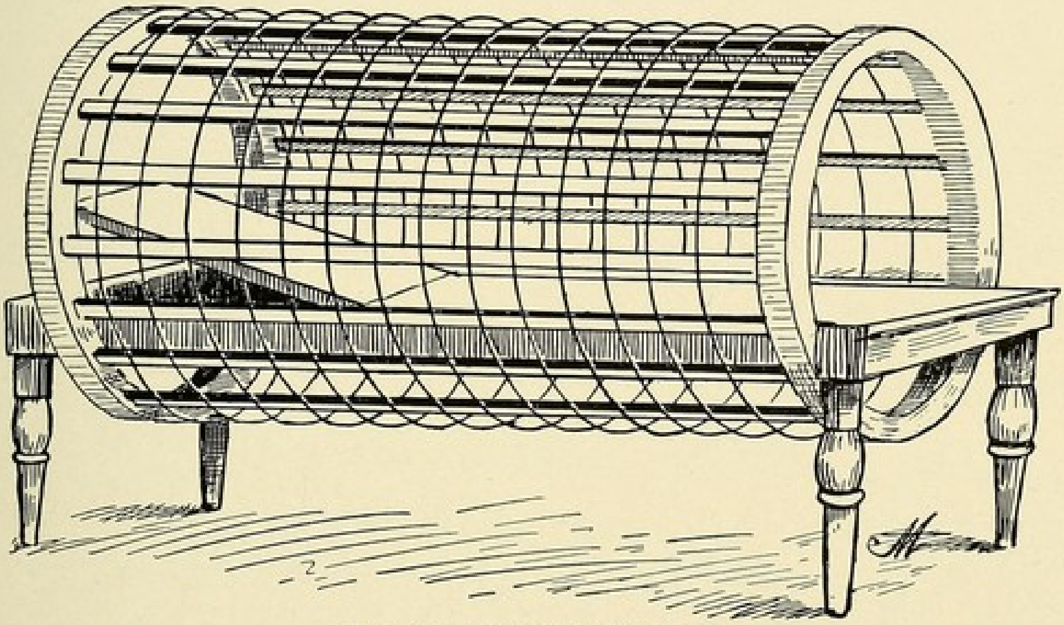


Fig. 37.—Autoconduction cage.

nator. The technic for the therapeutic application of vacuum tube modalities will be fully dealt with under the proper heading.

The autoconduction cage (Fig. 37) is made in several styles, only one of which is shown here. The patient is allowed to recline upon a couch that is surrounded by a large coil of wire or solenoid. This solenoid acts as an immense electromagnet, passing lines of force through the patient's body from the south to the north pole, yet producing no appreciable sensation whatever in the patient.

The author is not very favorably impressed with this method of treatment, and will devote very little space to it. Where this modality could be used, the author would recommend the autocondensation couch as being far superior in every particular.

CHAPTER V.

CONTROLLING AND MEASURING APPARATUS.

Without exact methods of controlling and measuring the different electric currents, we would be unable to use them as therapeutic measures with any degree of certainty. If successful in a given case, the dose or current strength could not be recorded because unknown, and results could not be duplicated. No one chapter in electro-physics is more important or should be more carefully studied. It will not be possible to describe or illustrate every kind of controlling device on the market, and it will be sufficient to explain the principle on which they are all built. A small volume might be devoted to this subject alone, but the student is interested only in that which he expects to use. Those who wish further information on the subject should procure the international textbooks on electro-therapeutics, in which the subject is exhaustively treated.

CONTROLLING DEVICES.

It has been stated that forty cells are necessary to operate a wall plate, but it must not be supposed that the entire output of all the cells is to be used at once. The output of an average cell is 1½ volts, with a rate of current flow of ½ ampere. When connected in series, a battery of 40 cells will furnish a pressure (EMF) of 60 volts, with the same rate of current flow furnished by one cell, ½ ampere. The rate of current flow in a circuit is in inverse ratio to its resistance—i. e., the current decreases as the resistance increases.

The resistance of the tissues of which the body is composed varies greatly. The strength of the current and the size of the electrode are determined by the resistance of the parts treated and the effects to be produced. Since resistance in a circuit controls the strength of the current passing through the circuit, it stands to reason that by introducing an external resistance in the circuit the current may be increased or decreased to any strength desired. The controlling device generally used consists of an adjustable coil of high resistance wire, generally German silver. The original method of controlling battery current was by means of cell selectors, a device that enabled the operator to select one or more cells from the group of forty. This method had its advantages and disadvantages; for instance, it gave a perfect control over the voltage, but did not change the amperage in the circuit, and it was impossible to increase or decrease the current with a smoothness so necessary in the treatment of delicate tissues or sensitive patients. A resistance coil arranged to control electric currents is called a rheostat, and will be illustrated and fully described.

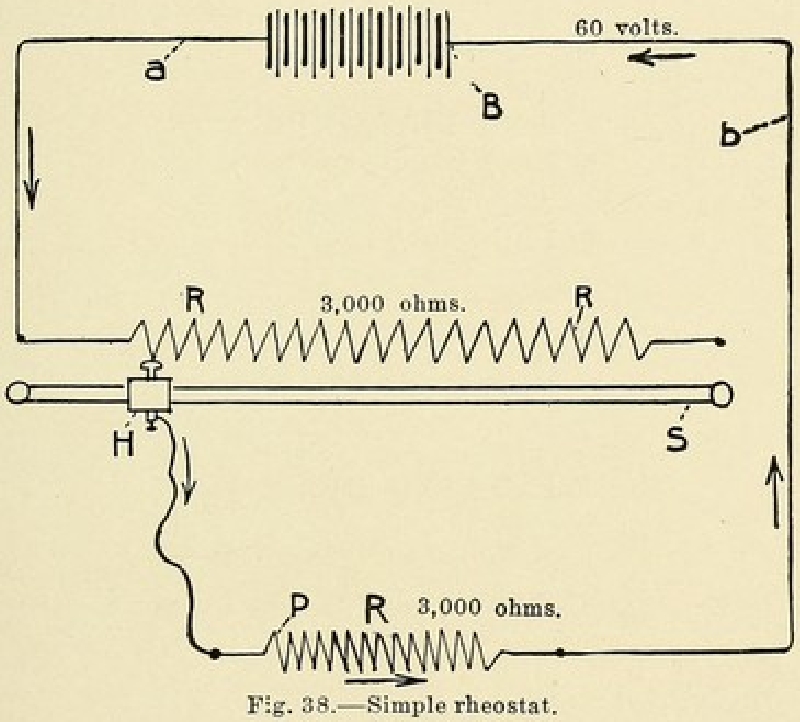


Fig. 38.—Simple rheostat.

After the rheostat came the measuring device or ammeter, which measures the current in amperes. A current rate of 1 ampere is seldom required in the treatment of diseased conditions. It was necessary, therefore, to subdivide the ampere into a thousand parts, each of which is called a milliampere. The apparatus used for measuring these delicate currents is called a milliamperemeter, and should be a part of every wall plate or galvanic equipment.

Rheostat.—We will consider only one kind of resistance material—that of German silver wire. The wire may be wound in a straight coil, or the coil may be bent into a circle or made in the shape of a horseshoe. Fig. 38 is a diagrammatic drawing of the simplest form of series rheostat. We will assume that the battery *B* has an EMF of 60 volts. The rheostat *R* has a resistance of 3,000 ohms. *a* connects the negative terminal of the battery to the resistance coil *R*. The contact shoe *H* is made to slide on the rod *S* so that it can be brought in contact with any single wire on *R*. As the shoe now stands, no current can get into the resistance coil *R*. It is allowed to pass on to the external circuit and through coil *P*, which is made to represent the patient, and on through conductor *b* and back to battery *B*. When the shoe *H* is moved to the other end of the coil *R*, the whole resistance of the coil *R* is in the circuit and the patient *P* will get the least possible part of the current. From this arrangement it will be seen that any strength of current

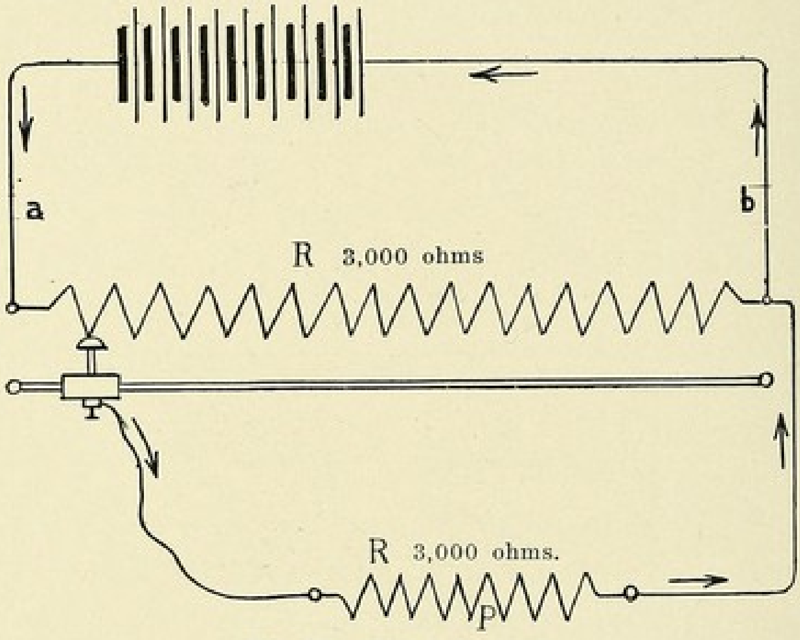


Fig. 39.—Shunt rheostat.

may be carried to the patient by moving the shoe *H* on the coil *R* so as to bring as few or many coils of the rheostat into the circuit as the case may require. Should the resistance of *P* be the same as the rheostat *R*, 3,000 ohms, it would not be necessary to move the shoe *H* from its first position, but, when the patient's resistance falls, the rheostat will not only be a great convenience, but an absolute necessity.

Where batteries are used, the series form of rheostat will answer all purposes, but when the current is taken from the commercial circuit, to guard against a possible "short" on the main line, a shunted rheostat (Fig. 39) should always be used. This form of rheostat differs from the series variety in that the resistance coil *R* is in metallic contact with *a* and *b*. When the patient *P* is connected in such a circuit, should the mains become "shorted" with a high-pressure current, the bulk of the charge would be short-circuited through the resistance coil *R* and the patient *P* would not be harmed. The series rheostat may be made something like Fig. 40. The lever or arm takes the place of the sliding shoe *H* in the former illustration. The German silver wire rheostats are far more reliable than the old graphite type, which gave very good service when new; but, since it was impossible to prevent the graphite from wearing unevenly, the resistance became correspondingly uneven and the current unreliable. The graphite rheostat, because of the objections mentioned, has been generally discarded for the more reliable German silver variety. Whatever form is selected, it should be

Fig. 40.—Series rheostat.

well made, controlling the current from zero to the full output of the machine. A rheostat that will allow the current to come on unevenly or by jerks is dangerous, and should never be used for any purpose. There are several good machines on the market, and there is no excuse for using defective apparatus.

The rheostat shown in Fig. 40 is made of small German silver wire carefully wound about a nonconducting hoop, each turn being carefully insulated from its fellow, and offering a high degree of resistance to the passage of the current. The coil is well inclosed by a metal case that thoroughly protects it from dust and dirt. The arm supporting the contact shoe moves easily around the circuit, allowing the resistance to be changed in such small quantities as to be entirely free from unpleasant sensations.

SWITCH-BOARD.

The electric switch-board used by the physician is usually called a wall or table plate. It usually contains a milliamperemeter, rheostat, rheotome, faradic coil, current selectors, pole changers,

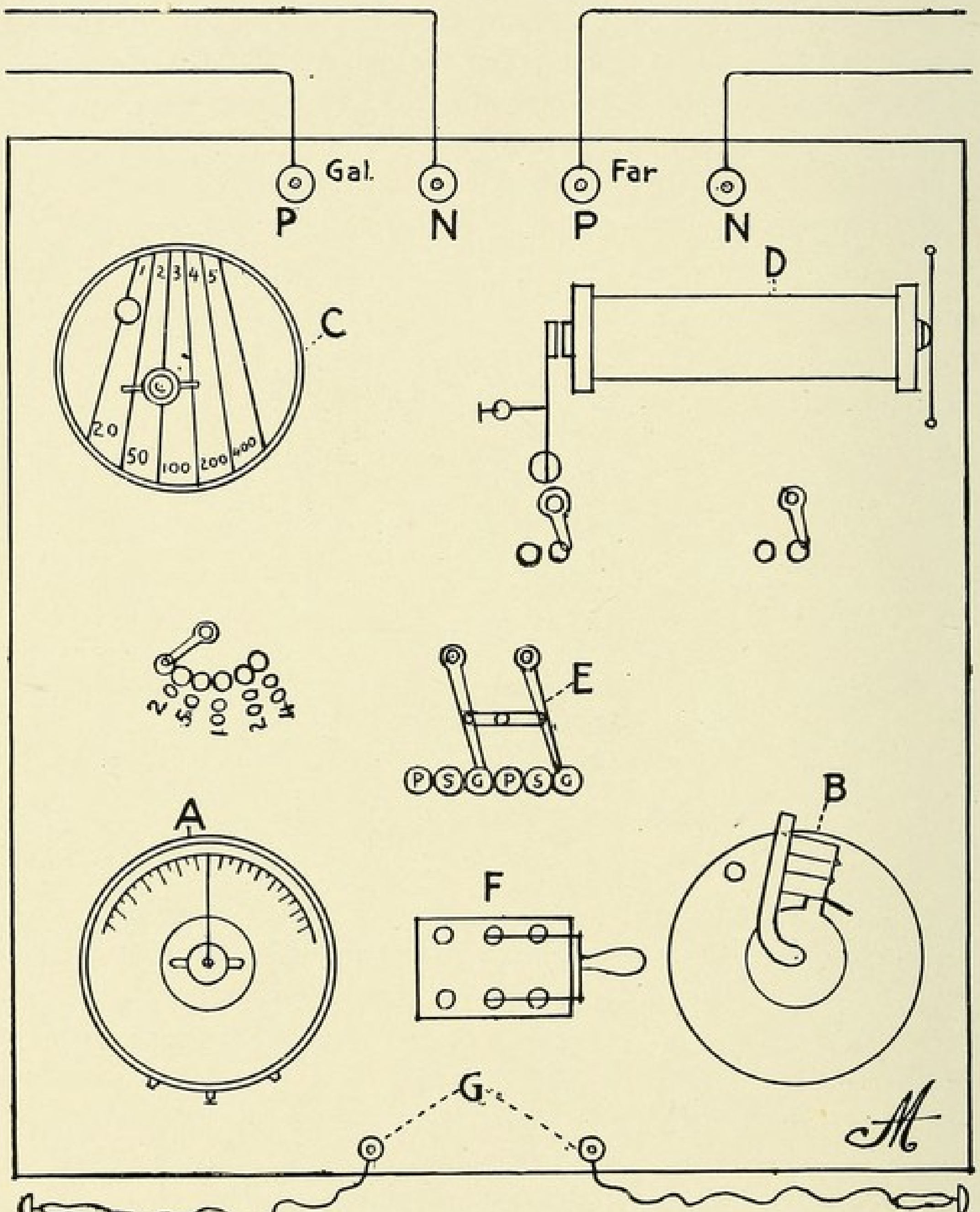


Fig. 45.—Physician's switch-board or wall plate.

binding posts, etc., and it may be arranged for the cautery and sinusoidal currents. Fig. 45 is a simple diagram of a physician's switch-board or wall plate. *A* is the milliamperemeter; *B*, rheostat; *C*, rheotome; *D*, faradic coil; *E*, current selectors; *F*, pole changer; *G*, binding posts for electrodes.

No one should attempt to use a wall plate until perfectly familiar with every switch and current, and the physician should know just what the apparatus will do and how to make it do it.

There are no two makes of plates exactly alike in their arrangement, though in principle they are the same. When one design has been thoroughly mastered, all others will be easy.

CURRENT SELECTORS AND POLE CHANGERS.

Current Selectors.—Most galvanic and faradic equipments are assembled on a board or marble plate, and have a pair of binding posts in common for the different currents. In Fig. 43 the double

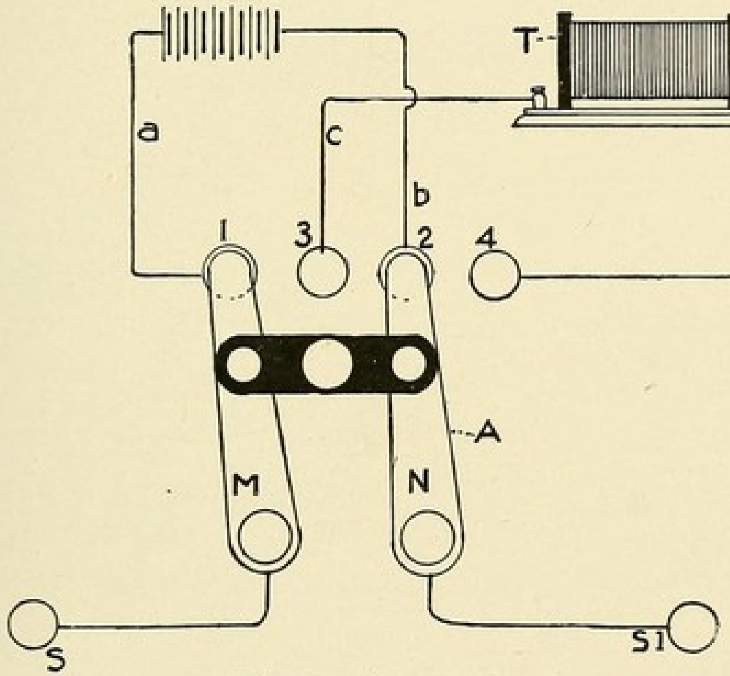


Fig. 43.—Current selector.

switch *A* is on contacts *1* and *2*, which are connected to the battery conductors *a* and *b*. When the current from the faradic coil *T* is used, the switch *A* is moved to the right and placed on contacts *3* and *4*, which are connected by conductors *c* and *d* to the secondary of coil *T*. *N* and *M* are in metallic contact with binding posts *S* and *S1*.

Pole Changers.—It is frequently necessary to change the poles a number of times in giving some forms of galvanic electricity. It would often be very inconvenient to change the electrodes every time a change of polarity is desired. A switch similar to the current selector is used, as shown in Fig. 44. If the illustration is studied, it will be clearly seen that the polarity of *S* and *S1* may be

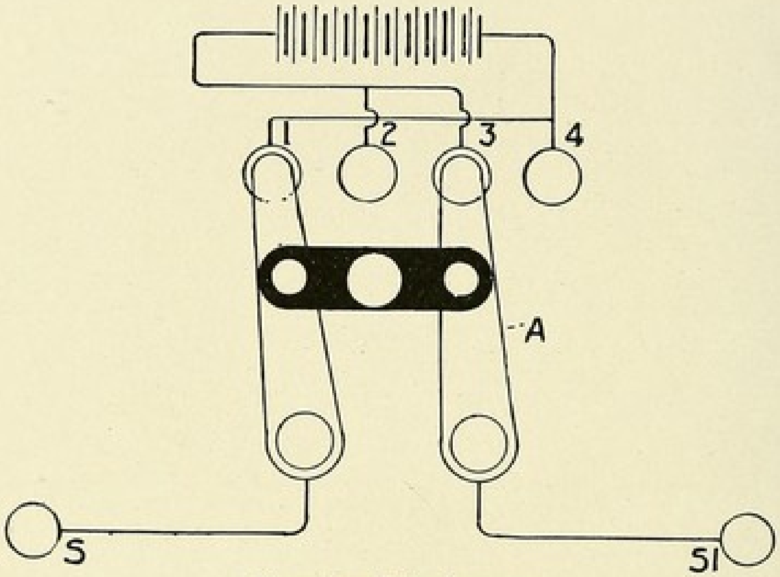


Fig. 44.—Pole changer.

changed by moving switch *A* from contacts *1* and *2* to *3* and *4*. The pole changer on the modern wall plate is sometimes in the form of a double knife switch.

DEVICES FOR MEASURING THE CURRENT.

Ammeters and Voltmeters.—The advent of the ammeter and milliamperemeter marks the most important stage in the evolution of electro-therapeutics—the passing from the unknown to the known. In the earlier days, when there were no methods of measurement, the dose could be only guessed at. Muscular reaction could be observed, but fine distinctions between the strength of the current and muscular tone in the reaction of degeneration could not be made, and a paralysis might progress or improve for some time before the changes would be manifested in the condition of the patient.

The ammeter and voltmeter are used to measure the strength and pressure of the current in a commercial lighting circuit. A milliamperemeter is used to measure the current passing from the table or wall plate to the patient, and the scale is calibrated in thousandths of an ampere. The three instruments are made on the same principle, and depend for their action upon the electromagnetic influence of different-sized coils of wire on a magnetic needle, which is delicately jeweled and made to move over a carefully cali-

Fig. 41.—Ammeter.

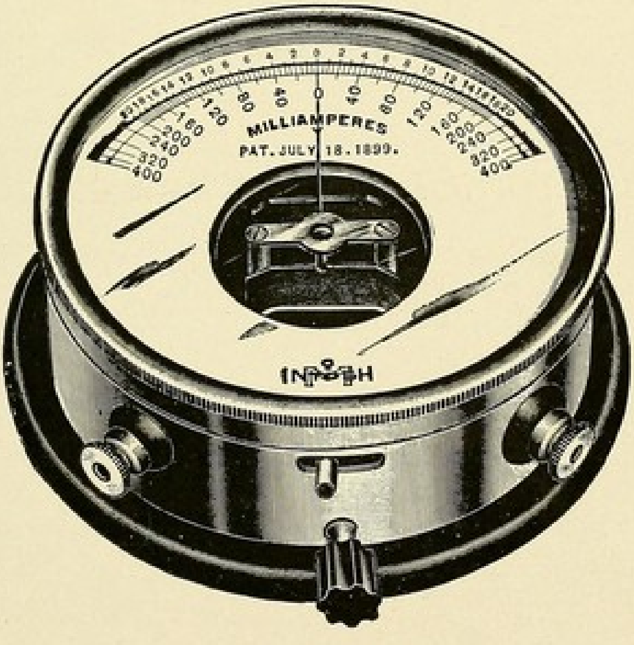


Fig. 42.—Milliamperemeter.

brated scale, which indicates the pressure or current strength, as the case may be.

Construction and Operation of the Ammeter.—If several turns of insulated copper wire are passed around a delicate galvanometer, so that the turns will be parallel with the needle when at rest, and a galvanic current passed through the coil, the needle will be deflected in proportion to the strength of the current going through the coil; if the current is strong enough, the needle will take a position at right angles to the coil, proving that the coil is temporarily made a magnet, with a distinct north and south pole, which attracts the needle the same as an ordinary magnet. When the galvanometer is made to move over a scale, the amount of deflection can be read and recorded, as the same amount of current will cause the same deflection of the needle. The ammeter is wound with a low resistance, and is placed in series with the circuit. It is calibrated in amperes (Fig. 41). The voltmeter differs from the ammeter in having a coil of very high resistance, and is placed in parallel with the battery or source of current. On account of the high resistance, very little of the current passes through the coil of the instrument. The pressure of the current is read in volts.

The voltmeter is seldom used by the physician, and then only to measure the pressure of the current going to the primary of an x-ray coil. The ammeter is seldom used, while the milliamperemeter (Fig. 42) should be a part of every galvanic apparatus, and is, therefore, indispensable. To be of service, a milliamperemeter must register accurately and quickly, the needle coming to a sudden stop the instant the rheostat is stopped. If a milliamperemeter is found to be defective, it should not be used, but returned to the manufacturers for the necessary repairs. Every portable galvanic battery should have a reliable milliamperemeter, and no treatment, however trivial, should be attempted without it. When not in use, the milliamperemeter should be cut out of the circuit by means of the switch provided for that purpose. This precaution may prevent an occasional burnout in the coil of the instrument.

CONDUCTING CORDS AND ELECTRODES.

Conducting Cords.—These should be made of several strands of small wire, well insulated, about 6 feet long and provided with universal tips. For convenience, they should be of different colors—i. e., one of red and one of blue. The universal tips should be securely fastened on the ends of the wires and kept well screwed up, as otherwise the current may at times be broken, causing a shock to the patient. Should the fine strands of wire of which the cords are composed become broken, the cords should be discarded for new ones.

Electrodes.—Thus far we have considered only metallic conductors. When electric currents are applied to the human body, the particular part of the tissues treated becomes a part of the circuit. It is, therefore, an important question how best to connect the current with the body, since it offers no metallic connections. The dry skin offers so much resistance to galvanism that it is next to impossible to pass a current through it from a dry electrode. Solutions of bicarbonate of soda or chlorid of sodium offer very little resistance to the passage of an electric current when used with properly prepared electrodes.

An electrode is a device used for the purpose of connecting the conducting cords from the wall plate or other apparatus to the body of the patient. They are made in various shapes and of various materials, depending upon the purpose for which they are to be used.

Metallic Electrodes.—Most electrodes are of metal, which may be used bare or covered. The bare electrodes are used in direct contact with the tissues when a cautery effect (electrolysis), or a deposit in the tissues of metallic particles of which the electrode is composed (cataphoresis), is desired, etc. Bare electrodes are indicated in the removal of superfluous hair, small growths, treatment of cancer, dissolution of strictures of the mucous tracts, and in the treatment of many uterine diseases, etc., all of which will be carefully explained in the proper place.

For surface work, the electrodes are generally covered with some easily sterilizable absorbent material, the best of which is probably absorbent cotton, which should always be soaked in a solution of bicarbonate of soda. This solution softens the cuticle and makes an excellent contact between the tissues and the metallic circuit. Care must be taken that the metal plate, ball, or disk of the electrode is thoroughly covered with the cotton, as otherwise a burn will be the result of the metals coming in contact with the moist skin. Such cotton coverings may be sterilized and used a number of times, or new ones may be used at each application.

Since two electrodes are used in every galvanic, faradic, or sinusoidal application, they are distinguished as active and indifferent electrodes. The indifferent is so named because it often makes no material difference where it is placed. It is the larger of the two, and generally consists of a piece of brass or block tin 4 by 6 inches or larger, well covered with a thick layer of thoroughly wetted cotton or other spongy material. This electrode may be placed anywhere over the spine, or upon the chest or abdomen. The active or small electrode will measure from 2 to 1/4 inch in diameter. It may be used bare or covered, in the same manner as the other electrode. It is called the active electrode because it is brought near to or in direct contact with the parts to be treated. The methods of carrying different substances into the tissues will be thoroughly explained under phoresis.

HYDROELECTRIC BATHS.

Because of the great difficulty in using these modalities, the hydroelectric baths are seldom used outside of sanitariums and well-appointed bath houses. If properly understood and rightly conducted, much good may come from such methods.

The water, acting as a shunt, will, when its resistance is very low, carry most of the current around the patient's body, while, on the other hand, if the resistance of the water is very high, the greater part of the current will go through the patient's body. When the current is supplied from the commercial lighting mains, the bath must be in shunt with the main feed wires, with ample fuse protection to prevent a possible accident with high-pressure currents.

Construction of the Bath Tub.—Tubs used for the purpose of giving hydroelectric baths must be made of nonconducting material, as otherwise the current will pass through the conducting material of the tub and the patient will feel nothing.

Fig. 46 shows the general arrangement of the tub and the electrodes. Note that the tub is insulated from the sewer connections.

Monopolar and Bipolar Methods.—In the monopolar method the electrode (active) is applied to the body external to the water, the water acting as the indifferent electrode, carrying the current to the metallic electrode, which is submerged in the water. With this method of application the body carries the whole current, which enters the body through the active electrode in a concentrated form, the density depending upon the size of the electrode, and emerges from the body throughout the distribution of the water. In the bipolar bath the body is not in direct contact with either pole, though both poles are in the water. Here the body receives only a portion of the current as it passes through the water. The larger the patient's body and the closer it is placed to the negative electrode, the more current it will be likely to receive.

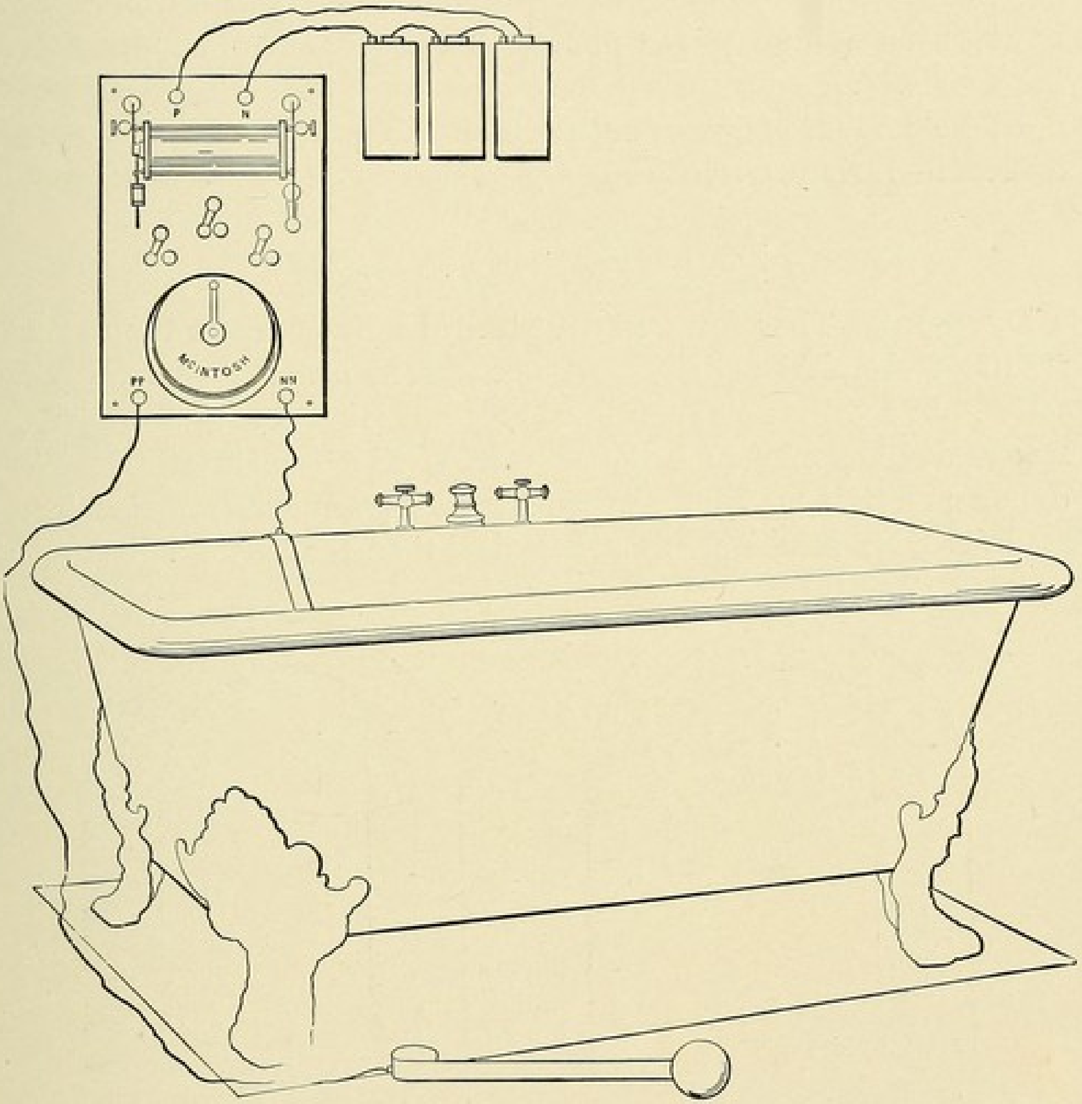


Fig. 46.—Hydroelectric bath tub.

Varieties of Currents Used for Hydroelectric Baths.—The direct, alternating, and faradic currents are used in giving the hydroelectric bath, each of which has its particular field of usefulness. We believe these currents are particularly valuable, and should be used much more than they are today, but the great amount of expense necessary to equip and maintain such an outfit puts it beyond the possession of the average electro-therapist. It is only a question of time when all well-equipped sanitariums will install a complete hydroelectric bath for the treatment of the many diseases for which it is peculiarly adapted.

The author can not close this section without sounding a word of warning to users of the hydroelectric bath where the current is derived from the commercial lighting circuit. The wiring should be so perfectly done that a "short" with a high voltage current is impossible. No one should be allowed to operate such an outfit until he is thoroughly familiar with the nature of the different currents—their possibilities and probabilities.

DYNAMOS AND MOTORS.

Dynamos.—Thus far we have studied only currents that are the result of chemical action—currents started by cells—galvanic batteries. We will now consider currents that are the result of **mechanical energy** and the apparatus that generates them—the dynamo electric machine—which for most purposes furnishes a current far more practical and economical than the battery.

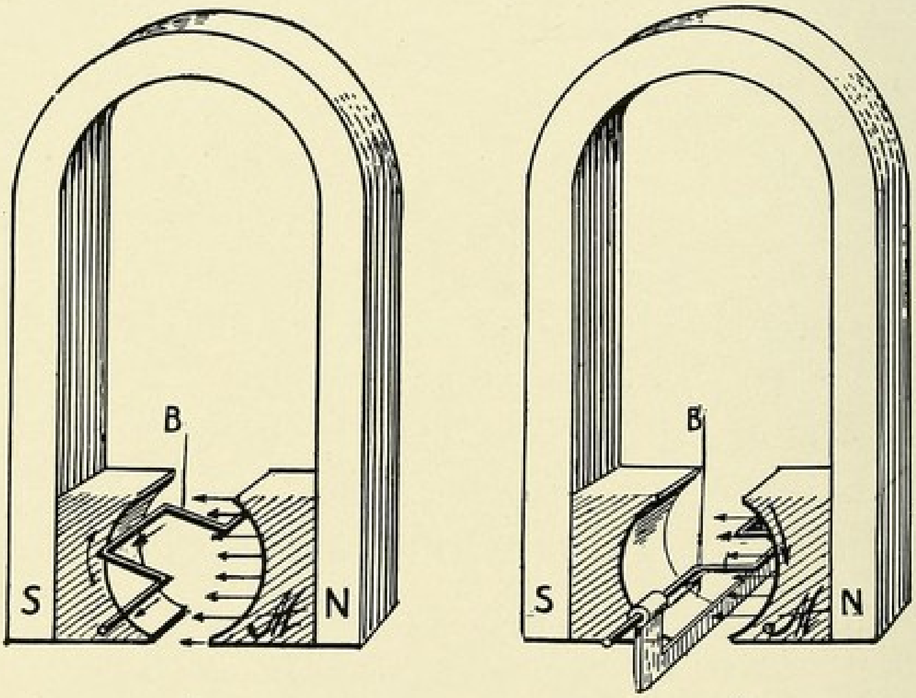


Fig. 47.—Principle of the dynamo.

If the lessons in magnetism and electromagnetism have been closely studied, the operation of the dynamo and motor will be easily understood. When a wire conductor is moved through a magnetic field, a current is started in the conductor. The direction of this induced current will depend upon the direction of the lines of force and the direction in which the conductor cuts the lines of force. In Fig. 47, 1 is a horseshoe magnet, with lines of magnetic force passing from the north pole *N* to the south pole *S*, as indicated by the arrows. If a wire conductor *B* is allowed to pass upward between the poles *N* and *S*, across the lines of force, a current will be started (induced) in conductor *B* in the direction of the arrow. If the conductor is turned downward, cutting the lines of force in a downward direction (1), the induced current in the con-

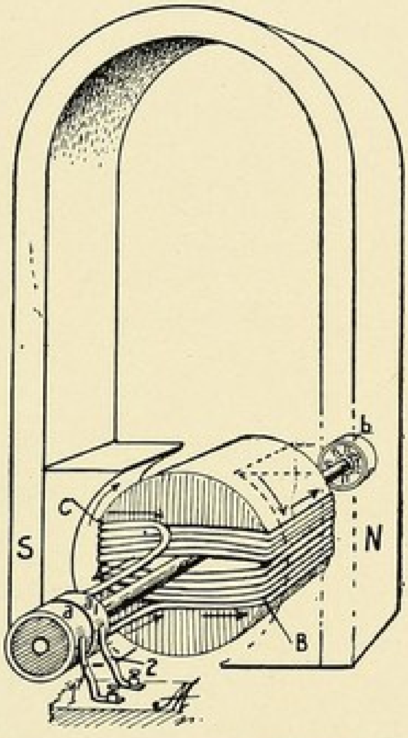


Fig. 48.—Alternating current dynamo.

ductor *B* will be reversed and will flow in a direction opposite to the current induced in the conductor during an upward motion. This change in direction of the current in a conductor when cutting lines of force in opposite direction produces in the conductor what is known as an alternating current. The stronger the magnetic field, the stronger will be the induced current in the conductor. A single conductor cutting lines of magnetic force would, at best, start a very weak current in the conductor. Like the induction coil, the current may be increased by increasing the conductors in the magnetic field. In Fig. 48 the conductor has been bent into a number of coils, and made to revolve between the poles of a magnet *N* and *S* in such a way that conductor *B* is cutting lines of force in a downward direction and conductor *C* is cutting lines of force in an upward direction, with an induced current in *B* and *C* in the direction of the arrows. When the conductor is coiled about a revolving iron core, it forms what is called an armature. When this armature is rotated between the poles of a magnet, each coil of wire will cut lines of magnetic force, which in turn induce currents in the conductor or coils of wire that flow in the same direction as the currents in the single coil of wire illustrated in Fig. 48. The output of the whole coil or armature will be a current the strength of which is the product of the current in one coil of wire multiplied by the number of coils on the armature. For the purpose of conducting the current away from the dynamo, two rings or wheels, well insulated from each other, are placed on the armature shaft. Pieces of copper *1* and *2*, called brushes, are

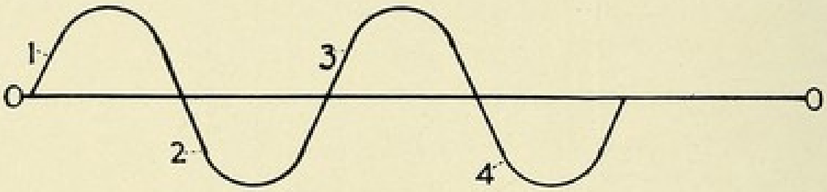


Fig. 49.—Sine or cycle of the alternating current.

placed in such a position that they rub against the rings *a* and *a1*, and act as conductors from the coils of the armature to the external circuit. On one end of the armature shaft a wheel *b* is placed for the purpose of operating the armature from some source of power, which may be steam, gasoline, or electric. The current from such a generator is a truly alternating current, as indicated in Fig. 49. Compare the curves, rise and fall, in the current with the positions of the conductor in Fig. 49. When the conductors *B* and *C* are opposite *N* and *S*, they are cutting the maximum lines of force. The rise above the zero line at *1* and *3* is due to the conductor cutting lines of force at the north pole *N* of the magnet, and the curves *2* and *4* below the zero line are due to the conductor cutting lines of force at the south pole *S*. A complete revolution of the coil (armature) produces a rise above and a like fall below the zero line, as shown in curves *1* and *2*, and is called a cycle or sine. The strength of the current and the rapidity of these changes depend upon the rate at which the armature is made to revolve, and it is estimated in cycles per second.

The current from the alternating current dynamo is not so well adapted to the physician's wants as that from a direct current dynamo. The only place where the alternating current is superior is in heating the electrocautery and producing the sinusoidal current, which can be had only from an alternating current generator. The direct current dynamo is wound with many coils, the free ends of which are connected to copper segments, placed around one end of the armature core, but insulated from it, as well as each segment from its fellow. These segments, taken together, are called a commutator, because they commute the current and deliver it to the brushes and the external circuit as a unidirectional current, the same as from the batteries.

The alternating current is described as a 60- or 133-cycle, with 110- to 500-volt pressure. The 60-cycle 110-volt current is the ideal alternating current for operating the x-ray coil, the cautery, and delivering the sinusoidal current. The direct current may have a pressure of 110 to 500 volts. The 110-volt current (DC) is ideal for use in a physician's office. The 220-volt current may be used, but is inferior to the 110. The 110-volt direct current will operate the wall plate, x-ray coil, all sizes of motors, etc. It is the only current that will successfully operate the mercury interrupter, which is indispensable in doing therapeutic work with the x-ray coil. The mode of construction and operation of alternating and direct current motors is the same as the dynamos, and need not be described here.

In describing the various apparatus for the physician's use, the particular currents by which they are to be operated will be mentioned in each instance. It must be understood that each piece of electric apparatus is built for a particular current, and will not work on any other. In buying machinery where but one current is available, this fact must always be mentioned with the order. If the current is alternating, the number of cycles and the voltage must be known; if direct, the voltage must be known. Liquid rectifiers are sometimes used to change the alternating to a unidirectional or direct current.

CHAPTER VI.

X-RAY APPARATUS.

The laity, as well as a majority of the physicians from the country districts and the sections where large induction coils are rare, have learned to associate the idea of the x-ray with the static machine. As an x-ray generator the static machine can in no way be compared with the modern coil; but, since the coil can not be successfully used except where the commercial (dynamo) electric current is to be had, it is out of the question in rural districts and small towns without a light plant. In these isolated districts the

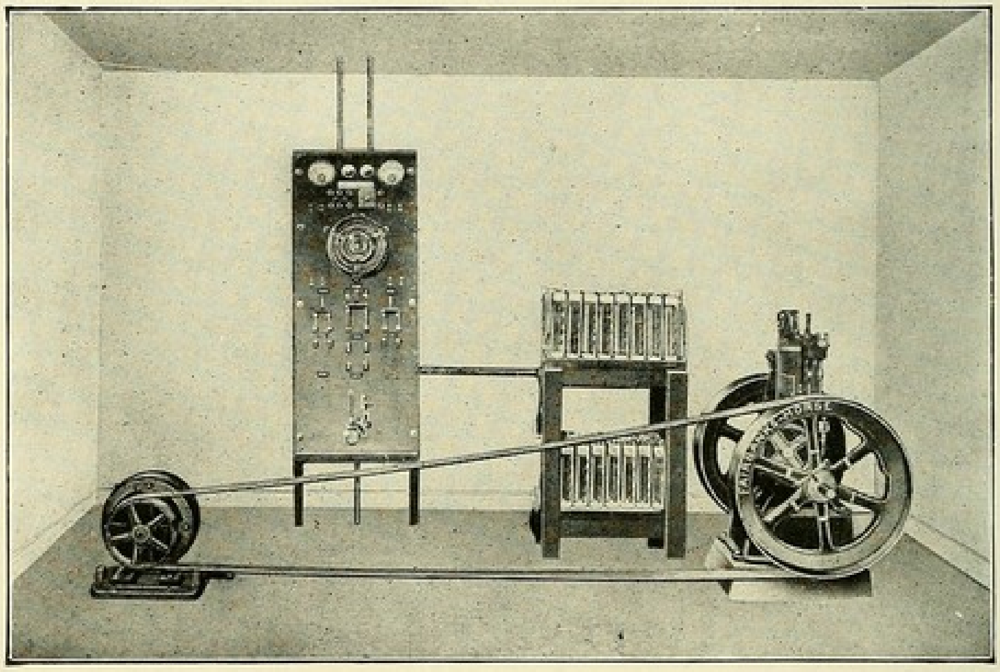


Fig. 50.—Private lighting plant.

enterprising physician may generate his own currents from a dynamo operated by a gasoline engine, or water or steam power. These small independent light plants should always be of the 110-volt direct current. An 8- to 10-ampere dynamo can be pulled by an 8- to 10-horse power engine. The current furnished by a dynamo of this size will be ample to operate an x-ray coil, motors, wall plate, pumps, etc., and, when necessary, light the office and home of the physician when near.

Fig. 50 shows a modern equipment for a small lighting plant that will meet all of the requirements in the physician's office. The cost of installing such a plant is not very great, and the cost of maintaining and operating is very little compared with the amount of service it will render.

Excluding the commercial or private lighting plant, the hand or mechanically operated static machine is the only hope for an x-ray generator. The static machine for skiagraphic purposes is greatly inferior to the induction coil, but the author would not on this account discourage enterprising physicians living in country districts from using a good static machine where it would be of

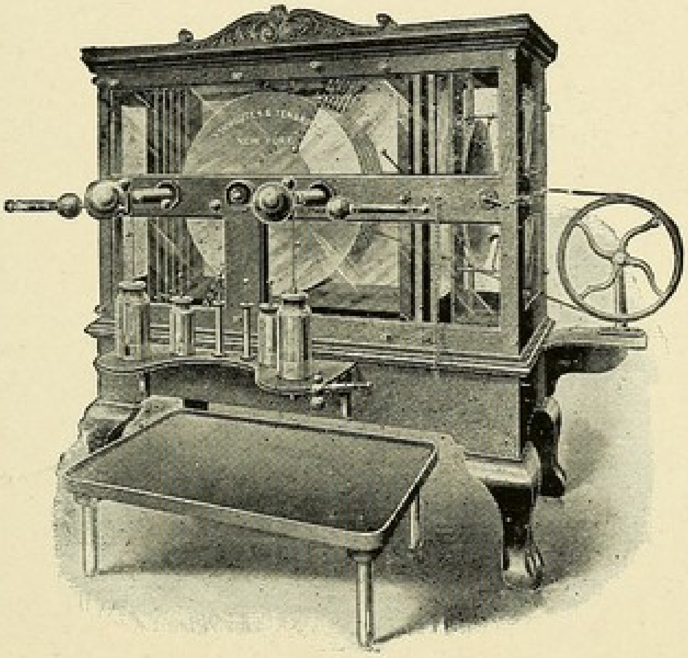


Fig. 51.—Static machine (Holtz type).

diagnostic or therapeutic value. A well-built static machine, kept in perfect repair, besides being of great value as a therapeutic agent, will produce x-rays sufficiently powerful to skiagraph the extremities, and in thin subjects will often give a very good picture of the other parts of the body. In the x-ray treatment of skin diseases the static machine will give most excellent results as a generator.

Fig. 51 is a modern static machine of the Holtz type, sometimes called the induction machine. This machine, though very sensitive to moisture, will, when properly cared for, give excellent satisfaction in most climates.

Fig. 52 illustrates the Toepler-Holtz or compound variety of static machine. These machines are largely used because they are lower in price. If well built, this type of machine will give excellent service for a number of years. As a rule, however, the cases are not so well built as in the Holtz machines, and on this account

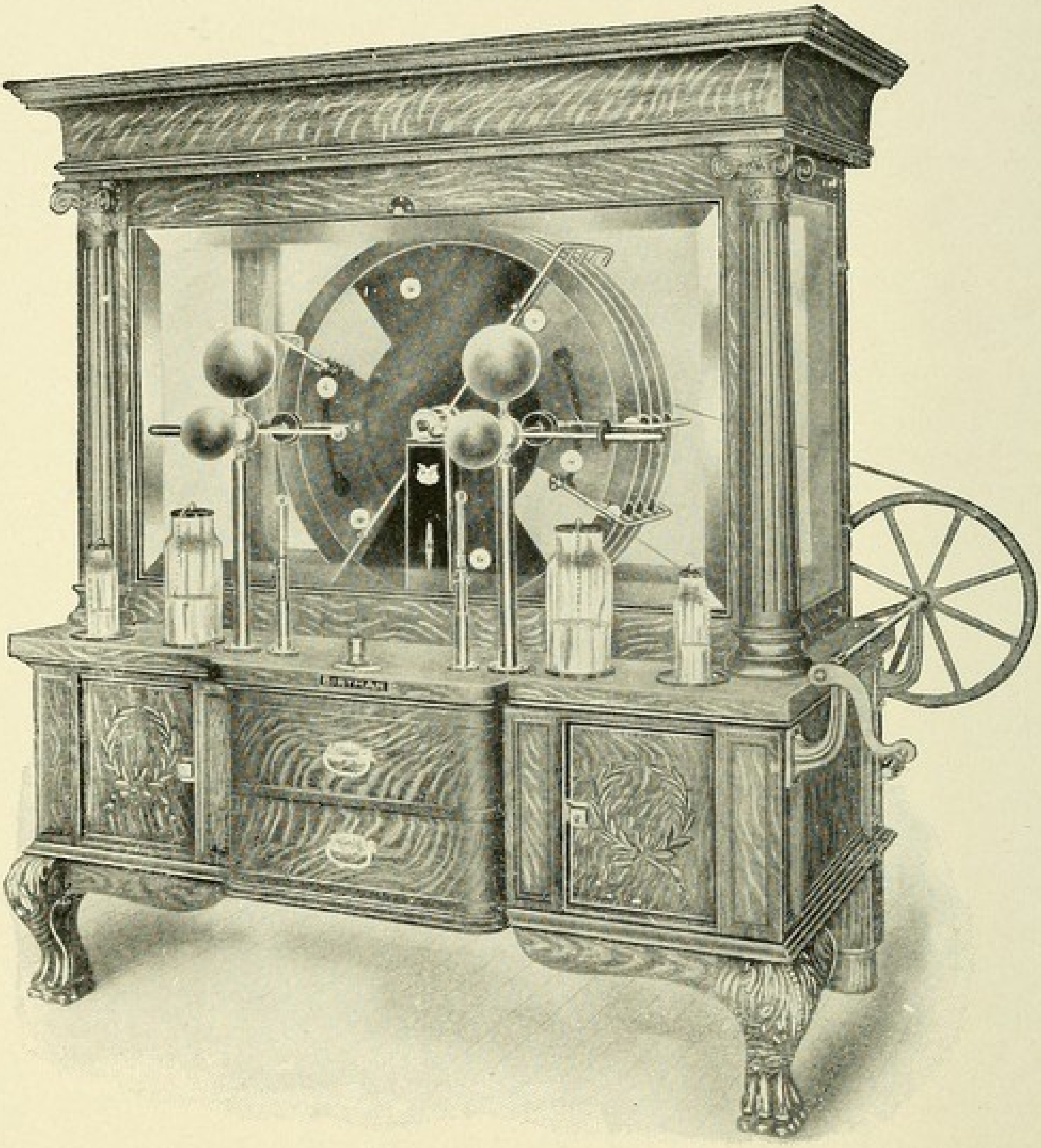


Fig. 52.—Compound static machine.

it is more difficult to keep them dry on the inside. A static machine, for all-around work, should not have more than twelve revolving plates or less than ten. The author has been using a 10-plate Holtz machine for a number of years, and has found it sufficiently large in most cases. It is noticed that a static machine will deliver a much stronger current on some days than on others. This is due to the fact that moisture decreases the resistance of the atmosphere, and on damp days there is a leakage to the atmosphere around the machine and particularly from the patient, making it next to impossible to condense any current on the patient's body, while on dry, cool days the current is much stronger. Static machines do very poor x-ray work when the weather is very wet and damp. If the weather is cold, a good fire in the room may sufficiently dry it out; otherwise it will be necessary to wait until the weather clears up before the machine can be operated to its full capacity. Moisture, either outside or inside of a static machine, seems to be its greatest enemy, and is about the sum total of our electrical troubles. For removing the moisture from the inside of the case, a number of dryers have been recommended from time to time, but the best that the author has tried is commercial caustic potash (concentrated lye), sold at about 10 cents per can at all grocery stores. Procure four clean glass bowls that hold at least a pint. Place in each bowl one-half the contents of a can of potash, put a bowl in each of the four corners of the machine, close the doors as tightly as possible, and let the machine alone for a few hours, when it will be dry. If the machine is a Holtz, it will be necessary to place an extra bowl in the Wimshurst, or small compartment where the small friction or charging machine is placed. After a time the potash liquefies and will take up no more water, when the bowls must be taken out, emptied, washed, and dried, and new potash placed in them as before. By this means the machine may be kept thoroughly dry and delivering a good spark three hundred and sixty-five days in the year, one year after another.

At the time of the discovery of the x-ray there were only a few ordinary static machines in this country, and they were in the larger cities and mostly in the hands of quacks and fakers. At that time the literature on the use of the static machine could be carried in the vest pocket. With the advent of the x-ray, however, the static machine received an impetus. For a long time it was the only means of exciting the Crookes tube, and enterprising manufacturers led the physicians to believe that all they needed was a static machine, tube, and fluoroscope, and that they could easily make their patients transparent from head to foot. The people got the same idea, and the graft spread on the heels of the new discovery, and has not entirely disappeared from some localities where fake newspaper advertising is eagerly read and blindly patronized.

To be of service, a static machine should deliver a spark from 10 to 12 inches in length—i. e., when the prime conductors are 10 to 12 inches apart sparks should freely pass across the air gap between them, going from the negative to the positive conductor. When working at its best, a static machine can produce a spark in length equal to only one-half the diameter of the revolving plates. The static machine has some advantages over the coil, one of which is its ability to generate an electric current independent of any other apparatus. The static machine may be operated by hand or any other power, but unquestionably the only ideal power is the electric motor.

With all the disadvantages that daily confront the country physician, he is often able, with very inferior apparatus, to produce

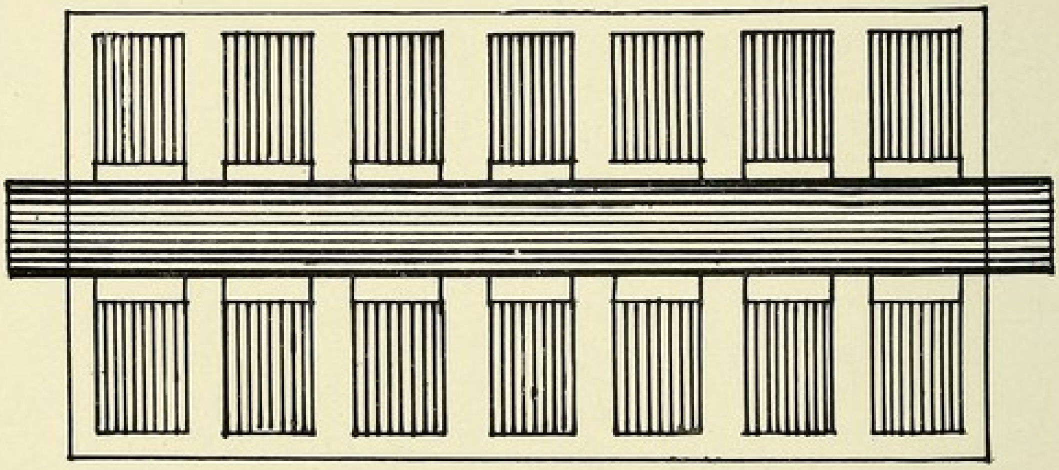


Fig. 53.—Diagrammatic view of the secondary of an x-ray coil.

results that makes the city physician wonder how he did it. It is easy to do good therapeutic work with a static machine when kept in perfect repair, and some passable skiagraphic work may be done, but, if skiagraphic work is to be a strong feature, the induction coil is indispensable. The x-ray coil is built on the same principle as the faradic coil described in Fig. 22. The main difference is in the way the secondary is wound, which is made into a number of spools in series in place of one. This method of winding the secondary will greatly simplify their repair should one of the spools burn out.

X-ray coils are built in several sizes, which are indicated by spark lengths. They come in 8, 12, 16, 18, 20, 22, and 24 inches.

The primary and secondary should be so tuned to each other that the current delivered from the terminals of the secondary coil will energize a Crookes tube to its full capacity for thirty seconds without overheating it. Few coils seem to be constructed with this idea in view. Fig. 53 gives a diagrammatic view of the secondary of an x-ray coil, showing the arrangement of the spools on the insulated primary coil. The number of these thin secondary spools will depend upon the size of the coil or the length of its spark gap. The ordinary ribbon vibrator used on small faradic coils will not give satisfaction as an interrupter for an x-ray coil.

The electrolytic interrupter (Fig. 54) may be used for the purpose of interrupting any current, no matter what the voltage, and it is the only interrupter that can be used with the alternating current. It consists of a jar about two-thirds full of a solution of sulphuric acid and water. The amount of acid in the solution will depend upon the particular current used and the resistance in the primary coil. The following formulas will answer as a guide for preparing the solution for the electrolytic interrupter when used for the various currents in general use. The more acid, the stronger will be the current.

FOR 110-VOLT DIRECT CURRENT.

Sulphuric acid (commercial)	1 part.
Distilled water	7 parts.

FOR 220-VOLT DIRECT CURRENT.

Sulphuric acid (commercial)	1 part.
Distilled water	10 parts.

FOR 110-VOLT 60-CYCLE ALTERNATING CURRENT.

Sulphuric acid	1 part.
Distilled water	3 parts.

FOR 104- TO 110-VOLT 25- TO 133-CYCLE ALTERNATING CURRENT.

Sulphuric acid (commercial)	1 part.
Distilled water	2 parts.

The above proportions are by measure and not by weight. The solutions should not be mixed in the glass jar because the intense heat generated by the combination of the water and acid is liable to break it. Always add the acid to the water. Earthen jars are now being supplied by some manufacturers. These are stronger, and there is no danger of the heat from the mixture breaking them. The above formulas are only approximate, and manufacturers of the various coils and interrupters will provide detailed instructions

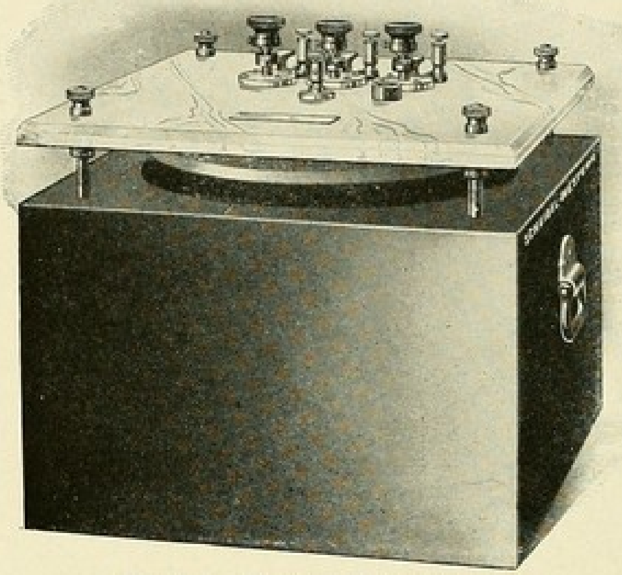


Fig. 54.—Electrolytic interrupter.

for making the electrolytic solution. While the electrolytic interrupter may be used with any current, it gives the best satisfaction with the 110-volt direct and the 110-volt 60-cycle alternating. The

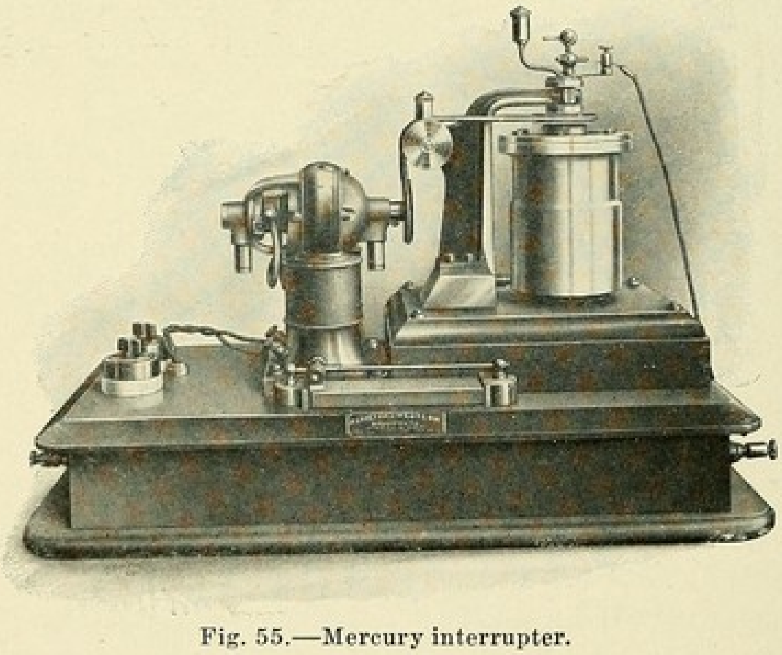


Fig. 55.—Mercury interrupter.

electrolytic interrupter will carry very strong currents, and on this account it is particularly adapted for skiagraphic work.

The mercury interrupter (Fig. 55) can be used only with the direct current, and will give its best service with the 110-volt direct. It is the ideal interrupter where weak current and long exposure are needed. In giving therapeutic applications, as in the treatment of cancer, etc., the mercury interrupter should be used when possible. If much therapeutic work is to be done, a mercury interrupter is indispensable, and no other interrupter is so economical when the tube bill is considered. The mercury will after a time become amalgamated, clogging the machine and stopping the current. It is necessary to empty the contents of the interrupter into a pan, burn off the oil, and strain the mercury

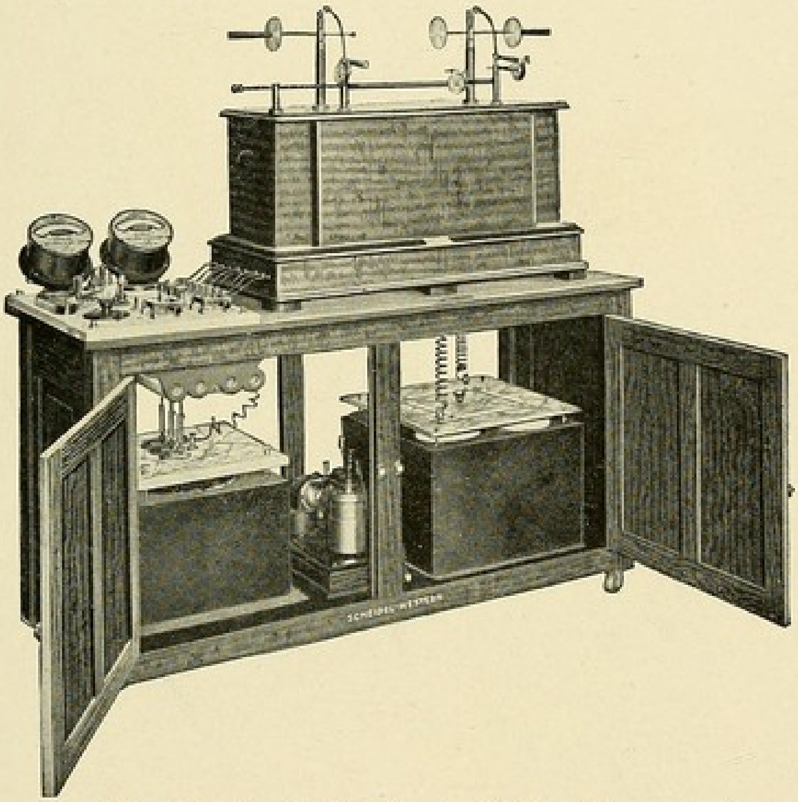


Fig. 56.—Induction coil for direct and alternating currents.

through a cheese cloth to free it from the dirt. About five pounds of mercury are required in the interrupter at a time, and, if any is lost in the process of cleaning, more must be added. From 1 quart to 3 pints of best kerosene oil is poured on the mercury. If too much oil is put on the mercury, the interrupter makes a rattling noise. If the oil is allowed to get too low, strong currents going through the interrupter will generate and explode a gas. The remedy is to put in more oil.

Fig. 56 illustrates a modern induction coil, fitted out with every appliance necessary for doing excellent x-ray work of the most exacting character. It will be noticed that the coil is supplied with both electrolytic and mercury interrupters. When possible to use them, every coil should have both interrupters. As this equipment stands, it is intended for both the direct and alternating currents.

ALTERNATING CURRENT COIL.

The alternating current for commercial lighting is rapidly growing in popularity, gradually crowding out the 110-volt direct current, thereby compelling x-ray operators to provide themselves with

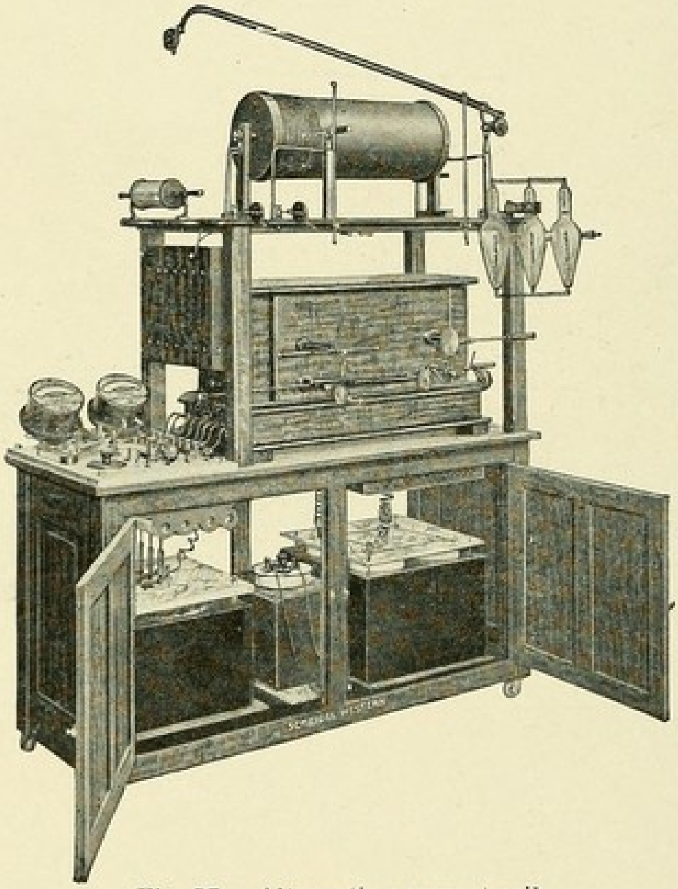


Fig. 57.—Alternating current coil.

apparatus adapted to that current. Fig. 57 illustrates a complete and modern equipment for the alternating current. This coil is provided with a four-jar rectifier and electrolytic interrupter for skiagraphic work, and an antiacid interrupter and step-up transformer for treatment work. This combination makes a very complete equipment for the physician who is, by circumstances, compelled to use the alternating current. This equipment is provided also with a high-frequency resonator of the Oudin type, placed above the coil, which greatly condenses the equipment, saving both space and time in operating. The three-bulb ventril tube, shown in this illustration, is a valuable addition to the equipment, as it chokes back the inverse current, prevents false rays in the tube, and greatly lengthens the life of the tube.

The large number of x-ray coils on the market is very confusing to the inexperienced buyer. Every maker claims that his is the best, and by the time the buyer has examined the various styles of coils he is so thoroughly confused that he is ready to give up in despair.

Most of the coils do fairly good work, but some are far better

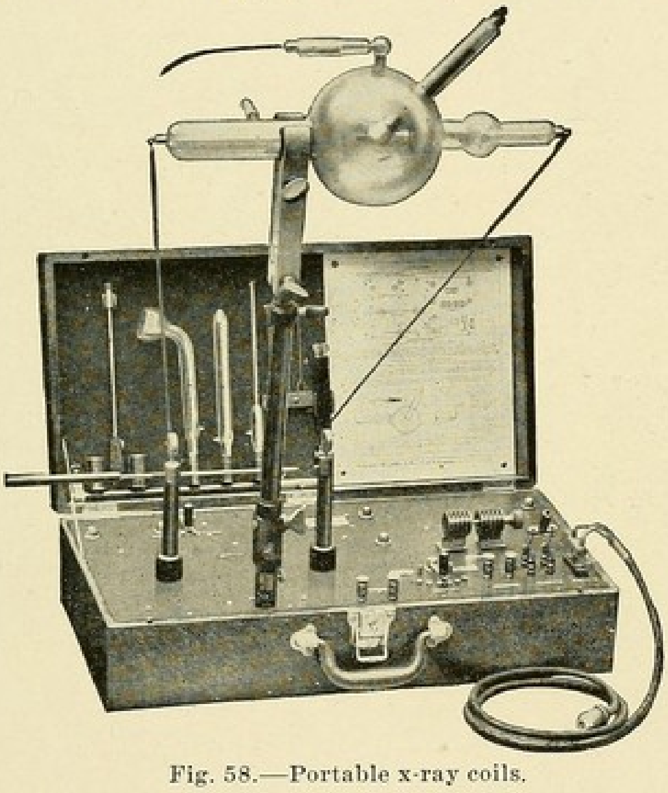


Fig. 58.—Portable x-ray coils.

than others. The test of a good coil is the work it does, and no one should buy a coil until he is capable of judging that work. A coil and tube that will make a good, clear picture through the head or pelvis of an adult in from five to ten seconds will meet all the requirements of an x-ray coil. A coil with a 16-inch spark gap will be as large as needed for the most exacting work.

Quite an interest was taken for a time in portable x-ray coils. These coils are in reality only high-frequency transformers. Fig. 58 is an example of this class of coils, and they are of particular value in many ways. They are small and light, and may be taken in a buggy or auto to any home or institution where the direct or alternating currents can be had. While they are recommended for making skiagraphs of any part of the body, the author has never been able to get a very clear hip picture even in an ordinary-sized subject. The portable coil that he has will do about the same class of skiagraphic work that a good static machine will do. A

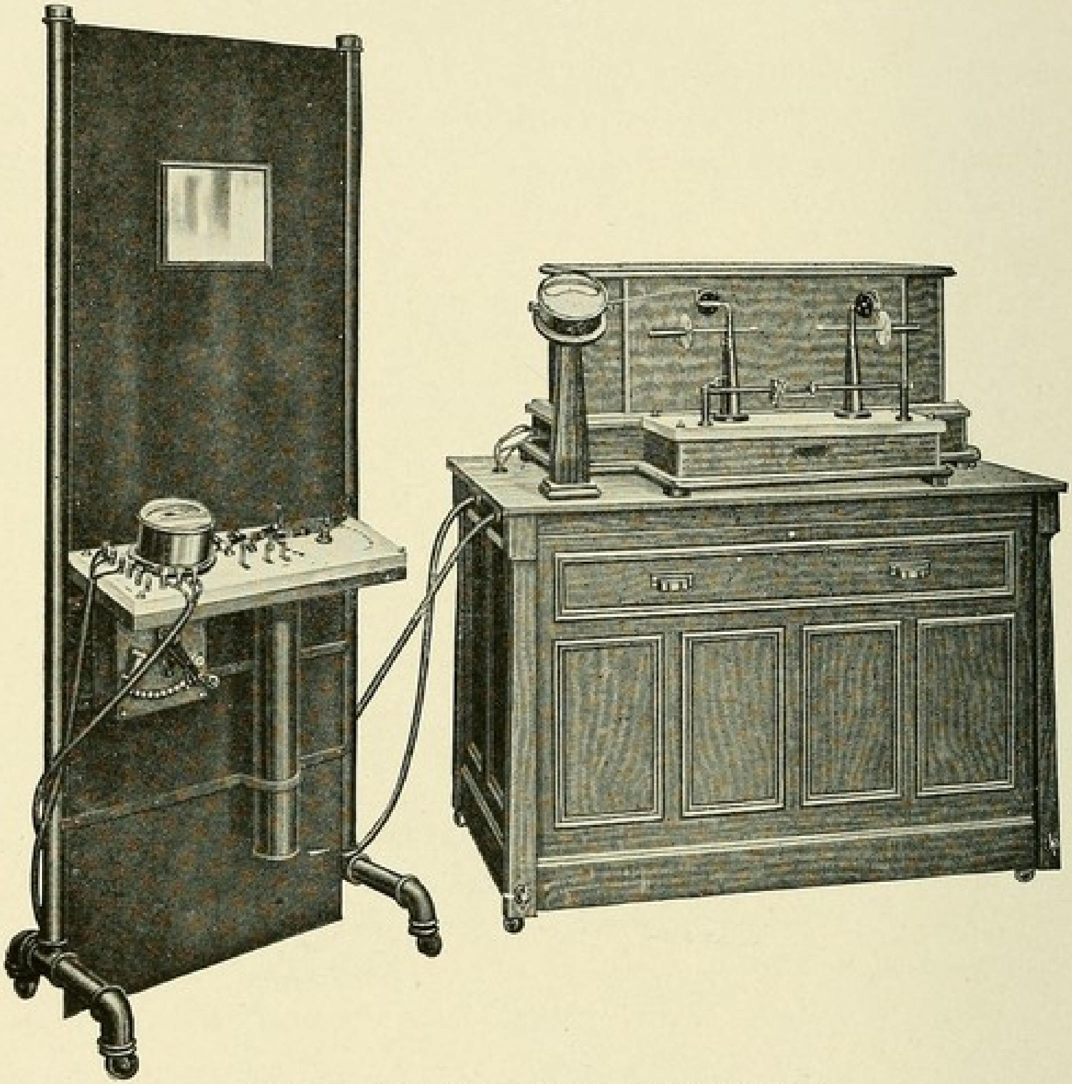


Fig. 59.—Large transformer as x-ray generator.

special double focus tube must be provided for the portable coil, as the ordinary x-ray tube can not be used.

The portable coil will undoubtedly be greatly improved, and, while it will never in any way take the place of the large special skiagraphic coil, it will be a necessary adjunct to the equipment of the skiagraphic specialist in cases that can not be moved to the laboratory.

Both in this country and Europe a large transformer as an x-ray generator is being favorably spoken of. It is claimed that it eliminates the inverse current and that tubes have a much longer life. It is also stated that it is particularly adapted to instantaneous skiagraphic work. If these claims stand the test of time, the transformer will be a great boon to the skiagraphic specialist. Fig. 59 shows this transformer, which is built for either current and any voltage. The manufacturers claim that it requires little or no attention, and that quicker and better skiagraphic work can be done with it than with the induction coil. Even if all this is true, it will be some time before this machine will come into general use on account of the high price asked for it.

The possessor of a good coil may have the high-frequency currents by the addition of the Oudin resonator shown in Fig. 31, which is a type of the step-up transformer. The prime conductors of the coil are connected by means of conducting cords to the inside coatings of the Leyden jars. The out-put of the resonator is regulated by the amount of current going to the primary of the coil, the length of spark gap in the resonator, and the number of turns of large wire on the resonator drum placed in circuit with the outside coating of the Leyden jars. Glass vacuum electrodes are generally used in the administration of high-frequency currents. But one conducting cord is necessary, and it is attached to the binding-post on top of the drum of the resonator.

Vacuum electrodes (Fig. 60) are made to fit all the cavities of the body. They are made in two varieties—the insulated and the noninsulated. The insulated cost more, but they are better because they carry the current directly to the particular parts where the full strengh of the current is needed.

The autocondensation couch (Fig. 32) is operated from the high-frequency resonator by means of two conducting cords, one of which is connected with the binding-screw from the outside coating of the Leyden jars and carried to the metallic plate on the couch. The other cord, from the other Leyden jar connection, is generally held in the patient's hand. The metallic plate is covered with a very heavy insulating cushion, on which the patient is allowed to recline during a seance, which should last from ten to thirty minutes, and be repeated daily for some time, all of which will be fully discussed under the therapeutics of high-frequency currents. The autoconduction cage (Fig. 37) may have some therapeutic indications, but is in no way superior to the autocondensation couch. The reader will probably notice what may appear to him an unnecessary repetition in this chapter, but, since high-

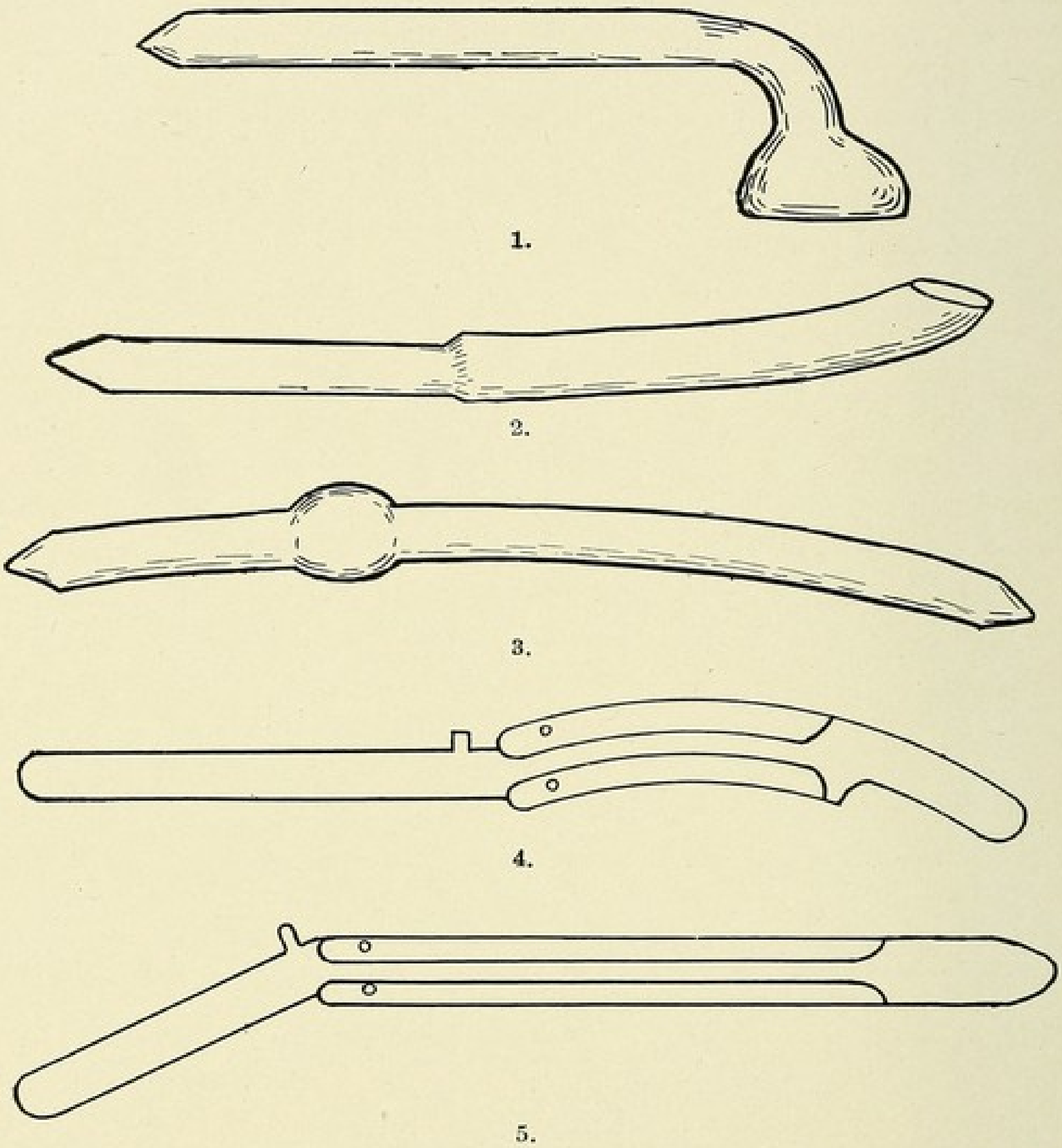


Fig. 60.—Both types of high-frequency glass vacuum electrodes. 1, body; 2, vaginal, noninsulated; 3, rectum, noninsulated; 4, vaginal, insulated; 5, rectum, insulated.

frequency apparatus and modalities are so little understood, the author has made these repetitions for the purpose of popularizing this feature and bringing it into general use.

X-RAY TUBES.

The Crookes, or x-ray, tubes are probably less understood than any other part of the equipment. When new, these tubes have a vacuum of about one-millionth of an atmosphere. The vacuum increases as the tube is used until a point is reached where it will carry no more current. A certain amount of air in the tube is necessary to carry the cathode rays. When the proportion of air is just right, the tube will be working at its best. Tubes are generally spoken of as being low, medium, and high, each having its own particular field of usefulness. Low vacuum tubes contain, comparatively, a considerable amount of air, which checks to some extent the speed of the cathode rays, though greatly increasing their volume. Since a low vacuum tube will carry more cathode rays, but with less velocity, the impact against the target will not be so sudden, and the resulting x-rays, though large in volume, will not have the velocity to reach to great distances. From this fact it is easily understood that low vacuum tubes, though giving off a large quantity of x-rays, have little power of penetration, the slow, weak rays being absorbed on the surface of objects with which they come in contact. This accounts for the fact that a low vacuum tube will produce the most dangerous burns in surface structures, because they are slow and easily absorbed, and rich in chemical rays. Great care should be exercised in the use of such tubes in order to prevent disastrous burns. Tubes of this kind are valuable in the treatment of chronic and malignant skin lesions. Low vacuum tubes can not be used for skiagraphic work, except in the thin parts of the extremities, and then it requires a comparatively long exposure.

Medium vacuum tubes have a higher vacuum, and may be used for treating the deeper structures and skiagraphing all parts, except the deeper structures. Medium tubes are not so apt to burn the tissues, but, when such burns do occur, they are deeper and of a very chronic nature, lasting over many months and even years, if, in fact, they ever get well. High vacuum tubes contain a very small amount of air, and consequently conduct the cathode rays with the greatest possible velocity, giving off in turn x-rays of the most penetrating character. Tubes of this kind require very strong coil currents to energize them, and are valuable only for skiagraphic work and for the treatment of very deep-seated growths. High vacuum tubes are less likely to burn the tissues than the low or medium variety, but it must be remembered that it is not impossible, even with these tubes, to produce a burn in some tissues where the blood supply is poor or the blood impoverished.

Fig. 61 is a diagrammatic representation of a modern heavy coil x-ray tube. This illustration should be carefully studied until the student is familiar with all the different parts of the x-ray tube.

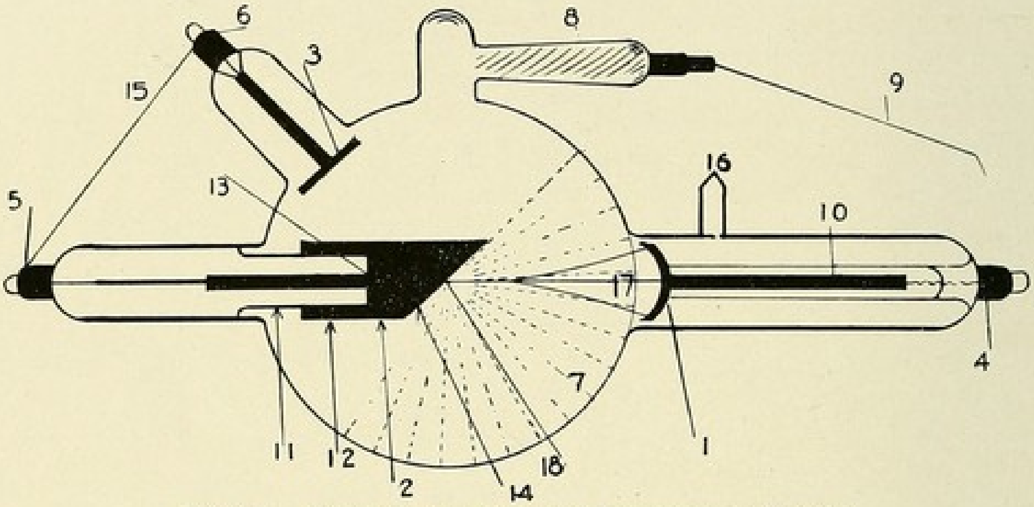


Fig. 61.—Diagrammatic view of a heavy x-ray coil tube.

1. Cathode.
2. Target.
3. Disk terminal. Either or both may be connected as the anode.
4. Cathode cap.
5. Target cap.
6. Disk terminal cap.
7. X-ray hemisphere.
8. Glass pocket containing reducing or vacuum regulating agent.
9. Movable swivel.
10. Glass support for cathode.
11. Glass support for target.
12. Target shell.
13. Base metal of target.
14. Platinum face of target.
15. Wire connecting target and disk to make both terminals the anode.
16. Pumping tip.
17. Cathode stream, generally invisible.
18. Focus spot.

Tubes are of various sizes and of two general kinds—regulating and nonregulating—which may be further subdivided into high-frequency, coil, and static tubes. At first the tubes were nearly

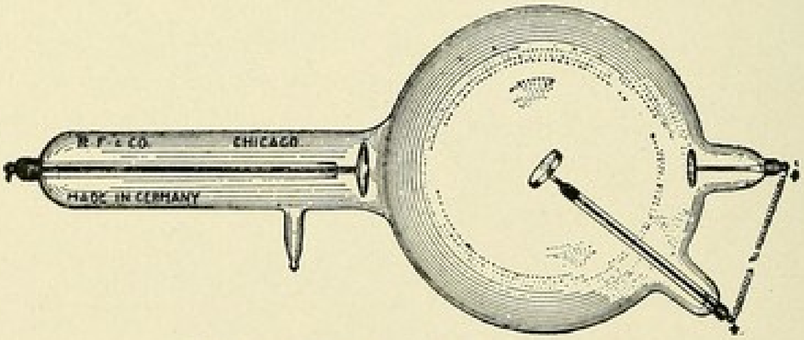


Fig. 62.—Nonregulating x-ray tube.

all of the nonregulating type (Fig. 62). These tubes were not stable, for the vacuum was continually rising, until it became so high that currents could no longer be forced through them. By baking them, it was possible to lower the vacuum for a time, but it was impossible to control them to any degree. They are no longer used as coil tubes, but in some localities static machine workers are using them to a considerable extent—mainly because they are very cheap in first cost, a practice that is the poorest kind of economy. Since good tubes are of the greatest importance, no pains or expense should be spared to procure and keep in perfect working order the very best tubes that skill can make and money can buy. The author has tried almost every tube that has been put on the market, and the experience has been costly in both time and money.

The modern self-regulating tubes (Fig. 63) are far superior to the nonregulating variety, and should be used exclusively. The auxiliary tube on the side at *A* contains a chemical salt which,

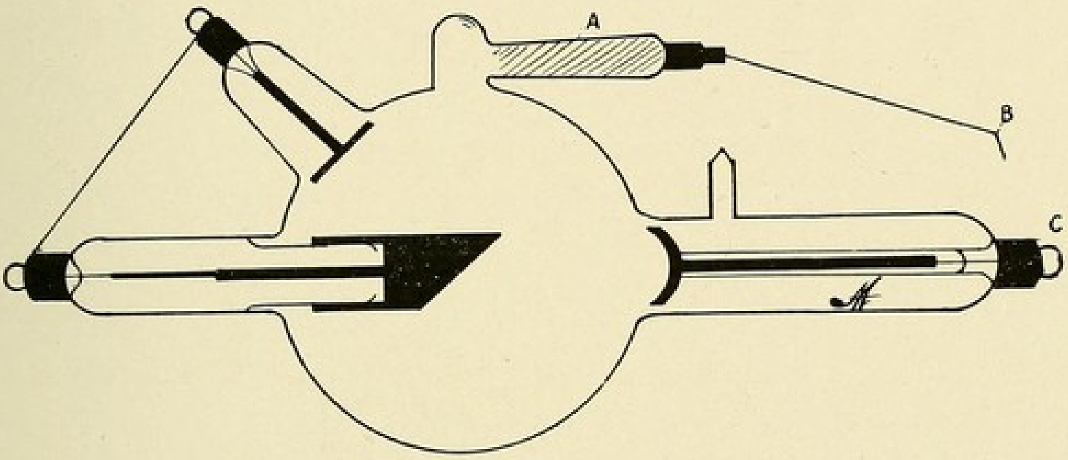


Fig. 63.—Modern self-regulating x-ray tube.

when heated, gives off a gas that enters the main tube and lowers the vacuum to a point where the current will pass through it. The tube is connected to the coil or static machine in the usual way. If the vacuum is too high for the current to pass through it, sparks will jump across between the wire *B* and *C* until enough gas has been liberated from the salt in *A* to lower the vacuum in the main tube to such a degree that it will admit the current through it, when it will light up. The vacuum may be held at this point indefinitely if the current through the main tube is not too strong to overheat it. Very strong currents must not be forced through the auxiliary tube while lowering it, for fear of overheating and breaking the glass.

Fig. 64 is a type of high-frequency tube intended only for the transformer or high-frequency x-ray apparatus as seen in the portable x-ray coils shown in Fig. 58. These tubes are generally strongly built, and are all of the automatic regulating variety. It must not be forgotten that they are the only tubes that can be used with these portable coils for x-ray work.

The coil tube comes in for a large share of our consideration, for upon it depends our success or failure in skiagraphic work. These

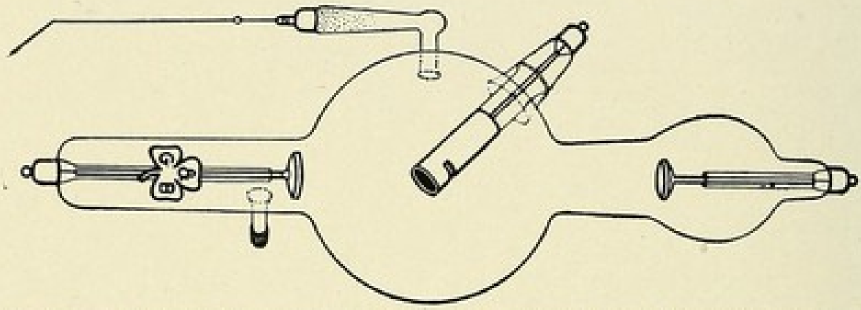


Fig. 64.—Modern self-regulating x-ray tube. For use with high-frequency transformer like the portable x-ray coil.

tubes are heavier and stronger than the static tubes, and will stand many times the amount of current without overheating or puncturing.

Fig. 65 represents an excellent type of coil tube. It will be noticed that the target (anode) is very strongly and heavily built. It is said by the makers that this target is a heavy piece of copper, faced with a metallic alloy that will stand double the heat of platinum. This is again surfaced with a thin (.001-inch) plate of platinum-vidium. With strong currents the author has been able to

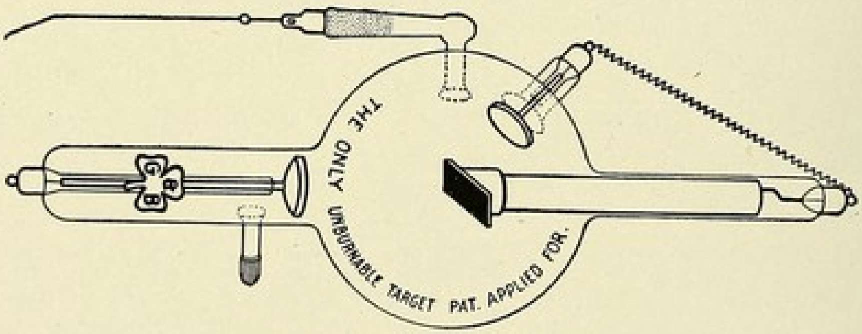


Fig. 65.—X-ray coil tube.

melt the face of this disk or target, but nothing is gained and everything is lost by using currents of this strength. When the face of the target is melted, it becomes roughened, and the efficiency of the tube is destroyed for skiagraphic work. When the target is heated to the melting point, it gives off a considerable amount of gas, and the tube is lowered to such an extent that the rays lose their power of penetration, making it necessary to allow the tube to rest until cool, when it will have regained its vacuum. When properly handled, these tubes will last for a long time, even for the heaviest skiagraphic work. As the tube gets older, the vacuum will grow higher and higher, and after a time it will be necessary to reduce its vacuum a little every time it is used. This process requires great care to keep from overheating and puncturing the auxiliary tube. There is very little danger of getting the vacuum too low in these extremely high tubes, but, if such should occur, a very few minutes' rest will allow the tube to regain a sufficient vacuum to do good work. With a spark gap of 5 to 6 inches between *B* and *C* (Fig. 63), the tube should work to its full capacity for thirty seconds without lowering its vacuum enough to destroy its efficiency. With the best of care, it will be noticed that these tubes get higher and higher in vacuum. The inside walls become covered with a fine dust from the target that gives them a bluish-black appearance. It is thought that these heated particles absorb a portion of the gases of the tube as they are thrown off from the target by the impact of the cathode rays. The more the tube is used, the greater will be this process, until so much of the gas is taken up and imprisoned that the cathode rays will no longer find a means of conduction through the tube, after which it becomes useless unless returned to the makers and repumped, when it may do fair work for a time, but can not be depended upon as when new.

High-vacuum tubes that will do good skiagraphic work should never be reduced for therapeutic purposes, but should be kept for skiagraphic work only. Well-built coil tubes are sometimes received that are very low in vacuum, in which case they may be used for therapeutic work until the vacuum has increased to a point where the x-rays are sufficiently penetrating to make good skiagraphs.

Tubes are a very expensive part of the equipment, and are often a source of much annoyance. In inexperienced hands they frequently puncture or lose their vacuum when most needed, while in the hands of a master they may be made to last a considerable while, working at their best all the time.

Besides the regular tubes, there are a number of specialty tubes on the market that deserve mention. These tubes are made in many shapes and are adapted for the cavities of the body. Fig. 66 is what is known as a **shield glass treatment** tube. The tube is made of leaded glass, with a window of lead-free glass through which the rays pass. Leaded glass speculums of different sizes are provided with these tubes. These speculums are a great protection to both

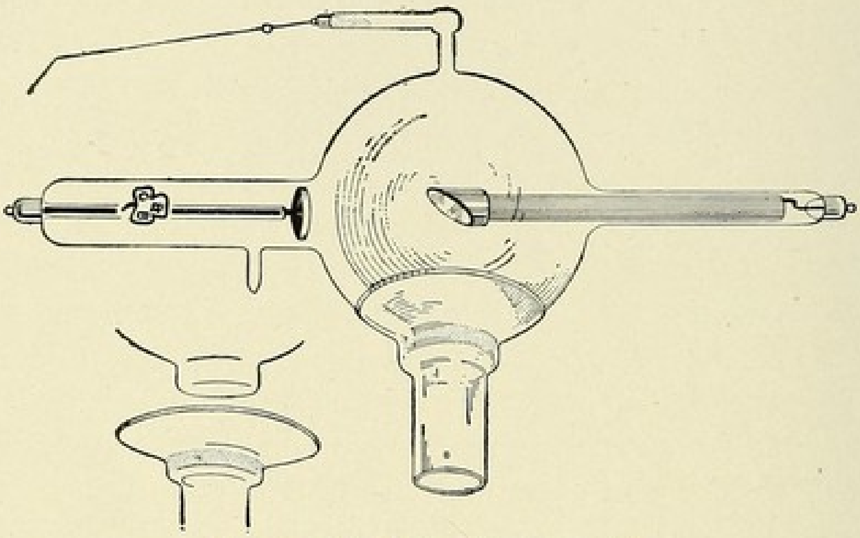


Fig. 66.—Shield glass treatment tube.

patient and operator, and should be used in all treatment work where possible. In treating vaginal and uterine conditions, the

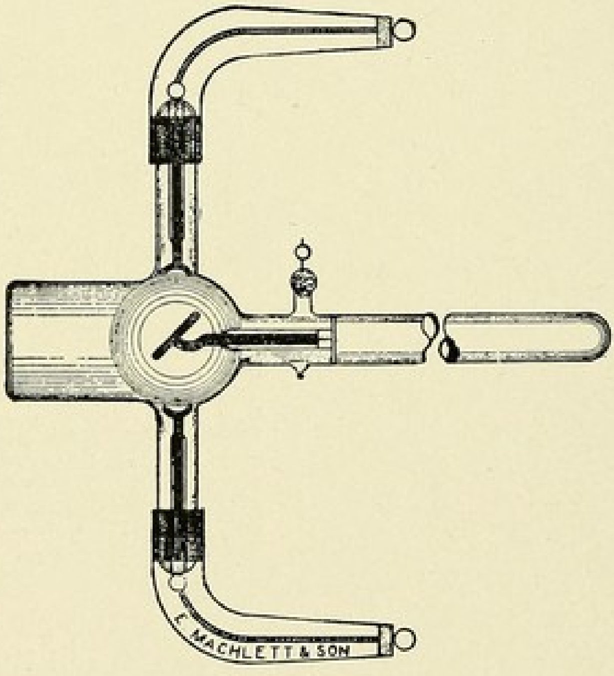


Fig. 67.—Cornell tube.

author has found the Cornell tube (Fig. 67) to render splendid service. Although very small and apparently frail, these tubes will with ordinary care last a surprisingly long time. At first this tube was not considered of much value, but after an experience of more than two years in the treatment of a number of cases the conclusion is that, while it is impossible to cure these malignant uterine conditions by this or any other method, the daily use of x-radiation through the vagina with a Cornell tube will give the patient more comfort than any other method the author has tried.

There are a great many tubes that might be mentioned, some of which are very good, but space will not allow a discussion of all. A discussion of the water-cooled tubes has been purposely omitted because they are not believed to be practical. The anodes in the water-cooled tubes are entirely too light for heavy skiagraphic purposes. The author has never seen one that would not burn out in a very few seconds when used for deep picture work.

All the skiagraphic work of the author is done with a 7-inch tube on a 24-inch induction coil, with an electrolytic interrupter. Tubes have caused 95 percent of all the trouble encountered and will probably continue to cause trouble.

CHAPTER VII.

ACCESSORY X-RAY APPARATUS.

The accessory apparatus for x-ray workers, as listed in the catalogues, have become so numerous that it seems wise to devote a few pages to a discussion of the most practical pieces that are almost indispensable if good and rapid work is to be done.

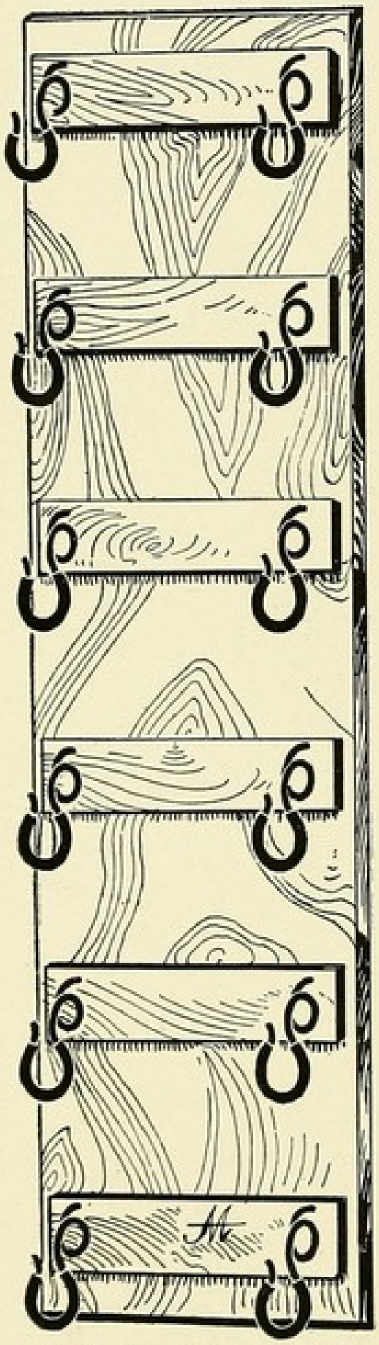


Fig. 68.—Tube rack for holding x-ray tubes.

The penetrating properties of an x-ray tube are usually measured by the length of spark it will back up between the prime conductors of the coil or static machine. Low tubes will back up from 1 to 2 inches, medium tubes from 2 to 3 inches, and hard tubes from 3 to 5 inches or more. Since the tubes vary greatly in vacuum, and consequently in their power of penetration, several measuring devices have been brought out for the purpose of estimating the penetration of the rays of a tube in action. Instruments of this kind are called skiameters. The Walter skiameter consists of sixteen pieces of tin-foil of varying thicknesses, before which is placed a screen of barium-platinum-cyanid, all made into a kind of fluoroscope. The penetrating properties of the rays are read off by the lumination of the squares of tin-foil as indicated by the numbers on each. The Benoist skiameter consists of twelve aluminum disks of varying thicknesses arranged about a central silver disk of standard penetration. When placed between an active tube and a fluorescing screen, the penetration of the tube is determined by the disk that is equal in density to the central silver disk. Other devices, as the chromo-radiometer and the osteoscope, have been recommended, but none are practical. The x-ray operator will in time become so familiar with the behavior of his tubes that he can determine at a glance if a certain tube is low or high.

Fig. 68 is the author's tube rack. The habit of laying tubes on tables, putting them on top of desks or static machines, or into cases or boxes, is a bad one. Where several tubes are used, this rack will be found a valuable convenience. It is cheap, and can be made by the physician or a carpenter. It should be fastened to the wall in some out-of-the-way corner, and will be the means of

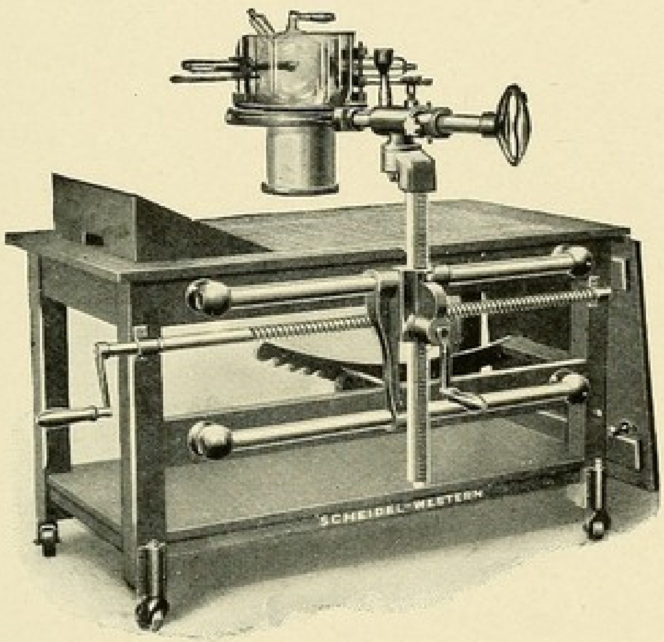


Fig. 69.—Skiagraphic table and compression diaphragm.

protecting from injury many valuable tubes. The supports are made of No. 8 soft iron wire, covered with ¼-inch rubber tubing.

Fig. 69 illustrates a very complete skiagraphic table and compression diaphragm. The table is very strong and substantially built, and will not vibrate if the floor is solid. The compression diaphragm here shown is complete in every part, being flexible and adjustable, giving ample range of tube distance between the subject and the tube, a defect in some of the apparatus because of the fixed length of the diaphragm tube.

The fluoroscope (Fig. 70) should be in size either 5x7 or 6x8 inches. The screen should be made of the best barium-platinum-cyanid, with a very fine grain, and, for protection from dirt and dust, should be covered with a plate of glass. While the fluoroscope is valuable in determining and aiding in the removal of foreign bodies, examination of fractures, dislocations, etc., its frequent use is a very dangerous practice. Fluoroscopic work is fascinating, and the operator is apt to be lured on and on by revelations of hidden conditions that cause him to lose sight of self-interests until he wakes up some day to the terrible fact that he is a victim of a

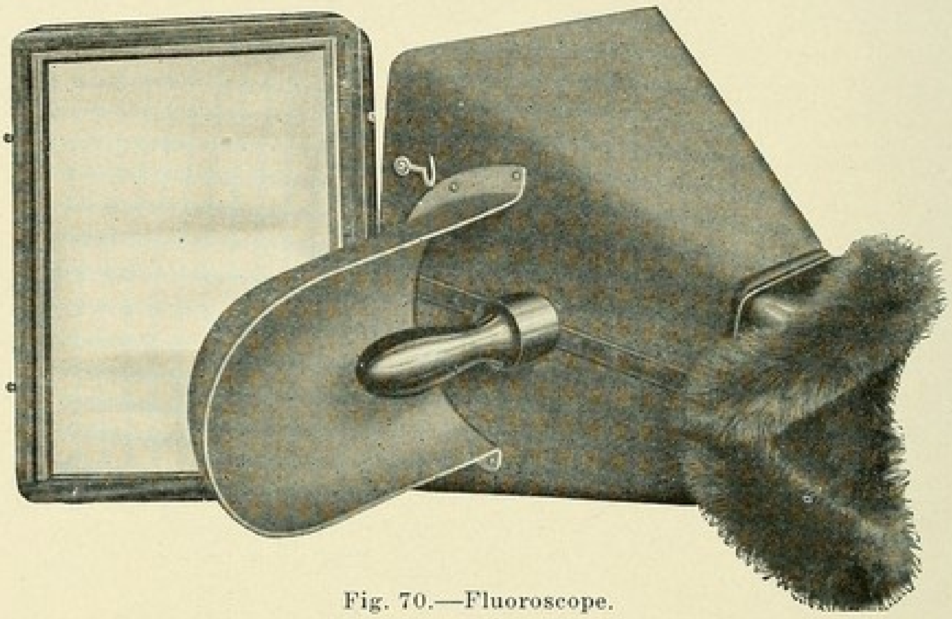


Fig. 70.—Fluoroscope.

deadly x-ray burn. The author keeps a good fluoroscope in the operating room for physician friends, to use when occasion demands such examinations, but he never uses it. The fluoroscope should be kept in a dark, dry place, free from dust, and not allowed to be thrown about the room, as is too often the case. After a few months to a few years the screen turns orange or a dirty-brown, showing first at the edges, when it has lost a good deal of its fluorescence and should be discarded.

TUBE SHIELDS.

Various kinds of tube shields have been recommended for therapeutic work. The protection idea is a good one, but the tube shields, except glass, seem to shorten the life of the tube by carrying a part of the current around the tube, making it necessary to use stronger currents and thereby increasing the liability to puncture. The author has discarded tube shields, except those of glass.

LEADED GLASS TUBE SHIELD.

The leaded glass tube shield (Fig. 71) is the only shield that does not seem to shorten the life of the tube. It protects both the operator and the patient, and allows the tube to be seen at all times. This tube shield is used with the compression diaphragm shown in Fig. 69. Both the tube and shield should be thoroughly wiped after each treatment to free them of the dust that rapidly accumulates on their surface when in use.

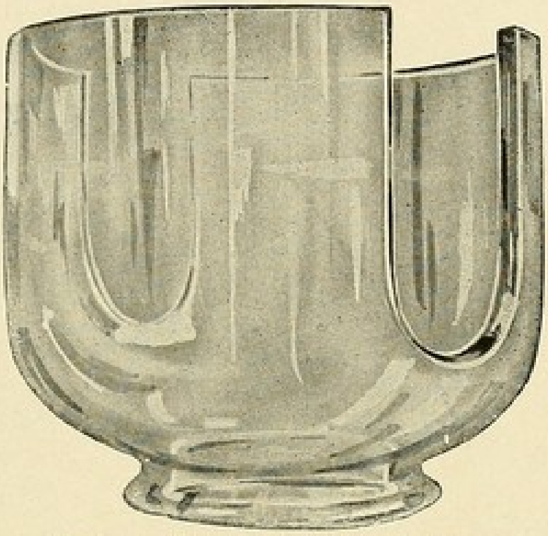


Fig. 71.—Leaded glass tube shield.

Where a great deal of skiagraphic work is done, the operator should stand behind a leaden screen (Fig. 72) and observe the tube through a leaded glass window in the top. It is the custom of some operators to wear leaden aprons, gloves, and glasses, but, if the screen is properly used, it will afford all the protection necessary.

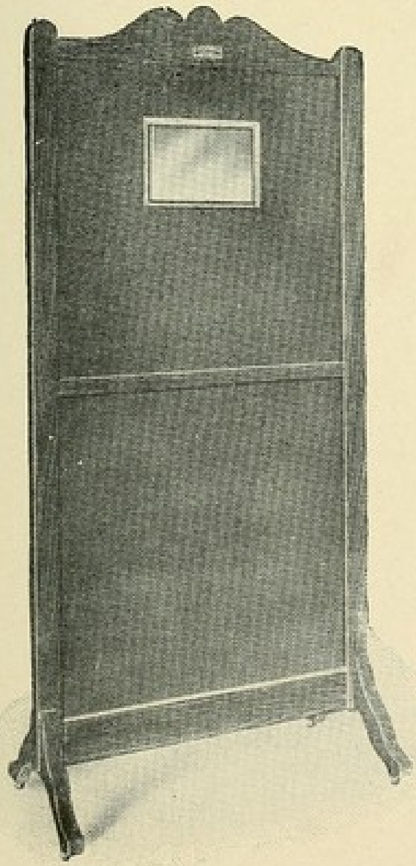


Fig. 72.—Leaden screen.

While on the subject of protection, a word of warning is given to the operator not to become careless, for, if he does, he will pay the penalty of an x-ray burn; it may be slow in coming, but it will surely come, and great will be the punishment.

We will have more to say on the subject of x-ray burns in another chapter; in fact, it will be mentioned at every opportunity, for it is hoped to so impress the operator with the horrors of such burns that he may protect both himself and patient at all times.

X-RAY PLATE BOX.

If any considerable amount of skiagraphic work is to be done, some means of protecting the plates from the destructive influence of the rays is necessary. The operator will have to keep a stock of plates

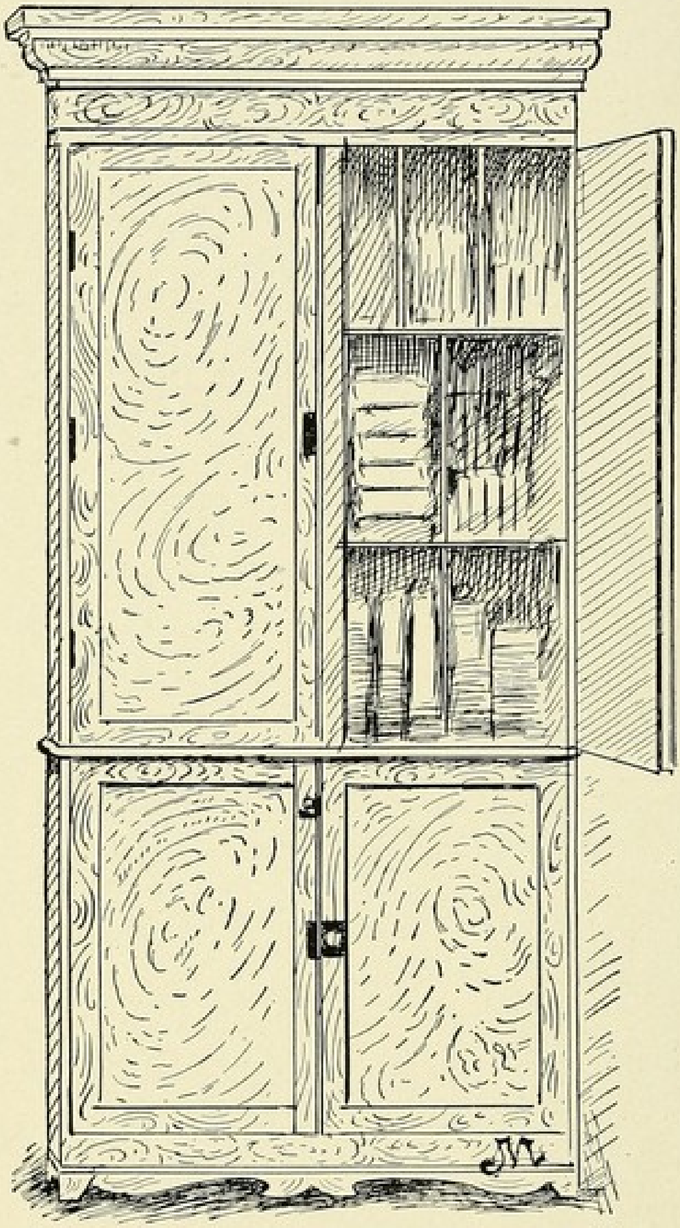


Fig. 73.—X-ray plate box.

somewhere near the operating room as a matter of convenience. Fig. 73 is an illustration of the author's plate box. It is built to hold half a gross each of 11x14, 10x12, and 8x10 plates, and many smaller sizes for photographic work. The box is lined with sheet lead $\frac{1}{16}$ inch thick, neatly soldered in all corners, and made to lap over all edges in front where the doors close. This box is placed in a room next to the coil room, and has protected many plates over a long period of time. The box might be made much smaller where but few plates are to be used.

STORING NEGATIVES.

In the course of time many fine negatives will accumulate, and the operator will want some systematic method of storing and preserving them. It would be better not to keep them at all than to pile them away on a shelf in a haphazard way, where it would be impossible to find one when needed without a great deal of trouble and loss of time. Quite frequently a skiagraph is made for a patient injured in a railroad accident, the resulting lawsuit is dragged out over many months, and you are often called to furnish the facts as you found them. In most cases the negatives are required in evidence, and it is always embarrassing, when summoned, not to be able to find the particular negative. A thorough and systematic method of filing all valuable negatives that may be needed at any time will not only save the operator a great deal of time and trouble, but will impress those desiring his services with the fact that he is both practical and careful about his work, and thorough in what he does.

Fig. 74 is an illustration of a card index negative filing cabinet designed by the author, and has met all the demands and requirements that have been made upon it. It is built in compartments that will hold fifty negatives each, the whole cabinet holding sixteen hundred negatives, and containing a 5x8-inch card index drawer. A careful record of each negative is made, and the negative and record filed in the index drawer in alphabetical order. Each case is carefully interrogated as to the cause, time, place, and manner of accident, and the patient's version taken just as he understands it. The version may not be entirely true, but in the majority of cases the patient will come nearer telling the facts if seen soon after the injury than at any other subsequent time, and especially before he has been seen by a designing attorney, who is constantly on the lookout for cases of injury, real or supposed. We will have more to say on this particular subject under "Medico-Legal Aspect of the X-Ray" (Chapter XXIII).

The records of these cases are taken on cards printed on both

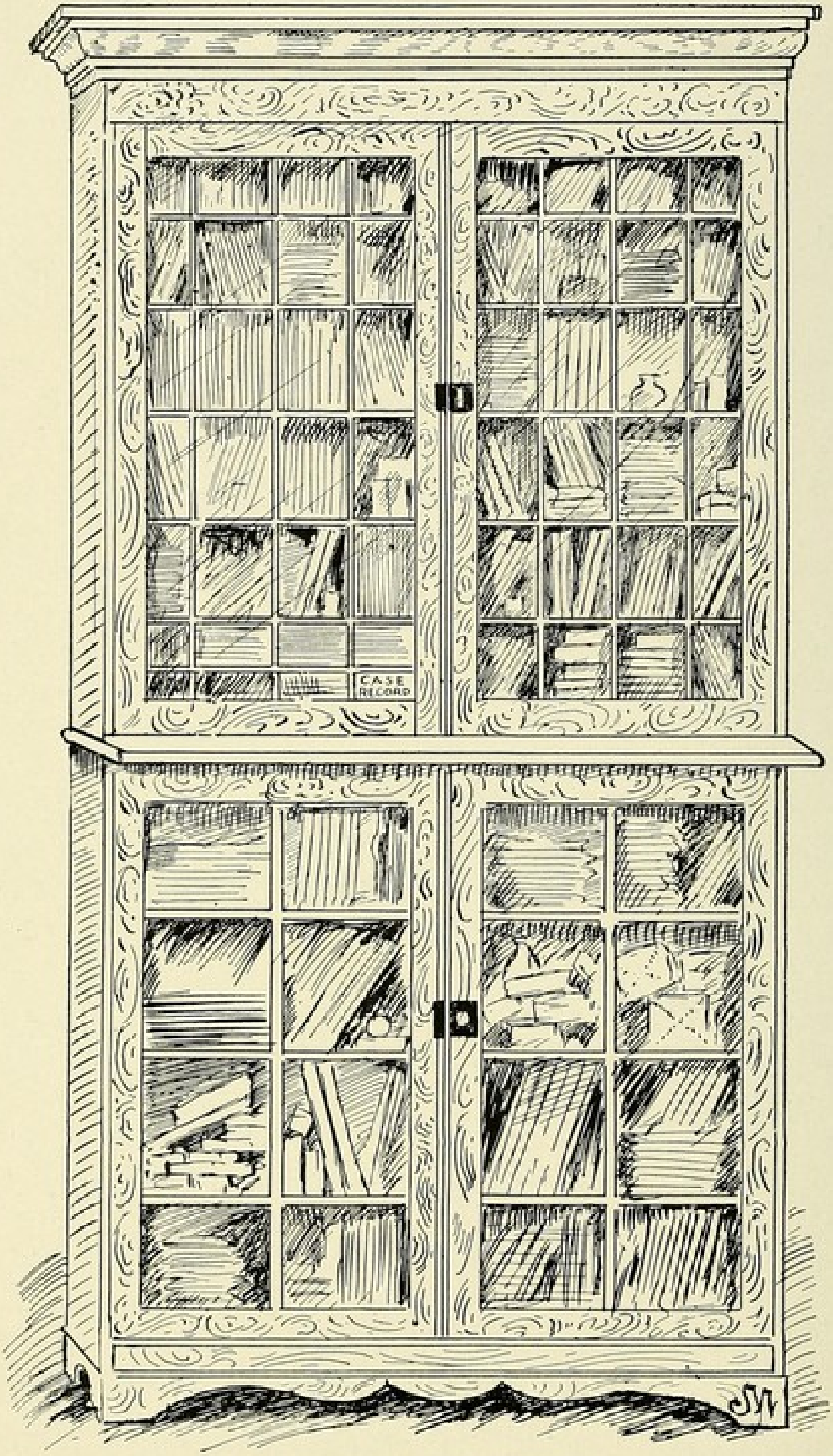
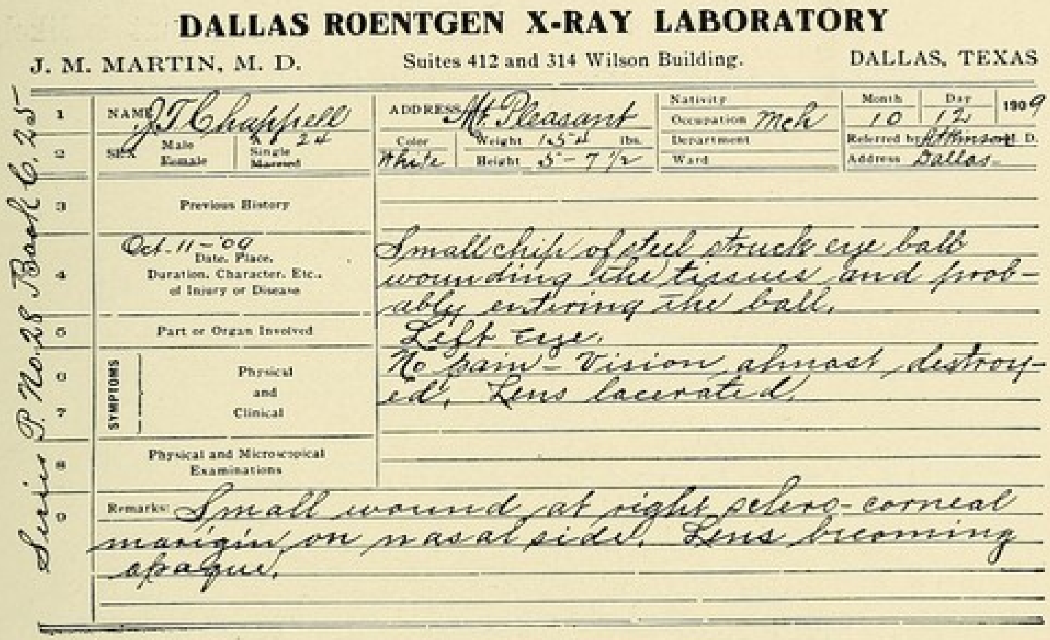


Fig. 74.—Negative filing cabinet.

sides. Fig. 75 represents one side of the card and is the history of the case as the patient remembers it at the time the examination is made. This includes his name, residence, occupation, and other



DALLAS ROENTGEN X-RAY LABORATORY

J. M. MARTIN, M. D. Suites 412 and 314 Wilson Building. DALLAS, TEXAS

Series P. No. 28 Book C. 25

1 Name J. T. Chappell — Address Mt. Pleasant — Nativity — Occupation Mch — Month 10 Day 12 1909

2 Sex Male Female — Age 24 — Single Married — Color White — Weight 154 lbs. — Height 5'-7½ — Department — Ward — Referred by Atkinson M. D. — Address Dallas

3 Previous History

4 Oct. 11-09 Date, Place, Duration, Character, Etc., of Injury or Disease — Small chip of steel struck eye ball wounding the tissues and probably entering the ball.

5 Part or Organ Involved — Left eye.

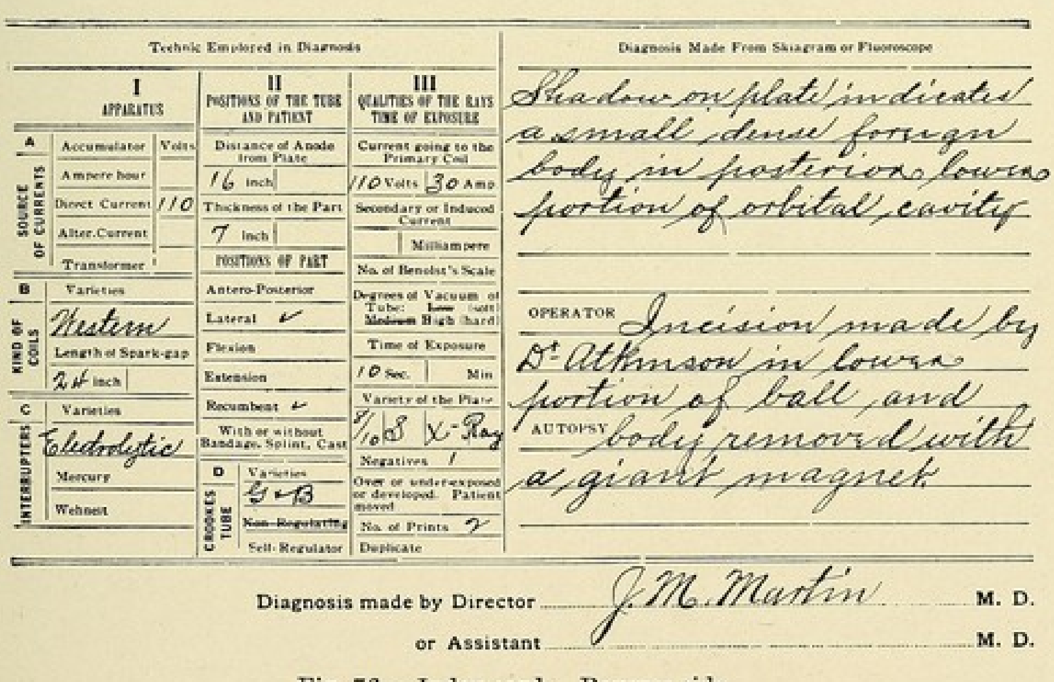
6 Symptoms — Physical and Clinical — No pain - Vision almost destroyed,

7 ed, Lens lacerated.

8 Physical and Microscopical Examinations

9 Remarks: Small wound at right sclero-corneal margin on nasal side. Lens becoming opaque.

Fig. 75.—Index card. Front side.



Technic Employed in Diagnosis — Diagnosis Made From Skiagram or Fluoroscope

I Apparatus — A Source of Currents: Accumulator, Volts; Ampere hour; Direct Current 110; Alter. Current; Transformer — B Kind of Coils: Varieties Western; Length of Spark-gap 24 inch — C Interrupters: Varieties Electrolytic; Mercury; Wehnelt

II Positions of the Tube and Patient — Distance of Anode from Plate 16 inch; Thickness of the Part 7 inch; Positions of Part: Antero-Posterior; Lateral ✓; Flexion; Extension; Recumbent ✓; With or without Bandage, Splint, Cast — D Crookes Tube: Varieties G & B; Non-Regulating; Self-Regulator

III Qualities of the Rays Time of Exposure — Current going to the Primary Coil 110 Volts 30 Amp; Secondary or Induced Current, Milliampere; No. of Benoist's Scale; Degrees of Vacuum of Tube: Low (soft) Medium High (hard); Time of Exposure 10 Sec. Min; Variety of the Plate 8/10 X-Ray; Negatives 1; Over or under-exposed or developed. Patient moved; No. of Prints 2; Duplicate

Shadow on plate indicates a small dense foreign body in posterior lower portion of orbital cavity

Operator Incision made by Dr. Atkinson in lower portion of ball, and

Autopsy body removed with a giant magnet.

Diagnosis made by Director J. M. Martin M. D.

or Assistant M. D.

Fig. 76.—Index card. Reverse side.

important points as shown by the card. The number and series of the negative in the filing cabinet is written across one end of this side. On the reverse side of this card (Fig. 76) is recorded the facts as revealed by the examination. When the negative is developed and dried, it is studied over an illumination box, as shown in Fig. 77, and the report is made according to the findings, regardless of what the symptoms may have been. Though short, the record is complete and answers every important point that is likely

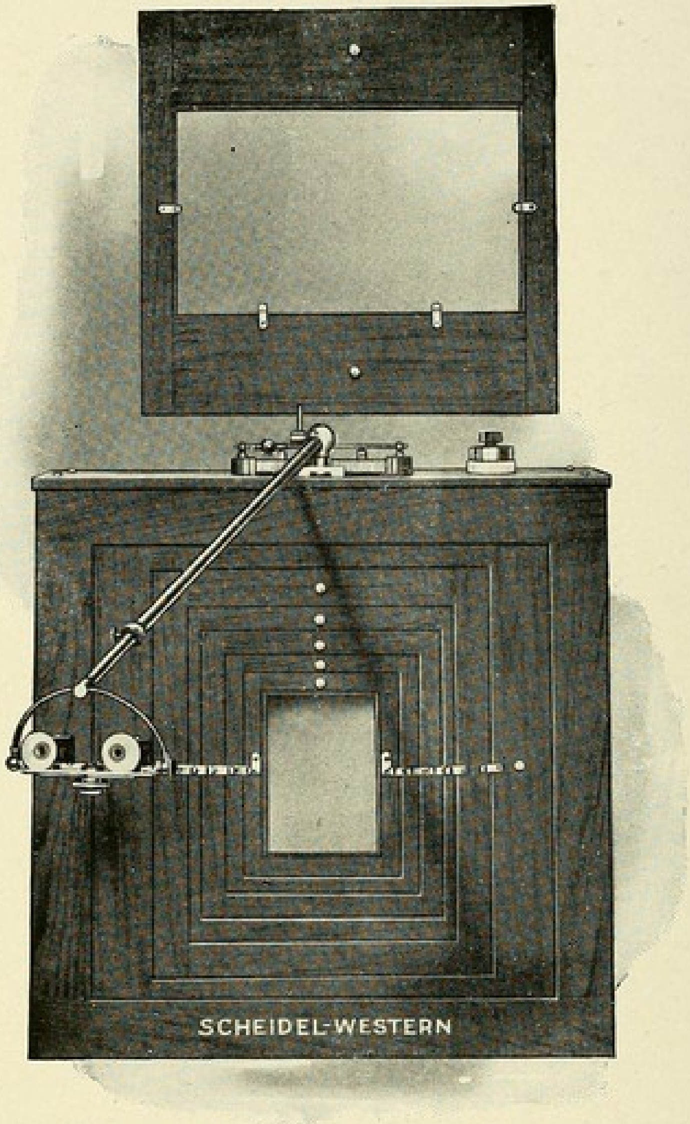


Fig. 77.—Negative illumination box.

to arise in any case. Each plate is given a letter and a number that corresponds with the compartment to which it belongs, the reference being placed on the film side with a soft lead pencil. The plate is now placed in an envelope, on which are written the same letter and number that were written on the plate. At first thought it may appear that this will entail too much work, but, if adopted, it will be found to require very little work compared with the great loss of time and worry in trying to care for a lot of negatives without a system.

For additional convenience a 3x5-inch card index drawer may be placed in the cabinet. In this drawer a card is to be assigned to each physician who has sent a patient to the laboratory, and on this card is to be recorded the name of such patient and the nature of the case, which will serve as a kind of cross index. The operator may, after a time, forget the name of a certain patient, but remembers an interesting case from a physician that he would like to review, and by referring to these cards he will be able to obtain the name of the patient and refer to the case in question. If the skiagraph is desired or negative wanted, it is only necessary to look in the larger index drawer for the report, and then go to the particular compartment for the negative, all of which is done in much less time than it requires to read the description of the method. Other methods may be adopted as circumstance and necessity require.

ILLUMINATION BOX.

When the negative is finished, it may be held before a good white light for examination. A good north light through an open window will answer with most negatives, but, when the negative is dense or thick, a stronger light will be required. For this purpose the negative illumination box (Fig. 77) will be of the greatest assistance in studying the plate. It is a box containing six strong electric lights, having either frosted or clear globes, with a piece of ground glass over the front of the box. The box should either be of tin or lined with asbestos, and care taken to turn out the lights when not in use.

CHAPTER VIII.

METHODS OF APPLYING CURRENTS.

It is expected that the physician has familiarized himself with the contents of the preceding chapters, and understands the wall plate and its manipulations. The galvanic current is carried into the tissues through electrodes.

Electrodes are of three general kinds—body, cavity, and tissue electrodes—as follows:

(1) Surface electrodes.

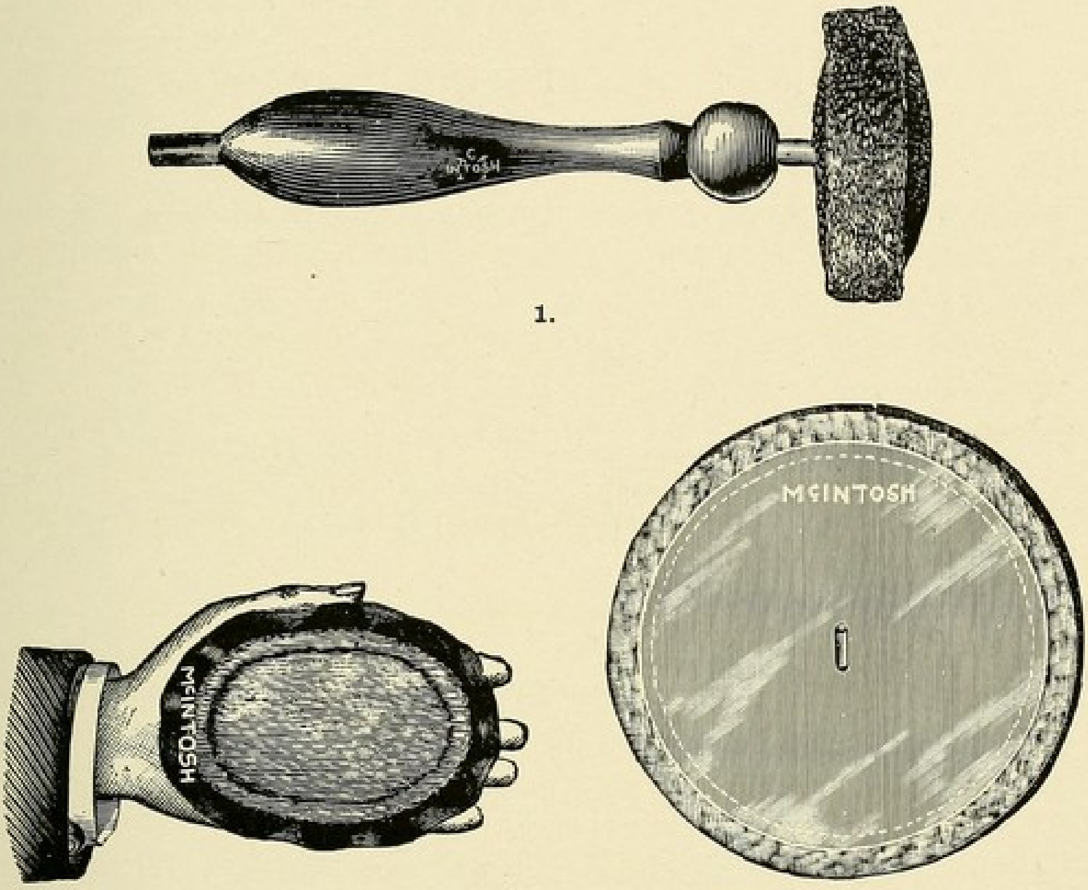
(2) Bare metallic electrodes, used in moist mucous cavities.

(3) Sharp metallic electrodes, forced directly into the tissues.

SURFACE ELECTRODES.

The surface electrodes are made in various sizes and shapes, the sizes varying from ½ to 20 or more square inches. The larger sizes are made with a metallic disk, covered with some good absorbent—as cotton or spongiopiline—thoroughly soaked in an alkaline solution or thoroughly saturated with an alkaline soap. The use of soap on the surface electrode facilitates its movement over the surface of the body, and makes cleaning the electrode an easy matter.

Fig. 78 (1, 2, 3) shows the surface electrodes in general use. 1 is a small round electrode about 2 inches in diameter, two of which are usually sent with the battery equipment. 2 is about 4x6 inches, and may be used as an indifferent electrode where medium currents are required. 3 is 8 or 10 inches in diameter, and will be useful in gynecological work as an indifferent electrode where large currents are needed. Very small electrodes may be necessary in testing the reaction of single nerves and muscles. Bare metallic electrodes are never used in making galvanic surface applications. The covering should be even over the entire surface of the electrode to avoid an increase in density at any spot where electrolysis might occur. Where the skin is broken from any cause, the current will meet with very little resistance, and the density may be beyond the endurance of the patient. Severe and troublesome burns may be caused in this way. All abrasions in the skin should be protected by covering them with small squares



1. 2. 3.

Fig. 78.—Surface electrodes.

of rubber or oxid of zinc plaster. The size of the electrode is important, as the density of the current in the tissues decreases as the size of the electrode increases, the intensity or current strength remaining the same.

The density per unit of surface area of an electrode may be found by dividing the current strength in milliamperes by the size of the electrode in square inches or centimeters, as the case may be. An electrode of 60 square inches may carry a current of 150 milliamperes with comfort, while the same current through an electrode of 10 square inches would be painful. When the continuous flow of the galvanic current is to be used for any considerable time, the electrodes should either be large or the current weak.

BARE METALLIC ELECTRODES FOR MUCOUS CAVITIES.

These electrodes are usually applied bare, and may be connected with either pole, depending upon the particular chemical effect required. These electrodes are made of pure metallic copper, zinc, or silver, and occasionally of nickel-plated brass. All plated electrodes are intended for negative electrolysis, while the copper, zinc, and silver electrodes (soluble) may be used on either pole, but are

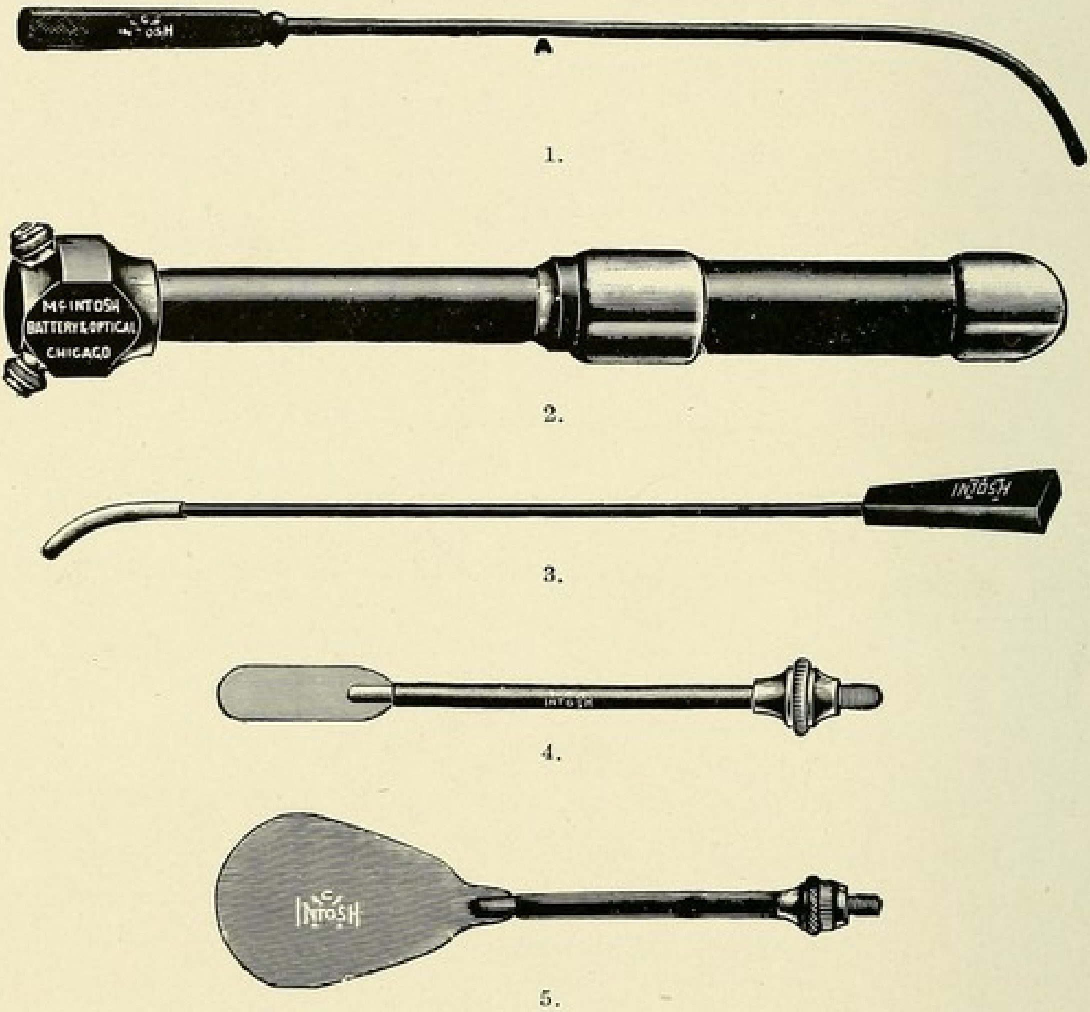


Fig. 79.—Metallic electrodes for mucous cavities. 1, urethral; 2, vaginal; 3, uterine; 4, eye; 5, tongue.

particularly designed for **cataphoresis** with the positive pole. These electrodes are made in various sizes and shapes for the urethra, uterus, and other mucous cavities and surfaces. Fig. 79 shows the various metallic electrodes of this class: 1, urethral; 2, vaginal; 3, uterine; 4, eye; 5, tongue. Other shapes might be shown, but these are representatives of their class. All metallic electrodes should be kept clean and bright. They should be cleaned immediately after having been used, and not allowed to remain dirty until needed again, as is often the case.

SHARP METALLIC ELECTRODES FOR USE IN THE TISSUES.

Electrodes of this class may be of any material, but zinc and steel are ordinarily used (Fig. 80). 1 is a sharp, flat zinc electrode used in the treatment of cancer. It is used at the positive pole, and is generally amalgamated with mercury just before being pushed into the tissues. Particles of both zinc and mercury are

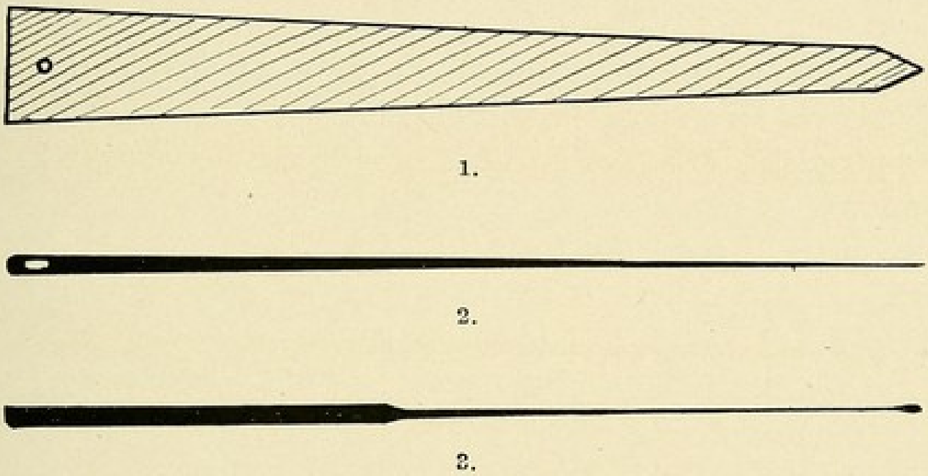


Fig. 80.—Sharp metallic electrodes.

carried into the tissues by cataphoresis, which will be fully explained in another chapter. 2 is a sharp needle electrode—a cambric needle free from rust will answer. Electrodes of this kind are always used at the negative pole for their electrolytic effect on moles, warts, and other small growths of a nonmalignant type. 3 represents a Hayes bulbous-pointed needle, and used only in the removal of superfluous hair.

The uses of these electrodes will be fully explained under the subjects of electrolysis and cataphoresis. Many forms of electrodes are in common use, and will be illustrated and explained in the proper place. Care should be exercised in selecting well-made electrodes and only such designs as will be required. Few physicians, if any, will ever find need for all the various shapes and designs illustrated in the catalogues sent out by the various manufacturers.

CHAPTER IX.

APPLICATION OF THE DIRECT CURRENT TO THE HUMAN BODY.

When any part of the human body is made a part of the circuit of the galvanic current, the effect upon the tissues may be divided into two general classes:

(1) **Biological effects,** common to all living animal organisms, and characterized by **contractile** and **electrotonic** effects.

(2) **Effects** common to animal tissue and metallic conductors, and known as **electrolytic** and **cataphoric.**

The **physiological effects** will depend upon the manner in which the current is permitted to flow into the patient's circuit. The current may be suddenly turned into the patient's circuit and as suddenly returned to zero, producing an interrupted current, with contractile effects. This method of rapidly changing the current strength in the tissues is known as **opening** and **closing** periods. The current may be allowed to enter the patient's circuit gradually until the required intensity is reached, and as gradually withdrawn. This is known as the steady flow of the direct current, the effects of which are **electrotonic, electrolytic,** and **cataphoric.**

ACTION OF THE DIRECT CURRENT ON MUSCLE TISSUE.

Direct muscle stimulation is produced by applying the current directly to the muscle.

Indirect stimulation is produced by applying the current to the nerve supplying the muscle.

EFFECTS OF THE STEADY FLOW OF THE DIRECT CURRENT.

The effects produced by the steady flow of the direct current will depend upon the kind of electrodes and whether they are covered or bare—whether the metal is in contact with the mucous or cutaneous surfaces or pushed into the tissues of the body.

It will be remembered that muscle contraction does not continue throughout the whole time the current is passing through the muscle or nerve, and occurs only

(1) When the current is made.

(2) When the current is broken.

(3) When the current is suddenly increased or decreased.

(4) When the current direction is suddenly changed.

It is, therefore, not the quantity of current passing through a motor nerve or muscle that causes muscle contraction, but the rapid variation in the current density.

The effect produced in motor nerves and muscles by varying the current density depends upon

(1) The current strength—whether feeble, medium, or strong.

(2) Current direction—whether ascending or descending.

(3) Whether the current is made or broken.

PFLÜGER'S LAW.

(1) **Weak currents** produce contractions in both current directions, but on closure only.

(2) **Medium currents** produce contractions in both current directions, both on opening and closing.

(3) **Strong currents** produce contractions on opening with descending currents and on closing with ascending currents.

The effect of the **direct current** upon a nerve is to change its irritability and conductivity. At the **anode** the irritability is decreased and at the **cathode** the irritability is increased. This changed condition of the nerve during the passage of a direct current is called **electrotonus.**

The increased irritability beneath the cathode is known as **catelectrotonus.**

The decreased irritability beneath the anode is called **anelectrotonus.** The difference between **anelectrotonus** and **catelectrotonus** will vary with the current strength. The stronger the current, the greater will be the difference in irritability.

A stimulant increases and a sedative decreases the irritability of a nerve. Catelectrotonus is the result of negative stimulation and appears at the negative pole, while anelectrotonus is the result of positive sedation and appears at the positive pole. Catelectrotonus is, therefore, a stimulant and anelectrotonus is a sedative.

In accordance with Pflüger's law, when the direct current is closed, catelectrotonus appears beneath the cathode (negative pole) and produces muscular contraction. This occurs in both current directions and for medium and feeble currents.

When the direct current is opened (broken), the irritability of the nerve is changed; the increased irritability at the cathode disappears and is replaced by a state of decreased irritability, which does not produce muscular contraction. The muscular contraction produced by disappearing catelectrotonus is not so strong as that produced by appearing catelectrotonus. When the current is weak, disappearing catelectrotonus (opening the current) is not sufficiently strong to produce muscular contraction, and therefore contractions appear only on closing the current.

When the currents are strong, the irritability beneath the cathode is very much increased and the irritability beneath the anode is very much decreased, and may be completely lost. Muscular contraction takes place on current rise at the cathode and on current fall at the anode. Electric stimulation is, therefore, polar, being cathodic on closing and anodic on opening.

POLAR AND PERIPOLAR ZONES.

When the direct current is applied to the human tissues, two zones of opposite signs and different degrees of irritability and density appear, the appearance and disappearance of which cause muscular contraction. The negative and positive poles of the direct current each produce two contractions—one on closing and one on opening. The tissues directly beneath an electrode are of the same sign or polarity as the electrode, and constitute the **polar zone,** while the tissues surrounding the electrode are of an opposite sign and form the **peripolar zone.**

When the current is closed, the polar zones immediately appear beneath the electrodes, while the peripolar zones, with opposite signs, as quickly appear around them. Fig. 81 is a diagrammatic outline of the zones. When the current is closed, catelectrotonus appears beneath the cathode (negative pole) and anelectrotonus appears beneath the anode (positive pole). The irritating and stimulating effects of appearing catelectrotonus excite the nerves and muscles, and a contraction in the muscle or muscles results.

This occurs in both current direction—with weak and medium currents—as before mentioned.

When the direct current is opened, anelectrotonus disappears from the anode and catelectrotonus disappears from the cathode in the polar zones. With weak currents the stimulating effect of the negative peripolar zone about the anode is too weak to cause a muscular contraction. At the cathode the disappearance of catelectrotonus is followed by the sedative influence of anelectrotonus in the peripolar zone and no contraction occurs.

With **medium currents** there is a changed condition in the irritability at the poles. Contraction follows the opening and closing of the current at both poles and in both directions of the current.

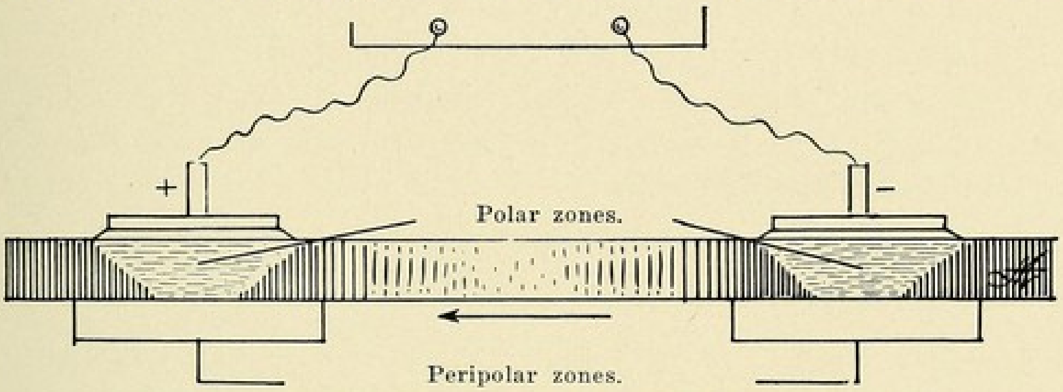


Fig. 81.—Diagrammatic outline of the electric influence in the zones.

It must be remembered that muscular contraction results only from negative stimulation, whether in the polar or peripolar zones. Muscular contraction at the anode is the result of negative influence in the peripolar zone.

Strong currents produce contractions on opening with the descending current and on closing with the ascending current.

On closing with a descending strong current the sedative effect of anelectrotonus in the polar zone (on the muscle) is so great that the irritability of the muscle and nerve is completely lost, and catelectrotonus in the peripolar region has no effect on the muscle and nerve; therefore no contraction occurs.

On opening with strong descending currents, anelectrotonus in the polar region disappears, and the strong negative influence in the peripolar region contracts the muscle.

On closing with strong ascending currents, negative stimulation (catelectrotonus) in the polar zone produces strong and painful contractions.

Opening with strong ascending currents causes no contractions, because disappearing catelectrotonus in the polar zone is counteracted by the sedative effect of anelectrotonus in the peripolar zone. The above changes in Pflüger's law were made necessary on account of our recent changes in the direction of the current—i. e., from the negative to the positive pole instead of from the positive to the negative pole, as we were taught before the advent of the **electron theory.**

Currents may be made to pass from the spinal column toward the extremities and from the extremities toward the spinal column. These are known as ascending and descending currents. When the negative pole is placed between the positive pole and the central nervous systems, the current will be passing from the center outward and is termed **descending.** When the negative pole is placed at the extremity and the positive pole between it and the central nervous systems, the current is passing toward the center and is termed **ascending.**

UNIPOLAR AND BIPOLAR METHOD.

In the examination of animal tissues two methods are used. When both poles are placed on the muscle, the method is bipolar. When only one pole is applied to the muscle and the other placed on some indifferent part of the body, it is unipolar.

The unipolar method is best adapted for nerve and muscle examination. The indifferent electrode may be 4x6 inches and well covered with sponge or cotton, and is usually placed on the sternum or back of the neck. The active electrode is small and usually round, and is well covered with wash leather or felt. A contact spring in the handle of the active electrode enables the operator to make and break the current at will.

Fig. 82 (1, 2, 3) illustrates the electrodes and handle necessary in the examination of muscles and nerves. All covered electrodes must be thoroughly wet and the electrodes well soaped, which facilitates the passage of the current into the tissues and allows free movement of the electrodes over the body without irritating the skin.

The battery should be in perfect order, and supplied with a rheostat, milliamperemeter, pole changer, and electrodes as mentioned above. A pressure of 70 volts with a current strength of ½ ampere will be ample for any class of work. Only very weak currents are needed in the examination of muscles and nerves.

With the patient reclining in a chair or on a table in a good light, the large positive indifferent electrode is placed over the sternum and the small electrode is placed over the ulnar nerve. As the current is slowly turned into the circuit, the interrupter is closed in the electrode handle until the strength of the current is sufficient to contract the muscle at the instant the current is closed. This is termed cathode closing contraction. The current strength will be found to be about 2 milliamperes. Change the

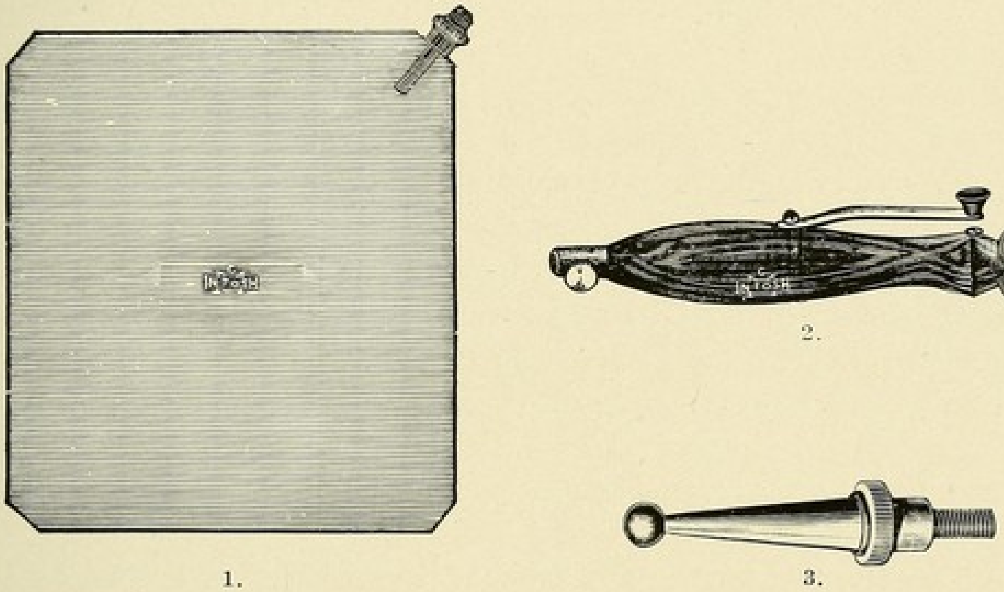


Fig. 82.—Electrodes and handle for examination of muscles and nerves.

poles by turning the double-throw switch (commutator), which now makes the pole on the muscle positive. Proceed as before, and it will be found that it will require a stronger current to cause the same muscle to contract with the anode on closing. About 3 milliamperes will be required, and is termed **anode closing contraction.** Without changing the poles, the current is increased to a point where the muscle contracts when the current is opened. This will require from 3½ to 4 milliamperes, and is termed **anode opening contraction.** The poles are again changed, and the cathode is made the active pole. The current is slowly increased to a point where the muscle contracts when the current is opened. This will require from 10 to 15 milliamperes, and is termed **cathode opening contraction.**

These current strengths are after Doctor Verhoogen, and, while they may vary slightly in different patients, are generally accepted as the amount of current necessary to cause minimum muscular contraction in a normal muscle and nerve. Simplifying, we have the following:

(1) 2.0 milliamperes cause muscular contraction on closing at the cathode.

(2) 3.0 milliamperes cause muscular contraction on closing at the anode.

(3) 3.5 to 4 milliamperes cause muscular contraction on opening at the anode.

(4) 10 to 15 milliamperes cause muscular contraction on opening at the cathode.

If the muscle is normal, it responds quickly to electric stimulation and as quickly returns to its original position. Qualitative and quantitative contraction should be carefully studied. The student should familiarize himself with the reaction of normal muscles before he can appreciate the abnormal changes he will frequently meet in degenerated nerves and muscles. During the examination the electrodes must be kept well covered with some absorbing material, thoroughly saturated with an alkaline solution.

ELECTRIC EXAMINATION OF SENSORY NERVES.

Nerves of sensation respond to electric stimulation according to their several functions. The optic nerve responds with a sensation of light, the auditory nerve with a sensation of sound, the gustatory nerve with a sensation of taste, etc.

Method of Examining Sensory Nerves.—The galvanic test for the reaction of sensory nerves is identical with that of motor nerves. The stimulation is always indirect. The indifferent electrode should be of large size, and may be placed over the sternum, while the smaller or active electrode is placed over the nerve to be stimulated. The current is gradually turned on, and the circuit is made and broken until the first sensation is felt, which is always on closing with the cathode. With a stronger current the same sensation may be produced on closing at the anode (anode closing sensation). A still stronger current will produce the same sensation at anode opening, and the last sensation to appear will be at cathode opening, which requires a current of considerable strength.

ELECTRIC STIMULATION OF STRIATED AND NONSTRIATED MUSCLES.

There is quite a difference in the effect of electric stimulation on striated and nonstriated muscular tissue. Striated muscular tissue responds quickly and energetically, and as quickly returns to a state of repose. Nonstriated muscular tissue requires some time in which to act after the current is turned on, and the contractions thus produced will continue for a considerable period after the current has been shut off. It is seen that the effect of the current rises slowly and disappears in the same manner—coming and going in a wave-like effect.

Stimulation of nonstriated muscles is best obtained through the use of the direct current, periodically interrupted, or by means of the sinusoidal current of very low frequency. Such currents are valuable in the treatment of the various organs composed of nonstriated muscular tissue, as the stomach, intestines, and esophagus.

EFFECTS OF ELECTRICITY ON THE BRAIN AND SPINAL CORD.

Direct electric stimulation of these organs will seldom, if ever, be required. The effect upon either will depend upon whether the electrodes are applied to the denuded brain or to the surface of the skin.

Those interested in electric stimulation of the central nervous system are referred to more pretentious works on the treatment of the brain and spinal cord.

FARADIC EXAMINATION OF MUSCULAR TISSUE.

When testing the reaction of muscles, the examination should begin with the faradic current. It is far less complicated, and often renders the use of the direct current unnecessary, for it is a known fact that, if a muscle responds to faradic stimulation, it will also respond to galvanic stimulation. Because of its more stimulating effect, the coarse or medium wire coil, with a slow interruption, should be used. The interruptions should range from forty to sixty per minute.

The method of examining a muscle with the faradic current is as follows: the indifferent and large electrode is placed on the sternum, and the active electrode is placed on the motor point, nerve, or muscle; with the rheostat the current is gradually turned into the circuit until the muscle is seen to contract. The approximate amount of current and the quality of the contraction is to be noted in order to determine its variation from normal, if any. If muscular contraction does not occur under faradic stimulation, the patient is switched onto the direct current circuit. The nerve and muscle are farther examined according to Pflüger's law, as described on page 121.

PATHOLOGICAL MODIFICATIONS OF MUSCLES AND NERVES.

Anatomy and Physiology of Motor Paths.—In order to refresh the student's mind and make the subject easier to understand, the neuron theory will be briefly outlined.

The entire nervous system is composed of countless cells or units, which are noncontinuous. Each unit is made up of a ganglion cell, with its processes, which are of two kinds: (1) the protoplasmic processes or dendrons, which constitute an integral part of the cell; (2) the axon, neuraxon, or axis process.

There is one, and may be two, axis processes to a cell. The pyramidal cells of the cerebrum constitute the motor region. The dendrons or protoplasmic processes are directed toward the cortex, and the axis processes are passed downward toward the periphery. They pass through the white substance of the hemispheres, through the posterior segment of the internal capsule, through the crus, the pons, and the medulla oblongata. Ninety percent of these axons cross over at the lowest point of the medulla, each one decussating with the symmetric fiber of the opposite side. The crossed bundles form the anterior pyramids and pass into the lateral columns of the spinal cord to form the crossed pyramidal tract.

At different levels of the spinal cord, according to whether they are to convey impulses to the muscles of the arms or of the legs, fibers take a horizontal course and pass into the anterior horn, where they split up into their arboreal endings. These arboreal endings, or end brushes, surround the large polygonal cells in the anterior horn and enter into connection with them by contact.

Each pyramidal cell with its processes is designated a **central motor neuron.**

The polygonal cell of the anterior horn gives off numerous short processes, which have centripetal conduction, and a single long process or neuraxon, which conducts to the periphery. The neuraxon passes through the anterior horn to the anterior root as a fiber of the root, and then as a fiber of the peripheral motor nerve reaches the muscle fiber. When it reaches the muscle fiber, it splits up into terminal brushes and enters into connection with the muscle fiber by means of contact; this polygonal cell of the anterior horn, with its processes, is designated a **peripheral motor neuron.** The motor path of the cranial nerves is constituted in the same manner, consisting also of two neurons. The central motor neuron has its cell on the cortex, with its neuraxon and end brush, which enter into connection with a cell of the nucleus of the cranial nerve of the opposite side. With this cell begins the peripheral motor neuron of the cranial nerve. The neuraxon of this cell runs as a fiber to the base of the brain and then as a cranial nerve fiber to the muscle fiber. It connects with the muscle fiber by means of its end brushes, as described.

From these facts it is evident that the cell of the cranial nucleus has the same physiological significance for this cranial nerve that the polygonal cell of the anterior horn has for its spinal nerve. Each neuron constitutes an embryologic and histologic unit and acts physiologically as a unit.

When one of the two neurons that constitute the motor path is injured or diseased, so that its continuity is broken, or if the cell belonging to one of the neurons is injured or diseased, the neuraxon of the injured or diseased neuron undergoes degenerative changes. These degenerative changes take place only in the neuron in which the disease is located, the remainder of the motor path remaining intact.

When the peripheral motor neuron degenerates, the muscle fiber to which it is connected by contact degenerates also. As each neuron is an independent unit, the degeneration caused by disease or injury is limited to the neuron so affected. Muscle fiber virtually forms a part of the peripheral motor neuron, and, when the neuron degenerates, the muscle fiber degenerates with it. In lesions of the central motor neuron the muscle fiber is not so affected.

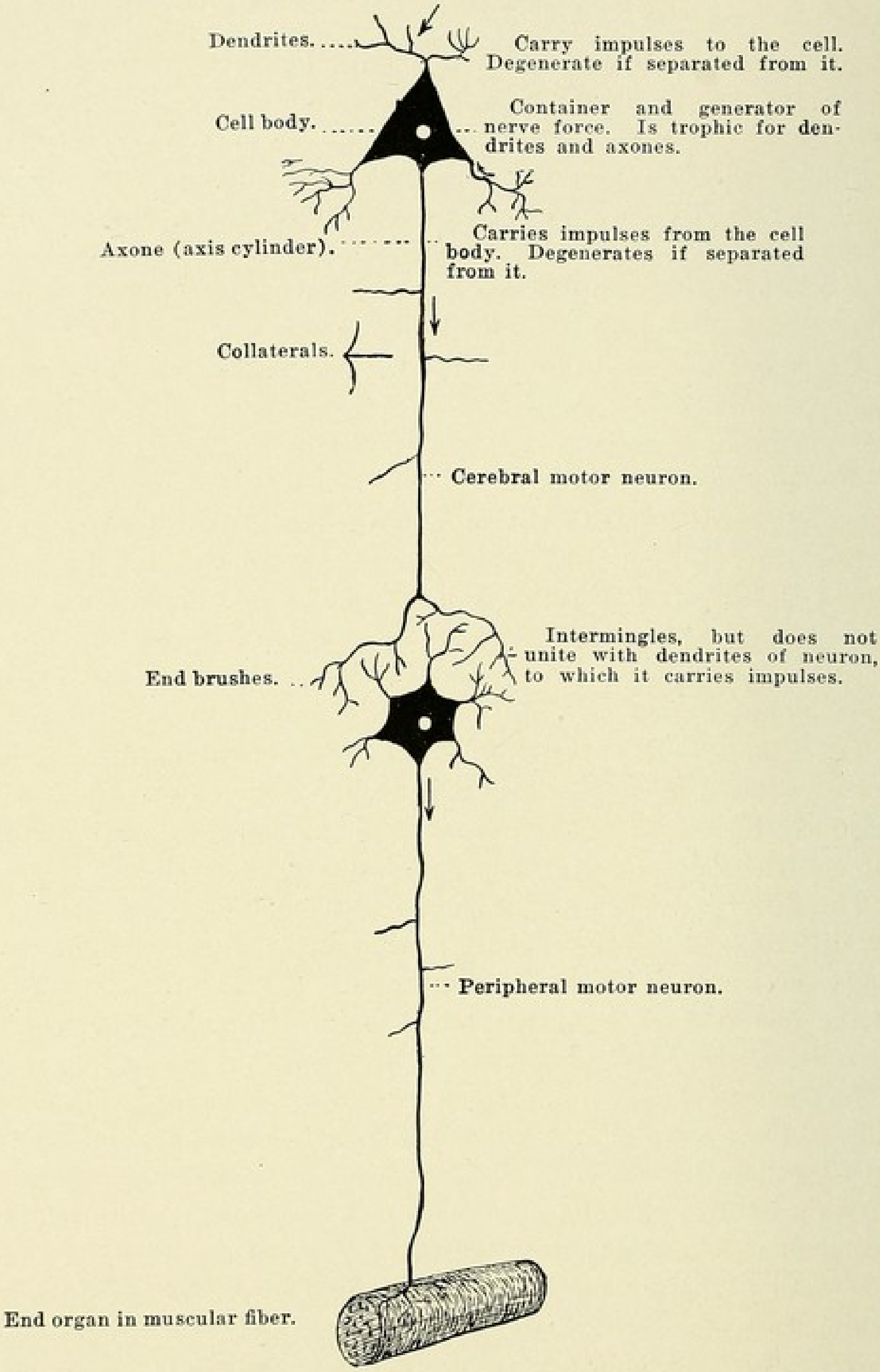


Fig. 83.—Diagrammatic arrangement of the central and peripheral neurons. (From Butler.)

REACTION OF DEGENERATION.

Since normal muscle tissue responds to electric currents according to the **normal polar formula,** any variation from the normal may be observed in both quality and quantity of reaction. The reaction of degenerated muscles differs in a marked degree from the reaction of normal or atrophied muscles. Reaction of degeneration is the result of injury or disease of the peripheral motor neuron. Disease of the central nervous system or of the muscle will not exhibit the electric reaction of degeneration.

Duchenne made an exhaustive study of faradic excitability of normal and diseased muscle tissue. Erb discovered the reaction of degeneration. He noted the quality and quantity changes in nerve and muscle irritability, and pointed out the importance of these changes in the diagnosis and prognosis of certain diseases.

Reaction of Erb.—The reaction of degeneration as described by Erb presents the following distinct phenomena, which are manifest in the muscles corresponding to the neuron lesion:

(1) Faradic excitability is completely lost, no matter how strong the current employed.

(2) The galvanic excitability may be increased, decreased, or entirely wanting. The normal polar formula may be entirely reversed, the anode taking the place of the cathode, and the muscular contraction becoming lazy, sluggish, and prolonged.

The different degrees of reaction of degeneration are manifested by different degrees of galvanic excitability. The reaction is always the same for each of these cases. The quantitative changes in the reaction of degeneration are easily detected by the galvanic current, whether the reaction is increased or decreased.

To accurately determine the qualitative reaction in degenerated muscle tissue requires a great deal of practice and experimental investigation. In normal muscles and nerves, and in mild cases of reaction of degeneration, the cathode closing contraction is always the strongest, but, as the degeneration advances, positive closing contraction may equal and even exceed cathode closing contraction. While the polar formula is being determined, the quality of the contractions should be carefully noted and recorded.

Simplifying, we have the following condensed result of the electric examination of degenerated muscular tissue:

(1) Complete loss of faradic excitability in both nerve and muscle.

(2) Complete loss of galvanic excitability in nerve.

(3) Increased galvanic excitability in muscle, and in advanced stages decreased excitability.

(4) Inversion of the normal polar formula—cathode closing contraction becomes less than anode closing contraction.

(5) Sluggish contractions, which are the most important of all the symptoms of reaction of degeneration.

Reaction of Rich.—In this case cathode closing contraction and cathode opening contraction are nearly equal to anode opening contraction. It is not always possible, and never easy, to determine the cause of this reaction.

Reaction of Remak and Doumer.—In this case the muscle responds with more energy to a current applied near its extremity or tendon than to its motor point. This reaction promptly appears soon after the injury to the nerve, and is sometimes noticed in muscles which do not show Erb's reaction of degeneration.

Reaction of Fatigue.—In this case contractions require stronger and stronger currents to produce them. It may be noticed in paralysis of cerebral origin, hemiplegia, progressive muscular atrophy, sciatica, anterior poliomyelitis, etc.

Reaction of Degeneration in Prognosis and Diagnosis.—The application of electric currents to the diagnosis and prognosis of injured and diseased nerves and muscles is of the greatest possible importance.

(1) There may be a complete absence of faradic excitation, or an exaggeration of galvanic excitation, with inversion of the normal polar formula, which may be complete or incomplete.

(2) Complete loss of excitation to all currents.

The different stages of reaction of degeneration have known histologic changes of nerve and muscle structure; so, when the degree of excitability is determined, the degree of degeneration or the histological changes that have taken place may be ascertained with a considerable degree of certainty.

In making out a diagnosis and prognosis in peripheral neuritis, the anatomic cause of the disease must be taken into consideration. A peripheral neuritis, as in rheumatic paralysis, is curable, while a paralysis due to the destruction of the ganglionic cells of the peripheral motor neurons is incurable, and yet the reaction to the electric current in the two conditions may be very similar.

In a given case of rheumatic facial paralysis, if the electric reaction is normal on the third day, the paralysis will soon disappear. If on the seventh or eighth day the reaction is still normal, we may affirm that reaction of degeneration will not develop; but, if there is a decrease in electric excitability, there is a possibility of a beginning degeneration.

In the second or third week the prognosis may be established. If sluggish contractions remain up to this time, reaction of degeneration is certain. A little later it may be determined whether it is partial or complete. If partial reaction of degeneration is present, the paralysis will last from four to twelve or more weeks. If complete reaction of degeneration is present, the disease will last for several months and may be incurable.

It is good practice not to give a hasty unfavorable prognosis, for after many months there may be a return of neuromuscular irritability and normal muscular or neuromuscular reaction later.

METHOD OF RECORDING AN ELECTRODIAGNOSTIC EXAMINATION.

This should state the faradic and galvanic excitability and qualitative and quantitative changes in the same muscle or nerve on both sides of the body, as follows:

(1) Faradic excitability—normal, weak, or lost.

(2) Galvanic excitability.

(*a*) Cathode closing contraction (CCC).

(*b*) Anode closing contraction (ACC).

(*c*) Anode opening contraction (AOC).

(*d*) Cathode opening contraction (COC).

The examination should be begun in the order of the normal polar formula, always writing the number of milliamperes required to produce the minimum contractions after each particular test. Any change from the normal polar formula will indicate a change in the muscle or nerve under examination. The quality and quantity of the reaction will determine the extent of the diseased condition existing at the time of the examination. Careful records should be kept of each electric examination for frequent comparison.

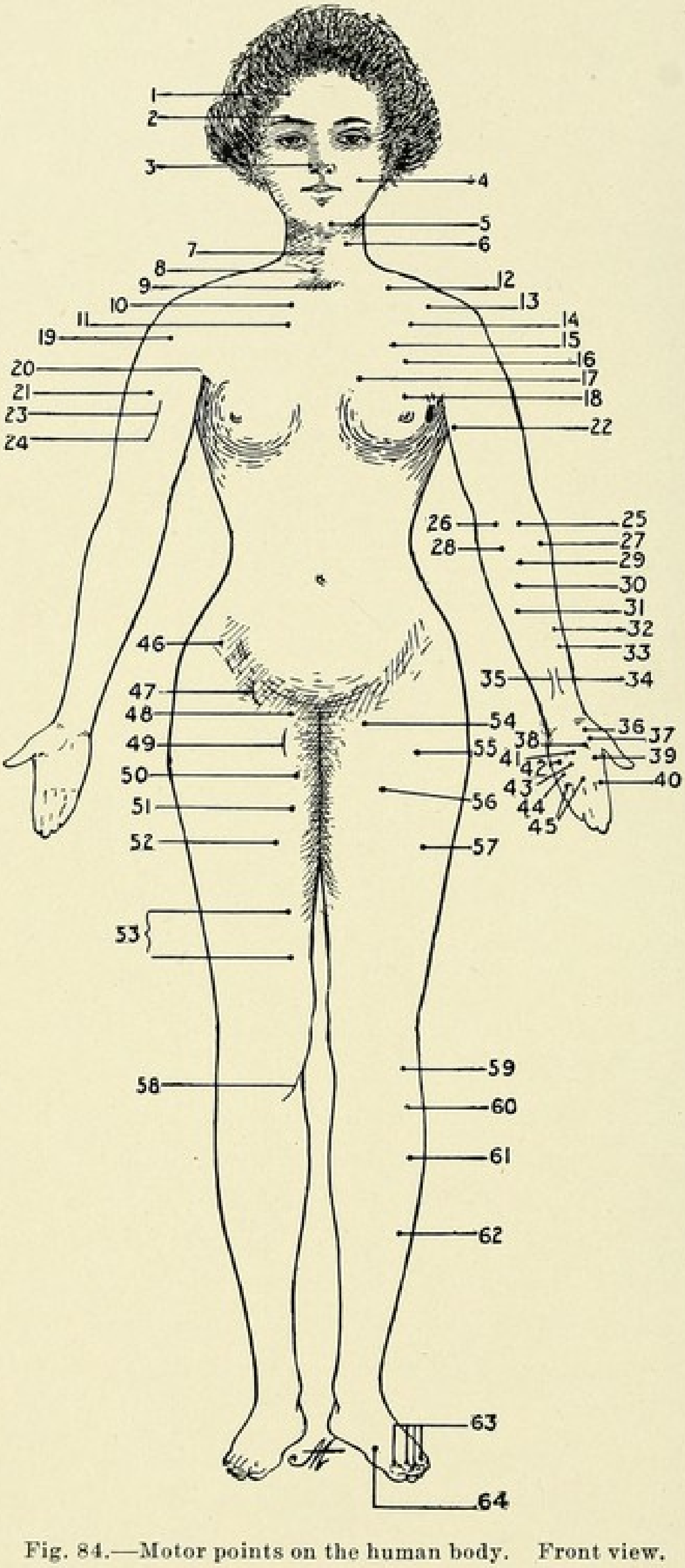


Fig. 84.—Motor points on the human body. Front view.

Fig. 84.—Motor points on the human body. Front view.

1. M. frontalis.
2. M. corrugator supercilii.
3. M. dilator nasi.
4. M. buccinator.
5. M. levator menti.
6. M. sternomastoid.
7. N. hypoglossal.
8. M. platysma myoides.
9. M. sternohyoid.
10. N. phrenic.
11. M. omohyoid.
12. N. spinal accessory.
13. M. trapezius (anterior fibers).
14. N. long thoracic.
15. N. circumflex.
16. N. brachial plexus.
17. N. thoracic anterior.
18. N. of pectoralis major.
19. M. deltoid.
20. N. musculocutaneous and M. coracobrachialis.
21. M. biceps.
22. N. ulnar.
23. N. median.
24. M. brachialis anticus.
25. M. pronator radii teres.
26. M. flexor carpi ulnaris.
27. M. supinator longus.
28. M. flexor profundus digitorum.
29. M. flexor carpi radialis.
30. M. palmaris longus.
31. M. flexor sublimis digitorum.
32. M. flexor sublimis digitorum.
33. M. flexor longus pollicis.
34. N. median.
35. N. ulnar.
36. M. adductor pollicis.
37. M. opponens pollicis.
38. M. flexor brevis pollicis.
39. M. abductor brevis pollicis.
40. M. first and second lumbricales.
41. M. palmaris brevis.
42. M. abductor minimi digiti.
43. M. flexor minimi digiti.
44. M. opponens minimi digiti.
45. M. third and fourth lumbricales.
46. M. tensor vaginæ femoris.
47. N. anterior crural.
48. M. pectineus.
49. N. obturator.
50. M. adductor magnus.
51. M. adductor longus.
52. M. crureus.
53. M. vastus internus.
54. M. sartorius.
55. M. quadriceps extensor femoris.
56. M. rectus.
57. M. vastus externus.
58. N. internal popliteal.
59. M. peroneus longus.
60. M. tibialis anticus.
61. M. extensor longus digitorum.
62. M. peroneus brevis.
63. M. dorsal interossei.
64. M. abductor hallucis.

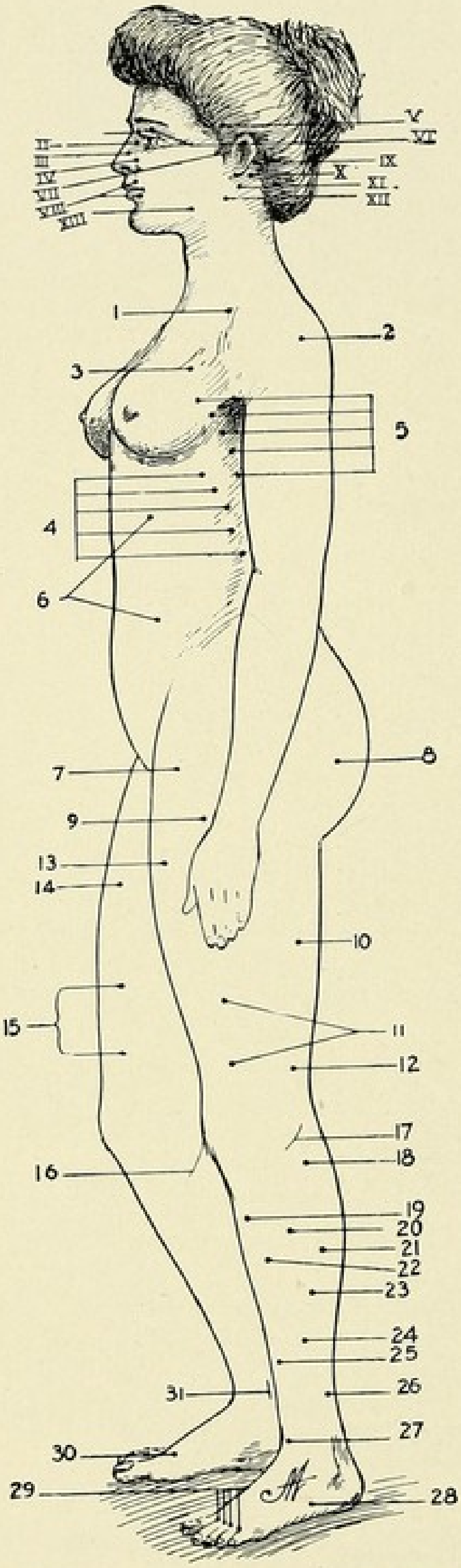


Fig. 85.—Motor points on the human body. Side view.

Fig. 85.—Motor points on the human body. Side view.

I. M. pyramidalis nasi.
II. M. levator labii superioris alæque nasi.
III. M. compressor nasi.
IV. M. levator labii superioris.
V. M. temporal.
VI. M. orbicularis palpebrarum.
VII. N. facial, median branch.
VIII. M. orbicularis oris.
IX. N. posterior auricular.
X. M. occipital.
XI. M. stylohyoid.
XII. M. digastric.
XIII. M. masseter.
1. N. of pectoralis major.
2. M. deltoid, anterior fibers.
3. M. pectoralis major.
4. M. obliquus externus.
5. M. serratus magnus.
6. M. rectus abdominis.
7. M. sartorius.
8. M. gluteus maximus.
9. M. quadriceps tensor femoris.
10. M. biceps femoris, long head.
11. M. vastus externus.
12. M. biceps femoris, short head.
13. M. rectus femoris.
14. M. crureus.
15. M. vastus internus.
16. N. internal popliteal.
17. N. external popliteal.
18. M. gastrocnemius.
19. M. tibialis anticus.
20. M. peroneus longus.
21. M. soleus.
22. M. extensor longus digitorum.
23. M. soleus.
24. M. peroneus brevis.
25. M. extensor proprius hallucis.
26. M. flexor longus hallucis.
27. M. extensor brevis digitorum.
28. M. abductor minimi digiti.
29. M. dorsal interossei.
30. M. abductor hallucis.
31. N. posterior popliteal.

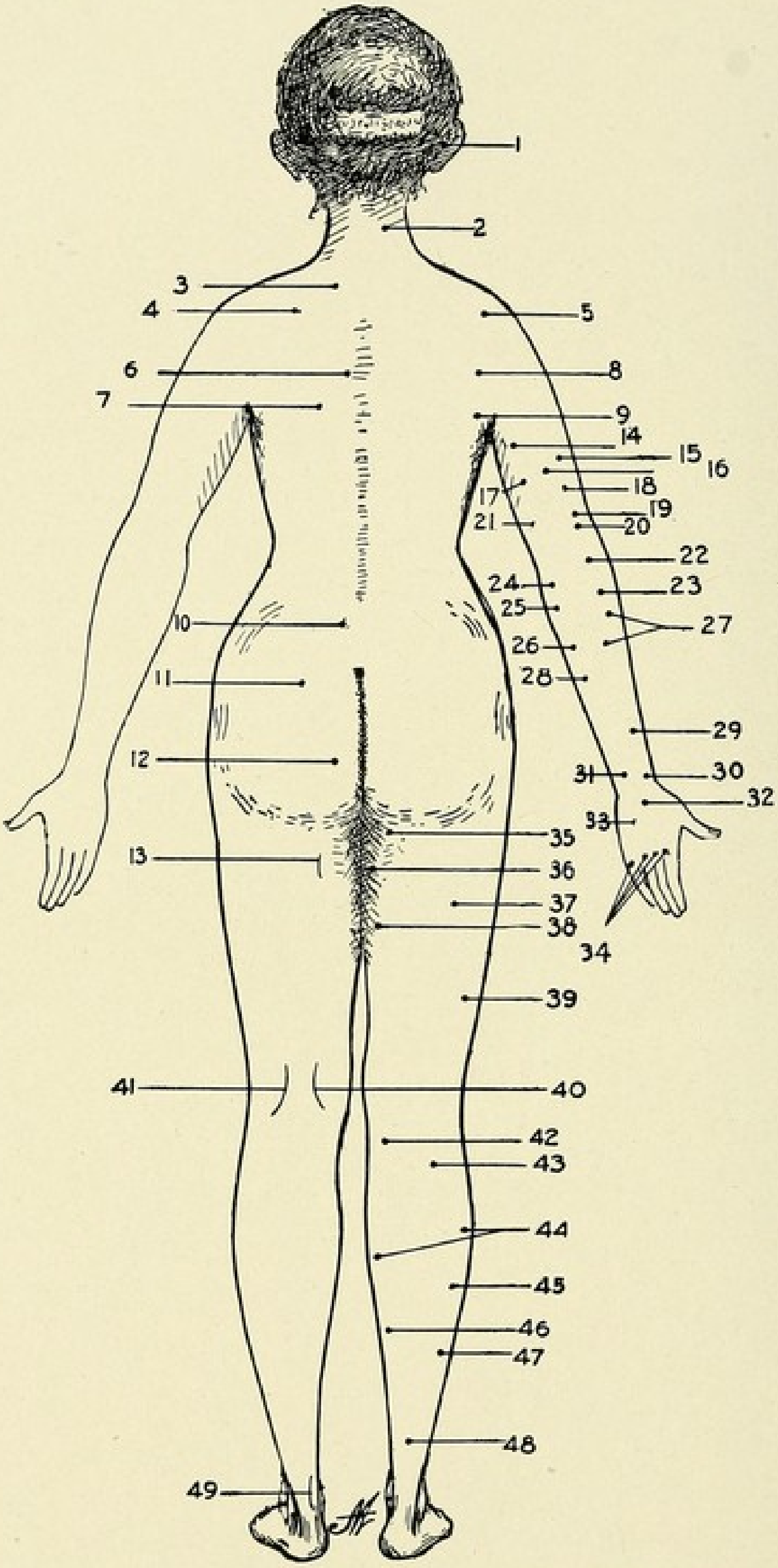


Fig. 86.—Motor points on the human body. Back view.

Fig. 86.—Motor points on the human body. Back view.

1. M. retrahens aurem.
2. M. splenius.
3. M. trapezius, middle fibers.
4. M. infraspinatus.
5. M. deltoid.
6. M. trapezius, inferior fibers.
7. M. rhomboideus.
8. M. infraspinatus.
9. M. teres minor.
10. M. erector spinæ.
11. M. gluteus medius.
12. M. gluteus maximus.
13. N. sciatic.
14. M. triceps, long head.
15. M. triceps, external head.
16. N. musculospiral.
17. M. triceps, internal head.
18. M. brachialis anticus.
19. M. supinator longus.
20. M. extensor carpi radialis longus.
21. M. anconeus.
22. M. extensor carpi radialis brevis.
23. M. extensor communis digitorum.
24. M. extensor carpi ulnaris.
25. M. supinator brevis.
26. M. extensor minimi digiti.
27. M. extensor indicis.
28. M. flexor carpi ulnaris.
29. M. extensor ossis metacarpi pollicis.
30. M. extensor primi internodii pollicis.
31. M. extensor secundi internodii pollicis.
32. M. extensor secundi internodii pollicis.
33. M. abductor minimi digiti.
34. M. dorsal interossei.
35. M. adductor magnus.
36. M. semimembranosus.
37. M. biceps, long head.
38. M. semitendinosus.
39. M. biceps, short head.
40. N. internal popliteal.
41. N. external popliteal.
42. M. gastrocnemius, internal head.
43. M. gastrocnemius, external head.
44. M. soleus.
45. M. peroneuslongus.
46. M. flexor longus digitorum.
47. M. peroneus brevis.
48. M. flexor longus hallucis.
49. N. posterior tibial.

ELECTRIC RESISTANCE OF THE BODY.

The electric resistance of particular tissues and the body as a whole vary greatly in different individuals. The resistance in men is generally less than it is in women. Certain diseases increase, while others decrease, the resistance of the body. Exophthalmic goiter is thought to decrease the resistance of the body, while hysteria and melancholia are believed to increase it.

In testing a nerve or muscle for the reaction of degeneration, if cathode closing contraction appears, followed by anode closing contraction, with a slightly stronger current, reaction of degeneration is not present. If, however, anode closing contraction equals cathode closing contraction, reaction of degeneration is present.

Prognosis.—After an electrodiagnosis, the prognosis will depend more upon the nature and cause of the lesion than upon the electric resistance.

ELECTRODIAGNOSIS.

This consists mainly in determining the electric resistance of the body, in whole or part, the stimulation of nerves, and the reaction of muscles.

Electrodes.—The indifferent electrode may be almost any size from 4 to 20 square inches. After it has been carefully covered with some good absorptive material—as sponge, spongiopiline, or absorbent cotton—it is thoroughly soaked in a weak solution of bicarbonate of soda and applied to some convenient part of the body, as the sternum, back of the neck, etc. The active electrode should have a surface of 3 to 4 square centimeters, and should be well covered with cotton, thoroughly wetted and soaped to facilitate perfect contact with the skin and easy movement from place to place without lifting the electrode. The active electrode is applied over the motor point of the muscle or nerve.

Pflüger's Law.—Careful study of this law will enable the student to thoroughly understand the normal and abnormal reaction of nerve and muscle tissue.

Motor Points.—The illustrations shown in Figs. 84, 85, 86 exhibit the points where the active electrode is to be placed to produce the most effective stimulation of the muscle or motor nerve under examination.

Current Intensity, Density, and Surface Area of Electrode.—With a given size of electrode, the current density per surface area of electrode increases as the current intensity increases. The density per unit of surface area of electrode may be increased by increasing the current intensity or decreasing the size of the electrode.

CHAPTER X.

ELECTROLYSIS.

Compound substances that dissolve in water break up into their elements or ions. Each element has, by nature, a definite electric charge, and these charges combine in definite proportions according to their electric attraction for one another.

It has been stated in Chapter I that electric currents pass through solids by going from one atom to another, while in liquids the current travels with the atom or ion.

When an electric current passes through an electrolyte (a compound in solution), the ions are attracted toward the elements of an opposite polarity. The alkaline metals have positive charges and journey toward the negative pole, and are therefore called cations (ions going away from the positive pole toward the negative). They are principally hydrogen, sodium, potassium, calcium, magnesium, and ammonium.

The metalloids have negative charges and journey toward the positive pole, and are therefore called anions (ions going away from the negative pole toward the positive). They are oxygen, carbon, chlorin, bromin, sulphur, and phosphorus.

Since we know the action that takes place in an electrolyte during the passage of an electric current, we are able by the same reasoning to determine the changes that take place in the animal tissues while an electric current is passing through them.

CHEMICAL CHANGES IN THE SKIN.

The amount of reaction beneath a body electrode will depend upon the composition of the electrode, its size, whether moist or dry, and the strength of the current in the circuit.

When the bare metallic electrodes are brought in contact with the skin, the resistance of the epidermis is so great that little, if any, current is allowed to pass. If the skin is moistened, the resistance is lowered, and the current will flow through the tissues in proportion to the decreased resistance. After a few minutes the skin will become red beneath each electrode, and blisters may form as a result of the electrolytic action of the current. The chemical reaction at the positive pole will be acid and at the negative pole alkaline. To prevent such electrolytic action, the metal disks of the electrodes are covered with a spongy material that will hold moisture, and make even and sure contact with the surface of the skin. Should these coverings become worn to such an extent that the metallic disks come in contact with the skin, a blister is likely to occur.

CHEMICAL CHANGES IN THE MUCOUS MEMBRANE AND TISSUES.

Certain chemical changes take place when a bare metallic electrode is brought in contact with the mucous membrane or plunged into the tissues. We will suppose that both electrodes are of the same kind of metal, which we will call copper. Whether the electrodes are brought in contact with moist mucous membrane or stuck directly into the tissues, the results are the same.

The tissues, being a semi-solid, will act as the electrolyte in the voltaic cell. Ionization must take place before tissue dissociation. The tissues contain a great deal of sodium chlorid, oxygen, and hydrogen, besides traces of the alkaline metals and metalloids. An interesting experiment may be performed by procuring a piece of beef of suitable size, into which two copper electrodes are placed three or four inches apart. These electrodes are connected by means of copper wires to the binding-posts of a wall plate or a galvanic battery, and 25 to 50 milliamperes are turned into the circuit. In a few minutes it will be noticed that the electrode at the positive pole has corroded and stuck fast, while the negative electrode is bright and is easily movable. After the current has been allowed to pass for some time, the tissues about the positive pole will be dry and shrunken, and of a dirty-green color, due to the deposit of the oxychlorid of copper in the tissues. When the electrode at the positive pole is soluble, it is corroded by electrolysis. The metallic deposit in the tissues around the electrode will always be an oxychlorid of the metal of which the electrode is composed. When a current is passed into the electrodes and through the tissues, ionization of the liquid elements takes place.

The acid elements (oxygen, chlorin, and metalloids in general) are electronegative elements—i. e., they have a negative charge and are attracted toward the positive pole, whereas, if this pole is a soluble metal, as copper, a new compound is formed by the corrosive action of the acids (electrolysis) upon the electrode. The new compound thus formed is rapidly dissociated (ionized) by the acid elements of the electrolyte, and the positive alkaline copper element is forced away from the positive pole into the tissues, which action is known as **cataphoresis.**

The alkalies and alkaline metals are electropositive elements, having a positive charge, and are attracted toward the negative pole. This accumulation of acids at the positive and alkalies at the negative pole explains the chemical reaction at the respective poles. The electrolytic action at the positive pole is that of an acid, and at the negative pole is that of caustic potash.

In studying drug medication by electric currents, the above facts must be well understood in order to determine which pole to use with a given drug.

Since cocain is an alkaloid, it should be placed at the positive pole in order to carry it into the tissues for its local anesthetic effect; while iodin, acting as an acid, will be carried into the tissues from the negative pole.

The ions of the electrolyte are named for the pole toward which they are attracted. The cations, though carrying electropositive charges, are attracted toward the negative pole; likewise the anions, carrying electronegative charges, are attracted toward the positive pole.

CATAPHORESIS.

The term cataphoresis seems to be misunderstood by many who make more or less pretensions to a knowledge of electric methods. The transportation of the ions of an electrolyte—some to the negative pole and some to the positive—is known as **phoresis.** The repulsion of the ions from the positive pole is known as **cataphoresis,** and from the negative pole as **anaphoresis.**

Cataphoresis with copper, zinc, and mercury is much used because of its styptic and antiseptic effect in the tissues, making it possible to carry these metals in a soluble form deeply into the tissues, where they will do the most good in the smallest possible quantities.

Electric currents always travel the route of least resistance, which is likewise true of the phoretic action of the ions in the tissues. In the electric treatment of cervical and corporeal endometritis the infection in the mucous follicles is easily reached by the cataphoretic action of metallic copper. The contents of these follicles are liquid or semi-liquid, which has an electric resistance lower than the mucous membrane or muscular tissues of the uterine walls. Because of this low resistance to electric currents, the ions of copper or the oxychlorid of copper are freely deposited in the follicles, where the infective germs, of whatever nature, are promptly destroyed.

A little practice will enable an observing physician to successfully treat these cases in a most conservative way.

POLAR PROPERTIES.

The following outline of the polar properties of the direct current is the gist of what the operator must know before he can use galvanism with any degree of success:

Positive pole.	Physiological sedative.	Anelectrotonus. Diminishes irritability.
	Chemical.	Accumulation of oxygen, chlorin, and nitric, phosphoric, sulphuric, and muriatic acids. It is an acid caustic, producing mummifying effects. The eschar is small, dry, hard, and noncontractile.
	Cataphoric.	Antiseptic. Loss of fluids and salts. Starvation of the tissues. Diffusion of drugs in solution, or nascent salts formed by electrolysis of soluble metallic electrodes.
Negative pole.	Physiological stimulant.	Catelectrotonus. Increases irritability.
	Chemical.	Accumulation of hydrogen and alkalies and hydrate of calcium, potassium, sodium, and ammonium. These form saponaceous matter, and are caustic alkalies. The eschar is large, soft, and retractile.
	Anaphoric.	Accumulation of liquids and salts. With mild currents, promotes nutrition; with strong currents, destroys tissues and has denutritive effects. First effect is to cause ischemia; second effect is to cause hyperemia, and then the equalization of the circulation.

THERAPEUTIC TECHNIC OF THE DIRECT CURRENT.

There is no question that the direct current possesses greater advantages than all the other currents combined, due mainly to the fact that by the use of the galvanometer it can be accurately measured, and by the regulation of the size of the electrodes the current density may be regulated to any degree.

The current dosage depends upon the size of the electrode, the strength of the current, and the length of time the current is allowed to flow. The therapeutic effects of the electric current will depend not only upon the current density per unit area, but the number of units used must be considered as well as the length of the seance.

GALVANIZATION.

Brain.—Galvanization of the brain will seldom, if ever, be necessary. When such a procedure becomes necessary, great care must be had that the current is equally distributed throughout both hemispheres. The current must be slowly and gradually turned into the circuit and as carefully withdrawn. Large electrodes are used, usually of block tin, well covered with wetted gauze or cotton. One of such electrodes is placed over the forehead and the other over the nape of the neck and well down on the shoulders. Throughout the seance the pressure on the electrodes should be uniform to prevent fluctuation in the current strength. Galvanization of the brain is recommended only in cerebral neuroses.

Spinal Cord.—The direct current may be applied to the entire length of the cord or to a single section at a time. In making the application to the entire cord, one electrode is applied over the cervical region and the other over the lumbar. This general application may be made either labile (moving) or stabile (stationary). The area of the electrode will be determined by the current strength employed.

When only a section of the cord is treated, one electrode is placed on the sternum or abdomen and the other (active electrode) is placed on the part of the cord to be electrified. In either case—whether general, local, labile, or stabile applications are made—the treatment should last from two to five minutes, according to the indications and the results desired.

Diseased Joints.—In subacute and chronic diseases of the joints, galvanization will be found a serviceable therapeutic measure. The current should be passed directly through the joint, and the size of the electrode will depend upon the size of the joint. If electrochemic action is desired in these cases, from 50 to 100 milliamperes may be used from ten to fifteen minutes.

Because of its well-known stimulating and nutritional action, many cases of arthritis will yield to galvanism that would have gone on from bad to worse, resulting in some degree of ankylosis, with greatly impaired function.

By means of phoresis some valuable remedies may be carried directly into the tissues, where they are expected to do the most good. From a solution of iodid of potassium, iodin is carried into the tissues by anaphoresis at the negative pole, while from the same solution potassium salt is carried into the tissues by cataphoresis at the positive pole. The amount of these elements used in any given case will depend upon the size of the electrode, strength of the current, and length of time that the current is allowed to flow. The treatment should be given daily, and in some cases twice a day. Because of its analgesic effect, the positive pole is always placed over the most painful part. While the electrodes should be large, care must be taken that they do not touch each other, thereby short-circuiting the current.

ZINC MERCURIC CATAPHORESIS.

So far as the author knows, Massey first described this method of tissue medication. He has used the method successfully in the treatment and permanent destruction of favorably located malignant growths. In growths of considerable size, heavy currents, ranging from 100 to 400 and even 1,000 milliamperes, are sometimes required for complete tissue destruction. In the application of such heavy currents an anesthetic is always necessary, as the operation is quite painful, and on this account resolves itself into a formidable surgical operation and should be so regarded.

The indifferent negative electrode must be large and well covered with a thoroughly moistened absorbing material, on which the patient is allowed to lie. Care must be taken that no part of the metallic electrode is allowed to come in contact with the skin during a treatment of this kind. If, however, such an accident should occur, an ugly burn will be the inevitable result. Such burns (negative electrolysis) are very painful and slow to heal. With the novice in electro-therapeutics this accident occurs only too frequently.

The positive wire may have from four to eight strands, each of which is attached firmly to a narrow piece of sheet zinc about 4 inches long and cut to a sharp point. (See Fig. 80, 1.) The zincs are dipped in a 10-percent solution of muriatic acid and then in metallic mercury, by which process they are completely coated with a thin film of mercury. With the current at zero, one of the zincs is inserted into the base of the growth as nearly parallel with the skin as possible, and from 20 to 30 milliamperes are turned into the circuit. The other electrodes are now inserted one by one around the growth. It will be noticed that the current has been increased according to the reading of the milliamperemeter. The surface area of the electrodes has been increased and the current density decreased, while the resistance of the circuit is decreased in the same proportion. The current strength is now increased to the desired amount, which may run from 20 to 100 milliamperes to the zinc point. The current must be gradually increased and as gradually decreased to avoid a shock. The tissues will assume an ashy whiteness.

This method has one advantage—viz., there is no hemorrhage or infection. The tissues destroyed form a dry slough, which later becomes a dry scab that is thrown off by the processes of nature. The cicatrix thus formed usually leaves a scar, and for this reason the author has not used the method where cosmetic effects are to be considered. There seems to be some question as to whether the effect of this treatment is due to the ions of mercury and zinc, or to the destructive action of the electric current.

LOCAL ANESTHESIA BY COCAIN CATAPHORESIS.

The sponge or felt covering of the positive electrode may be moistened with a 20-percent solution of cocain, or a 10-percent solution of cocain in guaiacol may be used in the same manner with a current of about 5 milliamperes for about five minutes. This method of local anesthesia may be used for small operations and for relief in neuralgias. In the removal of superfluous hair over sensitive areas, this method of anesthesia will be found to be of great service.

CHLORIN IONIZATION.

In the treatment of joint affections resulting from a fibrous ankylosis, the use of the direct current with electrodes, wet with a solution of chlorid of sodium, has given marked relief in the hands of competent operators. The benefit is, in all probability, due to the transportation of chlorin ions into the tissues of the joint. It is believed that the chlorin ions have the property of causing the fibrous tissue that produces the ankylosis to be absorbed.

The method of application is of particular importance and the technic, which should be carefully observed, is as follows:

The joint to be treated is well wrapped in absorbent gauze, which is afterward thoroughly saturated with a 5-percent solution of chlorid of sodium. Over the gauze, and a little smaller, is firmly bound a piece of block tin or lead-foil, which is attached by an insulated metallic cord to the negative side of a galvanic battery or wall plate. This constitutes the active electrode. The inactive electrode should be considerably larger, and may be placed on the back, abdomen, or any indifferent part of the body. When everything is ready, the current is very gradually turned into the circuit. Should the patient complain of pain, the rheostat is reversed until the current is painless. The current strength will vary from 3 to 5 milliamperes per square centimeter. The amount of current that the patient will tolerate, as indicated by the milliamperemeter, will depend upon the size of the electrodes. While the reading of the milliamperemeter is important, the comfort of the patient is of first importance. In beginning the treatment, the patient may complain of intense pain before the current strength has reached one milliampere per unit of surface area. On removing the gauze, it will be found that the skin has been broken, which lowers the resistance at that point and allows the greater part of the current to enter the tissues at one place, making the application quite painful, and, if continued for any considerable length of time, is likely to produce an ugly sore that may require weeks to heal.

The treatment should last about thirty minutes. At first it may be given every other day, and less frequently as the patient improves. If a sufficient amount of chlorin ions can be forced through the skin into the sclerous tissue, resolution will be promoted, ankylosis relieved, and the movements of the joint greatly improved.

Where the ankylosis is fibrous, skill and perseverance will accomplish excellent results in every case. Immediate results should not be expected, for it takes time for resolution to remove the offending material and re-establish the functions of the joint.

In the use of the gauze electrodes, as above described, it must be distinctly understood that they are not to be used a second time unless thoroughly washed and sterilized.

COPPER ELECTROLYSIS.

In the treatment of ringworm and diseases of the hair follicles the use of the oxychlorid of copper by means of the direct current, while new, is a method that should have first place. The application may be made by saturating a gauze electrode with a 2-percent solution of copper sulphate. The positive pole is used with a current strength in proportion to the size of the electrode. The application should last long enough to cause a marked redness in the skin, and may be repeated as often as necessary to cure the disease.

COPPER CATAPHORESIS.

Chronic Fistulas and Infected Punctured Wounds.—These may be successfully treated by means of copper cataphoresis. The positive electrode is connected to a pure copper rod, which is introduced into the fistula or wound. The current should be from 5 to 10 milliamperes, and should last long enough to thoroughly deposit a film of the green oxid of copper in the tissues surrounding the electrode. At the end of the seance the electrode will be found firmly adhered to the tissues, and must not be forcibly removed. **Reduce the current to zero, change the polarity and increase the current in the circuit to 3 or 4 milliamperes, and the electrode will soon come loose.**

Erosions of the Cervix.—This condition usually responds to copper cataphoresis in a remarkably short time. Fitzhugh's round disk electrode is made with a pure copper face in such a manner that it fits the external os. It is connected with the positive pole of the direct current, and during its application should be firmly held against the cervix. The strength of the current should be about 10 milliamperes, and the seance may vary from three to five minutes and be repeated once a week.

Intrauterine Cataphoresis.—Of all the methods of intrauterine medication at the hands of the conservative gynecologist, cataphoresis, when properly understood, is the most valuable. For this work Goldspohn's solid metallic copper intrauterine electrodes are used. They come in four sizes, as illustrated in Fig. 79, 1. The distal end is made of pure metallic copper, is 1½ inches long, slightly curved to facilitate its passage through the cervical canal, and is insulated with hard rubber from the main shaft. By means of this electrode cupric cataphoresis may be easily and thoroughly applied to the uterine canal from the external os to the fundus. If there is any trouble in passing the electrode into the uterus owing to the narrow or stenosed condition of the cervical canal, the pole should be made negative and from 3 to 5 milliamperes turned on, using gentle pressure on the stem of the electrode. If the electrode is not too large, it will glide along the cervical canal and soon pass through the internal os into the uterus. The polarity is now changed and the intrauterine electrode made positive. The current is slowly increased to 10 or 15 milliamperes during five or ten minutes, moving the electrode with a slow twist to prevent its adhering to the tissues. Weak currents for a longer period will be of greater value than strong currents for a short period. During a seance of this kind, if the patient should complain of sharp or cramping pains, the current must be reduced to zero, and, without removing the electrode, the galvanic current is to be switched out and the faradic current switched in, using the long fine wire secondary coil with the fast interrupter. A few minutes' treatment with this current will generally relieve all pain started by the direct current. This treatment should not be given oftener than once in five or seven days, and should be supplemented by proper directions as to rest, diet, laxatives, douches, etc., so necessary in the successful treatment of this class of cases.

MAGNESIUM IONIZATION.

Flat Warts.—The positive electrode, large enough to cover the parts to be treated, is well moistened with a 5-percent solution of magnesium sulphate and a current of from 10 to 15 milliamperes is used for about fifteen minutes. Two or three treatments will be required at intervals of about ten days.

Fungating Warts.—This method of treatment of fungating warts has not been a success. Electrolysis or the electrocautery should be used instead.

IODIN IONIZATION BY ANAPHORESIS.

Gonorrheal Arthritis.—The joint is wrapped in absorbent gauze thoroughly saturated with a solution of iodid of potassium, and connected with the negative pole of the galvanic current. The current should be as strong as the patient can tolerate, and be repeated two or three times a week.

Chronic Suppurative Adenitis.—It has been recommended that the pus be aspirated, the cavity injected with a solution of iodin or iodid of potassium, into which an insulated needle is introduced, and connected with the negative pole, using a current strength of from 10 to 15 milliamperes for ten minutes. It is stated that three or four applications will effect a cure.

The x-ray in the author's hands has given such universally good results that he has not had occasion to resort to other methods of treatment.

Goiter.—A thick gauze or felt electrode that will cover the tumor is well moistened with a solution of iodid of potassium, and connected with the negative pole of the direct current. The positive electrode must be considerably larger than the negative, and may be placed on any part of the body. The current should be as strong as the patient can possibly stand, and the treatment should last until the skin is quite red. Unless electrolysis is produced, the treatment may be repeated daily. The treatment may be supplemented by x-ray exposures, to be described later.

ZINC CATAPHORESIS.

Fistula.—Most excellent results have been obtained in the treatment of fistula in ano by means of zinc cataphoresis. A small zinc electrode well insulated, except for about ⅓ inch at the distal end, is introduced well down to the bottom of the fistula. A current of from 3 to 6 milliamperes is allowed to flow for three to five minutes. The bowels are kept constipated for two or three days. At the next treatment the electrode is not passed quite so far into the fistula, and in this manner the treatment is continued until the entire tract has been subjected to the action of the zinc. It may require from five to twenty or more treatments to effect a cure. Some cases are very obstinate, and an occasional failure may be expected.

Chronic Hemorrhagic Endometritis.—This is successfully treated by means of zinc cataphoresis. The method is very simple. A zinc electrode of the same style of construction as the Goldspohn intrauterine electrode is passed into the uterine cavity and connected with the positive pole of the battery, the indifferent electrode being on the abdomen or back. A current ranging from 10 to 60 milliamperes, according to the indications, may be used for from five to ten minutes. To prevent the intrauterine electrode from adhering, it should be moved continuously throughout the application. The treatment may be repeated once or twice a week until a cure is effected. As a rule, only a few treatments are necessary.

Epithelioma.—Zinc ionization for epithelioma differs somewhat from **zinc cataphoresis** to the extent that the former is simply a local application, and is effective only in very superficial growths. The application is best made with a zinc electrode, using a disk large enough to cover the surface to be treated. The disk is covered with absorbent cotton, which is saturated with a 1-percent solution of chlorid of zinc. The current should not be less than 2 milliamperes per unit of surface area of electrode and the seance should last about fifteen minutes. If the pain is too severe, cocain may be used, but never a general anesthesia. After the treatment it will be noticed that the zinc ions have turned the tissues a dead-white color, which later become red and inflamed. Mild applications are used, and the electric treatment may be repeated after a week. From two to four treatments are generally required to effect a cure. It is understood, of course, that this method of treatment is used only in very favorable cases of early development, and can not be relied upon in advanced cases.

Gonorrhea.—In prostatic affection, the result of a chronic posterior urethritis from gonorrheal infection, zinc electrolytic medication will give excellent results in the majority of cases. The technic is not difficult. A small soft rubber catheter, with eyelets about 4 inches along its distal end, is inserted into the urethra well down to the bladder, and connected to the positive pole of the battery by means of a small platinum wire passed through the entire length of the catheter. The catheter is now connected with a reservoir containing at least a quart of ½-percent sulphate of zinc solution, which is allowed to pass slowly into the catheter and return through the urethra. The current strength that the patient can comfortably tolerate will vary from 3 to 10 milliamperes. The treatment should be repeated every other day and continued until a cure is effected, which will be from three to six weeks. The author has had no experience with this method in acute cases.

Alopecia.—It has been claimed that the application of the positive pole, wet with a 1-percent solution of chlorid of zinc, to the bald spots will after a time cause a rapid growth of hair.

IONIZATION OF SALICYLIC ACID.

The use of salicylic acid by ionization has been favorably reported by eminent operators who have given the subject thorough study. The conditions in which it has given the best results are acute rheumatism, muscular rheumatism in the lumbar region, arthritis, tic douloureux, etc. A 10- to 20-percent solution of salicylic acid is used on the negative electrode. The electrode should be large enough to cover the parts affected. The positive electrode is placed on some indifferent part of the body, and should also be of large size. The current strength should be from 15 to 60 milliamperes, and the seance should last from twenty to thirty minutes, and often longer. The treatments should be repeated daily, and continued for a week or ten days or until relief is experienced.

The method is worthy of trial in all troublesome cases, though failure will sometimes occur, which is often traced to the technic employed instead of to the method itself.

TREATMENT BY ELECTROLYSIS.

Warts and Moles.—Various methods have been advocated by different operators, some using the positive pole and others using the negative for the active pole. The method that has given excellent results is to puncture the growth well through its base with an ordinary bright steel needle connected with the negative pole of the battery. With the current at zero, the patient is allowed to place his hand in a pan of water containing the positive electrode. The current is gradually turned into the circuit, using from 3 to 10 milliamperes, until the tissues about the needle have assumed a dirty-ashy color. The current is reduced to zero, and the needle is removed and passed through the growth at right angles to the first puncture, using the same current for the same length of time. The growth should be punctured in as many directions as seems necessary to thoroughly destroy it. In a few hours the growth will have turned black and soon forms a hard, dead, dry scab, that should not be removed until it comes off of its own accord. Pulling or scratching it off too soon will in many cases leave a small pit or scar. The scab usually comes off in from seven to ten days. The pain is very slight, but, where the patient is particularly sensitive, a little cocain may be used by cataphoresis, or a few drops injected under the skin before the treatment is begun. In using a steel needle, care must always be taken to use the **negative pole,** for, should the positive pole be used instead, there will be a black indelible deposit of oxid of iron in the tissues, which will be more annoying to the patient than the tumor or growth.

Removal of Superfluous Hair.—The electrolytic removal of superfluous hair is the only reliable method by which it can be permanently destroyed. The method is very simple, though quite tedious. The patient should be placed in a reclining chair in a good natural light if possible, for otherwise a head light will be required. A Hayes bulbous-pointed steel needle is carefully passed into the hair follicle, allowing it to pass gently down to the bottom. The patient now places her hand in a bowl of water containing the positive pole. A current of from 3 to 5 milliamperes is slowly turned into the circuit. In a few seconds a little foam will be noticed around the needle. After from five to ten seconds the patient is told to raise her hand from the water and the hair is grasped with a pair of depilatory forceps. If it comes away without resistance, its bulb has been destroyed and it will not return. The needle is now introduced into another follicle, not too near the one just treated, and the patient is told to put her hand into the water as before. Where the hairs are very close together, they should not be removed at one sitting because of the electrolytic destruction of the tissues when the needle is inserted too close together. Quite a little practice and experience is necessary to enable the operator to determine the direction of the hair follicle and pass the needle into it without penetrating its walls. Should this accident occur, it is more than probable that the bulb will not be destroyed and the hair will grow again. Very few operators have become sufficiently expert at this kind of work to do it well. Good eyes and a steady hand are absolutely necessary to insure success. In the treatment of blonds a hand magnifying glass is a necessity.

Vascular Nevi.—Vascular nevi are of common occurrence, and we are frequently asked to remove them. Because of the vascularity and the presence of telangiectasis the positive pole is the one of selection because of its properties of contracting the blood vessels, in which case the needle must be gold or platinum, or some nonoxidizable material. After inserting the needle in the tissues, a current of from 3 to 4 milliamperes is used until the tissues around the needle turn white, when the needle is moved to another place and the treatment is continued until the whole surface of the nevus has been covered.

Large nevi may be treated by the bipolar method, the needles being placed near each other and usually arranged parallel. The current should not be very strong or allowed to act in one place too long, for tissue destruction is not desired, the object being to contract or destroy the blood vessels.

Port-Wine Stains.—These may be treated by the bipolar method. This treatment is not, however, so uniformally successful in port-wine stains as in the treatment of small vascular nevi. The liquid air, or carbon dioxid snow, seems to be productive of better results. The x-ray treatment for port-wine marks will be considered in its proper place.

Acne and Acne Rosacea.—This is of little practical importance in view of the fact that the x-ray is almost a specific.

Stricture.—Since Newman's time the treatment of narrowed mucous canals by means of negative electric currents, or rather the negative pole of galvanic currents, has met with great success and has found many enthusiastic advocates. Those who have condemned the method have either selected the wrong technic, or cases which were unsuited to electric dilatation. Electrolytic dilatation is accomplished by slightly dissolving the mucous membrane in contact with the electrode, and at the same time stimulating and softening the stricture to such an extent that it is easily dilated with a sound or bougie several sizes larger than could have been passed before the electric application. Newman speaks of this method as being one of absorption—"galvanochemical absorption." In doing this work successfully, several things must be taken into consideration: (1) current strength, (2) the right pole, (3) size, shape, and material of the electrode, (4) the length of the seance and the time to intervene between the treatments. A disregard of any of these cardinal points will promptly meet with defeat.

Stricture of the urethra is the result of an inflammatory process, the most common of which is gonorrhea, or any other urethritis that takes on a chronic character and is treated by strong injections. When a stricture is to be treated, the diagnosis should be carefully made by the proper sounds and bougies, and the size, length, and nature of the stricture carefully determined. If much manipulation during the diagnosis is required, it is better to put the patient on some urinary antiseptic for two or three days before beginning the electric treatment. The patient should be placed on a table in a reclining position, or he may be entirely recumbent. An olive electrode, two or three sizes larger than the stricture, is selected and lubricated with glycerin, and introduced into the urethra until arrested by the stricture. The electrode is now connected to the negative side of the battery, and care must be taken that there is no mistake in this. The positive or indifferent electrode is placed on the abdomen or under the lumbar region. The current is gradually turned into the circuit until the patient begins to feel a decided warmth in the urethra. From 3 to 5 milliamperes will be required in most cases. If the operator has held the bougie gently, but firmly, against the stricture, it may be noticed to fairly jump through when the stricture gives away. When this occurs, the bougie should be brought back to the tightest part, where it is held for a few minutes longer; then, if there are no other strictures, the bougie is allowed to pass on to the bladder and gently withdrawn. The treatment should not be repeated oftener than once a week. Should the urethra be very sensitive, a 4-percent solution of cocain may be instilled a few minutes before the treatment is begun. The treatment should never be painful, for it should never be applied when the urethra is in an acute inflammatory condition. As the stricture is absorbed, larger electrodes are used until the dilatation is complete.

In the hands of the intelligent, conscientious, careful, and painstaking operator the galvanochemical dilatation of urethral strictures will seldom, if ever, be disappointing. It requires, however, as much technical skill to do the work successfully as for a surgeon to do a capital operation. No bungler can hope to succeed, and all such the author would advise to let the operation strictly alone.

Stricture in the Esophagus.—Treatment of this stricture by means of an olivary esophageal bougie is perfectly safe. The metallic olive is placed 2 or 3 inches from the distal end of the electrode. The method of procedure is the same as in the treatment of urethral stricture, the electrode being immersed in warm water and passed down the esophagus to the stricture, where it is gently held by the operator. The electrode is now connected with the negative pole of the battery, while the positive pole is placed on some indifferent part of the body. The current is slowly turned on to 4 or 5 milliamperes, when after a few minutes, if the bougie is not too large, it will pass through the stricture. If little or no trouble is experienced in passing the first bougie, a size larger may be passed in the same manner at one seance. The treatment should not be repeated oftener than once a week. It must be distinctly understood that this treatment is contraindicated in obstruction of the esophagus from pressure from any cause.

Stricture of the Lachrymal Duct.—Such stricture may be absorbed by insulating a Bowman sound with shellac, except for 1/8 inch of the extremity, and connected with the negative pole, while the positive pole is placed in a pan of water, into which the patient is told to place his hand. The sound is introduced into the duct and held gently against the stricture. Three or 4 milliamperes for from two to three minutes once a week will generally result in a cure after very few treatments.

Other Conditions.—Electrolysis may be used in the treatment of a great number of conditions, a description of which would make this chapter entirely too long. Besides those conditions mentioned, the method has been highly extolled for the treatment of acne and acne rosacea, sebaceous cysts, keloid, nasal polypi, ozena, nasal deviations and spurs, vegetative conjunctivitis, etc. There is no limit to the method in the hands of a competent operator who thoroughly understands its possibilities, but its use should not be attempted until the polar effects are thoroughly understood, for much harm has been done in the treatment of urethral stricture by confusion of the poles.

CHAPTER XI.

DISEASES OF THE NERVOUS SYSTEM.

In Chapters IX and X the student was made familiar with the various methods of electric examination and treatment of normal and diseased conditions appearing in the human body. In this chapter it will be necessary to describe only particular diseases of the nervous system, with the electric technic necessary for the treatment of each case or variety of cases.

A few years ago neurologists paid little or no attention to electricity, either as a diagnostic or therapeutic agent. With greatly improved apparatus and technic, electric methods are rapidly taking the position of first place in diagnosis and treatment of a large class of diseases where experience has proven them to be of the greatest possible value. In this limited work the author will be able to outline the methods of treatment in only a few of the most common diseases. To treat the subject of the nervous system exhaustively from an electro-therapeutic standpoint would require a volume many times the size of this, with no space whatever for other considerations.

The author has been greatly pleased with the outline of nervous diseases used by Doctor Tousey in his splendid work, just published, on "Medical Electricity and Röntgen Rays," and because of its simplicity and practical application will give it first place in the opening of this chapter, though the discussion that follows will vary at times to accord with the personal experience of the author. The complicated and complex nature of the nervous system, and the extreme difficulty of concentrating currents in the nerve trunks under ordinary circumstances, makes the duplication of electric findings extremely difficult for inexperienced operators. Because of this fact much experience and long study of the subject is necessary before serviceable work can be done.

The following features will be considered in this chapter:

(1) The use of electricity in diagnosis. (*a*) Diagnosis of dis-

orders of the peripheral nervous system—motor and sensory. (*b*) Diagnosis of disorders of the central nervous system.

(2) The use of electricity in therapeutics. (*a*) Therapeutic application of electricity in diseases of the peripheral nervous system. (*b*) Therapeutic application of electricity in diseases of the neuromuscular apparatus—neuromuscular disorders. (*c*) Therapeutic application of electricity in organic diseases of the central nervous system. (*d*) Therapeutic application of electricity in functional diseases of the central nervous system.

(3) Electric sleep and death due to electric currents.

DIAGNOSIS OF DISORDERS OF THE PERIPHERAL NERVOUS SYSTEM.

Motor Reactions.—Nerve and muscle stimulation and reaction have been discussed at some length in Chapter IX, and it will be necessary here to call attention to only some of the most important points. The student must remember that muscular contraction produced by the action of direct currents is not a continuous contraction, but takes place only

(1) When the current enters the muscle—current closing.

(2) When the current is broken—current opening.

(3) When the current is suddenly increased—change in density.

(4) When the current is suddenly decreased—change in density.

(5) When there is a sudden change in the direction of the current.

It is not the strength of a current at a particular time that causes muscular contraction, but such contractions are due to a sudden or rapid change in current density. On this fact Pflüger's law and the normal polar formula are based.

In the examination of the normal and diseased conditions of muscles and nerves, it must be remembered that no definite figures can be given for the contractions that follow such examinations. The figures given for the normal polar formula in Chapter IX are, however, a good guide to follow. A list of figures might be given for the reactions of the various accessible nerves in the body, but they would be difficult to verify.

For a method of study of the neuromuscular apparatus, the student is referred to Chapter IX, where the subject is discussed at some length. There will be no attempt to treat this subject exhaustively, for that would require several volumes. If we succeed in clearly outlining the electrical methods in the few nervous diseases commonly met in general practice, we shall have accomplished our main purpose in this chapter.

DIAGNOSIS AND TREATMENT OF DISEASES OF THE PERIPHERAL MOTOR NERVES AND MOTOR CENTERS.

Palsies of Cranial Nerves.—The cranial nerves generally affected are the facial, hypoglossal, and spinal accessory.

Ocular Muscles.—Examination of the eye muscles is a very difficult matter. The third nerve supplies the muscles of the eye, except the superior oblique, which is supplied by the fourth. Complete paralysis of the third nerve produces ptosis, external strabismus, inability of the globe to move upward, or downward, or directly inward.

Electrical treatment of these conditions is not of much practical value, and should be resorted to only after every other method has failed.

Facial Nerve.—This nerve is more likely to become affected than any other cranial nerve. When it ceases to functionate, the condition is known as facial paralysis, or Bell's palsy. The paralysis usually comes on suddenly, and may be the result of cold, injuries, tumors, or one of many causes. When discovered, the cause should be removed if possible, but, since this is often difficult and frequently impossible, electricity is used for the purpose of maintaining the nutrition of the paralyzed facial muscles and to hasten the return of power.

The different branches of the facial nerve should be tested to determine the extent of the paralysis. By placing the active electrode just in front of the ear on the main trunk of the facial nerve, the stimulation may be carried to all of the branches at the same time, though the superior branch will be less affected.

The three branches of the facial nerve may be stimulated separately, and the student is referred to Figs. 84, 85, 86 for the motor points. In making these tests, it must be remembered that of the three branches the upper branch is the most excitable, and the middle branch the least. In mild cases reaction of degeneration may be absent, though it is often complete, and it comes on slowly and often irregularly.

Electricity promises more in these cases than any other method of treatment. Cases due to cold will often get well without treatment, but their recovery can always be shortened by the proper use of faradism and galvanism. The treatment should be given daily, direct applications being made to both the nerve trunk and the muscles. The positive electrode is generally placed on the nape of the neck, and the active or negative electrode should be passed along the affected nerve from the center toward the periphery.

Five minutes is usually about the length of time required for a treatment. The faradic current is used first, and is generally all that is necessary unless degeneration has set in, in which event the galvanic current will be needed. The current strength will depend upon the amount of degeneration present, and only enough current should be used to cause full and complete contraction of the muscles under consideration.

Cases due entirely to cold will usually recover in from two to three weeks, though it is not uncommon to see cases due to other causes last for several months. Treatment should be continued as long as there are even the slightest symptoms of improvement. The author has never seen a case that did not respond to proper treatment if continued long enough.

If the disease is of central origin, electricity will be of service, but, as a rule, does not produce as good results as in the peripheral variety. If the condition is due to syphilis, electricity will not be of any use.

Vagus Nerve.—Paralysis of the soft palate and the larynx results from lesions of the vagus. Where the paralysis of the palate is due to diphtheritic neuritis, electricity is especially valuable in shortening the period of regurgitation of food through the nose.

Cervical Region.—When a paralysis occurs in this region, it is usually not difficult to determine whether it is central or peripheral. In that of central origin the muscles involved are usually affected at once, and acquire the full paralysis very rapidly, while in peripheral paralysis the onset is slow and gradual. In both cases the entire limb is affected and is entirely helpless, while muscular atrophy follows in due course of time.

In making a diagnosis in paralysis, it is necessary to determine whether it is of organic or functional origin. In some cases the differentiation is quite a difficult matter. Muscular atrophy seldom occurs in functional disease, almost never in the early stages, and reaction of degeneration is not found unless muscular atrophy has occurred from many years of paralysis in a group of muscles.

The muscles most generally affected in paralysis of the cervical region are the sternomastoid, trapezius, serratus magnus, supraspinatus, infraspinatus, and deltoid.

Erb's Paralysis.—This condition exists as an injury to the root fibers in the nerves of the brachial plexus where they emerge from the spinal cord. The damage is generally done to the fifth and sixth cervical nerves, though the trouble may be primarily in the fifth, sixth, or seventh, and the muscles involved will be the deltoid, biceps, supinator brevis, brachialis anticus, and spinati.

In Erb's palsies electric treatment with both the galvanic and faradic currents should be continued for a considerable time. Mild cases may get well without treatment, but severe cases will recover only after electric stimulation covering a long period.

Musculospiral, Median, and Ulnar Nerve Paralysis.—These are of such frequent occurrence that each requires special attention.

Musculospiral Paralysis.—This is usually the result of an injury to the nerve outside of the plexus, and results in a loss of power in the extensors of the forearm and wrist and in the supinators. It is impossible to extend the elbow, and the muscles of the forearm become atrophied. The cause of musculospiral paralysis may be due to injury to the nerve, or from long periods of pressure, as when sleeping on the arms, pressure of crutches, or anything, in fact, that causes long pressure upon the nerve. Unless actual section of the nerve has taken place, faradic and galvanic treatment will be productive of excellent results.

Median Nerve Paralysis.—The median nerve supplies the pronators, flexor carpi radialis, the flexors of the fingers, the abductors and flexors of the thumb, and the two radial lumbricales, which flex the first phalanx. Fracture of the ulnar or radius, or other traumatic injury, may involve the nerve above its muscular branches.

The principal symptom of median nerve paralysis is an inability to flex and to pronate the forearm. It is impossible to grasp anything with the hand, and the thumb can not be brought to the tips of the fingers, nor can it be abducted. Pain is often a symptom. Median nerve paralysis is often the result of toxic agents. Electric diagnosis and treatment is the same in this condition as in other cases of neuritis. If on examination it is found that the degeneration is limited to the median nerve distribution, it is probable that the injury is due to some mechanical cause.

Ulnar Nerve Paralysis.—This nerve arises from the brachial plexus, and supplies the flexor profundus digitorum, flexor carpi ulnaris, all the muscles of the little finger, the interossei, two ulnar lumbricales, abductor pollicis, and the flexor brevis pollicis. The claw hand is the usual result of ulnar paralysis, in which the third and fourth fingers are more particularly affected. Injuries, fractures, and dislocations in the bones of the forearm are likely to injure the nerve and result in a paralysis. Since this nerve carries some fibers of sensation, there will be, if the nerve be divided, a loss of sensation in the little and ring fingers and the palm, depending, of course, on the extent of the paralysis in the nerve.

MOTOR CENTERS OF THE SPINAL CORD AND MOTOR CENTERS OF THE LOWER EXTREMITIES.

The nerves of the lower extremities are less often involved in injury than those of the upper limbs, while the gray matter in the cord is more apt to be the seat of disease than in the cervical region. In acute poliomyelitis the muscles of the lower extremities are mainly affected, the peronei suffering most.

Obturator Paralysis.—This nerve is derived from the third and fourth lumbar nerves, and supplies the abductors of the thigh. Its function, mainly, is to cross one leg over the other or to spread the legs apart. Paralysis of this nerve may follow difficult childbirth, but is not likely to be of long standing.

Anterior Crural Paralysis.—If this nerve is injured within the pelvis, there will probably be a loss of power to flex the knee and hip; if the trouble is outside of the pelvis, the knee alone will be involved.

Sciatic Paralysis.—When this nerve is involved above the middle third of the thigh, the flexors of the knee, the extensors of the hip, and all of the muscles below the knee are generally affected. While paralysis of this nerve is uncommon, sensory disturbances are very common, and the neuralgic pains are frequently quite severe.

Peroneal Paralysis.—Paralysis of the external and internal popliteal nerves greatly interferes with locomotion. In external popliteal injuries the tibialis anticus, long and short extensors of the toes, and the peronei are chiefly affected. Foot drop, followed later by talipes equinus, is a result of the unopposed action of the gastrocnemius. Because of its superficial location, it is often injured from without and may suffer from fracture of the fibula, and occasionally it seems to be the seat of primary disease.

When the internal popliteal is injured, the muscles of the back of the leg, the long flexors of the toes, and the muscles of the sole of the foot suffer. If this nerve is diseased, the foot can not be extended, and the leg can not be inwardly rotated. Injuries to the internal popliteal are likely to occur in extensive fractures of both bones of the leg.

Plantar Paralysis.—Injury to the external plantar nerve results in paralysis of the interossei, the abductor of the big toe, the two outer lumbricales, and the accessory flexor of the foot, the patient having lost the ability to spring forward on the foot and stumbling is frequent. Injury to the internal plantar results in paralysis to the short flexors of the toes, the muscles of the big toe, save the abductor and the inner lumbricales. Paralysis of this nerve interferes less with walking than paralysis of the external plantar.

Treatment.—The diagnosis, prognosis, and treatment are the same in palsies of these nerves as elsewhere. The degree of degeneration should first be determined, which will furnish some idea as to the length of time that may be necessary for recovery. It may take several days, with frequent examinations, to arrive at a diagnosis and prognosis.

Electric interference, even for diagnosis, should not be attempted before the last of the second week. Should there be pain in the nerve trunks, the result of a neuritis or irritation in the meninges, electricity is contraindicated. If there is no pain present, and at about the end of the second or third week there is a typical reaction of degeneration, it is probable that the paralysis will last at least three months and may continue for a year. If no improvement appears after three months, it is not likely that recovery will take place, though some cases do recover after a much longer period, and hope of recovery should not be abandoned until after twelve months have passed. If on examination a partial reaction of degeneration is found, the chances of recovery are very much better, and the patient will probably recover in from ten to twelve weeks. If the reaction is but slight, and responds to faradism and galvanism, the chances of recovery are good, and the patient will usually recover full motion in from four to six weeks.

Electric treatment should, if possible, be associated with massage and exercise.

TECHNIC OF ELECTRIC TREATMENT.

The technic of electric diagnosis has been explained in Chapter IX, and it remains now to describe in some detail the methods employed in the treatment of the various nerves and muscles that have undergone a degenerative process.

Electricity is useful in the treatment of these paralyzed muscles and nerves, for through its aid the muscles may be made to contract very much as they do when stimulated by the normal nervous influence. The exercise of the muscles by means of the different electric currents seems to have about the same nutritional effects upon the tissues as the natural exercises.

It must be understood that electricity has a specific tonic effect upon the tissues traversed, whether muscular contractions are produced or not. This nutritional effect is dependent, to a certain extent, upon the amount of electricity that passes through the tissues. When a muscle is contracted by an electric current, it receives a twofold effect. The tissues are exercised by the movement, the same as by any other mechanical method, and when traversed by the current are stimulated to greater functional activity.

The currents capable of producing the greatest nutritional effects in the tissues are the galvanic, faradic, and sinusoidal. The stimulating and nutritional effects of the electric currents are indicated in most muscular palsies where the reaction of degeneration is not too marked.

The limb to be examined or treated should be placed in such a position that the muscles stimulated may produce normal movements. The treatments should not be too prolonged, as fatigue may result the same as in normal exercise.

Galvanic Current.—This current has an excellent tonic and nutritional effect. When the current is gradually increased and decreased, though moderately strong, muscular contractions will not be produced. To produce contractions, the current must be made and broken, or **suddenly increased or decreased,** the strength of the current being weak. For their therapeutic effect, galvanic currents are generally applied so as to flow in the physiological direction of the nerve force. Contrary to the writers who do not recognize the electron theory, the negative electrode should be applied to the tissues near the nerve center and the positive electrode should be applied to the motor nerve or its muscle.

Faradic Currents.—These currents are not employed as much as they once were, though the older men in the profession still cling to the faradic battery. The effect of these currents is almost entirely mechanical, and should be used solely for the purpose of exercising the muscles, while the galvanic current is to be used for its trophic effect.

Combined Galvanic and Faradic Currents.—These currents may be used simultaneously or successively. When using the faradic current alone, polarity is not important, but, when the currents are combined, the polarity must be recognized the same as in individual galvanic currents.

The physiological effects of the faradic current will depend upon the size and length of the wire in the secondary and the rapidity of the interruptions. The secondary may be composed of several sizes of wire, each of which may be used independently or connectedly. A review of Fig. 14 will refresh the reader's memory as to the construction and operation of the faradic coil. It must be remembered that the longer the wire in the secondary coil the higher will be the voltage in the induced current, and consequently the lower will be the amperage. While the current from an induction coil is truly alternating, the physiological effects of such currents are those of a unidirectional current of high voltage and low amperage. In the large induction coils there is a distinct polarity, which is negligible in the smaller coils. The primary is that of the galvanic current plus the induced current, which greatly increases its voltage. It is that of a rapidly interrupted galvanic current of high voltage, and has a highly nutritional and stimulating effect on animal tissue.

The secondary coil or coils, being free from metallic contact with the battery circuit, will depend wholly upon induction from the electromagnetic field, and will consequently have a low amperage, with a high voltage, in proportion to the number of turns of wire in the secondary coil. Both primary and secondary coil currents contract muscles. Indirect stimulation is greater than direct. For the purpose of muscular contraction, slow interruptions are better than fast, since rapid interruptions tetanize the muscle. Currents from primaries and short secondary coils are stimulating and nutritive, while currents from long secondary coils, with rapid interrupters, are tetanizing and markedly sedative. Induced currents, slowly interrupted, produce a kind of electric massage in the tissues, with a stimulating and nutritional effect, while the same current rapidly interrupted produces anemia, with destructive changes.

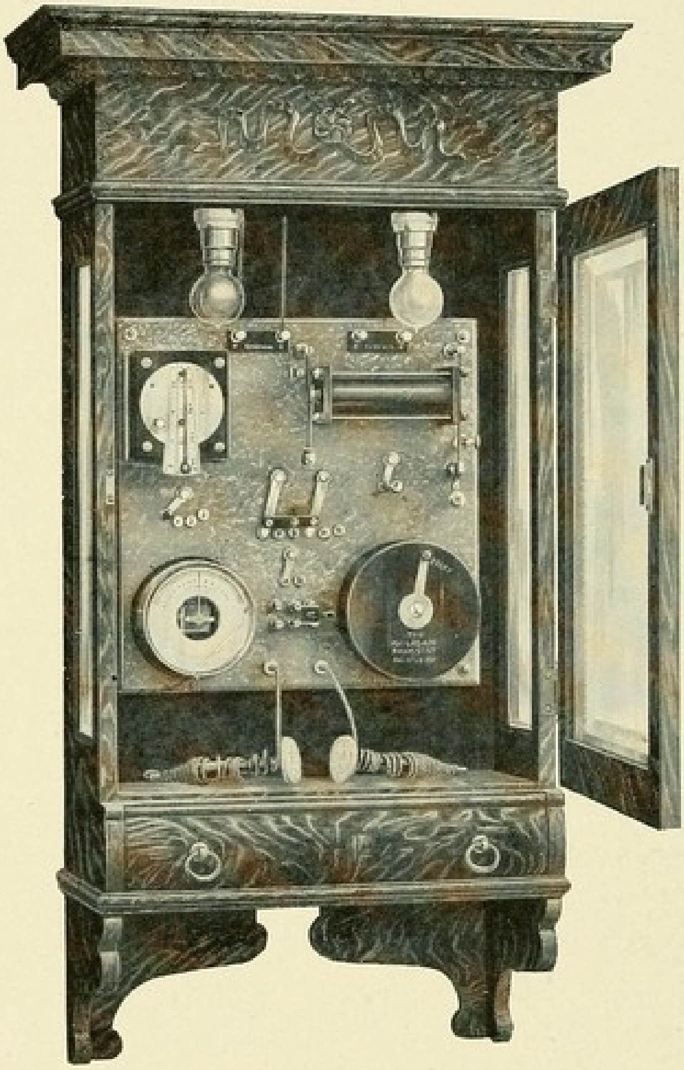


Fig. 87.—Wall plate.

The faradic current is useful in the treatment of all functional paralyses where there is no destructive lesion in the nerve tissues. In the treatment of female pelvic conditions it frequently serves a double purpose by increasing nutritive processes and relieving pain and irritation.

It should be remembered that intrauterine applications of galvanism should **always be followed** by a few minutes' use of the high-tension faradic current through the same electrodes for the purpose of allaying any irritation that may have been caused by the galvanic application.

To illustrate and describe each galvanic battery or wall plate now on the market would fill a fair-sized volume. Unfortunately for the physician and the cause of electro-therapeutics, the average table or wall plate seen in the physician's office is almost worthless; a few are good, but only occasionally do we find one that is first-class.

The physician gets the idea that wall or table plates are all alike, and he buys where he can get one the cheapest. As he learns more about the work and apparatus in particular, he discards his first purchase for the very best to be had at any price, after which he begins to do some really good work.

Fig. 87 illustrates a wall plate usually seen in the physician's office. (For a diagrammatic drawing of the plate the reader is referred to Fig. 45.) This plate is all right as far as it goes. The modalities derived from it are the galvanic current, interrupted galvanic current, primary faradic current, secondary faradic current, slow interrupted faradic current, rapid interrupted faradic current, etc. When operated from the 110-volt direct current, from a battery of cells, or from a rectified alternating current, electrolysis and cataphoresis may be done as successfully as with any other class of battery.

Where both the 110-volt direct and the 110-volt 60-cycle alternating currents can be had in the same office, the wall plate shown in Fig. 88 will answer all of the requirements of the most exacting physician, save perhaps the sinusoidal current, the frequency of which can not be regulated. This will probably be improved in the near future. In addition to the plate shown in Fig. 87, this plate has the galvano-faradic, sinusoidal, and cautery. This plate is designed to be operated by the 110-volt direct and 110-volt 60-cycle alternating currents. The 110-volt direct current is the only dynamo current that will successfully operate the galvanic side of the plate. Where this current is not to be had, the current from a battery of cells may be used. Forty cells connected in series will furnish a current of ½ ampere, with a pressure of 60 volts. The cautery and sinusoidal side of the plate must be operated from the 110-volt alternating circuit.

If the 110-volt direct is the only available current, it will be necessary to add a small motor generator for the purpose of generating an alternating current for the cautery and sinusoidal apparatus.

This motor generator (Fig. 89) is operated from the 110-volt direct current, and delivers an alternating current of about 70 volts' pressure, which is ample for operating the cautery and sinusoidal current apparatus.

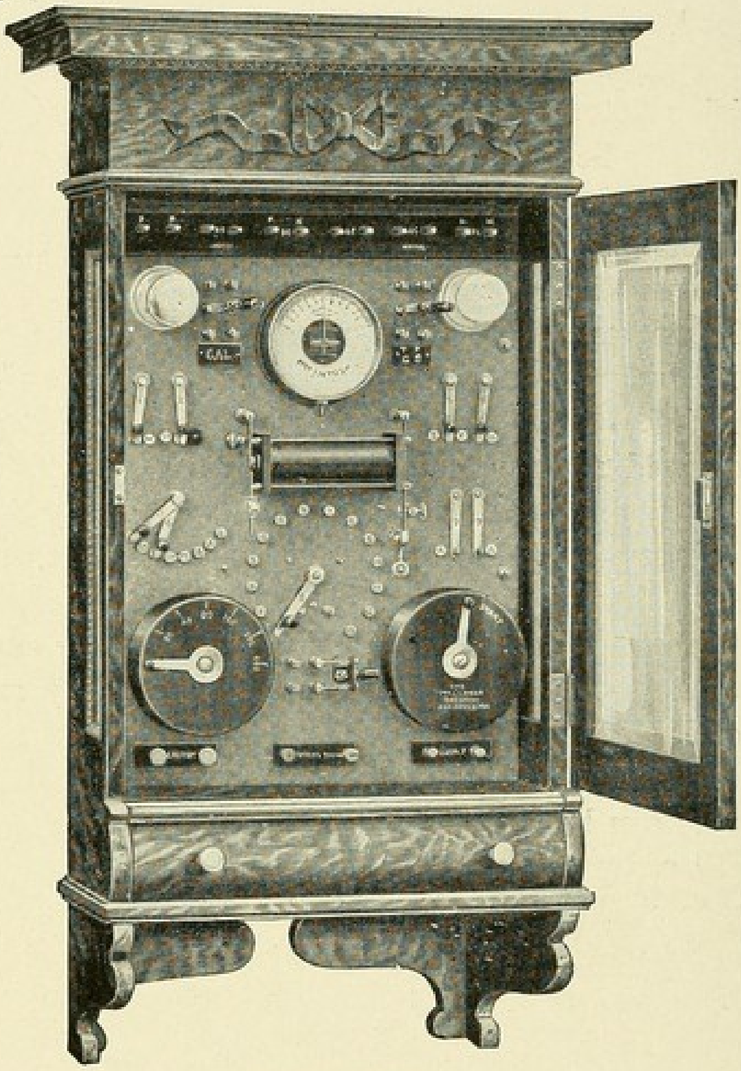


Fig. 88.—Wall plate.

The second wall plate (Fig. 88) is provided with switches for the purpose of combining the galvanic and faradic currents, but there is no provision for increasing or decreasing one of these currents without affecting the other in like proportion. There is no question that the combined galvanic and faradic currents are productive of great good in the treatment of peripheral paralysis, but provisions for properly regulating the strength of the currents separately should be a part of every plate or switch-board where these currents are to be used.

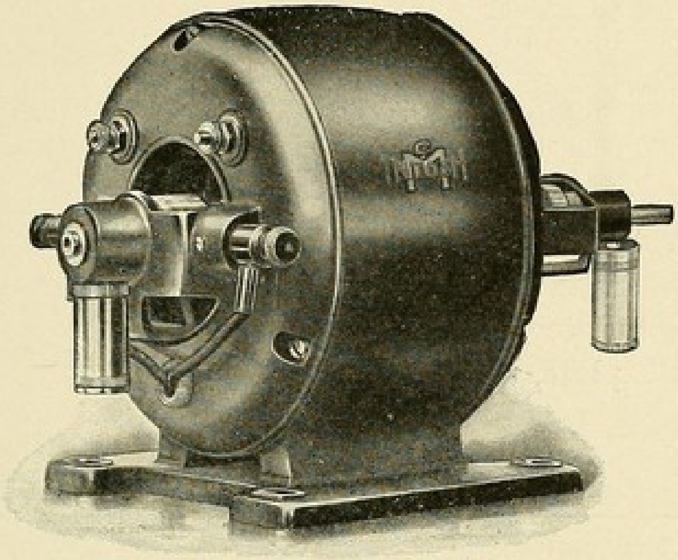


Fig. 89.—Motor generator.

Alternating Current Rectifier.—Because of the greater economy in the transmission of alternating currents, the alternating electric lighting current seems to be the current of choice in the smaller cities and towns. The kind of current must be taken into account by the physician who contemplates installing a wall plate to be operated with the commercial circuit.

The physical properties of the alternating current are entirely different from those of the direct current. The alternating current consists of a number of cycles of constantly reversing polarity.

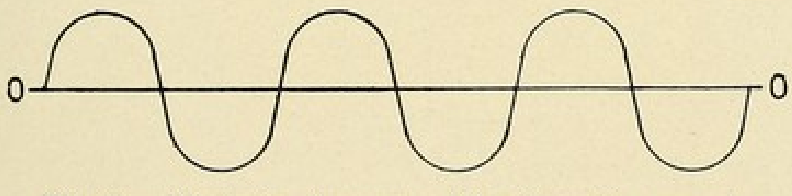


Fig. 90.—Illustrating the course of the alternating current.

The 60-cycle variety of alternating current has 7,200 alternations per minute, or 3,600 cycles per minute, each cycle being half positive and half negative during its period of flow. Its positive effect is, therefore, completely neutralized during the negative period. Fig. 90 illustrates the course of the alternating current. The straight line represents the zero point, which is exactly between the negative and positive influence. The curved line represents the rise and fall of the current above and below the zero line. The rise above and fall below the line constitutes a period or cycle. This class of current is not unidirectional, and is, therefore, unfit for use with a wall plate. Before this current can be used it must be transformed or rectified. Heretofore the only means of transforming the alternating current for wall plate use was by means of the motor dynamo, a valuable, though rather expensive, piece of apparatus. To obviate the expense of the motor dynamo, the chemical rectifier, an inexpensive appliance for changing the alternating current into a unidirectional current suitable for use with the wall plate, has been constructed. This device is of

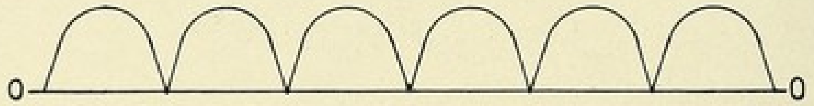


Fig. 91.—Influence of the rectifying valve on the alternating current.

a chemical nature, and operates on the principle of transposing one-half of the cycles and delivering a direct current which possesses the polar properties required in galvanism, but consists of a number of minute impulses flowing in the same direction as shown in Fig. 91. To overcome this pulsating current, it has been found that by placing a special type of condenser between the direct current terminals of the rectifier the rise and fall in voltage shown in Fig. 91 may be overcome or equalized with the result shown in Fig. 92.

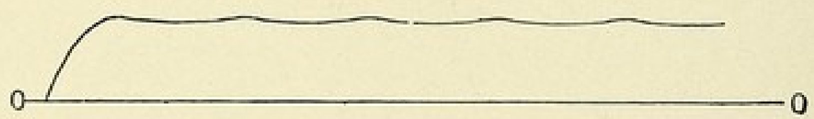


Fig. 92.—Influence of the chemical rectifier, with the potential equalizer, on the alternating current.

The chemical rectifier with the potential equalizer, as now made, is said to completely rectify the alternating current, so that it may be successfully used with the wall plate. Fig. 93 represents the rectifier with the potential equalizer. It is furnished with complete directions for installing. The author has had no experience with this machine.

The sinusoidal current has not come into general favor because of the kind of apparatus with which we have had to work. The average machine is provided with a rheostat, by which the strength of the current is controlled, but there is no provision for regulating the rate of the interruptions, a very important matter.

Rapid interruptions and high-frequency currents have gone too far in the high-frequency direction, and not enough attention is being paid to quality and quantity. Ordinarily the sinusoidal current has an interruption of 7,200 per minute, with an equal rise in potential at each alternation. A current of this class, like the induced current, causes more or less tetanic muscular contractions,

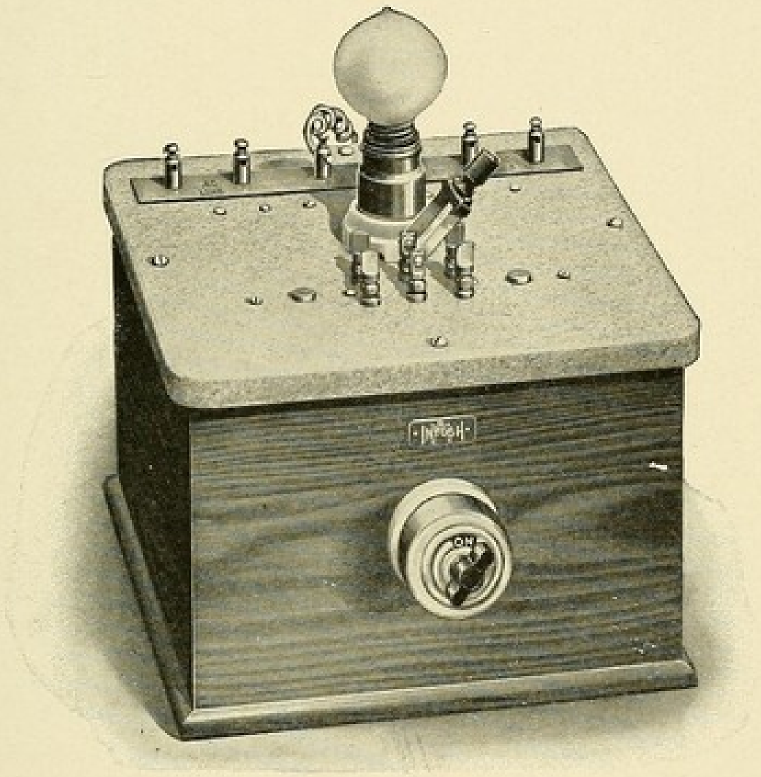


Fig. 93.—Chemical rectifier, with the potential equalizer.

without any intervening periods of muscular relaxation. In degenerated muscles very slow interruptions are necessary to produce anything like normal physiological contractions, and for this purpose the alternations should be as few as 10 per minute. A sinusoidal apparatus, producing a current that may be slowly interrupted, with a gradual rise and fall in potential, producing a slow sine wave, that may be made undulating, fluctuating, or surging, will leave but little to be desired.

A manufacturing firm has lately placed upon the market a plate known as the McIntosh polysine generator. It is claimed that this new apparatus is capable of furnishing the following modalities:

rapid sinusoidal, at 60 cycles; slow sinusoidal, from 1 to 10 cycles; surging sinusoidal, from 1 to 10 periods; superimposed wave, from 1 to 10 periods; combined galvanic and sinusoidal, 60 periods; rapid surging galvanic, 60 periods; slow surging galvanic, from 1 to 10 periods; galvanic, diagnostic lamps; alternating current, 60 cycles for cautery purposes, etc. This instrument has much to rec-

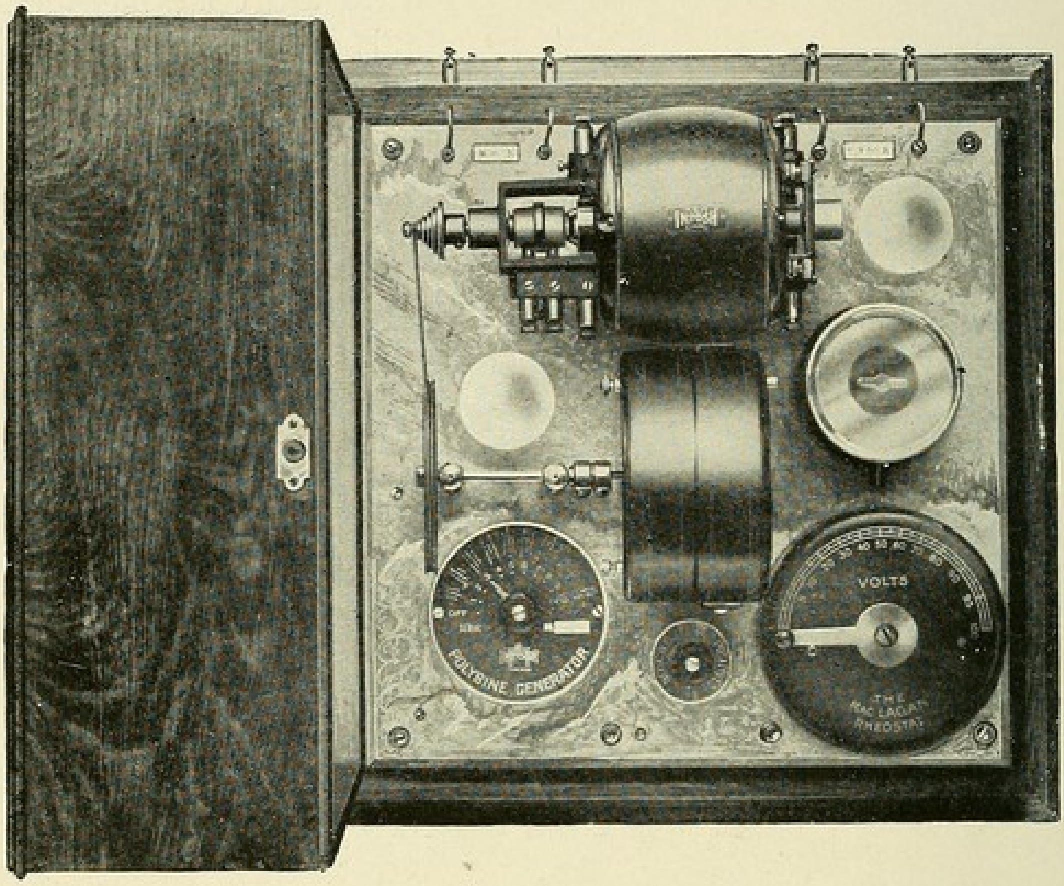


Fig. 94.—Polysine generator.

ommend it, since it furnishes both alternating and direct currents that are entirely independent of the commercial lighting circuit, and are, therefore, not grounded, and may be used with the ordinary bath tubs with perfect safety.

The author has never been favorably impressed with the therapeutic value of the rapid 60-cycle alternating current, because the alternations (7,200 per minute) are too fast. The polysine generator seems to overcome this defect in the old type of sinusoidal apparatus by so regulating the interruptions that the cycles may be controlled from 1 to 10 per second, and may be made surging or wave-like.

Fig. 94 illustrates the polysine generator. It contains a rotary converter, a rotar, rheostat, milliamperemeter, pole changer, resistance lamps, dial selector, binding-posts, etc. The instrument is very simple, and requires very little attention to keep it in perfect working order.

Another style of wall or table plate is being offered by the same firm that furnishes a galvanic current of light or heavy dosage, diagnostic lamp current, fast primary faradic current, fast secondary faradic current, slow primary faradic current, slow secondary faradic current, combined galvanic and faradic current, low potential sinusoidal current not grounded, high potential sinusoidal current suitable for baths, combined galvanic and sinusoidal current, and cautery current of small and large volume. This is an excellent type of machine, though inferior to the polysine generator from a sinusoidal standpoint. Fig. 95 shows the arrangement of this wall plate, which is a great improvement over plates shown in Figures 87 and 88.

The galvanic is a direct or unidirectional current, whose potential remains the same throughout, but, for the purpose of producing muscular contractions, it may be subjected to any number of interruptions by means of what is known as a rheotome. This rheotome is an automatic device with a clock mechanism, and may be set to interrupt the current from 8 to 660 per minute. The galvanic current is the stronger stimulus, and will produce muscular contractions when all other currents have failed. When there is no response to galvanic stimulation, if properly conducted, it is certain that the nerve has either been severed or that degeneration in that nerve is complete.

The examination of a nerve or muscle is generally begun with the faradic current, because it is much simpler and often makes the more complicated galvanic examination unnecessary. Muscles and nerves that respond to faradic stimulation in a normal manner will always respond to galvanism. In making the diagnosis of injured muscles and nerves, the galvanic current is applied according to Pflüger's law, as described in Chapter IX. Each muscle is carefully examined, and the amount of current necessary to produce a contraction on opening or closing, ascending or descending, is carefully noted and recorded, together with the manner in which the muscle contracts. A muscle may be made to contract under electric stimulation and yet be far from normal, and it is, therefore, necessary to carefully note the particular manner in which the contraction takes place in order to determine the different degrees of reaction of degeneration. As compared with the reaction of normal muscles, if the contractions are weak and sluggish, slow or wormlike, reaction of degeneration is in progress. The course of the degeneration is easily determined through frequent electric examina-

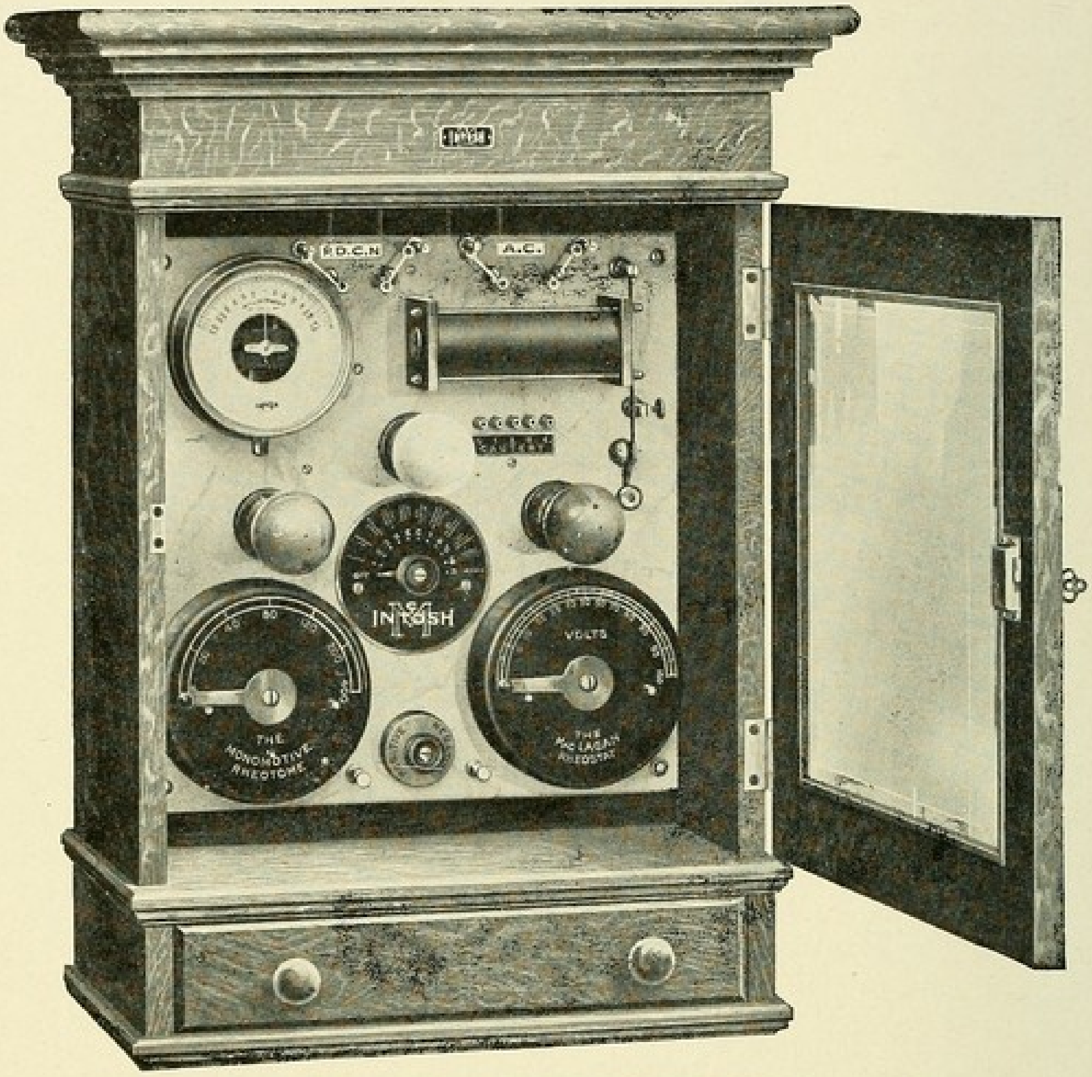


Fig. 95.—Wall plate of modern type, without polysine generator.

tions. As the condition improves, the contractions become more and more normal until the muscles and nerves assume their natural functions.

When the paralysis extends to all of the muscles of a member, instead of the sponge electrode so commonly used, the author has the patient place the hand or foot in a pan of water to which the active electrode is connected, the other electrode being on the lumbar region or some indifferent part of the body. This method of administration will also give excellent satisfaction with the faradic and sinusoidal currents.

Static and High-Frequency Discharges.—Besides the currents above described, the high-frequency discharges from the static machine and the various forms of condensers may be successfully used in the treatment of degenerated nerves.

The direct or indirect static spark from the large ball electrode, though sometimes painful, may often be used with good effect. With the positive side of the machine grounded and the prime conductors close together, the muscles may be made to contract by bringing in contact with them a glass vacuum electrode connected with the other side of the machine. The machine should be made to run as slowly as possible to get a slow, but regular, spark between the prime conductors. The farther the prime conductors are pulled apart, the stronger will be the muscular contraction under the vacuum electrode.

The Leyden jar or static induced current may be used for the same purpose, the same precautions being observed as mentioned above. These are generally spoken of as high-frequency currents of the alternating type, and, while they possess some merit and may be used in the absence of other methods, they are inferior to the faradic, sinusoidal, and galvanic currents.

The high-frequency resonator and various kinds of condenser electrodes are used by as many different operators, each claiming some special virtue for his individual pattern. They are all valuable, but no one operator can ever hope to install and use everything he sees or has recommended as being superior to something else. He must learn to discriminate for himself, and use only that which, in his hands, produces the best results.

ELECTRIC TREATMENT OF NEURALGIA AND NEURITIS.

The neuralgias that are amenable to electric treatment, and which the electro-therapeutist is most often called upon to treat, are those of the trigeminal, brachial, musculocutaneous, and sciatic nerves.

A neuralgia is not a disease, but a symptom of a disease that may have its origin in some distant part of the body. It stands to reason that a correct diagnosis of nerve pain is of first importance. The seat of the trouble may be in a cerebral, spinal, or visceral nerve, and the symptoms referred to some other part of the body, in which case treatment of the symptom would in no way benefit the patient, as the cause would not be relieved. Visceral disturbances often cause referred pains in certain skin areas. This fact emphasizes the importance of a careful study of visceral diseases.

Cause of Neuralgias.—Among the predisposing causes are anemia, sexual excesses, pregnancy, and menorrhagia. The most frequent exciting causes are cold, injury to the nerve in the way of direct violence or pressure of a tumor, syphilis, gout, or systemic poisoning.

Neuritis.—In cases of neuritis the diseased nerve is best treated by franklinism and galvanism; the paralyzed muscles, by galvano-faradism or faradism.

Static Method.—The method of administering a static treatment in an obstinate case of sciatic neuralgia is shown in Fig. 96. It will be noticed that the patient has placed his bare foot in a tub of water, which is connected to one of the prime conductors of the static machine. Sprays and sparks are vigorously applied over the region of the sciatic nerve. The metallic point or ball electrodes are used for this purpose. The electrode is grounded, and the application is known as an indirect static spray or spark. The treatment should begin with the spray and end with sparks, which should be as strong as the patient can tolerate. If the treatment seems to relieve the pain and give the patient comfort, it should be repeated once or twice a day until a cure is effected or the treatment fails to be of service. Many cases are cured by this method of treatment.

If the sinusoidal current is used, the alternations should be made as slowly as possible. The sinusoidal is a valuable modality in paralysis, and often succeeds when other currents fail.

When the cause of a neuralgia is determined, removal of the cause will in most cases stop the pain, but, should the established neuritis tend to continue, the galvanic or galvano-faradic currents will nourish and stimulate the nerve to perform its normal functions. In applying the galvanic current to nerves of this character, the current is passed from the center toward the periphery, which places the positive pole on the muscle to which the nerve is distributed. Should the muscle exhibit a painful area, the sedative effect of the positive pole will tend to relieve the pain. Sometimes a very strong current—from 40 to 60 milliamperes—is used over periods of half an hour at a seance. This requires considerable caution on the part of the operator to prevent a severe shock to the patient. Large well-moistened electrodes are necessary, and care should be exercised to prevent a burn.

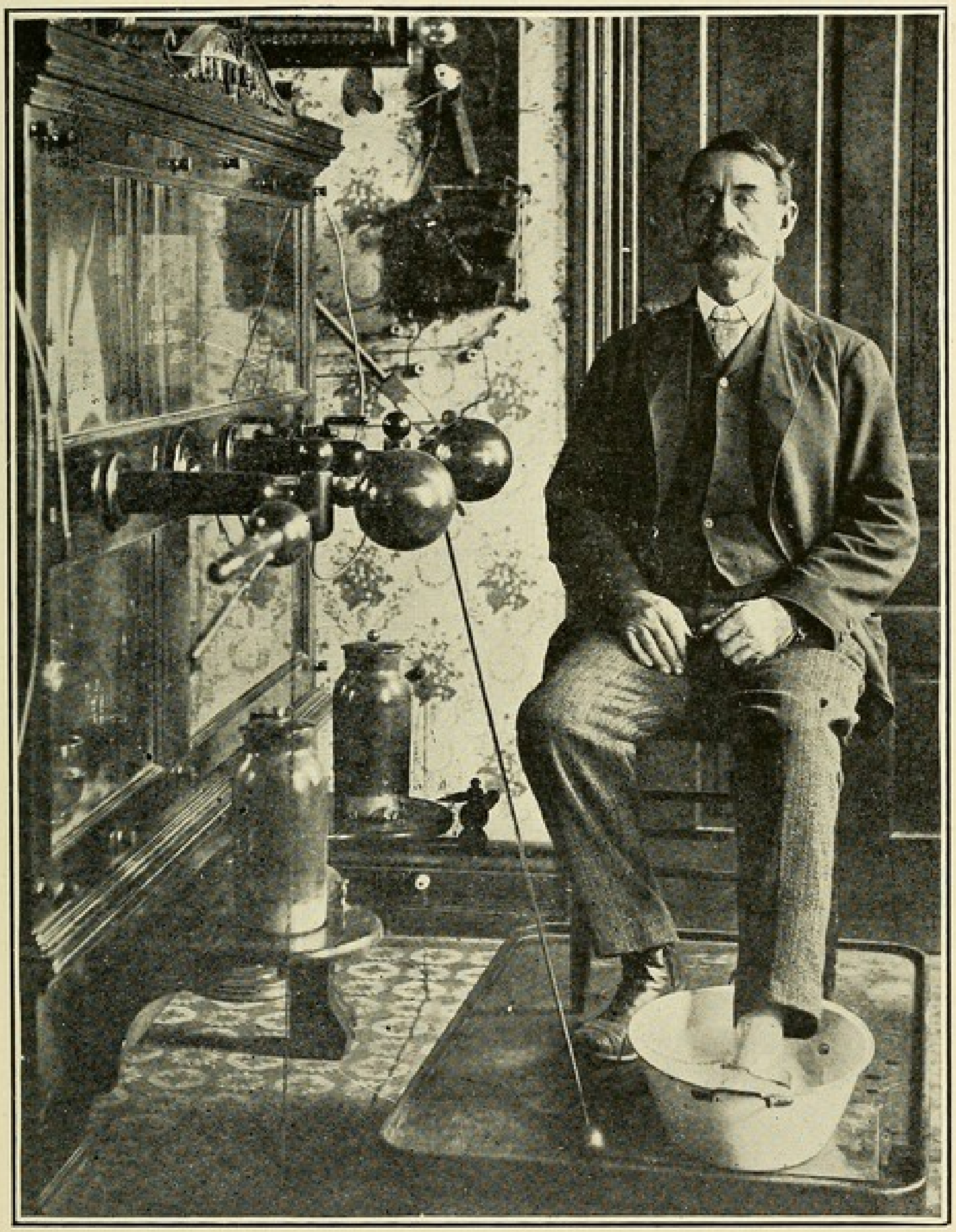


Fig. 96.—Method of administering a static treatment in an obstinate case of sciatic neuralgia of twenty-five years' standing.

Mild galvanic currents sometimes seem to afford greater relief than strong currents. Where the nerve is deep, the electrodes should be quite large and the current correspondingly strong in order that the nerve may be reached. Where benefit is derived from the applications, the seances should be repeated often enough to relieve the symptoms.

Trigeminal is probably the most persistent neuralgia of the face, and often requires long and active electric treatment. Leduc has reported success in the treatment of this troublesome malady by means of the cataphoric use of quinin. In the treatment of this condition the positive electrode is applied to the painful area and the indifferent electrode (the negative) is applied to the nape of the neck. Where heavy currents are used, the metal parts of the electrodes must be well protected by cotton, felt, or other absorptive material to prevent the skin from being burned.

Wherever found, the treatment of a neuralgia is very much the same, the technic varying with the area to be treated and the depth of the nerve to be reached. As before stated, some nerves will respond quicker to weak currents long continued, while others will require strong, active stimulation. Since every case is a law unto itself, the successful electro-therapeutist will soon realize existing conditions as he finds them, and will set about in a practical way to right the trouble and bring about a normal state of affairs.

One should not form the habit or acquire the reputation of recommending electricity for every case that comes into his office, but, if every other method has failed, the judicious use of one or more of our many electric modalities may meet with success. The author recalls a number of cases of suspected kidney stone, where the patients had suffered long and severely, that had no more pains after two or three exposures to the x-ray for the purpose of making skiagraphs. No stones were found in these cases, and some of the relief might have been due to the mental effect on the patients caused by telling them that they had no kidney stones, but this could hardly be true in every case. The author would never have recommended the x-ray treatment as a curative measure in these cases, and yet it may have, in a way with which we are not yet acquainted, been the direct cause of bringing about a normal condition. Careful study along this line may prove that the x-ray has therapeutic properties that will be found helpful in the treatment of a large class of cases where pain is a prominent feature.

Cases having symptoms of stone in the kidney, with negative skiagraphic reports, should have the benefit of at least three exposures to a medium or high vacuum x-ray tube.

THERAPEUTIC APPLICATION OF ELECTRICITY IN ORGANIC DISEASES OF THE CENTRAL NERVOUS SYSTEM.

Spinal Cord.—The principal diseases of the spinal cord are those due to

(1) Diseases of the motor ganglia—poliomyelitis type.
(2) Disease of the motor paths—lateral sclerosis type.
(3) Disease of the sensory paths—tabes dorsalis type.
(4) Diffuse disease—myelitis type.
(5) Intraspinal disease—syringomyelia type.

Motor Ganglia.—The varieties of paralysis that result from diseases of the motor ganglia are poliomyelitis (acute and chronic) and the various mixed types of lateral sclerosis. The main diagnostic symptoms of the poliomyelitis type are loss of tendon reflexes, muscular atrophy, trophic disturbances, no sensory phenomena, and reaction of degeneration. In grave forms of neuritis the pain will generally serve to distinguish it from poliomyelitis.

Acute Poliomyelitis (Infantile Spinal Paralysis).—Electric treatment should be begun soon after the acute symptoms have passed. A fair degree of improvement may be expected, even though reaction of degeneration has been present for several months, and cases of two years' standing have been materially improved. There is no limit to the time in which electricity may not be of great benefit to patients suffering from this form of paralysis. The electric treatment should not be begun so long as there is any tenderness in the muscles or nerve trunks. When these patients suffer from pain in the early stages, meningeal involvement should be looked for. Each muscle should be carefully tested, giving special attention to its motor point, muscle substance, and tendon reaction. Electric treatment should be directed toward relief of the abnormal condition through stimulation of unused muscles and nerves. The galvanic and faradic currents are generally employed, and will best meet the requirements in the majority of cases.

In cases of paralysis of this type it is believed that a few uninjured or nondiseased fibers remain intact, and that the first symptom of improvement is noticed by a weak response to electric stimulation of these remaining fibers. Persistent electric stimulation of these fibers may improve them to such an extent that they begin to take on something of their normal function, and the contraction of the muscle gradually returns to normal, or at least the improvement is so marked that the muscle is under fairly good control.

Chronic Poliomyelitis (**Progressive Muscular Atrophy**).—This is differentiated by two general types—the **neuritic** and **central.** In cases of complete atrophy, electric stimulation is entirely negative. While electric treatment may to some extent retard the atrophy, it is not expected that it will redevelop the atrophied muscle.

In the central or spinal variety, electric stimulation meets with better success. The current is to be applied directly to the cervical and lumbar enlargements of the spinal cord. The faradic current may be used in mild doses, but the greater benefit is to be derived from the galvanic current.

Motor Paths (**Lateral Sclerosis Type**).—Little or no benefit may be expected from electric treatment of this type. Cases have been reported as cured, but the reports are questionable.

Sensor Paths (**Tabes Dorsalis Type**).—Electricity is of little value, except to relieve pain and tone up the functions of the bladder and rectum.

Diffuse Spinal Disease (**Myelitis Type**).—Little or nothing can be promised by electric methods in this class of cases.

Intraspinal Diseases (**Syringomyelia Type**).—Relief and benefit has been claimed from x-ray treatment, but the evidence is not sufficient at the present time to warrant any positive claims.

BRAIN.

Diseases resulting from organic brain affections, producing hemiplegia and diplegia, **causing infantile cerebral palsy and epilepsy,** may at times be benefited, but the enthusiastic claims of some ardent electric advocates can hardly be vouched for by the conservative workers.

GENERAL NERVOUS CONDITIONS.

Wry Neck.—This painful condition is promptly relieved by either the galvanic, faradic, static, or high-frequency currents. When the galvanic current is used, the positive pole is placed over the painful muscle or muscles. The current may be continuous or interrupted, so long as the pain is relieved. One to three treatments will suffice to overcome the muscular contraction and relieve the pain in the majority of cases.

Chorea.—Some cases are apparently promptly benefited, while others are cured by electric treatment. The static breeze or Morton wave current will improve most cases, but occasionally the treatment seems to aggravate the trouble and has to be discontinued.

Exophthalmic Goiter.—Perhaps every remedy known to the modern and ancient physician has been recommended at one time or another for the cure of exophthalmic goiter. X-ray treatment of this condition has met with splendid success in a large number of cases, though in some instances it has failed.

Hysteria.—In all cases of pure psychoneurosis, electricity, properly used, is the best remedy. In this class of cases the static machine will best meet the indications. General electrification in the form of the breeze or static wave current is the most popular modality in hysteria, though the sinusoidal or faradic currents may be used in the absence of the other.

Neurasthenia.—Nowhere else in the domain of medicine will electricity, wisely and judiciously used, be productive of greater results than in cases of neurasthenia. In the majority of these cases we have patients with low vitality (general debility); they have poor circulation, bad digestion, and are nervous and restless, and often highly imaginative. Their nerves are strung to a high pitch, and they are never satisfied unless when working under some mental excitement; they never take their surroundings quietly and patiently, but are continually working at high pressure until overcome by exhaustion and collapse. This class of patients requires rest and quiet, and influences stronger than their own. They should have associates with natures opposite to their own, where they may learn the wisdom of self-control.

The static insulation in the form of the bath or breeze and the static wave currents are indicated in these cases. Begin the course of treatment with the static insulation, making the patient positive and grounding the other side of the machine. The seance should last twenty minutes, and be repeated every day until marked improvement is noticeable. Care must be had that the patient is not frightened by giving her an accidental spark before she is in a condition to receive such treatment. At a later date, when there has been marked improvement and the patient's full confidence has been secured, direct or indirect static sparks may occasionally be applied to the spine. In the absence of the static modalities, galvanism and faradism, or the sinusoidal currents, may be used with some degree of success, but the stimulating and nutritional effect of the static modalities is far superior to any other.

ELECTRIC SLEEP.

According to the experiments of Stephane Leduc, begun in 1902, certain kinds of electric currents may be used for the purpose of producing general anesthesia to the extent that operations may be performed without producing painful sensations.

Leduc claims to have produced complete narcosis in animals, during which the most difficult operations were done without pain or suffering. In order that he might describe the sensations, Leduc allowed himself to be made the subject of an experiment. A metallic plate, well covered with absorbent cotton soaked in 1:100 solution of chlorid of sodium, was securely bound to the forehead and connected with the negative pole of the battery. A similar electrode, though larger, was placed over the back. For this work Leduc uses a low tension interrupted current. The interruptions range from 90 to 110 per second, with an electromotive force of from 30 to 35 volts and a current strength of about 4 milliamperes.

Leduc claims that the sensation is not unpleasant; that a few minutes after the current was turned on a general calm sensation passed over him, and, while he knew all that was being done, he was unable to speak. In a little while the motor·centers were inhibited, and no amount of stimulation would produce a contraction in the muscles. Respiration was somewhat diminished. He describes the sensation during the seance, which lasted twenty minutes, as being something like a dream or nightmare. Awakening was immediate, and the general sensation was that of a mild stimulation.

Leduc uses a current from an apparatus of his own construction. The current is galvanic, and has a rotary interrupter placed in series, with one of the wires leading from the battery to the patient. This interrupter has periods of rest, with an almost abrupt rise in current strength, which is constant through a certain period, when the fall in the current strength is as abrupt as the rise, followed by another period of rest. It is not likely that this method of general anesthesia will come into use during our time. Though particularly valuable, it will take several generations to eliminate the superstitions in the public mind regarding the dangers of electricity.

ELECTRIC DEATH.

Among the workers in our powerful lighting plants it is not an uncommon thing to hear of some one being instantly killed or severely burned by electric currents. These accidents have occurred, and will continue to occur until rigid precautions are taken to prevent them.

Currents of high voltage and large amperage are always dangerous, and must be avoided unless the necessary precautions are taken in handling them. High voltage currents with small amperage are not necessarily fatal, unless the subject should form a short circuit with another wire or the ground, in which event death may be produced by a very weak current. Many fatal accidents have occurred in bathrooms where the electric fixtures were not properly insulated, the victim attempting to turn the light off or on while his body was immersed in the water in the bath tub, making a perfect electric contact with the ground, and causing instant death. Linemen are frequently horribly burned or instantly killed by getting a short circuit through their bodies. For a long time pathologists were not able to discover any marked tissue change in the nervous system in victims of electric death, but later more careful investigations have demonstrated conclusively that distinct changes in the cellular tissues are to be found in every victim of death from electric currents of whatever nature. Very much is yet to be learned regarding the immediate cause of death from electric currents. Very much must depend upon the particular kind of current and the condition of the subject, together with the manner in which the current is conducted into the body and the part of the body directly affected by the charge. There is a difference of opinion as to whether death is due to the action of the current on the brain and spinal cord (nervous system), or whether the heart is the organ principally affected.

During the use of heavy galvanic currents for the zinc cataphoric treatment of cancerous growths about the face and neck, the author has seen suspended respiration and inhibited heart action when, to all appearances, the patient seemed dead and would have died without the application of prompt resuscitating methods. In cases of this kind, where only from ½ to 1 ampere is being used, we would not expect any pathological changes in the central nervous system. The suspension of respiration and circulation was unquestionably due to an overstimulation or a paralysis of the nerve centers controlling these organs. The question is often asked, How much electricity does it take to produce death? No very clear answer can be given to this question, because so many factors enter into the conduction of an electric current that it would be necessary to state exact conditions in every case. Some time ago a lineman in Dallas, Texas, while working among the wires on a pole, short-circuited through his body a 3,500-volt current. He was fearfully and horribly burned, but lived more than a week. It is natural to suppose that, although he was badly burned on different parts of the body, there were few, if any, internal injuries, or death would have been instantaneous.

The author, from his experience, advises energetic efforts at resuscitation in all subjects unconscious from electric currents, provided, of course, the victim is seen at once or very soon after the accident. In such cases the faradic current may be found useful in stimulating respiration and the heart's action. One electrode may be placed over the sternum and the other on the nape of the neck, or on the back.

CHAPTER XII.

HIGH-FREQUENCY CURRENTS.

There seems to be a great deal of confusion as to what is really meant by the term **high-frequency** currents. Static currents like the Morton wave, potential alternation, currents from vacuum electrodes connected directly to a prime conductor, etc., have been long referred to as **high-frequency** currents. As a matter of fact, these static currents are possessed of rapid oscillations and rather high frequencies, but, when compared with the frequencies obtained from the Oudin and D'Arsonval resonators, they are relatively low. We are just beginning to learn something of this wonderful modality, and no one can foretell its future possibilities.

TYPES OF APPARATUS, METHODS OF APPLICATION, AND PHYSIOLOGIC EFFECTS.

The types of high-frequency apparatus in general use are those known as the D'Arsonval, Oudin, and Tesla. The Oudin type shown in Fig. 31 is used in this country more than any other. While there is a great difference in the character of the currents produced by these coils, they have very much in common. Each consists of a pair of Leyden jars so arranged that they discharge through one or more solenoids, according to the character of the current desired.

When an electrostatic discharge takes place between the sliding rods, forming a spark gap between the inside coatings of the Leyden jars, what appears to be a single spark does not neutralize or equalize the electric condition in the two jars. The state of neutralization or equilibrium is reached only after a series of oscillations back and forth at the rate of about 500,000 per second. If the jars are continuously charged from an induction coil or static machine, the oscillations between the sliding rods will be continuous. If the outside coatings of the jars are connected together, an alternating or oscillating current will pass between them. This current is called a high-frequency current, and its frequency is determined by the number of sparks that pass per second between the prime conductors, to which are connected the inside coatings of the jars. If there are 500,000 oscillations for each discharge and there are 100 or 500 discharges per second, it is seen that the frequency of these currents may reach millions per second. It is impossible to obtain directly from an induction coil or static machine a high-frequency current. The possessor of a coil or static machine may, for a small sum, install a high-frequency equipment that will produce either of the

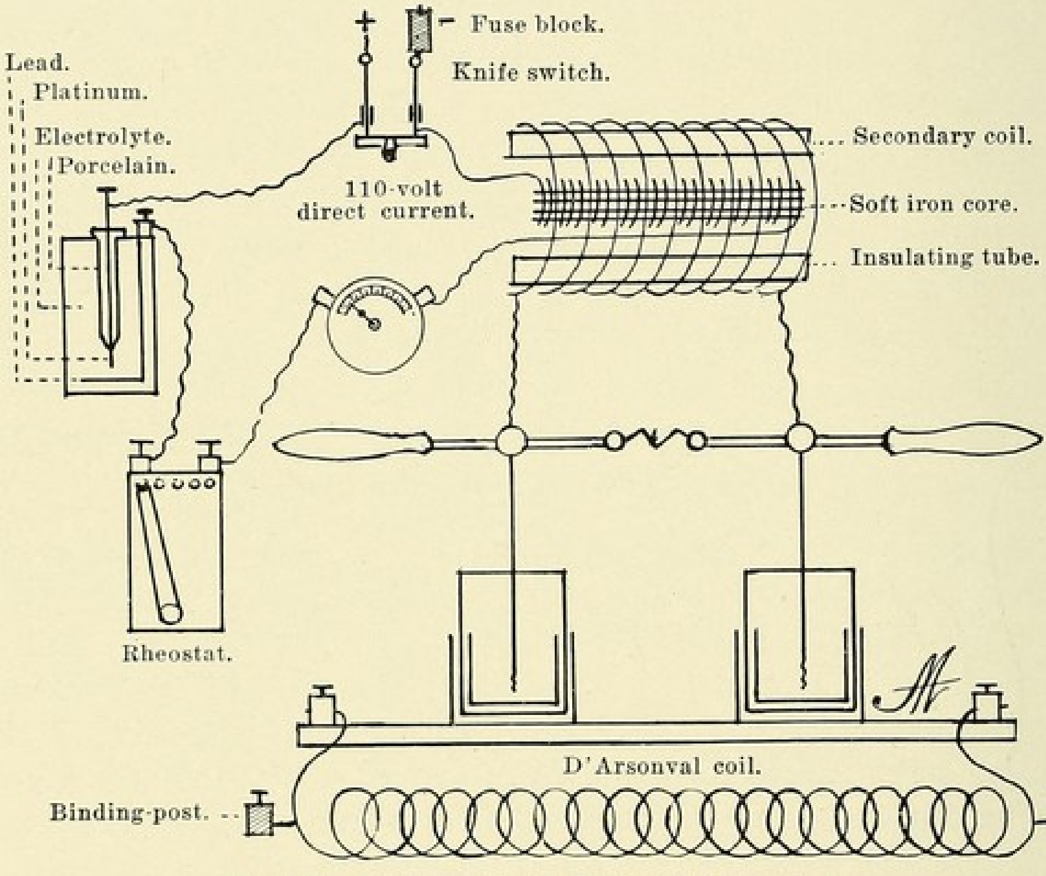


Fig. 97.—Apparatus for the D'Arsonval resonator.

currents mentioned above. As before stated, the Oudin or some modification of the Oudin resonator is to be preferred. The simple interposition of a coil or resonator between the outside coatings of a pair of Leyden jars, energized by a static machine or induction coil, is all that is necessary to produce the D'Arsonval high-frequency current.

Fig. 97 illustrates the apparatus for the D'Arsonval high-frequency current. This equipment is to be operated from the 110-volt direct current through the electrolytic interrupter, rheostat, ammeter, induction coil, Leyden jars, and D'Arsonval coil. This schematic drawing also shows the correct arrangement for the x-ray coil.

It will be noticed that the current is the 110-volt direct, and that both negative and positive wires have a knife switch by which the current may be completely cut out of the apparatus when not in use. As a safeguard during the time that the apparatus is in use, a fuse block is placed on the negative wire, through which the current enters the apparatus. This fuse block contains a short piece of lead wire that will carry only so much current without melting—

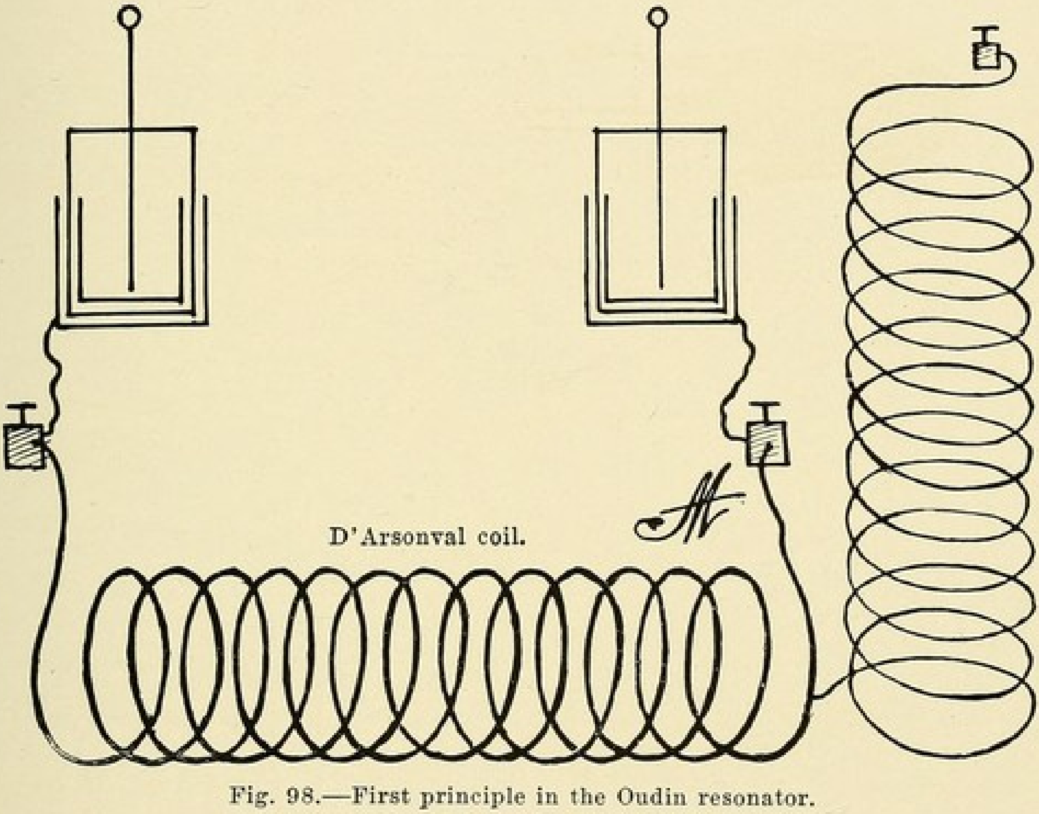


Fig. 98.—First principle in the Oudin resonator.

say, 5, 10, or 20 amperes. If an accident should occur in the light plant or along the circuit, and a high amperage be thrown on the wires, no damage to the apparatus or patient who might be receiving treatment at that time could occur, for the piece of lead wire in the fuse block would burn out and the current could no longer enter the coil. From the negative wire the current enters the primary of the coil, which surrounds a soft iron core, acting as a magnet. Emerging from the primary, the current passes through the rheostat, which measures the current strength; then through the rheostat, which controls the current; then to the electrolytic interrupter, and back to the main circuit again. The secondary winding of the coil is connected with the sliding rods of the Leyden jars. When these rods are brought close enough together to allow sparks to pass between them, rapid oscillations take place between the jars, at the same time producing a current between the outside coating of the jars through the coil connecting them. This current is alternating in character, and because of its rapid change in direction, millions per second, it is called a high-frequency current.

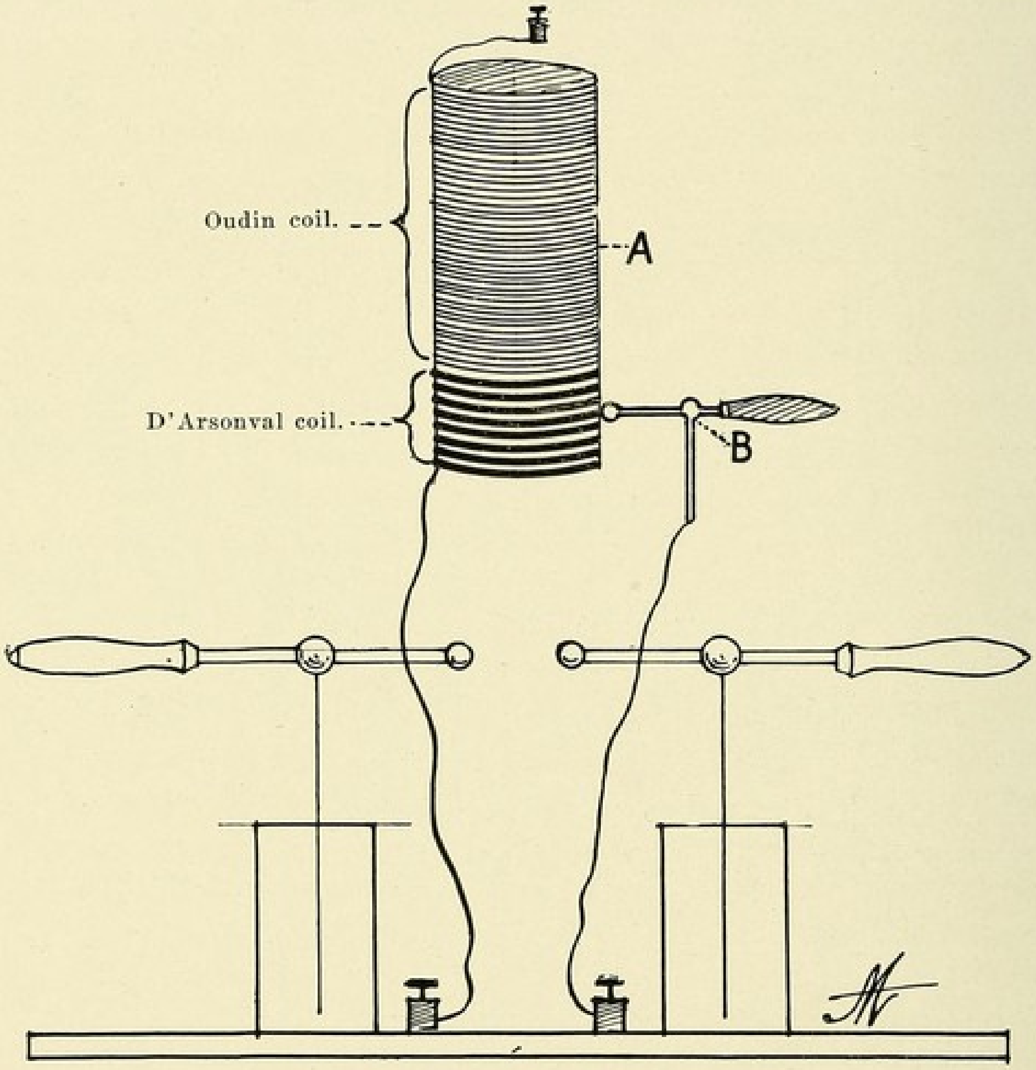


Fig. 99.—Outline of the Oudin resonator.

From the D'Arsonval apparatus it is only a step to the Oudin. If one end of a solenoid or coil is connected to one end of the D'Arsonval coil, a current of an entirely different character will be produced. This combination of the second coil with a D'Arsonval coil is known as an Oudin resonator. Figure 98 shows the first step in this arrangement. Oudin found that, by regulating the number of turns in the D'Arsonval coil he was able to regulate the discharge from the terminal of the secondary coil. Figure 99 roughly illustrates the present plan of the Oudin resonator, as shown complete in Figure 31.

In the Oudin resonator the drum *A* is wound with two sizes of wire; the lower six or eight turns are made of coarse wire, about No. 8 or 10, while the remaining greater portion of the drum is wound with about No. 20. The upper end of the coarse wire coil is soldered fast to the lower end of the small wire coil, while the upper end of the small wire coil is soldered to a binding-post at the top of the drum. The lower end of the coarse wire coil is connected to the outside coating of one of the Leyden jars, while the outside coating of the other jar is connected with an adjustable contact shoe *B*, that may be brought in contact with either of the windings of the coarse wire coil. The more windings of the coarse coil that are placed in the Leyden jar circuit, the greater will be the resonance or inductance in the fine wire coil, and the stronger will be the current delivered from an electrode connected with the binding-post on the top of the drum.

To control a high-frequency current of this character, taken from an Oudin resonator, the current going to the primary of the induction coil may be increased or decreased as required, or the contact shoe *B* may be raised or lowered, and, as a farther means of regulating the output of the resonator, the spark gap between the Leyden jars may be increased or decreased.

The Tesla high-frequency apparatus is best operated by a step-up transformer, energized by an alternating current of 110 volts, as shown in Fig. 100. It will be noticed that the outside coatings of the Leyden jars are connected by a coarse wire solenoid, through the center of which is placed a small wire solenoid, well insulated in oil. This small coil delivers an induced current of a high potential and a rapid discharge.

Several modifications of the above distinct types of high-frequency coils, for which has been claimed some particular therapeutic value, have been described. The Oudin high-frequency resonator manufactured in this country answers all general purposes for which high-frequency currents are indicated. It should be so made that the D'Arsonval current may be used for the autocondensation couch, the current coming directly from the outside coating of the Leyden jars and the coarse wire solenoid or coil on the lower end of the drum.

The Oudin resonator is intended principally for unipolar applications, using mainly the vacuum electrodes, held at a distance from

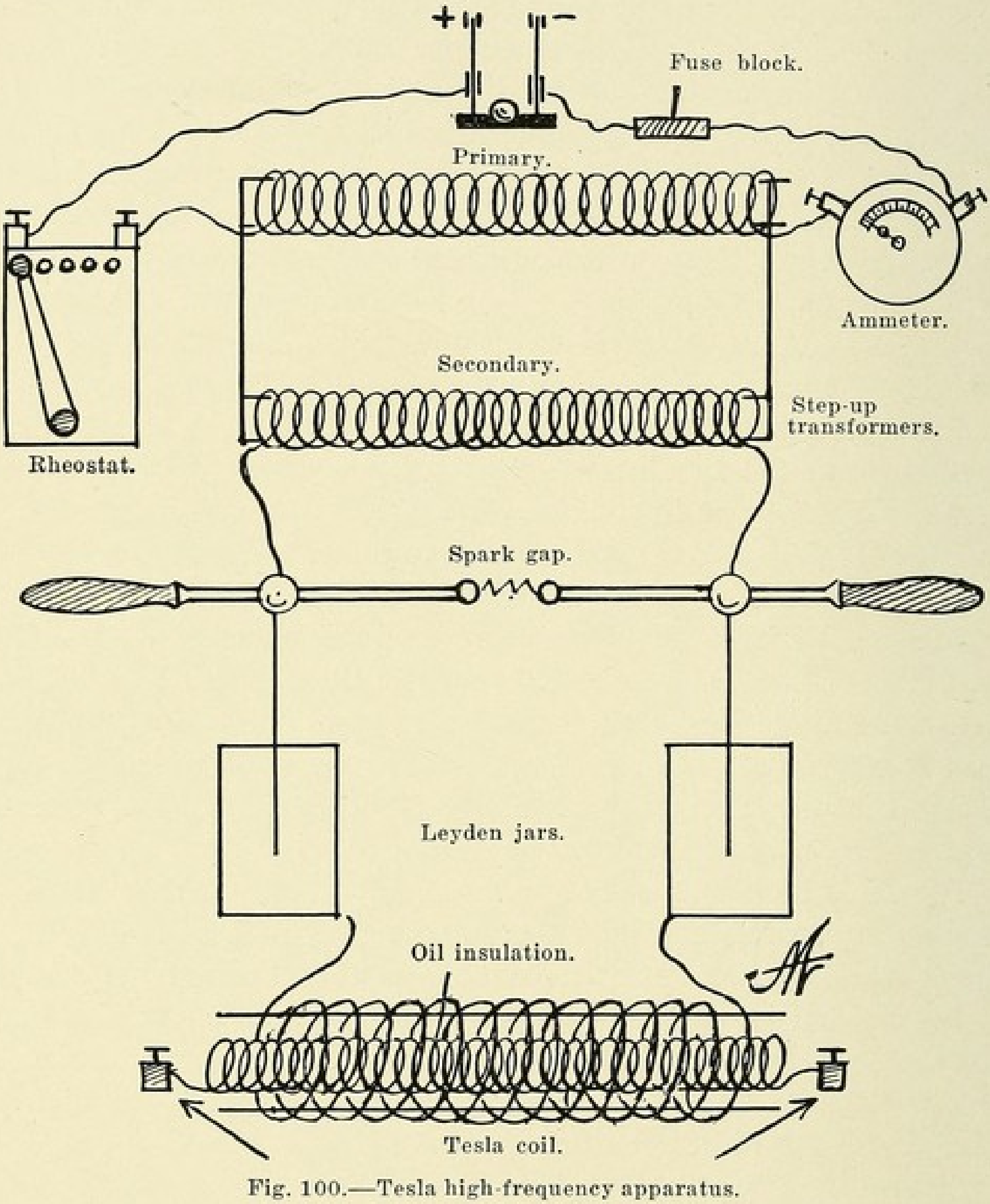


Fig. 100.—Tesla high-frequency apparatus.

the body or by direct application to the skin or mucous surfaces. Where twin or double resonators are used, the application may be made bipolar by using an effluve from each resonator, which may be applied to different parts of the body at the same time. When double resonators are used, it will require at least a 16-inch induction coil to operate them, as a 12-inch coil is too small.

APPLICATION OF HIGH-FREQUENCY CURRENTS.

Currents from the D'Arsonval solenoid and the primary of the Tesla coil are of relatively low voltage and high amperage. The modes of application are two—direct and indirect. With the direct method the application is bipolar, which may be **stabile** (stationary electrodes) or **labile** (movable electrodes). The method of application of these currents is very much like that of the direct current (galvanism). The indirect application of these currents is by autoconduction or autocondensation, using the **cage** or **condenser couch.**

Currents from the Oudin resonator are of very high voltage, with relatively low amperage. An Oudin resonator is best operated by a Ruhmkorff coil, which should not be less than 12 inches. The method of application of the Oudin high-frequency current is monopolar, and the application is direct in the form of an **effluve, spark, arc,** and **vacuum electrodes.** Indirect applications of the same modalities may be made.

PHYSIOLOGIC EFFECTS OF HIGH-FREQUENCY CURRENTS.

The physiologic effect of currents of high frequency upon a debilitated constitution is that of a general tonic through its power to stimulate the cellular chemic processes, increasing combustion and eliminating waste products. The vasomotor system is stimulated, followed by a slight rise in arterial tension, which increases the oxidizing power of the blood and improves the general metabolism, restoring to normal the inhibited functions of the body. Sluggish conditions, with diminished circulation and an accumulation of waste products, may be made to promptly disappear under the influence of static wave and high-frequency currents.

Local Effects.—When a metallic electrode is brought in contact with the skin or mucous membrane, and the high-frequency current is of medium strength, the only sensation is that of warmth. If the electrode is moved a short distance from the skin, a spark or arc will pass to the patient, causing sharp pain and muscular contraction, and, owing to the high amperage (100 to 500 milliamperes), will soon produce a severe burn.

When the metallic electrode is held too far from the body to produce a spark or arc, a high-tension effluve will take place between the electrode and the skin, the sensation being that of a warm breeze. When vacuum electrodes are placed in contact with the skin, a very slight warmth is felt; but when they are held a short distance away from the surface, the sensation will be in proportion to the strength of the current. If the current is strong and the electrode is held in one place for any length of time, it may cause a blister or even necrosis.

Heavy discharges from a high-frequency apparatus are strongly bactericidal, but it is not likely that currents which can be tolerated by the patient will be of any particular value as germ destroyers. Moderate applications produce vitalizing effects upon the skin and mucous membrane to the extent that these high-frequency currents are valuable in the treatment of all indolent and chronic skin lesions.

Deep effect of local high-frequency currents is probably more marked than that of any other modality. The deeper tissues feel the effects of the treatment, the lymphatic and other glands are stimulated and their functions are increased, producing both a local and general tonic effect upon the tissues of the patient.

The high-frequency current from the Oudin resonator is generally applied to the patient with the glass vacuum electrode. When the condition is local, as in some skin affection, the electrode should be in contact with the skin during the seance; but when used for its general effect on the whole system, the treatment may be given through the patient's clothing, provided the clothing is not too thick and the current is not made too strong. The thicker the clothing, the stronger will be the spark and the greater the pain. Because of its resolvent effect upon infiltrations and indurations, the high-frequency currents are particularly indicated in chronic inflammations generally, producing absorption and elimination more satisfactorily than is possible by any other method with which we are acquainted.

Violet and Ultraviolet Radiations.—The hollow glass electrodes, made for use with the high-frequency apparatus, are exhausted to about $1/1000$ atmosphere. The color in the tube will vary with the degree of exhaustion from a pale blue to lilac, violet, or apple-green color, the latter showing the presence of x-rays. We are not aware that the visible light from a vacuum electrode has any physiologic or therapeutic effect. Ultraviolet radiations emanate from these vacuum electrodes, with the properties of liberating from the atmosphere ozone which may be absorbed by the superficial layers of the skin, which is probably the extent of the physiologic effect of the application of the vacuum body electrode. This method of liberating ozone in connection with the skin, where it is carried into the tissues, is very important. Its general effect is to increase the oxidation in the blood, promoting the elimination of urea and other waste products.

The pungent odors accompanying all high-frequency currents are due to the liberation of ozone and the formation of nitrous acid.

Systemic Effect of High-Frequency Currents.—The effect is that of a general tonic—the blood pressure is slightly increased, oxidation and elimination are improved, digestion is stimulated, and the patient experiences a state of well-being, during which time he is more energetic and active.

High-frequency currents are indicated in the treatment of all cases of defective metabolism, as in rheumatism and gout, where there is an excess of nitrogenous matter as a result of defective elimination.

Arterial Tension.—The indirect application of high-frequency currents by means of the autoconduction cage, couch, or pad has a tendency to dilate the capillaries and reduce the blood pressure, thereby lowering the tension in the arteries. The autocondensation couch, or some modification of the couch, seems to best meet the indications. Patients should be placed in a comfortable recumbent position during the treatment, and the autocondensation couch fulfills all of the requirements.

Cases of arteriosclerosis are greatly benefited by the use of high-frequency currents and the autocondensation couch and the wire cage. Since the patient is only in the secondary or induced current, similar to that coming from an induction coil, the field should be made as strong as possible. Great care must be taken to prevent the production of an arc from any part of the apparatus to the patient. Such an accident would not only frighten the patient, but might do him a positive harm. The seances should last from five to ten minutes and be repeated two or three times a week.

Because of the increased metabolism resulting from high-frequency treatments, particular attention must be paid to free elimination in the way of diuretics and laxatives, as neglect in this might cause the patient to become a victim of self-poisoning from auto-intoxication.

Diabetes.—The D'Arsonval high-frequency current is indicated in this class of diseases. The bipolar method is used. One bare metallic electrode is placed in the patient's hand and the other is placed in a foot-bath in contact with the patient's feet. The treatment may last ten or fifteen minutes, and should be given every day for twenty or thirty days, and even longer. General improvement is always noted, whether the sugar in the urine is or is not affected.

Tuberculosis.—The high-frequency treatment in pulmonary diseases of this class is not for the purpose of destroying the bacilli, but for its general tonic and nutritious effect upon the whole system. The judicious use of the x-ray, high-frequency currents, diet, and fresh air will do much toward aiding nature in throwing off this deadly infection.

Metrorrhagia, Pelvic Exudates, Fibroids, and Cancer of the Uterus.—In the treatment of metrorrhagia from fibromyomata or fibrocystic tumors, success will usually follow the use of the insulated vacuum vaginal electrode or the large copper insulated stem electrode, introduced into the vagina, or a copper intrauterine electrode may be introduced into the uterus. These electrodes may be connected up with any one of the various forms of high-frequency apparatus heretofore described, or the electrode may be connected directly to one side of an x-ray coil or static machine. When the induction coil is used, the prime conductors are pulled wide apart in order to prevent sparking between them. The opposite side of the coil is not grounded. The electrode is connected to one of the cords used in connecting up the x-ray tube, while the other cord is removed. When this arrangement is used, the vacuum tube lights up and the sensation is vibratory in proportion to the strength of the current.

When these electrodes are connected directly to one of the prime conductors of the static machine, the prime conductors are brought close together and the opposite side may be grounded. The strength of the current in the electrode will depend upon the length and frequency of the spark between the large balls.

For several years the author has been using these high-frequency currents as a supplement to the x-ray in the treatment of all kinds of pelvic exudates and abnormal growths. Under these combined methods of treatment he has seen uterine fibroids, of considerable size, melt down and disappear. These cases had been carefully examined by one or more surgeons, and radical operations not only recommended, but urged as absolutely necessary.

Inoperable cancer of the uterus, though not cured, may be greatly benefited by the combined use of the x-ray and high-frequency treatment. The x-ray exposures are made through the abdomen with high vacuum tubes, last about ten minutes, and should be given two or three times a week.

The Cornell vaginal x-ray tube may be used for the treatment of uterine and pelvic conditions through the vagina.

The x-ray specialist seldom sees these malignant diseases of the pelvis until they have been operated and reoperated, and nothing more can be done. The best that can be done in these extreme conditions is to make the patient comfortable by relieving the aggravating symptoms, which are generally pain and hemorrhage. Where these symptoms are severe, the high-frequency treatment may be given daily for two or three weeks. The combined x-ray and high-frequency treatment should be continued for three or more months, with such periods of rest as may, in the judgment of the physician, appear to suit the individual case.

If these patients are not seen too late, they will show a considerable degree of improvement after the first month of treatment. The hemorrhage often ceases altogether, the pain is less or not at all, the strength and appetite improve, and the patient is able to get much natural sleep at night without the aid of morphin or other sedatives. The author has had some of these cases under observation for more than two years, during which time they have had periods of regular treatment, with splendid results in every case. Even if these cases can not be cured, there is no reason why they should be allowed to die an early and miserable death when their lives can be prolonged and made comparatively comfortable to the end. There is probably nothing gained in prolonging a life of misery, but, when the influence of a mother can be saved to her loved ones—if for but one short year, during which time she is reasonably comfortable—we are more than compensated for any effort.

Genitourinary Diseases.—In the treatment of orchitis and epididymitis of long standing, the combined use of the x-ray and high-frequency currents, in obstinate cases, will accomplish excellent results. In view of the fact that the x-ray produces azoöspermia, the sound organ must be carefully protected during the treatment.

In the use of the high-frequency current, the bipolar method from a D'Arsonval apparatus or the unipolar method from an Oudin resonator is indicated. In the first, one electrode may be held by the patient, while the glass vacuum electrode is carefully passed over the scrotum for several minutes, avoiding all spark effect. The treatment should be given daily or every other day.

Tuberculosis and cancer of the genitourinary tract should receive the combined influence of the x-ray and high-frequency currents.

Spasmodic Stricture of the Urethra.—This is successfully treated with high-frequency currents through glass vacuum electrodes. The electrode should be lubricated with oil or vaselin, and the current should not be strong enough to overheat the electrode.

Gonorrhea.—From the author's experience he is not able to say that high-frequency currents applied through the urethra will diminish or destroy the gonococcus. High-frequency currents probably have no place in the treatment of acute gonorrhea, but in the chronic cases of posterior urethritis (gleet), with prostatitis and vesiculitis, these currents through the urethra, rectum, or over the perineum will accomplish most excellent results and often lead to a complete cure.

Impotence.—In all cases due to a loss of function from a lowered vitality, high-frequency currents over the genitals, perineum, in the rectum, and over the spine will seldom fail, after a few treatments, to bring about normal erections. This treatment should be used in conjunction with the author's method of concentrated sunlight treatment described under **light treatment** in Chapter XIII. These methods, properly and judiciously used, will stimulate the failing powers of most men, and, if adopted by the regular profession, will soon put out of business those who prey upon and grow rich from the self-accused victims of "lost manhood."

HIGH-FREQUENCY CURRENTS IN DISEASES OF THE NERVOUS SYSTEM.

The massage or mechanical effect of the high-frequency currents on the muscular tissue is very slight, if any, and therefore the good effects can not be due to the exercise of the muscles. From what has already been said we must expect the good effects to come from the general tonic effect upon the whole system through the improvement in nutrition. The improved oxygenation of the blood and increased elimination from all sources is summed up in one word—improved **metabolism.**

Paralysis, Paralysis Agitans, Epilepsy, Chorea, Locomotor Ataxia, Neuritis, Neuralgia, Rheumatism, Constipation, Chronic Eczema, Pyorrhea Alveolaris, Chronic Ulcers, Etc.—All of these conditions, or like conditions having either a local or constitutional cause, may be improved or cured by the proper use of high-frequency currents. The treatment in all cases is so similar that a detailed description of the technic in each would be only a waste of space. Where the disease is local, the treatment is concentrated as far as possible to the parts affected, and the unipolar or bipolar method may be used. In constitutional conditions the treatment is general, and may be applied in many ways—autoconduction or autocondensation, or vacuum or metallic electrodes.

After having mastered the technic and operation of the various electrical apparatus, the physician who knows the nature of the condition in the patient with whom he is confronted will be able to select and apply the particular modality indicated in the case in question. In the successful treatment of nervous diseases it must be remembered that time is an essential factor in every case, and this must be explained in the beginning, in order that the patient and friends may not become discouraged long before improvement could be expected.

Neuritis and Neuralgia.—The most common of all the conditions coming under this head is, probably, trifacial neuralgia. All of the electric modalities have been used, more or less successfully, in the treatment of this painful condition. Static electricity, in the form of the Morton wave and the indirect static spray, has cured many cases of long standing. The high-frequency modalities generally give prompt and permanent relief. When these cases are not relieved after a reasonable time, we may be sure that some aggravating condition outside of the nerve is responsible for the trouble. In such cases the diagnostic value of the x-ray must not be underestimated. There may be trouble about the teeth, as abscesses, impactions, improper fillings, cysts, or tumors of the frontal sinus, and the antrum of Highmore may be involved. It goes without saying that local conditions, when present, must be removed before relief and cure can be expected. An early diagnosis should be made, and, when these complications are found to exist, the patient should be promptly turned over to the surgeon or dentist, as the case may be. The electro-therapist who is not a careful diagnostician will make many errors and bring discredit upon electric methods. One of the severest cases of facial neuralgia seen by the author was caused by the presence of a tooth in the antrum of Highmore. This condition was diagnosed by a skiagraph, and the tooth removed by a dental surgeon, with prompt relief to the patient. Many similar cases could be cited, but space forbids.

The mode of treatment for the different forms of nerve diseases will depend upon the conditions existing in each case—whether local or general. In purely local conditions the vacuum electrode will be indicated and will probably meet all requirements, but, when the condition is more general, the autocondensation couch will give the best results. The static modalities should not be neglected in aggravated nervous conditions.

Pyorrhea Alveolaris.—To Doctor Tousey, more than to any one else, we are indebted for our knowledge of the successful treatment of Riggs' disease. Occasionally we find a dentist who pays some special attention to this disease, but, as a rule, very little is done for it by the average dentist. The condition is a most annoying one, and, if allowed to continue any great length of time, will completely undermine the health of the individual. The old idea that it is caused by a uric acid diathesis should be abandoned. It is unquestionably a local infection, and should be treated as such. The condition is a chronic one, and seems to have irregular periods of development and many stages. In some cases there is only a slight tendency to the disease. The gums will be a little red, tender, and spongy for several years; the teeth may or may not be loose, and the patient may not know that there is anything unusual about his mouth. In other cases the disease makes a more rapid progress; the alveolus is more or less absorbed, pus pockets and concretions are formed around the roots of the teeth, and the teeth become loose and often drop out without showing any signs of decay. The milder cases of pyorrhea may be cured by the x-ray and high-frequency, but the majority of cases should have the aid of the dentist. The teeth should be freed from all concretions and treated in the most modern manner with regard to infectious conditions.

A few years ago, before the author's attention had been called to the successful treatment of pyorrhea with the x-ray and high-frequency currents, a very prominent gentleman was being treated with the x-ray for an epithelioma of the lower lip. All the lower incisors were loose from pyorrhea. He often remarked that if he could be freed from the cancer he would have his teeth treated. The author was using a low vacuum Piffard tube in contact with the lower lip. The gums and lower jaw were not protected. Quite a degree of dermatitis was caused in the lower lip, but disappeared in a few weeks, leaving the lip smooth and well, and, strange to say, the teeth became tight, the gums firm and normal, and every vestige of pyorrhea disappeared. This was not an extremely aggravated case, as there were no concretions about the teeth. He received no attention from the dentist because it was next to impossible for him to open his mouth on account of the soreness and swelling of the lower lip.

After reading of Doctor Tousey's success in this disease, and remembering the experience in the case above mentioned, the author took occasion to treat every case of pyorrhea that came under his observation. The results have been gratifying in the extreme. For this work the author continues to use the Cornell type of x-ray tube, though Doctor Tousey has a tube, of his own design, that would probably be more convenient. These tubes are made of leaded glass, except an area about one inch in diameter, composed of soda glass, through which the rays pass. These tubes are of very low vacuum, and may be placed directly on the gums and moved about as required. The ordinary x-ray tube may be used by protecting the face in the usual way, in which case the tube is placed from eight to ten inches (measuring from the target) from the gums. The lips may be held away with plaster, and the patient made to open or close his mouth as becomes necessary to expose the gums.

In conjunction with the x-ray, the high-frequency currents from the glass vacuum electrodes, particularly designed for the mouth, are indicated in every case. The electrodes are designed to fit the curve of the gums on both outer and inner side. After an x-ray treatment of from two to three minutes' exposure, an insulated vacuum electrode is placed in contact with the gums for half a minute or longer, then moved to another position until all the affected tissue has been subjected to high-frequency medication.

High-frequency currents are successfully used in a large number of local and constitutional diseases, but space forbids a further consideration here.

CHAPTER XIII.

PHOTOTHERAPY.

So much has been said during the past few years on the subject of light, by both author and manufacturer, that the physician is somewhat confused as to its real therapeutic value. Light is exceedingly complex, having luminous, chemic, and heat rays throughout the spectrum, all of which must be taken into account when considered as a therapeutic agent.

Each manufacturer makes specific claims for his lamp with regard to number of bulbs, candle power, design of reflector, luminosity, heat, and chemical effect. There is probably therapeutic value in all the lights, though some may be far better than others. No attempt will be made to extol one or condemn the other. All lamps have, in common, light, heat, and chemical effect. The heat and luminosity of a lamp may be regulated by the number of watts consumed, as well as by the shape and design of the reflector. Which property of a lamp (heat, light, or chemic) is of the greatest therapeutic value in a particular case is yet to be determined. The lamps in common use will be described as they are understood, with no particular claims for any.

Of the incandescent lamp and reflector type there are a number. They are of all shapes and sizes, ranging in candle power from 50 to 500, and having from one to four or more bulbs.

The stereopticon, spiral filament, 50-candle power bulb, with an oval reflector, is the lamp in most common use. It is light and may be carried about from place to place, and operated on 110-volt or 220-volt direct or alternating circuit. Fig. 101 illustrates one of these lamps with a 50-candle power bulb. These small lamps produce a very strong light and very intense heat, and are indicated in cases of muscular pain, rheumatism, and neuralgia. They may be used by the physician, nurse, or even by the patient himself.

Many extravagant claims have been made for 500-candle power lamps, with single and multiple bulbs and specially designed reflectors. Some of the reflectors are parabolic, while others reflect the light so as to focus at different points, and other reflectors are

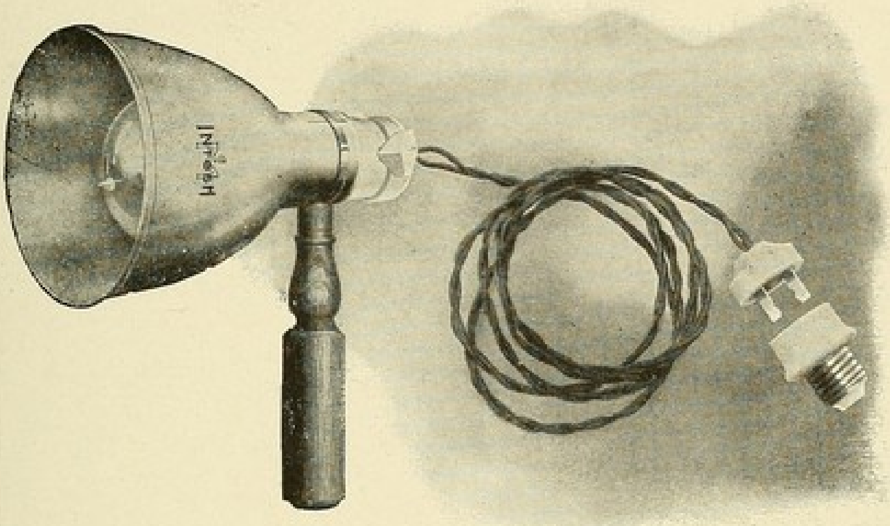


Fig. 101.—Fifty-candle power incandescent lamp and reflector.

nonfocusing. Ray or colored screens are fitted to most of these lamps for the purpose of giving the colored light treatment, a subject that has received considerable attention.

LIGHT BATHS.

The local electric light bath and the electric light bath cabinet are being used by a great many physicians, especially in institutions. The local bath apparatus is so made that it can be used in the treatment of any particular part of the body, and is useful where it is not desired to give the patient a body bath. For general and more thorough treatment the more elaborate electric light bath cabinet may be used. These cabinets are so arranged that the entire body, except the head, is subjected to the influence of sixty or more incandescent lights. The lamps are arranged in groups, so that one or more groups may be switched out, as the case may require. Some of these cabinets are supplied with from two to four arc lights, with metallic or glass mirror reflectors. Colored glass screens may be used in these cabinets when indicated.

Fig. 102 illustrates an incandescent electric light bath cabinet. This cabinet is without the arc lights, and will be found to be a most excellent equipment where the electric light bath to the whole body is required. The author's experience with electric light bath

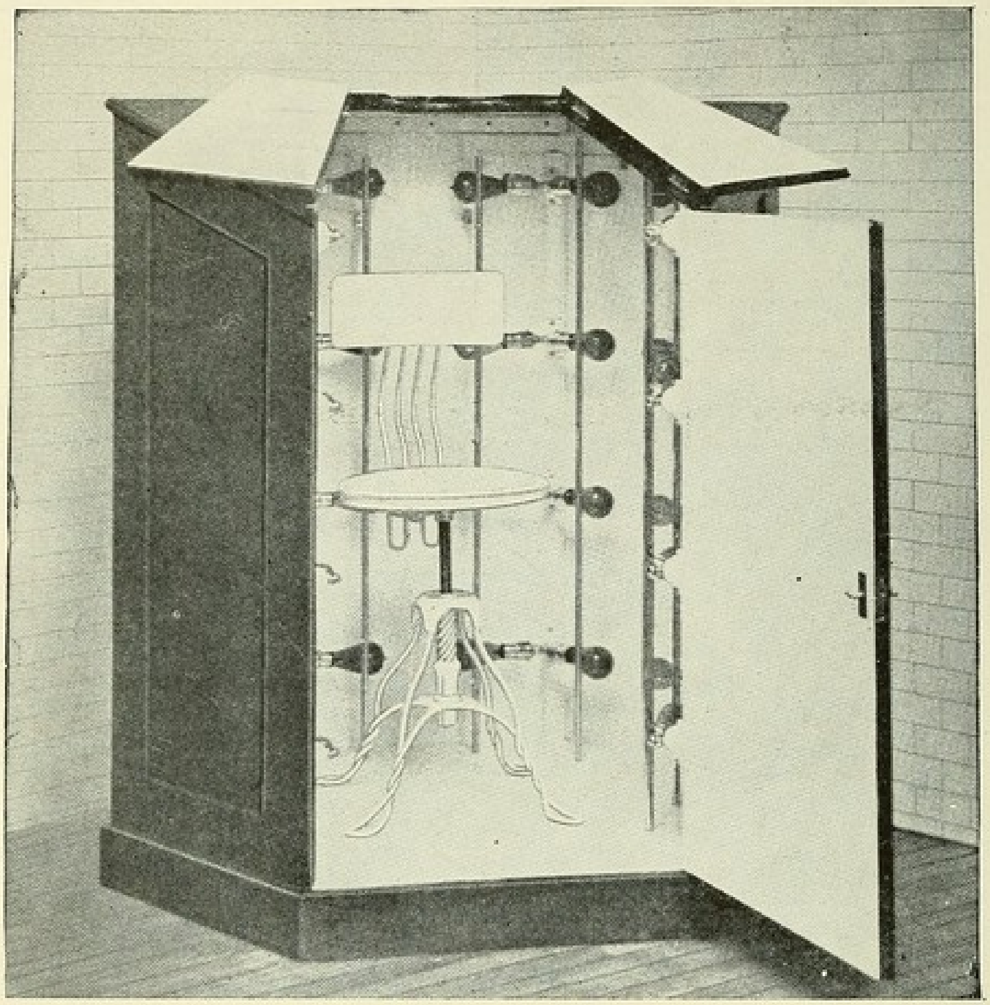


Fig. 102.—Electric light bath cabinet.

cabinets has been limited, but according to the reports of good authority they have a distinct therapeutic value that should not be underestimated.

THERAPEUTIC ARC LAMPS.

Since Finsen's report of the therapeutic value of the arc light in the treatment of skin diseases, many kinds and designs of arc lamps have come and gone. The original Finsen lamp was a large, massive affair, costing, when imported to this country, about $2,500. The lamp required a current of about 80 amperes and produced a very intense heat. The rays were carried to the patient through long telescope-like tubes, which were furnished with condensing lenses. To overcome the effect of the heat rays, hollow rock-crystal lenses, through which a stream of water continually flowed, were firmly pressed against the parts treated. These lenses answered a double purpose by absorbing the heat rays and making the skin anemic by preventing the circulation of the blood. While four patients may be treated at one time with this lamp, the price is prohibitive in anything but institution work.

Many simple modifications of the Finsen lamp have been made in this country, some of which sell as low as $100. It is claimed that the ultraviolet rays are greatly increased by substituting iron electrodes for the carbon. To use iron electrodes, a stream of water must pass through them continuously. The author used an iron electrode lamp for some time, but was not favorably impressed with its therapeutic value. Several kinds of hand lamps of various designs, each claiming more or less ultraviolet effect, have come and gone the way they deserved to go.

Some therapeutic value is being claimed for the Cooper-Hewitt or mercury vapor lamp. This lamp may be seen in almost any city or town. It is used for lighting what is known as the "electric photo studio." The lamp is rich in actinic rays, and, when three or four are used in series, dry plates may be fully timed by the instantaneous method. This lamp causes the patient to assume a deathly or corpse-like appearance. The writer has had no experience with this lamp as a therapeutic agent, but, since it is so rich in ultraviolet rays, it should be thoroughly tried before condemned.

Other lamps might be described, but space forbids farther discussion, and many are no longer manufactured. The inquiring physician is directed to books treating solely of phototherapy.

PHYSIOLOGIC EFFECTS OF LIGHT.

All things of an animal and vegetable nature must, in order to live, have a certain degree of light. The shrub or flower that is shut away from the light becomes diseased, pines away, and dies; in a like manner is the human being affected. Examples of this are seen in robust criminals long confined in dark, close cells. While sunlight is recognized as a powerful bactericide, it does not actually destroy the germs, but vitalizes and tones up the individual by supplying him with the fighting force that either destroys or throws off the bacteria and their products.

Colored Lights.—Each color has its own chemic effect. Red light is stimulating, while blue light is depressing. To get the stimulating effect from an ordinary incandescent lamp, a plate of red glass is placed between the lamp and the patient, while, if a depressing effect is required, a plate of blue glass is used.

Ultraviolet Ray.—It is believed that the effect of the ultraviolet ray is confined to the skin, where the cells are stimulated and the metabolism increased. Prolonged exposures, however, cause a degeneration, that may result in an erythema and blistering. This condition is accompanied by a dilatation of the blood vessels, a local leucocytosis, with an extravasation of blood into the tissues. Chronic and indolent ulcers heal faster when exposed to the violet ray. The effect of the ultraviolet light applied to the whole body causes a general hyperemia, with a slowing of the respiration, which condition may remain for several days after a single treatment, or for a month or more after a course of treatments.

Incandescent Electric Light Baths.—Electric light baths produce profuse sweating, with superficial dilatation of the arterioles and a lowering of arterial tension. This effect is probably due mainly to radiant heat, but the deep penetration of the intense light unquestionably causes oxidation and tissue changes.

Red Light.—It has long been claimed that red light would prevent pitting in cases of smallpox, and even in the eruptive fevers.

Blue Light.—A great many extravagant claims have been made for the anesthetic effect of blue light. There is no question that it has a sedative influence by producing a sense of well-being or a restful feeling. The heat and light from an incandescent blue glass bulb may, in some cases, relieve the pain in neuritis and neuralgia.

THERAPEUTIC USE OF ELECTRIC ARC LIGHTS.

Ulceration, X-Ray Dermatitis.—The ultraviolet rays are of service in the treatment of chronic ulceration, and, in conjunction with high-frequency currents, greatly benefit cases of x-ray dermatitis.

Rheumatism, Gout, Arteriosclerosis.—Rheumatism, gout, and arteriosclerosis, from whatever cause, may be greatly benefited by the judicious use of the incandescent or arc light bath. All cases of arteriosclerosis should be treated with extreme caution, increasing the temperature and length of the seance as the patient improves.

Impotency.—In the treatment of functional impotency the author has found that the application of the concentrated rays of sun and arc light directly to the testes for from ten to twenty minutes each day is the most effective means of restoring normal vitality to these organs. When using sunlight, a condensing lens is required, while the arc light should be provided with a parabolic reflector. The testicles are exposed to the direct rays of light at a distance that will not cause too much heat in the tissues. The treatment is continued until the integument is quite red, but should not be carried to the point of soreness. After eight or ten days it will be noticed that the symptoms of impotency are gradually giving way to normal, vigorous erections.

Tuberculosis.—Doctor Tousey speaks favorably of the Cooper-Hewitt mercury vapor lamp in the treatment of laryngeal and pulmonary tuberculosis. He uses a lamp of 450-candle power, with a reflector. He places the lamp horizontal to and from five to six inches from the skin, with an exposure of ten minutes. A temporary reddening of the skin takes place. He used the light in conjunction with the x-ray and high-frequency currents with great improvement in one case.

RÖNTGEN X-RAY.

From the time of the discovery of the x-ray by Wilhelm Conrad Röntgen, of Würzburg, Germany, April 30, 1895, to the present time the world has been astounded by its revelations. The history of this epoch-making discovery has been repeated so often that it is familiar to every school boy, and for this reason will be omitted here.

The first published account of the x-ray had an electrical effect, for it was carried over the entire civilized world with lightning-like speed. One of the first skiagraphs published in this country was made of a hand, and may be found in volume 49, page 233, of the *Medical Record* for February 15, 1896. This skiagraph was made January 17, 1896, by Professor Röntgen in the physical laboratory at Hamburg, Germany. While it must have been a revelation at that time, it would be considered a complete failure now, so great has been the improvement in x-ray work. The length of the exposure was not given. At about this time exposures were frequently made for from thirty minutes to an hour and a half.

The first coils and static machines used to energize Crookes' tubes were, like the tubes, very inferior. Four-inch induction coils, one to four small plate static machines, and from 2- to 4-inch vacuum tubes, with a tungstate of calcium screen, constituted the sum total of the early experimenter's equipment. While his skiagraphs, as compared with ours today, are very poor, they were really excellent when we consider the circumstances under which they were made, and serve to teach us, even now, a very important lesson—viz., to make the very best use of the equipment we have until we can get something better. Those interested in the evolution of the x-ray will find interesting reading in the representative medical journals of the latter part of the year 1895 and throughout the years 1896 and 1897. Volumes 49 and 50 of the *Medical Record* are particularly interesting.

As soon as it was made known that the new force which had been named by Professor Röntgen "x-rays" would reveal and photograph what had heretofore been invisible in the human body, the progressive element of the medical profession went wild over the idea and made a stampede to the various manufacturers for apparatus. Quite a few static machines were scattered over the country, others were eagerly bought, and, so great was the demand for x-ray apparatus, that factories were run night and day.

Because of the fact that static machines could be operated anywhere and by almost any power, enterprising manufacturers were responsible for the idea that the static machine was the only ideal x-ray generator, an idea that soon became general and is still prevalent in many localities.

SOURCE OF ELECTRIC ENERGY.

When considering the installation of an x-ray equipment, many things must be understood and carefully considered from every standpoint by the intended operator in order that he may not be disappointed in his undertaking. The first thing of importance that should receive his attention is the particular kind of work that he intends to do—whether mainly diagnostic or therapeutic. The next step is the selection of a generator—whether it be a static machine or transformer. Then comes the tube or tubes, and the last, but by no means least, is the fluoroscope. In the following pages the author will endeavor to make the reader so thoroughly familiar with each piece of apparatus that he can make no mistake in selecting just what he needs for his individual work.

Static Machine.—As the static machine was first generally used in this country, it will receive first attention. The *modus operandi* of the static machine has been explained in Chapter IV, to which the reader is referred for such information. Hundreds of static machines are to be found throughout this country, a few of which are worthless, though the majority are fairly good machines. They are unquestionably the simplest form of apparatus for energizing the x-ray tube. They furnish a steady current and require no interrupter. In the operation of a static machine the rotation of the plates should be continuous and regular. When in reach of the commercial electric current, the motor is the only ideal power for driving the machine. Water power or the gasoline engine may be used, or the machine may be run by hand, but the electric motor is to have first place when the current is available.

For x-ray purposes the static machine should have not less than ten revolving plates, twelve are better, and they should be at least 30 inches in diameter. Many large static machines have been built with a view of using them for high-grade skiagraphic work, but in nearly every instance they have been abandoned for the induction coil. Atmospheric changes have such an influence on a static machine that there are times during extremely humid weather when most of the current will leak away to the air or near-by objects.

So much good diagnostic and therapeutic work can be done with a static machine, if in good order, that every owner is wasting his opportunities by not using it unless he is the possessor of a modern coil. For therapeutic purposes the static machine, when properly cared for, is quite as efficient as the induction coil, the coil being superior only in fluoroscopic and skiagraphic work.

Some authors describe three methods of connecting the tube to the static machine, but only one method, which embraces them all, will be described here. The positive end of the tube (anode) must be connected by wire to the positive prime conductor, while the negative terminal (cathode) is to be connected in the same manner to the negative prime conductor. Instead of being connected directly to the metallic parts of the prime conductors, the wires from the terminals of the tubes are fastened to sliding rods or handles, which may be brought near to or in metallic contact with the prime conductors. By this arrangement a spark gap or resistance may be placed in series with either terminal of the tube. Fig. 103 illustrates the correct arrangement of the tube and shows how it is connected to the prime conductors, *A* and *B* being the spark gaps, as above mentioned.

When the machine is started with the prime conductors far apart, and the tube fails to light up, the prime conductors should be brought close together until a vigorous spark passes between them, after which they must be widely separated, when the tube will usually light up, provided, of course, it is a static tube in good condition.

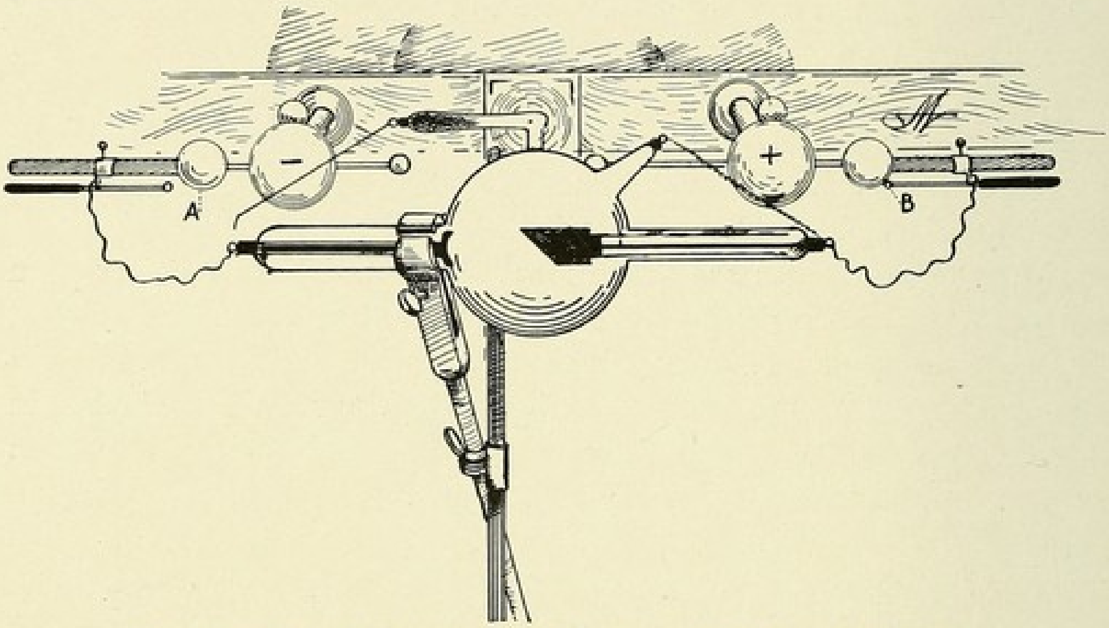


Fig. 103.—Method of connecting an x-ray tube to a static machine.

When the vacuum of the tube is quite low and the rays fail to penetrate the tissues, a ½- to 1-inch spark gap on the negative side of the tube will raise the vacuum and considerably increase the penetration. This spark gap should be placed at *A*, between the wire connecting the negative terminal of the tube and the negative prime conductor.

If the machine is kept dry and clean inside and out, it should do excellent work every day in the year. The stronger the current carried through the tube, the greater will be the volume of x-radiance given off. The only way that this can be regulated is by regulating the speed of the revolving plates—the faster they revolve, the greater will be the output of electricity and the stronger the current through the tube.

There seems to be current an opinion that a tube energized by a static machine is not likely to produce a burn. Men of small experience have been heard to make the statement, "I never heard of a burn produced by a static machine." There could be no greater mistake. One of the most severe burns the author has seen was caused by a small inferior tube and an equally inferior static machine.

The author wants it distinctly understood that he is in no way prejudiced against the static machine as a piece of x-ray apparatus. Good static machines, properly cared for and rightly operated, will do excellent work up to a certain point, but they have their limitations, beyond which they can not go. For therapeutic work they will probably equal the coil, and they can be relied upon in light work—as in the extremities—for a fairly good skiagraph, but heavy skiagraphic work is beyond their reach.

Transformers.—The physician who has access to the commercial electric current, and expects to do a considerable amount of skiagraphic work, must have a transformer of some kind.

Induction Coils.—Large induction coils, with either the mercury turbine or electrolytic interrupters, have long been in popular favor. They have their faults, and it is only a question of time when they will be either greatly improved, or something entirely different and better will be produced.

The primary and secondary currents, and principles of the induction coil, have been fully explained in Chapter II, to which the reader is referred for a careful study. These coils are generally named by their spark length, which ranges from 12 to 24 inches, or even longer. If properly wound, it is generally believed that a 16-inch coil, a coil that will produce a 16-inch spark of the proper kind, will be sufficiently large to do the very best and quickest skiagraphic work. From what the author has seen, he has no good reason to question the statement, though he uses a 24-inch coil.

Most induction coils built for x-ray work are fairly good, though some are easier on tubes than others, and this is a point that should be well considered. The higher the amperage in a coil, the quicker it will heat the tube. When the tube becomes quite hot, gases are liberated from the anode and other parts, and to a certain extent it temporarily loses its vacuum. A coil that will not overheat the tube will allow it to stand at a stable vacuum long enough to make a skiagraph of any part of the body without injury to the tube.

Because of their low amperage and high voltage, large coils, properly built, are believed to do better work and greatly lengthen the life of the tube. In the author's experience this seems to be true, and the exchange, three years ago, of a 16-inch for a 24-inch coil has greatly lowered tube expenses.

Induction coils may be operated by the 110- and 220-volt direct and the 110-volt 60-cycle alternating current. The 110-volt direct current is greatly to be preferred. With this current the mercury interrupter is ideal for therapeutic work, allowing the tube and machine to run for hours at a time without injury. The mercury interrupter may be used with the 220-volt direct current, but the results are not so good, as the mercury amalgamates more quickly—sometimes in a single day or even sooner. For skiagraphic work the electrolytic interrupter should be used with either the 110- or 220-volt direct currents, the 110-volt being always preferred.

In many localities the alternating is the only current that can be had. It may be transformed, or rectified, and used with the mercury interrupter, though this method is no longer recommended. The liquid rectifier gives more or less trouble, and should be used only as a last resort. When the alternating current is used without converting, the electrolytic interrupter will give fair satisfaction, and until a short time ago was the only interrupter that could be used with this current on large coils.

A mercury interrupter is now being advertised for the alternating current for which extravagant claims are being made. It requires only two pounds of mercury, which does not amalgamate, and will break the strongest or heaviest current. The author has not seen this interrupter, but, if these claims are true, it will come as a great boon to alternating current workers, and will make that current equally valuable with the 110-volt direct current.

In selecting an induction coil, this matter of current and interrupters is no small one and must be thoroughly understood. No physician should buy any kind of electric apparatus until he has a practical working knowledge of it.

Transformer.—A new type of transformer, illustrated in Fig. 59, is meeting with considerable success among some of our large x-ray workers. The machine is built for either current, but is better suited to the 220-volt direct. It has no interrupter, and the manufacturers claim that it has no inverse current and that tubes will last longer with this machine than with the induction coil. It is also claimed that difficult skiagraphs may be made very much quicker, with an improvement in their quality. These machines are not rated in spark length, as is the coil, but are rated according to their output or energy, which is listed in kilowatts. The machines are built in 1, 2, and 4 kilowatts capacity, the latter being particularly adapted for hospital and sanitarium work.

PORTABLE X-RAY APPARATUS.

Because of the difficulty in moving injured patients about for the purpose of skiagraphic examination, portable x-ray machines of various kinds have found ready sale among physicians who are trying to prepare themselves to meet their obligations as necessity requires. The author has had considerable experience with portable outfits, none of which has given entire satisfaction, though all have been more or less valuable. Portable coils, like those shown in Fig. 58, are of the high-frequency transformer type, and require specially designed high-frequency tubes for x-ray work. These coils will do fairly good skiagraphic work, but they can in no way be compared with the large stationary coils.

Tubes, fluoroscope, tables, compressors, and other x-ray paraphernalia have been illustrated and described, in a general way, in Chapter IV, and will be more particularly described, as occasion requires, in succeeding pages. In order to prevent a too frequent repetition of illustrations of apparatus, frequent reference will be made to the illustrations in that chapter.

No attempt has been made to describe or illustrate all kinds of electric or x-ray machinery. The reader will often fail to find his particular machine among the illustrations in this book, and will, of course, feel disappointed. This book is not a catalogue, and the products of any certain manufacturer or class of manufacturers are not being exploited. The illustrations have been selected because they represent certain classes of machines, and, if the reader will take the pains to thoroughly learn the principles on which they are constructed, he will find that the text applies to all machines of the same class.

X-RAY AS A DIAGNOSTIC AGENT.

Each great scientific discovery, necessarily, had a very small beginning, and usually a very imperfect beginning. Those now living know something of the evolution of the microscope. Great authorities spoke of it with unutterable contempt. Even anesthesia was denounced as unscriptural. The ophthalmoscope was ridiculed by many of the greatest men in the profession, who stated that it was useful only to men who had poor eyesight, and claimed that they had no use for this new aid to diagnosis. Electricity, the telegraph, telephone, and many other great discoveries met the same fate.

The evolution of the Röntgen ray has been a repetition of earlier experiences. Many of the ablest physicians and surgeons at first treated this new aid to scientific diagnosis with cold indifference. There were causes for this state of affairs, for which the physicians were not always to blame. At first the source of energy was entirely inadequate. Enterprising manufacturers pushed their static machines out over the country, and insisted that they were capable of furnishing ample current for the heaviest skiagraphic work. Buyers of these machines soon found that they could make only passable skiagraphs of the extremities, with an occasional one of the deeper tissues. Physicians and surgeons alike soon became disgusted with this uncertain method, and denounced the Röntgen ray as worthless.

Since the introduction of well-made transformers, on which complete reliance can be had for good fluoroscopic and skiagraphic work, the x-ray has become absolutely necessary to the rapid and accurate diagnosis of bone injuries and the location of foreign bodies. It is rapidly taking the place to which it rightly belongs, and in which it will become more and more popular as its technic is better understood.

Fluoroscope.—The fluoroscope is shown in Fig. 70. The x-rays being invisible to the naked eye, it is necessary to place a screen, coated with a fluorescent substance, between the observer and the object examined. These observations may be made with the simple screen or the closed fluoroscope. If the former is used, the room should be perfectly dark, while, if the closed fluoroscope is used, it is not absolutely necessary to darken the room, though it is much better if the room is made dark and the observer allowed to remain in the dark for several minutes before making the examination. His eyes are then accustomed to the darkness, and he is able to get a much clearer vision through the fluorescent screen.

All clothing should be removed from the parts to be examined to prevent the possibility of pins, buttons, and other metallic structures producing a shadow upon the screen. In surgical cases, if careful diagnostic work is required, all dressings, powders, and splints must be removed to prevent doubtful shadows on the screen, and to enable the joints to be bent when necessary.

The fluoroscope has advantages and disadvantages. It is quickly and easily used, and allows rapid comparison with normal parts of the body; but it makes no permanent record of what is seen, and the observer is compelled to rely upon his memory, unless operating under it.

In long fluoroscopic examinations the patient as well as the observer is likely to receive a burn. Because of the dangers of chronic x-ray dermatitis, the author never uses the fluoroscope for any purpose—not even for a few seconds. It is to be greatly regretted that so valuable an agent should have limitations of such a character, for, were it not for the dangers of fluoroscopy to both patient and observer, much valuable work could be done, and the fluoroscope would become one of our most popular diagnostic instruments. Notwithstanding all this, the fluoroscope is valuable in the location of and as an aid in removing many foreign bodies, the methods of which will be fully described under their proper headings.

Skiagraph.—The method of photographing the invisible by means of the emanations from a vacuum tube is known as skiagraphy, and has many synonyms. The skiagraph is in no sense a photograph. It is not a reflection from the body, but, instead, a shadow made by the rays passing through opaque bodies and affecting the sensitive photographic plate in proportion to the amount of radiation that reaches the plate, and is, therefore, a shadow picture, made by transmitted light. Unlike the photographic print, the print from a skiagraph is reversed, a point that must be remembered when studying such pictures.

Patient.—The first thing to do when a patient presents himself for a skiagraphic examination is to take a complete and systematic history of his case. A modification of Kassabian's record will answer the purpose. (See Figs. 75 and 76). These cards are 5x8 inches and printed on both sides. By reading the cards it will be noted that all of the patient's history is on one side and the method of making the skiagraph and the x-ray findings are on the other side. These cards are filed away in an indexed drawer. The cards bear numbers corresponding to numbers on the negatives, which are placed in heavy envelopes or cases, and filed for future reference. Many injuries will result in damage suits, and the skiagraph will be introduced as evidence. If the physician who made the skiagraph is called as a witness, and he is without careful notes made at the time the work was done, it will be impossible for him to call to mind all of the facts in the case. When he has a careful record of the case and the methods employed in making the skiagraph, his technic can not be questioned.

Position of the Patient.—The patient should be placed in such a position as to bring the parts to be most prominent in the skiagraph as near the sensitized plate as possible. This is necessary in order to prevent distortion. In order to get a perfect picture, the patient must be absolutely still during the exposure. If the patient is unfamiliar with the working of the machine, he should be made to understand that there will be some noise, but that the flashes can in no way hurt him in the least. Small children, if nervous and easily frightened, should be chloroformed. Blurring of the picture may be caused by shaking the tube, due to an unsteady tube stand or overhead fans, or a shaky table. As far as possible, no one should be allowed to touch the table during the exposure. The patient should be instructed not to move any part of the body or speak during the exposure. With nervous patients it is often necessary, when skiagraphing a limb, to strap it to the table or weight it with sand bags, unless a compression diaphragm is used.

Sensitized Plate.—The sensitized plate is very similar to the photographer's dry plate, and must be handled and developed in exactly the same way. The plates come from the manufacturers with the larger sizes half a dozen in a box. Double envelopes, one of black and one orange, are supplied for the protection of the plates during the exposure. The unopened box of plates is taken into the dark room, from which all light, except a faint red or yellow light from the lantern, has been excluded. The box is opened by cutting the binding paper around the edges and removing the double cover—or two lids, as it were. The first plate will be found to have its film side downward. It is lifted up by its edges, and, without touching the film surface, is placed in the black envelope, with the film side away from the flap side of the envelope. The black envelope is now placed inside of the orange envelope, introducing the flap end, and keeping the film side toward the smooth side of the envelope, or away from the flap side. In this way it is always easy to determine which is the film side of the plate when it is ready to use. The size of the plate will depend upon the size of the part to be skiagraphed. As a rule, the author uses only two sizes of plates—8x10 and 11x14 inches, and occasionally a 14x17, but the latter are seldom needed. To prevent breaking the plate, it should be placed on a smooth board or heavy plate of brass, the latter being better. When the patient's body is moist from perspiration, the envelope should be covered with celluloid, oiled silk, or a sheet of blotting paper. When the patient is small, it is wise to use a large plate and take both sides for comparison. Sometimes, on account of the distorted shape of the patient, it is impossible to bring the parts near enough to the plate to prevent distortion. In such cases a film may be used to overcome the trouble. The celluloid film may be bent into almost any shape without injuring it. The part to be made most prominent in the finished picture should be placed as near the center of the plate as possible, and the rays should fall perpendicular to it. For the purpose of identifying the plates, the name of the patient is written on the end of the film with a lead pencil just before developing. The writing is permanent, and the record may be made at a later and more convenient time. If more than one plate is made, they should be numbered.

X-Ray Tube.—The tube selected in a given case will depend upon the thickness and density of the parts to be examined. Soft or medium tubes are generally required for thin parts and tissue differentiation, but almost any class of work can be done with a high tube with the proper exposure and right development. The question of tubes is a problem; there are no two alike, even of the same make and design. The only way to know a really good tube is to give it a thorough test, as it carries no evidence on its surface.

Position of the Tube.—In a properly made tube it is believed that the strongest rays are given off at right angles to the long axis of the tube, in which case it is necessary to place the tube parallel with the plate and the object to be examined. Some operators place the tube in such a position that the plane of the target is parallel with the plate. This position may be correct for some tubes, but not for all. Each tube should be tested with metallic cross bars for direct rays and then labeled for future use.

Distance of the Tube from the Plate.—The thicker the parts and the larger the area to be skiagraphed, the farther the tube should be placed from the plate. The distance should always be measured from the anode, and not from the surface of the tube, as is frequently done. It should be understood that the greater the distance the tube is placed from the plate, the longer will be the exposure.

Length of Exposure.—So many factors are concerned in the question of exposure, that no definite or fixed rules can be laid down with regard to time. The main factors that must be considered in every exposure are

(1) The kind and capacity of the apparatus and the condition of the tube.

(2) The size and density of the part to be examined.

If a static machine is used, we must consider the size and number of plates and their number of revolutions per minute. When a coil is used, we must consider its size and the kind and frequency of interruptions. As a rule, the thicker the parts, the more prolonged must be the exposure, though this is not always so. The chest is as thick as the abdomen, yet it requires a much shorter exposure.

Quality of the Rays.—The vacuum of the tube determines the quality of the rays. We speak of tubes as being low, medium, and high. The higher the vacuum of the tube, the higher will be its degree of penetration and the shorter the exposure. The lower the vacuum, the lower will be the degree of penetration and the longer the time of exposure.

Intensifying Screens.—From the very first the tendency has been to shorten the exposure in skiagraphic work. When a screen of fluorescent substance is placed in contact with the film side of the sensitized plate during an x-ray exposure, it acts like ordinary light and reduces the time of exposure to about one-fourth of the time required without the screen.

While the intensifying screen greatly shortens the exposure, it has disadvantages that make its use impossible in delicate work. It has been claimed that its granular appearance reduces the definition of the skiagraph, destroying the finer details of the structures. These conditions are unquestionably found in negatives made with the intensifying screen, but it is a question whether the granular condition of the screen has as much to do with blurring the image as other factors. Those who have used the screen in a perfectly dark room have noticed the fact that the screen is luminous for some time after the current has been cut off. This prolonged fluorescence is, unquestionably, the main cause of the injury to the plate. To prove this conclusion, expose an intensifying screen to an active x-ray tube for a few minutes, then quickly place it against the film side of an unexposed sensitized plate for a minute and develop the plate. The same granular condition will be found in the unexposed plate that is seen in the skiagraph when made with an intensifying screen. If it were possible to stop the action of the screen at the time the tube is stopped, very little of the bad effect of the screen would be noticed in the finished plate. As it is, the intensifying screen will never become very popular; though it reduces the time of exposure, it decreases the quality of the plate.

Secondary Rays.—Since secondary rays are produced in a body when x-rays pass through it, and the secondary rays in turn produce a tertiary ray, it stands to reason that the exposure should be made as short as possible in order to prevent these useless rays, which often fog the negative and spoil the results.

Diaphragm.—By means of the compression diaphragm the indirect primary rays are cut off, with a considerable reduction in the secondary rays. The area exposed is diminished and the thickness of the parts is reduced on account of the pressure of the diaphragm. A heavy lead plate, with an adjustable diaphragm, will answer the same purpose. An adjustable compression diaphragm, illustrated in Fig. 69, and being a part of the examination table, is a very necessary adjunct to the x-ray laboratory, as it shortens the exposure and increases the quality of the skiagraph.

PHOTOGRAPHY.

The method of treating a plate that has received an exposure from an x-ray tube does not differ materially from the methods of ordinary photography. Unfortunately a large number of physicians who are doing their own skiagraphic work content themselves with making the exposure and sending the plate to a local photographer for development. This is unquestionably a great mistake, and often defeats the very purpose for which the skiagraph is made. If the x-ray is to be made a means of accurate diagnosis, the work must be done throughout by a thoroughly experienced physician.

Dark-Room.—Dark-room methods of the photographer are, to the average physician, more or less a mystery. He imagines that the work is complicated, and requires an endless amount of study, for which he has neither time nor inclination. As a matter of fact, if the dark-room is properly built and arranged, the extra amount of work required to develop and finish a skiagraph is a pleasure rather than a task.

The dark-room need not be large, 6x7 feet being sufficient where only a small amount of work is to be done. The room should be absolutely free from white light, and so constructed that it may be perfectly ventilated. A room of this size, built of tongue-and-groove flooring, may be placed in a corner of the x-ray room, or,

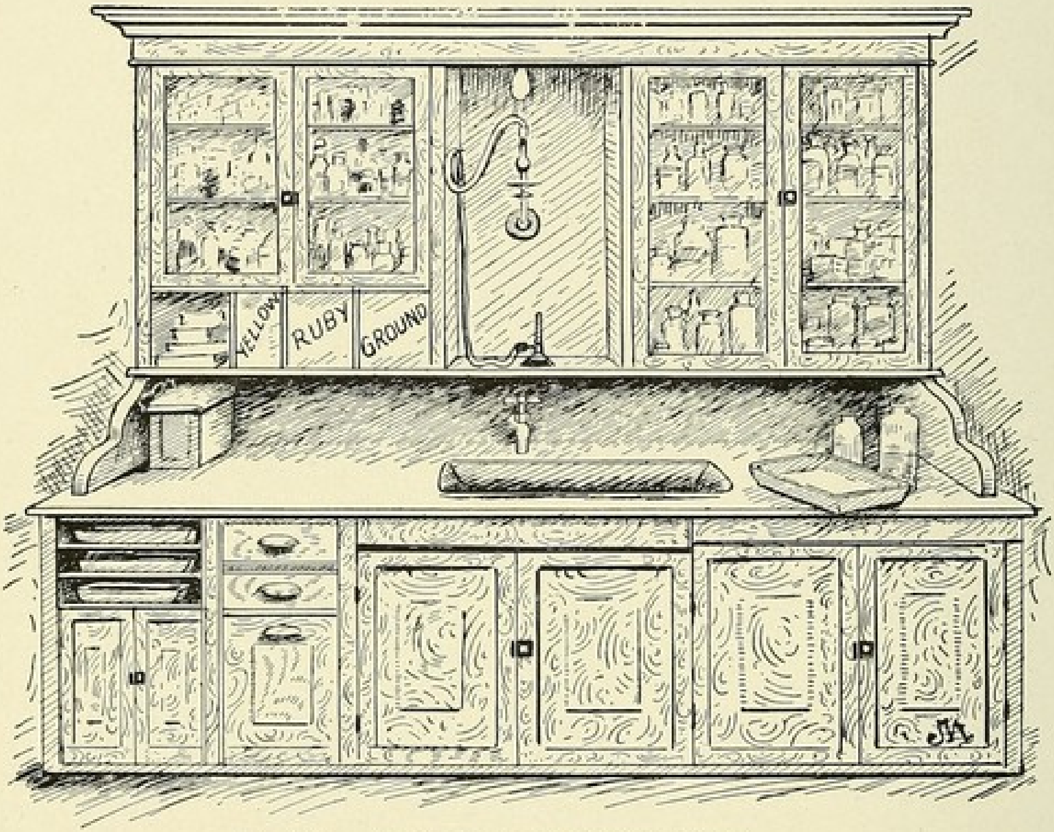


Fig. 104.—Developing and printing cabinet.

if space is at a premium, as it often is in doctors' offices, it might be placed in a near-by room or in the basement. Where there is a sewer system, a sink, with running water, should be placed on one side, and a wide base shelf run from the sink along the wall to the end of the room. This shelf is used for the support of trays while developing. A number of shelves should be arranged above and below the sink for trays, printing frames, stock, etc.

Fig. 104 is a fairly good representation of the author's developing and printing cabinet. This cabinet is 7½ feet long, accommodates a 3-foot sink, and has a broad base shelf, with a number of shelves below and above. The base shelf is covered with roofing glass 1/2 inch thick. The portion above the base has double glass doors. It is fitted with two ruby lights, one orange, and one ground glass. This cabinet furnishes ample room for a complete developing and finishing equipment, together with the large stock of chemicals and solutions necessary in a large business. The portion of the cabinet beneath the base is used for trays, printing frames, hypo, cards, and many other things that must be kept out of the way.

Dark-Room Light.—As the room is perfectly dark so far as white light is concerned, it is necessary to have some kind of light to enable the operator to see what he is doing. The only light that may

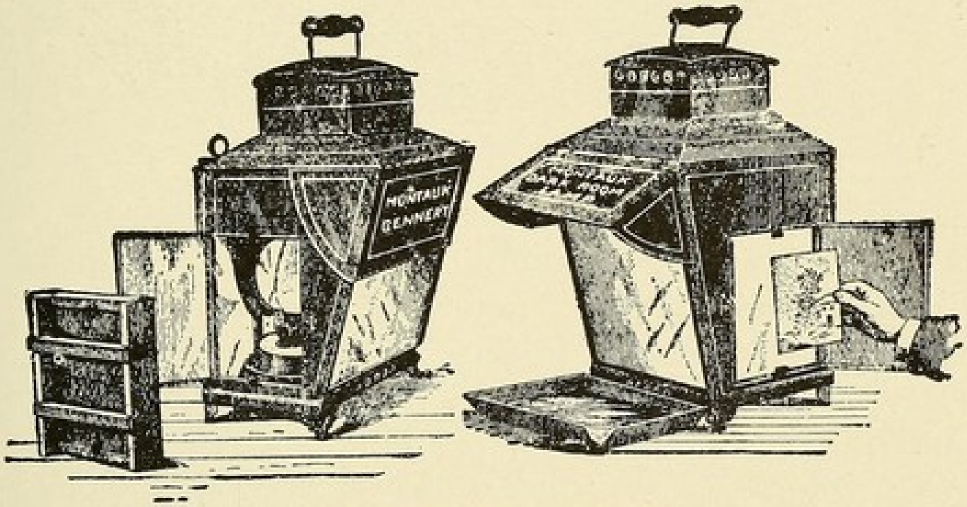


Fig. 105.—Dark-room lantern.

be permitted in the room while handling dry plates is either a pale ruby, orange, or green. Ruby is generally used. It is obtained by allowing either natural or artificial light to shine through several thicknesses of ruby glass. The ruby light should be on or near the base shelf and near the developing tray. Fig. 105 illustrates an excellent dark-room lantern. When possible, it should be lighted with electricity. As this lantern has a door that exposes a white-light window, it will serve a double purpose by furnishing a light for printing developing paper. Any handy tinner will make a light-proof box with a ruby glass window for a small price. By inserting a large cork in a hole in the lid, the light is complete except the electric wiring. Bore a small hole through the cork for the passage of the electric wires, connect them to the regulation socket, and screw in an 8-candle power electric bulb. Place two panes of ruby glass, with a strong piece of ruby celluloid between them, in the slot; then connect the wires to the main line with a switch located near the box, and your ruby light is complete.

Developing and Finishing Trays.—The best and most convenient trays are those made of first-grade steel, well enameled. In selecting the larger variety, care should be exercised in getting trays that are not warped. Two to four trays of a size are sufficient. The sizes in general use are 8x10 and 11x14 inches. Of course the

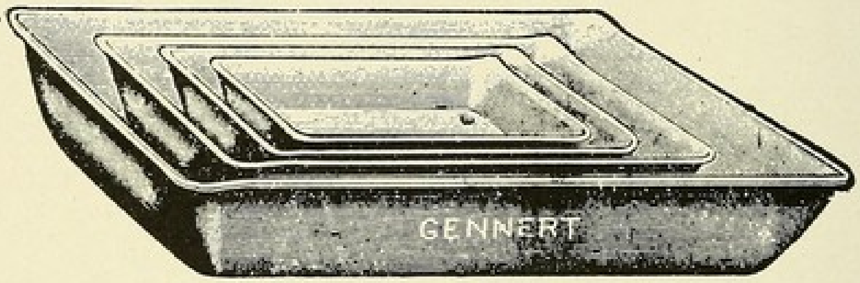


Fig. 106.—Developing and finishing trays.

number of trays necessary will depend upon the amount of work to be done. Where trays are used for fixing and washing, it will require several of a size, but, if a fixing and washing box is used, only one or two trays of a size will be necessary. A good washing box is almost a necessity where cold water can be had throughout the year.

Printing Frames.—It is only occasionally that a print will be needed from a finished negative, but every operator should know how to make one when needed. To make a print from a negative it is necessary to have a printing frame for each size of plate. Their use will be explained under the head of printing and finishing.

Plates and Films.—Photographic dry plates, papers, and films are very sensitive to the x-ray, while wet or collodion plates are said to be only slightly affected. Double emulsion plates give better results for x-ray purposes than single emulsion plates. Flexible celluloid films may be used where it is necessary to bend the plate to bring it in contact with uneven surfaces. The successful use of films requires considerable experience to prevent distortion or exaggeration, and they are therefore less desirable than glass plates.

Care of the Plates.—Dry plates should not be kept on hand any great length of time. They should be kept in a dry, cool place, and allowed to remain in the box in which they came from the makers until ready for use. If kept near the laboratory where the x-ray is operated, they must be stored in a lead-lined box that is kept securely closed. (See Fig. 73 for a description of the author's x-ray plate box.) Plates stored in another room are not always safe from the harmful effects of the rays.

Developers.—Every x-ray worker thinks he has formulated the only reliable developer, and is generally extravagant in his claims. A large number of formulas are confusing to the beginner. They are all good when understood and properly used. The author will introduce only one formula, which is not original, though somewhat modified. While a developer may consist of several chemicals, it really has but four parts—reducer, preservative, accelerator, and restrainer. The following formula is so written that the student will readily see the part that each chemical plays in the process of development.

FORMULA FOR DEVELOPER OF X-RAY PLATES.

Preserver	Acetone sulphite (Bayer)	75 grains.
	Sulphite of soda (crystals)	1 ounce.
Accelerator	Carbonate of potash (dry)	1 ounce.
Reducer	Edinol	30 grains.
	Hydrochinone	15 grains.
Restrainer	Bromid of potash	10 grains.
	Water—in warm weather	32 ounces.
	in cold weather	24 ounces.

In preparing the above formula the crystal sulphite of soda should be used where possible. If from any cause the dry or anhydrous must be used, it should be remembered that it is twice as strong as the crystal, and will therefore require only half the amount. This is a splendid developer, and may be used over and over again until it turns quite dark, when it should be discarded for a fresh solution. If well corked, it will keep several days, and, best of all, it will not stain the hands and has no disagreeable odor.

For routine work the author prepares a gallon of the concentrated solution, leaving out the reducing agents until ready for use. The formula for the gallon of stock developer is as follows:

Preservative	Acetone sulphite (Bayer)	2½	ounces.
	Sulphite of soda (crystals)	1	pound.
Accelerator	Carbonate of potash (dry)	1	pound.
Restrainer	Bromid of potash	160	grains.
	Water	1	gallon.

When wanted for developing, the concentrated solution is used in the following manner:

Preservative, accelerator, and restrainer (concentrated)			8 ounces.
Reducer	Edinol		30 grains.
	Hydrochinone		15 grains.
	Water—in warm weather		32 ounces.
		in cold weather	24 ounces.

The stock solution keeps well and works perfectly to the last. Of course it should not be kept for any great length of time—generally not more than ten days or two weeks, when it is exhausted and a new solution must be prepared. Where only a small amount of skiagraphic work is done, the physician may make up his developing solution according to the first formula.

Mode of Development.—When the plate has been properly exposed, it is taken to the dark-room, the door closed, the ruby light turned on, and the plate taken from the envelopes and placed film side up in a tray. The developing solution, previously prepared, is quickly and evenly poured over the plate, and the tray is gently rocked to keep the solution moving. If the exposure has been right, the image will begin to appear in about thirty seconds and will be complete in from two to four minutes. This solution will not fog the plate, and development should be carried far enough to bring out the image completely. When the skiagraph is of the extremities, the image may be distinctly seen on the plate during the whole time of developing, but in deep tissue work the plate should be developed until quite dark on the film side, and the shadows have penetrated the film and show on the reverse side. The tendency is to stop the development too soon, making the negative thin and indistinct. It takes a great deal of experience to know when to stop the development in any given plate.

When fine detail is wanted in the soft structures, care must be taken not to carry the development too far, as an underdeveloped negative is more to be desired than an overdeveloped negative. Negatives can be both reduced and intensified, as will be explained later, but it is always better, when possible, to get the exposure and development right, for only by this means can we expect a perfect skiagraph.

By a careful study of the above formula it will be seen that the physician may change his formula as the case may require.

Fixing.—When the plate is fully developed, it should be allowed to lie for a minute in a tray of clear cool water, from which it is passed to the fixing bath. When the plate comes from the developer, it is opaque to the ruby light. The fixing bath dissolves out all the bromid of silver that has not been acted upon by the light and developer. From ten to twenty minutes in the fixing bath will clear the film and completely fix the image. When all the muddy white color has disappeared from the back side of the plate, it should be allowed to remain in the fixing bath three or four minutes longer, after which it will be thoroughly fixed, and may be examined by strong white light without danger of injury. The plain non-acid fixing bath is made as follows:

Hyposulphite of soda	4 ounces.
Water	16 ounces.

When the soda is dissolved, it is ready for use. This simple hypo bath will soon deteriorate and must be thrown away. The acid chrome fixing bath is easily made and will keep for several days. It is made as follows:

Water	100 ounces.
Sulphuric acid	3 ounces.
Sulphite of soda	4 ounces.
Thoroughly dissolve and add	
Hyposulphite of soda	2 pounds.
Dissolve and add	

Chrome alum, 1 ounce dissolved in 20 ounces of water.
Add water to make a total of 160 ounces.

When only an occasional skiagraph is made, the plain hypo bath first mentioned will answer all purposes. From the developer, through the fixing, and final washing, the temperature of the solutions and water must not be above 70° F. When the solutions and water is warmer than this, the gelatin film or coating on the plate is likely to soften and melt off.

Washing.—After the plate is thoroughly fixed it must be well washed, to remove every trace of the hyposulphite of soda, the slightest remains of which would soon destroy the film through crystallization and decomposition.

If not supplied with running water and a washing box, the plates may be washed in the developing trays. The water must be frequently changed—say, eight or ten times during an hour. During all this time the plates must be carefully handled by their edges. The film may be quite firm, but it is easily scratched or broken. Great care must be taken not to injure the film by careless handling. Plates will at first meet with some injury, but after a little practice an injured plate will be an exception.

Drying.—The negatives should be dried in a room with a moderately low temperature, and free from dust. During warm weather the ceiling fan will rapidly dry the negatives, and at the same time keep them cool. When the plate has been thoroughly washed, it is placed in a negative rack to drain and dry. The rack should be in some out-of-the-way place, where it will not be disturbed. Should it be necessary to get a print from a negative in a very short time, the plate may be quickly dried by flowing it several times with pure grain alcohol, then holding it under a fan or where the air can strike it, provided, of course, the air is free from dust.

Intensifying and Reducing.—It frequently happens that a negative is too thin, and, without some means of strengthening, would be worthless. Weak negatives with plenty of detail may be greatly improved by intensifying. When it has been decided to intensify a negative, it is thoroughly washed and placed in the following solution:

Bichlorid of mercury	200 grains.
Bromid of potash	120 grains.
Water	8 ounces.

The negative is placed in a tray, film side up, and this solution is poured over it. Keep the negative in the solution until the film is bleached to an even whiteness. The longer the negative is allowed to remain in the solution, the denser it will become. It should now be washed for half an hour in running water or through several changes in the tray. It is then placed in the following solution to blacken:

Sulphite of soda	1 ounce.
Water	4 ounces.

When the negative is as dark as desired, it is again washed and set on edge to dry. Such negatives are usually quite dense.

Reduction is sometimes required when the negative is too dense, as a result of either overexposure or overdevelopment, or both. To correct an overexposed plate, use the following solution:

(1)	Water	16 ounces.
	Hyposulphite of soda	1 ounce.
(2)	Water	16 ounces.
	Ferrocyanide of potash	1 ounce.

Take 8 ounces of the first solution and 1 of the second. The negative may be transferred directly to this solution from the fixing bath, but, if the negative is dry, it should first be allowed to soak in water for at least half an hour. The reduction should be carried on in a subdued light. To prevent streaking the negative, it should be rinsed off before holding up for examination. The reduction will take place slowly and evenly, and, when carried far enough, the negative is thoroughly washed and placed on the rack to dry.

Failures in Negative Making.—It is simply impossible to mention every source of trouble the beginner is likely to encounter. As the making of x-ray negatives in no way differs from regular photographic work, the novice in x-ray work is advised to secure a good book on photography and carefully study the subject of negative making. Every formula must be correctly prepared and all instructions carried out to the letter. Poor work is the result of ignorance, carelessness, or bungling. All trays, and in fact everything in the dark-room, must be kept clean and in the proper place, ready for use at a minute's notice. A dirty operator can never hope to turn out even passable work.

Printing and Toning.—The image on the x-ray negative may be transferred to properly prepared paper in the same way as in ordinary photography. Print making should be discouraged, and the author very seldom delivers to the patient or the physician a finished picture. The negative furnishes the best evidence of the condition in the case, and the diagnosis is usually made from it. When possible, the physician should view the negative, from which he makes his diagnosis. Patients frequently carry their pictures around from one physician to another, getting a different opinion from each, due to the fact that the majority of physicians are not prepared to correctly interpret a skiagraph.

The first thing in printing is to decide upon the kind of paper to be used in making the print. The ordinary albumen papers (solio and cloro) are printed in sunlight and require some time for the completion of the process, depending, of course, upon the density of the negative. The printing of this paper may be controlled, as the print can be examined during the process of exposure. The other class of papers, known as developing papers—velox, azo, etc.—may be printed by direct or artificial light, and are very rapid. The printing process of this paper can not be watched, though its development can be controlled within a certain limit.

The first-mentioned papers are toned in what is known as a gold toning solution, and full directions accompany each package of paper. These papers, though slow to handle, produce the very best class of prints and make excellent half-tones.

The developing paper is developed very much in the manner as the dry plate, and does not require sunlight or even daylight for printing, for the work can be done as well by artificial light at night.

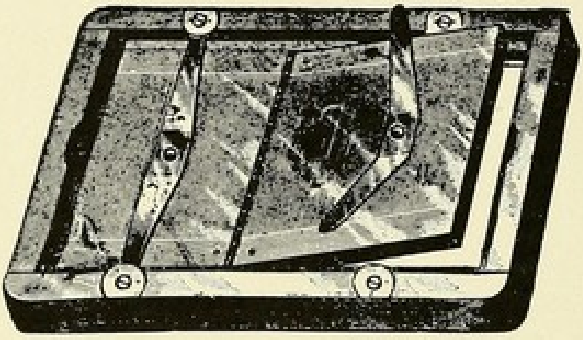


Fig. 107.—Printing frame.

The printing is done in what is known as a printing frame (Fig. 107). This frame has a removable back, which is held in place with brass springs. The back is removed and the plate is placed in the frame, glass side down. The paper is placed on the negative emulsion side against the film side of the negative, and the back is replaced and fastened. The paper is now ready to be exposed.

If the paper is of the albumen variety, the frame is placed in the sun. Every few minutes the frame should be removed to a shaded place, and the print examined by raising one section of the back, and, if not dark enough, the printing is continued.

If developing paper is used, the printing frame must never be placed in the sun. A very short exposure (one second) to subdued light will be ample for a well-made negative. The length of exposure to artificial light will depend upon the intensity of the light.

Full and complete instructions will come with each package of these papers. If trouble is had with them, the local photographer will be glad to give the necessary information. If the physician experiences many failures, he should not become discouraged, but take consolation in the fact that we have all traveled the same road and have had exactly the same vexations. The work is not difficult, but it requires considerable experience to do really good, neat work. Never be satisfied with only partial experimenting. Become perfect before you quit, if it takes a day, week, or month.

The developing paper is developed, fixed, and finally washed in very much the same manner as the plate is developed.

Mounting.—After the prints are washed they should be carefully mounted on good, strong card-board to prevent their destruction. Place a print, film side down, in a clean tray and cover its back evenly with photo paste. Place it centrally and squarely on a card, cover with a clean towel, and smooth down with a rubber roller, wiping the excess of paste from around the edge of the print.

Transparencies and Lantern Slides.—Normal or reduced transparencies and lantern slides may be made from any good x-ray negative, but, as the process requires considerable photographic experience, the methods will not be described here.

READING X-RAY NEGATIVES.

The interpretation of the x-ray negative is the most difficult part of the work. The trained eye of the x-ray specialist alone is capable of distinguishing the varying shadows and densities. The negative should be made so as to distinctly show the parts under consideration. If the negative is found to be defective, another should be made; but, if this is impossible or not practical, the negative may be improved according to the process mentioned under photography. Many negatives are so poor that they can not be improved, and no time should be lost with them.

The x-ray specialist should make himself thoroughly familiar with the normal appearance of the various parts of the human body as shown by the skiagraph, for only in this way can he hope to become a competent judge of a skiagraph. It must be remembered that a skiagraph is only a series of lights and shadows, of different densities, that to an untrained observer mean little or nothing. When studying the bony structures as seen in a skiagraph, many things must be carefully considered, and the age of the patient is by no means the least important. Physicians who view the skiagraphs of the joints of children for the first time are surprised at their normal appearance. The normal conditions of the different ages must be understood before abnormal conditions can be correctly diagnosed.

Viewing the Negative.—Before an x-ray negative can be rightly interpreted, it is necessary to know the relative relation of the tube, parts skiagraphed, and the plate. The finished picture will furnish good evidence of the position of the tube during the time of the exposure. If the object skiagraphed is too far from the plate, or the tube too close to the part skiagraphed, the finished skiagraph will be distorted or abnormally large.

To examine a finished plate, it should be held with the film (gelatin) side toward the observer. A strong north light will give the best results when using daylight to illumine the plate. Place the plate in a window, and exclude all light save that coming through the plate. A photographer's retouching frame will be found serviceable in the examination of small negatives.

The view box shown in Fig. 77 will be both convenient and entirely satisfactory for the examination of negatives of all sizes from 5x7 to 14x17 inches. The box, to be convenient, must have reversible kits, that the negatives may be viewed in their normal positions. What is practical, and still more convenient, is that the view box should have a revolving front, so made that the plate may be viewed at any angle.

It is far better for the operator to make his reading or interpretation from the negative than from the print. Fine details of the plate may be distinctly seen with a good view box. These delicate markings are too often lost in the print, causing the interpreter to make a false reading, which may lead to no end of trouble.

When a finished print is made, it must be remembered, it is reversed, a fact that must never be overlooked when operating for foreign bodies. Surgeons have frequently cut on the right side for a bullet because the skiagraph showed the bullet on that side in the reversed picture.

Foreign Bodies.—With the late improvement in technic in skiagraphic work it is possible to find and locate almost all dense substances anywhere in the tissues. Metallic bodies show best, though many others, as glass and stone, may be detected. Many opaque or semi-opaque bodies cast faint shadows when properly exposed. Defects in the plate, caused by air bubbles and other accidents during development, shadows from dressings, powders, etc., should be carefully excluded.

Fractures and Dislocations.—In this class of injuries the x-ray is indispensable, and the physician who undertakes the reduction of a fracture that is in the least complicated without the aid of the x-ray is taking upon himself a great responsibility. When the fracture has been reduced and dressed, a second skiagraph should be made to determine if the bones are in correct apposition. The physician will be surprised to find that in the majority of cases the apposition is very poor.

Greenstick, longitudinal, and impacted fractures are often very difficult to make out, and should be studied with the greatest care. The elbow-joint is frequently injured and often very poorly treated, resulting in complete or partial ankylosis.

Fractures at the hip are frequently overlooked until too late to repair the injury. In skiagraphs of the hip all lines should be carefully studied for traces of injury to the periosteum, femoral neck, head, trochanters, and acetabulum. Comparison should be made with the skiagraphs of normal hips of cases about the same age.

Dislocations.—The displacement of bones is easily determined by means of a skiagraph. Great care should be used in arranging the position of the parts to prevent a false appearance in the picture. More errors have been made in faulty skiagraphs of the shoulder than in any other part of the body. As a rule, a dislocation is not difficult to determine, though in fleshy subjects bones may be displaced for weeks without the fact being detected by the attending physician. In both fractures and dislocations, where the least doubt exists in the mind of the physician as to the exact condition present or the result of his treatment, the exact state of affairs should be explained to the patient or his representatives and an x-ray examination demanded, which, if refused, frees the physician from blame for any bad result that may follow.

Diseases of the Bones.—In diseases of the bones the x-ray has taught us much that could not have been learned in any other way. The skiagraphic appearance of normal bones should be carefully studied in order that the abnormal may be easily detected. Early cases of tuberculosis and osteomyelitis call for a very careful study.

Differentiation between bony tumors and tumors of the soft tissues is not always easy in the earliest stage, as in early periosteal growths the bone is generally affected, though not changed in density or proportion; later, bony changes become evident.

Callus may, at times, be taken for a bony growth, but the skiagraph will show that the enlargement surrounds the ends of a fractured bone.

Diseases of the Joints.—All bandages and dressings should be removed from joints when skiagraphing for diseased conditions. The limb should be bent so as to get as wide a space as possible between the articular surfaces. Pus and fluids can not always be determined in a joint. The various kinds of arthritis, in their earliest stages, are differentiated with difficulty. Differentiation between intra-articular inflammation with exudation and periarticular inflammation is not usually difficult because of the pressure produced by the intra-articular type.

Ankylosis is not always caused by bone formation. The skiagraph will differentiate between the true and the false by the absence or presence of dense bone shadows, and the obliteration of the intra-articular space.

Great care should be used in the skiagraphic examination of diseased joints. It is often necessary to make a number of exposures in as many positions. The time of the exposure should be regulated so as to show the greatest amount of contrast in the tissues.

The hip-joint is the site of frequent injuries, and, because of the thickness of the soft tissues surrounding it, the diagnosis is very difficult without a skiagraph. In some very heavy dense subjects a good skiagraph is often very difficult to make.

Diseases of the Soft Tissues.—It is unfortunate for all concerned that the x-ray will not differentiate between normal and abnormal tissues unless there be a marked difference in density. A certain amount of detail can be shown in the soft tissues, but ulcerations and the beginning of inflammatory processes are not easily determined.

The skiagraph of a brain tumor is possible, in which case the tumor must be very dense.

Diseases in the Thorax.—Notwithstanding the great thickness of the chest, the x-ray penetrates this region more easily than any other thick part of the body. The patient may be placed on the plate with his back or face downward, depending on the nature of the examination. There is a vast difference in the appearance of the ribs in the two positions. The skiagrapher should mark these differences, and be able to determine by looking at the negative or finished picture which of the two positions the patient was in when the exposure was made. The shadows made by the ribs from the first to the twelfth, the sternum, clavicle, scapula, and the intercostal spaces must all be carefully studied in the normal in order that diseased conditions may be detected when present.

A careful study of the apices of the lungs in incipient tuberculosis will frequently show shadows of the congested and infiltrated areas. In studying the lungs for tubercular deposits, comparison of the two sides must be made between like parts, as different parts vary in density, and consequently make different degrees of shadows on the plate.

Enlarged and congested glands and calcified deposits in the lungs are shown without difficulty. Consolidations produce denser shadows than abscesses or empyema. Pleural thickening and effusion are best studied with the fluoroscope.

Alimentary System.—The esophagus is often the location of disease. Stricture of this organ is frequent, though the diagnosis is sometimes quite difficult. The location of the stricture is easily determined by passing a metallic bougie down to the stricture and making a skiagraph. Strictures of the small and large intestines may be determined by giving the patient large doses of bismuth subnitrate and skiagraphing the abdomen from four to six hours later. By the same method the size and location of the stomach may be determined.

Genitourinary System.—Calculi of the kidneys and ureters are so common that x-ray examinations of suspected cases should be a routine practice. Outlines of the kidney structure are very seldom shown. The skiagrapher should be careful not to mistake opaque substances in the intestinal canal or fragments from the transverse processes of the vertebra for stones. Kassabian reports having mistaken an undissolved capsule of bismuth for a stone in the kidney.

Vesical Calculi.—Small calculi in the urinary bladder are sometimes overlooked by their being located over the sacrum or coccyx. Impactions in the rectum are sometimes mistaken for stones in the bladder. The bladder should always be empty before attempting to skiagraph it, as water offers a considerable resistance to the passage of the rays.

STEREOSCOPIC RADIOGRAPHY.

Stereoscopic examination of x-ray plates is of comparatively recent development. It increases the diagnostic value of the negative many times, and should be a part of the equipment of the progressive radiographer. The instrument here described is known as the

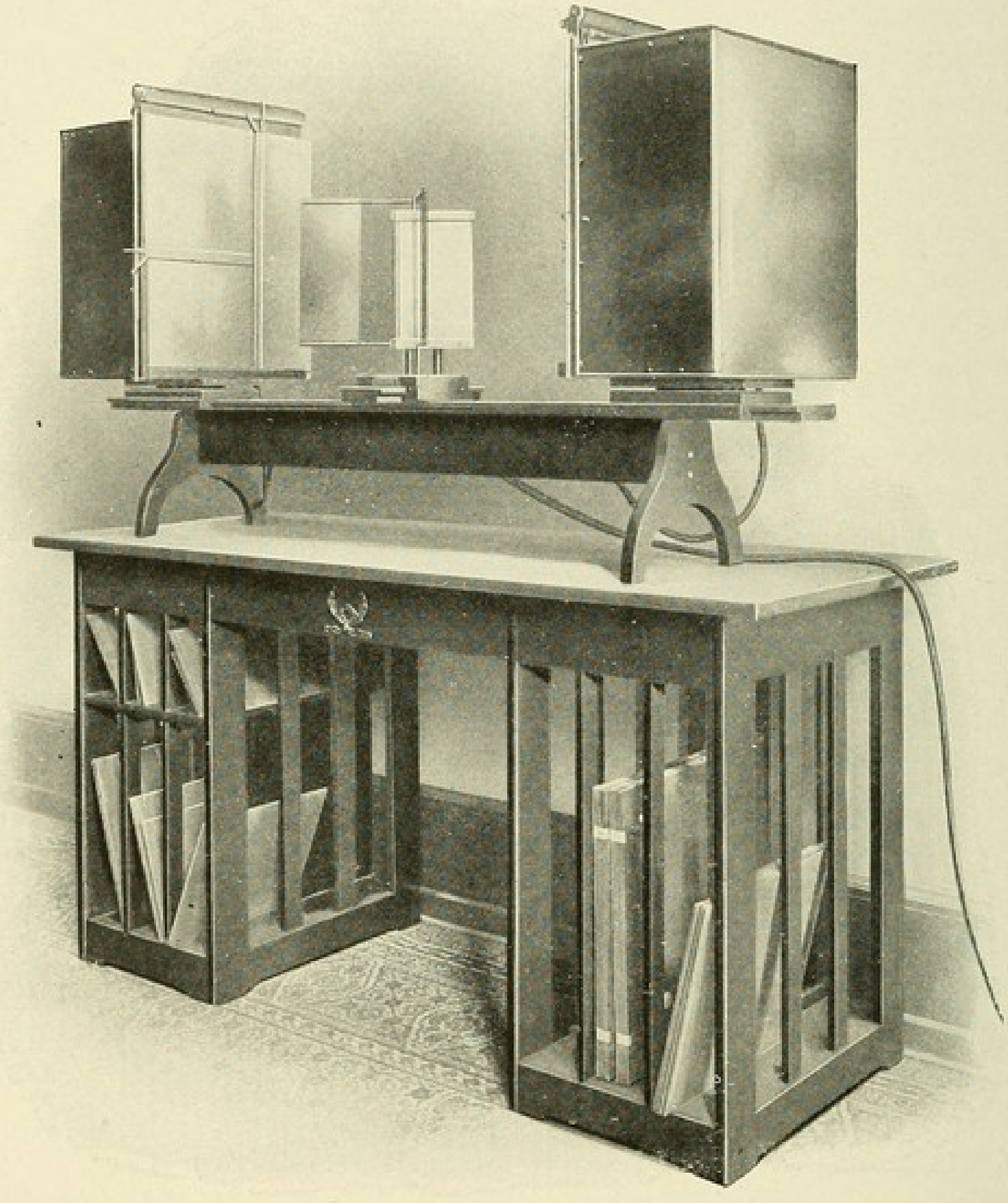


Fig. 108.—Wheatstone stereoscope.

Wheatstone stereoscope and is made to accommodate any size plate from the smallest to 11x14 inches. Fig. 108 illustrates the apparatus. It is completely adjustable and simple in its operation. It consists of two view boxes facing each other, and arranged on a graduated bed, so that their positions may be changed at will. Centrally, between the boxes, are placed two oblong mirrors arranged at right angles to each other as well as to the view boxes on either side. The mirrors are placed on a movable bed that works at right angles to the bed of the view boxes. To get results with this piece of apparatus, two carefully exposed and properly developed plates are required. After centering the tube directly over the part to be skiagraphed, it is moved to one side 3 centimeters and turned toward the object, so that the direct rays from the anode will pass through the object. The exposure is made and the tube is moved 3 centimeters to the other side of the center (6 centimeters from the point of first exposure), when the tube is again turned, so that the direct rays from the anode will pass through the object. The first plate is removed and a new one is inserted in the same position, when the second exposure is made in exactly the same way as the first. The plates are marked right and left to prevent confusion after they are developed. The distance from the tube to the plates should be measured and recorded, for this will be the distance the view boxes must be placed on either side of the angle of the mirrors.

The plate-holder must be so made that the plates may be changed without disturbing the position of the patient. A very convenient plate-holder is one so constructed that half of the plate is covered with a heavy sheet of lead during the first exposure; the plate is then pushed forward, when the first half will be protected with a sheet of lead and the second half will be the position of the first, ready for the second exposure.

The stereoscopic examination of skiagraphs is one of very great value. In well-made pictures the relative locations of the parts are distinctly seen. The normal relations of the parts may be studied with great profit to the inquiring student.

The stereoscopic method probably reaches its highest degree of usefulness in the location and study of foreign bodies and fractures. The position of a bullet with relation to other parts of the body may be plainly determined. In the ordinary skiagraph of the thigh, for the purpose of locating a bullet, it is impossible to determine whether the bullet is anterior or posterior to the femur. Stereoskiagraphs of the same parts will plainly show the position of the bullet, whether in front or behind the bone. The same is true in regard to fractures and dislocations, as well as many other conditions.

CHAPTER XIV.

EFFECTS OF THE X-RAY.

Soon after the discovery of the x-ray it was noticed that those who were exposed to its influences for any considerable length of time began to show tissue changes unlike anything that had ever been seen before. Diseased areas exposed for skiagraphic purposes seemed to heal more readily than when not exposed to the rays. It soon became evident that, besides its diagnostic value, the x-ray had a therapeutic value peculiar to itself. Though disappointing in some cases, the x-ray is rendering excellent service in the relief or cure of many heretofore obstinate cases.

GENERAL EFFECTS OF THE X-RAY.

On Tissue.—The histological changes induced in the tissues by the action of the x-ray depend upon the length and frequency of the exposures. A single mild exposure causes no perceptible change in the tissues or sensation to the patient. When a high vacuum tube is being used, the patient may experience a sensation similar to a static charge. This is caused by induced charges from the tube, and has no part in the x-ray results.

Repeated exposures, though mild, if placed too close together, have a cumulative effect. While no sensation is experienced at the time of exposure, an erythema may be produced, which will be followed by a branny desquamation or exfoliation of the epidermis. Very mild exposures produce only a bronzing or tanning of the skin similar to a sun burn. In many forms of superficial skin disease the abnormal conditions will rapidly disappear after mild exposures, leaving the skin smooth and clear. Malignant conditions, reaching deeply into the integument or down into the subcutaneous structures, will require more active treatment. Unless well protected, the operator may expect a twofold effect upon himself, the first of which is a chronic dermatitis and the second a temporary sterility.

On Micro-Organisms.—Some micro-organisms do not appear to be influenced by long or frequent exposures to the x-ray, while others show a marked disturbance, with their power of reproduction greatly inhibited.

The influence of the x-ray on seeds is to prevent them from germinating. Eggs exposed to the x-ray will not hatch. Frequent exposures of the ovaries and testes will produce temporary sterility. In x-ray operators who work unprotected the spermatozoa are either absent or have lost their power of motion. This condition of azoöspermia is not accompanied by any loss of sexual power, and is not permanent, but disappears when the operator discontinues the work or adopts some method of protection.

Toxic Effects.—The author has observed symptoms, following x-ray exposures for different purposes, that could be attributed only to toxemia. This condition was plainly seen in a case of splenomedullary leukemia. A young lady was submitted to four different exposures of the abdomen for skiagraphs. Within two hours after each exposure she became violently ill. Another young lady who underwent daily thirty-minute exposures for lymphosarcoma on either side of the neck and back complained of feeling sick after the exposures. It is believed that long exposures to any considerable portion of the body produces an increase in the metabolic processes, calling for greater activity in the organs of elimination.

Should the patient already be suffering from a toxemia or an impairment of the organs of elimination, great harm would result from such x-ray exposures. No such constitutional symptoms should result from exposures of limited portions of the body. To avoid toxic symptoms in treating epitheliomas of any size, the normal portions of the body should be well protected with sheet lead or metal screens.

Single Severe X-Ray Exposure.—The effects of a single severe exposure are not noticeable at once, but make their appearance in from one to ten days. The first changes are in the superficial tissues, and may vary from a slight browning or tanning of the epidermis to a deep tissue necrosis that may take months to heal.

Some degree of dermatitis is frequently necessary in the treatment of malignant skin diseases, and the experienced operator will be able to bring about such changes as the case may require. It must be remembered that repeated exposures are cumulative when given at short intervals. Full exposures should not be given oftener than once in two or three weeks. Tissue that has once been the site of x-ray dermatitis will be susceptible for a long time afterward.

Physiologic Effects.—The constitutional effects that often immediately follow the use of the x-ray have been mentioned above. Such effects may result from the treatment of a case of cancer, extensive skin affections, etc., and may be occasioned by an exposure ranging from a few seconds to several minutes.

In animal experimentation, mice have been subjected to x-ray exposures at a distance of 8 to 16 inches for a period of from two to ten hours. The mice exposed for four hours or longer died in a few days as a result of the destructive effects of the x-ray upon the blood-forming elements in the spleen, the lymphatics, and the marrow of the long bones. It makes no difference whether the exposure is a single one or is divided up into several exposures of varying lengths of time—the cumulative effect is the same. It is claimed that fifteen-minute exposures of the spleen, while not producing serious effects upon the animal, will cause necrotic foci in that organ soon after the exposure, but, if the exposure is not repeated, the effect will pass away in about eleven days.

The exposure of guinea pigs for ten hours produced similar temporary effects upon the blood-forming organs without being fatal.

According to reported cases, sterility in man may be produced by an accumulated effect varying from a hundred to two hundred minutes' exposure, which, of course, was divided into short exposures extended over several weeks.

Falling of the hair may be produced by a certain definite amount of exposure from a standard apparatus, which may be the result of a single exposure amounting to from 4 to 7 Holzknecht units, or by several exposures amounting to the same.

When small animals were subjected to long and severe exposures over the back, severe nervous symptoms were noticed in about three days. Mice subjected to such treatment died, but guinea pigs and rabbits, though exhibiting a marked dermatitis, showed no disturbance of the internal organs.

Deep tissue changes may be produced by x-ray exposures without showing any evidence of a superficial dermatitis. To avoid surface tissue changes while raying the deeper structures, leather filters or protection screens should be used.

EFFECT OF THE X-RAY ON DIFFERENT PARTS OF THE BODY.

On the Nervous System.—The author has never noticed any symptoms of nervousness in himself or in any patient from x-ray exposures. The symptoms that have followed such exposures were probably due to toxic effects instead of any direct effects on the nervous system. Powerful exposures of the brain have caused paralysis and convulsions.

On the Eye.—Mild exposures to the eye seem to produce no bad effects, but strong or powerful exposures are very harmful to all of its structures. The first symptoms will generally be a falling of the lashes, a congestion of the cornea and conjunctiva, with irritation and general discomfort. When the exposures are long and repeated, there is a general atrophy of all the tissues of the orbit. At first the crystalline lens is not affected. Where the eye receives short, but repeated, exposures, the sight is not affected for some time, but gradually becomes dimmer in proportion to the progress of the atrophy until the sight is permanently destroyed. The orbit may be protected by a shield. If the lids must be treated, a small, smooth, well-fitting shield may be placed over the ball beneath the lids.

On the Intestines.—In the experiment on animals, long exposures caused necrotic foci in the follicles of the intestines, but the effect disappeared in four or five days. In extensive burns over the abdomen the intestines are never permanently injured.

On the Liver and Kidneys.—From the author's experience the liver and kidneys are very little, if at all, affected by exposures to the x-rays. Slight changes may be produced in small animals which can not be duplicated by safe exposures in the human being.

On the Blood.—The blood undergoes a marked change. It appears that the first effect is on the white cells, their number being first reduced and then increased, producing a temporary leukocytosis. The specific gravity is increased, as well as the hemoglobin, without an increase in the number of red blood cells.

On the Marrow of Long Bones.—By animal experimentation it has been shown that the destruction of the white blood cells in the marrow of the long bones begins about two and a half hours after the exposure, is most active in about twelve hours, and ceases altogether in five or six days. The various kinds of leukocytes are reduced in number, but the lymphocytes and nongranular myelocytes are the most affected.

On the Spleen.—Doctor Tousey states that the immediate changes in the spleen are inflammatory hyperemia and an increased collection of leukocytes, which takes place in the center of each follicle.

General Tissue Changes.—The histologic effects of the x-ray is to produce an obliterative endarteritis in the superficial tissues and a destructive effect on cells of a rapidly proliferating or embryonal type.

X-Ray Dermatitis (X-Ray Burns).—Too frequent or too long exposures to an x-ray tube cause changes in the skin, which may be very slight or serious. So many factors enter into an x-ray exposure that all the facts must be known before it is possible to determine the probable cause of a dermatitis. It may be produced by a single long exposure, frequent short exposures, or the tube too near the surface. The cumulative effect of frequent x-ray exposures to both patient and operator are a source of considerable danger. Already a number of the pioneer specialists in x-ray work in this country have either lost parts of their hands or paid the extreme penalty as a result of chronic x-ray dermatitis. Such fatal results were caused by frequent exposures lasting over a period of many years. It has been reported that chronic x-ray dermatitis is likely to be followed by cancer, but there is nothing to indicate that x-rays burns are more likely to be followed by cancer than any other lesions of like severity and chronicity.

Degrees of X-Ray Dermatitis.—The early students of x-ray dermatitis divided the destructive process into three degrees, and later the condition has been divided into four degrees. Of course there are no well-defined lines of separation between the stages, but they are sufficiently marked for the trained and experienced observer to be able to recognize them without great difficulty. Doctor Tousey gives the following description of the four degrees:

(1) A mild, temporary redness of the skin occurs without anatomic changes; it may not develop until two weeks after exposure and lasts for only three days.

(2) Quite a decided erythema, with moderate itching and followed by desquamation of dry epithelial flakes, which may amount to a regular peeling of the affected region; no raw surface is produced and there is no pain; it develops about a week after exposure, and it is three or four weeks before the skin appears normal again;

slight atrophy of the skin may remain permanently, especially if a dermatitis of this degree has been repeatedly produced.

(3) After a period of incubation of only two days a severe dermatitis, with blistering, occurs, and this is followed by some destruction of the deeper layers of the skin and ulceration, which takes many months to heal. It is excessively painful until the sloughs have separated, and it leaves a permanent scar.

(4) The most severe degree has a period of incubation lasting for one or two days, beginning in much the same manner as the third degree, but it is soon evident that all the tissues have been destroyed, perhaps to a depth of half an inch. The separation of the slough is very slow and painful, and the ulceration has very little tendency to cicatrize. If at all extensive, it may take years to heal or it may remain as a chronic ulcer.

Chronic Dermatitis in X-Ray Operators.—Nearly all the early x-ray manufacturers and operators developed a chronic x-ray dermatitis, which resulted more or less seriously. The exposures were short and mild, and singly would not have caused the slightest tissue changes, but by the cumulative effect of frequent exposures a chronic dermatitis was produced that simulated chronic eczema. This condition is most frequently seen in the hands of x-ray workers, which are fissured, scarred, and discolored. The nails become brittle and deformed, and after long use hyperkeratotic areas may develop on the hands resembling warts or horny growths. If x-ray work is discontinued or complete protection adopted, these conditions may, after a long time, disappear, but they are prone to return. A few cases of epithelioma have been known to develop on the site of these horny growths, but cancer is no more likely to have its origin from x-ray dermatitis than from any other source of irritation. Operators who use the x-ray any considerable amount each day should take ample means of self-protection if they wish to avoid the fate of those who failed to adopt such protective measures.

Prevention of X-Ray Dermatitis.—As above mentioned, the operator should be careful to protect himself against the possibility of x-ray dermatitis of any degree. In therapeutic and diagnostic work, after carefully adjusting the tube and making everything ready for the exposure, the operator should step behind a heavy lead screen, from which he can control the apparatus. To prevent a dermatitis in the patient, he should not be exposed too long, too often, or to an intensely active tube. The action of a tube depends upon (1) the amount of current going through it, (2) the distance the tube is placed from the parts treated, and (3) the length of the exposure. The effect of the tube decreases as the square of the distance between the tube and the parts treated increases. The radiance of a tube can not always be determined by the number of milliamperes passing through it. The resistance and radiation in a tube changes with the vacuum.

Where the coil is not provided with an ammeter and milliamperemeter, a safe exposure for a full therapeutic dose would be ten minutes at a distance of 12 inches from the target (anticathode), with a radiance that would show the bones in the hand at a distance of 2 feet from the anticathode.

When the x-ray is used for therapeutic purposes, only certain parts are exposed, the rest of the patient being protected with a shield or sheets of lead-foil. Low vacuum tubes having a dense greenish-yellow radiance will produce a greater effect on the superficial tissue than high vacuum tubes with greater penetration.

Many methods for measuring the dosage have been recommended by as many different advocates. So many factors enter into an x-ray exposure that it is very difficult to lay down hard and fast rules that will be absolutely accurate under all circumstances and conditions. Holzknecht's chromoradiometer, Walter's or Benoist's skiameter or penetrameter will be of service in determining the amount of radiance given off from the tube. Screens of thin sheets of aluminum, tin-foil, or heavy pieces of leather may be used between the tube and the parts treated or exposed to intercept the soft rays and prevent superficial dermatitis. When it is desired that the rays penetrate deeply into the tissues and a superficial dermatitis is not wanted, a screen should be placed over the parts treated to absorb the soft rays.

CHAPTER XV.

X-RAY THERAPY.

The therapeutic use of the x-ray unquestionably belongs to the x-ray specialist, yet, like every other electric modality or curative remedy, it will be used from time to time by a large number of physicians who have had neither time nor opportunity to become familiar with its technic. In beginning this chapter the author wishes to sound a note of warning to the novice in x-ray therapeutics that, if heeded, will keep him within the bounds of safety both as to himself and his patients. There was a time when we did not know these matters—then there was some excuse for ignorance—but that time has passed. There have been many burns in the past—during the experimental stages—but a serious burn today would raise the question of competency.

USE OF THE X-RAY IN DISEASED CONDITIONS.

No other single remedy has made such rapid advancement or done so much in the different departments of medicine and surgery as the x-ray. Soon after its discovery it was learned that it possessed a curative influence upon a large number of indolent or malignant conditions. In safe doses it is not a bactericide, yet it has a curative influence in many infectious skin diseases. Its depilatory and stimulating effect will give it first place in the treatment of infectious diseases of the hairy parts. It is almost a specific in tubercular adenitis and epithelioma, and exerts a beneficial influence in other malignant conditions.

The exposures are made by allowing the direct rays from a low or medium vacuum tube to fall directly upon the affected parts. The amount of radiance from the tube, the distance it is placed from the parts, and the length of exposure will depend upon the change desired in the tissues, which will be anywhere from a mere tanning of the surface to an active dermatitis. This condition may be brought about by repeated mild daily exposures, or the full dose may be given in one or more strong exposures. Experience has shown that mild exposures, repeated in time and number as the case requires, will give the best results, and is by far the safest. Every experienced operator has worked out his own technic, to which he closely adheres in all his work. No definite rules can be laid down that are not subject to changes. The following technic has been adopted by the author and found to successfully meet most indications:

In all cases of superficial skin diseases—as acne, eczema, etc.—where the treatments are given once or twice a week, the tube is so placed that the anticathode will be about 12 inches from the surface of the parts treated. The vacuum of the tube should be medium low (equivalent to a spark gap of from ½ to 1 inch on a static machine, and from 2 to 3 inches on a coil), and should show the bones in the hand at a distance of 2 feet from the tube. The length of exposure, when a coil is used, should be about six minutes. Only the parts affected should be exposed to the action of the rays, and other parts should be well protected by shields or sheets of lead-foil.

In the treatment of epithelioma, where an active tissue change is desired, the tube is so placed that the anticathode is about 9 inches from the surface. The length of the exposure is ten minutes, and may be repeated every second or third day until a dermatitis begins to appear, when the treatments must be discontinued for a time at least. If after two or three weeks the dermatitis clears up, the treatment may be resumed if necessary.

Besides the regular x-ray tubes, several varieties of treatment tubes have been introduced. (See Figs. 66 and 67.) These tubes are made of leaded glass, save a small opening, which is of soda glass, through which the rays are allowed to pass out of the tube. When these tubes are used, lead-foil for the protection of the patient is unnecessary. Lead-foil furnishes ample protection, but, if the weather is warm, to cover the face is found to be very uncomfortable.

The subject of x-ray dosage has caused a great deal of discussion, and many methods have been tried and found wanting. We are sorely in need of a standard dose indicator. Until machines and tubes are standardized we will never be able to reproduce, at will, the reported results of operators using different machines.

TECHNIC OF X-RAY THERAPY.

The tube may be excited by a static machine or an induction coil. An 8-, 10-, or 12-plate static machine in perfect order will be found efficient in the majority of therapeutic cases. Unless the operator has become master of his machine, he will meet with a great deal of trouble and many disappointments.

Coils varying in size from 8 inches to 16 inches are in general use. When these coils are well made, they cause very little trouble. The interrupters, however, are a source of considerable trouble to the novice. When the direct 110-volt current is available, the author much prefers a mercury turbine interrupter. It gives a smoother current, and will run longer without attention than any other interrupter on the market. When the mercury amalgamates, it will stop work, and must be cleaned and refilled, after which it is again in good condition. When the alternating current is used, the Wehnelt interrupter, with a platinum point about 1 millimeter in thickness, with just the tip exposed, will give fairly good results. Rectifying valves may be used to convert the alternating current into a unidirectional current, but the antiacid interrupter with step-up transformer should be used with the alternating current for therapeutic work. A mercury interrupter for the alternating current is being advertised, for which great claims are being made, but the author has had no experience with it. The high-tension transformer, as furnished by several firms, may be used for therapeutic work, though these machines are designed particularly for skiagraphic purposes. Any good coil will be found to be amply sufficient for therapeutic work. Whatever kind of generator is used, there should be a reliable milliamperemeter in series with the tube, and, if a coil is used, an ammeter should register the current going to the primary. With a good radiometer or penatrometer and a sufficient amount of experience, satisfactory work may be done with only a very small degree of error. The tube should be medium or low, and carry about two milliamperes of current. When the tube is quite low, 1 milliampere will excite it, and, if a little high, it may require 3, but a tube requiring more than 3 milliamperes should be discarded as too high for the average therapeutic work. When a tube is working properly, there is a sharp, well-defined line between the hemisphere of fluorescence in front of the anticathode and the hemisphere back of it. When the tube does not show this equatorial line, but has patches of apple-green light throughout the sphere, it is either improperly focused or there are inverse discharges passing through it.

The active rays from the tube are given off at right angles to its long axis, and the tube should be so placed that its long axis is parallel to the surface of the parts treated, while the rest of the parts are well protected by lead-foil or opaque glass shields.

THERAPEUTIC DOSE OF THE X-RAY.

Many things must be taken into account when the dose of an x-ray exposure is considered. After long experience with a particular apparatus and a certain make of tube, one comes to know just what results he will get from certain lengths of exposures, while he would be very uncertain of his results with a coil and tube with which he is not acquainted.

Two methods of treatment are in use, and, while they differ widely in technic, they aim at the same results. In one, mild exposures are repeated every one, two, or three days until a reaction is produced. While this method requires some caution, the full dose is reached by degrees, and allows some time between treatments to observe the approaching changes. By the second method the dose is reached by a single application. This requires not only a large experience, but a definite knowledge of the action of the tube and its influence on the tissues.

There are idiosyncrasies for the x-ray, the same as there are for any other therapeutic measure. The surface of the skin carries no index to the amount of exposure it will stand in any given case, and therefore care must be exercised with both the above methods to avoid overexposure and a too active dermatitis.

The first method will be the one selected until a perfect method of measuring the dose is discovered. The chromoradiometer of Holzknecht, which consists of chemically prepared pastels, has met with some favor, and is considered reliable within a certain limit; yet it has many disadvantages, and has not come into general use. The method consists in exposing one pastel at the same distance as the parts treated. During the exposure the pastel changes color to agree with the color scale, which may be 1, 2, 3, 4, or 5. These numbers indicate that the exposure has reached a corresponding number of Holzknecht's units. Three or four Holzknecht units are a full dose, and should not be repeated until after the reaction has subsided, which is generally two or more weeks. Five of these units are a heavy dose, and are often required in cancer cases. Two units are considered about half a dose, and may be repeated once in two weeks. In using this method of dosage it is understood that the tube must be of the proper vacuum.

Quite a number of methods for regulating the dosage are mentioned in the larger works on x-ray therapy, but, as they all require considerable previous experience, with a wide range of error, we will not carry the subject farther at this time.

X-RAY AS A THERAPEUTIC MEASURE IN MALIGNANT DISEASES.

In the treatment and cure of superficial malignant conditions, the x-ray unquestionably holds first place among the methods today. It has an inhibitory effect on the cells of rapidly developing atypic growths. If these malignant conditions are seen early, and the treatment begun before the lines of invasion have been pushed into the deeper tissues and neighboring glands, x-ray exposures will meet the indications by retarding the development of abnormal tissue and hasten a return to normal. The three stages of skin cancer are discussed in Chapter XV. It will seldom be necessary to produce a deep dermatitis or tissue necrosis, even in extensive growths. This should be avoided on account of the dangers of a general toxemia, resulting from poor elimination, which sometimes causes the death of the patient. The question has been asked time and again if the application of the x-ray to cancerous tissue does not have a tendency to cause metastasis by carrying the infection to the deeper structures. Such fears are ungrounded, for the effect of the treatment is just the opposite. In all cases requiring an operation or use of caustic pastes, six or eight x-ray exposures should be given to the growth and the near-by tissues to prevent a possibility of further spread of the malignant elements. After the growth has been destroyed or removed, x-ray treatment should be continued for a time to prevent a recurrence.

While deep cancerous growths are not relieved with the same promptness as the superficial variety, yet so much good can be done in these otherwise incurable cases that they should all have the benefit of x-ray treatment, for where it does not cure it greatly palliates, and may prolong life for a considerable time. Cancer of the cervix is seldom seen until the second or third stage, when the body of the uterus and the pelvic glands are involved. If cancer in this location could be seen early, there is no reason why it should not be cured with the same promptness as the more superficial variety. The author has seen excellent results follow the x-ray treatment of inoperable cases of cancer of the uterus. Often the main distressing symptoms are either modified or completely controlled, and the patient is allowed months or years of comparative comfort.

Valuable as the x-ray is in all cancer cases, it must be distinctly understood that it is not to take the place of surgery in cases of the second and third degree where surgery can promise anything. In these cases it is an adjunct to surgery that must not be neglected if a return of the growth is to be prevented.

The technic is not difficult, and consists in exposing an area much larger than the parts affected to a low or medium vacuum tube, the target of which is 8 or 10 inches from the surface treated. The exposure should be from six to ten minutes, and repeated every two or three days until the desired reaction is produced. The tube should have sufficient penetration to show the bones in the hand at a distance of 2 feet. While this method of testing the penetration of the tube is mentioned as a reliable one, the operator should not use it often enough to get a dermatitis, as was the case with many of the pioneers. In repeated small doses the reaction in the tissues is gradual, and may be kept under control by a careful observer.

The method used by the author in the treatment of malignant conditions is practically as follows: When a given case is first examined it is determined from his general appearance about how much exposure he will stand. This conclusion is governed by the nature and thickness of the skin and kind of growth to be treated. It must be remembered that thin-skinned blonds will not require as much exposure as thick-skinned brunettes. Having decided on the diagnosis and the length of exposure, as well as the distance the tube is to be placed from the parts, a record is made of these points and the work of treatment is begun. The proper tube is selected with a low or medium low vacuum. After placing the patient in the proper position with relation to the tube, the current is turned into the primary of the coil—say, 2 amperes, and never over 5. The reading of the milliamperemeter will be from 1 to 3 milliamperes, the time clock is set, and the work goes on. A careful record is made of all of these points, and the subsequent treatments are given in the same manner until the full dose is reached. The patient is then allowed to rest until all evidence of dermatitis has disappeared, when the treatments are resumed if necessary, remembering that it will not require as many exposures to produce a second dermatitis as the first. This technic refers to cases of epithelioma of the first degree. Second-degree cases frequently require the use of surgery or caustic applications, though it is good practice to first use six or eight exposures. In cases where an extensive surgical operation is necessary, no attempt should be made to close or skin graft the wound. It should be left open, so that the x-rays may reach the deeper tissues unobstructed. After the wound has filled in, and there is no evidence of a return, skin grafting may be done if necessary. The proper use of surgery and the x-ray at an early period in the development of malignant growths will put an end to every case.

X-RAY TREATMENT IN SOME COMMON SKIN DISEASES.

Acne.—This disease, in some one of its many types, is quite common in this country, where it often reaches its most aggravating form. Fig. 109 is a reproduction from a photograph made by the author of a young man with a typical case of acne vulgaris. He was accused of having smallpox, and was confined at home for a considerable time. He had taken quantities of medicines of different kinds without relief. At the time he was seen there were many large pustules on the face. These pustules amounted to little boils, and were frequently opened and drained. This case received an x-ray exposure every other day for three weeks, then twice a week for three weeks, and then once a week for several weeks, after which he was well. The skin was a little rough and slightly pitted from the effect of the abscesses, but, with this exception, his skin appeared normal and there has not been a return after many months.

Fig. 110 illustrates a case even more aggravated than the former. Besides the face, the back and chest were covered with pustules, where the clothing kept them irritated, especially in hot weather. In addition to his unsightly appearance, this young man was in a state of discomfort all the time. What the x-ray did for him will never be forgotten. The technic in this class of cases differs very little from that of first-stage epithelioma. Very low vacuum tubes are required at a distance of 8 or 10 inches from the surface, regulating the effect to that of a slight redness or browning. The frequency of treatment will depend upon the severity of the disease and the length of time the patient can be kept under observation. Very mild cases will require weak exposures, which may be given

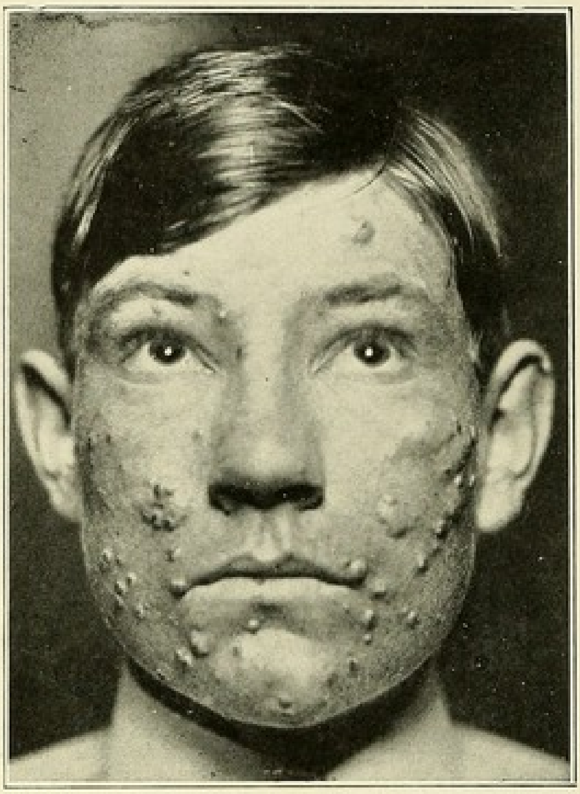


Fig. 109.—Typical case of acne vulgaris.

once a week or once in two weeks. The only other treatment necessary is to overcome constipation where it exists, and keep the skin as clean as possible with tar soap.

Acne rosacea will yield to x-ray treatment in a very short time, when the exposures should be continued at irregular intervals until a cure has been effected.

Hypertrichiasis (Excessive Hairiness.)—The author has never recommended the use of the x-ray for the removal of hair from the face in either men or women. To successfully remove the hair permanently requires something more than mere tanning of the skin, and this may produce a slight degree of atrophy, which should be avoided in conditions where the treatment is not absolutely necessary. Women who possess a beard or a few stiff hairs may have them removed by electrolysis; the method is slow, but is to be preferred to the x-ray. Where there is only an exaggeration of fine, downy hairs which are not unsightly, the lady should be discouraged in having anything done to remove them, for, if she persists, she is

Fig. 110.—Aggravated case of acne vulgaris.

likely to find some one who will injure her face with some remedy with which he is little acquainted.

There are cases of excessive hairiness that require treatment, and when located on other parts than the face the x-ray may be safely used to remove these hairy growths. Fig. 111 well illustrates such a case. This young man had long been annoyed with the hair extending from his head over the neck and well down the back. In this picture will be noticed the checkered appearance of the skin on the back of his neck. This was caused by a physician who scarified the skin in this manner, and then applied some caustic preparation that blistered the skin thoroughly. The undertaking was not a success; the hairs were destroyed along the lines of incision, but nowhere else. He was deeply humiliated because the scars added to

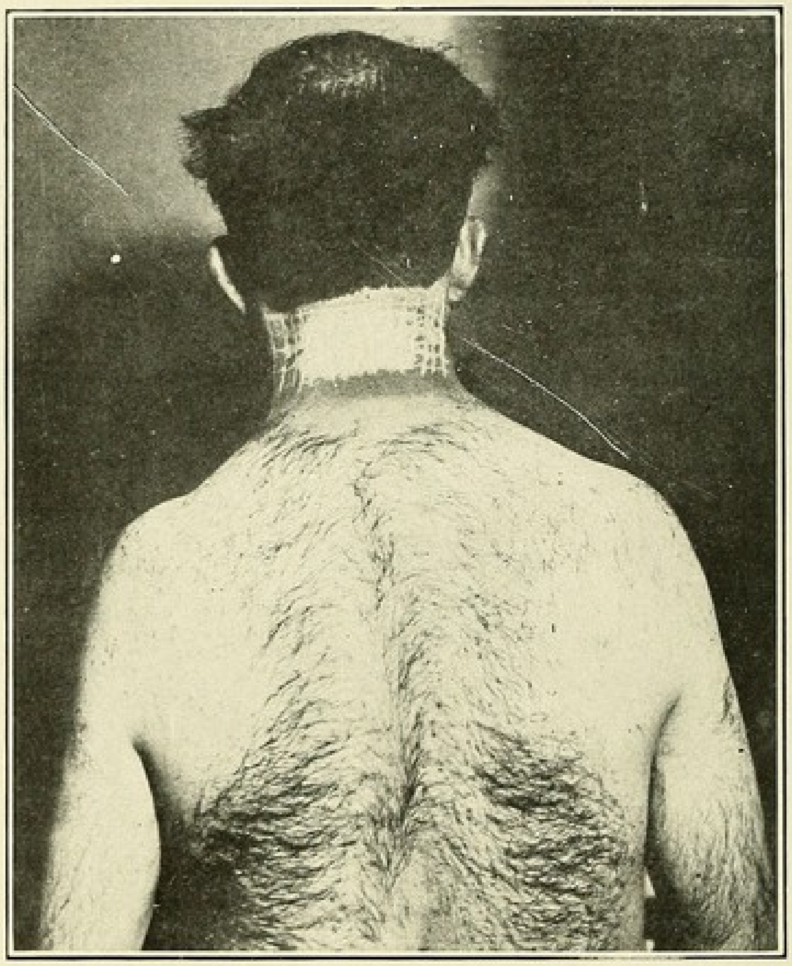


Fig. 111.—Hypertrichiasis (excessive hairiness).

his unsightly appearance. On account of the vast number of hairs on the neck of this patient the author decided to use the x-ray. It would have been next to impossible to have treated the case by means of electrolysis on account of the injury to the skin by the caustics that had been used. He received twenty ten-minute exposures to a low vacuum tube at a distance of 10 inches during a period of three months. At no time was there much dermatitis. The hair came away, and the scars caused by the caustic treatment were greatly improved. To destroy the hair follicles, it is not necessary to produce an active dermatitis. After two or three full exposures the hair will begin to fall. As soon as the dermatitis or tanning has disappeared, and before the hair begins to grow, the treatment should be resumed, but with shorter exposures at longer intervals. After a time the follicles will be destroyed and the hair will never return. The author has had the opportunity to observe the depilatory effect of the x-ray in many cases treated for epithelioma about the face. In men the beard is always destroyed over the region exposed. The main thing to be avoided in the treatment for the removal of hair is atrophy of the skin. This condition is not likely to occur if the exposures are not carried too far or repeated too often. It is not advisable for an x-ray operator to attempt to remove the hair from the face until he has become expert in the work. He should understand the action of his tubes and know what result to expect after a certain amount of exposure.

Favus, Alopecia Areata, Sycosis, and Psoriasis.—While these conditions differ widely, they are amenable to the same kind of treatment. In favus the x-ray cures by temporarily removing the hair, and therefore the exposures should not be severe enough to destroy the follicles. Low vacuum tubes should be used with mild exposures, repeated often enough to cause the hair to fall. This will require an exposure of about six minutes at a distance of 8 inches, repeated every second or third day for three or four exposures. If after waiting a week the hair is not loosened, treatments may be resumed, using the same precautions. The usual antiseptic and bacterial remedies should be applied to the skin during the depilatory stage to destroy the germs of infection, as they come away with the hair and prevent the infection of other parts.

In alopecia the exposures must be very light. It is supposed that the effect of the x-ray in this disease is to inhibit or destroy the bacteria and stimulate the functions of the skin, causing the hair to grow. This treatment can be of value only where the follicles are not destroyed. The exposures must be so mild that no visible reaction is produced. It is worth while to try the method in every case; if it does no good, it will do no harm, and, should success follow, the patient will be grateful for a growth of new hair. Where the hair has been temporarily removed from the head by the x-rays, it returns thicker, stronger, and generally one or two shades darker.

The x-ray treatment of sycosis has been so satisfactory that it is regarded as a specific by many. The technic is about the same as for favus. The removal of the hair destroys the homes of the parasites and cures the disease.

Psoriasis.—This disease is often so extensive that large portions of the body are covered at one time. The vitality of the diseased areas is very low, requiring a small amount of exposure to produce a reaction. The strength of the exposure will depend upon the amount of reaction required, care being taken to keep within the safety limits until the dose in a given case can be ascertained. Satisfactory results usually follow proper x-ray treatment, though a relapse may take place at any time.

Keloid.—There seems to be very little literature on the x-ray treatment of keloid. The author has treated several cases that have responded promptly and remained cured. It is necessary to produce a marked degree of dermatitis over the affected area. This is brought about by a number of six-minute exposures to a low vacuum tube, repeated two or three times a week for two or three weeks, when a rest is advised for two or three weeks, when the treatment is resumed if there is not sufficient evidence of improvement. Several failures have been reported, but the technic in these cases was not given.

Eczema.—The author has seen some cases of eczema that had existed for many years, and had withstood all medicinal measures, disappear after a few mild exposures to the x-ray. One case of fourteen years' standing on the inside of the thighs, that had caused the patient no end of distress, was permanently cured by four exposures to a very low vacuum tube.

Warts and Moles.—Warts and moles should not be treated by the x-ray. The method is too slow, and will produce no better results than electrolysis or the electro cautery.

Pruritus.—In almost all cases of severe itching of the skin relief may be secured from x-ray exposures. Other forms of electrical as well as local medicinal measures should not be neglected.

Nevi (Port-Wine Marks).—The author does not favor x-ray treatment of extensive areas of pigmentation. To be effective, it is necessary to produce a considerable amount of dermatitis. This is frequently followed months afterward by a telangiectasis, which is often as annoying as the discoloration for which it was treated. Some cases have been successful, while others have not improved.

Chronic Ulcers.—Contrary to the reported experience of others, the author has had some splendid results in the treatment of chronic ulcers where the bony structures beneath were not affected. These ulcers are generally caused by a low-grade infection, on which the x-ray seems to have very little influence. To destroy the infection, the ulcer should be thoroughly cauterized with C. P. nitric acid, after which, if all the infection has been destroyed, x-ray stimulation from a low vacuum tube will shorten the stage of recovery.

Tinea Capitis (Ringworm of the Scalp).—As in favus, the x-ray is of the greatest possible value in the treatment of ringworm of the scalp. By removing the hair over the infected area the cause of the disease is removed. The depilatory action of the x-ray must be accompanied by active germicides to prevent infection of other hairy parts. New hair grows out without infection. If local germicides are properly used, the case will be permanently cured.

Ringworm of the beard should receive the same treatment, though fewer exposures will probably be required to effect a cure.

Lupus.—Finsen demonstrated that lupus could be cured by the concentrated rays from powerful arc lights (Finsen lights), but the prohibitive cost of these lamps, together with the long time necessary to effect a cure, places that method of treatment for the average physician entirely out of the question. The x-ray treatment for lupus has given even better results than the Finsen method, and is far less expensive. The author's method is to use frequent mild applications. Only a slight erythema is necessary, and should never be carried to an active dermatitis unless the condition is complicated with epithelioma, which is often the case. Lupus of any variety will respond to careful x-radiation, causing the skin to clear up and assume a normal appearance. This condition, however, is prone to recur, and a case of lupus should be kept under the closest observation; should nodules begin to reform, the treatment must be resumed. A few well-directed exposures, given early, will control a condition that would soon become troublesome if neglected.

X-RAY TREATMENT IN TUBERCULOUS CONDITIONS.

Tuberculosis.—It was hoped that the x-ray would have a curative influence upon pulmonary tuberculosis. Laboratory experimentation has, however, proven that it has no destructive effect upon tubercle bacilli, either directly or indirectly. Frequently phthisical patients seem to improve for a time when subjected to x-radiation, but the improvement is not lasting.

It is probably true that x-radiation does not benefit pulmonary tuberculosis, but in localized tubercular lesions, as in tubercular diseases of the skin and adenitis, the x-ray has repeatedly furnished positive proof of its curative value. The effect may not be directly on the bacilli, and they may not be destroyed outright, but their growth and development are certainly inhibited to such a marked degree that the natural processes are able to prevent their invasion, and in many cases destroys them altogether. Doctor Tousey, as well as others, recommends the use of high-frequency currents in the treatment of tubercular conditions, believing that the ozone which is liberated in considerable quantities is of great value in these conditions. The author's experience has not been very wide in the treatment of pulmonary tuberculosis, but in the local conditions due to that disease he has seen so much benefit derived from the use of the x-ray that he has come to believe it the most valuable agent in the treatment of these conditions.

Cutaneous Tuberculosis.—Mild exposures two or three times a week will be sufficient to cure most types of cutaneous tuberculosis. Tubercular ulcers and fistulas will require exposures, in strength and frequency, in proportion to their depth.

Tubercular Adenitis (Tubercular Glands).—Tubercular adenitis, both acute and chronic, responds to x-ray therapy. In the chronic form the nodule will not always entirely disappear; it will, however, become much smaller, hard, and fibrous, and cease to cause trouble. In the early stages of the acute form, before softening has begun, the x-ray will cause a speedy disappearance of the enlargement. In acute cases, where suppuration has begun, as shown by softening, the gland may be made to undergo cheesy degeneration. The author has treated a number of cases of tubercular adenitis of the acute variety, where the glands were large and hard, all of which responded to x-radiation. A few cases have been treated in which suppuration was far advanced, where it was necessary to open and drain the glands. These cases have also responded to the effect of the x-ray. In tuberculosis of the lymphatic glands of the neck x-ray exposures have produced better results than any other method with which the author is acquainted. It is not necessary to produce an active dermatitis—a slight browning or tanning of the skin is all that is necessary. Two or three treatments a week for two or three weeks, using a medium vacuum tube at a distance of about 10 inches, will bring about the desired results. After two or three weeks' rest the treatment may be resumed if necessary. Tubercular glands in other regions will respond in the same manner, provided the radiance is made to reach the affected glands in the same strength.

Pulmonary Tuberculosis.—The author has never been able to greatly benefit any cases of pulmonary tuberculosis. At times a few cases seemed to improve, but the improvement was of short duration, and probably had no connection with the treatment.

Tuberculosis of Bones and Joints.—There are numerous favorable reports of the treatment of bone and joint tuberculosis with the x-ray, many of which are unquestionably true. The combination of the x-ray and high-frequency treatment seems to have produced the best results. Where a bone or joint is affected, the exposures should be applied from different directions. The penetration of the tube will depend upon the thickness of the parts to be treated. The wrist requires a low vacuum tube, while the hip requires a medium or high vacuum. The treatments should be repeated about twice a week until a slight reaction appears. The usual rest is taken until all evidence of dermatitis has disappeared, when treatment is resumed, though fewer exposures should be given in the second seance if a dermatitis is to be avoided.

X-RAY TREATMENT IN OTHER DISEASES.

Prostatic Hypertrophy.—The author's experience in this class of cases has been far more favorable than he expected. After thoroughly protecting the surrounding parts, the exposure is made through the perineum, with rays of sufficient penetration to reach the prostate gland. The tube should be medium high, at a distance of about 12 inches, and the treatment may be repeated once or twice a week. In two weeks' time the patient will notice that he can retain his urine better and longer, and will not have to use the catheter as often. Patients often complain of various complications following the use of the x-ray, which they attribute to the treatment. Such symptoms as increased cystitis, bloody urine, and other changes are not caused by this method of treatment; they are merely coincidences, and should be so regarded. The scrotum must be thoroughly protected with sheet lead to prevent a possibility of sterility.

Goiter.—The author's experience in the treatment of ordinary goiter has not been altogether successful. Out of five cases, two have been greatly improved, though not entirely cured. Three made no improvement that could be noticed. These cases were exposed until there developed a slight degree of dermatitis. Three of the cases were under observation for several months.

Exophthalmic Goiter.—In the treatment of exophthalmic goiter the x-ray has met with much better success. The three cases that have come under the author's observation seem permanently cured after, respectively, one and three years. One of these cases was extremely aggravated, the gland being greatly enlarged and the exophthalmus marked. The heart beat was very rapid, and the patient was so nervous that it was almost impossible to keep her still long enough for a treatment. She received twenty-five exposures over a period of three months, during which she developed a mild dermatitis. The tumor, as well as the exophthalmus, tachycardia, and nervous symptoms, disappeared and she has remained well for more than three years.

Hodgkin's Disease, Pseudoleukemia, and Lymphosarcoma.—The x-ray has been known to greatly benefit all these diseases—lymphosarcoma probably less than the first two. The beneficial effects of the x-ray are believed to be due directly to its action on the lymphatic glands. The glands are reduced in size and the aggravating symptoms become less marked. To be effective, these diseases must be treated early, before marked tissue changes have taken place in the glands. There always has been, and probably always will be, great difficulty in making a differential diagnosis between Hodgkin's disease and lymphosarcoma in the early stages; at a later period the difficulty is not so great. In order to get the full therapeutic effects of the x-ray in the glandular tissue with as little superficial dermatitis as possible, leather screens should be used over the parts exposed. These screens should be of thick sole leather, which may be used wet or dry. Other materials have been used for screens, but leather has been the most satisfactory.

The author had the pleasure of seeing and examining a case of Hodgkin's disease presented by Doctor J. B. Shelmire, of Dallas, to the Dallas County Medical Society in 1909. The case had been referred to Doctor Shelmire by Doctor Rodman, of Dallas. The symptoms were very marked, and medicinal treatment had failed to be of any value. According to Doctor Shelmire's case record, this patient received thirty-two x-ray exposures as follows: from July 8 to 30, eleven treatments; from August 21 to September 15, eleven treatments, and from November 1 to 29, ten treatments. Here we have three series of treatments where the exposures were made two or three times a week. The first intermission was about three weeks and the second about six weeks. Rapid reduction in the glands took place, with marked improvement in the patient's general health.

All cases of leukemia of the splenomedullary type respond quickly to the influence of the x-ray. The spleen is reduced to something near its normal size, the leukocytes are reduced in number, the anemic condition improves, and there is so much general improvement that the patient believes himself well. These cases are prone to relapse, and it will frequently be found necessary to continue the treatment for several months. The author has never known a case permanently cured by x-ray treatment, though all were greatly benefited. Failures to cure were, in a large number of cases, unquestionably due to the fact that the patients discontinued treatment too soon.

The x-ray treatment of this disease consists in the exposure of the spleen, lymphatic glands, and long bones to the action of a medium high or high vacuum tube, at a distance of from 12 to 15 inches, for a period of from six to ten minutes, one to three times a week, over a period of two to six weeks, according to the reaction produced and the results required. Care should be taken not to overdo this treatment. A dermatitis of the abdomen is likely to occur unless the skin is well protected with heavy leather screens. A too active change in the tissues of the spleen, lymphatic glands, and bone marrow, calling for an extra action in the organs of elimination, may cause serious trouble by producing a toxemia that may prove fatal.

The following case had a remarkable history: A strong, hard-working man had suffered for about three years from what was believed to be malaria. He had lost flesh, was pale and bloodless, and was unable to do anything about the farm where he lived. Fig. 112 shows the appearance of his abdomen at the time he began x-ray treatment. The spleen was so large that it almost filled the entire abdomen, reaching across nearly to the crest of the ilium on the opposite side. After eleven exposures, extending over a period of six weeks, the spleen was reduced to something near its normal size. No screen was used, and he developed a dermatitis of the second degree that was slow in healing. He improved so much that he was able to do considerable work about the farm, but had a relapse in about twelve months and died in less than two years. No blood

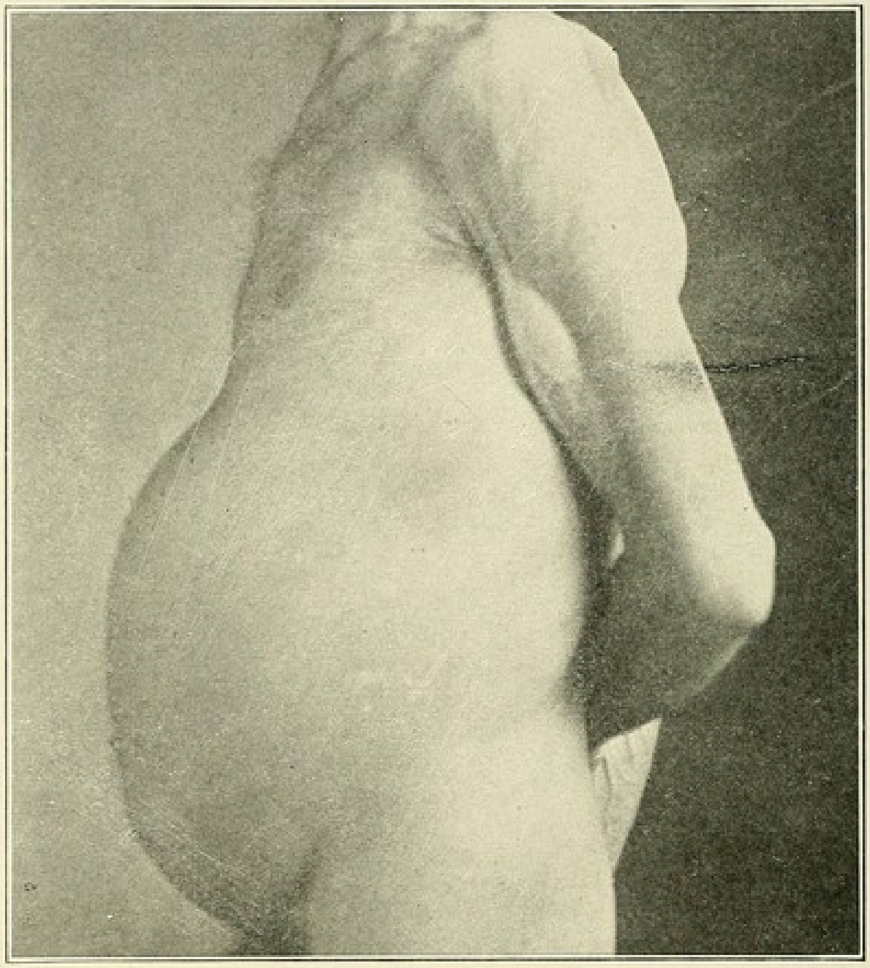


Fig. 112.—Splenomedullary leukemia.

examination was made in this case at any time, though the changes must have been very marked. Dermatitis should be prevented in this class of cases, as nothing is gained and much is often lost by such an accident.

In private practice it is very difficult to keep up with these cases; they improve so rapidly that the patients think themselves well and disappear for a time or altogether, and much valuable experience is lost. In treating these cases with the x-ray the spleen should receive attention, but in a less degree than the long bones, which will lessen the danger of a dermatitis and insure better results.

There are different opinions as to how the x-ray benefits leukemia and pseudoleukemia. As the x-ray is not a bactericide, we can not look for improvement from that direction. It has been claimed that its action is probably due to its destructive effect on pathologic lymphoid tissue, while others believe its influence due mainly to its action on the tissue ferments. Both these views may, in a measure, be correct, and they may both be far from the truth. It is nevertheless true that the influence of the x-ray on the spleen, marrow of the long bones, and lymphatic glands is to greatly reduce the size of the spleen, reduce the number of leukocytes, decrease the size of the glands, increase the red blood, and improve the feelings and general appearance of the patient.

In the majority of cases, the author believes, the treatment has been pushed too fast, that too active tissue changes have been produced, and, while improvement was noticed in the reduction of the spleen and number of leukocytes, there was developed a condition equally as bad as the first—a changed condition in the spleen that destroyed its function and allowed the patient to die at a later date from the want of the proper blood-making organ.

These patients should, unquestionably, have x-ray treatment, but such treatment should be carefully regulated as to strength and time, so as to slowly and gradually influence the spleen and other tissues, allowing the organs of elimination ample time to take care of the waste products and thereby preventing any overwork or abnormal tissue change that might later show itself in a disastrous way.

Epithelioma.—It has been said that every specialist who enjoys an enviable reputation and has a large clientele soon comes to believe that half of the human family is suffering from diseases coming under his department of medicine. While this statement can not be true of skin cancer, yet it is astonishing how many cases may be seen in a day's search in any of our large cities. Cancer does not seem to cause any alarm among the inhabitants of a community. The disease comes on so slowly that no one takes any notice of the victims until a late date, when the condition is considered incurable. Many good physicians completely ignore these skin changes by advising their patients to let them alone.

Three methods of treatment are now practiced, either separately or in combination, according to the requirements of the case.

In the early stages the x-ray will cure practically every case.

This includes all cases of cancer of the first degree, where the disease is entirely local. The dry, scaly skin of the hands and face of old age is frequently the site of cancerous tissue. If these conditions are neglected, it is only a question of time when the life of the patient will be destroyed. Properly used, the x-ray will relieve such skins, leaving them smooth and free from disturbance.

The second method is surgery, which includes the knife, curettage, galvanocautery, and mercuric cataphoresis. This method consists in the actual removal or destruction of the cancerous tissue, but, radical as this method is, it frequently fails, as it is impossible to determine when all of the cancer tissue has been removed or destroyed. Unless the work is thorough, there is sure to be a more or less rapid return, which last condition is far worse than the first. Ugly scars usually follow surgical measures, and the timid patient not only dreads the knife, but is heart-broken because of the disfigurement that usually follows its use. In neglected cases—cases of the second and third degree—well-directed surgical measures, followed by x-ray treatment until the wound has entirely healed, offer the only hope to the man or woman today who is seeking a permanent cure.

Caustics—like arsenic, sulphate of zinc, and pyrogallic acid—may be considered the third method. At one time they were extensively used, with a considerable degree of success. Combined with properly directed x-ray treatment, they may still meet the indications, in well-selected cases, better than any other method, but should be used with extreme caution where large surfaces are to be treated, to prevent absorption of toxic products that are sometimes fatal to the patient.

Quite a good deal is being said in favor of the use of the high-frequency glass vacuum electrode as an adjunct to the x-ray in the treatment of cancer. Doctor Tousey mentions the high-frequency spark from the metal electrode as an excellent application for epitheliomata which do not yield readily to x-ray treatment. The author made use of this method more than seven years ago by using a brass point electrode, well grounded, from which sprays and sparks were given to cancerous growths while the patients were insulated and charged from a static machine. This method of treatment is of considerable value, and should not be neglected in cases that do not seem to respond to x-ray exposures. The metal point electrode is to be preferred to the glass vacuum electrodes.

HISTOLOGICAL CHANGES OF THE TISSUES UNDER X-RAY TREATMENT.

Opinions widely differ as to how the x-ray causes a destruction or disappearance of cancer tissue. X-radiation has unquestionably a destructive action on all tissue. Abnormal growths have a lower vitality than normal tissue, and are therefore more easily affected by x-ray influences. The histological changes in cancer tissue exposed to the x-ray, according to Pusey, are (1) a stimulation of the cells, which is followed by (2) degeneration, and (3) absorption and a disappearance of the morbid elements, which are replaced by connective tissue. The nutrition of the tumor is inhibited by an inflammation of the internal coats of the arteries, arresting circulation and lowering the vitality of the parts affected in proportion to the amount of x-ray influence produced. Complete arrest of circulation causes necrosis, sloughing, and complete death of the tissues. As the influence of the tube extends for some distance into the surrounding tissues, we can begin to understand why healing of an x-ray dermatitis is frequently very slow or not at all. It is the result of a low vitality caused by poor circulation.

Doctor Tousey believes, when a cancer is exposed to the influences of an active x-ray tube, that toxins or antitoxins are developed, the absorption of which may cause toxic symptoms, but that in proper proportions they have a curative effect upon the cancer. It is claimed that the serous discharges from a growth that has received active x-ray treatment are strongly toxic, and should not be allowed to accumulate where they may be reabsorbed.

We are not certain of the manner in which the x-ray favorably influences cancer tissue, but we do know from much clinical experience that it is of the greatest possible value in the treatment of this class of diseases. It will cure all first-degree cancerous growths, may cure the second-degree variety having a slow growth, is a most valued adjunct to surgery in advanced second-degree cases, and will palliate and relieve the symptoms in the incurable third-degree variety.

In the opinion of the author it is criminal to deny a patient with a cancer, in any degree, the beneficial effect of well-directed x-ray treatment, for there is no longer any excuse for the physician's want of knowledge of the virtues of the x-ray, though he live in a remote district. The best medical journals and text-books are giving considerable space to the excellent work being done in every part of the country by x-ray operators, who are producing splendid results.

The x-ray specialist and the surgeon should have a better understanding, that there may not be an encroachment on the field of either. If the physician hopes to make a success of the treatment of cancer, he must bring to his aid all the known methods that have proved their value in actual practice. The surgeon must have the aid of the x-ray and the x-ray must have the aid of surgery. The more that is seen of the surgery of cancer, the more one is convinced that it is a specialty of its own. Very few surgeons, when operating for advanced second-degree cancer, are thorough in their work. They often leave cancer tissue in the primary lesion, and seldom dissect out all the glands that might possibly be affected.

The author takes a very solemn and serious view of every case of advanced cancer that comes under his observation. It is a serious matter for the patient, as it is a matter of life or death. We know what he does not know, and is probably not willing to believe—that his days are numbered unless radically and thoroughly treated without loss of time. Temporary measures are worse than criminal, because they do no good and cause the patient to delay radical measures until a time when nothing can be done. The patient or some member of his family should be told the whole truth of his condition and the probable outcome of the treatment proposed. No true physician can afford to deceive his patient for a single minute if he knows his methods will not cure. If the case is so far advanced that palliation is the only hope, let the responsible parties know the facts. If treatment is continued, leave nothing undone that could be of any curative value, for occasionally the unexpected happens, and a hopeless case gradually, but surely, returns to normal. Fig. 112 is such a case, and the satisfaction obtained from the results in that instance has more than repaid the author for his painstaking efforts.

X-RAY TREATMENT IN CANCEROUS GROWTHS.

Skin Cancer.—Cancer is as old as the history of medicine, and probably had its origin soon after the beginning of animal life. From a close study of the disease we learn that no living thing is exempt, for its ravages may be traced through every civilized and uncivilized tribe on the globe—through every living thing from man on down to the fishes and reptiles; and it does not stop there, but finds its analogy in the trees, flowers, plants, and vegetables. Nothing is immune from the destructive influence of this **fell destroyer** that counts its victims by the thousands every year.

History leaves us completely in the dark as to when and where it made its first appearance. That it existed at a very early period, there can be no question, for the earliest medical literature describes a condition that can be none other than cancer. Because of the lack of early classification, much confusion long existed, and in a measure still exists, making statistics of skin lesions very unreliable.

Cause.—As to the cause of cancer of the skin, we are probably no wiser than our ancient colleagues. Why the elements of which the different tissues are composed should take on a new and distinct growth, that retains many characteristics of the original, though differing from it in the main, is still surrounded by the deepest mystery. That these new atypical cellular growths should finally invade other tissues, carrying the products of infection to the surrounding glandular system and quickly destroying the victim, seems to be an error in the economy of nature. Whether carcinoma of the skin is the result of a specific infection, or caused by a cell proliferation of an embryonic nature, is still a question of dispute.

Cancer of the skin is pre-eminently a disease of advanced life. All authors agree that a very large percentage of these malignant neoplasms occur between the ages of forty and seventy. The tissues of advanced life unquestionably have a low vitality, and consequently less resisting force than the same tissue in youth, and on this account are an easy prey to the destructive agency so active in malignant growths.

Irritation and traumatism seem to be important factors in the early history of every case of cancer of the skin. Almost every patient with a cancer about the face will say that he was in the habit of cutting the ''pimple'' with knife or razor, or pinching or scratching it off; but it continually returned, a little larger each time. These growths, like everything else, have a very small beginning. Sometimes a little dry scale appears on the side of the nose, around the eyelid, or on the side of the face; it may disappear for a time, but always returns, larger and larger, until a malignant ulcer is formed. A wart or mole, after months of rubbing, pinching, or cutting, may suddenly develop into a malignant growth. After years of bruising the lower lip with the pipe stem, a small papule may appear at the mucocutaneous margin, that soon takes on alarming features and may rapidly end the life of its host.

It is not believed that cancer of the skin is contagious, infectious, or hereditary; but, as it is often met with in members of the same family throughout several generations, predisposition, which is probably a family trait, should be considered. Thin-skinned blonds and red-complexioned, full-blooded people are frequent sufferers. Not more than 20 percent of the cases of epithelioma of the face that have come under the author's observation were brunettes. More cases occur in men than in women. While filth is a predisposing factor, epithelioma is not essentially a disease of the poor and filthy, for it frequently invades the homes of comfort and fashion.

Of all the predisposing factors, irritation and traumatism unquestionably are of first importance. Had the dangers of irritation and traumatism been thoroughly understood, and the little defects in the skin left alone, many a victim who has been sacrificed to cancer might have lived longer and died from other causes. Perhaps a few would have eventually taken on a malignant growth under the best of care. From whatever cause cancer may come, there is no question that it is on the increase. This increase may be due wholly or in part to an increased population, but, be that as it may, the disease is now so frequent that every community, city or country, has several old people in different stages of cancer of the face, to say nothing of other varieties.

Varieties.—No attempt will be made to discuss the different varieties of skin cancer. The student is referred to the excellent text-books on the subject, of which there are several. While the histological structure of these abnormal growths differ as the tissues vary in which they are found, their nature and treatment are so nearly alike that a separate description will be unnecessary.

Diagnosis.—An early diagnosis of skin cancer is of first importance. These epithelial growths have a very small beginning, starting probably from a single cell, which for a longer or shorter period remains dormant or develops with difficulty. A scratch, fissure, bruise, wart, or mole in an otherwise normal skin may, in an entirely unknown way, take on the elements of malignancy, but, because of the resistance of the surrounding tissues, remain for months or even years a very insignificant growth, of which little notice is taken. At a later period, when the patient is entering the decline of life, when the normal tissues have less resisting powers and the growth has met with constant irritation, it begins to grow and invades the surrounding tissues, developing in proportion to the external irritation and inversely to the resistance of the normal tissues.

At this period the patient may take the matter seriously, and naturally consults his family physician. The growth is generally so insignificant in appearance, and appears so small and harmless, that the physician's usual advice is to let it alone, which is the very thing that the patient will not do; or a prescription is given for a bland ointment, which does no good and causes a delay, during which the patient thinks something is being done for him.

The family physician usually sees these cancer cases in their early stages, when a cure is sure and easy. He should be impressed with the importance of an early, thorough examination of every growth, no matter how small, appearing on the face of a patient, man or woman, who has passed the age of thirty. Every growth with a tendency to grow, that has existed for six months on a patient in the decline of life, should be regarded with suspicion. Every patient should be made to fully understand the nature and tendency of these small growths, and the necessity of prompt and early treatment if a cure is to be expected.

No physician, however expert he may be in the observation and diagnosis of malignant conditions, will always be able to determine with mathematical certainty just what a certain growth will eventually do, but, when he remembers that the patient's life may depend upon his diagnosis and advice, he should consider well his opinion, remembering that it has been aptly said that "it is better by far to err nine times on the safe side than that the tenth should be neglected until too late."

With the above ideas before us, the only course to be pursued, with safety to the greatest number of patients and with credit to ourselves, is to look upon growing neoplasms as malignant or that they will sooner or later become malignant.

Well does the author remember some of the mistakes he made in diagnosing these innocent-looking growths during his early medical experience. They all ended fatally in an astonishingly short time. At that time surgery and caustic pastes and plasters were the only treatment. Then, as now, all cutting methods met with strong opposition. The paste methods were largely in the hands of advertising quacks, or peddled about the country by men and women who knew practically nothing of their composition and far less of their effects on the tissues.

Because of the frequent indifference of the family physician, many of these early cancer cases drifted into the hands of these advertising quacks, who often attempted to treat them at home for a small monthly consideration. About 95 percent of the cases treated in this manner die from cancer in from one to three years.

The family physician is the only man who can stay this wanton waste of life by recognizing the early stages of these cancerous growths and supplying the proper treatment, or sending them where it can be had.

Treatment.—The successful treatment of skin cancer will depend entirely upon the stage and extent of the growth at the time the patient is seen. In the early stages only a small amount of tissue is involved, and the treatment is very simple, with the best results in every case; but, as the growth becomes larger, it spreads deeper into the surrounding tissues, making the treatment more and more severe, and the prospect of a cure correspondingly less sure.

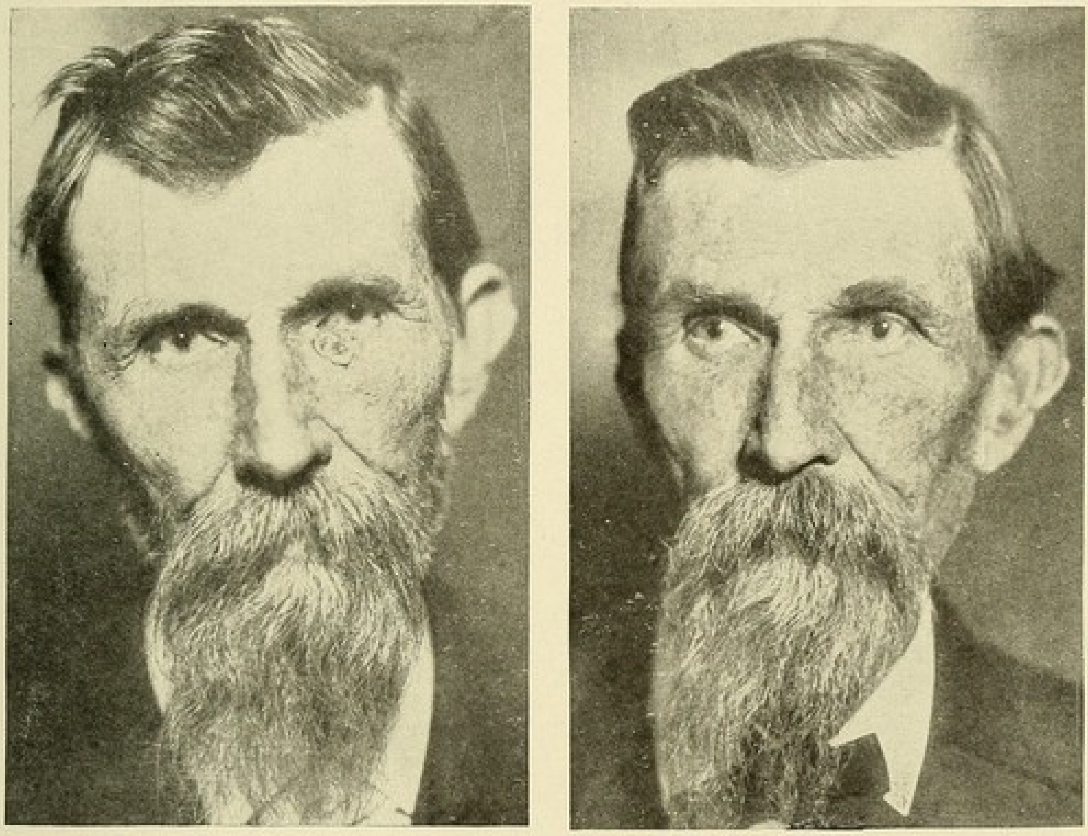
Every case of skin cancer can be cured if treated early, before the growth invades the subcutaneous tissues; and they may be cured after this stage, but there is a stage after which no treatment, however radical, can do more than give the patient a certain degree of comfort and prolong his life for a limited time.

No matter what method of treatment is adopted in any given case, the object sought is a complete removal or a radical destruction of every vestige of the cancer tissue or its products of infection, whatever that may be. In choosing the treatment, the patient's interest and wishes must be consulted. He must be made to fully understand the true nature of the condition and the probable results of the proposed method of treatment.

The author seldom sees a case of cancer in its earliest stage. The growths as they usually appear on first examination vary in size from a 5-cent piece to the size of a silver dollar or larger. In using the word "stage" the author does not mean that there are any definite or well-defined lines of separation between the stages referred to, but, as the treatment will depend upon the size of the tumor and the extent to which it has invaded the surrounding tissues, for convenience he has divided the cases into three main subdivisions or stages.

In the first stage there is an indurated infiltration in the skin. It is entirely local, and does not extend to the subcutaneous tissues.

The author is frequently asked why he does not have sections made from all of his cases and have them examined by a pathologist. Occasionally he does, but as a rule he does not. It is not



1. 2.

Fig. 113.—Epithelioma of the left lower eyelid.

good practice to incise these early growths when the patient's interest is considered, and it is because of this fact that he seldom does it. At a later date the diagnosis is unquestioned, and a microscopical examination is unnecessary.

Fig. 113 shows a patient, 59 years old, with an epithelioma of the left lower eyelid, representing the first stage. He first noticed a little dry scale beneath the eye about eight months before; the scale would remain for a time and then disappear, but would promptly reform. A few weeks before he was seen the tissues underwent a destructive process, and an ulcer about the size of a 5-cent piece was formed, which began to cause him some pain and trouble with the lower eyelid. It was slowly growing larger and evidently taking on an active, malignant process, though no pathological examination was made. This is the kind of cases in which a microscopical examination will, as a rule, be out of the question.

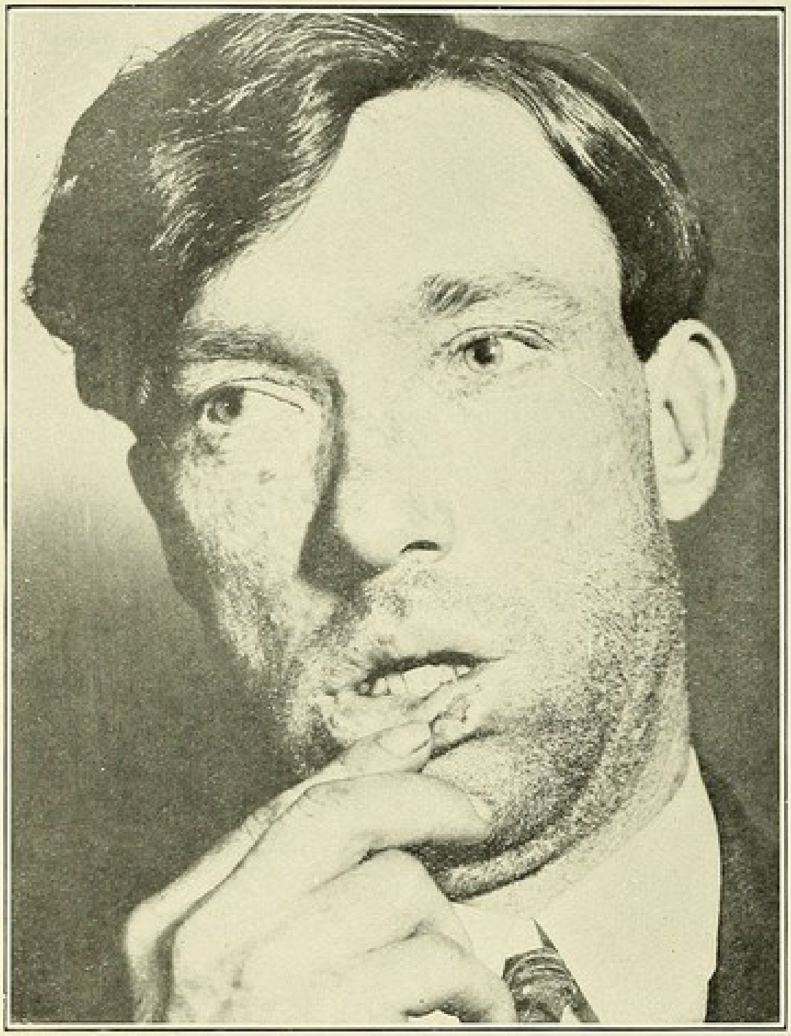


Fig. 114.—Beginning of epithelioma of the lower lip.

This case, contrary to the usual practice, had received no treatment of any kind beyond the application of simple ointments. It is true that it might have been carefully incised and the section studied, but it would have marked the patient with a scar, and the after-treatment would have been the same and the final results no better.

Fig. 114 shows a case of beginning epithelioma of the lower lip. The young man was 24 years old and a leather worker by trade.

He consulted the author on December 31, 1907, when the ulcer appeared as shown in the picture. The trouble started as a little fissure, such as is often seen from an ordinary fever blister. It remained about the same for several weeks, and then began to get larger, harder, and more painful. He tried many remedies, but nothing seemed to have any control over the trouble. At the time he was seen the ulcer was more than half an inch long and well marked by a hard induration. This is a splendid example of a first-degree cancer of the lip. Had this case been allowed to progress, there is no question that this man would soon have fallen a victim to its destructive processes.

An exhibition of first-degree cases could be continued to the end of this volume, but, as they are all practically of the same character, requiring the same method of treatment, with the same final results, the cases cited will serve to illustrate the point in question. All of these cases are rapidly amenable to the method of treatment to be described later. The patient is not subjected to discomfort, pain, or disfigurement of any kind, provided, of course, he seeks treatment during this stage. Physicians should keep a watchful eye over their patients for these little evidences of malignancy or senile degeneration, **which are almost sure to end in a malignant growth** unless the process is arrested. If the general practitioners throughout the country were to do their full duty in this respect, it would be only a very short time when a fatal case of cancer would be an exception instead of the rule.

After ten years of use and careful study by hundreds of careful observers, it has been conclusively proven that the x-ray is an ideal remedy in the treatment and cure of these early growths, or first-stage epitheliomas. This work has been so universally successful in the hands of the author that, were he to hear of a case of failure in such a case, he would question the method of treatment. It must, however, be distinctly understood that there is much for the operator to learn if he hopes to get favorable results in this class of work. The possession of an x-ray generator and a vacuum tube is no guarantee that the possessor is in any way competent to use them. There has been too much unscientific work of this kind in the past, for which the patients have usually paid very severe penalties. Like every other department or specialty in medicine, physicians should be compelled to qualify before being allowed to make use of the x-ray for either diagnostic or therapeutic purposes.

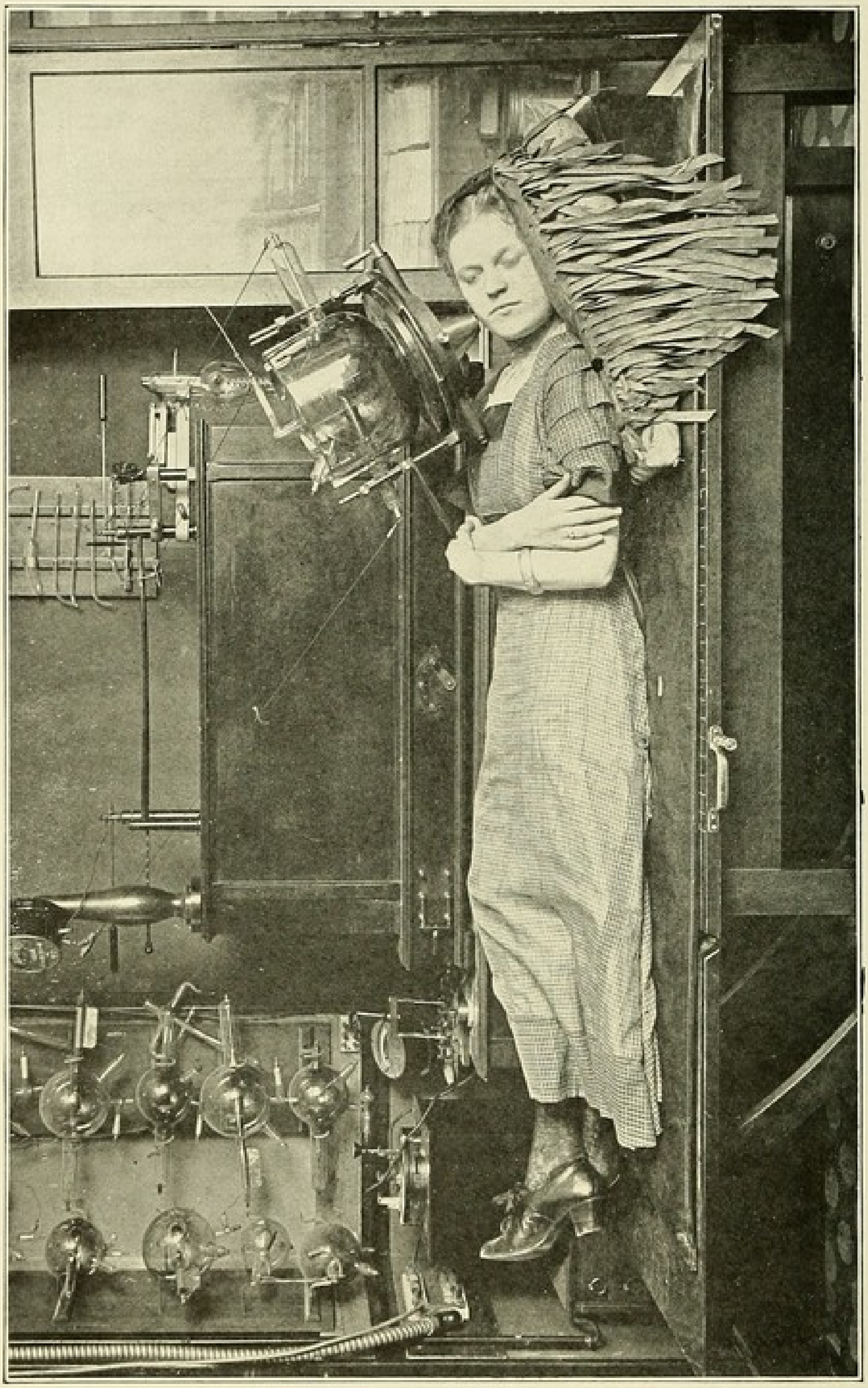


Fig. 115.—Method of x-ray treatment for cancer of the face.

Technic and Mode of Operation.—The technic and manner in which the x-ray is applied to the treatment and cure of skin cancer is very simple, but it demands a thorough knowledge of the vacuum tube and its possibilities. Unless the tube has the correct vacuum, and the distance, length, and frequency of exposure are properly regulated, the results of such treatment will be very disappointing.

The patient may be placed in a sitting or reclining position, so as to allow proper application of the tube to the parts to be treated. If the growth is of the size of a silver dollar, it will be well to expose the tissues over twice this area during the first few treatments. Then the opening in the shield may be decreased so as to expose the growth only. The shield is composed of thin sheet-lead, in which holes are cut to the size of the parts to be treated. The material is inexpensive, and there should be one or more for each patient, all of which should be destroyed when the patient is dismissed.

Fig. 115 shows a patient taking an x-ray treatment for cancer of the face, and attention is called to the relative position of the tube, patient, table, and coil. There may be other methods quite as convenient, but the author prefers the couch and reclining position. The patient is comfortable, and is allowed a quiet rest during the seance. Patients have been known to drop off to sleep while taking the treatment in this manner.

In the treatment of all superficial growths a low vacuum tube should be selected. The tube should be so low that it will not back up more than a 2-inch spark between the prime conductors of the coil or static machine. The hemisphere of the tube filled by the apple-green light should be quite dense, making that portion of the tube opaque. Such a tube will possess therapeutic rays in abundance, and can be depended upon to produce destructive effects in the skin in a very short time. The tube should be placed about 8 inches from the surface of the skin, measuring always from the center of the anode or origin of the x-rays. The length of the treatment will depend upon the vacuum of the tube, kind of generator, and the nature of the particular case under treatment. Perhaps the length of exposure should be a little longer when a static machine is used to energize the tube, though this is not necessarily so; if the static machine is in good working order, it should furnish ample current to fill a low vacuum tube to its full capacity.

Red-complexioned and thin-skinned blonds are more quickly affected by the x-ray than thick-skinned brunettes, the latter often requiring twice the number of exposures to get an equal result. When the growth is quite small, and the skin thin and delicate, it is often unnecessary to produce any visible dermatitis. In such cases the treatments must be very mild, and several days be allowed to elapse between the exposures. If the growth is large, and the patient thick-skinned and dark-complexioned, it will require longer and more frequent exposures. No fixed rule for the length and frequency of exposures can be laid down, as each case is a law unto itself. The work must be learned through long experience.

Speaking generally, it may be said that in the treatment of small growths on thin-skinned subjects, with a tube 8 inches distant from the surface, the length of exposure should be about six minutes and repeated every other day until a slight redness—or, rather, a brown tanning—becomes visible, after which a rest should be ordered until either the growth or the x-ray effect disappears. If there is need for further treatment, it may be continued as before, with the same precautions. If the growth is larger, and there is urgent necessity for active tissue destruction, the exposure may be lengthened to ten minutes and be repeated every day until ten treatments have been had. At the end of this time, whether a dermatitis is visible or not, a rest should always be ordered for the purpose of awaiting developments. After three to six weeks it is easy to determine whether farther treatment will be required. These first-degree growths will seldom require more than the second series of treatments to effect a cure.

Where the cure is almost, but not quite, complete, the patient should not neglect to return for a few more exposures. Occasionally a very small place will be very obstinate and require a number of exposures, and sometimes both physician and patient become discouraged, but in the majority of such tardy cases the technic is at fault and must be corrected before rapid results can be expected. The author has frequently seen cases that had been x-rayed for some time, during which they seemed to take on a more rapid growth, but in almost every case the failure was due to the fact that the treatment had been of such a nature that the growth was stimulated instead of inhibited.

Caustic pastes and surgery are not necessary in the treatment of these first-degree growths when properly treated by the x-ray.

The worst that can be said about this method is the time it takes to effect a cure, but to most people time is a secondary consideration when the treatment is painless and leaves the patient without a scar. Were it possible to get all cases to submit to x-ray exposures at the time when these little, insignificant growths first make their appearance, a large majority of cancers would be prevented, saving many a man and woman from months of mental and physical torture and a slow and painful death.

In many elderly, thin-skinned, red-complexioned people is observed a condition on the face, and sometimes on the backs of the hands, characterized by a more or less horny or scaly excrescence, and known as hyperkeratosis. This condition may last for several years, remaining about the same all the time, when suddenly one or more of these keratotic areas may take on a malignant ulceration that may destroy the life of the patient; in fact, it seems that the greater number of these destructive skin cancers about the face can be traced back to just such an origin.

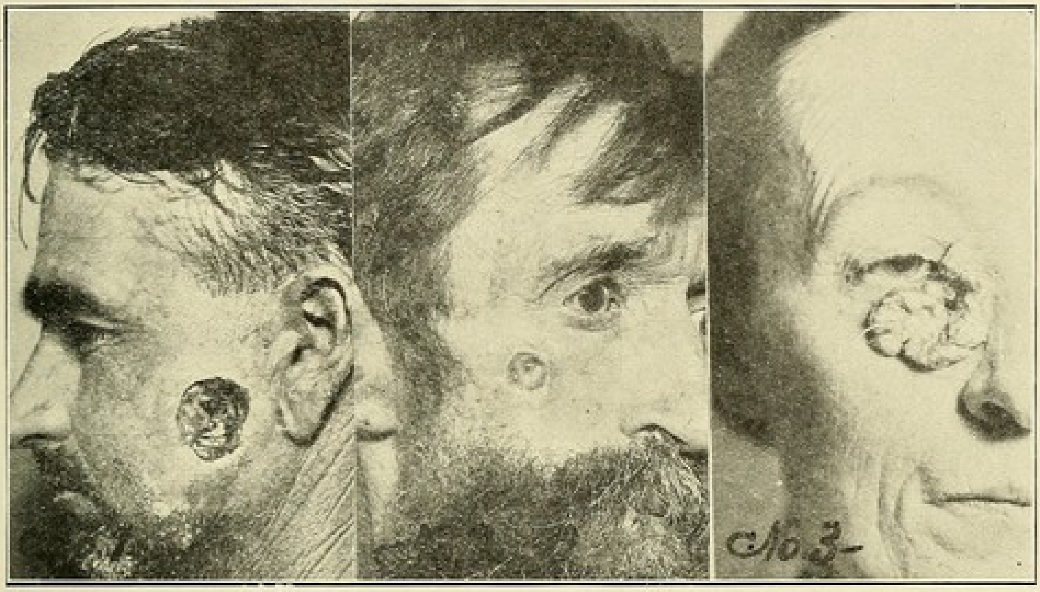
The stimulating effect from exposure to the rays from a low vacuum x-ray tube will rapidly cause a disappearance of this horny condition of the skin. It will do more—it will heal the ulcers after that destructive process has set in, provided, of course, the growth remains local. After the proper x-ray treatment for the conditions mentioned, no scars remain to mark their locations. This fact alone is of considerable importance to the patient, and is an active factor in helping him to decide on having something done at an early date before the process of destruction has extended beyond control.

Second Stage.—The second stage is that period in the growth and development of these malignant neoplasms when the destructive process has spread beyond the tissues of the integument and has pushed its lines of invasion into the subcutaneous structures and the neighboring glands. The first stage may have lasted over a period of several months or years. With the beginning of the second stage the invasion is more rapid, and the growth spreads often at an alarming rate. As a rule, it is about this time that the patient wakes up to the fact that he is in a dangerous condition and begins to look around for a treatment, but, because of the previous slow growth, he is not particularly alarmed and takes his own time. This is a very deceptive stage. The author has learned from long experience that what often appears to be a very small and simple growth proves on closer examination to be a very serious condition, which has spread far beyond all expectation. The treatment of this stage, to be successful, must be radical and thorough. In order to stay the products of infection, it is good practice to give the growth and the tissues surrounding it eight or ten six- or eight-minute exposures in as many days to a medium vacuum x-ray tube, after which, in the majority of cases, it is advisable to thoroughly remove the affected tissue, including the near-by glands and all other glands found to be affected.

Following the operation, x-ray exposures should be continued once or twice a week until the wound has entirely healed and there is no evidence of a return. In this way many second-stage cases may be cured, never to return, but no definite assurance can be given before the case is undertaken. A limited number of these cases may be cured by x-ray treatment alone, but the majority of second-stage cases must have the benefit of modern surgery. All operative interference must be thorough or not attempted at all. Simply removing a portion of the malignant tissue is criminal and should not be allowed, for it will do far more harm than good. Very frequently the malar bone and the inferior and superior maxillary bones become involved, and it becomes necessary to remove a portion of these bones. Occasionally it is necessary to remove the entire inferior maxillary when nothing short of it will succeed. In many cases it is very difficult to get the consent of these patients for such extensive operations until it is entirely too late for any kind of surgical measures to be of value. A case in this stage is seldom seen until after the patient has been the victim of several plaster cures, or, may be, one or more partial operations. After such disturbance it usually takes on a rapid growth, and may soon become incurable. One or two failures from any method usually discourages the patient and causes him to hesitate, and it is because of this want of confidence that he often waits too long before seeking the proper treatment.

Fig. 116 illustrates three early second-degree cases of skin cancer. The stages of these growths were very nearly the same, though differing widely in character. Case 1 was seen July 17, 1908. He was a farmer, 36 years old, dark-complexioned, and of dissipated habits. His father died at the age of 68 from cancer of the face, and a brother at 45 years had cancer of the lip and face. The first he noticed of the condition was about six years before he was seen.

A scale would form on the side of the face, and, after remaining for a time, would disappear, to soon reform. The ulcer shown in the illustration was about eighteen months in forming. At the time he was seen it was about 2 inches in diameter, and extended deep into the parotid gland, interfering considerably with the movements of the inferior maxillary, allowing the teeth to open only a short distance. He had had two or three months' pseudo-cancer treatment, during which time he grew worse and lost more than 20 pounds in weight.



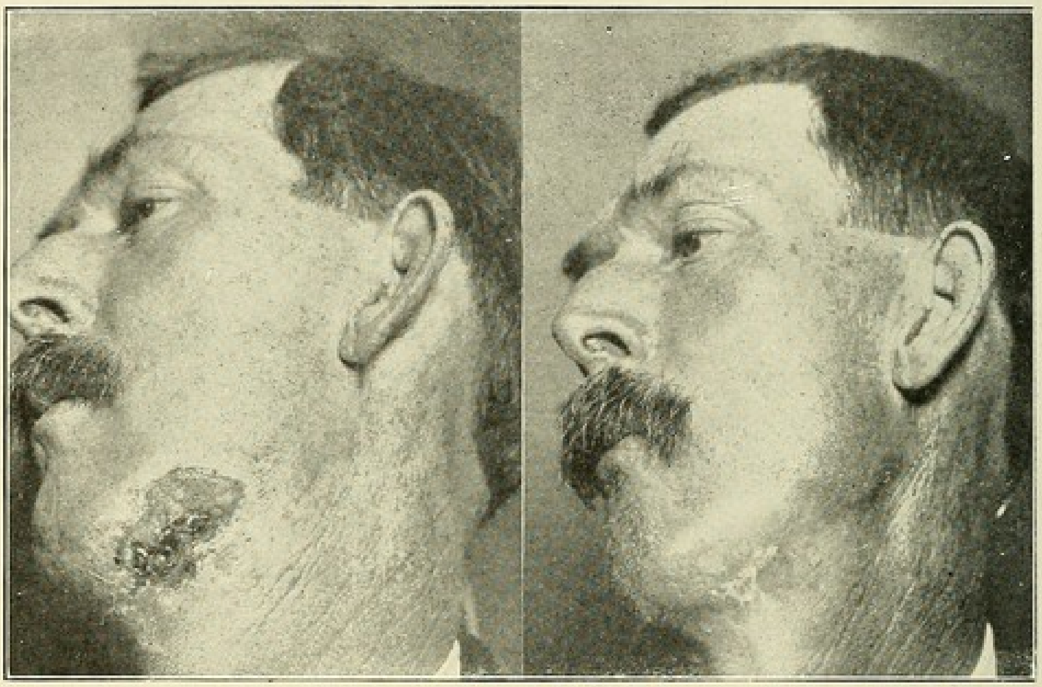
1. 2. 3.

Fig. 116.—Three early second-degree cases of skin disease.

Under x-ray treatment he rapidly improved, gained 26 pounds, and the development of the cancer was completely inhibited. Because of the external drainage of the parotid gland, complete removal was advised, together with any tissues that might appear malignant. He refused to have operative interference, after which the author declined farther responsibility. He drifted from one advertising institution to another, finally paying the penalty of neglect with his life. He learned after it was too late where he had made the fatal mistake. This one case illustrates the class of cases that refuse operative interference at a time when relief or cure is possible.

Case 2 began in a very similar way to the one just described. This man was seen February 20, 1907. He was a farmer, 50 years old. Besides the ulcer shown in the illustration, he had the characteristic pearls on his face, neck, and hands. The ulcer was about the size of a silver dollar and very painful, causing him great distress. This ulcer rapidly healed under x-ray treatment, but, because of the horny growth of epithelial tissue mentioned, this man will again have malignant ulcers at the site of these scaly patches. They may, of course, recur on the site of the old ulcer, though no more likely to form there than elsewhere. Should such a destructive process begin, a very mild series of x-ray exposures will suffice to stop the development.

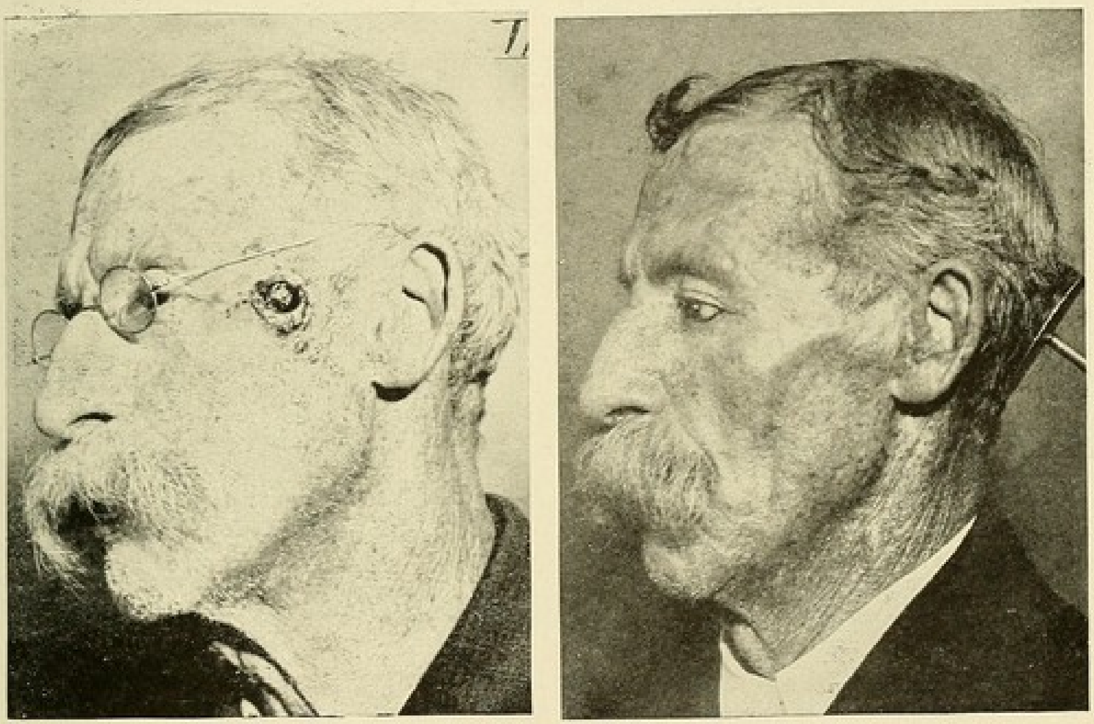
Case 3 represents the condition of a patient 47 years old, who had a growth about 2 inches in diameter located on the inner side



1. 2.
Fig. 117.—Second-degree cancer.

and below the right eye. The tumor had been of slow growth, covering a period of about eighteen years. Some months before she was seen necrosis began in the center of the growth, which began to break down, became offensive, and caused considerable pain. After twelve x-ray exposures, Marsden's paste was applied to the raw surface and the tumor destroyed well down through the integument. The wound healed nicely and appeared to be well, but on close examination the tissues back of the eye were found to be involved. The eye, with much of the surrounding tissue, was removed. The operation was followed by active x-radiation for some weeks, and so far there has been no evidence of return.

Fig. 117 illustrates a case of second-degree cancer that is remarkable for the area involved. This man was a farmer, 44 years old. The main ulcer (1) was rather deep and measured $1\frac{1}{2}$ inches long by about $\frac{3}{4}$ inch wide, raw and bleeding. A section from this case confirmed the diagnosis of epithelioma. He had a number of epithelial pearls about his face. The ulcer began a number of years ago higher up on the side of the face, gradually working its way downward, getting larger all the time. During the first series of treatments he was given nine exposures in as many days. He was sent home and allowed to rest fourteen days, after which he returned and received five exposures as before. In three months' time the ulcer had entirely disappeared, as seen in 2, taken at the time he was dismissed.

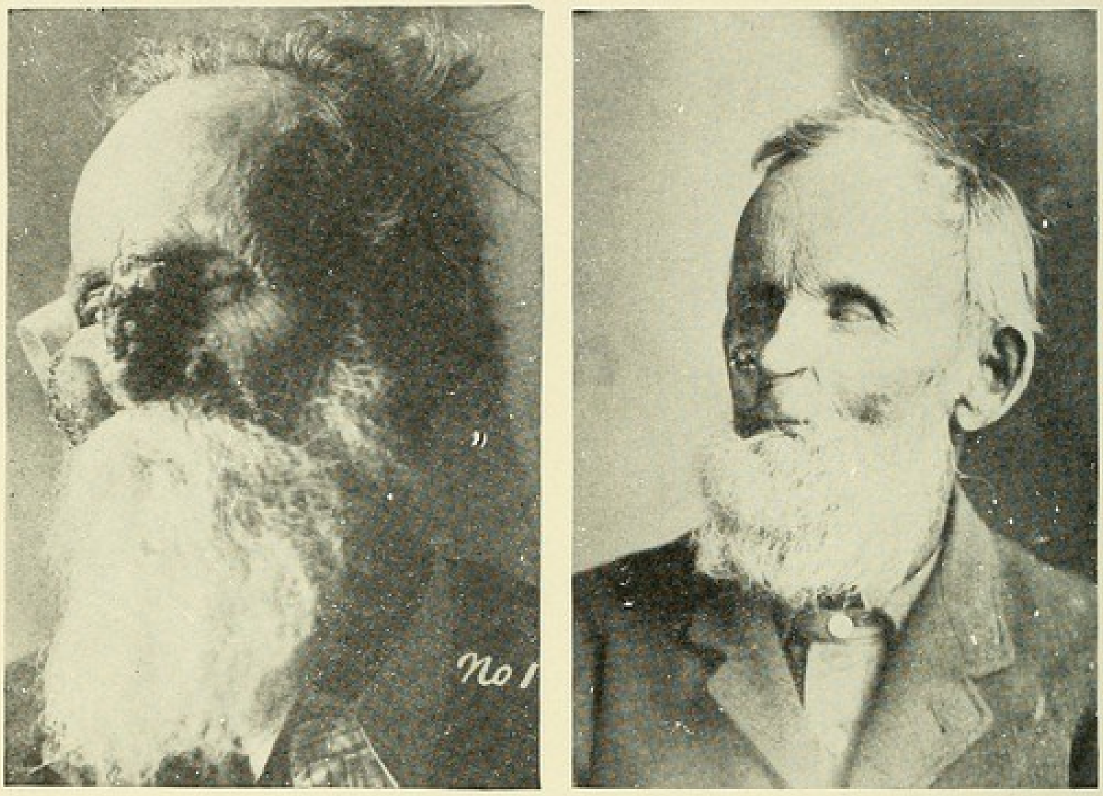


1. 2.

Fig. 118.—Cancer of the face.

Fig. 118 is a fairly good illustration of this case before (1) and after (2) treatment. The ulcer was about $1\frac{1}{2}$ inches in diameter and had been more than two years in forming. It had pained him considerably, though the pain was never great at any time. No pathological examination was made in this case, for there could be no question about the diagnosis. He received thirty x-ray exposures, twenty during the first and ten during the last course, allowing six weeks to intervene. The second picture (2) was made more than a year after the last course of treatment and speaks for itself. There is no scar to mark the location of the ulcer, and the skin is soft and normal.

The subject of Fig. 119 was an old Confederate soldier, who had a number of horny epithelial growths on his face, with which he had been afflicted for about twenty years. About ten years before he was seen an ulcerated area slowly began to form about the nose and on the side of the face. At the time he was seen (1) the nose

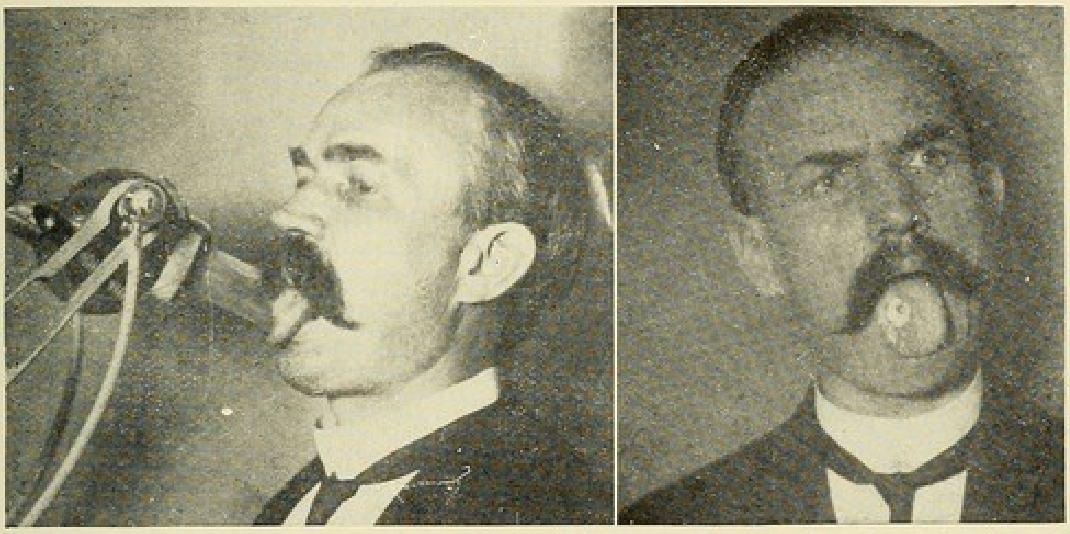


1. 2.

Fig. 119.—Cancer of the face.

was completely covered with a thick, dense, hyperkeratotic growth, beneath which exuded a mucopurulent discharge. A dense tumor, about 2 inches in diameter and $1\frac{1}{4}$ inches thick, was located beneath the right eye, while a second hard, horny growth was located just to the left of the nose, near the malar eminence. Strange to say, he suffered little or no pain, and his health was fairly good for a man in this condition and 77 years old. A study was made of the tumor on the right side of the face, and it proved to be epithelioma of a low grade, which accounted for its slow growth and painlessness. Marsden's paste was used over the large tumor on the right side of the face, and the remainder of the work was done with the x-ray. He at once improved rapidly, and after twelve months (2) there was hardly any evidence on the left side of the face of the former trouble, while on the right side there was a place about the size of a dime just over the malar bone that was covered with a hard scab. His condition had improved so much that friends who had known him for many years would pass him on the street without recognizing him. The left eye had long been destroyed from an injury.

The author has not seen this case for several years, but he has been informed that the patient neglected treatment and that several of these horny growths have redeveloped. This is to be regretted, as an occasional x-ray exposure during the early stage of these horny excrescences would cause them to completely disappear, and in this way this man could be kept free from trouble of this kind during the remainder of his life.



1. 2.

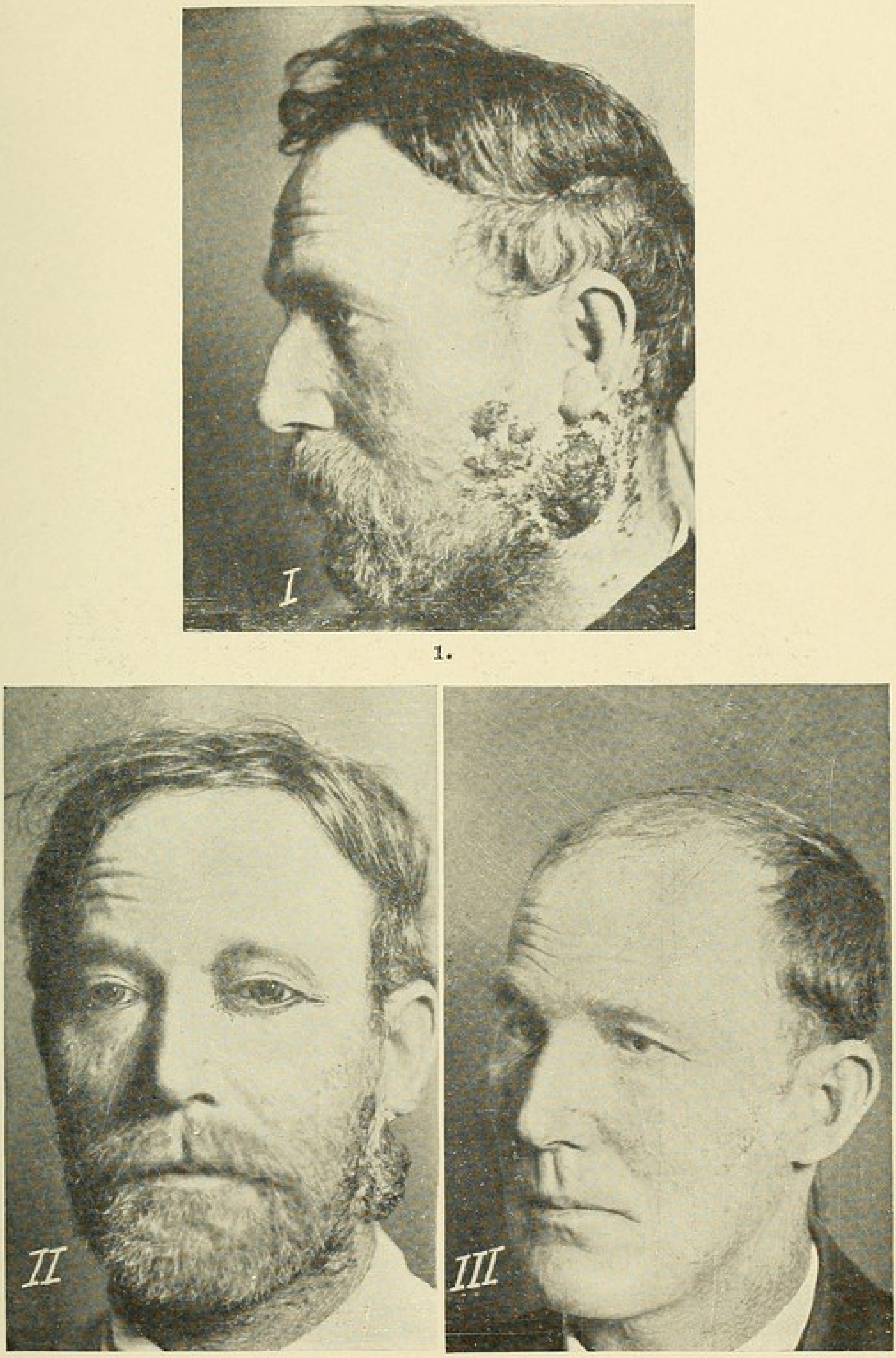
Fig. 120.—Cancer of the tongue.

Fig. 120 illustrates cancer of the tongue, which occurred in a German minister, a very worthy gentleman. At the time this case was seen an operation would have given him a chance for his life, but he positively refused all surgical interference. He received x-ray treatment in the manner shown in the illustration, but in this particular case it seemed that the x-ray did little or no good. He went to Chicago and fell into the hands of some nature cure advocates, and soon died. The tongue is one of the most unfavorable locations for cancer. Its highly vascular condition, together with a constant irritation from many causes, greatly aggravates cancer in this organ. This man had been an inveterate smoker of a pipe, the stem of which he allowed to rest against this particular portion of the tongue. The author has seen only a few cases of cancer of the tongue, all of which have been fatal.

Fig. 121 illustrates a vivid chapter in the history of the most deadly and dreaded disease from which our race is an entirely too frequent sufferer. The subject of this picture is a farmer, 38 years old, sandy-complexioned, and, but for the trouble on his face and neck, was in most perfect health. He was referred to the author by Doctors Wood and Wood, of Hubbard City, Texas. During the preceding October a scaly growth began to form on the left side of his neck, beneath the ear. The tumor grew at a rapid rate until the time he presented himself, when it had an area and thickness as shown in 1 and 2. He had consulted some good surgeons without receiving one ray of hope. When he appeared, May 5, 1907, he was a picture of abject despair. Weary from travel and disappointment, exhausted from pain and the mental burden he was carrying, he was almost bereft of reason, and, instead of being seated while talking to the author, he walked up and down the room in a fit of nervous agitation. His features relaxed and his face brightened up a little when he was told that he could be relieved, but at no time was he promised a cure.

This man received in all fifty-four x-ray exposures. The tumor was sloughed off with Marsden's paste and then given active x-ray treatment. The first series of treatments extended over a period of six weeks, during which time he received an x-ray exposure every day. A dermatitis of the first degree was induced in the tissues, after which he was allowed to rest at home for three weeks. When he returned there was marked improvement in the tissues; the dermatitis had disappeared, the skin was free from scales, and the ulcer was rapidly healing. For the next three weeks he received an x-ray treatment every two or three days, after which he was allowed to return home for another rest. On October 21 he returned the second time. The ulcer had entirely healed, the skin on the side of his face and neck was smoother than on any other part of his face, and he had gained 25 pounds in weight. A few epithelial pearls had developed on the back of his neck that caused him some alarm, but after three or four x-ray exposures they disappeared.

These pictures are worthy of the closest consideration. The



1.

2.

3.

Fig. 121.—Cancer of the face.

growth beneath the ear was more than 2 inches thick, and so painful to the touch that the slightest manipulation would almost drive the patient into a spasm. This man was being rapidly hurried through the maelstrom of malignant infection and tissue disintegration, where death would soon have put an end to his earthly existence.

The third picture (3), three years after treatment, is a perfect representation of his present appearance. This man has a treacherous skin, which is likely to cause him much trouble in after life if he neglects conditions that are sure to arise. As the result of sunburn and other sources of irritation, scaly patches will develop

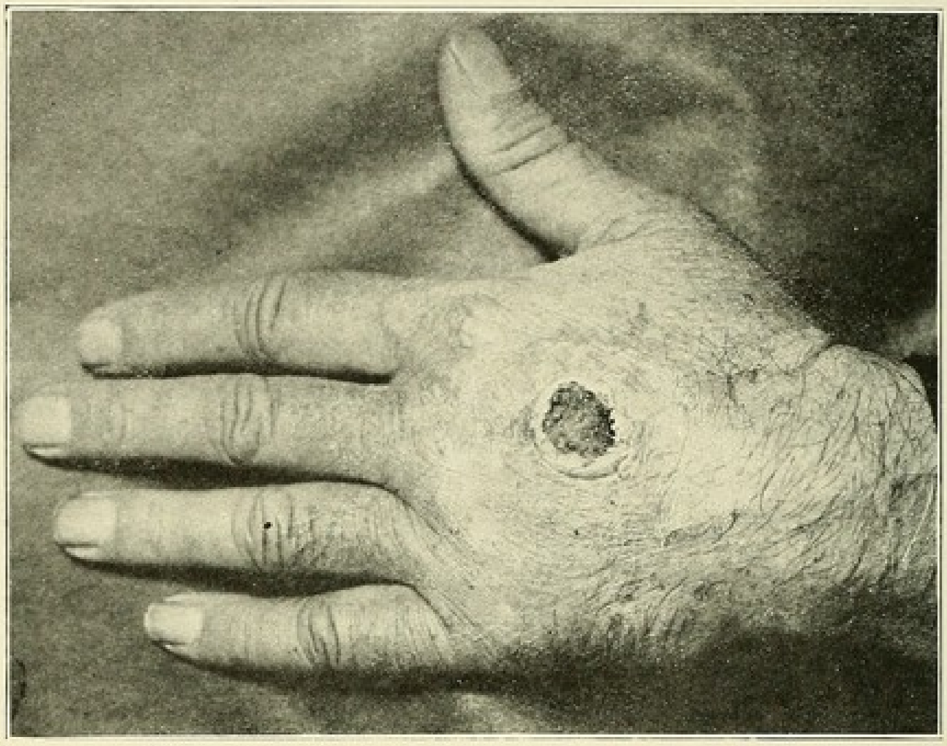


Fig. 122.—Epithelioma on the back of the hand.

from time to time, which, if allowed to continue, will eventually prove fatal. If this man will use the proper care, returning occasionally for a few x-ray exposures, he may live to an old age entirely free from cancer and its accompanying horrors.

Fig. 122 represents a second-degree cancer on the back of the hand of a patient who has passed the meridian of life. This was a hard, horny growth about $\frac{3}{4}$ inch across and about $\frac{1}{2}$ inch thick. After six x-ray exposures to a low vacuum tube, Marsden's paste was applied and the growth destroyed down through the integument. X-ray exposures were continued until an active first-degree dermatitis was produced. By the time the dermatitis had disappeared, the ulcer had entirely healed, and there is today no evidence of a growth of a malignant nature. This is one of many similar conditions the author has seen on the back of the hand. They all have about the same history in common, starting, as a rule, from a little scaly excrescence, which continues to get larger and larger until the destruction of the hand or the life of the patient is threatened. When seen in the first stage a few x-ray treatments will usually remove these conditions, but, when allowed to continue to a later date, surgery or caustic applications will be necessary to remove the mass of abnormal tissue, after which the x-ray should be used during the stage of repair.

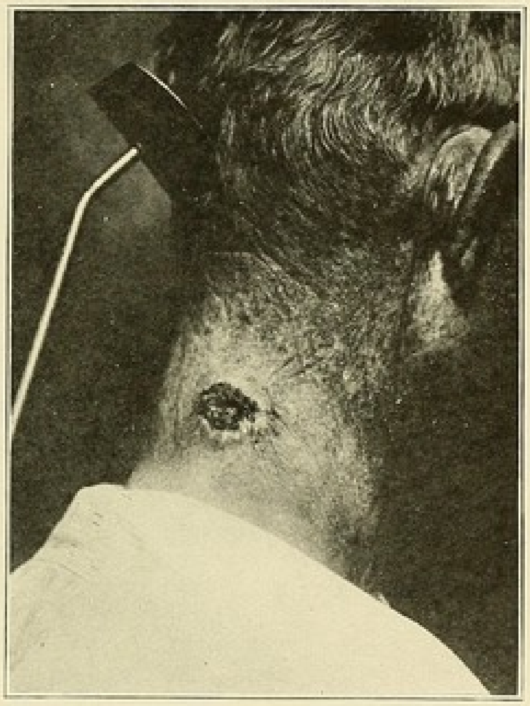


Fig. 123.—Epithelioma of the neck.

Fig. 123 illustrates a very deceptive variety of skin cancer. This man had long had a dry scaly patch on the back of his neck that was more or less painful and tender to the touch, but he thought it was only a trifling affair and paid no attention to it. A few weeks before he was seen the horny growth had broken down, and an ulcer about the size of a 5-cent piece had formed and was causing considerable pain. This new condition caused some alarm, and he applied for treatment. On examination it was found that the tissues around the ulcer were hard and dense over an area 3 inches in diameter. He refused all surgical interference from the start. After eight x-ray exposures to a medium vacuum tube the epithelium was destroyed with caustic potash over an area 4 inches in diameter and a plaster of Marsden's paste applied to the whole surface, using sufficient cocain to make it bearable. The plaster was allowed to remain twenty-four hours, after which flaxseed poultices were applied until the slough came away. X-ray exposures were given every second day during the healing stage, and the final results were all that could be asked for. There is no scar to mark the location of this ugly and painful tumor, nor is there any contraction or other uncomfortable feeling in the muscles of the neck, so common after

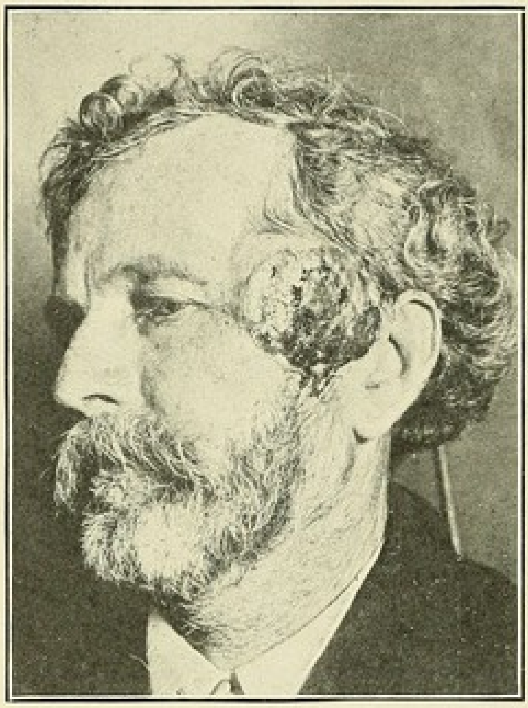
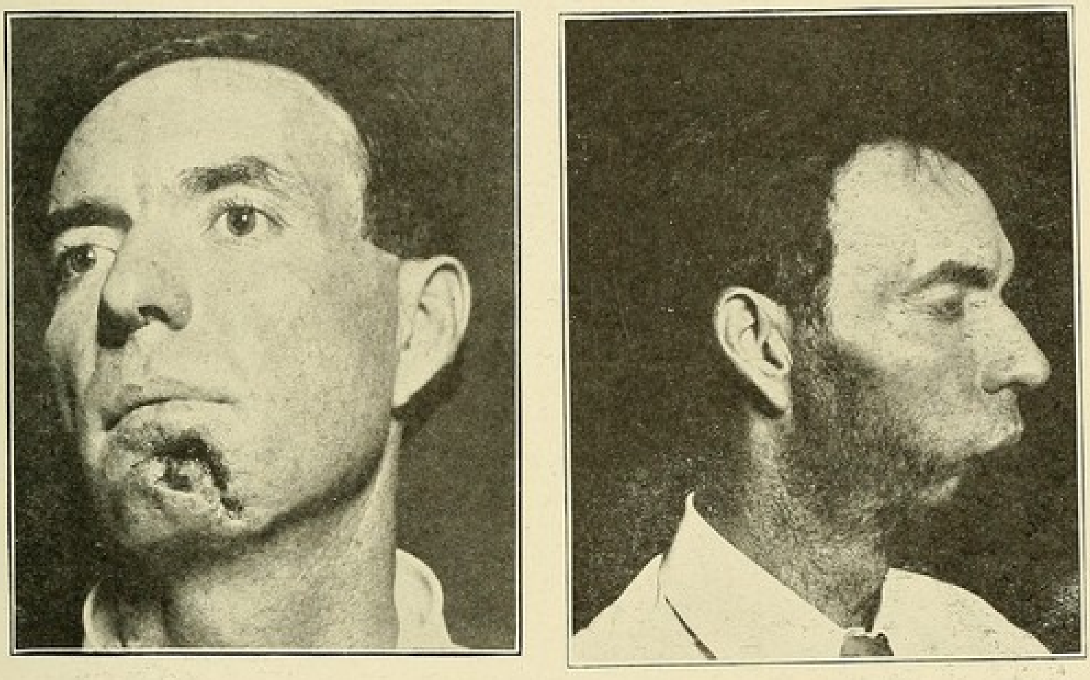


Fig. 124.—Epithelioma of the temporal region.

surgical methods for the same conditions. It was the location of this growth that made the plaster treatment possible. Had it been on some other part of the body where the surrounding glands were involved, nothing short of a thorough surgical section would have been of any benefit. These dense, hard growths are very stubborn, and prone to return unless the treatment is radical and thorough.

Fig. 124 teaches a lesson that every man who attempts to treat this class of cases should learn early—i. e., do nothing unless you are prepared to do it thoroughly. At the time this picture was made the author insisted on his having a thorough, radical operation performed, to which he agreed. The operation was not thorough, and, while he had active x-ray treatment, in six weeks' time there was evidence of return. The surgeon removed the cancerous tissue with a curet and cauterized the surface with Paquelin's cautery. Ten active x-ray exposures were given afterward, but we will probably be defeated in this case because the primary operation was not as thorough as it should have been. When this case returned the third time, about three months after the operation, the malignant tissue had developed so rapidly that a farther treatment was out of the question.

We can not understand why so many physicians keep this class

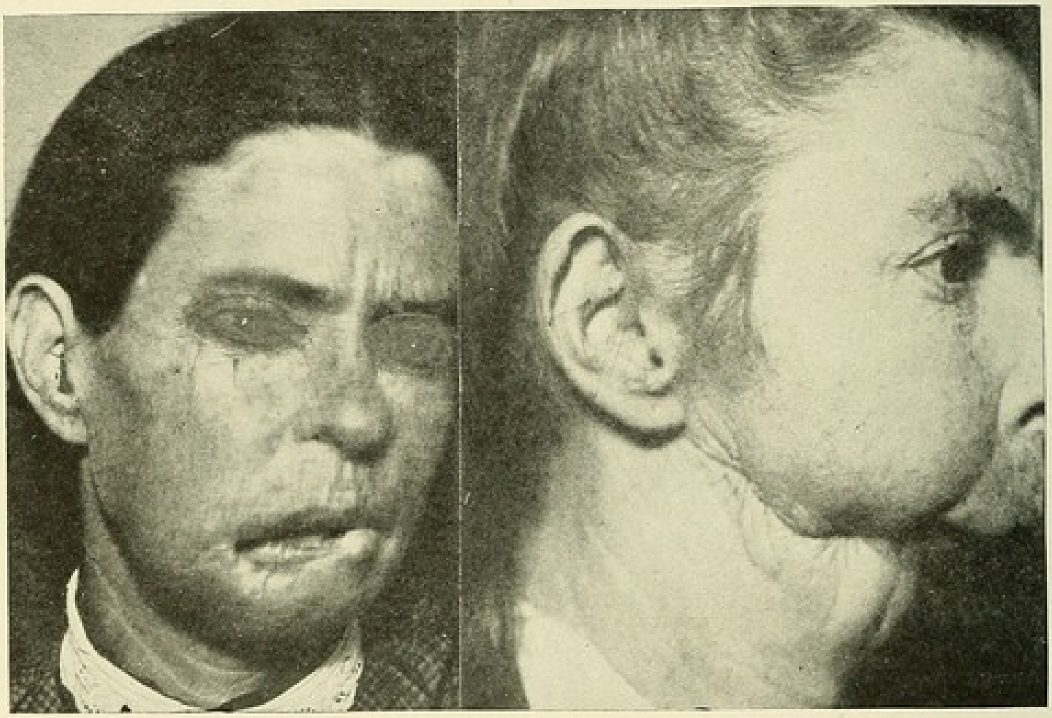


1. 2.

Fig. 125.—Epithelioma of the chin. 1, before the treatment was begun; 2, one year after the patient was dismissed.

of cases on indifferent treatment so long when it is plain to be seen that they are getting worse every day. We know that many physicians are wide-awake and always looking after the welfare of their constituents, but too often they are responsible for these late and dangerous conditions by allowing the victims to put off active treatment until too late.

Fig. 125 illustrates an advanced case of cancer of the chin, in which case radical surgery and the x-ray scored a victory where either alone would have failed. The subject of this illustration had been the rounds that are usually traveled in an effort to find a cheap cure, with the result that he was very much worse for his experience. The case was referred to the author for preliminary x-ray treatment by Doctor W. W. Samuell, of Dallas. After the usual number of exposures he did a very thorough operation, in which much of the soft tissues, a part of the inferior maxillary, and the sublingual and the lymphatic glands of the neck were removed. X-ray treatment was resumed immediately after the operation and continued until the wound had healed. The patient disappeared, and nothing was heard from him for more than a year, when, while on a business trip to Dallas, he called on the author. His condition at that time, as seen in the second picture (2), was sound and well, as far as could be determined.

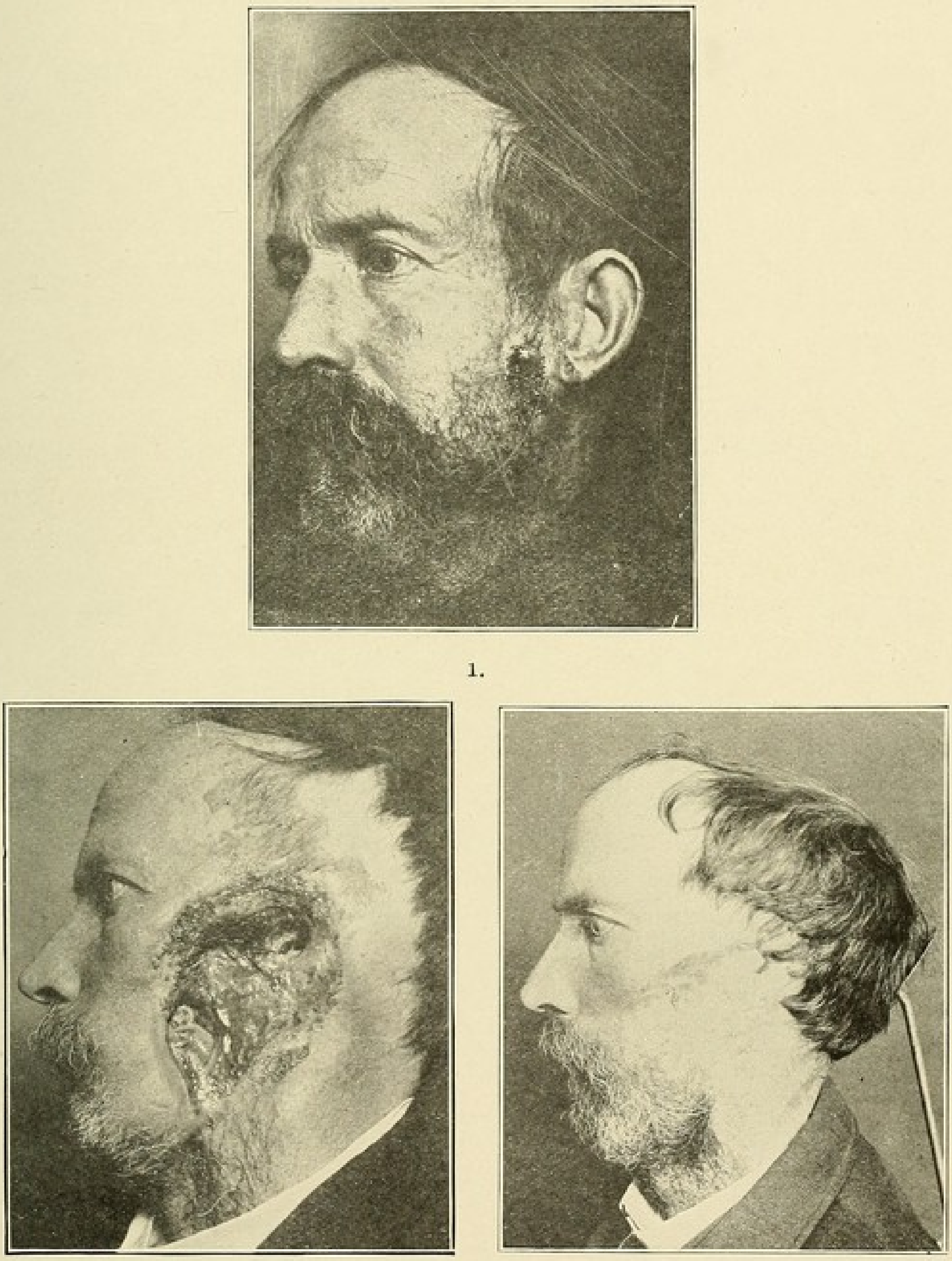


1. 2.

Fig. 126.—Epithelioma of the lower jaw.

Fig. 126 illustrates a case similar to Fig. 125. This woman had been the victim of advertising cancer cures. The illustrations are not very good, but will serve to impress the reader with her desperate condition and the radical means necessary to get the proper results. This case was treated in the same manner as the one described in Fig. 125, the only difference being in the operation, which was more radical. The entire inferior maxillary was removed, and the section was so thorough that it seemed impossible that her face could ever again look like a human face. She made a slow, but uneventful, recovery, and when seen two years later there was no evidence of a return.

The illustrations shown in Fig. 127 (1, 2, 3) represent a



1.

2. 3.

Fig. 127.—Epithelioma of the face. 1, before the operation; 2, soon after the operation (the root of the tongue is seen through the wound in the side of the face); 3, after the wound was skin-grafted and healed.

class of cases that are generally fatal, and due always to neglected treatment. This man was an early victim of plaster methods, which did him a great deal of harm.

When first examined, his condition was that shown in 1. The ulcer was not large, and there was very little induration in the tissues surrounding it. The parotid gland was affected, and on close examination it was found that the inferior maxillary was involved. Radical surgical measures were recommended and accepted. Doctor W. W. Samuell did a very thorough operation, going wide and deep, completely removing everything that looked suspicious, including the inferior maxillary from its articulation down to the angle, making the large ugly wound seen in 2. The operation was followed by x-ray exposures every second day. Nature was kind to this case, and improvement was rapid from the beginning. At a later date the unhealed surface was successfully skin-grafted, leaving the man in a somewhat disfigured, though very respectable, condition. 3 represents his condition more than a year after the operation, and, while it is too early to state definitely that he is cured, his present condition is so favorable that we feel justified in recommending radical measures in meeting this desperate condition. At the worst, it is safe to say that his life will be spared several years, giving him time to accomplish much that he had planned to do for those dependent upon him.

Fig. 128 will bring to the mind of the reader recollections of several similar cases, most of which have died. This man, like most others, had gone the rounds of the advertised cures, refusing operative interference until nothing else could avail. After a careful examination he agreed to return for a thorough operation, but failed to come, and as a result paid the penalty of neglect.

Third Stage.—The third stage of skin cancer is that period of this destructive process after which no cure should be expected, and surely none could be promised from any method or combination of methods of treatment. The growth has progressed for a longer or shorter period, and the tissues are affected far and wide. It is no longer a local affection. All of the surrounding glands are indurated, and the infection has spread to the deeper and more vital organs. The patient begins to lose strength, and the skin takes on a more or less cadaverous hue. These poor sufferers never lose hope, and as long as they are able to travel they are busy in going from place to place, seeking the aid of men in the guise of doctors who are willing to so prostitute themselves as to offer hope as long as a price can be extracted from their victims.

There are in many localities so-called "cancer cures"—some advertising as physicians, and others merely peddling recipes. All of these persons draw their victims mainly from the class of patients who have reached the third stage of the disease, and are "like a drowning man grasping at a straw." These take the treatment because a cure has been promised and in most cases guaranteed. Of course the guarantee is absolutely worthless. The author has

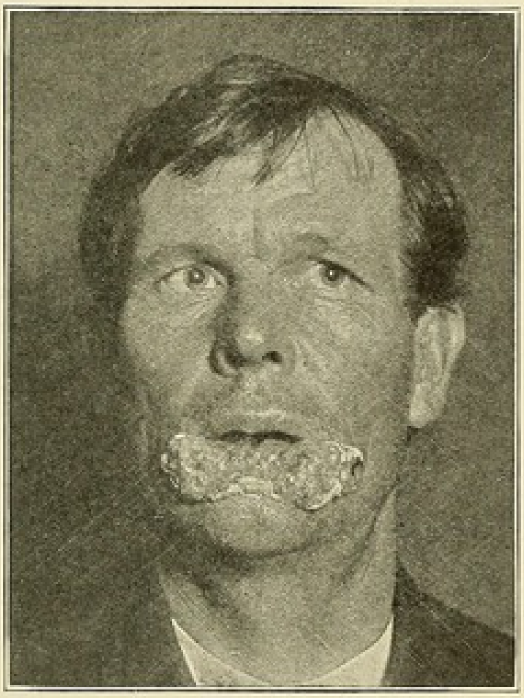


Fig. 128.—Epithelioma of the lower lip.

declined as incurable many cases of third-stage cancer, and learned later that they had been gladly accepted as curable by certain "cancer cures," who, without exception, rushed them to an early grave. The majority of these unfortunates have only a limited supply of this world's goods, and need for actual expenses the little they have. To rob them of the few comforts that might be theirs by increasing their suffering through an inhuman treatment, and at the same time taking their last dollar, is an act to which no physician worthy of the name would stoop. While we can not cure these poor sufferers, we can in many instances add much to their comfort and greatly prolong their lives.

Well-directed x-ray treatment will often produce results little short of wonderful. It may be used in a large majority of incurable cases for temporary relief. All necrotic tissue should be destroyed or removed as rapidly as formed, and the growth carefully cleansed and dressed. If this is thoroughly done, septic absorption and systemic poisoning will, in a great measure, be prevented.

In the third stage of cancer the primary lesion may improve or heal over, but the products of the growth are certain to re-establish

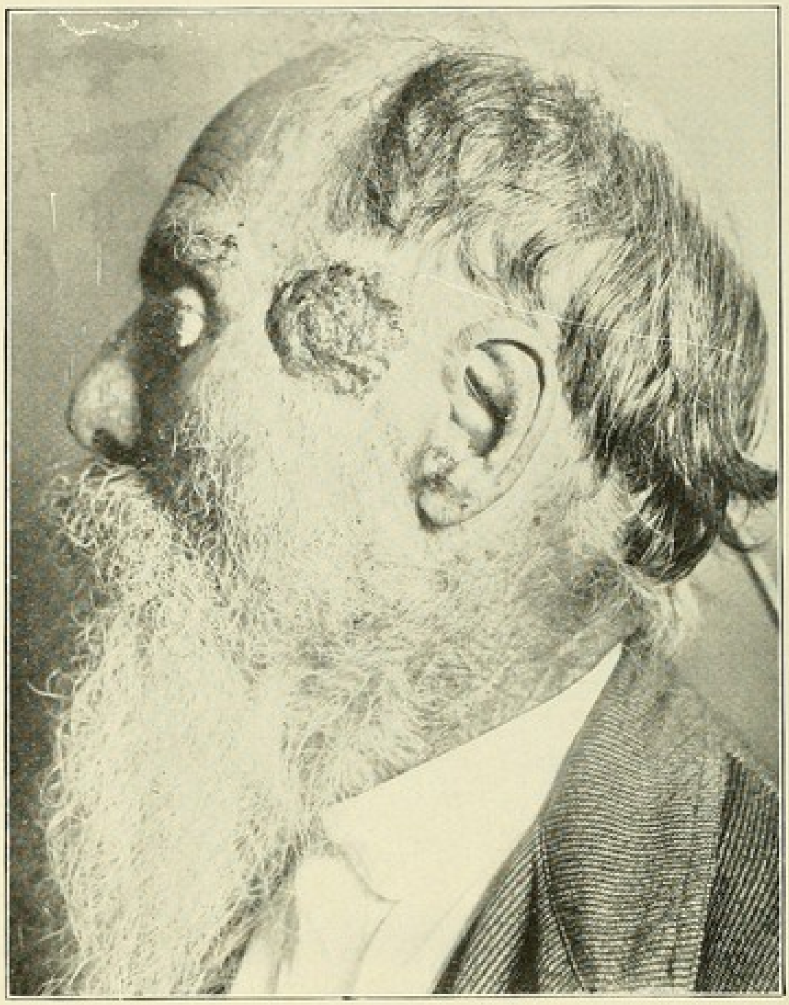


Fig. 129.—Cancerous growth of the eye and temple (third degree).

the disease in other less fortified locations, as in the deeper lymphatic glands and the internal organs. In a case of recurrent cancer of the uterus, x-ray treatment greatly improved the pelvic symptoms, and we were much encouraged, when the patient developed cancer of the stomach and soon died.

The subject shown in Fig. 129 was brought to the author by Doctor Wm. G. Elliott, then of West, Texas. Besides the growth seen on the side of the face, the left eye was a mass of cancerous tissue and his condition was entirely hopeless. He lived only a short time after this visit. Cases of this nature are quite common. Many of them are so far advanced that it is impossible to do anything for them. It is hard to inform a patient that he has waited too long and that nothing can be done to benefit him, but, when such is the case, we are forced to do our plain duty and state the facts.

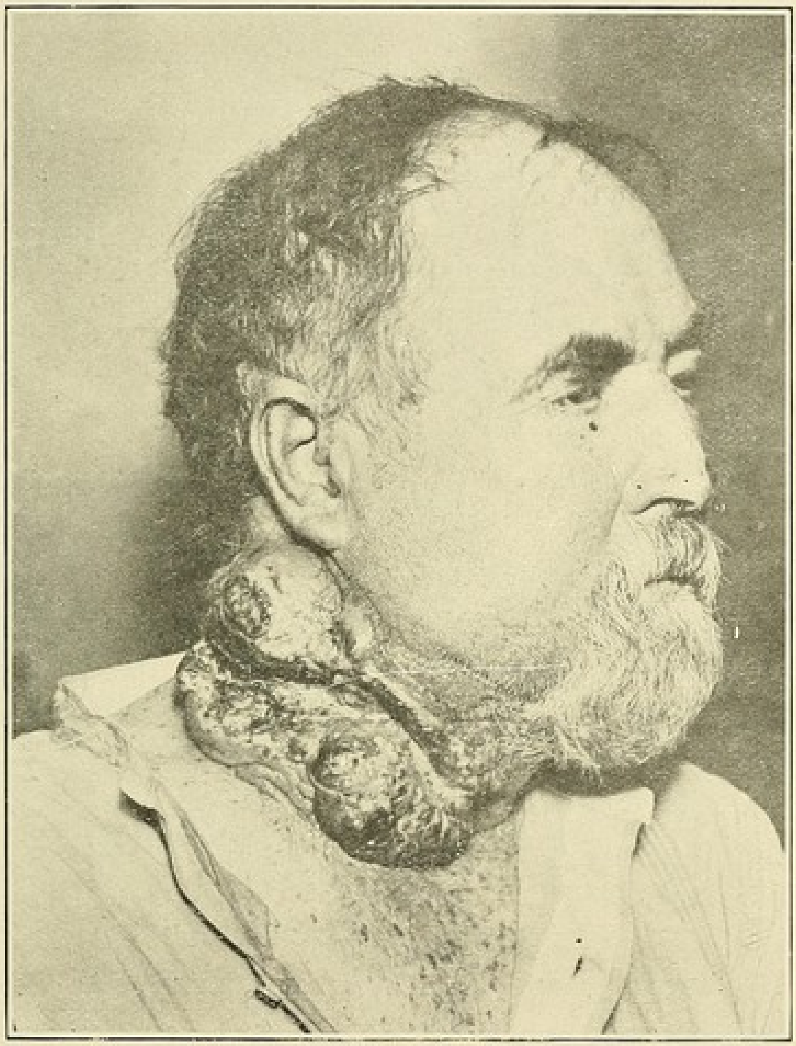
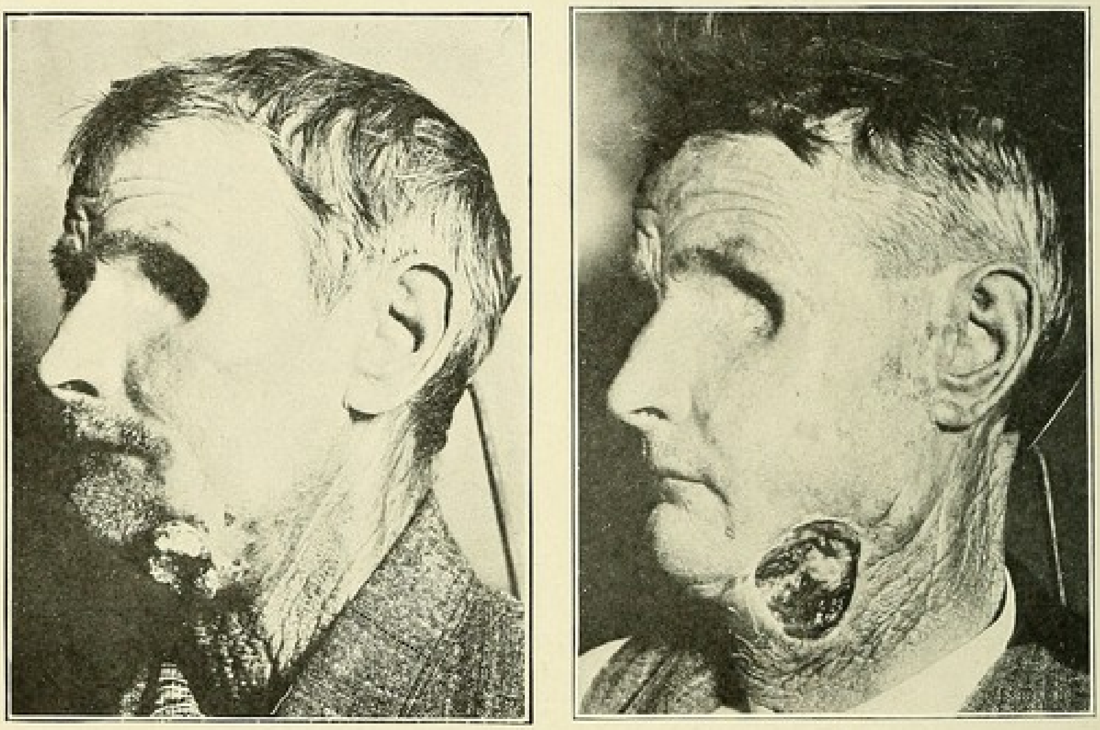


Fig. 130.—Epithelioma of the neck (third degree).

Fig. 130 represents a case of epithelioma of the skin in all of its dreadful manifestations. Shortly before the death of the old gentleman who is the subject of the illustration he wrote the author a long letter, describing in detail all that had transpired from the time the growth was first noticed, as a mere scale on the side of the neck, to the time of writing. The letter would be interesting reading, but it is too lengthy for insertion here, and is a repetition of the experience of every case of the same nature. He gives a minute description of the usual temporary methods of treatment and his journeys from place to place in search of relief or cure, without finding either. This man died a victim of skin cancer, either through his own neglect or because of both the ignorance and neglect of his physician. At the time he was seen his condition was as shown in the illustration. Nothing could be done but to endeavor to relieve his distressed condition, which course was followed. Fortunately he suffered very little pain, and was one of the best patients ever treated by the author. In his letter he took no blame on



1. 2.

Fig. 131.—Epithelioma of the neck (third degree).

himself for his condition, claiming that he had consulted many physicians of reputation at a time when the condition was not alarming, and believed at the time that he was receiving the treatment his case required. He was so broad-minded that he blamed none of the physicians for their failures, as he believed they had treated him according to the best of their knowledge and he met his fate with the stoicism of Zeno.

Fig. 131 represents an interesting case that was fought to the very verge of the grave. 1 represents the appearance of the patient before his second operation. Some years before he had cancer of the left eye, which was removed by Doctor E. H. Cary, of Dallas. The operation was followed by x-ray treatment, and the after-results were all that could have been desired by the most critical. Some years later he received a severe bruise on the left side of the lower jaw, resulting in an ugly ulcer that early took on a malignant appearance, as seen in 1. The greater part of the cancerous tissue was removed and the external carotids were tied. X-ray treatment was continued for some time. All the glands about the neck were affected, and the old gentleman grew worse rapidly. It is evident from the culminating conditions that the operation was not thorough. No vestige of cancerous tissue should be allowed to remain when it can be found, and all glands and chains of glands that are susceptible to being affected must be removed in the initial operation; failing in this, a return may be expected in a very short time. 2 represents this patient's condition some time after the operation. The procedure at the time was according to the best information on the subject, but year by year we have learned in the school of experience that where an operation is necessary in such a case, if attempted at all, it must be thorough.

Cancer of the Breast.—Carcinoma of the breast may occur in either male or female, but is most frequent in the female breast. The author has had considerable and varied experience with every method of treatment in carcinoma of the female breast. Early cases have responded to x-radiation alone, and more advanced cases were treated with surgery or caustic plasters and the x-ray.

The author's preference is in favor of surgery, combined with thorough x-radiation before and after the operation. If the treatment is begun early, and the operation is thorough, followed by well-directed x-ray treatment until the wound has healed, there is little or no danger of a return. The tube should be of medium vacuum, at a distance of about 12 inches from the target to the tissues. The seance should last about ten minutes, and be repeated two or three times a week until slight evidences of a mild dermatitis are noticed, when a rest of two or three weeks should be advised. X-ray treatment should be resumed, if necessary, as soon as the dermatitis disappears. All cases of cancer of the breast requiring extensive operation should be kept under close observation for more than twelve months. In regard to operation, the same is true here as in cancer of the face—the operation is too often a failure, and the second condition is far worse than the first. Many cases of inoperable cancer of the breast may be greatly relieved by x-ray and high-frequency currents. Many cases are very slow to respond to the influence of the x-ray, requiring many months to effect any noticeable degree of improvement.

Carcinoma of the Internal Organs.—The x-ray treatment of cancer of the internal organs can be little more than palliative, though it often affords much relief from pain and increases the strength of the patient. The combined use of the x-ray and high-frequency currents may prolong the lives of these incurable cases for a considerable time.

Carcinoma of the Uterus.—Cancer of the uterus is seldom seen until it is well established and the patient is being weakened from a loss of blood or toxic infection. We would naturally expect very little aid from the x-ray in this class of cases, and yet here is just where we have seen some of our most wonderful results. Few cases have been cured, but most, even of the worst cases, have been greatly benefited and life made tolerable for a long time. At the present time the author is treating a number of incurable cases of carcinoma of the uterus which have been so much improved that the poor victims believe they are getting well because the aggravating symptoms have disappeared and they have gained weight and strength.

These cases are receiving x-ray and high-frequency treatments two and three times a week. The technic consists in making x-ray exposures over the uterus through the abdomen with a high-vacuum tube at a distance of from 12 to 15 inches from the anticathode to the surface of the abdomen, the seances lasting about ten minutes. To prevent the possibility of a dermatitis, the abdomen is covered with a piece of sole leather. When a dermatitis is threatened, the x-ray is discontinued over the abdomen and a series of treatments given with a Cornell tube through the vagina. After six or eight such treatments a vaginal high-frequency glass vacuum electrode is introduced and connected to one side of the x-ray coil. The tube should be low in vacuum and enough current used to fill the tube with a deep violet color. The seance should last about ten minutes and may be repeated every day. Care should be taken not to touch timid patients at such times, as they may become frightened at the shock and large flashes of electricity that leap from every part of the body when touched. This method of applying the high-frequency current has a very palliative effect on weak and nervous patients who suffer from pelvic pains of any character. The author has seen hemorrhage and offensive discharges cease after a few treatments; in fact, the use of the high-frequency current as described has never failed to control a case of uterine hemorrhage resulting from cancer.

Sarcoma.—Sarcoma is not nearly so common as epithelioma. Having its origin in the deeper tissues, it is frequently not recognized until far advanced. As a rule, its development and destructive influence is quite rapid, and, unless checked by active or radical measures, will soon destroy the life of the patient.

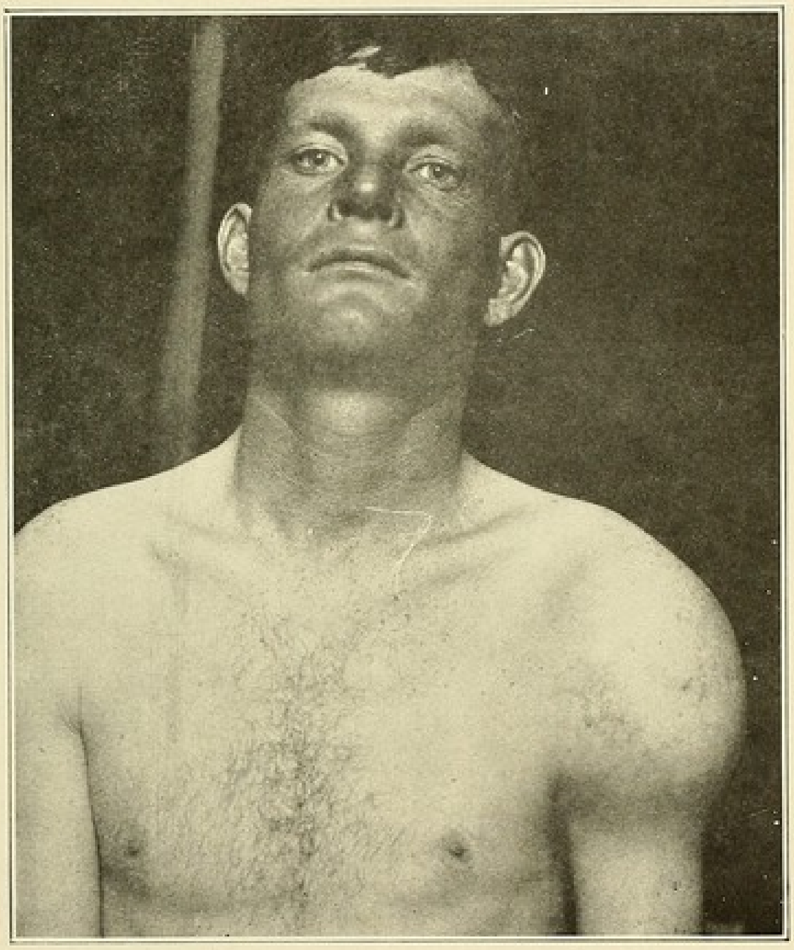


Fig. 132.—Sarcoma of the shoulder of two years' standing.

In the treatment of sarcoma the x-ray has been regarded by some as the most important single remedy. Many of these cases are inoperable, and can be treated with the x-ray and Coley's mixed toxins only as a palliative measure. The author has seen very few cases of sarcoma that were benefited by any method of treatment.

Fig. 132 illustrates a case of advanced sarcoma of the shoulder of more than two years' duration. This man had consulted many physicians and had, no doubt, taken every rheumatic remedy known to medical science without having received the least benefit. The shoulder was skiagraphed on the same day that the photograph was made. At least 3 inches of the upper end of the humerus was completely destroyed and the surrounding tumor was almost as dense as bone. The arm was firmly fixed. He suffered no pain at this time. He was put on Coley's mixed toxins, but grew rapidly worse and soon died. The x-ray was not used, except to make the skiagraph.

Other cases gave, for a time, promise of better results. Fig. 133 is a reproduction from a photograph that the author made of

Fig. 133.—Sarcoma of the right orbit.

a case of sarcoma in a boy 10 years old. This case was referred to the author by Doctor F. J. Hall, who had been consulted for some trouble about the eye. It was found that the right eye-ball was almost fixed and there was some enlargement over the temporal region, but at this time he did not complain of any pain. His first symptoms were double vision. At the time this case received x-ray treatment he had not more than ten degrees of motion in the right eye. The x-ray was pushed to a dark tanning of the skin over the temporal region and a slight degree of dermatitis. By the time the dermatitis had subsided, the enlargement over the temporal region had subsided and double vision, as well as all other symptoms, had disappeared. The improvement was so great that there was a doubt about the diagnosis of sarcoma. About this time the patient was presented at a meeting of the Dallas Medical and Surgical Society, where he was again examined by physicians who had examined him before the treatment was begun. Doctor J. B. Shelmire was of the opinion that the case was one of sarcoma, and that the rapid improvement was remarkable. He seemed to be in the very best of health, and was working every day in one of our large department stores. He continued in splendid health for some time, and neglected to present himself for farther observation until after several weeks, when he came in one day complaining of a severe pain under the right shoulder. In a few days the right eye began to show returning symptoms of the former trouble by the appearance of double vision, a restricted motion in the eye-ball, and some pain. X-ray treatment was resumed over the side of the face. The swelling on the side of the face and the protrusion of the right eye-ball was never so marked as at the beginning of treatment. Instead of improving as before, he rapidly grew worse and in a few weeks was blind and deaf. At times he suffered a great deal of pain, became emaciated, extremely irritable, and was only a shadow of his former self. He lived much longer than seemed possible. The sarcomatous elements gradually pushed their way downward until every function seemed to be interfered with.

If a mistake was made in this case, it was because the diagnosis of sarcoma was doubtful and the treatment was discontinued too soon, and the glands over the side of the neck and chest were not exposed during the early treatment. Judging by the way this case improved at the time treatment was begun, thorough raying of the tissues of the neck and chest might have changed the course of the disease and greatly prolonged his life.

A case of recurrent multiple sarcoma was treated with a good deal of benefit for a long time, but the patient finally succumbed to the effect of the disease in the internal organs. Such cases are inoperable, and, although the x-ray will not cure such conditions, it is the only remedy that can promise any degree of comfort, and should not be refused these poor sufferers who have but a short time to live. Medium vacuum tubes should be used, and the technic is the same as for deep-seated growths. The production of a dermatitis is not necessary.

STUDY OF ANATOMY AND PHYSIOLOGY.

Since the advent of the x-ray and its general adoption by the leading physicians, surgeons, and teachers, many errors in our text books have been brought to light, which have been either discarded or rewritten.

An x-ray study of the cadaver may be made both interesting and instructive by injecting the various organs with substances opaque to the rays. By carefully injecting the veins and arteries with different materials, as concentrated emulsions of bismuth and red oxid of lead, the position and relation of these vessels to each other may be studied with a great deal of interest. Single organs or parts of organs may be treated in the same manner, as the stomach, kidney, liver, spleen, heart, etc. It is understood, of course, that the two substances used must be of different densities, in order that a clear differentiation may be made between the veins and the arteries. The lungs may be injected in the same way as the blood vessels, using either of the solutions mentioned.

The skiagraphic study of the bony skeleton from infancy, year by year, to the age of 25 has been of immense value, and has greatly changed some of our views on the growth and development of the bones. During the early stages of bone formation the cartilaginous portion makes no shadow in an x-ray skiagraph, but as ossification progresses every step may be noted and studied. Slight injuries, as in the epiphysis of the long bones, may be diagnosed from a skiagraph at a very early date. Joint injuries have always been the source of a great deal of worry to the physician, as well as discomfort and deformity to the patient.

Fractures, sprains, and bruises about the joints often result badly under the very best treatment. Failure to recognize the exact condition at the outset is responsible for more than 90 percent of the stiff joints resulting from traumatism. Deformities from unreduced fractures constitute a large percentage of the cripples of our country.

In repairing a fracture, nature throws out a material that later becomes as dense as the injured bone. Soon after the injury this exudate begins to ossify until a dense callus is formed around the ends of the fragments, whether they are well in apposition or not. Where bones do not unite in a reasonable time after the injury, very little exudate or callus is formed about the fragments.

Fractures of any consequence in the bones of adults will show marked evidence of the fact for many years, and in most cases as long as the patient lives. This is an important fact in determining the extent of an injury at the point of an old fracture. Unscrupulous characters have been known to claim a second fracture soon after the first injury had united when, as a matter of fact, there had never been a union after the first fracture, as evidenced by a lack of callus about the ends of the bones. These people frequently make journeys on railroads and other public conveyances for the purpose of claiming a second injury as a basis for a damage suit. Carefully made skiagraphs will clear up the facts in these cases and place the responsibility where it justly belongs.

Fractures near the joints are frequently complicated by dislocations that can not be made out by any other method than the skiagraph. Such cases may require several x-ray examinations at different times to determine the condition of affairs and give the patient the very best possible result.

In the examination and treatment of fractures, the fluoroscope is not to be relied upon. The injured part should be carefully skiagraphed before an attempt is made to reduce the fracture, as only by this means is it possible to determine the exact condition of affairs—whether there be a simple fracture or one complicated with fragments, displacements, and dislocations. After the reduction, or attempted reduction, a second skiagraph will show the progress made, and will guide the careful physician in his advice and after-treatment. Skiagraphs of this kind should be shown and thoroughly explained to the patient, and copies, with all of the details of the case, filed away for future reference in case damage proceedings are brought against the attending physicians.

DISEASES OF THE BONES AND JOINTS.

Most diseased conditions of the bones may be determined by well-made skiagraphs. Anything that interferes with the density of the bones or the tissues surrounding the bones will show such changes in the skiagraph. Osteitis, periostitis, hypertrophy of the bones, and inflammatory changes in the bone structure, as well as destructive changes about the joints, are among the conditions that may be revealed with the x-ray.

The differential diagnosis of the several bone diseases from fractures and callus formation is not always an easy matter. The symptoms and history of the case will usually furnish sufficient aid to clear up the diagnosis.

As the quality of x-ray apparatus and skiagraphic technic improves, tissue delineations will become more distinct. The time is not far distant when many deep tissue changes in the soft parts will be revealed by means of the skiagraph. The advances in this line of work during the past twelve months have been wonderful. With the improvement in x-ray generators, vacuum tubes, dry plates, and technic in developing, vast improvement in the finished negative may be expected, which, of course, means more accurate diagnosis and better final results.

CHAPTER XVI.

X-RAY IN FRACTURES AND DISLOCATIONS.

The author believes that all cases of fractures and dislocations should be skiagraphed at the earliest possible moment. The skiagraph will reveal the extent of the injury, and will make possible an intelligent conduct of the case. After the permanent dressing is applied, the injured member should be reskiagraphed. Since aluminum offers very little resistance to the x-rays, metal splints should always be made of this material. Brass and copper absorb the rays, and should never be used for splints where skiagraphs are to be made. Plaster of paris is a very popular dressing, and meets with no objection from the x-ray operator, as good skiagraphs may be made through the heaviest casts.

FRACTURES AND DISLOCATIONS OF THE UPPER EXTREMITIES.

Hand.—In the treatment of fractures and dislocations in the hand it is possible for the experienced operator to make a very satisfactory diagnosis of the condition with the fluoroscope, but because of the necessary exposure to the rays he is seldom, if ever, justified in taking the risk. Frequently the physician accompanying the case wishes to look at the injury, and there is no reason why he should not where he examines only an occasional case, but, unless he has had considerable experience, he is not likely to arrive at the true condition. A skiagraph should always be made where it is possible to do so, as this is the only means by which the true state of affairs can be determined.

Making the Skiagraph.—The plate should be large enough to take in the whole hand. After being placed in the envelope while in the dark room, the plate is placed film side up on a table, and the patient is seated so as to rest the hand upon the plate and the forearm upon the table. The tube is arranged with its long axis parallel with the table, and the target directly over the center of the hand and about 20 inches above it. The tube should be quite low, and the exposure will range from one to twenty seconds, depending upon the kind of generator used. The position of the hand upon the plate will depend upon the condition and the evidence required. Anteroposterior and lateral views may be taken, as required. The fingers may be skiagraphed separately in any position. Fractures and dislocations in the phalanges are quite common. The develop-

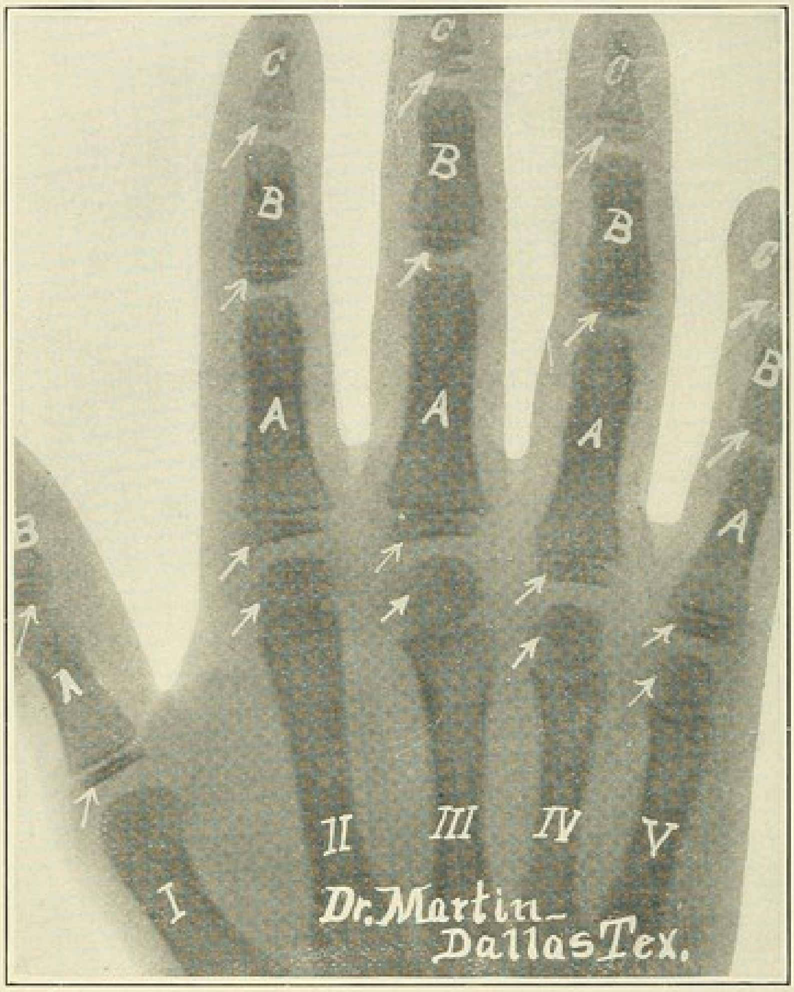


Fig. 134.—Skiagraph of the hand of an 8-year old child.

ment of the bones in the hand should be carefully studied, that no mistakes may be made in studying the skiagraphs of this member.

Fig. 134 is a reproduction from a skiagraph of the hand of an 8-year old child. Note the difference in the epiphyses of the first and the other four metacarpal bones. One not familiar with the appearance of the epiphyses of the metacarpal and phalangeal bones of the hand might mistake them for fractures. This is also true of the epiphyses of other bones during childhood and early adult life.

If space allowed, the author would like to show by means of skiagraphs the changes that take place in the joints each year from infancy to 25 years. No time can be considered lost that is devoted to a careful study of the normal relation of the bones during their growth and development. The bones of the hand are frequently injured, which often results in ugly deformities. Reduction of

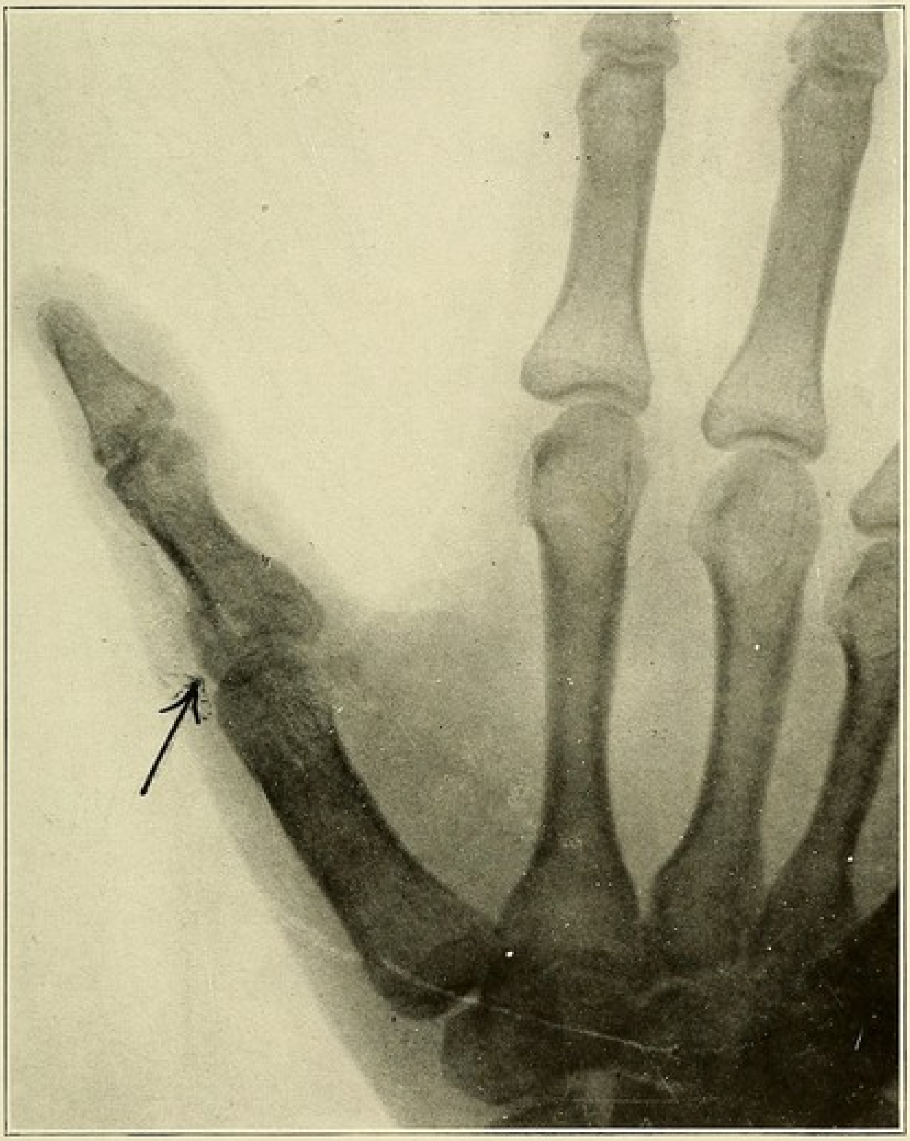


Fig. 135.—Fracture and slight displacement of the first phalangeal bone of the thumb.

fractures and dislocations in the carpal and phalangeal bones are often followed by bad functional results. It is often difficult to keep the fragments in position after reduction has been accomplished and the bandage applied. To make sure that the work has been well done, careful skiagraphs should be made before and after reduction in all hand injuries, and it will be surprising how many dressings will have to be removed and how many times the work be done over. Fig. 135 illustrates this point better than any word picture. The skiagraph was made from the hand of a young lady who had been devoting a great deal of her time to piano practice, and was very anxious that her injured thumb might be restored to its normal shape and function. It was treated without an x-ray examination, with the assurance that it would be all right with a little use to overcome the stiffness. The stiffness did not disappear, and she called on a physician who had an x-ray machine. He told her that her thumb was dislocated, but that he could put it back without hurting her. She was not satisfied with his attempt, and on the advice of her family physician she called on the author. The skiagraph plainly shows a fracture and slight displacement of the first phalangeal bone. Compared with a normal joint of the same finger, as seen in Fig. 137, the diagnosis is easily made. The knowledge came, however, too late, for the skiagraph was made several weeks after the injury and the joint was firmly fixed. Similar examples might be shown of every bone in the hand, but the lesson is the same, and should be remembered by every physician who is called upon to treat injuries to the bones of this member. This young lady's musical career is forever ruined simply because she had an unrecognized fracture, giving her a stiff thumb for life. Cases of this kind are difficult to manage, for patients can not understand the necessity of an x-ray examination for such simple injuries, and think that any physician should know enough to reduce them unaided.

Dislocations and fractures in the bones of the wrist are quite common, and are frequently accompanied by ugly deformities and lost function. The carpal bone most frequently injured is the scaphoid. Fig. 136 is a reproduction from a skiagraph of a wrist in which the scaphoid is fractured at its middle and weakest point. This fracture was unrecognized at the time of the injury, and the wrist was treated for a sprain. The styloid process of the ulna was fractured and displaced at the same time the scaphoid was fractured. Fractures of the scaphoid are very difficult to recognize by fluoroscopic examination, as the bone is generally broken obliquely and the line of fracture is not clearly seen with the fluoroscope. The well-timed skiagraph will seldom, if ever, fail to reveal these injuries, no matter how slight the line of separation may be.

Some time ago a physician brought his daughter to the laboratory with an injured wrist. After a careful and painstaking fluoroscopic examination it was decided that the trouble was due to a sprain. The author was not, however, satisfied with that diagnosis from the symptoms that she presented, and concluded to make a skiagraph of the wrist. When the plate was developed it revealed

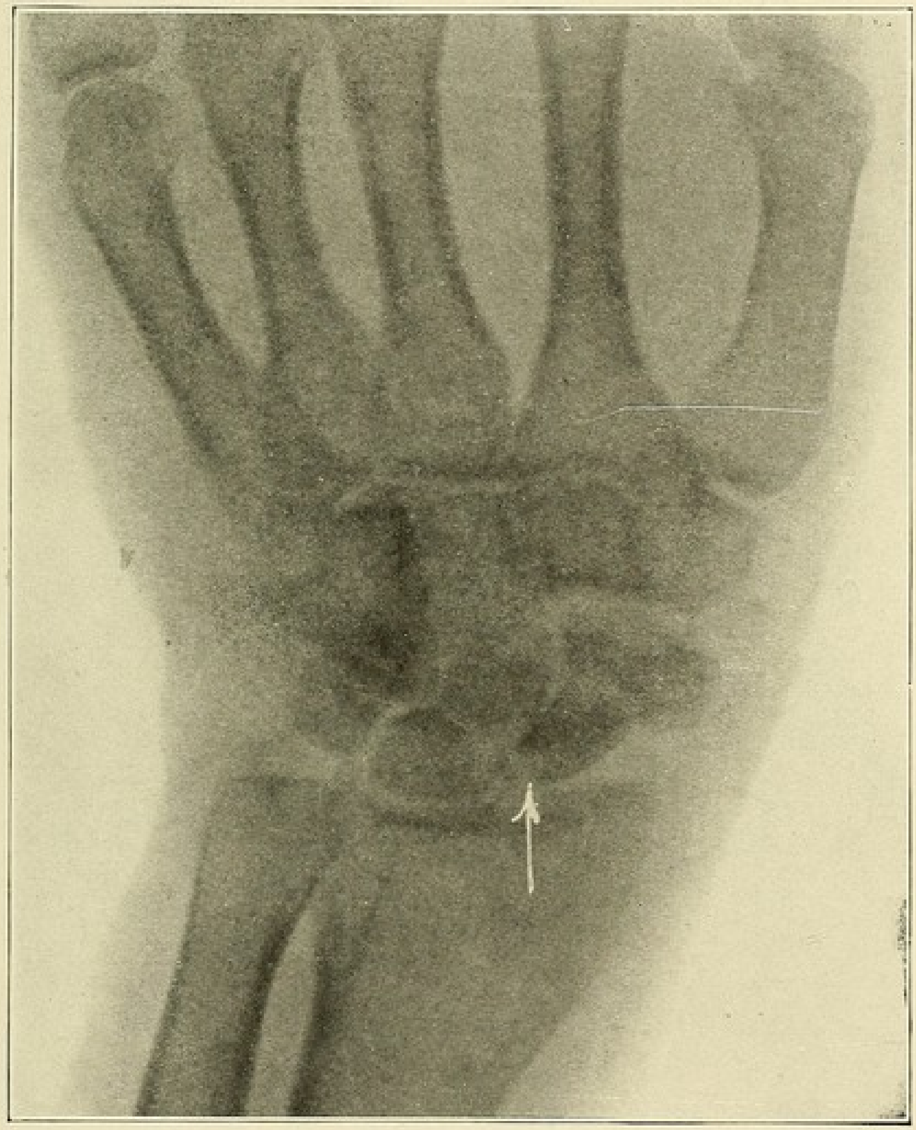


Fig. 136.—Fracture of the scaphoid.

a clearly marked fracture of the scaphoid near its middle. This fact explained why her wrist had been so slow in recovering from the injury. Most delayed recoveries from injuries to the wrist are due to fractures of one or more bones. Only by means of the skiagraph can these obscure injuries be revealed. The use of the fluoroscope should be discouraged, as it can not always be depended upon, even in the hands of careful observers.

Fig. 137 is a skiagraph of a normal hand and wrist of an adult. The epiphyseal unions are complete and the joints and bones are

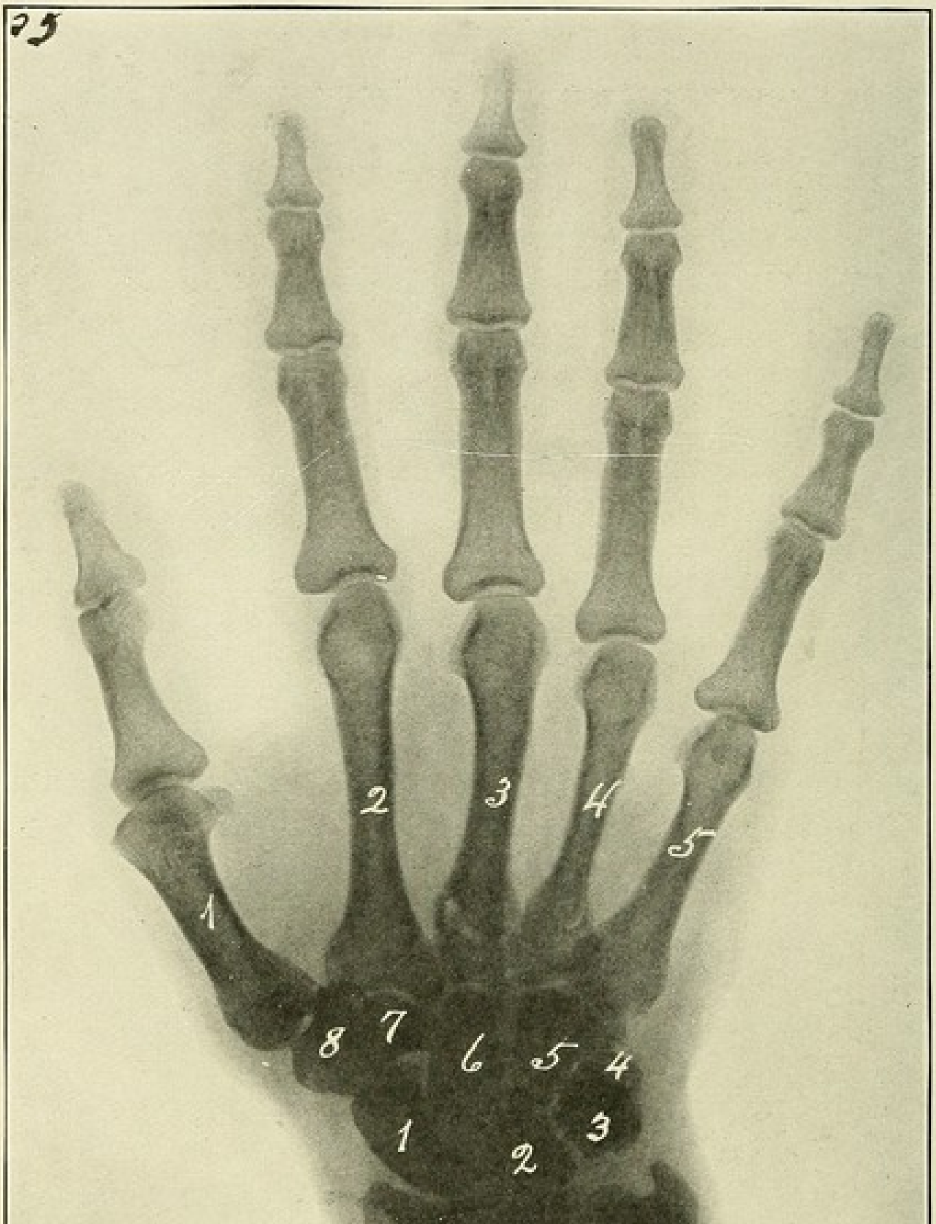


Fig. 137.—Normal adult hand and wrist.

well formed, and may be used as a guide in studying dislocations and fractures in the bones of the hand. This skiagraph was given two seconds' exposure to a medium low vacuum tube, using the electrolytic interrupter, with 25 amperes in the primary and 5 milliamperes in the tube circuit. The plate was developed with the formula given in Chapter XIII. The time was about right for the hand, but slightly too short for the wrist and larger bones; another second would have been better, but would have overexposed the hand.

Fractures and displacements in the carpal bones are generally accompanied by fractures in either the end of the radius or ulna, and often in both. Fig. 138 shows a skiagraph of an ugly and very

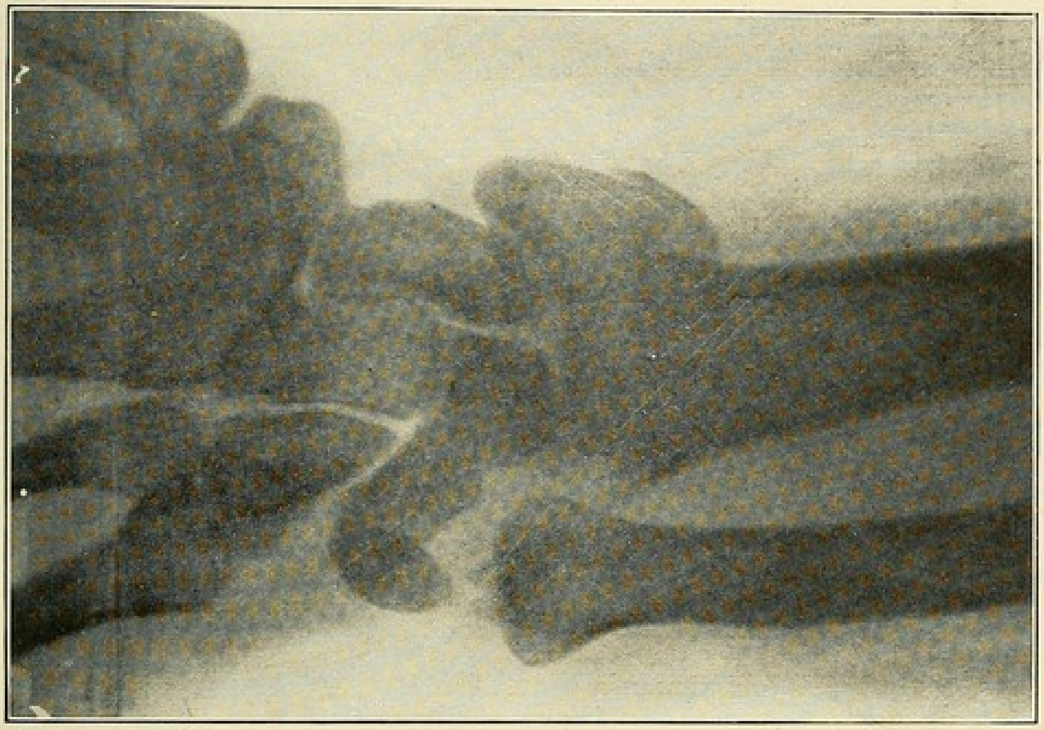


Fig. 138.—Displacement of the carpal bones and fracture of the articular surface of the radius (Colles' fracture).

difficult displacement of the carpal bones, as well as a fracture of the articular surface of the radius (Colles' fracture). Injuries of this kind should always be skiagraphed before reduction is attempted. No physician who cares anything for his reputation can afford to treat a case of this kind blindly, as the results will be bad enough after the very best treatment in the hands of an expert in the handling of bone injuries.

Fig. 139 shows a dislocation at the wrist and a fracture of the radius, with the fragment on the dorsal surface. This was a neglected injury, and was seen several weeks after the accident. It will be noticed that this is a very difficult fracture to reduce because the fragment from the radius is displaced to its upper surface and the end of the radius is left in the shape of a wedge. An early recognition of the exact condition in this injury might have changed

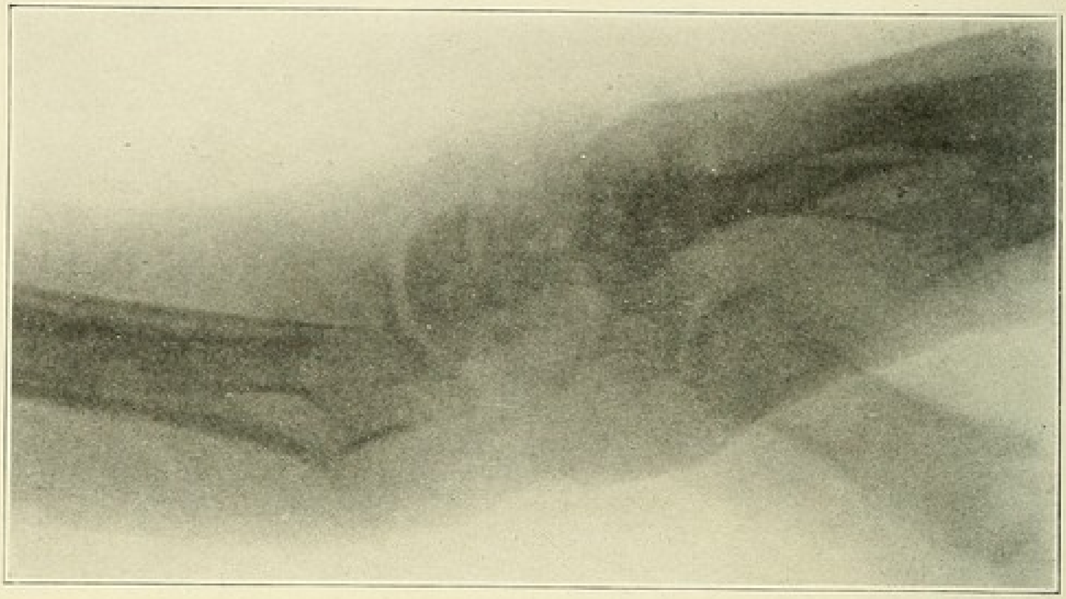


Fig. 139.—Lateral view of a fracture and dislocation of the lower end of the radius.

the results materially, and made this woman a useful wrist; but, as it now is, she has an ugly deformity, with a stiff wrist that greatly impairs the use of the hand.

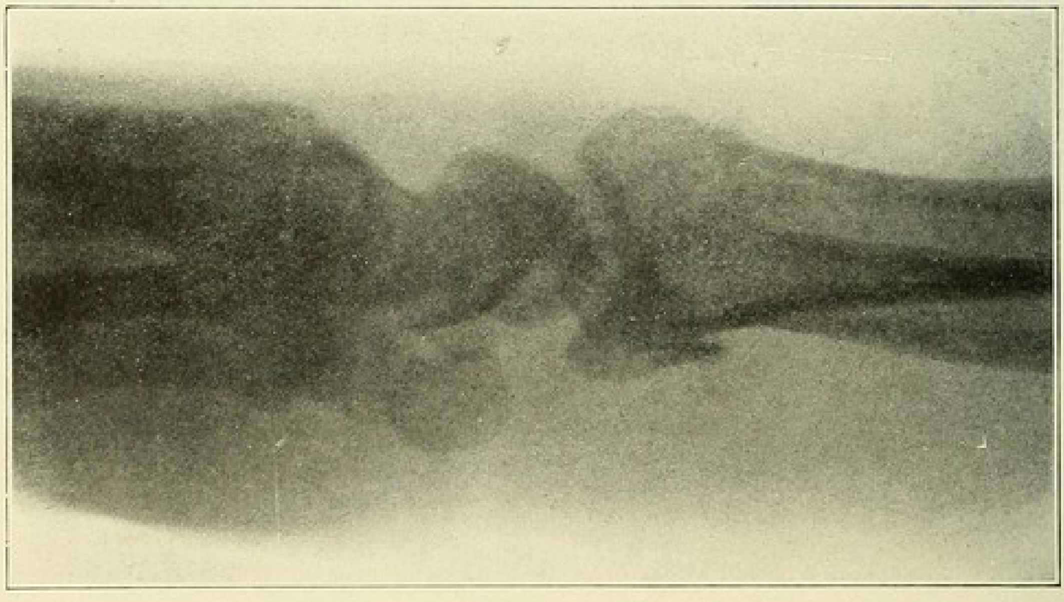


Fig. 140.—Small fracture on the palmar side of the lower end of the radius.

Fig. 140 shows a slight fracture on the palmar side of the lower end of the radius. The fragment is only slightly displaced, and, if properly treated, there should be no loss of function in either the wrist or hand. Unrecognized and carelessly treated, considerable trouble might result from a fracture of no greater consequence. Many skiagraphs of interesting cases showing dislocations and fractures in the wrist might be introduced, but space forbids the use of

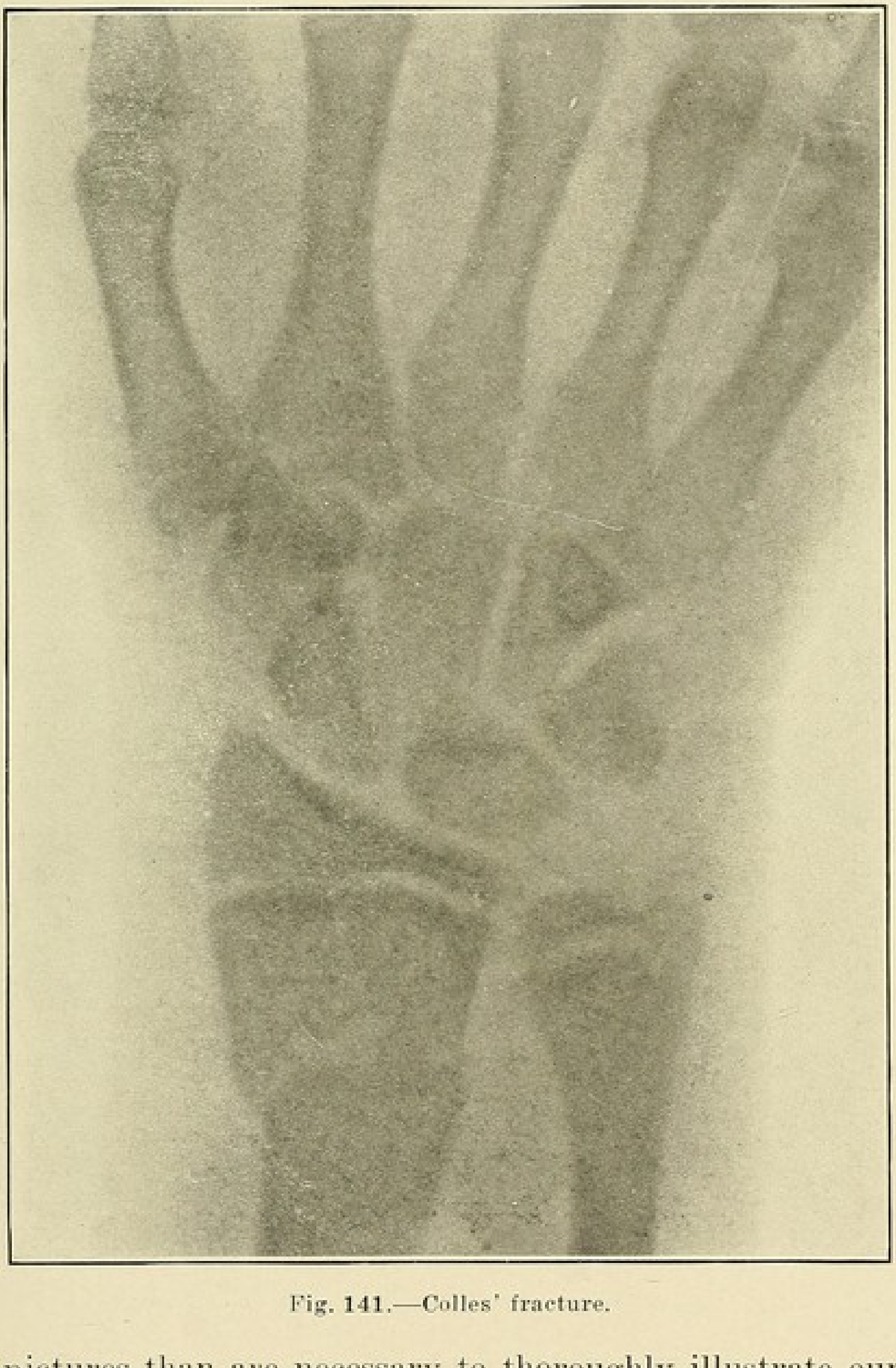


Fig. 141.—Colles' fracture.

more pictures than are necessary to thoroughly illustrate our text. Wrist injuries are extremely important, and come next to the elbow in point of interest. Where there is the least doubt as to the exact state of affairs, the x-ray will settle the question.

Fractures of the radius near the wrist (Colles' fractures) are very common, and are very seldom complicated by displacement and fractures in the carpal bones, as seen in Fig. 138. Fig. 141 is a typical Colles' fracture, in which the main fracture is a transverse

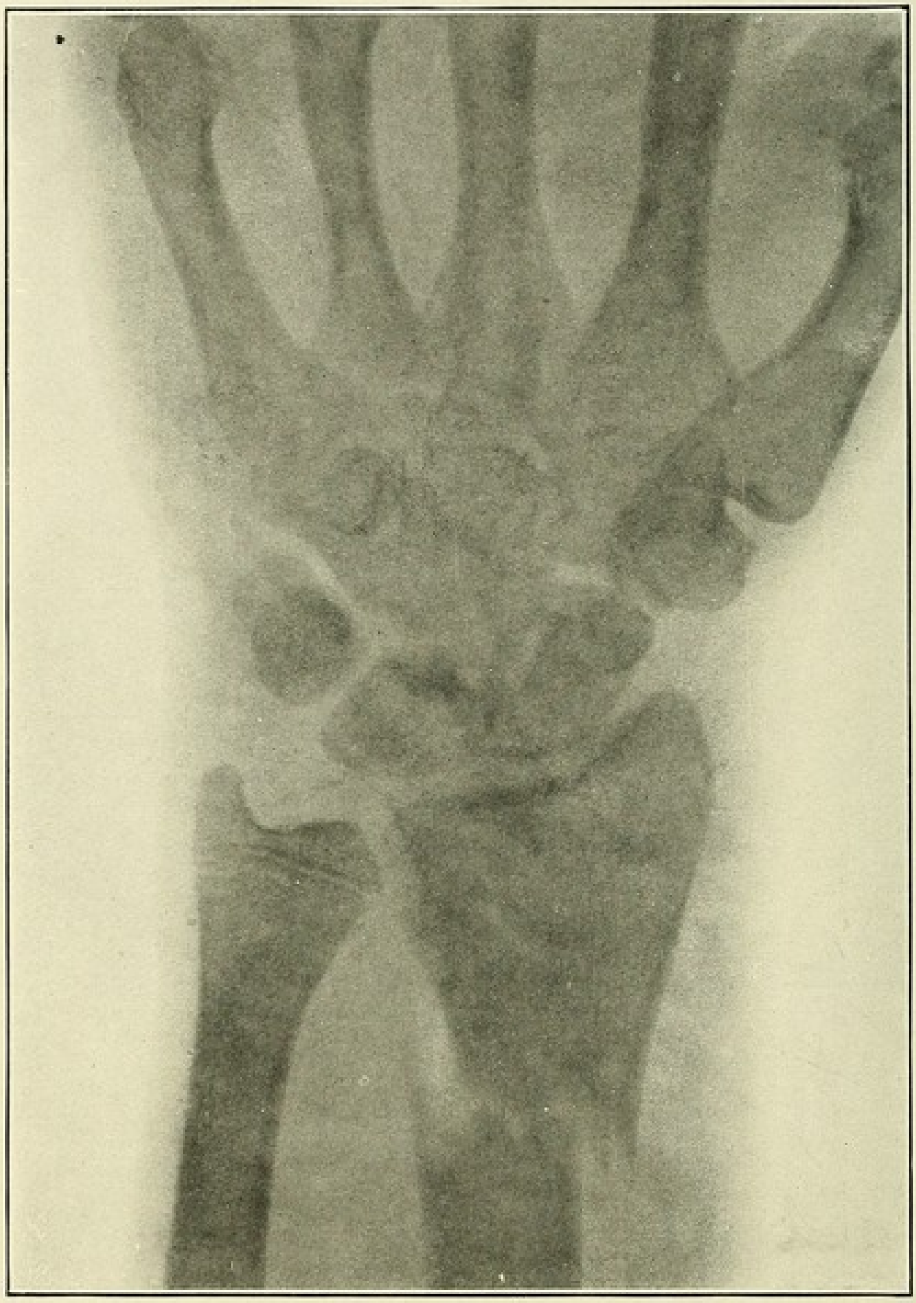


Fig. 142.—Fracture of the radius two inches from the wrist.

break in the radius, slightly more than 1 inch above the wrist. The styloid process of the ulna is also fractured. The epiphyseal lines are well marked, indicating the youth of the patient. In these cases it seems that the line of injury would be at the epiphyseal line, where a displacement of the epiphysis would take place, but such an occurrence seldom happens. In only a few of the many cases of fracture of the lower end of the radius in the youth seen by the author were there displacements of the epiphyses.

In Fig. 142 the radius is fractured about 2 inches above its lower articular surface. This patient was 18 years old, and the radial-epiphyseal line was almost obliterated, while the epiphyseal line in

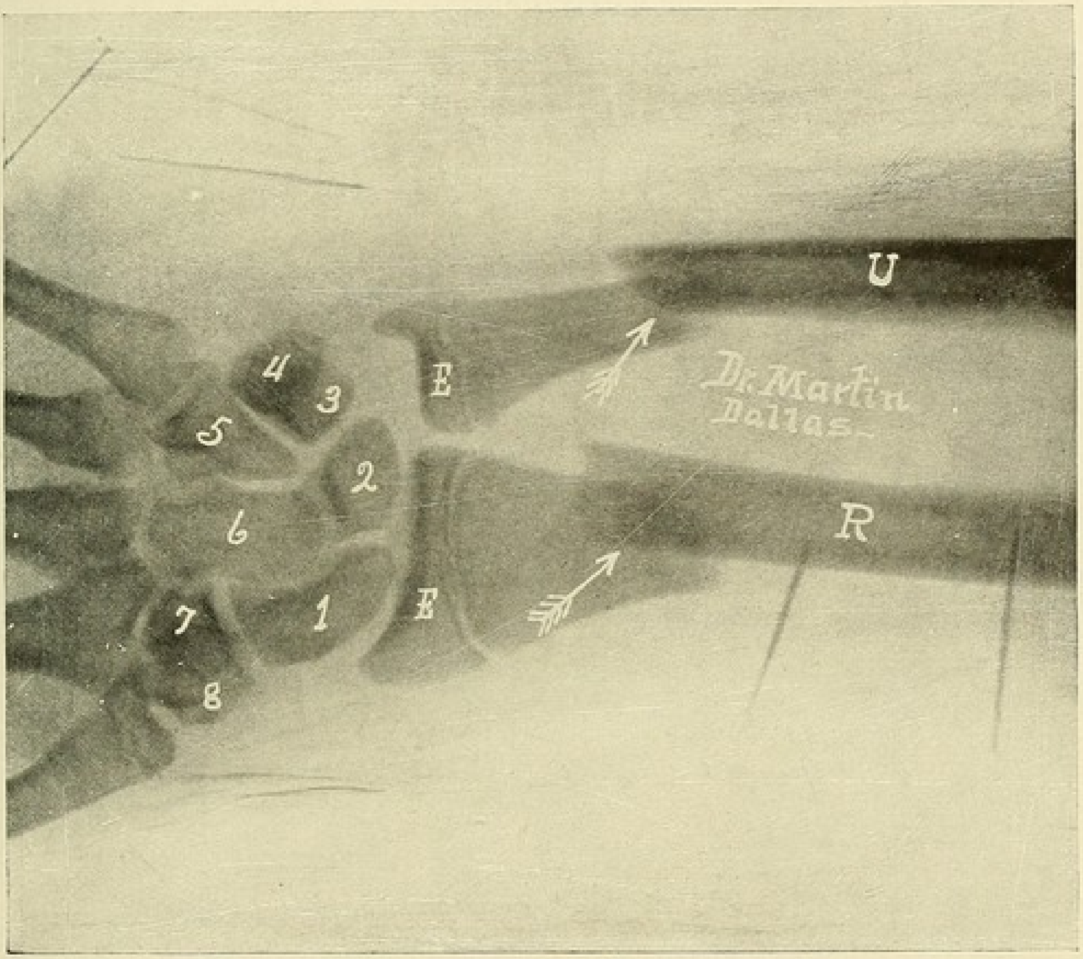


Fig. 143.—Fracture of the ulna and radius near the wrist.

the ulna was quite distinct. This arm had been injured two weeks before it was skiagraphed, and it would not have been skiagraphed then had it not been for the constant and severe pain that the patient was experiencing. There was no external evidence of the injury.

Fig. 143 is a skiagraph made of the wrist and lower ends of the ulna and radius of a young man between 16 and 17 years old. The fracture was the result of a fall while skating on roller skates.

The physician in charge had made little attempt to reduce the injury because he was not sure of the extent of the fracture. The other arm had been fractured about the same place and grossly neglected,

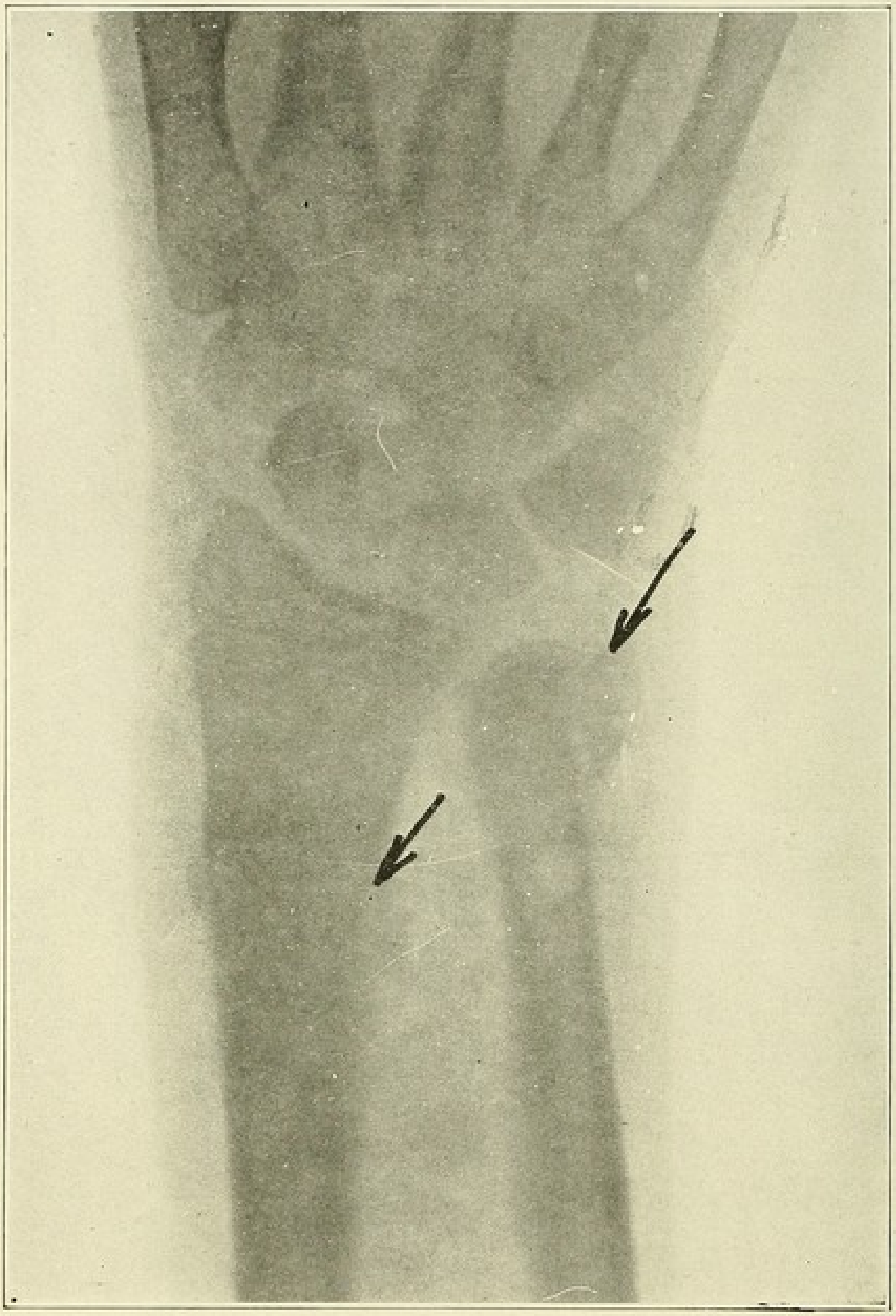


Fig. 144.—Fracture of the radius two inches above the wrist and the ulna at the epiphysis, or rather a dislocation of the epiphyseal end of the ulna.

resulting in a deformed and almost useless member. The fractures were reduced and a permanent dressing was applied while the patient was at the laboratory, after which another examination was made with the x-ray, when the bones were found to be in exact apposition. The final result was excellent, the arm being as strong and the function as perfect as before the accident.

Fig. 144 shows a fracture in both the radius and ulna. There is a slight bend in the radius at the point of fracture, with no displacement, while the fractured end of the ulna is completely displaced. Injuries of this kind are difficult to diagnose without a skiagraph. Unless the displacement of the bones is overcome, there will be a permanent deformity, with a considerable loss of function in the wrist and hand. Most of these cases are referred for fluoroscopic examination, as they are unwilling to pay for a

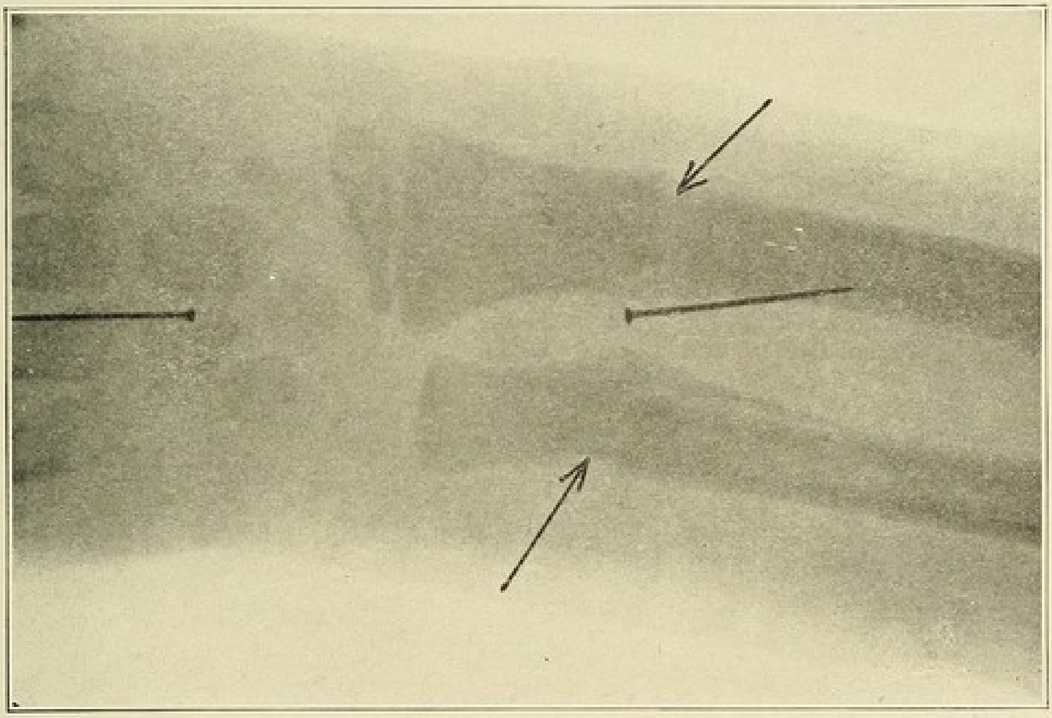


Fig. 145.—Greenstick fracture in both radius and ulna, with very little displacement.

skiagraph, but a skiagraph is always necessary if a positive diagnosis is to be made. The medical profession is beginning to recognize the absolute necessity of skiagraphic aids in the diagnosis of all fractures, whether in or near the joints or in the long bones.

Fig. 145 illustrates a case very similar to Fig. 144. Both radius and ulna sustained a greenstick fracture at the same point. The child was about 6 years old. The skiagraph was made several weeks after the injury. There was quite a little periosteal thickening on the radial side of the ulna, and the same was true to a slight degree on the ulnar side of the radius. In this case there was a difference of opinion as to whether a fracture had been sustained. There are very few really typical greenstick fractures. The bone is generally broken, and the fragments are held in position only by the periosteum. Injuries of this nature, when difficult to diagnose, should be skiagraphed before any attempt is made to reduce the fracture. This course is made necessary because it is simply impossible for the most careful observer and diagnostician to be absolutely certain of the exact state of affairs in a fracture at the lower ends of the ulna and radius. All of the cases mentioned had been treated for from one to four weeks before they were skiagraphed. They were in charge of excellent physicians, who were anxious to get the very best possible results. These cases well illustrate the absolute impossibility of correctly diagnosing and reducing these fractures, even by our ablest men, short of skiagraphic aids. Had these cases been skiagraphed for a diagnosis, reduced, and reskiagraphed a number of times, if necessary, the results in at least some would have been far different.

The time is near when every fracture or suspected fracture will be skiagraphed before a diagnosis, even in simple fractures, is ventured. The uncertain work of the past must give way to modern and more accurate methods.

Forearm.—Fractures in either the ulna or radius, or in both, are likely to occur at any point from the wrist to the elbow. These injuries may be examined and studied under the fluoroscope, but the well-made skiagraph will be of greater value, and should always be made where the physician and patient are anxious to get the very best results. There is often a difference of opinion as to the position in which a fractured forearm should be placed. Fig. 146 is a skiagraph of a fractured forearm that is a splendid example of the wrong position in a fracture of this nature. This fracture was near the middle of the ulna and radius. The arm was placed in a supine position, with the result seen in the picture. The arm was turned midway between supination and pronation, when the fracture was easily reduced with good result. Had the arm been left in extreme supination, the deformity and lost function in the arm would have been great. After the reduction and a plaster of paris dressing had been applied, a second x-ray examination showed the bones in splendid apposition.

In skiagraphing injuries of this kind an 8x10 plate should be used, and two exposures, one at right angles to the other, should be made. This will reveal the amount of displacement in either direction. One exposure is not enough, as the fragments may be in such a position that they appear in good apposition when there is a displacement parallel with the rays of more than ½ inch, or the full thickness of the bone. A second skiagraph, as stated, will prevent such a mistake. Hardly a day passes that the author does not see one or more cases of neglected bone injuries that might have had a different ending had they been properly skiagraphed at a time when reduction was possible.

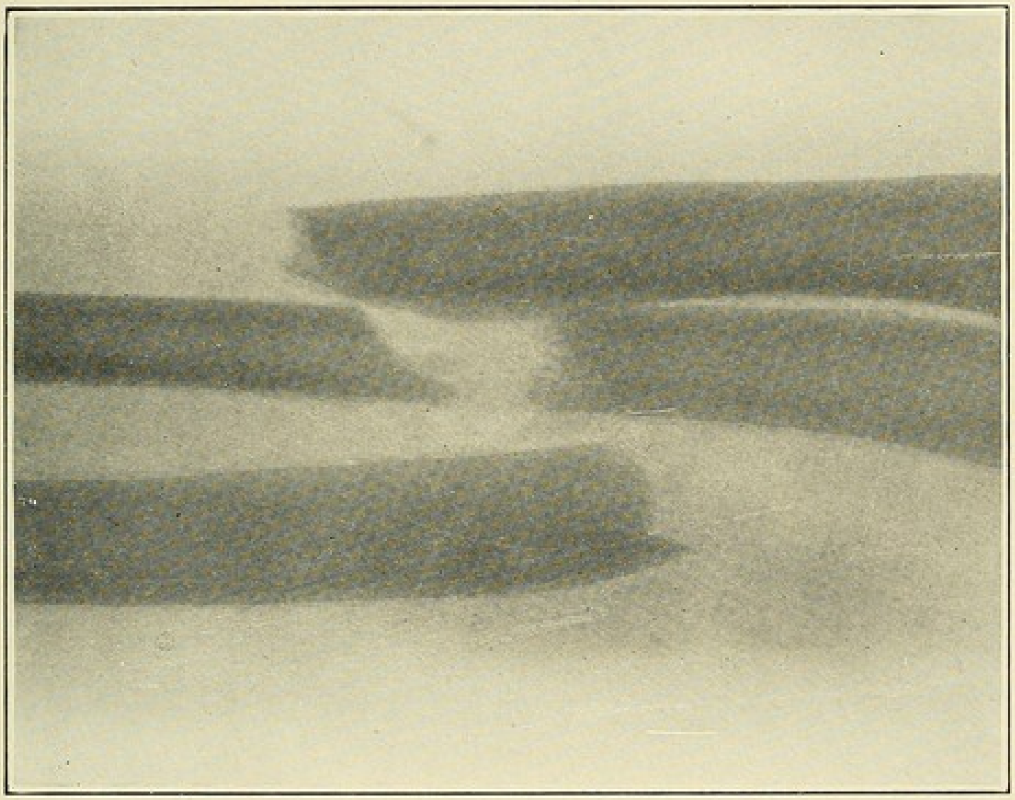
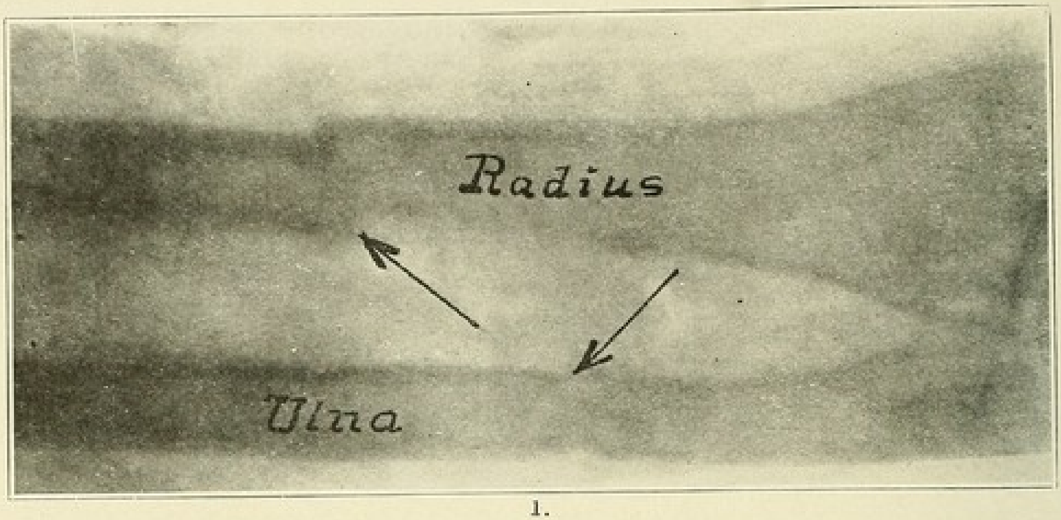


Fig. 146.—Wrong position of fractured forearm.

Fig. 147 (1, 2, 3) pictures a case that was interesting in the extreme. The radial fracture shows no displacement, but the displacement in the ulna was great. This case had been treated some weeks before the skiagraphs were made. The arm had been examined with the fluoroscope when it was in the condition seen in 1 and pronounced all right. This case was referred to the author by an excellent surgeon for a skiagraph. The patient was placed under an anesthetic, and every effort was made to reduce the displacement in the ulna. It was believed that the bones were in perfect apposition, a heavy plaster of paris dressing was applied,



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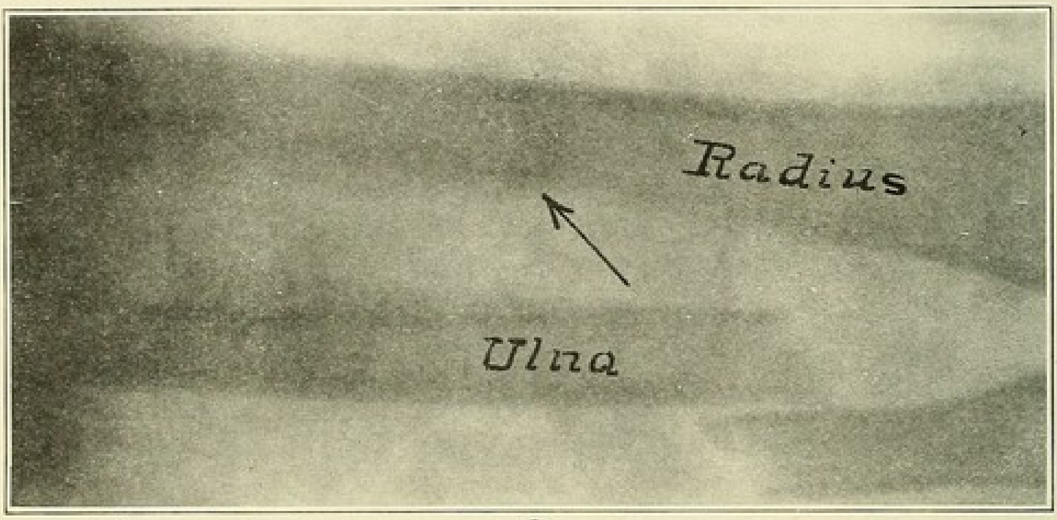

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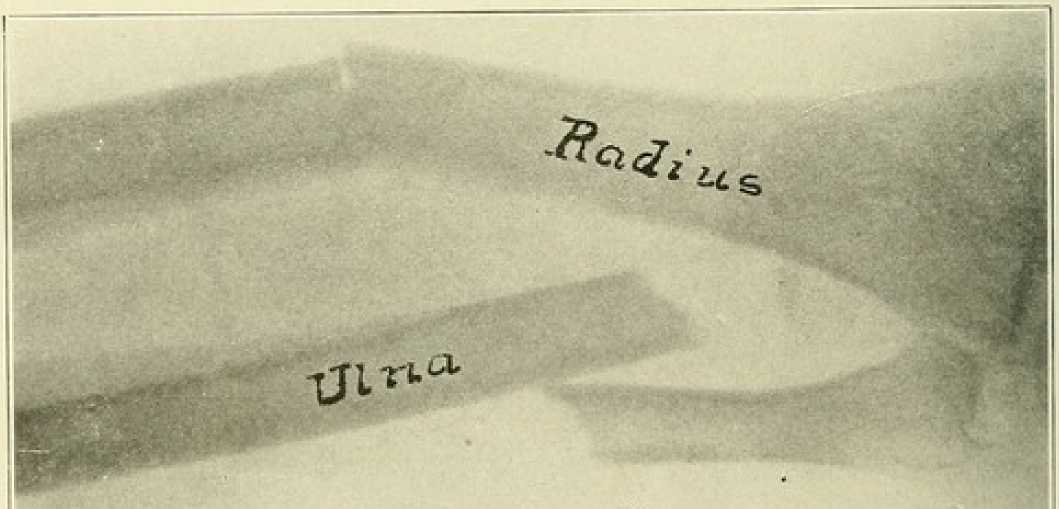


3.

Fig. 147.—Fracture of radius and ulna. 1, before attempted reduction; 2, after attempted reduction; 3, after bones were fastened with kangaroo tendon. 2 and 3 were skiagraphed through plaster of paris dressing.

and he was sent to the laboratory for a second skiagraph. 2 is a reproduction of the second skiagraph, which shows that the arm had been only straightened without reducing the fracture in the ulna. This condition of affairs was a great surprise and disappointment to all concerned, for it meant that the work had been of no avail and that a similar effort might meet with the same result. It was decided to cut down on the ends of the bone and fasten them together. In a few days the operation was done by fastening the ends of the bone together with kangaroo tendon, plaster of paris was applied, and the third skiagraph (3) was made, showing splendid apposition in the bones. This case teaches a most excellent lesson, one that will never be forgotten by physician or patient.

Skiagraphs, sufficiently clear to reveal the positions of the bones, may be made through plaster of paris dressings. A second skiagraph, after the fracture is reduced and the permanent dressing put on, should never be neglected. The first skiagraph is made for a diagnosis, and the second to determine if the bones are held in close apposition. Even though the bones are placed in apposition under anesthesia, there is no assurance that they will remain there when the muscles become rigid as a result of the irritation or traumatism. Had the second skiagraph been neglected in this case until the time to remove the permanent dressing, the patient would have had an unsatisfactory result. If these points were fully explained to such patients, they would never hesitate to have the necessary skiagraphs made.

Elbow.—Old fractures at the elbow are not only very difficult to treat, but are frequently exceedingly difficult to skiagraph satisfactorily, due mainly to the fact that the arm is generally kept in a flexed position until there is a partial ankylosis, making complete extension impossible. A lateral skiagraph of the elbow is never difficult, but, when the arm can not be extended, an anteroposterior exposure is almost impossible. In making the lateral exposure the injured side of the elbow should be placed next to the sensitized plate. When the injury is on the inner side, the patient may be placed beside a table, high enough to allow the arm to lie flat, with the humerus parallel with the plate. When it is necessary to place the outer side of the elbow on the plate, the patient is placed on a table on his back, with the injured arm over his head, when the outside of the arm will rest flat on the table and may be skiagraphed in this position.

When there is a suspected fracture of either the external or internal condyle of the humerus, with little or no displacement, a skiagraph in the lateral position will not reveal the injury. In this case it is necessary to get an anteroposterior exposure, even though the elbow is ankylosed. To do this, the arm should be extended as far as possible, and the point of the elbow allowed to rest about the center of an 8x10 plate, while the hand is supported on some kind of rest. Skiagraphs of this kind are usually not very clear, but will generally show existing fractures in the condyles. Many fractures in and about the elbow are treated as sprains. A fracture and displacement of the internal condyle frequently results in a stiff elbow.

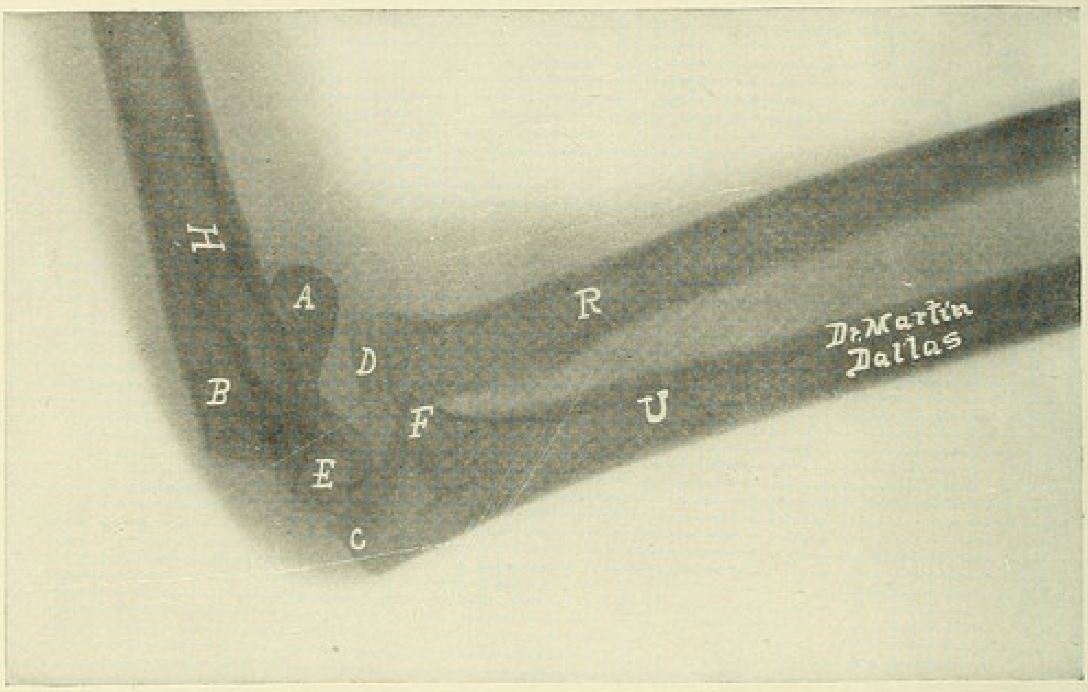


Fig. 148.—Fracture of elbow.

The stiffness comes on slowly, and the patient is hardly aware that he is losing the use of his elbow until a great deal of damage has been done that can not be easily undone. A stiff elbow is a great handicap to a man or woman, no matter what position they may occupy in life.

All elbow injuries should be skiagraphed early, at least two exposures being made at right angles to each other. If there is no fracture or dislocation, the patient may be allowed to use the arm at once, but, if there is a fracture of any consequence, continued use will only aggravate the condition. Fig. 148 is a skiagraph of the arm of a child 5 years old. To one not familiar with the appearance of an elbow at this age, a fracture would be the diagnosis. The fragment at *A* is the displaced epiphyseal end of the humerus, that part which would have been the internal condyle of the humerus. Displacement of the epiphysis at this point is very common.

Fig. 149 is a skiagraph of an injured elbow in another child of

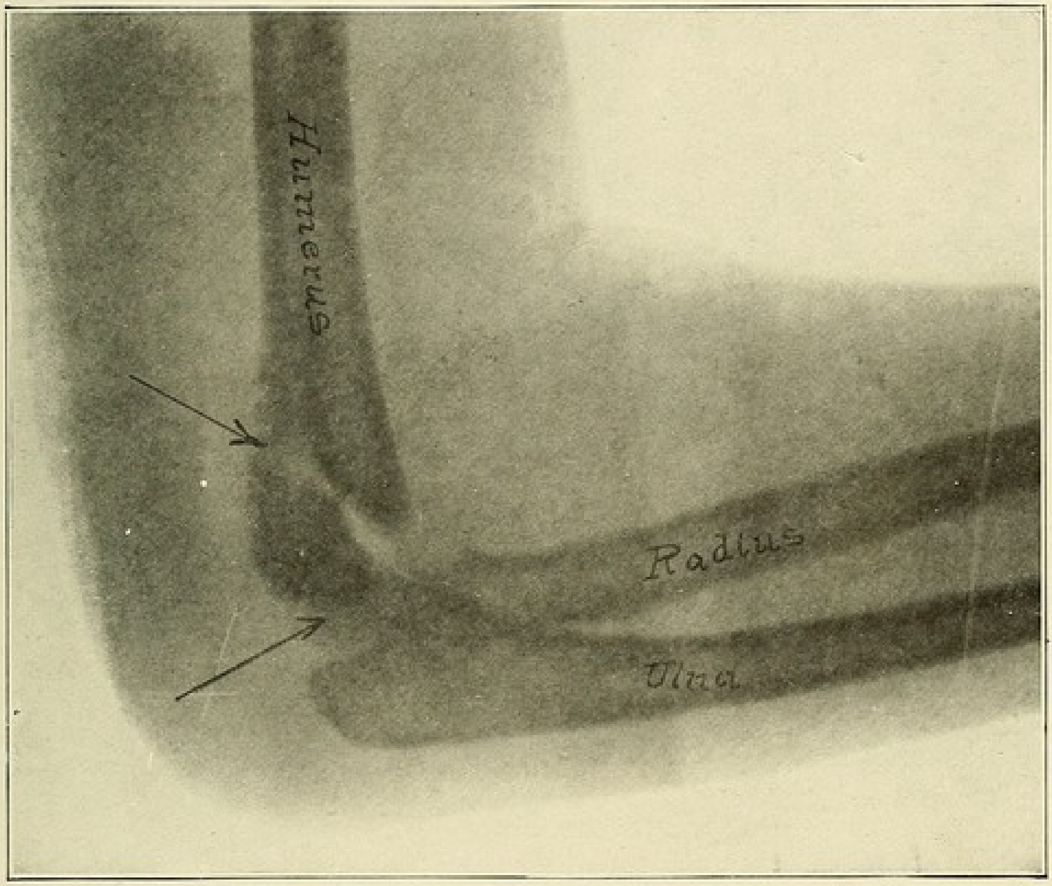


Fig. 149.—Fracture of the lower end of the humerus.

5 years. The epiphysis is not displaced, but the lower end of the humerus is split and the posterior portion is pushed backward, leaving the bone in an ugly shape. Recognition of an injury of this kind short of a skiagraph is out of the question. To wait to see what the results are is time wasted, during which the injury is rapidly getting beyond control.

Fig. 150 is a skiagraph of an adult elbow, showing a fracture, with slight displacement of the head of the radius. This injury was thought to be a sprain, and was so treated for about two weeks.

After the skiagraph was made the arm was placed in a fixed dressing for a time, when all of the distressing symptoms disappeared.

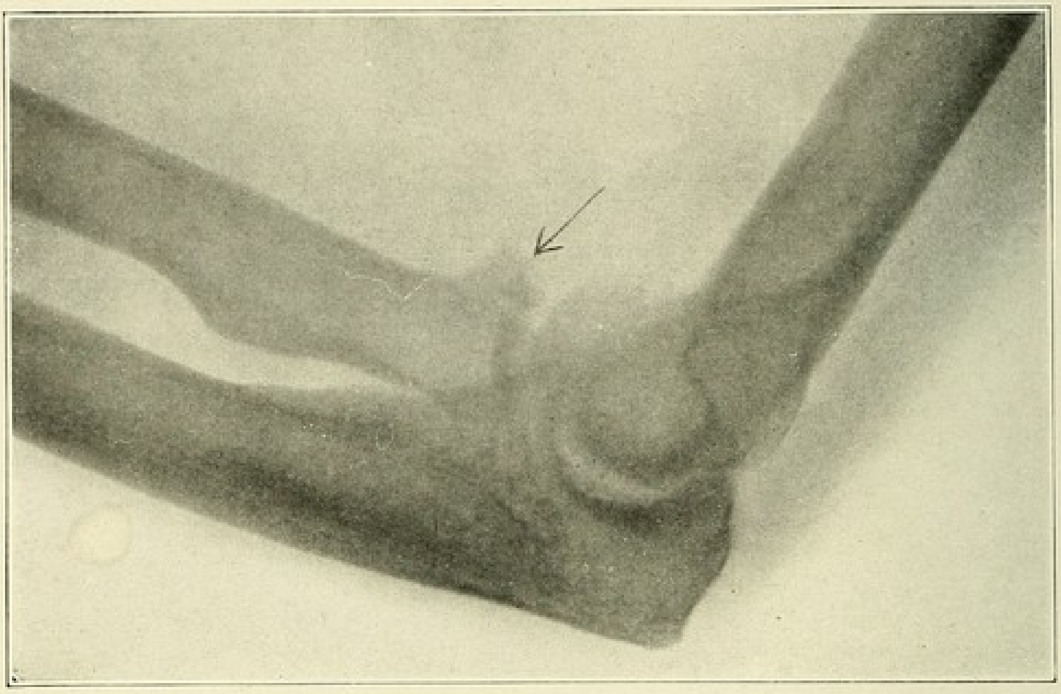


Fig. 150.—Displacement upward and fracture in the head of the radius.

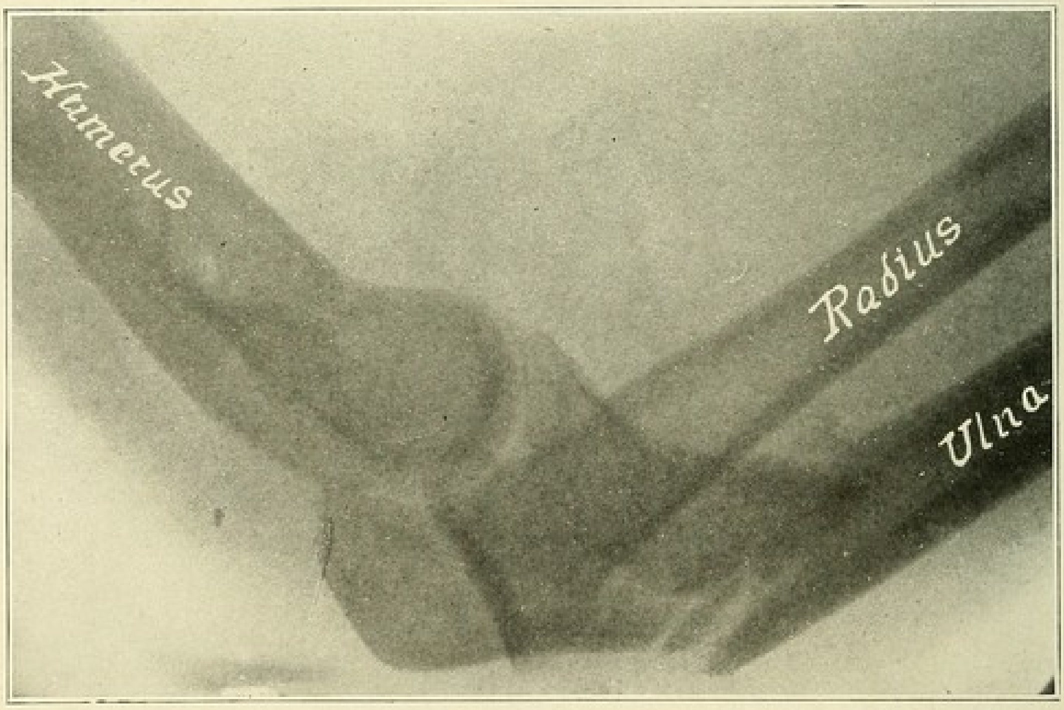


Fig. 151.—Fracture of the ulna and dislocation of the head of the radius.

Fig. 151 is a particularly interesting case because of its long standing. The patient had fallen down stairs, and sustained, as can be plainly seen, a fracture of the ulna and a displacement of the radius. The man was muscular, and there was very little deformity from outside appearances. The injury was thirty-one days old, and the arm had been in a flexed and semi-flexed position during this time. This is a rather peculiar injury, and the author has never seen a duplicate of it in practice, or in any text-book or journal article. Under complete chloroform anesthesia the displacement was reduced by making pressure on the end of the radius with the thumbs and gently extending the arm. When the radius went into place, the ulna was easily brought into its normal position, and the arm was dressed extended.

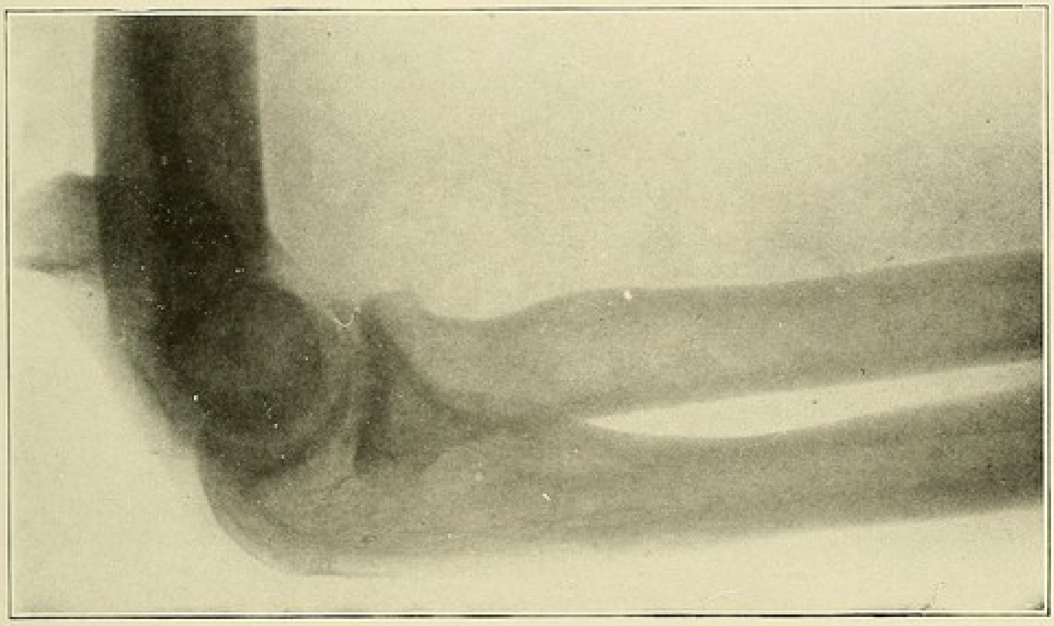


Fig. 152.—Fracture and displacement of the olecranon. Skiagraphed eight years after the accident.

Fig. 152 is a skiagraph that was made of an elbow eight years after the olecranon had been fractured. It will be noticed that the fractured end had been pulled up on the posterior surface of the humerus, where it had been allowed to grow and where it will probably remain as long as the patient lives, for he has no desire to have it removed.

The remainder of this book could be filled with skiagraphs of elbow injuries and not have two alike. Those shown are representative of their class, and emphasize the absolute necessity of having all injuries to the elbow joint carefully skiagraphed as early as possible after the injury. It would be better to skiagraph ten elbows that prove to be normal than to neglect one that was in need of such aid.

Humerus.—The humerus is very frequently fractured anywhere from its surgical neck to the elbow. As a rule, such fractures are not considered very difficult. Fig. 153 shows a fracture in the humerus that was an exception to the rule. When this case was

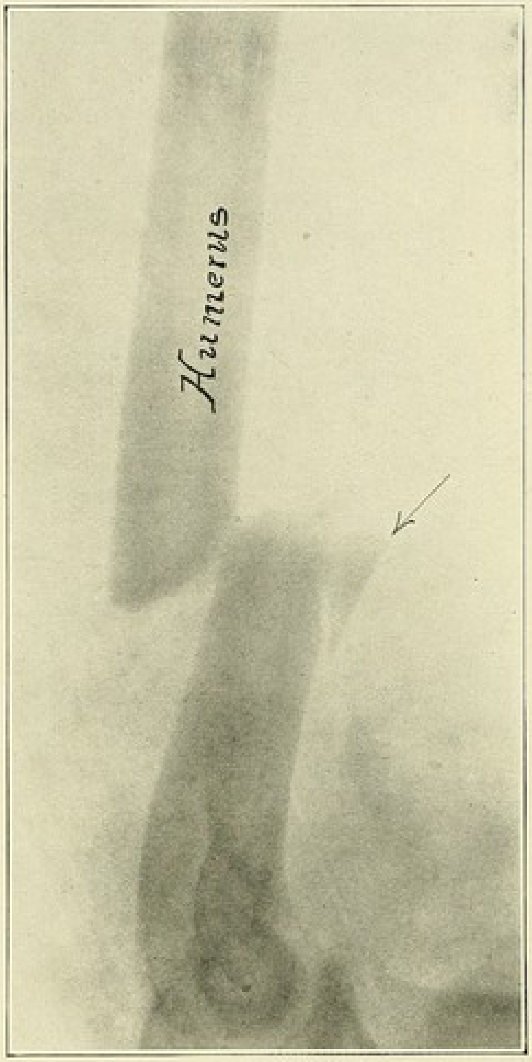


Fig. 153.—Fracture of the humerus. Skiagraphed through a plaster of paris dressing.

brought to the laboratory the arm was in a plaster of paris dressing. The skiagraph was made before the dressing was removed, with the result shown in the picture. The case never returned for a second picture, and the final results are not known. The majority of manufacturing and construction companies carry accident insurance on their men. The insurance companies should be interested in getting the very best functional results. The majority of damage suits are brought, not because of the injury primarily, but because the physician failed to recognize the true condition at the beginning of the case. Insurance companies will be glad to pay for all necessary x-ray examinations and skiagraphs where such examinations

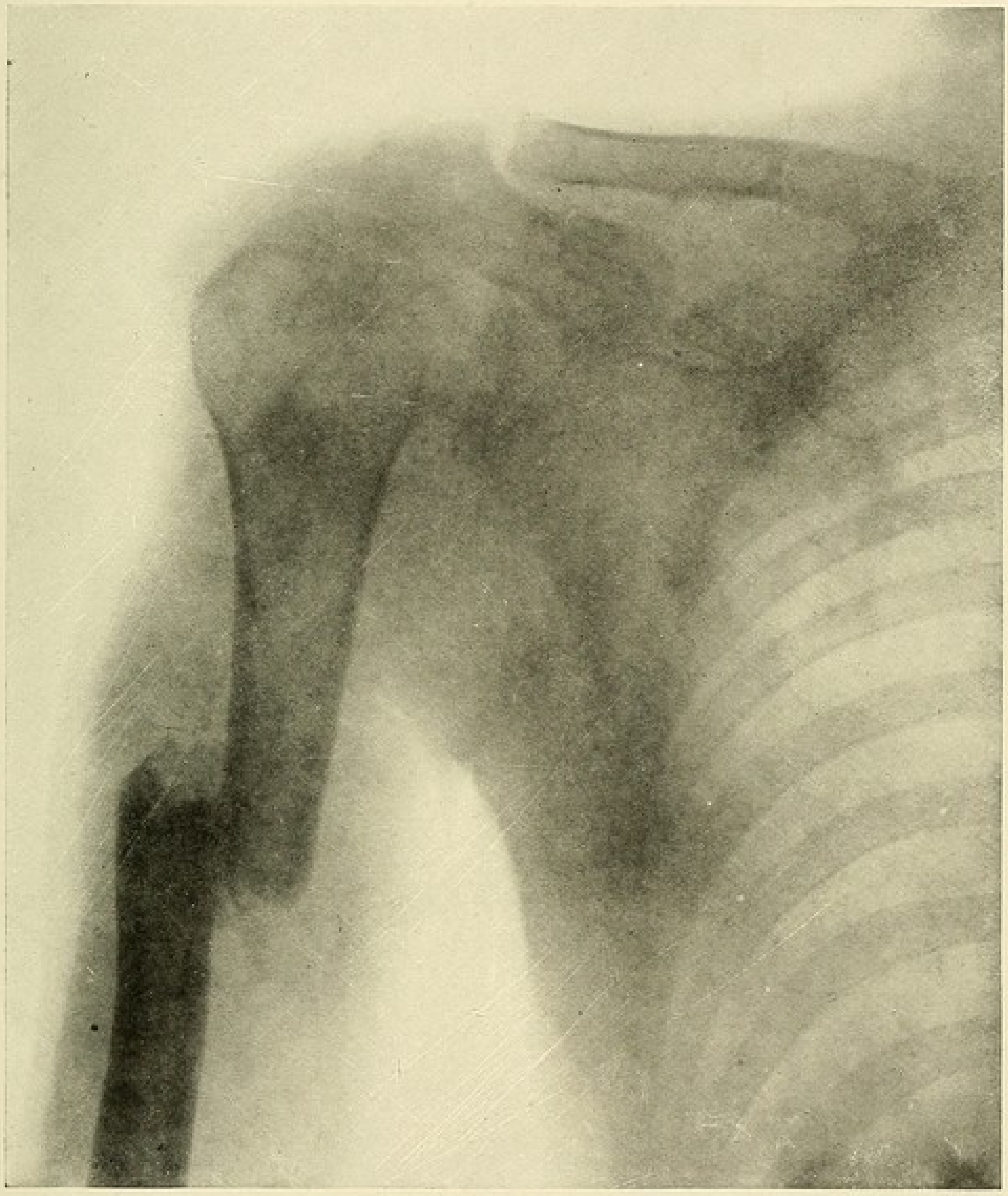


Fig. 154.—Fracture of the humerus. Skiagraphed six weeks after the accident.

will result in a better understanding of the existing conditions, insuring better final results. Suppose the humerus in this case had been left in the position seen in the skiagraph and a suit for damages had followed. Who would have been to blame—the railroad for breaking the arm, which may have been due to the patient's carelessness, or the physician, who failed to recognize the extent of the injury and supply the necessary treatment? Questions of this character will be given more consideration in the future as the means for studying and determining the extent of injuries become better known and understood.

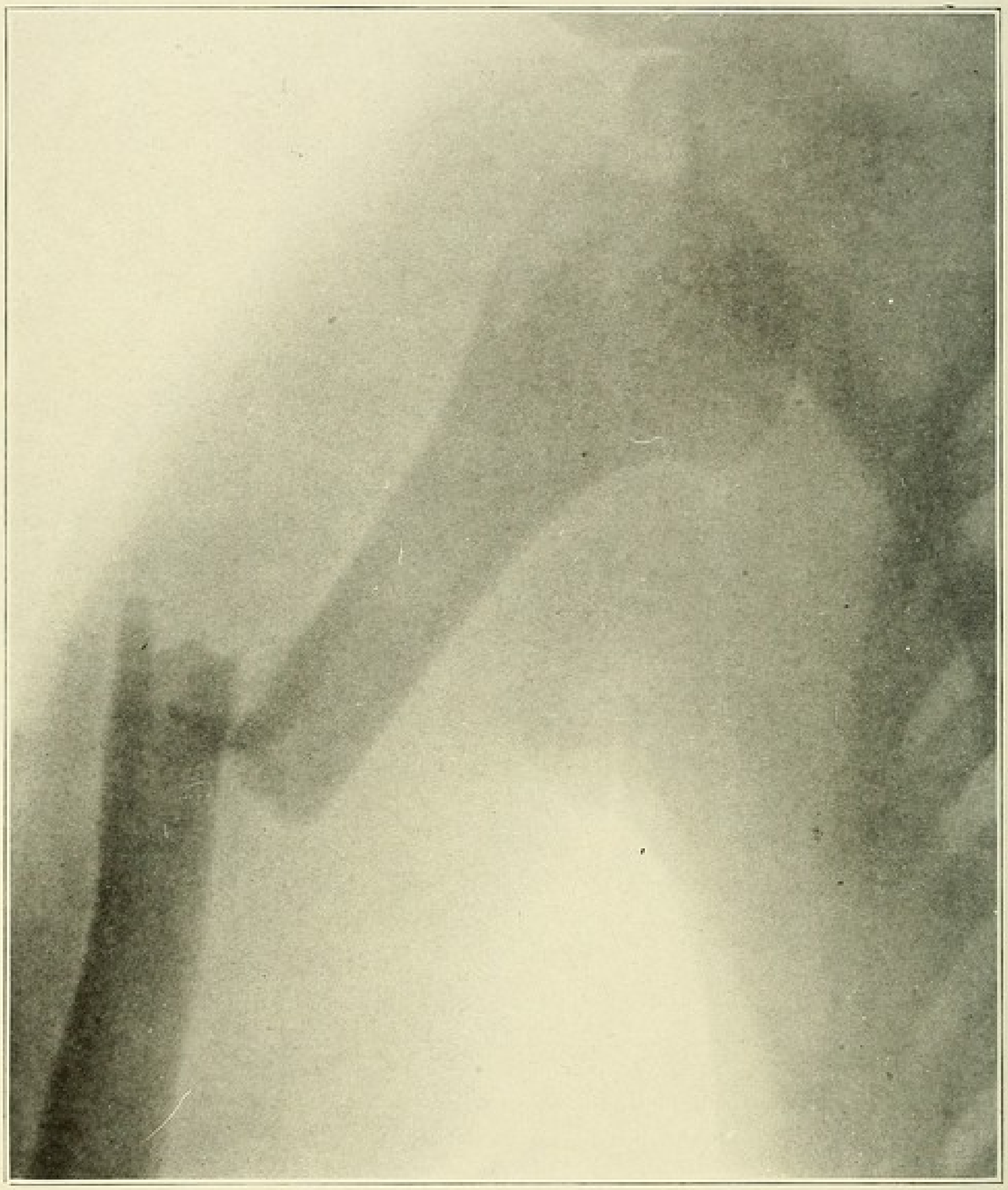


Fig. 155.—Fracture and dislocation of the humerus.

Fig. 154 is a skiagraph that was made of a fractured humerus six weeks after the accident. When this man was chloroformed this fracture may have been reduced, and the fragments may have been in perfect apposition, but that they did not remain in apposition there is no question. Had this case been skiagraphed after the permanent dressing was applied, the results would have been different—the physician in the case would have saved his reputation, and the patient would have had a better and more rapid recovery.

Particular stress is being put on the absolute necessity of careful and early x-ray examinations in all injury cases. Such examina-

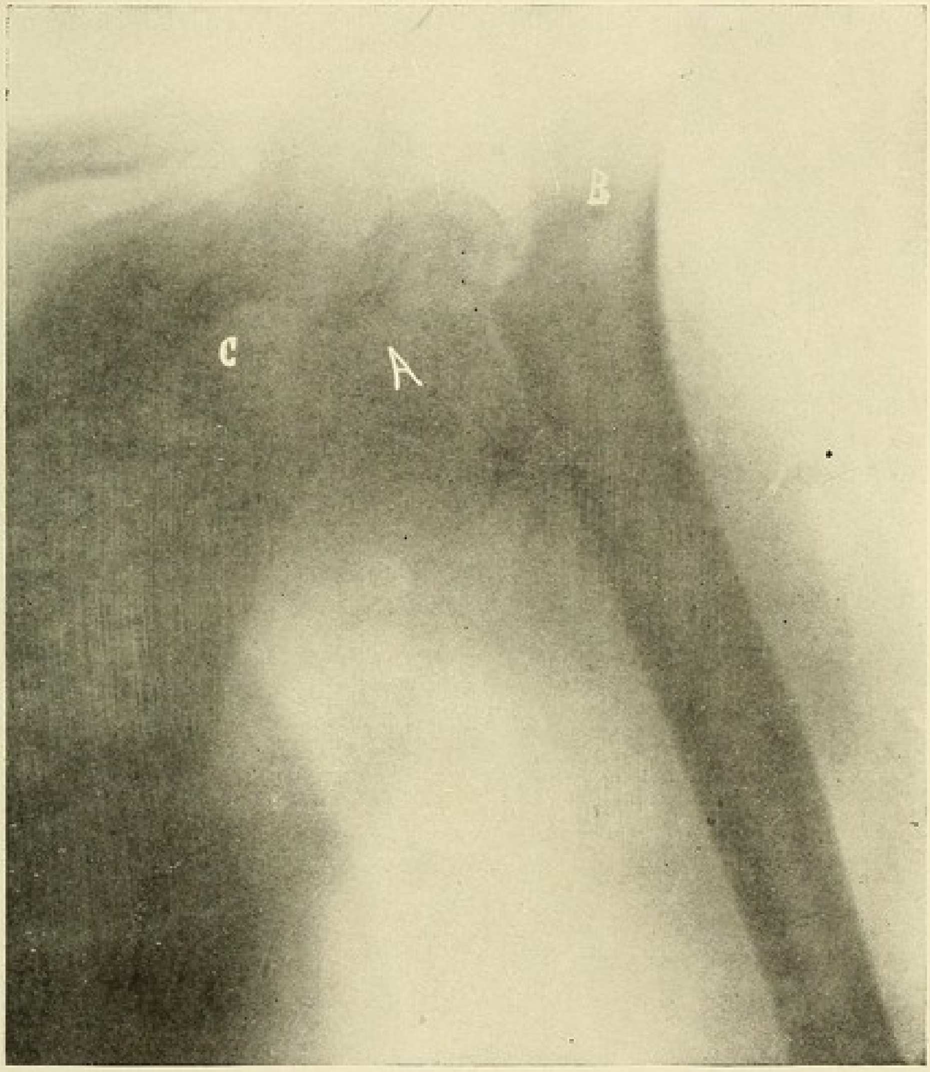


Fig. 156.—Fracture of the humerus and dislocation of its head.

tions are necessary in order to get the very best results for the patient, which is, of course, the first consideration. Well-made skiagraphs of fractures are of considerable value to the physician, as they are a permanent record of the condition before and after the reduction, and the physician who is alive to his own interests will see that such records are carefully kept, as they will be a means of self-protection in case a damage suit for malpractice is instituted.

Fig. 155 is a skiagraph of a rare case of arm and shoulder injury. It occurs often enough, however, to create considerable interest and call for careful study, particularly in fleshy subjects suffering from injuries of this nature. This fracture and dislocation were three weeks old when the picture was made. An effort had been made to reduce the fracture, but the dislocation had never been recognized.

In and About the Shoulder.—A fracture of the neck of the scapula, head or neck of the humerus, or glenoid cavity, or both a fracture and a dislocation, may occur at the shoulder joint. Fractures and dislocations at this point are, in thick subjects, frequently very difficult to diagnose by the old methods.

Fig. 156 is a skiagraph that was made from the shoulder of a young lady who had been thrown from a buggy more than six weeks before. Here we have both a dislocation and a fracture. The head of the humerus at *A* was turned almost completely around, remaining in the glenoid cavity and forcing the humerus outward and upward. An operation was done with the hope of wiring the head onto the humerus, but the head had undergone a process of softening and it was impossible to do more than curet it away. This teaches the folly of attempting to treat such cases blindly.

The best surgeons of our country are refusing to have anything to do with fracture cases unless they are x-rayed before and after the fractures are reduced. The same should be true of dislocations, for they are frequently accompanied by fractures. Fractures of the clavicle and scapula frequently occur, and especially is the clavicle in children subject to fracture. Many mistakes are made by the inexperienced in skiagraphing the shoulder. The cartilaginous union between the clavicle and the acromion, even in the adult, leaves a wide space in the skiagraph, and has frequently been mistaken for a fracture. Getting a correct skiagraph of the shoulder is not always an easy matter, especially in corpulent individuals. The patient may be placed either on his back or abdomen, as may seem best to bring the injured part as near the plate as possible, always guarding against any great amount of distortion. In the majority of cases an 8x10 sensitized plate will be as large as will be required for diagnostic purposes. The compression diaphragm should be used in most cases, and the arm may be elevated as high as possible where a dislocation of the humerus is suspected.

Fig. 157 illustrates a case very similar to Fig. 156. It teaches a lesson well worth observing. The accident and injury occurred about three months before the picture was made. The subject had been injured in a railroad wreck and had been under the care of

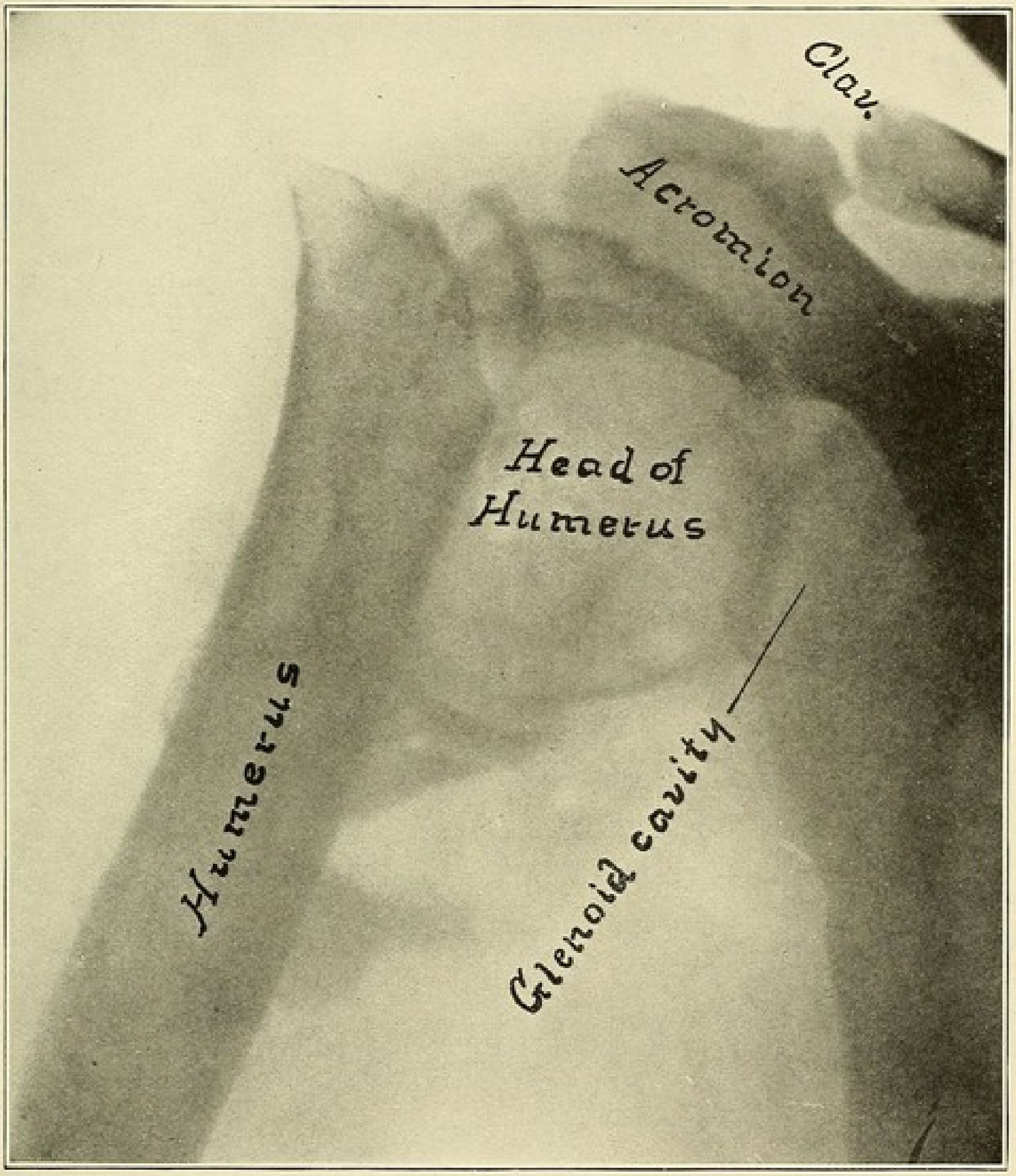


Fig. 157.—Fracture of the humerus and dislocation of its head.

the company's physician in a sanitarium. Whether the fracture and dislocation were ever recognized is not known, but it is quite clear that they were never reduced and kept in apposition.

Skull.—Fissured fractures of the skull are generally impossible to exhibit in a skiagraph, but injuries with a separation or loss of bone of any consequence may be shown with considerable distinctness.

Fig. 158 is a representative skiagraph of the head, and shows the possibility of this method of diagnosis in this locality. It will

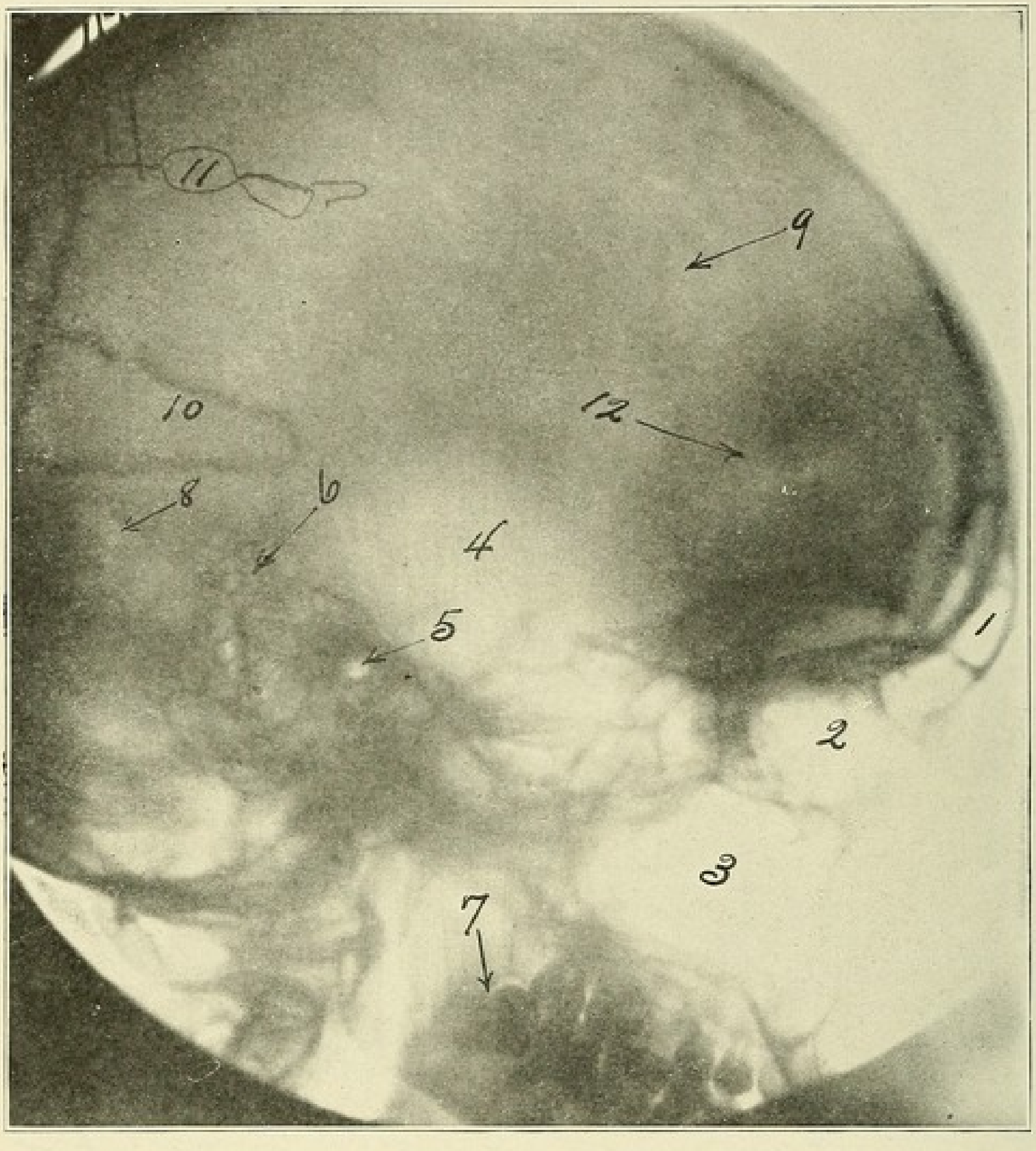


Fig. 158.—Skiagraph of an adult head made by the author in five seconds. 1, frontal sinus; 2, orbital cavity; 3, antrum of Highmore; 4, temporal bone; 5, auditory canal; 6, mastoid cells; 7, impacted third molar; 8, lambdoid suture; 9, coronal suture; 10, hairpin on the far side of the head from the plate; 11, wire fastening for switch near the plate; 12, light area showing fracture in tables of the skull.

be noticed that the various markings indicating the different degrees of density are very distinct.

Fig. 159 is a skiagraph made through the head of a patient who had lost his right parietal bone in an injury several months before. There was thought to be a fracture in the occipital bone, but the evidence in the skiagraph was not positive. The lateral skiagraph of the skull gives the best detail, and will generally be all that is required. Good, distinct anteroposterior skiagraphs are almost impossible to make.

In making a skiagraph of the head, the plates should range in size from 8x10 to 11x14 inches. Usually only certain parts of the head are required, and an 8x10 answers the purpose. The patient

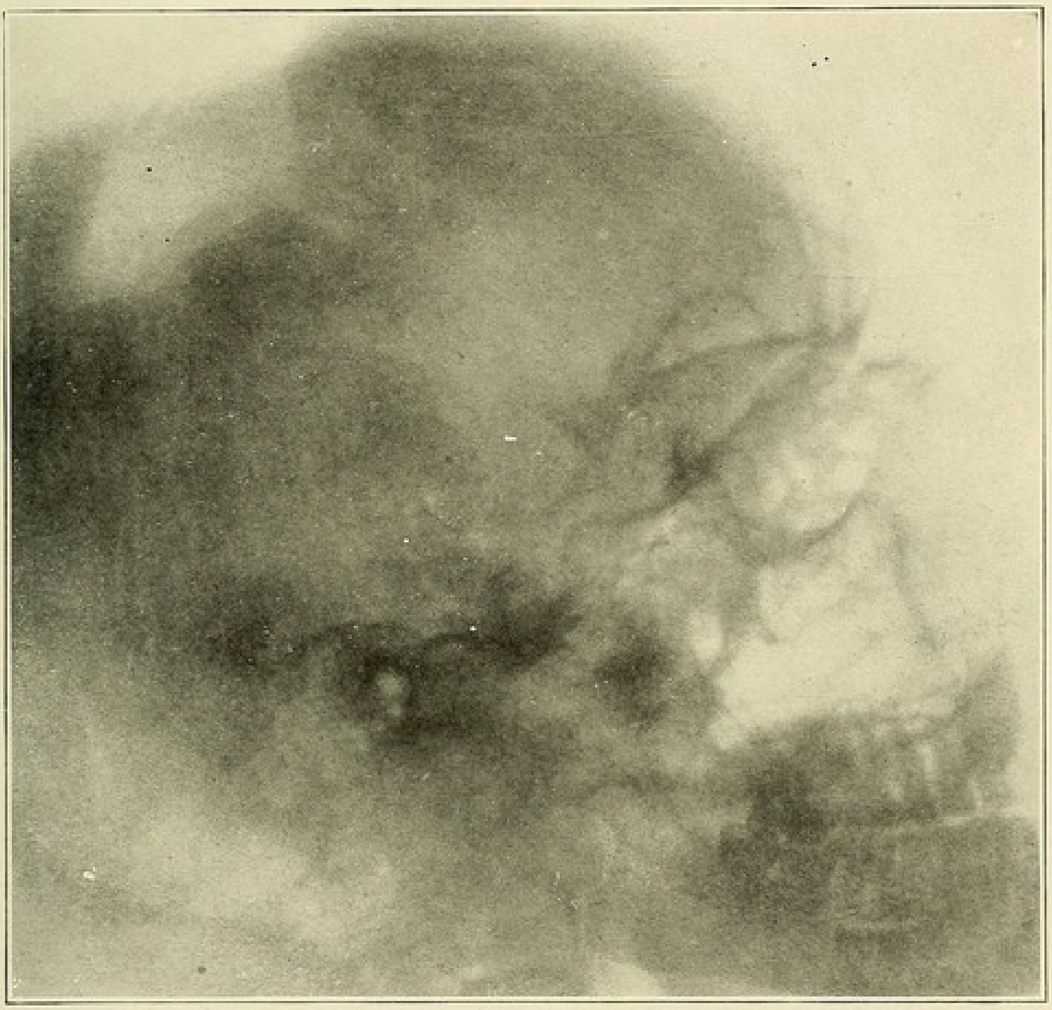
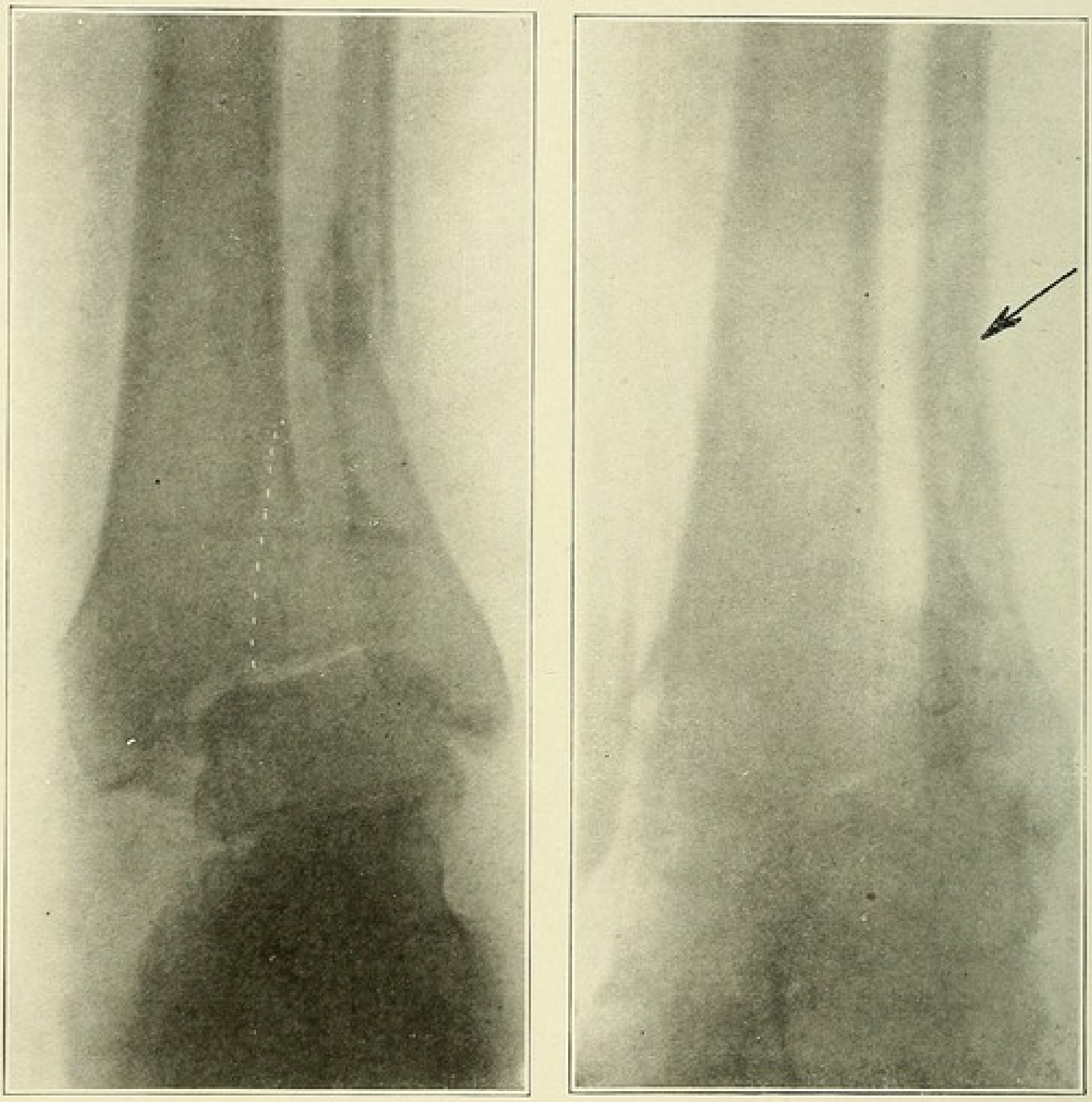


Fig. 159.—Fracture and destruction of the greater part of the parietal bone.

is placed on a table, with the injured side nearest the plate. A block or box about 5 inches high is placed beneath the head to make it level. The tube should be of high vacuum, of best quality, and placed about 18 inches from the plate and directly over the part to be most prominent in the skiagraph. The tube should be energized by a coil of not less than 16-inch spark gap. The length of exposure will depend upon the apparatus and the tube. From ten to thirty seconds should be time enough with modern apparatus. By the use of the sinegran the time may be reduced to the fraction of a second, but the picture loses considerably in distinctness when made by this method. Well-directed practice with a good equipment will qualify a physician, with a mechanical turn, to do excellent work in a reasonable time.

FRACTURES AND DISLOCATIONS OF THE LOWER EXTREMITIES.



1. 2.

Fig. 160.—Pott's fracture. 1, before reduction; 2, after reduction.

Foot.—Fractures of the phalanges of the foot are usually of the crushed or mashed variety, in which the bones are split or splintered. Fractures of the tarsal and metatarsal bones are more common than was thought before the advent of the x-ray. The metatarsal bones and the phalanges are easily skiagraphed, but the tarsal bones are more difficult. In injuries to the heel, in which fractures in the astragalus and os calcis are suspected, skiagraphs should be made in different positions and at different angles, as it is often difficult to determine the true state of affairs.

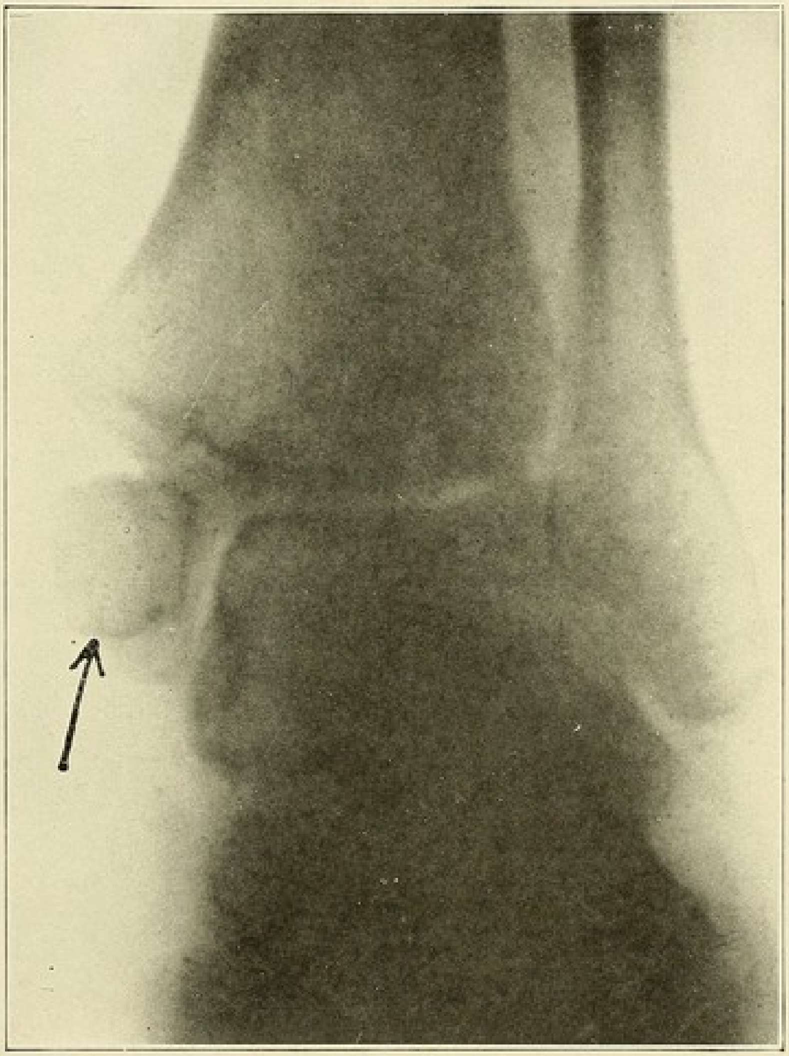


Fig. 161.—Fracture of the internal malleolus.

In and Near the Ankle.—Fractures of the ankle-joint involve all the bones of that region. The tibia, fibula, and tarsal bones are involved separately or in combination. Sprains of the ankle, so called, are generally fractures. Pott's fracture is probably the most frequent injury in this region. A typical Pott's is a fracture of the lower end of the fibula within its lower third, with a fracture of the malleolar process of the tibia. Many modifications of Pott's fracture are seen. Fig. 160 is a skiagraph of a fractured ankle, in which the fibula was obliquely fractured 3 inches from the lower end, with a longitudinal fracture of the external malleolus of the tibia, with the fragment slightly displaced. Skiagraph 1 was made some time after the injury. The patient complained of considerable pain, and, as there was some question as to the extent of the injury, an x-ray examination was asked for. The reduction was

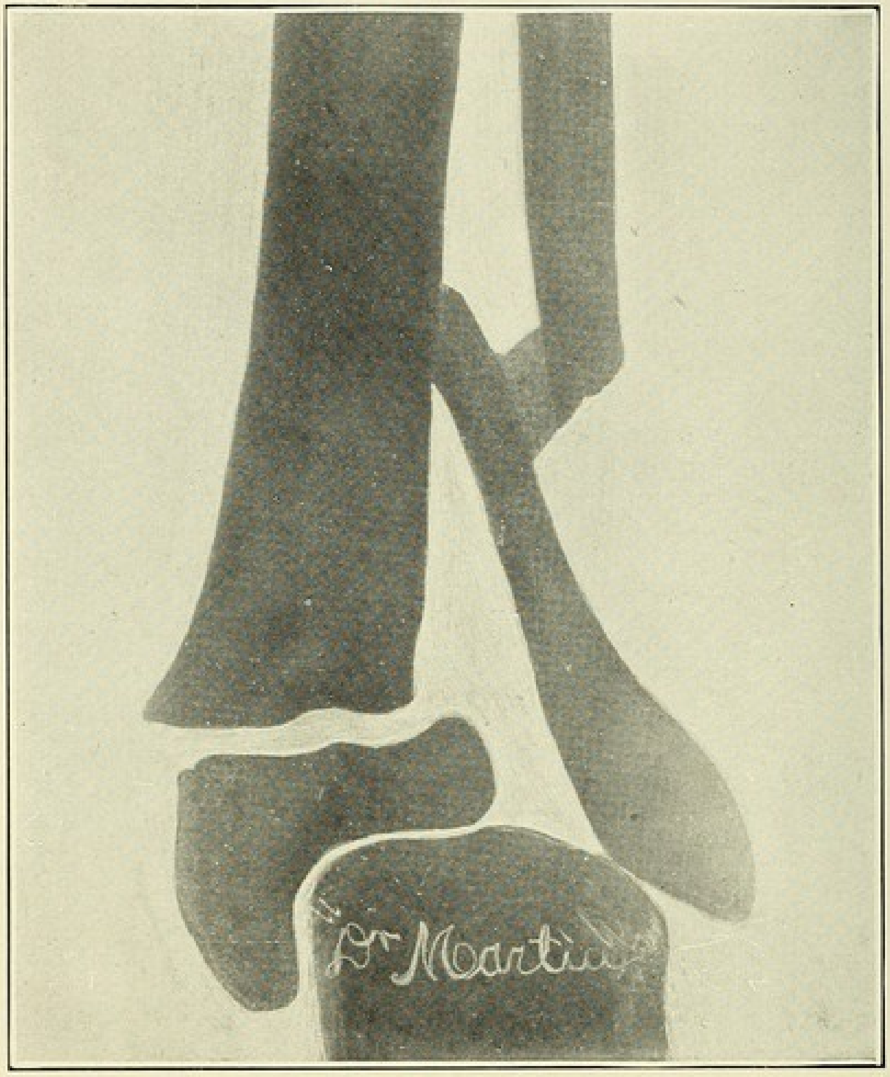


Fig. 162.—Typical Pott's fracture.

made and a plaster of paris dressing applied in the laboratory, when skiagraph 2 was made. This picture shows that the apposition of the fragments was as nearly perfect as it was possible to get them. Here the x-ray scored a victory by giving an almost perfect ankle to this good woman and saving the reputation of the attending physician.

Fig. 161 is a skiagraph made several weeks after the injury.

The internal malleolus is fractured and the fragment slightly displaced. There was a suit for malpractice against the physician who attended the injury. In skiagraphing cases of Pott's fracture, the best position for the patient is to sit or lie on the table, so as to obtain an anteroposterior exposure. Fractures in a longitudinal direction are sometimes best exhibited from a lateral view, and 8x10 plates are about the correct size. The compression diaphragm,

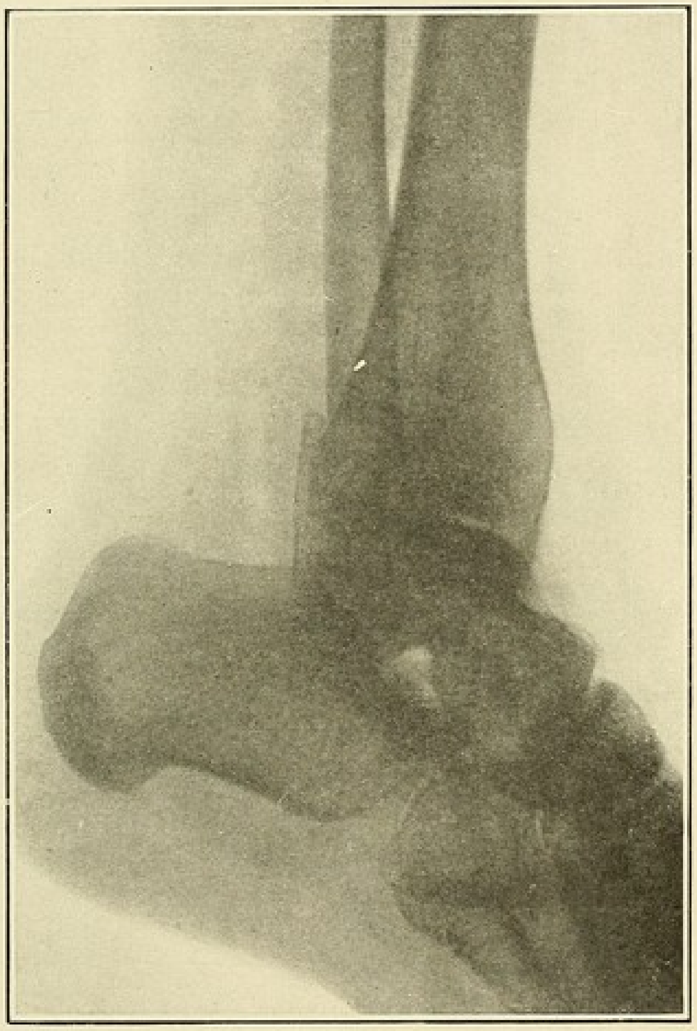


Fig. 163.—Fracture of the fibula.

with slight pressure, will enable the patient to hold the foot perfectly still. Skiagraphs of the foot and ankle are easily made, and with a proper equipment and a little care the x-ray operator should have no trouble in showing distinctly the exact condition of the most complicated injury to the bones of this region. Fig. 162 is a skiagraph of a typical Pott's fracture. The skiagraph was made with a static machine six months after the injury. The ankle was badly deformed, and the patient was unable to use his foot at that time. In this picture the soft tissues were penciled out, showing the bones in the exact position which they occupied at the time the exposure was made. This was a difficult fracture, yet, had it been skiagraphed soon after the injury, could have been corrected and the patient prevented from becoming a lifelong cripple.

Fig. 163 is an interesting fracture of the fibula. The ankle had been treated for a sprain for some weeks, but, as it refused to "get well" and was causing a great deal of pain, it was thought advisable to have a skiagraph made. The first exposure was made antero-posteriorly, and the plate was excellent, yet there was no evidence of an injury in the shadow of the bones. The attending physician was well satisfied with this report, as it agreed with his diagnosis, and wanted to take the patient away without further exposures. A lateral exposure was, however, insisted upon, with the result seen in the picture. The reason that the first plate showed no evidence of the injury in the fibula was because there was no lateral displacement in the fragments, and, as the line of fracture was obliquely downward and forward, the injury did not show. This case emphasizes the necessity of making skiagraphs of injured parts in different directions until all the facts are learned.

Tibia and Fibula.—Fractures of the tibia and fibula that are not wired soon after the injury nearly always result in deformity by allowing the bones at the point of fracture to be widely separated, or the fragments lap from 1/8 to 1/2 inch, or even 1 inch or more. When the permanent dressing is removed, the shortening is explained "to be a consequence of the injury that could not have been prevented." Fig. 164 is a splendid illustration of such a method, with the result that always follows—shortening of the leg. The time has passed when there is any excuse for such a result. If there is any question as to the position of the bones after the permanent dressing is put on, a skiagraph should be made, which, if properly done, should settle all controversy as to the relation of the fragments to each other. The leg from which this skiagraph was made was injured in a railroad accident, and was followed by the customary suit for damage. Railroads and corporations pay dearly for neglect and carelessness in the surgical and medical attention that these fracture cases receive. Conditions are improving, but entirely too slowly, and at this rate it will take several years for the average surgeon to recognize the absolute necessity of well-made skiagraphs before and after reductions in all fractures and in most dislocations. Corporations should, where they are liable, demand skiagraphic records of all bone injuries.

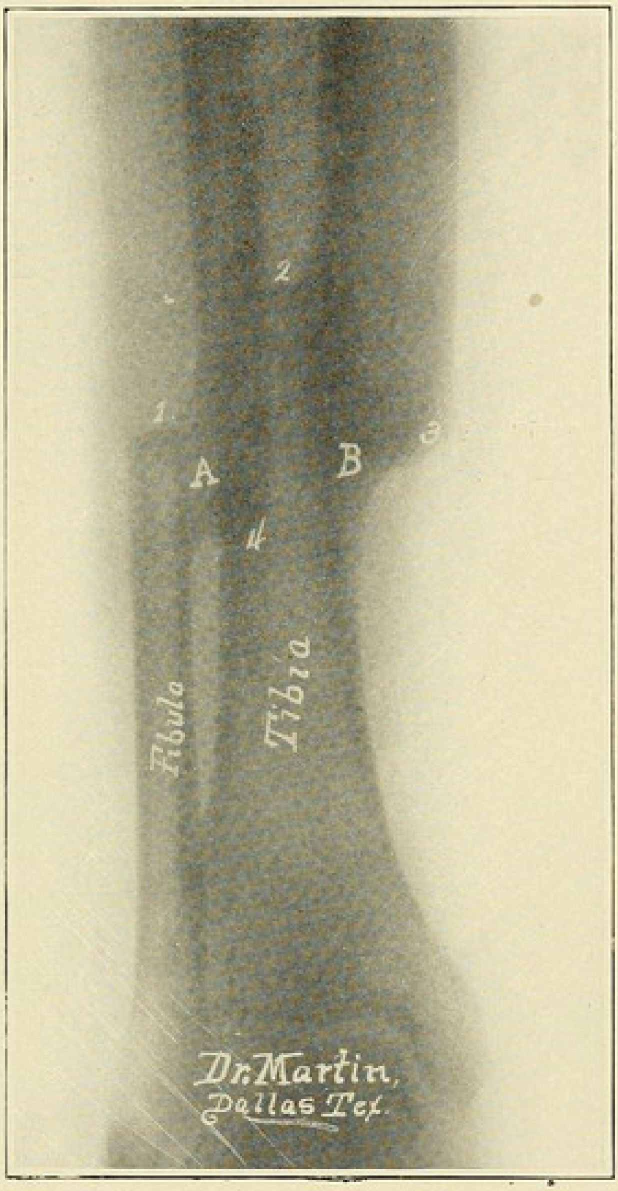
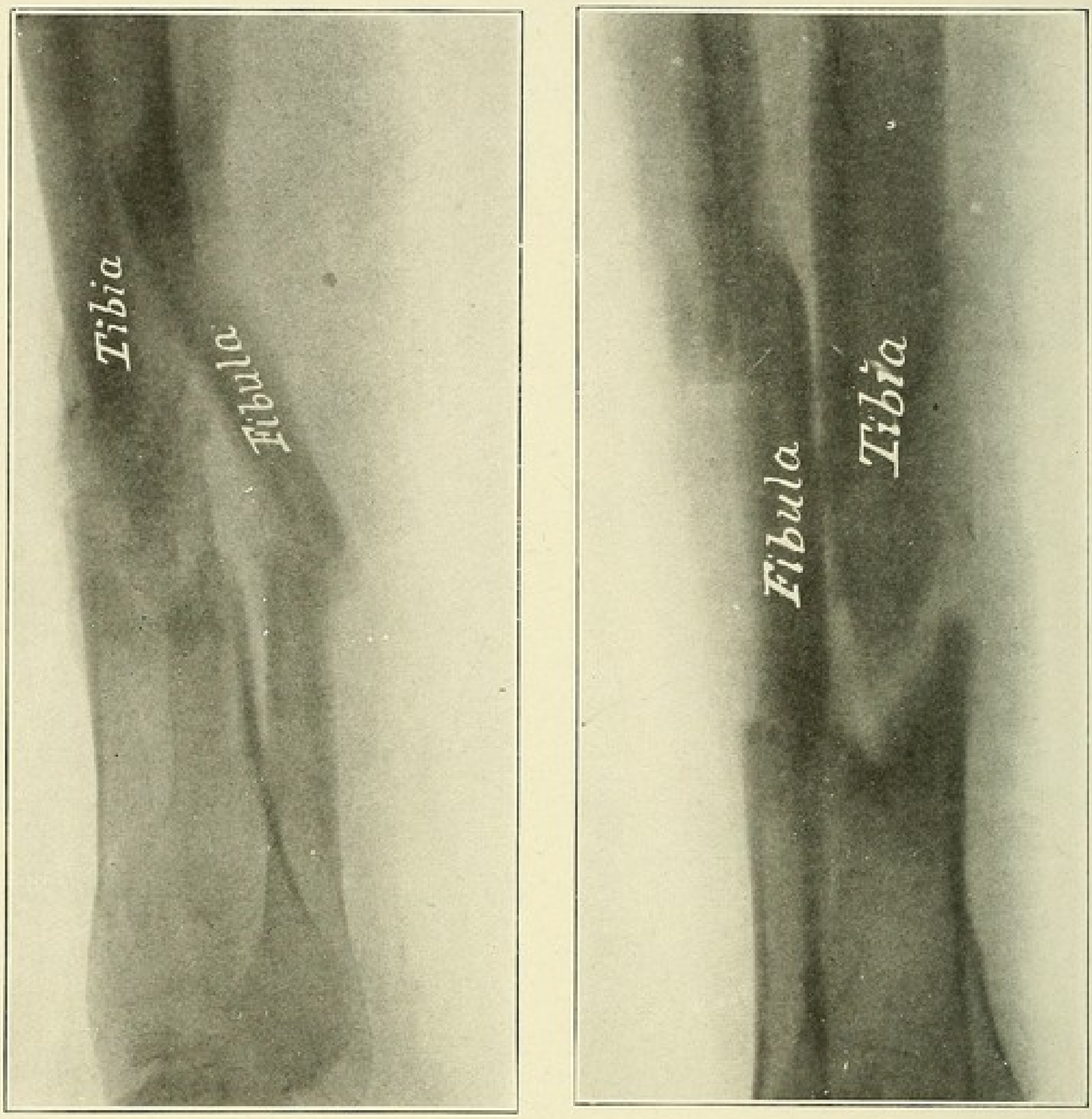


Fig. 164.—Shortening of the leg from fracture of the tibia and fibula.

Fig. 165 teaches its own lesson. It is clearly seen that the fracture was complicated and difficult. Early and frequent skiagraphs with modern methods of treatment would have given this man a strong and useful leg. The sanitarium in which this man was treated had no x-ray apparatus, and it is because of this fact more than any other that this man will be a life-long cripple.

Fig. 166 is a skiagraph that was made only a few hours after the accident. It would have been impossible for any surgeon, no matter what his experience, to determine by any other method than the x-ray the exact condition in this injury. This case was not skia-



1. 2.

Fig. 165.—Tibia and fibula. Skiagraphs were made in an anteroposterior and lateral direction of a tibia and fibula that had been fractured several months before in a railroad accident. The case was dismissed from the hospital in the condition shown in the skiagraph.

graphed after the permanent dressing was applied, a mistake that is too often made. Nonunion in fractures is usually the result of poor apposition. Should the bones be lapping and allowed to unite with a false union, which is later broken up in an attempt to reduce the fracture by getting better apposition, the case is likely to result in a nonunion, and especially is this true if the patient is in a low state of health or advanced in years.

Fig. 167 illustrates an interesting case of a long nonunion occurring in a young lady. Both tibia and fibula were broken near the same level. This was a compound fracture, and was treated on the expectant plan in the usual way for a long time, with the hope that

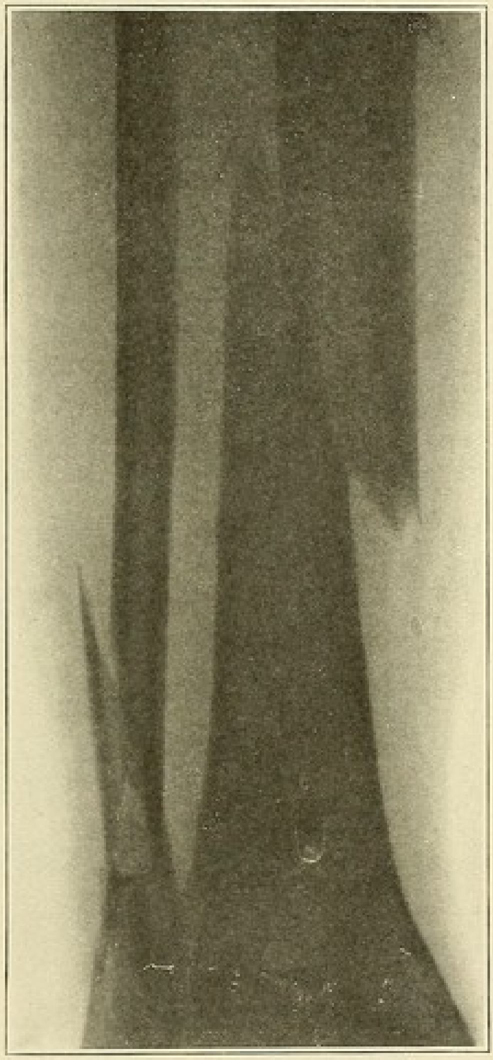


Fig. 166.—Fracture of tibia and fibula.

nature would come to the patient's aid and in some mysterious way bring the bones together. Two skiagraphs had been made previous to this. There was slight union in the fibula at this time, six weeks after the plates had been put on, and no union in the tibia. The upper end of the tibia was so softened from the processes of inflammation that it supported the screws poorly, and on this account it was difficult to hold the fragments firmly in place. After several months this patient has a leg that she can use fairly well, but it is somewhat shorter than the other.

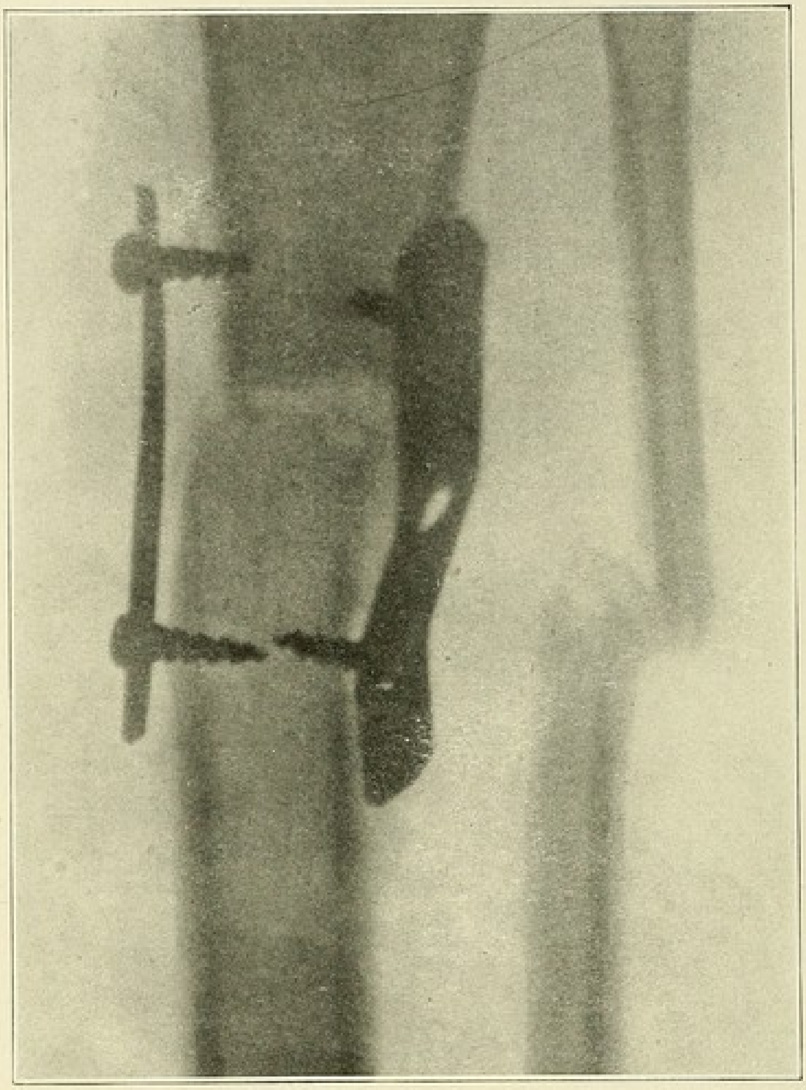


Fig. 167.—Fracture of tibia and fibula near the knee. Apposition secured with silver plates and screws.

In and About the Knee.—The treatment of fractures about the knee is frequently very unsatisfactory. There may be a complete fracture of the upper end of the tibia or a separation of its epiphysis. The tuberosities may be fractured and displaced, causing no end of suffering, with lasting bad effects. The patella may be fractured in any direction, or crushed or broken in many pieces. The knee-joint may contain floating or loose bodies, which at times cause more or less trouble to the patient.

Skiagraphs of the knee should always be taken in both the anteroposterior and lateral positions. If the patella is fractured transversely, the lateral skiagraph will reveal the condition, but, when it is broken in several pieces, the patient should lie face downward, with the tube behind the knee and the plate in front or beneath. In knee injuries the fluoroscope is not reliable and should not be depended upon, for much that a skiagraph would show is certain to be overlooked.

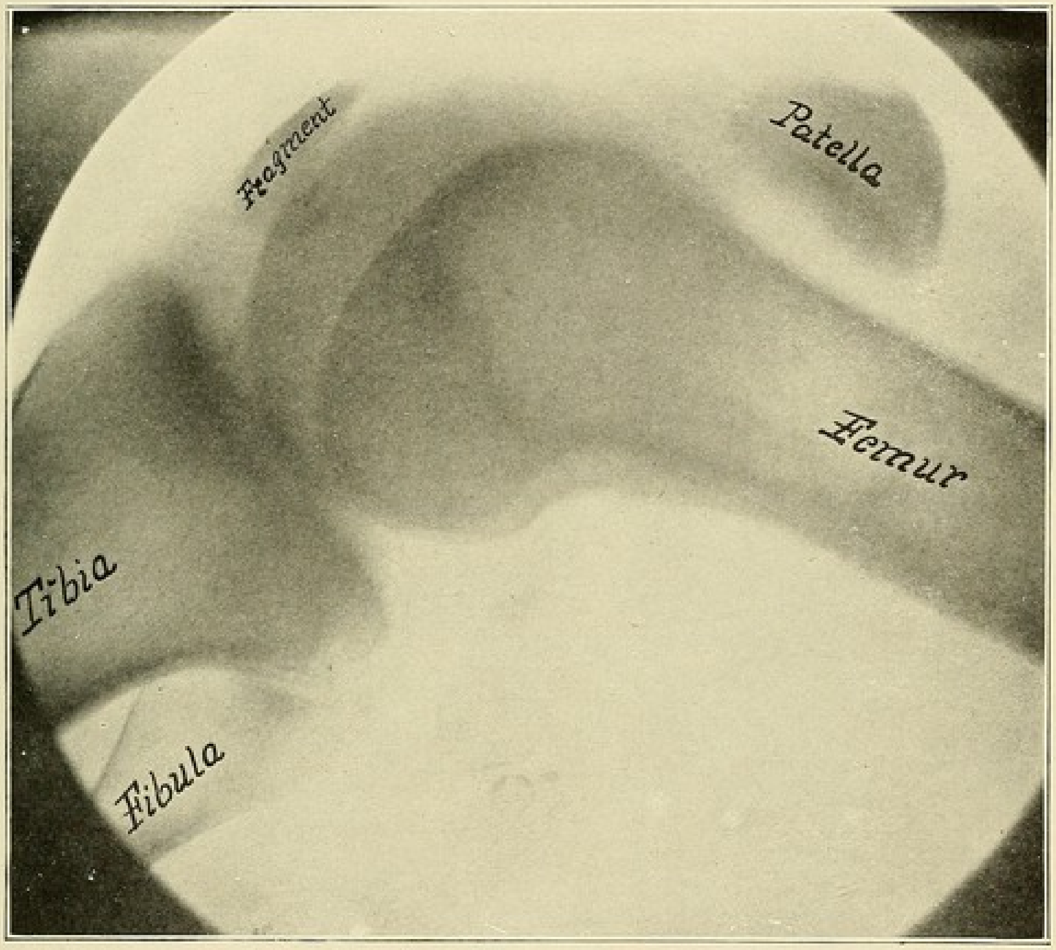


Fig. 168.—Spontaneous fracture of the patella in a Charcot knee. The faint outline of the bones distinctly shows the early changes that take place in this disease.

Patella.—Fig. 168 represents a case in which there was a spontaneous fracture of the patella without violence. The patient gave a specific history, and the knee presents a typical picture of a beginning Charcot. The fragments were wired together, and the patient is still in the sanitarium, with little or no hope of a useful knee.

Femur.—Fractures of the femur are very common. They may be transverse, with little or no displacement, or oblique, with considerable displacement. The displacement is generally greater in adults

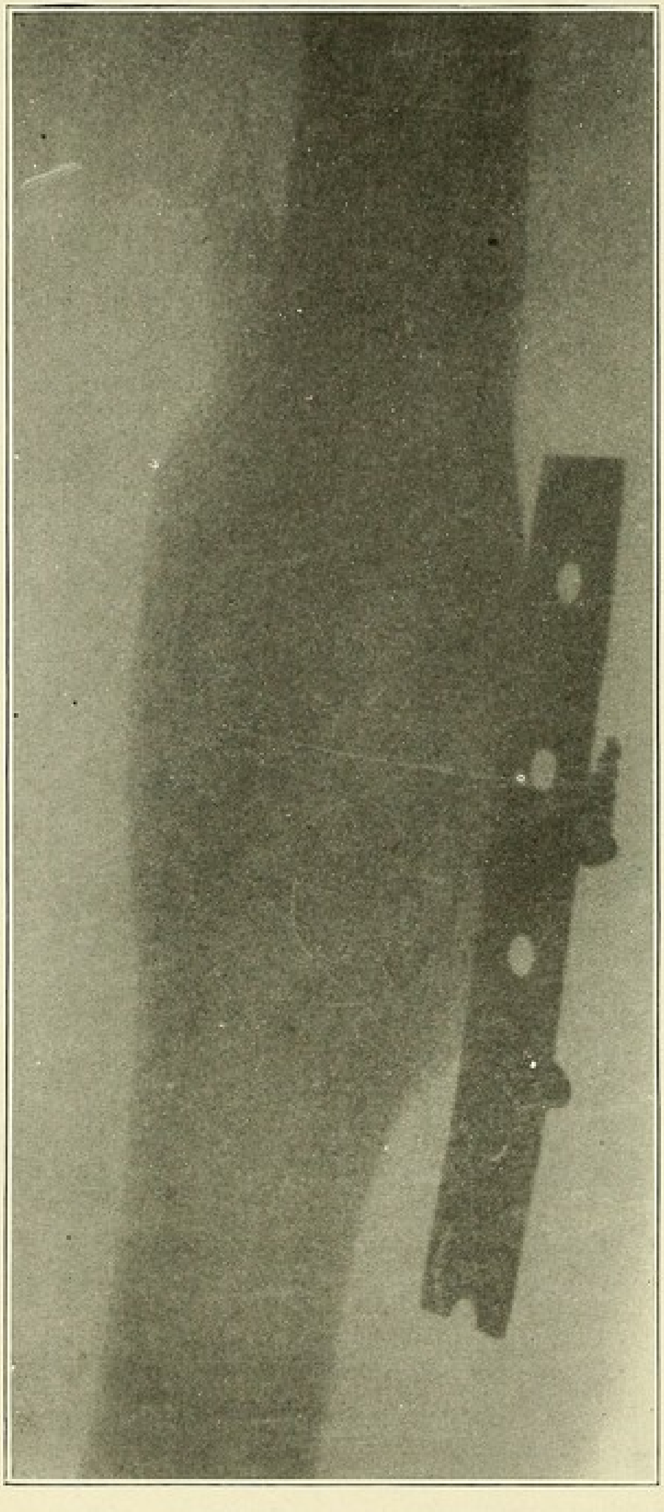


Fig. 169.—Appearance of a reunited femur months after the fragments were fastened together with a Lane plate.

than in children. Fig. 169 is a skiagraph that was made months after the reduction of the fracture and the application of the silver plate by means of screws. The fracture occurred in a boy 9 years old, was transverse, and the displacement was great. Two or three unsuccessful attempts were made to reduce the fracture and keep the bones in apposition. Without the use of the x-ray this boy would have had one leg at least $\frac{3}{4}$ inch shorter than the other, which would have been an impediment to him through life.

Fractures of the femur should be skiagraphed in two directions, the exposures being made at right angles to each other. Fractures in the shaft of the bone are usually not very difficult to skiagraph, but injuries in the head and neck are sometimes quite difficult, requiring a number of exposures in different directions to clearly outline the extent of the injury.

Hip.—Fractures at the hip usually occur in the femur, but may include the pelvic bones. Fractures in the upper end of the femur may be intracapsular, extracapsular, separation of the epiphysis, fracture of the greater trochanter, or fracture of the shaft of the bone immediately below the greater trochanter.

Good skiagraphs of the hip in large adults are sometimes very difficult to make unless the operator has a modern equipment and understands how to operate it. In very thick subjects the intensifying screen may be used, but it is always at the expense of definition or clearness. The plate may be any size from 8x10 to 11x14. It is well, when possible, to include both hips in the same exposure, in order that a comparison may be made. The center of the tube (the anode) should be directly over the symphysis pubis, so that the shadows of the hips may be exactly the same. When the skiagraph is to be taken of only one hip, the tube is placed directly over the acetabulum, with the center of the plate directly under the anode of the tube. Where the injury is localized, the compression diaphragm should be used. The time of the exposure will vary with the thickness of the parts and the kind of generator and tube. With a good 16-inch coil and a 6- or 7-inch high vacuum coil tube, the time should be from thirty seconds to one minute. Experts would do the work considerably quicker, but as a rule very few hip skiagraphs are made under thirty seconds.

Fractures of the neck and head of the femur occur more frequently in adults and old people, but are sometimes seen in the youth as well.

Fig. 170 is a skiagraph of an intracapsular fracture of the femur in an old lady four months after the injury. She was attended by an osteopath during this entire time and was taking regular osteopathic treatment. As there was no improvement, she consulted a regular physician, who sent her for a skiagraph. The diagnosis was easily made, but it was too late to attempt to reduce the fracture. Fractures of this nature are difficult to reduce when recognized im-

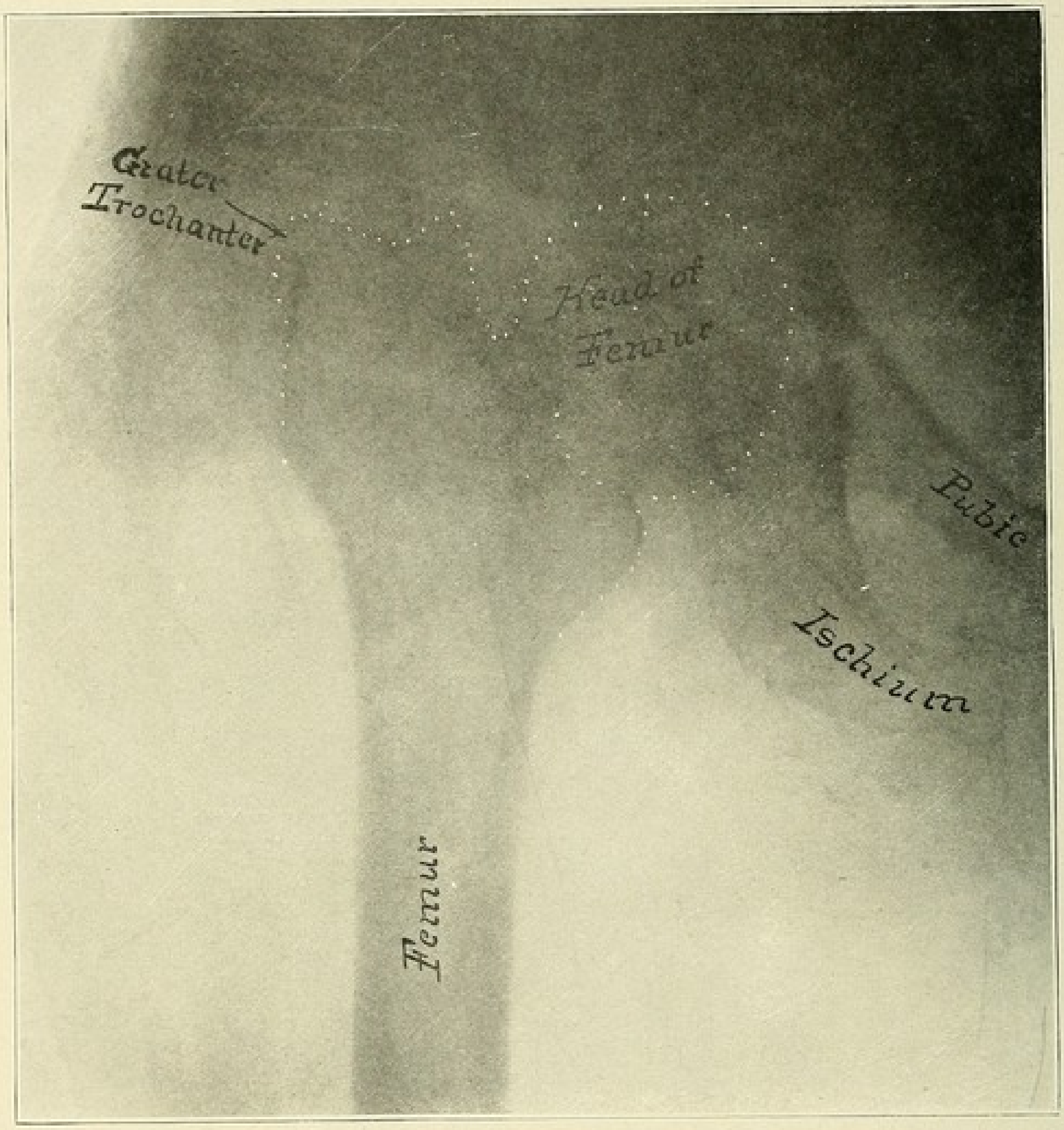


Fig. 170.—Intracapsular fracture of the femur.

mediately after the injury, and after four months, when adhesions are well formed, it is too late to do anything.

In dislocations at the hip the acetabulum is frequently fractured. By means of an impaction the head of the femur may be driven through the acetabulum, driving the pelvic bones into the pelvis. Dislocation of the head of the femur is usually accompanied by more or less injury to the femur itself or the walls of the acetabulum.

In skiagraphing the hip it is frequently very difficult to distinctly show the full extent of the injury in a single skiagraph, and it is

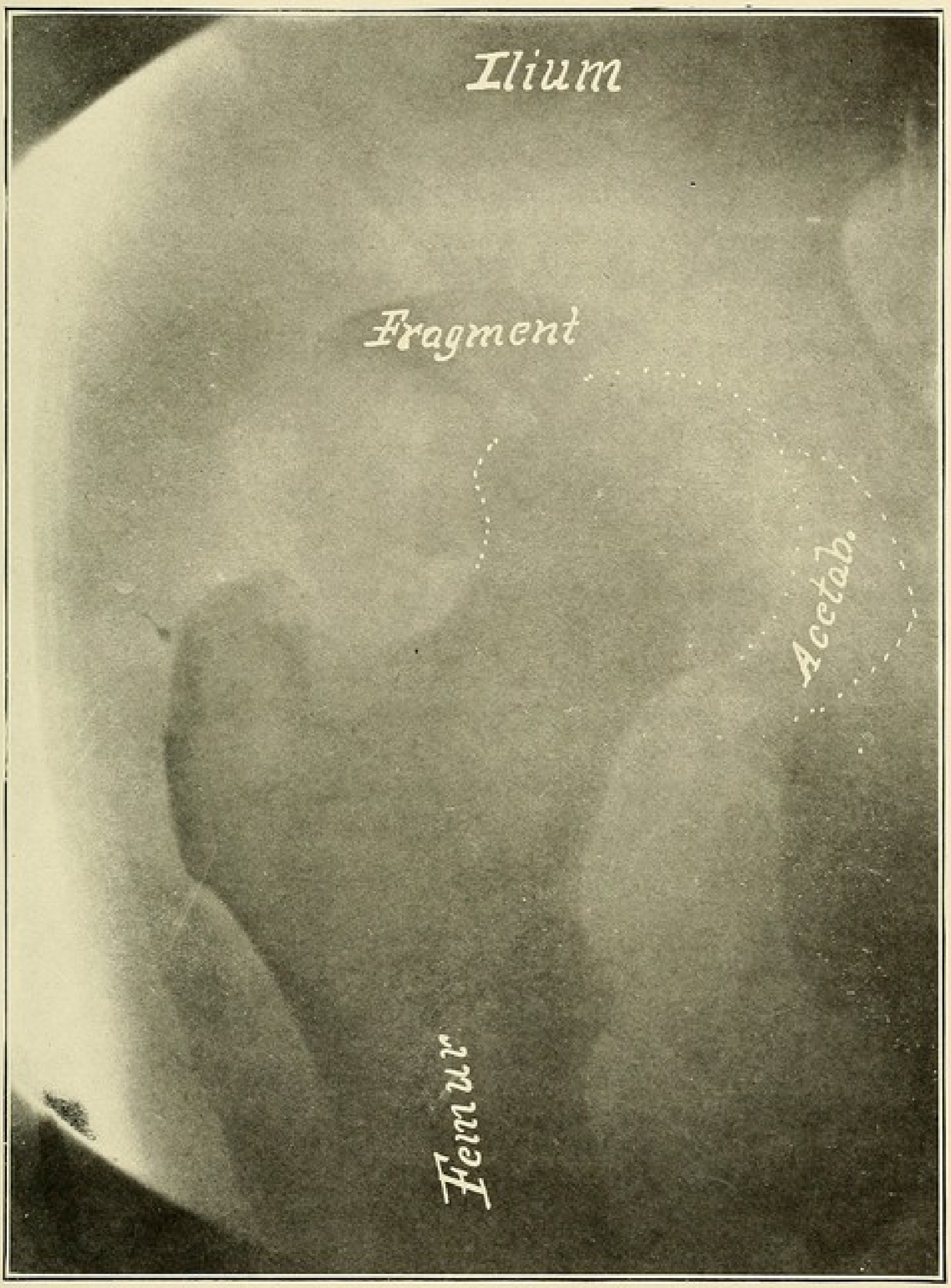


Fig. 171.—Fracture of the acetabulum, with displacement of a portion of the posterior wall.

often necessary to make two or three exposures at different angles before the exact condition can be made clear.

Fig. 171 is a skiagraph showing a dislocation of the femur upward and backward, with fracture of the posterior wall of the acetabulum. The fragments from the acetabulum are indicated by the dots. The head of the femur is uninjured. This skiagraph was made on an 8x10 plate, with a compression diaphragm and a medium vacuum tube energized by a 24-inch coil with an electrolytic interrupter, in twenty seconds. It would have required from two to five minutes to have made the same skiagraph with a static machine, provided the machine had been in perfect order, with other conditions equally favorable. Only the induction coil or transformer can be relied upon to produce satisfactory skiagraphs.

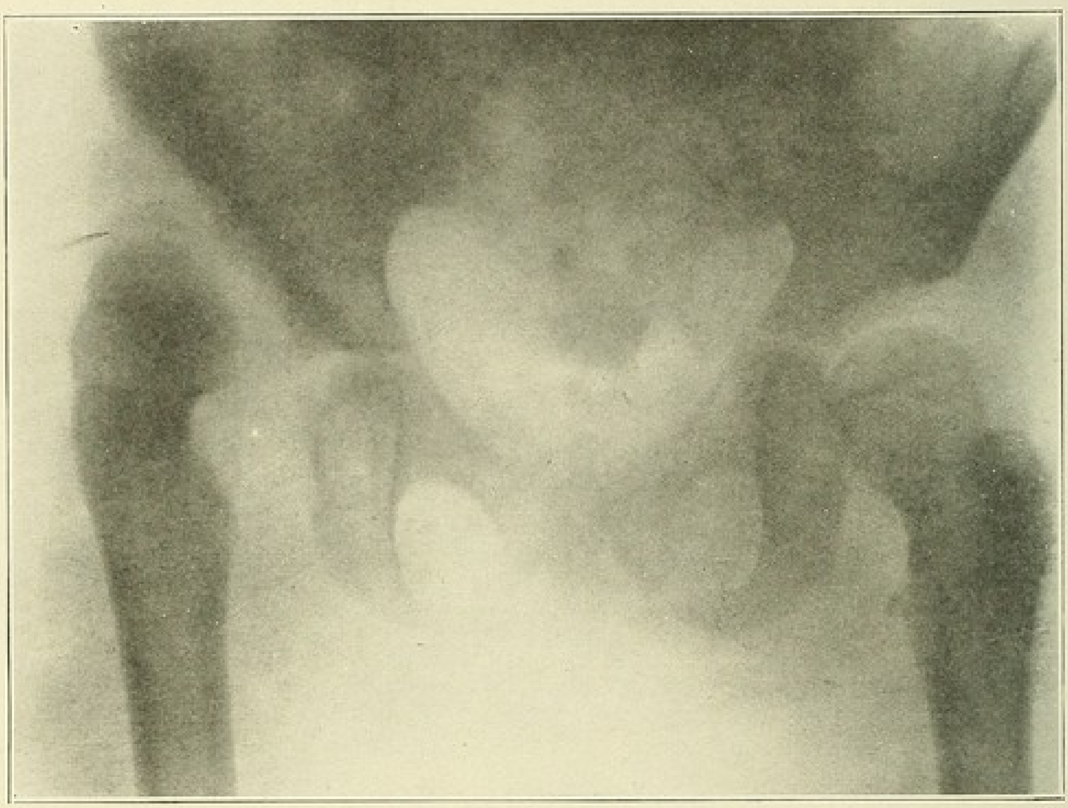


Fig. 172.—Congenital dislocation of the femur in a boy 6 years old.

Congenital dislocations at the hip are more common than one would think. Dislocations of this kind may result from violence during delivery or in utero from violence to the mother. Fig. 172 is a skiagraph of the hips and pelvis of a boy 6 years of age, who, it is claimed, was a cripple from birth. It will be noticed that the right acetabulum is almost completely obliterated. The femur appears well formed, though slightly straighter than the other. This child appeared in perfect health, and was certainly an ideal case for the Lorenz method of treatment.

Fig. 173 represents another case of congenital dislocation of the femur. This child was 3 years old and was in excellent health. He had learned to walk, and was able to get around remarkably well, considering his condition. This was another case that should have been treated by the Lorenz method. Unfortunately the author lost sight of both cases of congenital dis-

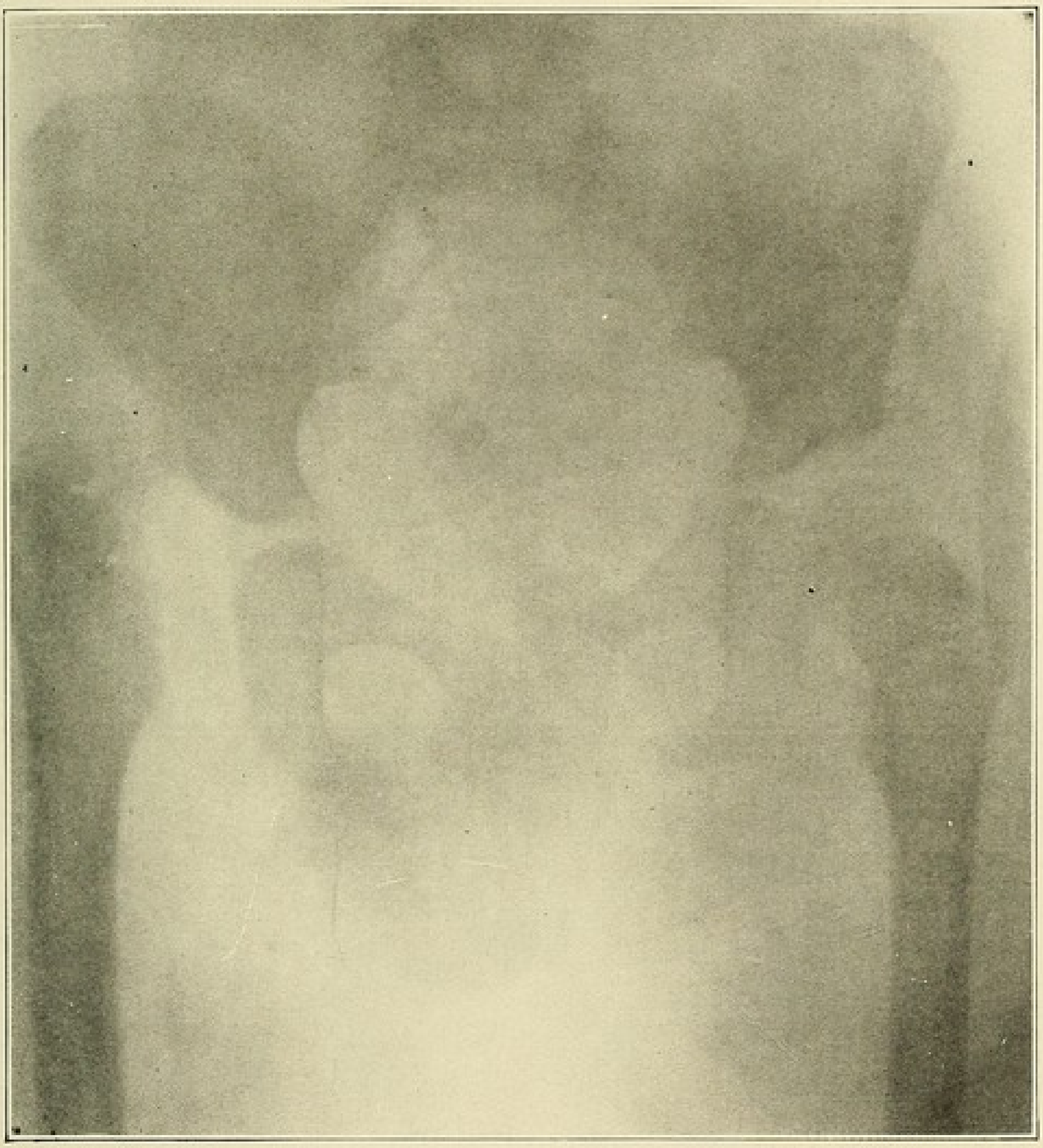


Fig. 173.—Congenital dislocation of the hip.

location of the hip shown in Figs. 172 and 173. These cases should have the femurs reduced according to the Lorenz method and skiagraphs made during the period of recovery. By this means much information could be gained as to the actual changes that take place in re-establishing the acetabulum, and making for the patient a hip that comes very close to the normal in both appearance and function.

Fig. 174 plainly shows an old ununited intracapsular fracture of the head of the femur. It will be seen that the greater trochanter is too high, and there is a marked displacement downward of

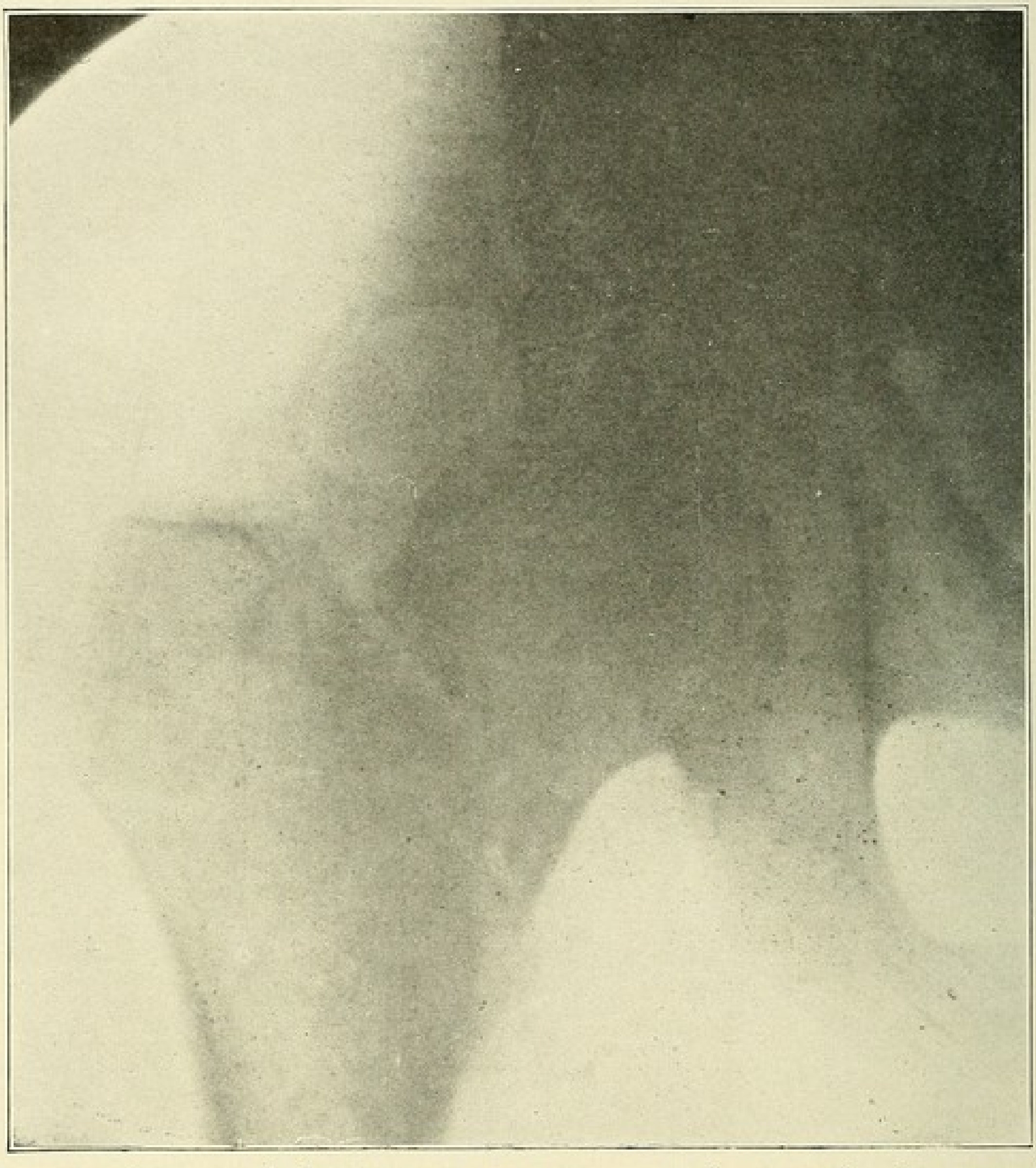


Fig. 174.—Skiagrapn of adult hip made with a sinegran in three seconds. Shows an old ununited fracture.

the head of the femur at the line of fracture. Fractures of this particular kind are quite common in elderly people, and frequently prove fatal.

Bones of the Pelvis.—Fractures in the pelvic bones are quite common, and may occur at any age, but are most frequent in adult life. The clinical diagnosis of fractures of the pelvis are usually not very difficult, but the exact determination of their location and extent is extremely difficult, if not impossible. Only the x-ray will reveal the conditions existing in fractured pelvic bones. Good skiagraphs of this region in thick subjects are sometimes very difficult to make. Where the injury is on one side, a general exposure should be made on an 11x14 plate to get a correct idea of the condition.

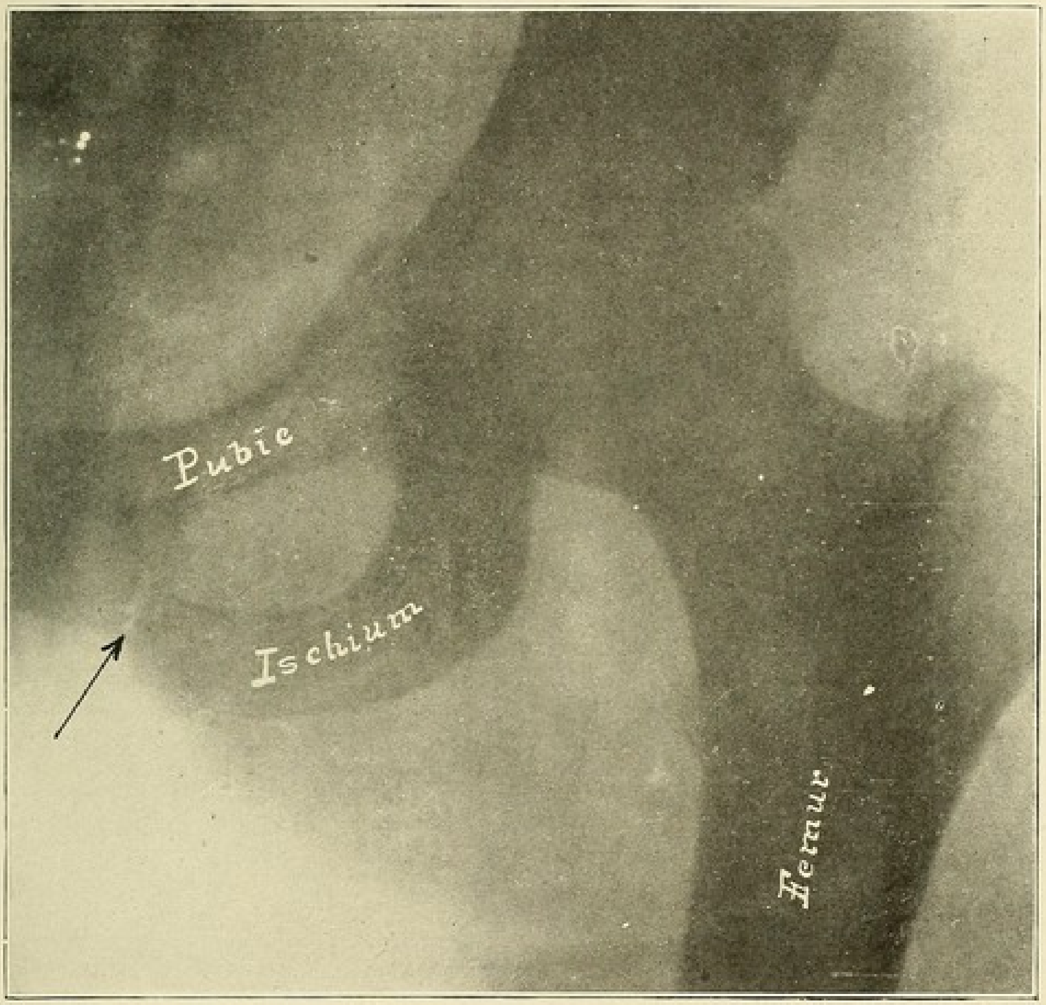


Fig. 175.—Fracture of the pubic bone near the symphysis.

If the plate fails in any particular to clear up the diagnosis, it will at least locate the injury, when a second and more localized exposure may be made through the compression diaphragm. Fig. 175 shows a fracture in the pubic bone on the right side, as indicated by the arrow. By physical methods it was impossible to determine the location or extent of the injury. There was no displacement of bone tissue, and the patient made an excellent recovery. The author has a number of skiagraphs showing fractures in the ilium. Some of them are not very extensive, while others extend through the main body of the bone—sometimes in several directions. There is an occasional separation of the ilium from the sacrum at the sacro-iliac synchondrosis. This may be the only injury present, or the ilium may be fractured in one or more directions. The author has seen severe cases in which the os innominate was broken in three pieces, with a fracture of both the ischium and pubic bones on the same side. These cases resulted from railroad accidents.

Fractures in the coccyx are not very common, but do sometimes occur. Injuries to the sacrum are probably less common than in any other part of the bony structure. The author has yet to see a fracture of the sacrum. Injuries to the coccyx and sacrum may be skiagraphed in an anteroposterior position, with the patient on his back and the plate beneath. The tube should be of high vacuum and about 18 or 20 inches above the plate. The length of exposure will depend upon the generator. With a 16-inch coil and electrolytic interrupter the time of exposure will be about thirty seconds and not over one minute. Short exposures produce good, clear skiagraphs. Time must be allowed for the rays to penetrate the parts, but when the time is too prolonged the picture is indistinct, the plate is blurred or fogged, and the finer details are blocked or completely destroyed.

Spinal Column.—Good skiagraphs of the spinal column are very difficult to make. The cervical vertebræ may be exposed either in the lateral or anteroposterior position. Fractures in this region are less difficult than in the dorsal and lumbar region. The lumbar and dorsal region must be skiagraphed in the anteroposterior position, and the tube may be set at different angles. Complete fractures are not very difficult to determine by means of the skiagraph, but incomplete fractures are always extremely difficult to make out even under the very best conditions.

Ribs and Sternum.—Complete fractures in the ribs, either with or without displacement, are easily shown in a skiagraph. Fractures near or at the angles in front are usually difficult to determine, and mere fissures in the ribs are always difficult to make out. The position of the patient during the exposure must be determined by the location of the injury. If the injury in the ribs is near the spine, place the patient on his back; if the injury is in the anterior portion near the sternum, place the patient on his stomach. It must be borne in mind that the injury must be brought as near the plate as possible if the skiagraph is to be clear and of any diagnostic value. Injuries to the sternum may be discovered by placing the patient face downward, so as to allow the sternum to come directly against the plate, while the tube is placed at such an angle as to allow the rays to miss the spinal column. Where it is possible to use the compression diaphragm in skiagraphing the chest, the parts may be immobilized to a considerable extent by the use of firm pressure.

CHAPTER XVII.

X-RAY IN DISEASES OF THE BONES.

The bones are largely composed of phosphate of calcium, and vary greatly in density and thickness throughout their structure. X-rays are absorbed by the bones in proportion to their density. During an exposure for a skiagraph the rays penetrate the bones, and, reaching the sensitized plate, oxidize the silver salts in the film in an inverse proportion to the density of the bones and other tissues. The soft tissues absorb very few of the rays, allowing the rays to reach the film on the plate and oxidize the silver. The parts of the plate so acted upon become quite dark during development. Thin parts of the bone leave darkened shadows upon the plate, while the dense parts of the bones leave the plate under them almost white because few rays pass through them at these points. The medullary canals are less dense than the walls. A well-timed skiagraph will show the density of the bones very accurately, and will also show the changes in the bony substance as the result of disease. Periostitis, ostitis, osteomyelitis, necrosis, caries, and tuberculosis of the bones produce changes in the structures that are easily exhibited by means of the x-ray.

Periostitis.—Fig. 176 illustrates a case of periostitis of the ulna in a boy 10 years old. There was no external evidence of the trouble existing in this arm. The boy complained of great pain on motion, and the arm was very tender on pressure. The arrow shows the location of the trouble, which is indicated by a rough, irregular shadow on the side of the shaft of the bone, the result of an inflammatory process in the periosteum. Frequent mistakes in diagnosis are made in cases of this character, causing the patient long suffering, and sometimes followed by disastrous results.

Osteomyelitis.—Osteomyelitis is frequently accompanied by very different symptoms from what has been taught. It may be very slow in its progress, with slight pain and little or no fever. Ulcers may develop in the soft tissues that defy all methods of treatment.

Fig. 177 (1, 2) is an illustration of a photograph and skiagraph of a case of osteomyelitis of the tibia in a woman past 30 years. This case was extremely deceptive, for the early symptoms did not

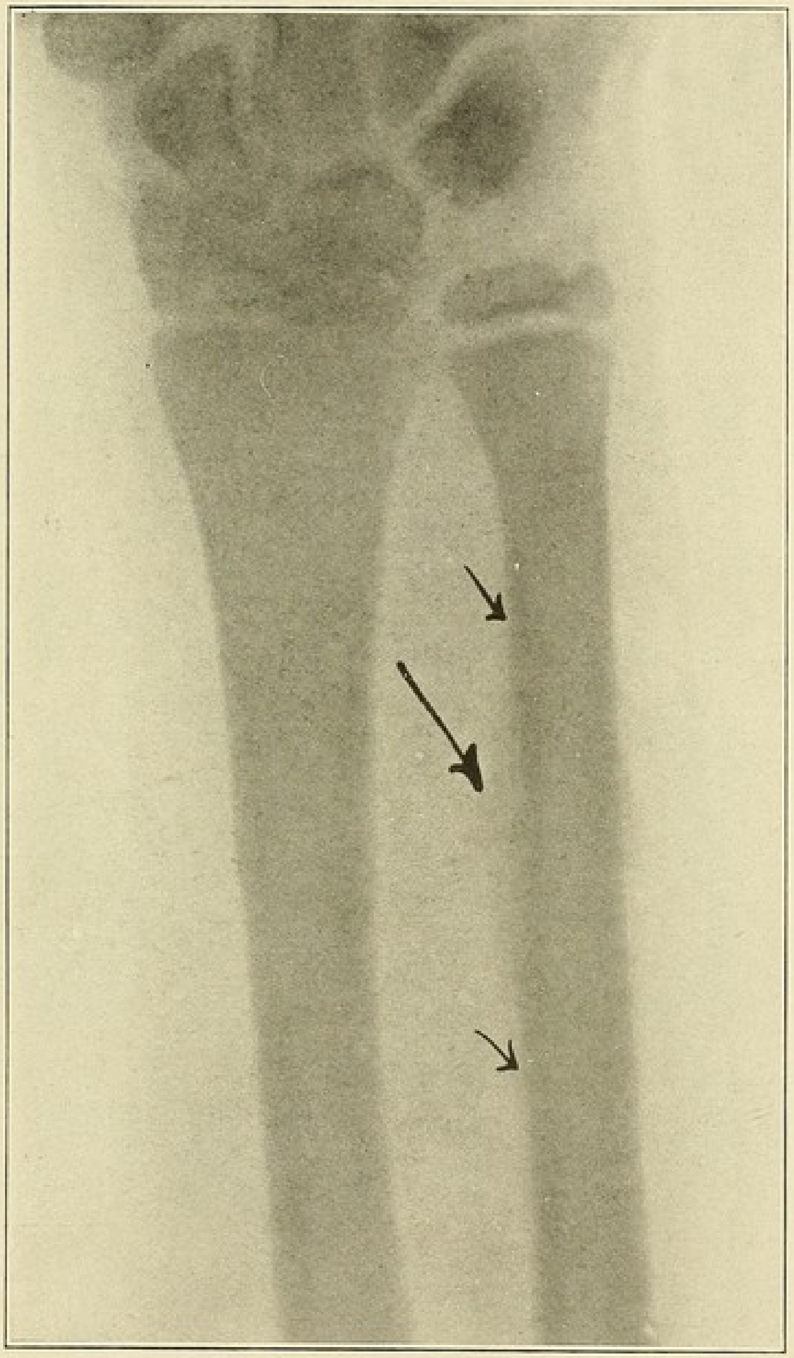


Fig. 176.—Periostitis of the ulna.

point to any bone involvement, and the case was treated for some time for local ulcers, but without improvement. After about a month she began to complain of aching pains in the bones at night. The reproduction from a skiagraph (2) made at this time shows the condition in both tibia and fibula. The arrows at *C* point out the diseased areas in the tibia and fibula, which are indicated by lighter shadows along the medullary canals. The arrow at *D* points out the periosteal thickening on the outer side of the tibia. From

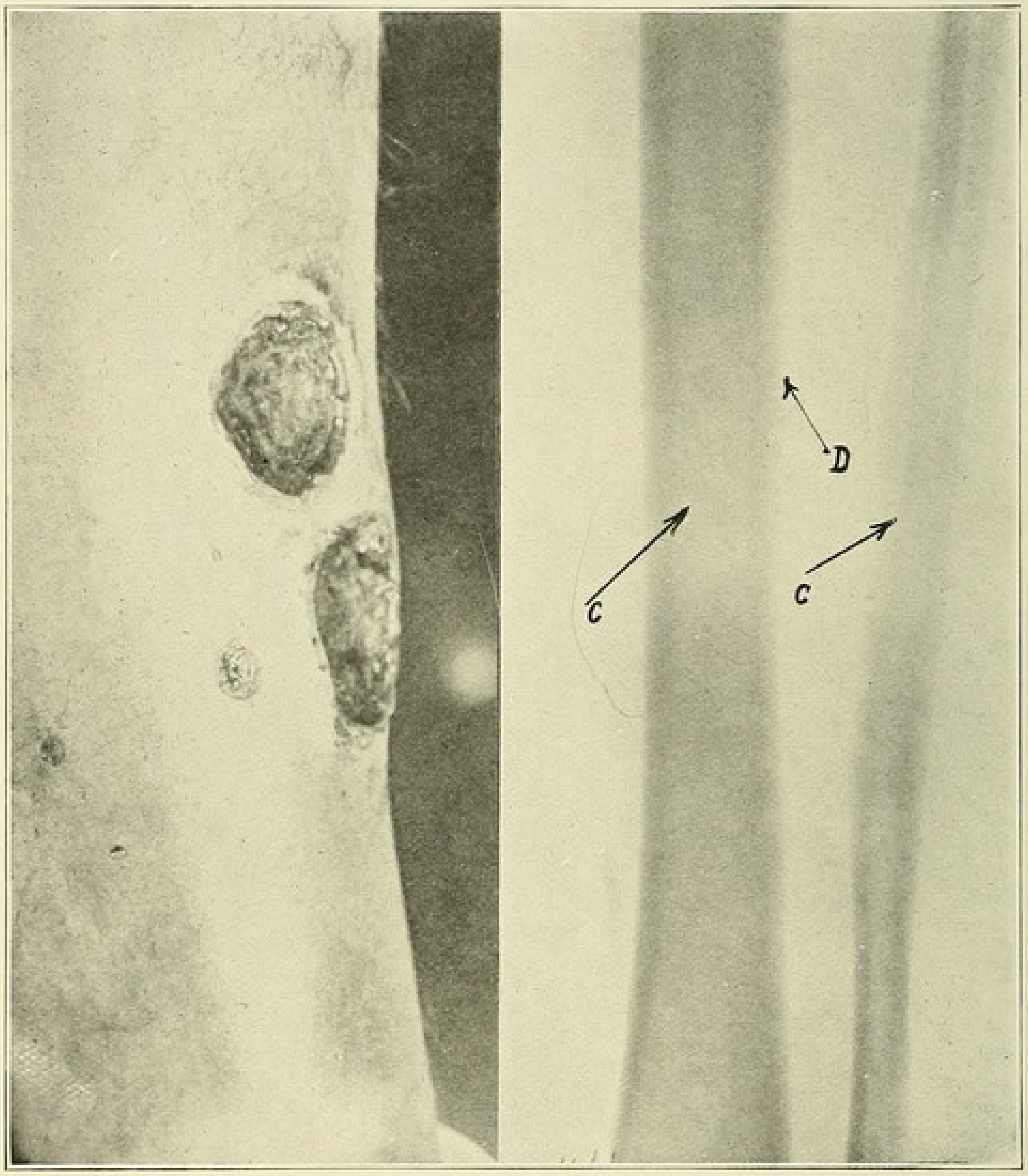


Fig. 177.—Osteomyelitis of the tibia and fibula. 1, photographic appearance of the leg; 2, skiagraph showing the condition in the bone.

these findings the case was diagnosed as osteomyelitis of the tibia and fibula, with periosteal involvement. The case was promptly turned over to Doctor J. Spencer Davis for an operation. When the tibia and fibula were opened, the medullary canals along the area indicated in the skiagraph were found to be full of pus. The case has made a slow, but uneventful, recovery.

Many cases of low-grade periostitis and osteomyelitis, without surface symptoms, are frequently treated as growing pains, neuritis, or rheumatism. The large majority of these cases may be diagnosed at a very early period by means of the skiagraph. Many interesting cases of neglected osteomyelitis have come under the

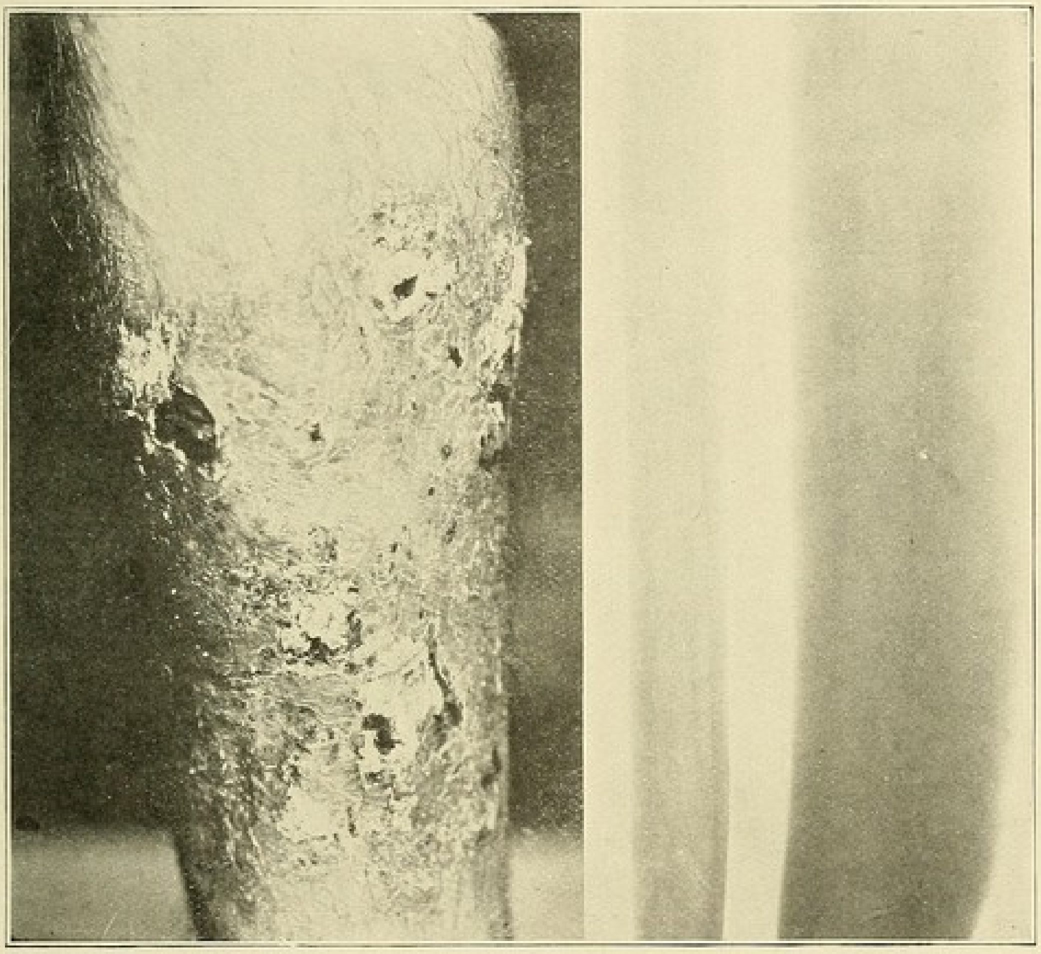


Fig. 178.—Photograph and skiagraph of a sore leg of three years' standing. Low grade of osteomyelitis of the tibia.

author's observation during the past four years. The attending physician can not be blamed for overlooking these early cases, for he has been taught to look for more violent symptoms. The low, grumbling, aching pains have been diagnosed and treated as rheumatism until the bone has broken down and the pus found its way to the surface.

Fig. 178 is a case similar to Fig. 177. The shaft of the tibia is thickened and appears to be giving way. The medullary canal contains pus. The patient refused operative interference, and has not been heard from since the examination was made.

Fig. 179 was thought to be a case of periostitis, with beginning of osteomyelitis of the lower end of the femur. The author suspected osteosarcoma. The case was operated recently.

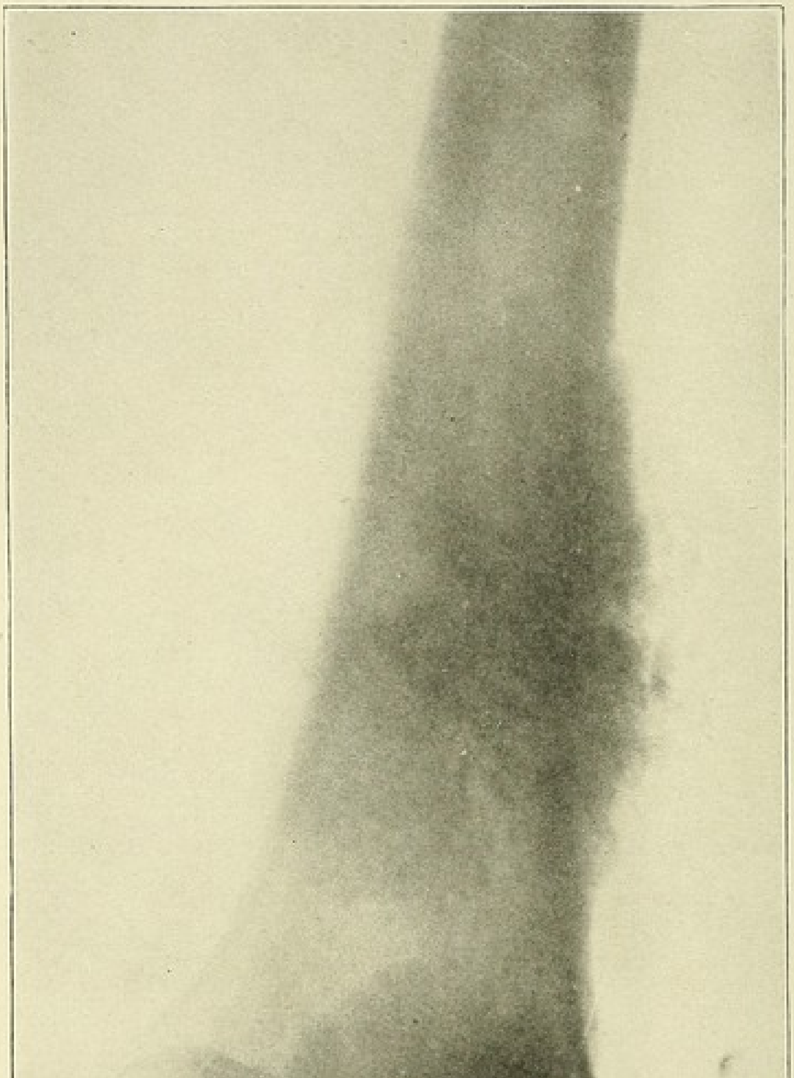


Fig. 179.—Osteomyelitis of the lower end of the femur of several years' standing.

Fig. 180 beautifully illustrates a neglected case of osteomyelitis of the femur. The skiagraph was made four months after the annoying pains in the bone began. The case was diagnosed and treated as rheumatism. When pus accumulated beneath the skin, the swelling was lanced and a large quantity evacuated. The discharge continued and tuberculosis was suspected. Much of the bone was destroyed. Before the skiagraph was made, bismuth paste was injected through the sinus, which is shown as dark deposits around the bone.

Caries.—Any destructive process or change in the contour of the bone will show in a well-made skiagraph. Fig. 181 is a skiagraph of an ankle. This was a troublesome case for diagnosis, and

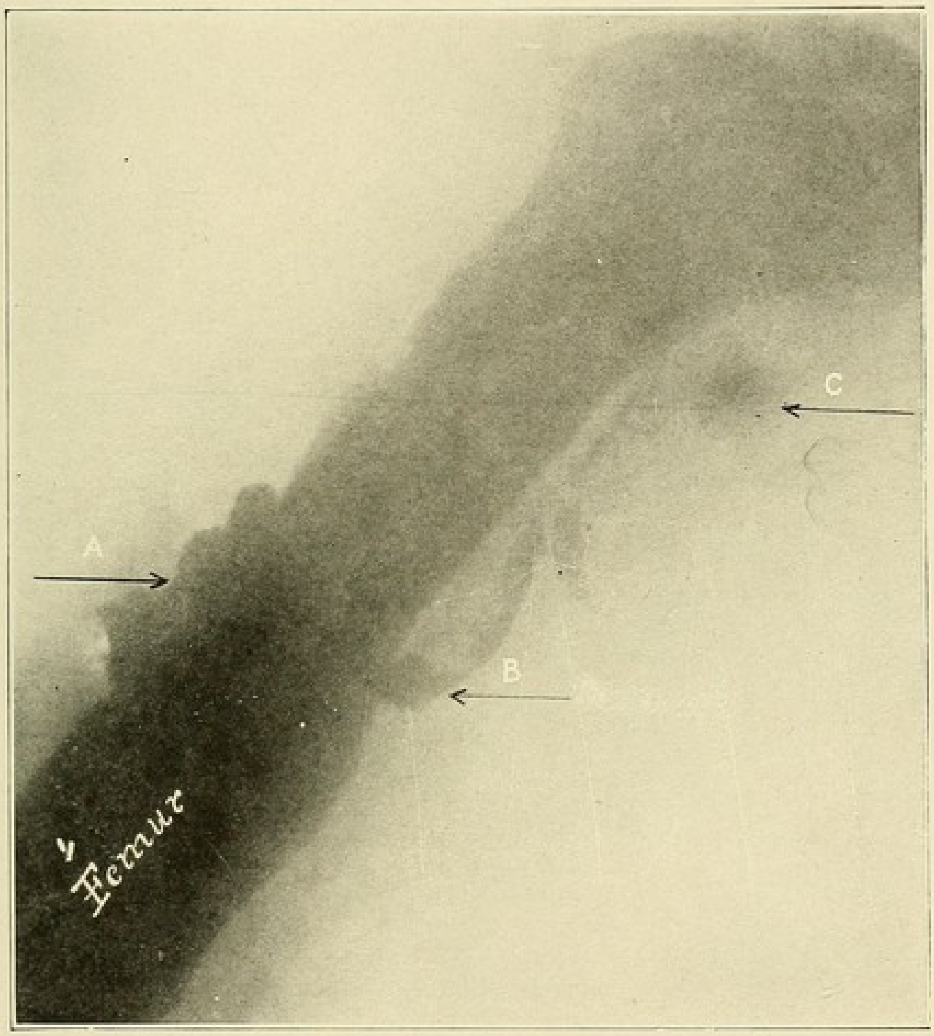


Fig. 180.—Osteomyelitis of the femur of long standing. A, B, bismuth; C, sinus and point of bismuth injection.

was referred to the author by Doctor J. B. Smoot for a skiagraph. As the skiagraph shows, the pain and distressing symptoms in this case were the result of caries of the internal malleolus. An early operation removed the diseased bone and cured the case. A condition of this kind was suspected in the case. The skiagraph confirmed the opinion, and showed the extent of the trouble. The diseased bone was removed, and the case made a rapid recovery.

Fig. 182 is a skiagraph of a tubercular hip in a child 6 years old.

By noting the appearance of the two femurs it will be seen that the epiphysis of the right is flattened and very much changed. The stage of shortening has begun, and, if the process is allowed to continue the damage will soon be beyond repair. This case should

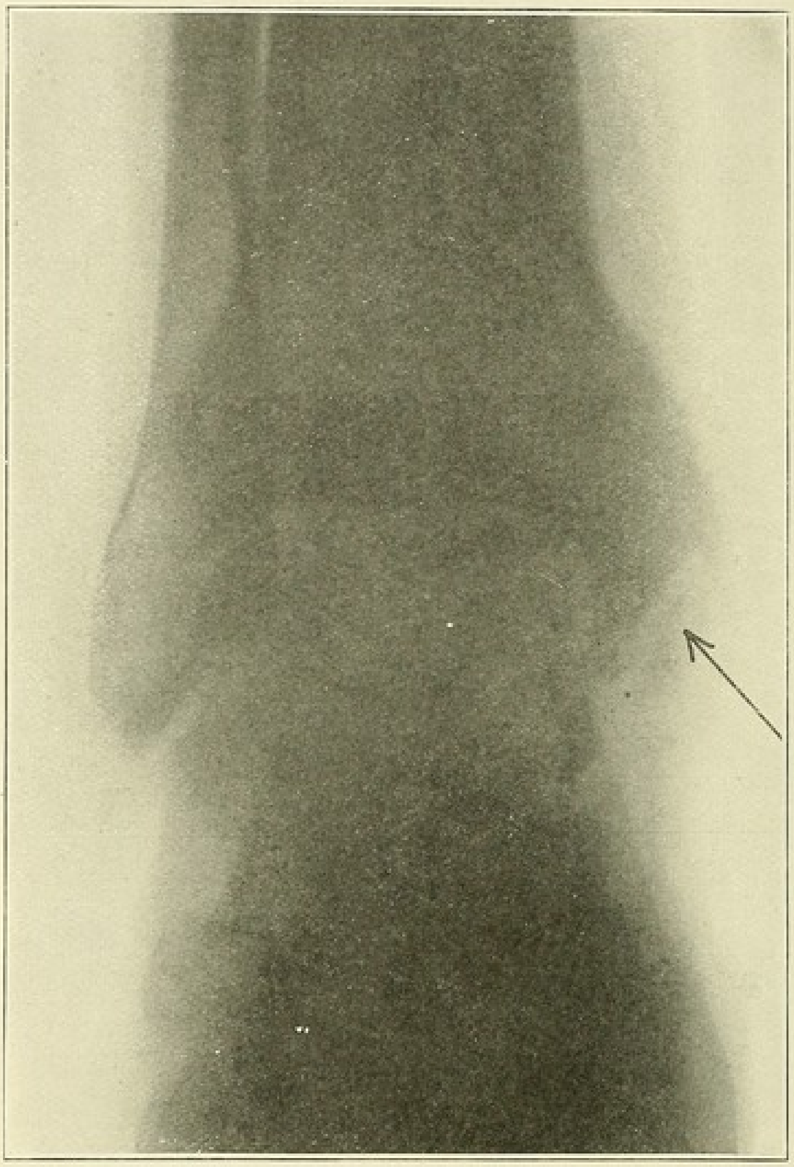


Fig. 181.—Caries of the internal malleolus.

have been skiagraphed earlier, for the sooner these conditions are recognized the easier will they be corrected. Marked tubercular conditions frequently make a blurred image, though distinct enough for diagnostic purposes.

Tuberculosis of the Hip.—Tuberculosis of the hip is very common, but very seldom recognized at a time when the disease is curable. Every case of hip-joint disease in the youth should be skiagraphed early and often until the diagnosis is made absolute. Fig. 183 is a skiagraph of an infected hip in a boy 14 years old, who had been afflicted for more than two years. The author has made a number of skiagraphs of this hip, which show that the destructive process is continuous. The irregular dark spots are shadows from bismuth paste that was injected through a sinus. The pus has burrowed its way through the soft tissues. The presence of the bismuth in and around the acetabulum indicates that the structures

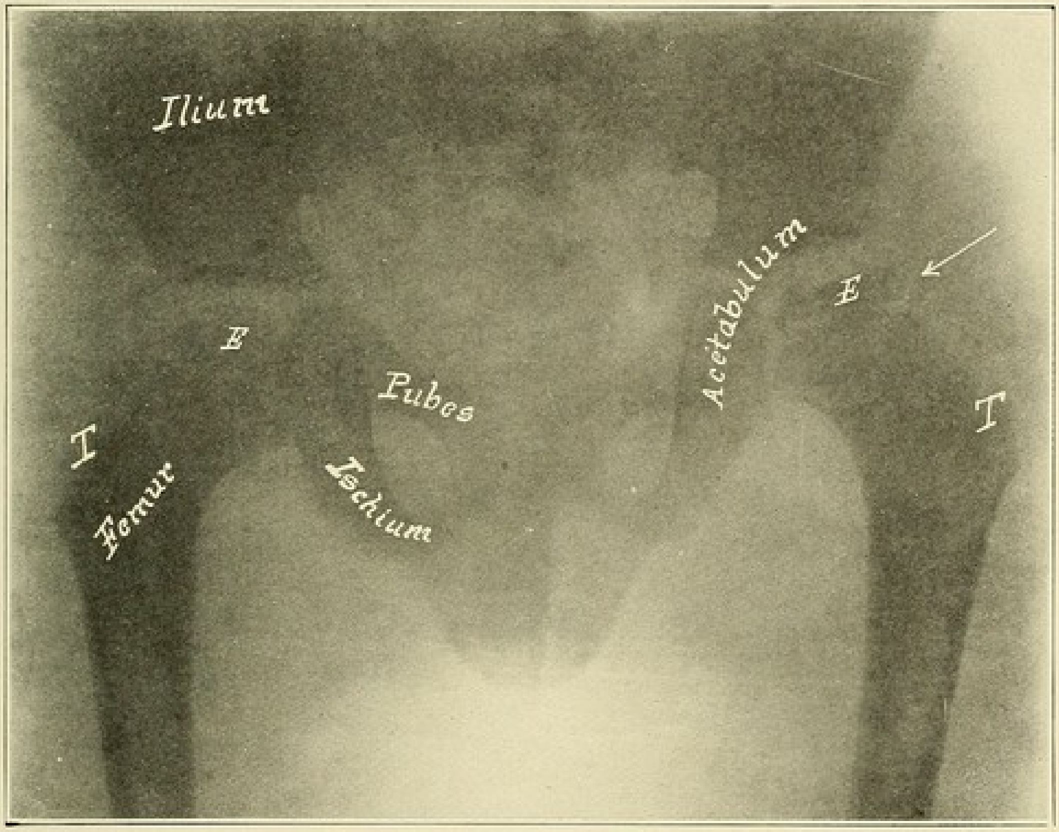


Fig. 182.—Tuberculosis of the hip in a child 6 years old.

of which the joint is composed are completely disintegrated and beyond a reasonable hope of repair. This skiagraph was made during a recurrent attack. Doctor J. W. Bourland, who referred the case, had treated the boy through his first attack, and for a time he seemed entirely well. After receiving a severe fall on this hip while roller skating, symptoms of the former trouble began to reappear, and thus far have not responded to treatment.

Because of the disease present in the hip-joint it is often extremely difficult to get clear and distinct skiagraphs that show the true condition. The negative should be studied before a suitable illumination box if the finer details of the parts are to be seen. Prints from such negatives are never clear and distinct, and should never be used when the plates can be had. The negative from which this skiagraph was printed is clear and rich in fine detail, and has

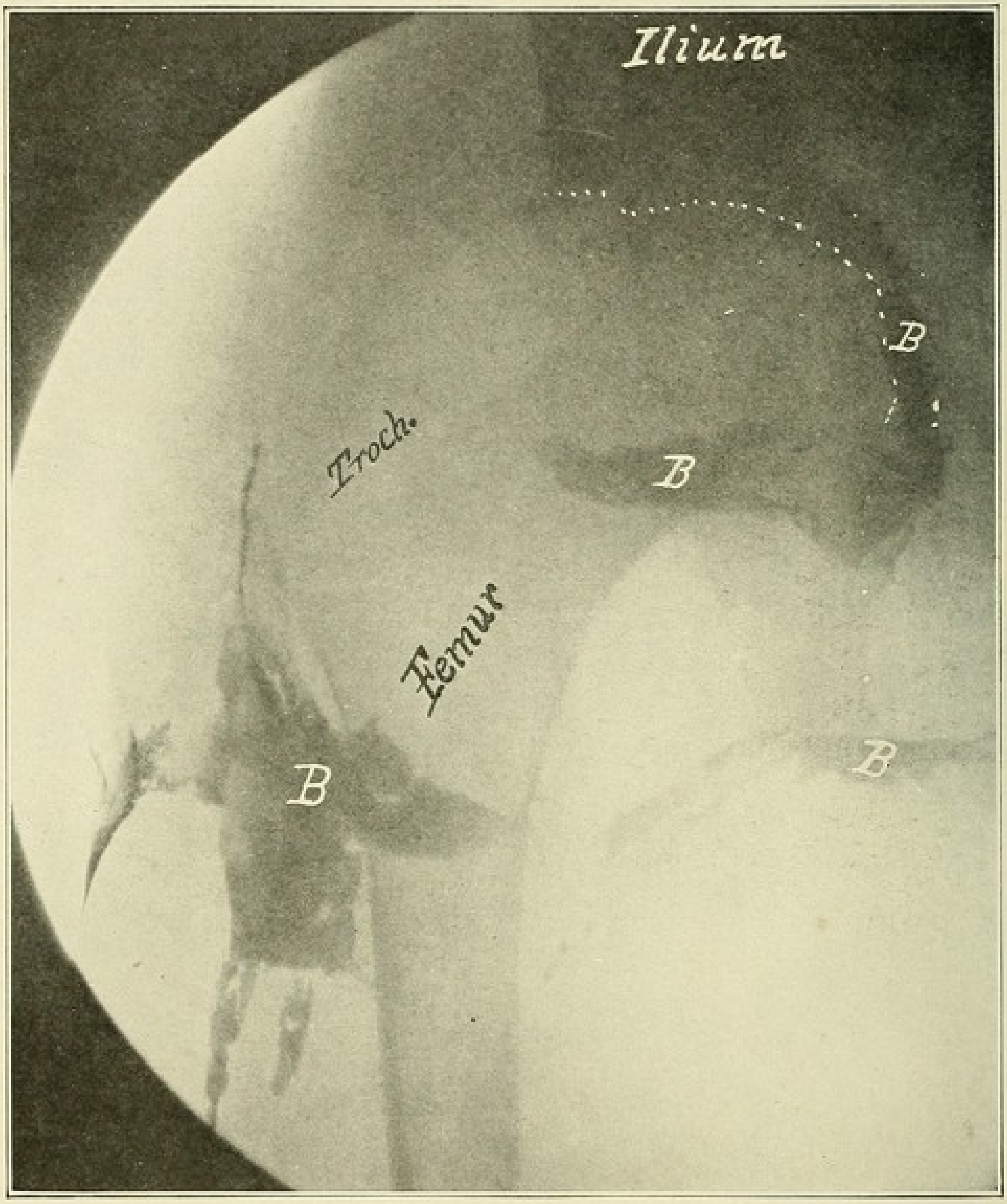


Fig. 183.—Tubercular hip injected with bismuth. B, bismuth.

sufficient contrast to outline the true condition. Much that is valuable in this negative has been lost through the process of printing and reproduction. This is unavoidable, as those who have had experience in similar work well know. Patients and many doctors insist that prints from these thin, delicate negatives be sent them

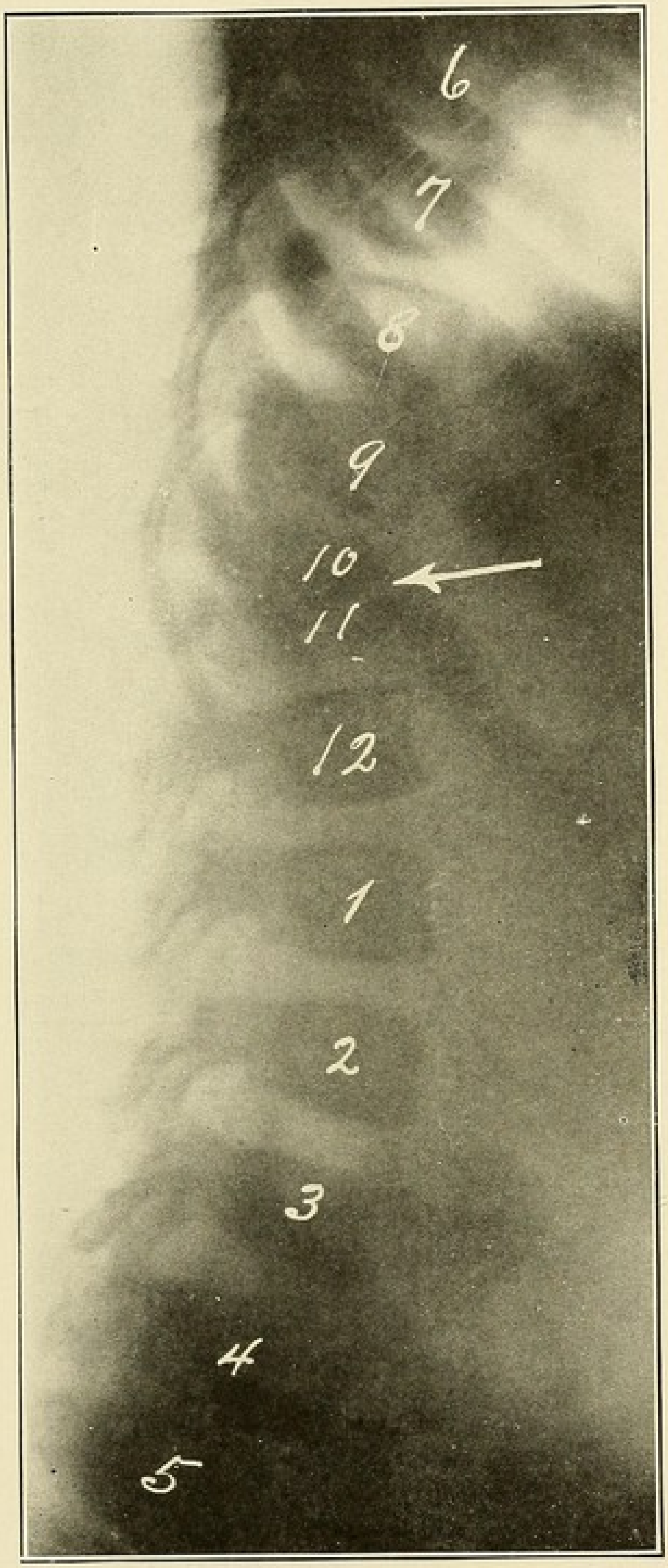


Fig. 184.—Tuberculosis of the spine. Pott's disease.

for study and diagnosis, but it should be remembered that the negative should be studied by the physician with the aid of the radiographer, for he alone is able, in many cases, to interpret the true findings as shown by the plate.

Tuberculosis of the Spine.—Tuberculosis of the spine is a very common disease, but is seldom diagnosed until irreparable damage has been done to the bodies of one or more of the vertebræ. Good skiagraphs of such lesions are always difficult, but not impossible. Exposures should be made in both the anteroposterior and lateral positions. If the disease is present and the skiagraph is well made, the plate will show the extent of the change that has taken place in the substance of the vertebræ. Fig. 184 is a skiagraph of a well-advanced case of Pott's disease. This was a lateral exposure, and distinctly outlines the bodies of the vertebræ. The bodies of the eleventh and twelfth vertebræ have melted down, or appear to have run together, and are little larger than one should be.

Tumors of the Bones.—By means of the skiagraph we are able to determine whether a tumor is connected with the compact or the cancellous portion of the bone. Occasionally tumors of the soft tissues are so dense that it is impossible, from physical examination, to determine whether they are myomata or osteomata. It is not always possible to determine from a skiagraph whether an osteoma is malignant (osteosarcoma), but the location, extent, and condition of the tissue involved may be determined with a great degree of certainty. Fig. 185 is a skiagraph of the upper ends of the tibia and fibula of a boy 18 years old. The growth had been six years in forming, according to the statement of the patient and other members of his family, and only lately had it been causing him any pain or discomfort. The skiagraph was made anteroposteriorly, and shows the extent of the tumor laterally. It appears that the tumor had its origin in the tibia, later affecting the fibula by pressure. On account of the pressure, the fibula was bent outward nearly 1 inch, as shown by a lateral skiagraph. This case was operated by simply removing the tumor and as much of the affected tissue as was possible without injuring the tibia to an irreparable degree. The pathologist reported that the growth was nonmalignant.

In skiagraphing bony tumors, care must be exercised not to overexpose them. As such tumors are usually in the bones of the extremities, a number of skiagraphs should be made with different lengths of exposure, varying from a few seconds to one of full time, and only in this way can a perfectly timed picture be obtained. A properly timed exposure will show the texture of the bone and the extent of the destructive process.

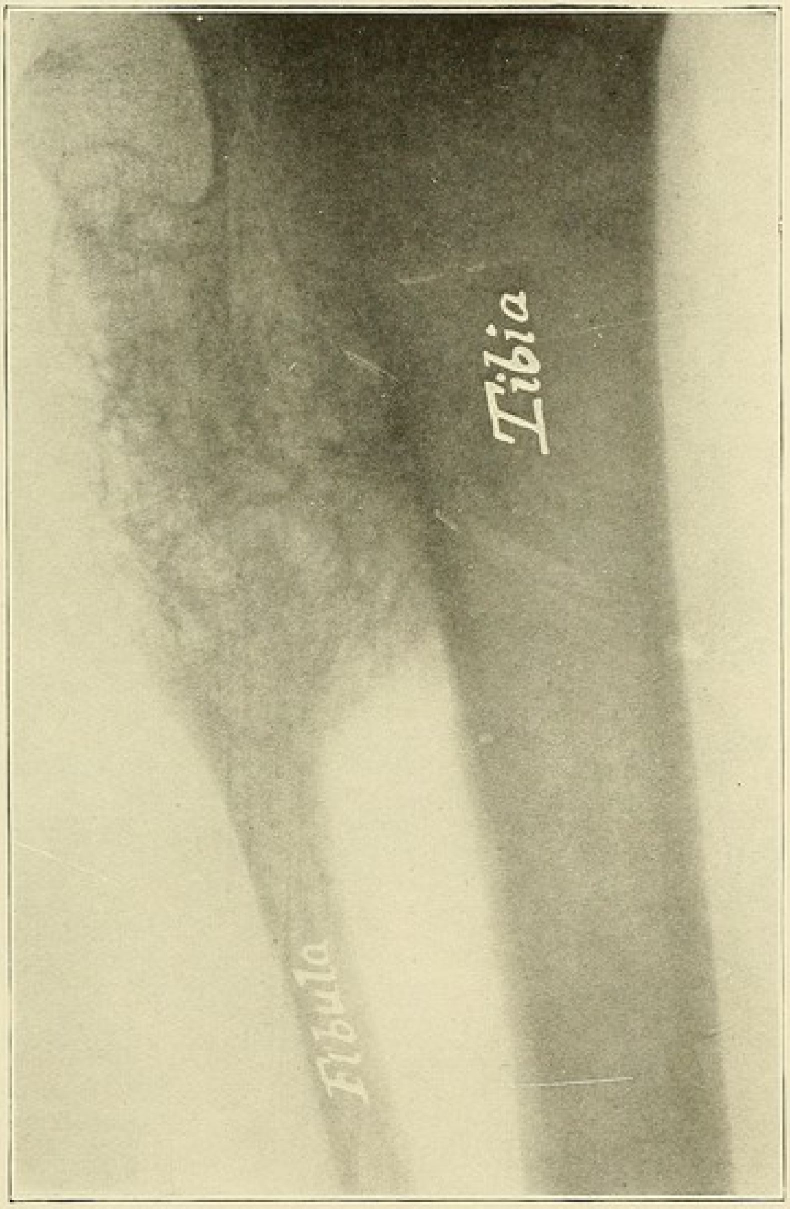


Fig. 185.—Osteoma of tibia and fibula.

Diseases of the Joints.—In diagnosing joint conditions the value of the x-ray can not be overestimated. The diagnosis is easily made by means of the skiagraph between infectious arthritis and rheumatoid arthritis. Since the treatment is widely different, the diagnosis is extremely important. Figs. 186 and 187 are skiagraphs of

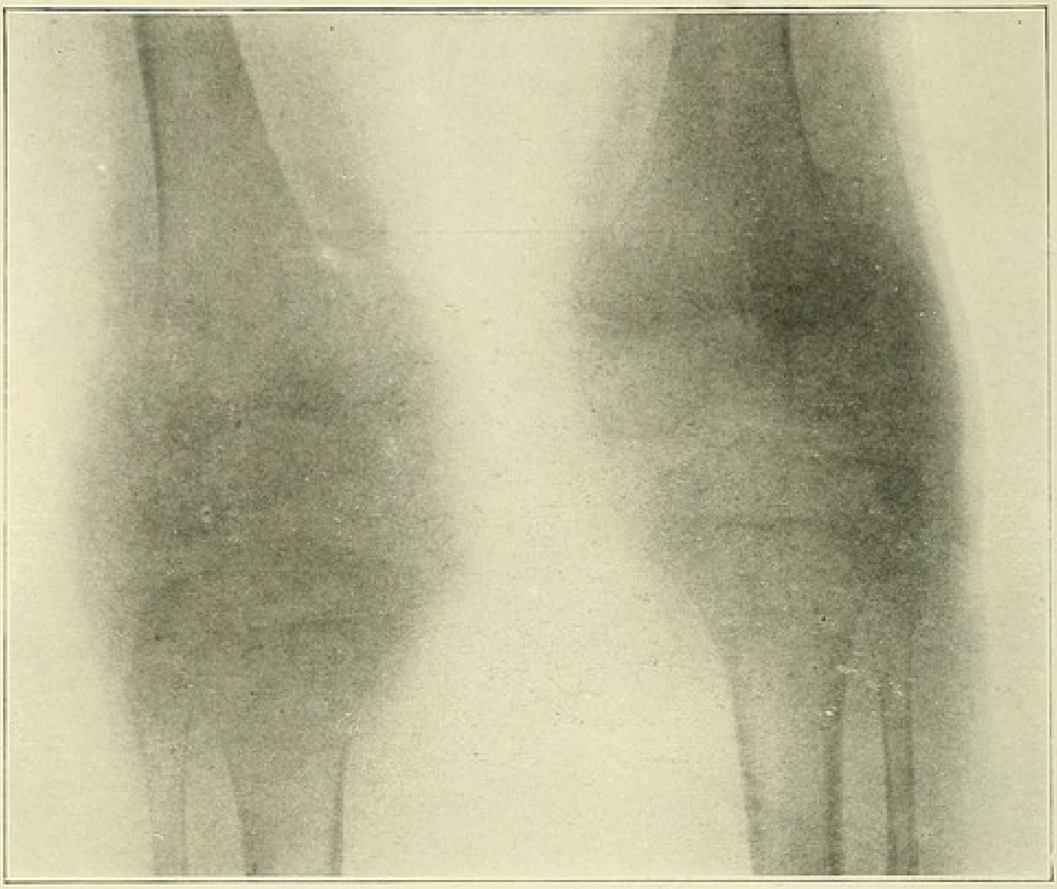


Fig. 186.—Infectious arthritis of the knees.

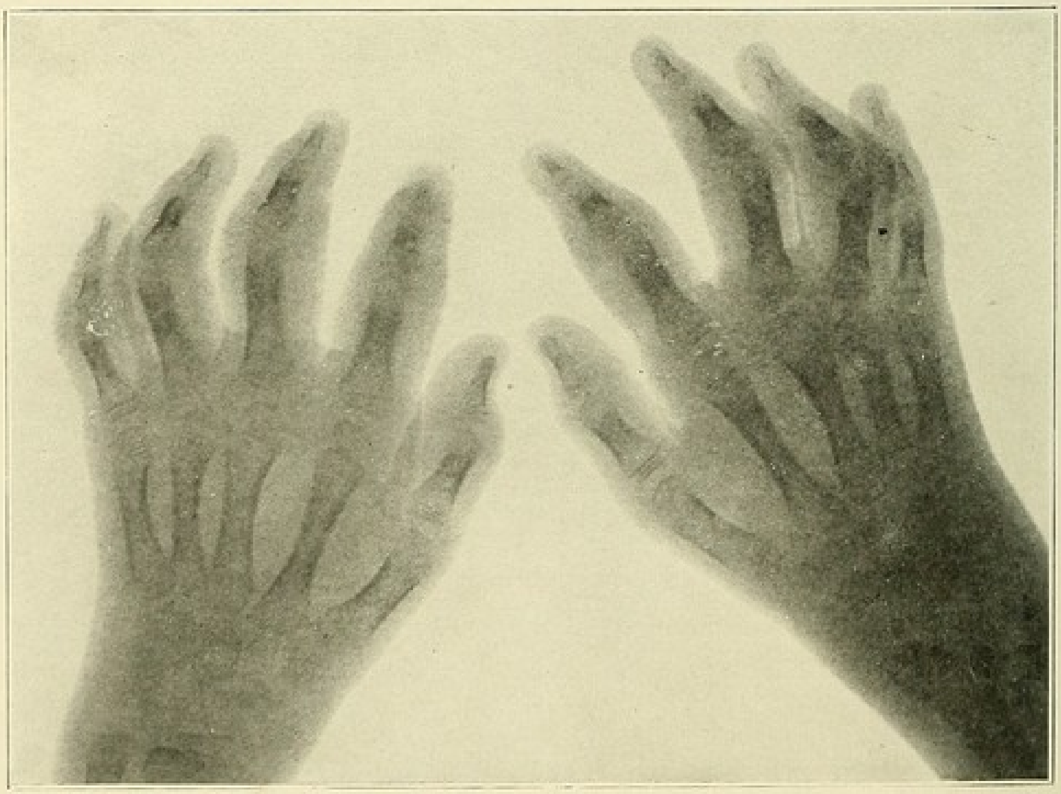


Fig. 187.—Infectious arthritis of the hands.

the knees and hands of a child which had suffered for some time from a condition that was thought to be rheumatoid arthritis. After the skiagraphs were made and the diagnosis changed to infectious arthritis, the patient promptly responded to treatment and rapidly recovered.

Tubercular arthritis, in its early stage, is very difficult, if not impossible, to distinguish in the skiagraph from other joint affections. When bony substance becomes involved, the skiagraph will show the change in texture and reveal the true condition of affairs.

Loose bodies in the joints, sometimes called floating cartilage, are frequently difficult to detect because of their transparency. Where such bodies are suspected, exposures should be made from several angles, with the hope of getting the object in a position not covered by the bones.

We would like to continue the exhibition of the value of the skiagraph in the diagnosis of bone diseases until the whole subject is covered, but enough evidence has been presented to convince the most skeptical physician of the great importance of the x-ray in the diagnosis of all cases of bone disease.

CHAPTER XVIII.

X-RAY IN LOCATION OF FOREIGN BODIES.

Foreign bodies may be divided into two general classes—(1) those which are purposely or accidentally carried into the esophagus or trachea and other cavities having external openings, and (2) those which are driven into the tissues by external force.

Since children swallow almost anything that can be swallowed, we frequently find coins (as coppers, nickels, dimes, and quarters), brass checks, etc.—in fact, any plaything that can be put into the mouth—in the intestinal canal. If these objects are obstructed anywhere, they usually lodge in the upper portion of the esophagus, at or about the junction of the third rib with the sternum. If these objects reach the stomach, they usually pass on through the intestinal tract without causing any particular trouble. Sometimes, however, these foreign bodies, instead of going into the esophagus, are carried into the trachea and on down into a bronchus, generally the right.

There was a time when the presence of a foreign substance in the tissues or the cavities of the body could be only guessed at by the physical signs and symptoms presented by the patient, who was often too young to furnish any evidence of diagnostic value. Every physician with a large experience in this line of work is well aware of the fact that much harm has been done to these sufferers in a blind and vain effort to dislodge and remove these foreign bodies, the presence and exact location of which he was unable to determine. Perhaps the reader can recall cases of gun-shot wounds which had been blindly probed in the hope of locating a bullet that probably never entered the body more than to make a superficial wound. The mortality rate from impacted foreign bodies in the trachea or esophagus was formerly very high, about 80 percent dying after surgical efforts for removal.

Cases of metallic bodies in the eye were seldom diagnosed until not only the injured eye was lost, but the other eye was destroyed through sympathetic ophthalmia. Cases that were formerly impossible of diagnosis, and that were treated expectantly or not at all until too late to receive benefit from any method of treatment, are now, by means of the x-ray, accurately diagnosed and promptly relieved, not only preventing distress and suffering, but saving the lives of many patients.

Foreign Bodies in the Esophagus.—It is surprising how often children attempt to swallow articles too large to pass through the esophagus. If they are obstructed, it is generally at a point about

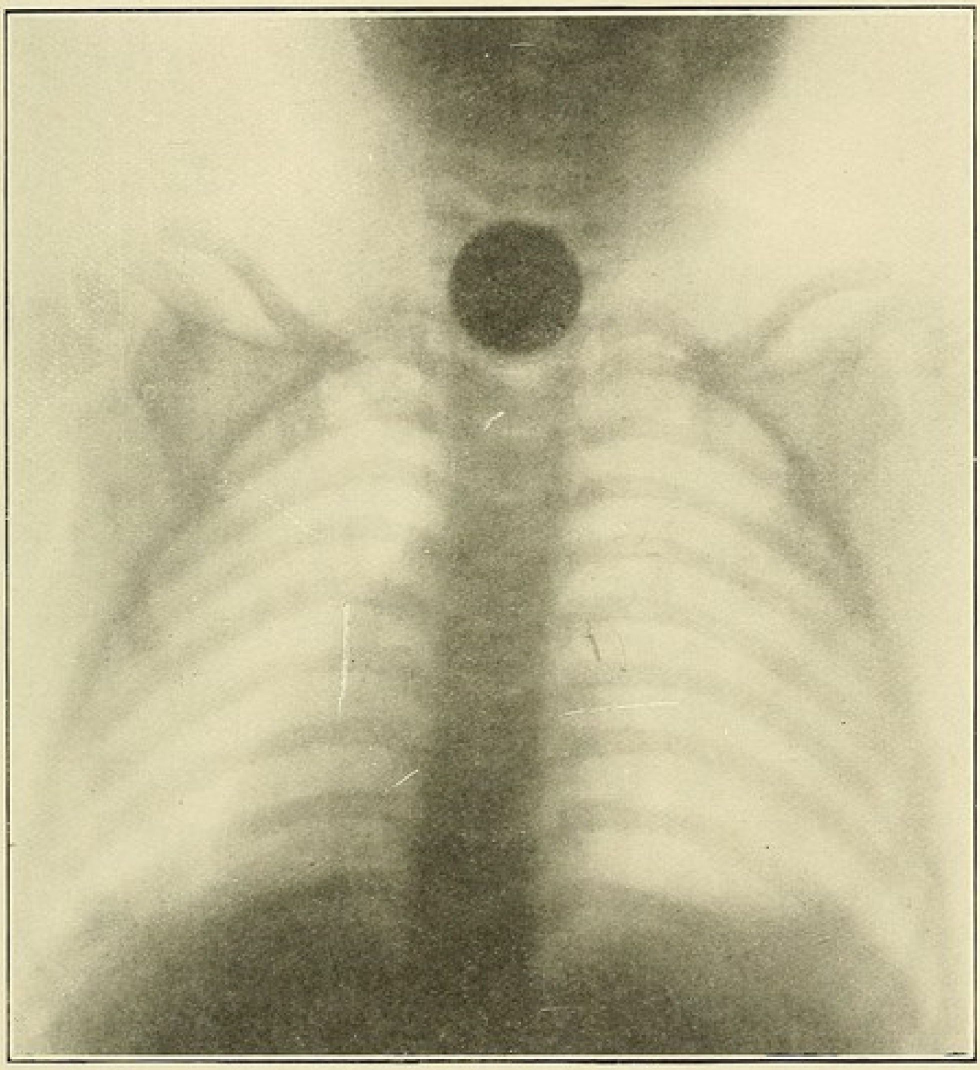


Fig. 188.—Location of foreign bodies. Coin shown at the upper end of the sternum.

opposite the junction of the third rib with the sternum, or it may be at or above the junction of the first rib with the sternum. In 1907 the author was asked by Doctor J. O. McReynolds to locate a coin in the esophagus of a little girl, the daughter of a physician. Fig. 188 is a skiagraph of the case, which shows the coin at the upper end of the sternum. It was decided to remove the coin through the mouth with Chevalier Jackson's esophagoscope, forceps, etc. On introducing the esophagoscope it was found that the lip of the instrument went posterior to the coin, which prevented it from being seen by the operator. In order to direct the instrument to the proper position, the author suggested the use of the fluoroscope while the esophagoscope was being passed into the esophagus. The removal of these coins through the mouth with Chevalier Jackson's electrically lighted instruments is often spoken of as being quite easy. A few minutes' experience in an ordinary case will, however, convince any physician that there are frequently many difficulties

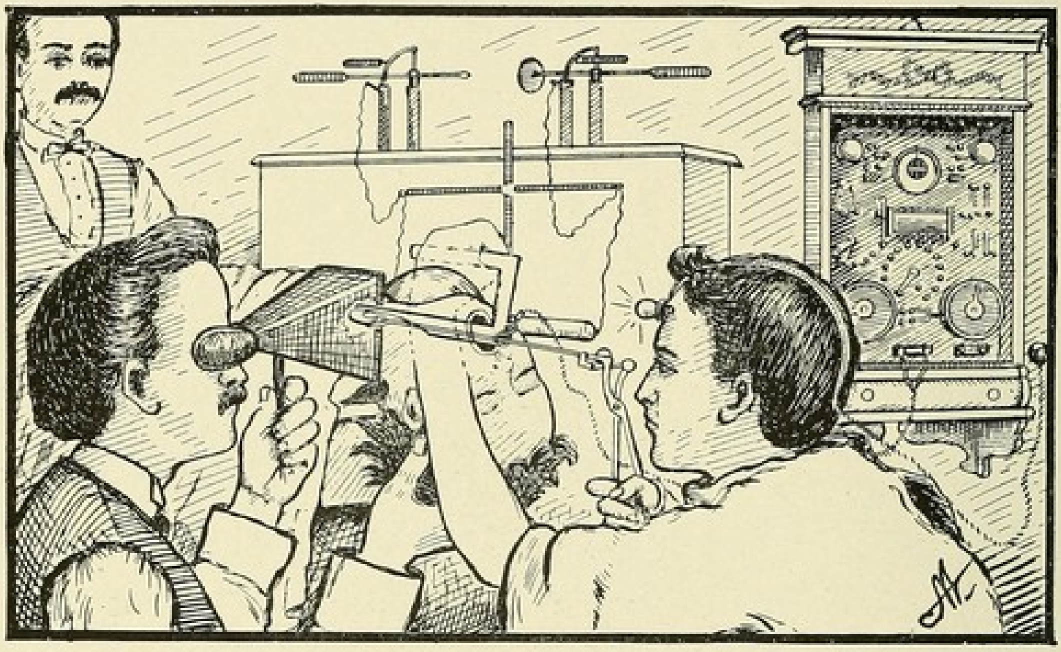


Fig. 189.—Location of foreign bodies. Method of locating foreign body in the esophagus.

in the procedure. The coin is generally covered with mucus, and the esophagoscope has a strong tendency to go posterior to the coin, which completely obscures it from vision. All of this uncertain work requires time, during which the little patient is often breathing with difficulty.

The method adopted in this case was as follows: As most of the operating and examination tables are too wide for this work, it being necessary to bring the tube very close to the patient on one side and the fluoroscope on the other, the author improvised a narrow table by placing a row of large books, as long as the patient and a foot high, on an ordinary table, covering the books with a piece of oil cloth for protection. After chloroforming, the patient was placed on this improvised table, with the head well over the end. The esophagoscope was introduced and pushed well down to the coin. The x-ray tube was quickly brought to the patient's side, and an assistant was asked to operate the fluoroscope from the opposite side of the table, where he could determine the position of the esophagoscope with relation to the coin. In this case, as well as all others that have been examined since, it has been found difficult to prevent the lip of the esophagoscope from going posterior to the coin. When the lip of the esophagoscope passes in front of the coin, it is usually readily seen by the aid of the electric light in the instrument, unless covered with a great deal of mucus, when it may be reached with the forceps and quickly removed.

Fig. 189 illustrates diagrammatically the method that the author has been using with perfect success in every case, save one. The

Fig. 190.—Location of foreign bodies. Brass check removed from esophagus of girl 3 years old.

case in which failure occurred was that of a child which had attempted to swallow a quarter five months before. The coin had either worked its way through the esophagus or was covered with granulations. It was not possible to see the coin with the esophagoscope, and for this reason the search was abandoned for the time, but the case never returned.

Fig. 190 is an illustration of a brass check that was removed, by the method shown in Fig. 189, from the esophagus of a little girl 3 years old. The check had been in the esophagus seven days, and the mother had visited almost every physician in the city in her frantic effort to have something done for the child. She was told by some to let it alone and it would pass all right, by others that they could push it down into the stomach, and by others that it would be dangerous to attempt to remove it through the mouth.

Foreign Bodies in the Trachea and Bronchi.—Foreign bodies in the trachea and bronchi present far greater difficulties than those taken into the esophagus. Contrary to popular belief, foreign bodies may be carried into the trachea and on down into a bronchus without causing any very marked symptoms. The author has seen two cases in children and one in adult in which metallic objects were carried in the right bronchus for months without the persons knowing that they were there until skiagraphs were made. The first of these cases was a child about 6 years old with symptoms of a foreign body in the right bronchus. Fig. 191 is a skiagraph

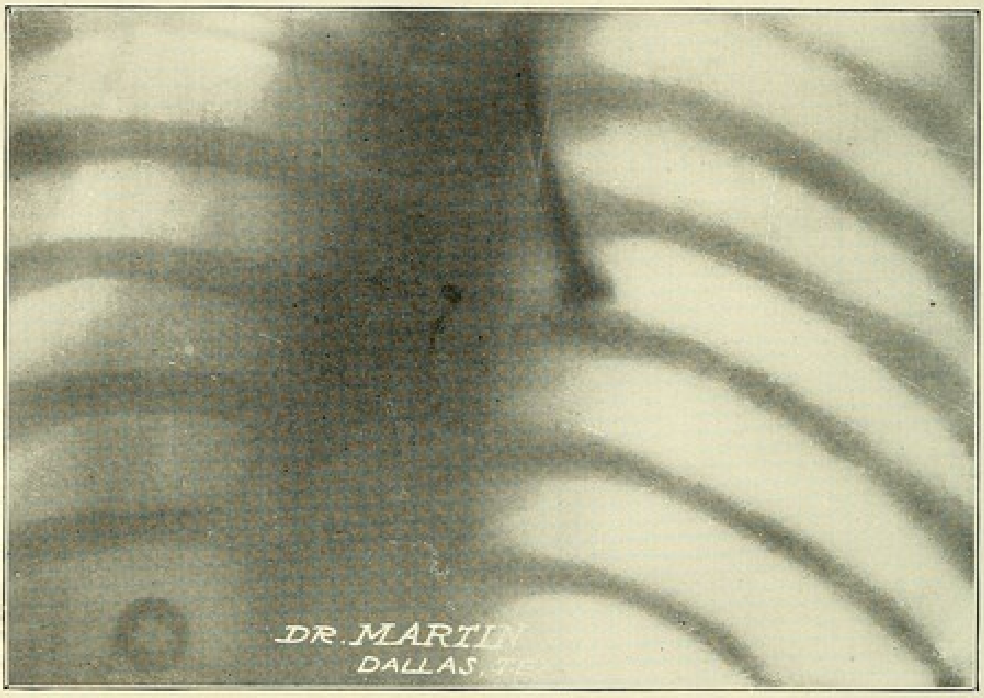


Fig 191.—Location of foreign bodies. Nail shown in the trachea.

of the child's chest, confirming the diagnosis previously made by the family physician. That was several years ago, when there were no Jackson instruments. The child was taken to a large city, where it was seen by several physicians of large experience. They advised the father to return home with the child, which he did. Some time after his return the child was afflicted with traumatic pneumonia, and in a paroxysm of coughing the nail, thoroughly enveloped in a tough mucus, was expelled, and the child promptly recovered. This occurred three months from the time the nail entered the trachea.

The most interesting case of foreign body in the bronchus was that of a boy 8 years old. About five months before he was seen he was playing with a screw $1\frac{1}{4}$ inches long. He put the screw in his mouth during a playful scuffle with his mother. The screw disappeared, and no one imagined that it had been allowed to enter the trachea. Some time afterward the boy became sick, had fever, and developed a cough, with a muco-purulent expectoration, accompanied by a continuous loss of flesh until he was, at the time he was seen, very much emaciated and confined to the bed.

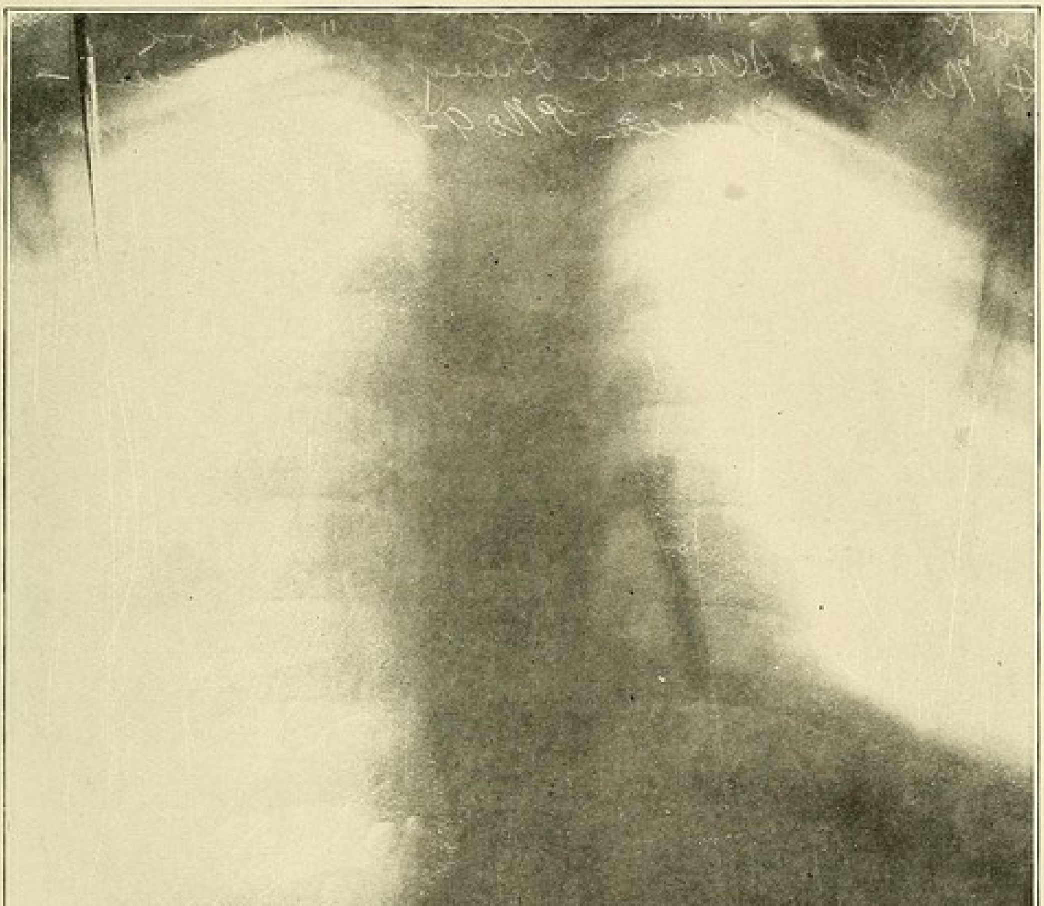


Fig. 192.—Location of foreign bodies. Metal screw shown in bronchus.

He had been treated by a number of physicians, who had diagnosed his condition as malaria, typhoid fever, etc. No one believed that the "screw story" had anything to do with his condition, and therefore no attention was paid to it. Some time before he was brought to the laboratory there had been a diagnosis of abscess in the right lung. A rib was resected and the cavity drained. For a time there was some improvement, but the main symptoms remained about the same. The case finally came into the hands of Doctor W. W. Samuell, who, giving some credence to the "screw story," sent the boy to the laboratory for a skiagraph. Fig. 192 shows the shadow of a foreign body in the region of the right bronchus. Owing to the great length of time it had been in the lung, it was not thought possible to remove it through the mouth. Doctor J. O. McReynolds was called into the case, and, after some discussion, it was decided to remove the screw through the opening formerly made to drain the abscess. A large pair of ovarian forceps, under the guidance of the x-ray, were passed through the external opening to the screw. A giant magnet, with a lifting force of four hundred pounds to the square inch, was brought in contact with the handle of the forceps, and with very little manipulation the screw was pulled out with the forceps through the attraction of the magnet, after which the boy made an uninterrupted recovery.

No physician in this case could at the time be blamed for neglecting to have the child skiagraphed, as it was generally believed that foreign bodies of any size in the trachea or bronchus would cause symptoms leading at once to their discovery. That these old beliefs must be changed is proven by frequently finding foreign bodies in the bronchi, where they have been, unsuspected, for days or even months. Where there is the least suspicion of a foreign body in the esophagus, trachea, or bronchus, a skiagraph should be made early, when the foreign body may be removed through the mouth by an experienced operator with the proper equipment. The successful removal of a number of foreign bodies from the trachea and bronchus (usually the right) have been reported. Fig. 193 is from a photograph of the boy who had carried the screw in his lung for five months. The photograph was made a few weeks after the screw was removed.

About two years ago the author skiagraphed the chest of an adult in search of the gold crown of a tooth, which had disappeared while the dentist was working in his mouth, and neither knew what had become of it. The crown was located firmly impacted in the right bronchus. The case finally developed pulmonary tuberculosis, from which the patient died recently. With our present methods—the x-ray and the Jackson electrically lighted instruments—this crown could have been removed with little danger to the patient.

Foreign Bodies in the Tissues.—Foreign bodies forced into the tissues by external violence may be almost anything, the most common being bullets, shot, needles, pins, and pieces of steel, iron, glass, crockery, etc.

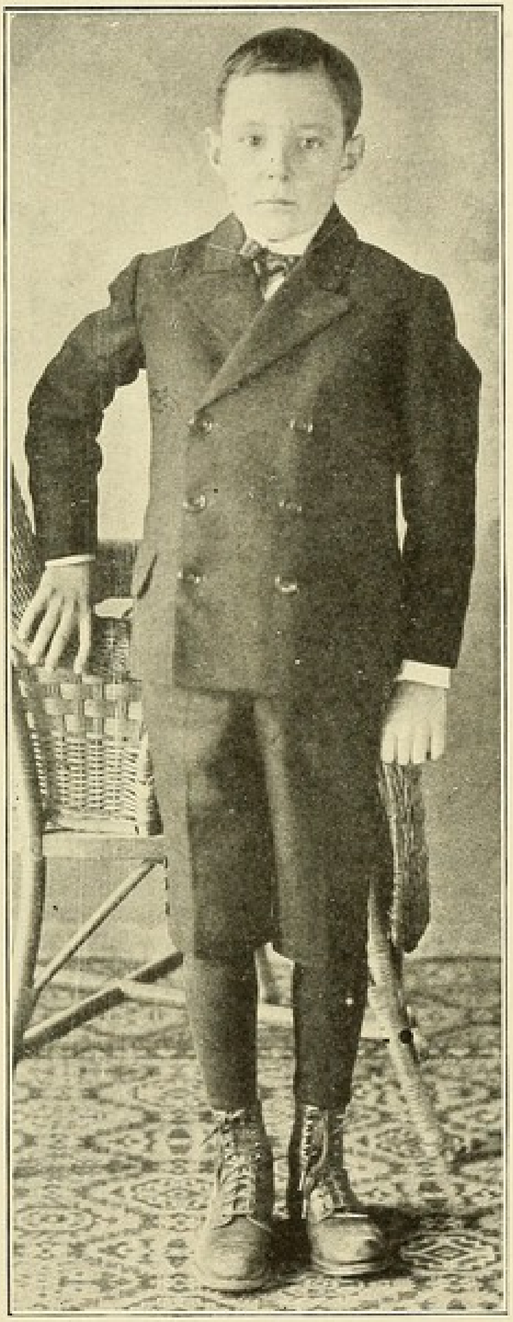


Fig. 193.—Location of foreign bodies. Picture of boy who carried metal screw in lung for five months.

Pins and Needles.—At first thought it seems an easy matter to remove a needle or pin from the foot or hand, but those who have had some experience with the old method of cutting and probing well know the difficulties encountered in such an undertaking.

These pins and needles are usually driven deeply into the tissues, and are sometimes broken into two or more pieces. The author, having had considerable experience in removing this class of foreign bodies, and having seen other physicians fail in their efforts to find and remove them, has devised a simple method that will greatly shorten these operations. While aiding a brother physician in locating a piece of needle in a woman's hand, and watching his unsuccessful efforts to reach it, although he could plainly see it with the fluoroscope, he conceived the idea of taking long-beaked artery forceps, and under the direction of the fluoroscope forced them through the tissues to the needle, where they were opened, the needle firmly grasped and the forceps locked, after which the removal of the piece of needle was easy. The description sounds simple enough, but the process of directing the forceps under the fluoroscope is far more difficult than it appears. To do the work well requires considerable experience with the fluoroscope. Fig. 194 shows the artery forceps used and the piece of needle removed with them. Forceps with longer, slimmer blades would be still better suited for this kind of work. This method greatly shortens the operation, and prevents mutilation of the parts by allowing the operator to go directly down on to the body, after which it can be removed in a very few minutes. This method may be applied to the removal of other objects.

Bullets and Like Bodies.—The location of the majority of foreign bodies in the extremities is usually not very difficult. Exposures should be made at right angles to each other. Careful study of the plates will give the surgeon a very accurate idea of the location of the object. In the thicker parts of the body lateral and anteroposterior skiagraphs are difficult to make, and other methods must be used.

The well-made skiagraph will locate a bullet, but it is often difficult to determine its depth, or whether it lies beneath or above a bony part. Two methods may be adopted to overcome this difficulty. One consists of making a stero-skiagraph, in which two pictures (skiagraphs) are made at proper angles, and viewed at the same distance and angles in a properly arranged stereoscope. The other method consists of making two exposures on separate plates as before, with the tube at different angles. A wire is fixed across the plate-holder at a central point. This wire may be coated with analine ink, so as to leave a mark on the tissues indicating the relation of the plate to the parts skiagraphed. The work is not difficult,

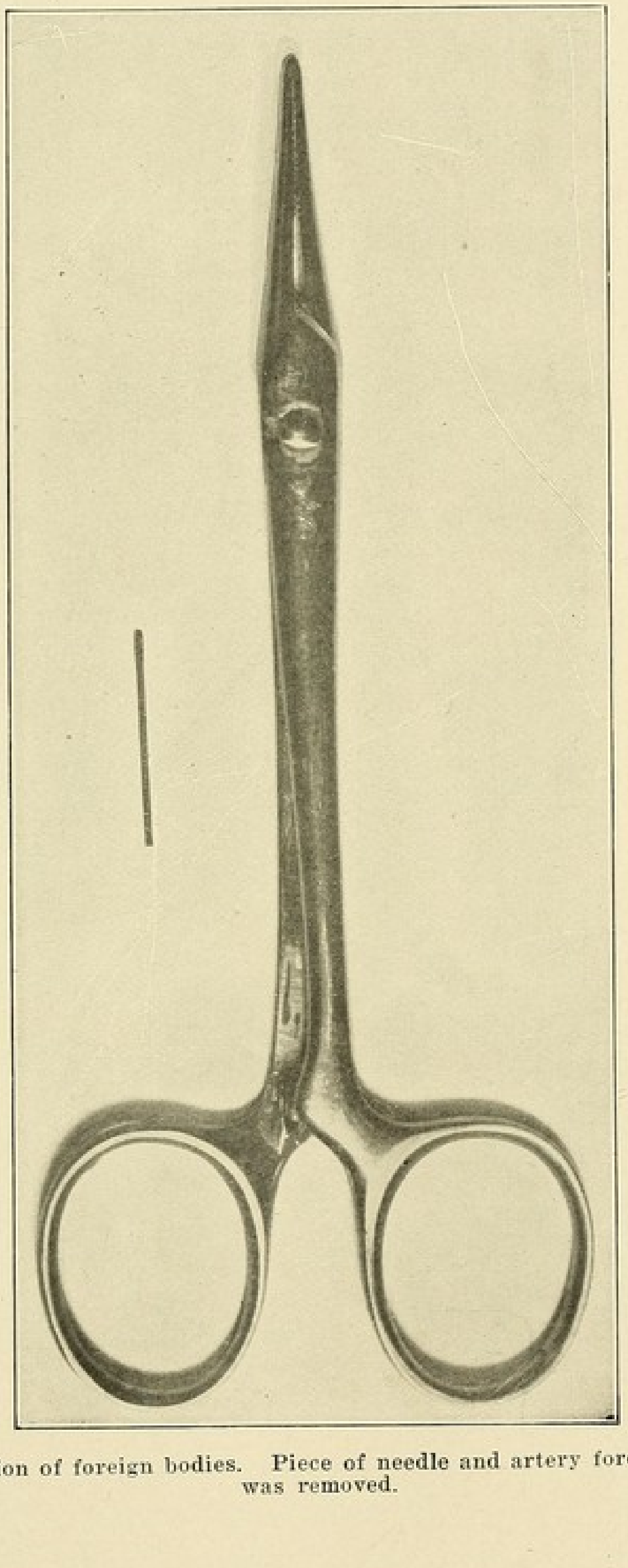


Fig. 194.—Location of foreign bodies. Piece of needle and artery forceps with which it was removed.

though it is necessary to have a properly constructed table and tube-holder, so made that the tube may be moved either way past the center to a definitely fixed point. It is necessary to have a plate-holder, from which the first plate can be removed and another inserted without disturbing the position of the patient. When the plates are developed, the distance between the shadow of the bullet and the shadow of the central wire is measured with a pair of dividers. A simple calculation by means of a drawing will determine the exact location of the bullet.

Fig. 195 illustrates the method of making the exposures. Let *A*

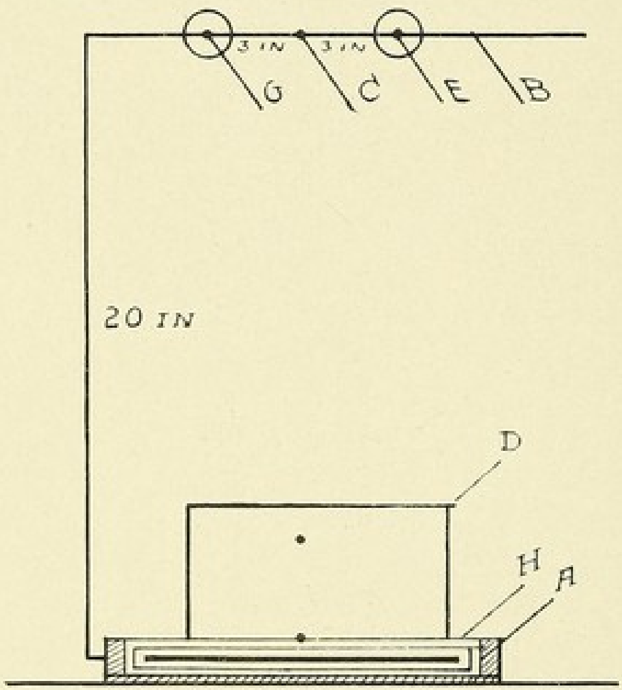


Fig. 195.—Method of making exposures for locating foreign bodies in the tissues. Manipulating the plates.

represent the plate-holder, with its removable plate *H*. *B* is the line along which the tube is moved in changing the angles to either side of the center *C*. *D* is the object to be skiagraphed. For the first exposure the tube is moved to *E*, 3 inches to the right of the center *C*. The exposed plate *H* is taken from the holder *A* and a new plate is put in its place. The tube is now moved to *G* along the line *B*, 3 inches to the left of the center *C* and 6 inches to the left of the first exposure, where the second exposure is made. The central wire on the plate-holder must be directly under the center *C* on line *B*. When these two exposed plates are developed, they will each show a shadow of the bullet and the central wire on the plate-holder. Both shadows of the bullet may be on the right or left side of the wire, or they may occupy almost the same position over the wire, or one may be on one side and one on the other, depending, of course, on the distance the bullet is situated above the plate. Should the bullet be very near the surface toward the plate, the shadows on the two plates will be almost identical. *m* and *n* in Fig. 196 will represent the appearance of the two plates, provided that the shadows of the bullets are so situated that one will

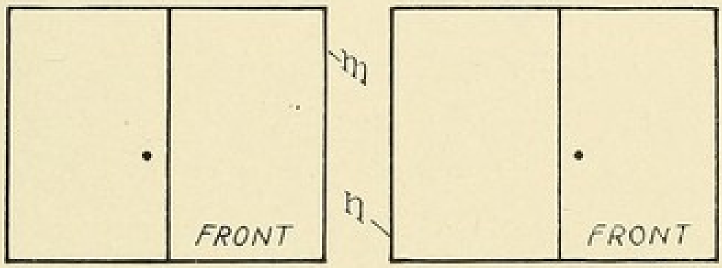


Fig. 196.—Method of making exposures for locating foreign bodies in the tissues. Compare the plates for shadow effects.

be on either side of the central wire on the plate-holder. The plates are placed on a table side by side, fronting the way in which they were made. The shadow on plate *n* was made when the tube was at *G* and the shadow on plate *m* was made when the tube was at *E* (Fig. 195).

To calculate the position of the bullet above the plate, a drawing board, a piece of blank paper 18x24 inches, a T-square, and a pencil are needed. Fig. 197 illustrates how the calculation is made. The paper is fastened squarely on the drawing board with four thumb tacks. With the T-square a line is drawn across the narrow way of the paper 1 inch from one end. Exactly 20 inches from this line another is drawn parallel with the first. The first line will correspond with plate *H* and the second line will have the position of *B* in Fig. 195. Make a dot on *B* at *C* and another directly under *C* on *H*. Now make a dot on *B* 3 inches on either side of *C* and mark them *G* and *E* respectively. By referring to Fig. 195 it will be seen that the points *G* and *E* represent the positions of the tube when the exposures were made. Take the plates as shown in Fig. 196, and with a pair of dividers carefully measure the distance between the shadow of the bullet and the shadow of the central wire on *m*, and make a dot the same distance to the left of the dot on *H*. Do the same with plate *n*, and place a dot to the right on line *H*.

Now carefully draw a line from *G* to the dot on the right and another from *E* to the dot on the left. The point where the two lines cross will be the location of the bullet above the plate *H*. In this case the bullet was exactly 3 inches above the plate when the exposures were made.

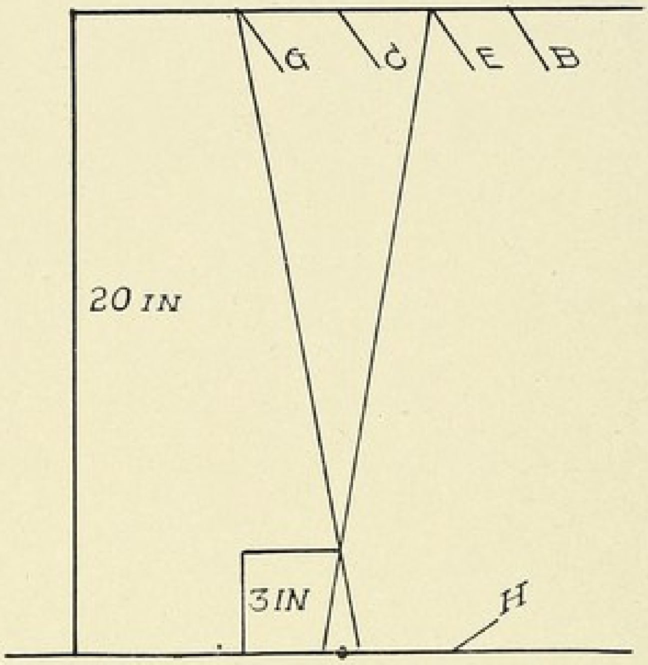


Fig. 197.—Method of making exposures for locating foreign bodies in the tissues. Calculating the location of the foreign body.

If the skiagraphs and drawing are accurately made, there is little possibility for error—not more than 5 percent. It should be remembered that at the time of making the exposures the tube must be turned toward the object skiagraphed, so that the direct rays may pass through it to the plate. A little practice will enable the operator with a good equipment to locate a bullet or other foreign body with so great a degree of accuracy that the surgeon will have very little difficulty in removing it.

CHAPTER XIX.

X-RAY IN GALL-BLADDER STONES AND KIDNEY STONES.

Perhaps no other symptoms are more difficult of diagnosis than those that frequently occur in the gall-bladder, kidneys, and ureters. Operations in these regions carry a considerable element of danger, and should never be done except upon the very best evidence—positive evidence when possible. Stones are found in cases

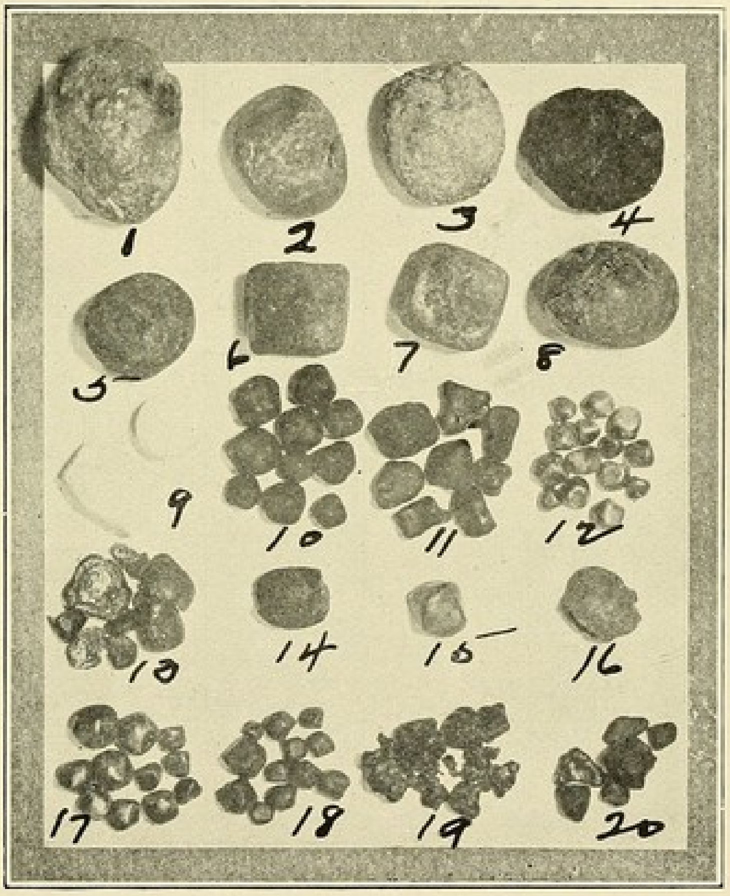


Fig. 198.—From photograph of nineteen groups of gall stones.

where we least expect to find them, and, again, we fail to find them where the clinical symptoms are almost conclusive. The x-ray diagnosis of gall and kidney stones are only conclusive when repeated skiagraphs show the presence of a foreign substance in a position where it is expected to exist. These stones differ so much in density and composition that in some cases a well-made skiagraph will not reveal the presence of a stone of considerable size. In order

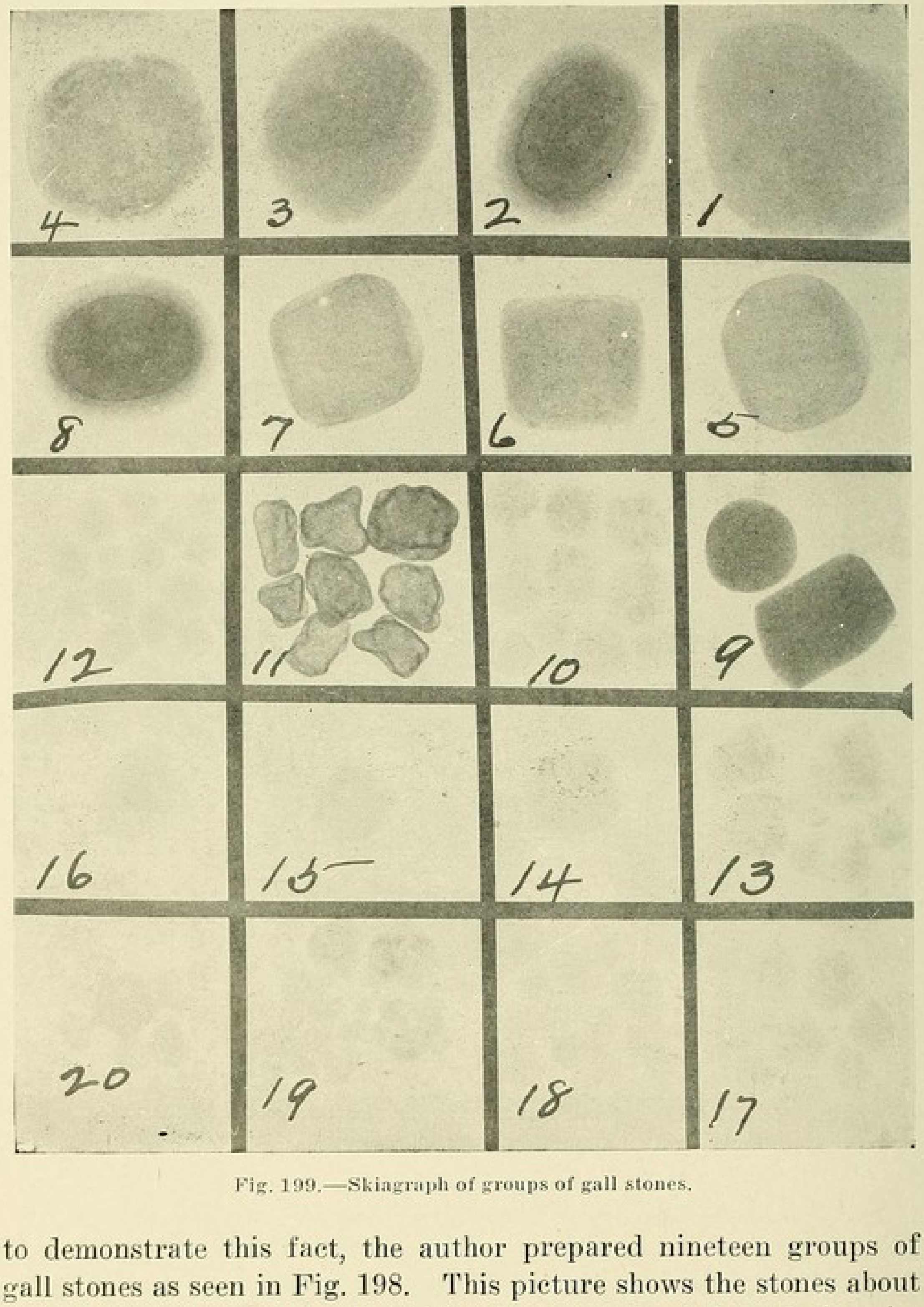


Fig. 199.—Skiagraph of groups of gall stones.

to demonstrate this fact, the author prepared nineteen groups of gall stones as seen in Fig. 198. This picture shows the stones about half their normal size. It is introduced to show the relative size and external appearance of the different stones. While the stones differ widely in size and shape, the picture furnishes no idea of their density or quality to absorb the rays; in fact, from their visual appearance we would naturally suppose that one group would make as dense shadows on the plate as another. Group 9 is two pieces of common chalk used as a control.

In order to determine the relative density of these stones, the

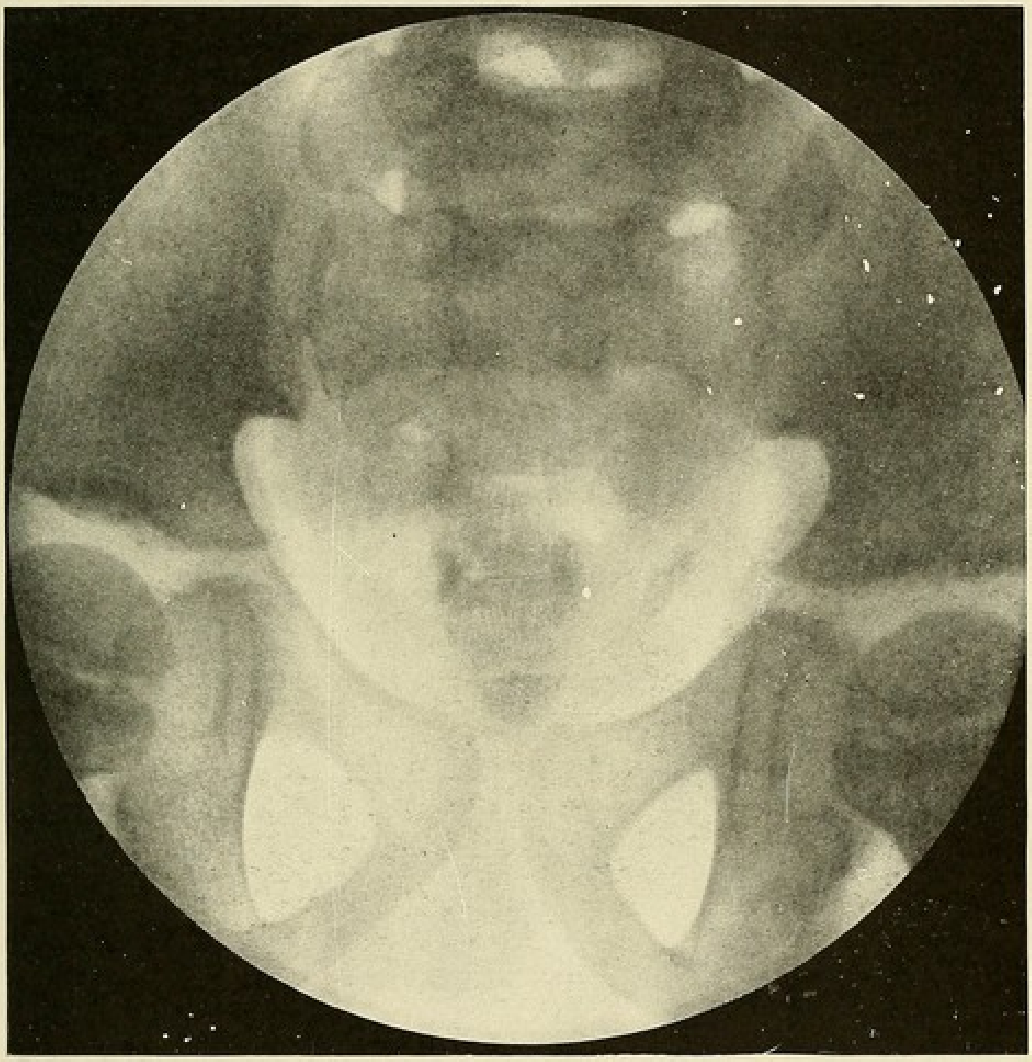


Fig. 200.—Stone shown impacted in the right ureter.

author conceived the idea of exposing the groups as they lay on the card to the rays of a low vacuum tube. The card containing the stones in the order shown was placed on a 5x7 sensitized plate in the usual way. The x-ray tube was placed 12 inches above the plate and directly over its center, where the plate and stones were given one-second exposure and the plate developed. Fig. 199 is a skiagraph thus made, and clearly shows the value of the experiment. Groups 2, 8, and 11 are about the same density as the pieces of chalk in group 9, while some of the other stones hardly make a shadow. The denser of these stones would make a very good shadow if skiagraphed through a medium-sized subject, while the less dense stones could not be shown at all through the thinnest patient. To those unfamiliar with the possibilities of the x-rays

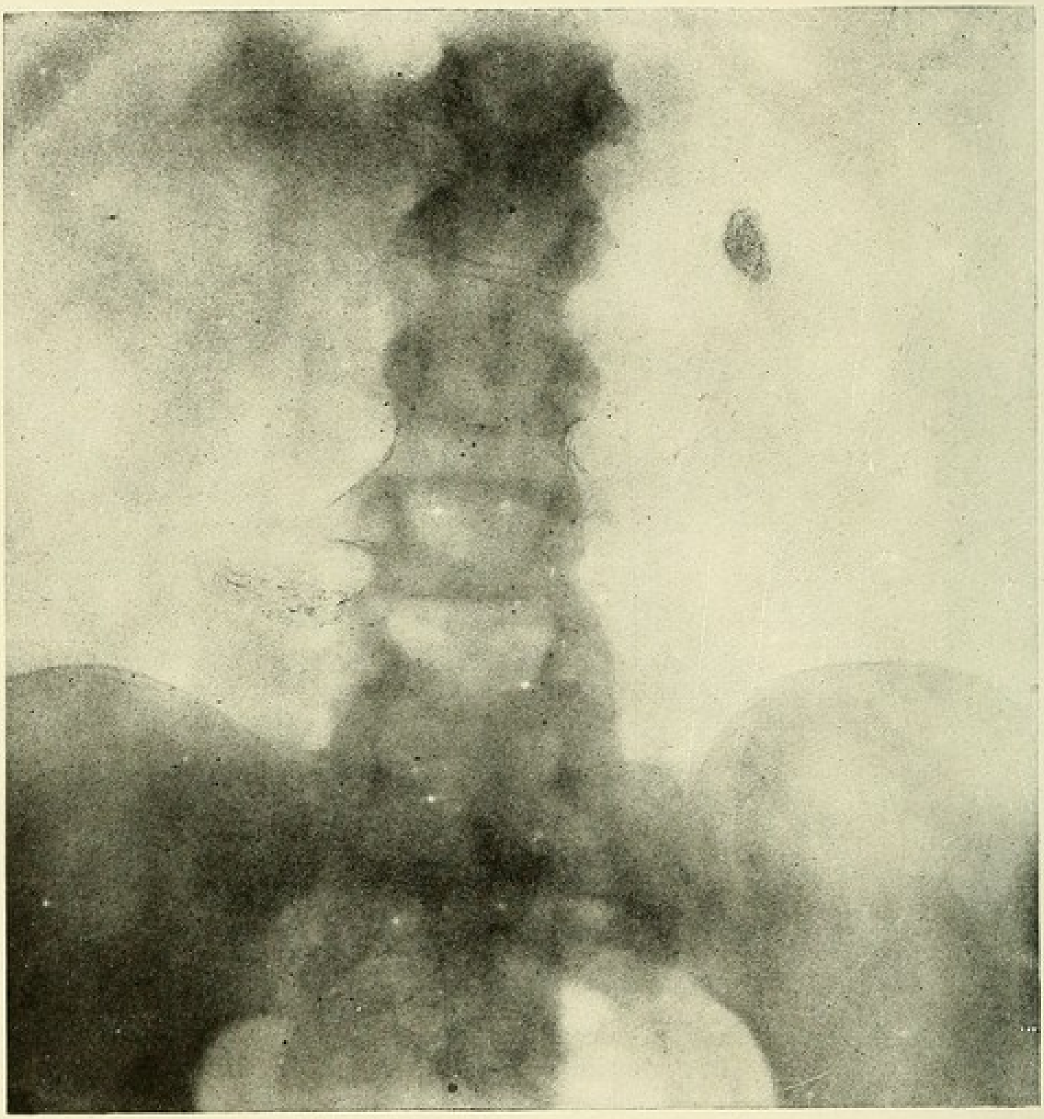


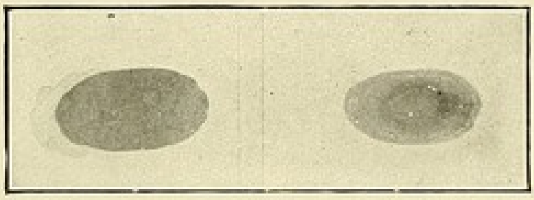
Fig. 201.—Stone shown in the right kidney.

in kidney and gall-bladder work, this is an object lesson that can not fail to correct any preconceived erroneous ideas.

Fig. 200 is a skiagraph of the pelvis of a child 9 years old. For some time it had symptoms of kidney and vesicle trouble. The picture shows the stone impacted in the right ureter only a short distance from the bladder.

An interesting study is presented in a case of stone in the kidney. The patient was a little girl 10 years old, who had suffered all her life with her kidneys. Doctor Elbert Dunlap sent her to me for a skiagraph on May 24, 1910. The plate revealed a stone in the right kidney. She was directed to return in a week for another exposure. On May 31 the second skiagraph was made, with the same result as the first. Soon after this she was afflicted with measles, and the operation was delayed until June 11, when a stone $\frac{3}{8}$ inch long and $\frac{3}{16}$ inch wide was found in the kidney and removed. Fig. 201 is a skiagraph of the case, and distinctly shows the stone as it lay in the right kidney at the time of the operation. The illustration is not as good as it should be, but clear enough for diagnostic purposes.

Fig. 202 illustrates a photograph (1) and a skiagraph (2) of



1. 2.

Fig. 202.—Stone after it was removed from the kidney shown in Fig. 201. 1, illustration from photograph; 2, illustration from skiagraph.

the stone after it was removed from the patient. The photograph simply shows the size and external appearance of the stone, while the skiagraph gives some idea of its density. In making the skiagraph of the loose stone, it was exposed to the rays from a medium vacuum tube for a period of one second. While the picture has lost much of its original detail through the process of reproduction and printing, the difference in density between the central nucleus and the outer coating is plainly seen.

Figs. 203 and 204 represent the extremes of kidney stone skiagraphy. Fig. 203 shows the shadow of a rather large stone in the kidney, and Fig. 204 shows distinctly the shadow of another stone. The difference in the shadows is due to the difference in the density of the two stones. Fig. 204 shows two shadows. The upper shadow is the stone, and the lower shadow may have been due to bismuth in the intestine.

If space allowed, a number of similar pictures could be shown, all teaching the same lesson—the value of the x-ray when properly used and understood. Because the x-ray occasionally fails to show an existing stone is no argument against its use; if every other method were perfect, we might demand and expect the same of the x-ray. The x-ray is, however, the most reliable diagnostic aid at our command, and, as we become more expert in our technic and the results become better known, it will be used in every questionable case.

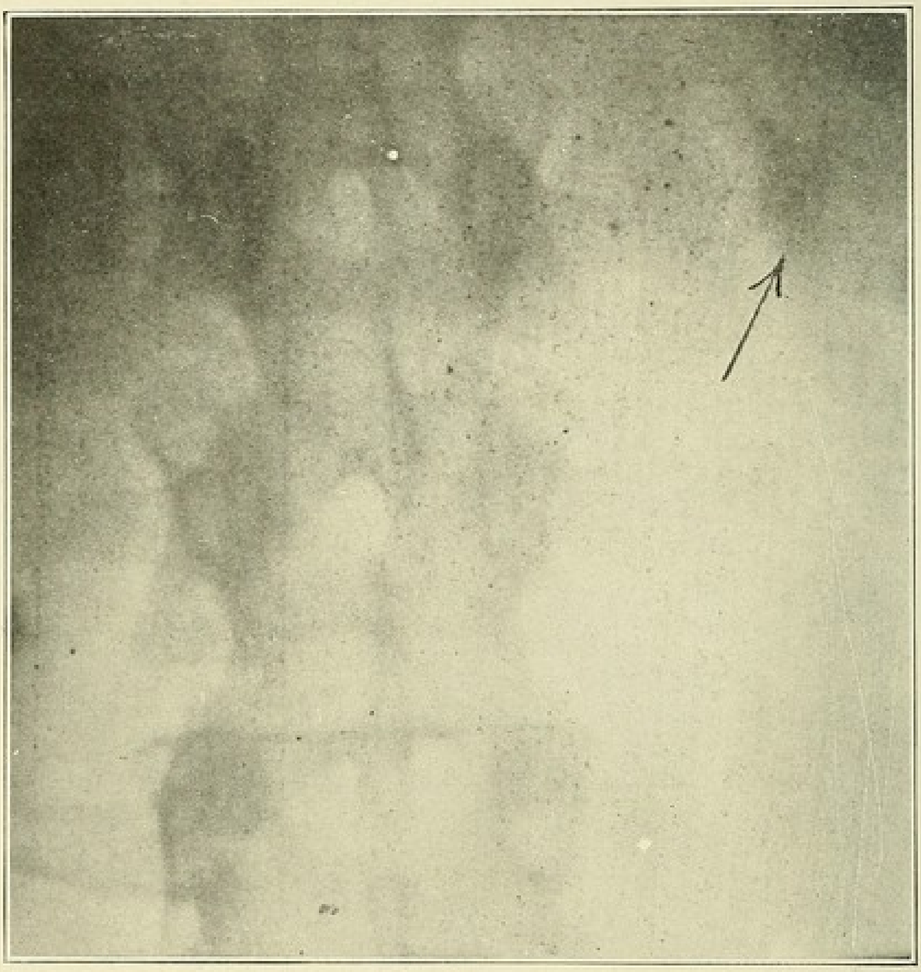


Fig. 203.—Skiagraph with a sinegran of the left kidney region, showing a stone in the pelvis of the kidney. The stone was removed and proved to be of irregular shape, as shown in the illustration. The exposure was five seconds, with the tube 26 inches from the plate.

Reliable pictures of the kidney and ureter regions are among the most difficult trials of the radiographer, and even the experienced or expert operator makes many failures. Uric acid calculi have less density than the floating ribs, and are very difficult to show, while calculi composed of oxalate of calcium, if properly skiagraphed, will make very clear shadows.

There are so many sources for error in diagnosing calculi in the kidneys and ureters that the x-ray diagnostician must be careful to avoid making grievous, if not unpardonable, errors. Calcified glands in the region of the kidney or ureter and bismuth salts or other metallic substances in the colon may make shadows so closely resembling renal calculi as to be very misleading. To avoid such

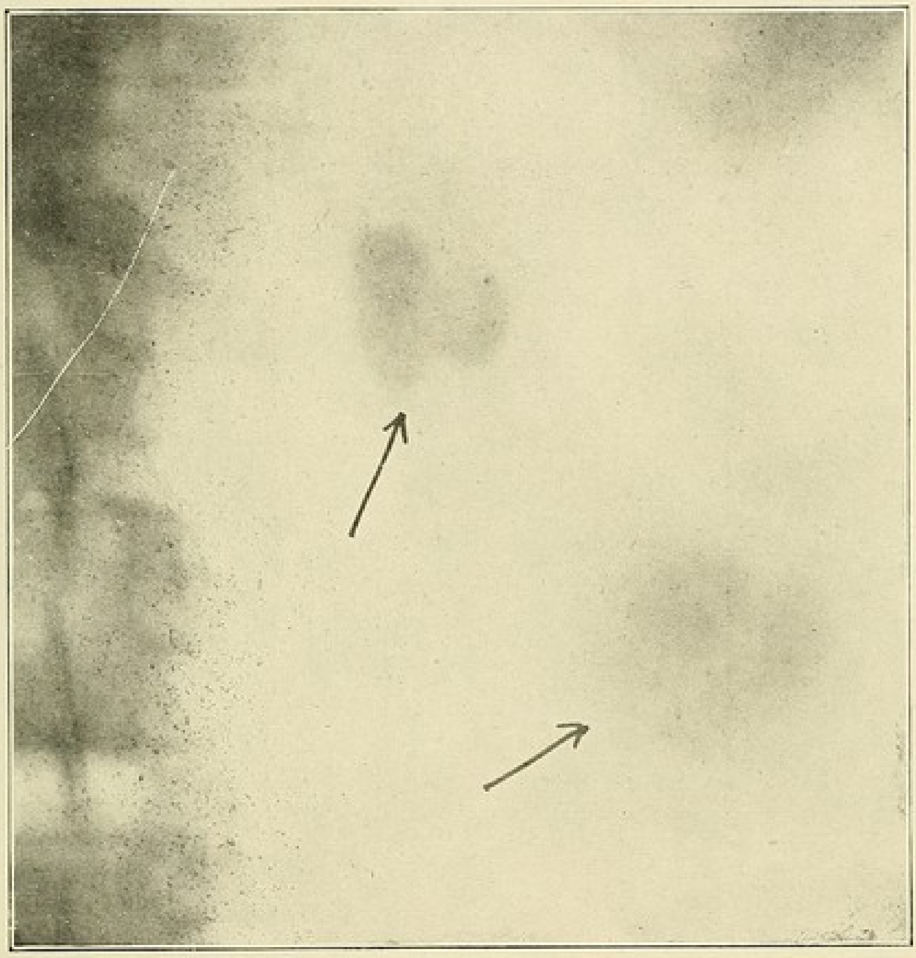


Fig. 204.—Skiagraph with a sinegran of the left kidney, showing a club-shaped stone in the pelvis of the kidney. Operation revealed a large kidney full of pus. The lower shadow was not positively accounted for.

accidents, the patient should be instructed to have the bowels thoroughly empty before coming to the laboratory. If the finished plate shows a shadow resembling a stone, and there is no occasion for an immediate operation, the patient should return the next day for another exposure. When two negatives on different days show the same reading, the diagnosis is reasonably certain. In this class of work the sinegran and a very low vacuum tube will give excellent results, especially in large subjects.

TECHNIC OF SKIAGRAPHING STONES IN THE KIDNEYS AND URETERS.

To be successful in skiagraphing stones in the kidneys and ureters, the operator must, of necessity, be equipped with a good induction coil and electrolytic interrupter. The operator should have had sufficient experience in a modern laboratory to enable him to judge for himself as to the kind and quality of apparatus he must have. As in everything else, individual taste differs, and some men will do reasonably good work with an outfit that others would not attempt to use. On account of the respiratory movements, a compression diaphragm is a necessity in skiagraphing kidney stones.

When a patient presents himself for a skiagraph to clear up the diagnosis of stone in the kidneys or ureters, his bowels must be thoroughly empty. If his physician has not thought to prepare him in this wise, the exposure must be delayed until it can be accomplished. A full dose of sulphate of magnesia or other laxative that will give the same result should be administered, with instructions to fast until after the x-ray examination. The patient should be placed in a recumbent position on his back, with the sensitized plate directly under the parts to be skiagraphed and as close to the patient as possible. The compression diaphragm is placed in position over the abdomen, so that the center of the tube will be over the center of the plate covering the parts of the patient to be examined. If the whole field can not be covered in one exposure, a second exposure may be made. When the diaphragm is in position, it must be slowly racked downward, using as much pressure on the patient as he can endure without pain. A strong, heavy anode (medium vacuum tube) is used and excited to its full capacity for the length of time required. These tubes will stand a very heavy current for a short time without serious injury. The exposure must be as short as possible, for short exposures give better detail, if not so much contrast. From fifteen to thirty seconds will be time enough for an exposure in a medium-sized man. If the patient is very large and thick, as is often the case, the sinegran may be used to lessen the length of exposure, though this is always at the expense of clearness in the plate, and should never be used where a reasonably good picture can be made without it.

Skiagraphs of this kind should be thoroughly developed. Very few plates are overexposed, the large majority being underexposed.

Many underexposed plates may be saved by long development and intensification. By using the edinol-hydroquinone developer, formula of which is given on page 223, an underexposed plate may be developed for thirty minutes, or an hour if necessary, without injuring the film, provided the temperature of the developer is not allowed to get too high and soften the emulsion. Unless the developed plate clearly shows the outlines of the vertebræ, with their transverse processes, the shadows of the floating ribs, and the crest of the ilium, it will not be of much diagnostic value. The presence of a stone dense enough to cast a shadow will leave a white spot on the plate. The larger and denser the stone, the larger and whiter will be the spot on the plate. These plates frequently require the closest study over an illumination box for the purpose of bringing out faint shadows that are not visible when viewed with a poor light. When a shadow about the region of the kidney or ureter looks suspicious, several exposures should be made on different dates; and if the same shadow repeatedly appears on the plates, and the clinical symptoms justify it, a diagnosis of stone should be made without question. If the shadows of the lumbar muscles are distinctly shown, with no shadows that would indicate the presence of a stone, a negative diagnosis should be given.

Errors in skiagraphing for renal calculi may be due to the extreme thickness of the patient, transparency of the stone or its small size, faulty exposure, errors in developing the plate, and inadequate apparatus. With a modern equipment and proper technic, very few urinary calculi should escape detection.

No case of suspected kidney stone should be operated without first exhausting the powers of the Röntgen rays to clear up the diagnosis. With a positive diagnosis of stone in the kidney or ureter, the patient and surgeon can begin the operation with a clear conscience, knowing that it is absolutely necessary. The surgeon will know the cause of the patient's trouble, where it is located, and how to get to it, and loses no time removing the stone. A diagnosis can not, however, be made from a single exposure unless the findings are very clear, which, as a rule, they are not.

FOREIGN BODIES IN THE URINARY BLADDER.

Children have a mania for poking things of various sizes and descriptions into the urethra and allowing them to slip back into the bladder. The author has found pins, hairpins, slate pencils, sticks, chewing gum, etc., in the bladder. Foreign bodies in the bladder soon become surrounded by concretions from the urine, increasing in size the longer they remain.

To skiagraph the bladder, the patient is placed in a half-sitting position on the plate, with the tube above the pubes and looking down through the pelvis toward the plate. The compression diaphragm should be used, and the parts made as thin and rigid as possible. The exposure should be about thirty seconds, and the plate developed as far as possible.

GALL STONES.

As shown in Fig. 199, gall stones are more difficult to skiagraph than stones in the kidneys and ureters. This is mainly due to the fact that gall stones are less dense and more transparent than kidney stones. Gall stones may be present in great numbers, a hundred or more, without making a trace of a shadow upon the sensitized plate. The more lime salts the calculi contain, the more distinct will be the shadow.

The patient may be placed on his abdomen, with the sensitized plate pressed firmly against the region of the gall-bladder. With the compression diaphragm the patient is pressed firmly against the plate. The exposure will vary with the thickness of the patient and the kind of apparatus, but from twenty to thirty seconds will be ample time. The tube should be of medium or high vacuum, and excited to its full capacity.

Fluoroscopic examination of the region of the kidney and gall-bladder is useless, for by such means nothing can be learned that will be of any value to either patient or physician.

CHAPTER XX.

X-RAY IN EYE SURGERY.

The use of the x-ray in surgery of the eye is confined almost exclusively to the location of foreign bodies. As far back as 1896 it was recognized as a valuable diagnostic aid in determining the presence of metallic objects that had been forced into the tissues of the globe. Several methods were devised by as many investigators, that were of more or less value, but it remained for Doctor Wm. M. Sweet, of Philadelphia, to perfect a method by which the exact location of a foreign body in the eye may be determined from lateral skiagraphs. To the ophthalmic surgeon the exact location of a bullet or a piece of steel is a very important matter. Upon this fact depends not only the diagnosis, but, what is more important, the prognosis with regard to vision.

LOCATING FOREIGN BODY IN THE EYE.

Mill and steel workers of all kinds are exposed to flying particles of steel and iron which frequently penetrate the orbital cavity. The wound in the cornea quickly heals, and it is often difficult to observe from external examination that an injury has been received. The well-made skiagraph will always reveal the presence of a piece of metal, no matter how small; but simply showing that a piece of metal or other foreign substance exists in the eye is not enough—its exact location, whether above or below, in the nasal or temporal side, or in the anterior or posterior portion, must be known. This might be determined by making two exposures at right angles to each other—i. e., one laterally and the other anteroposteriorly. An anteroposterior skiagraph of the head, showing a great amount of detail, is very difficult to make. It was soon found that all skiagraphs of the head must be made from side to side when searching for foreign bodies in the eye or face. Several methods have been used, some of which are very good, but the method of Doctor Sweet is probably the best, and will be exclusively used here.

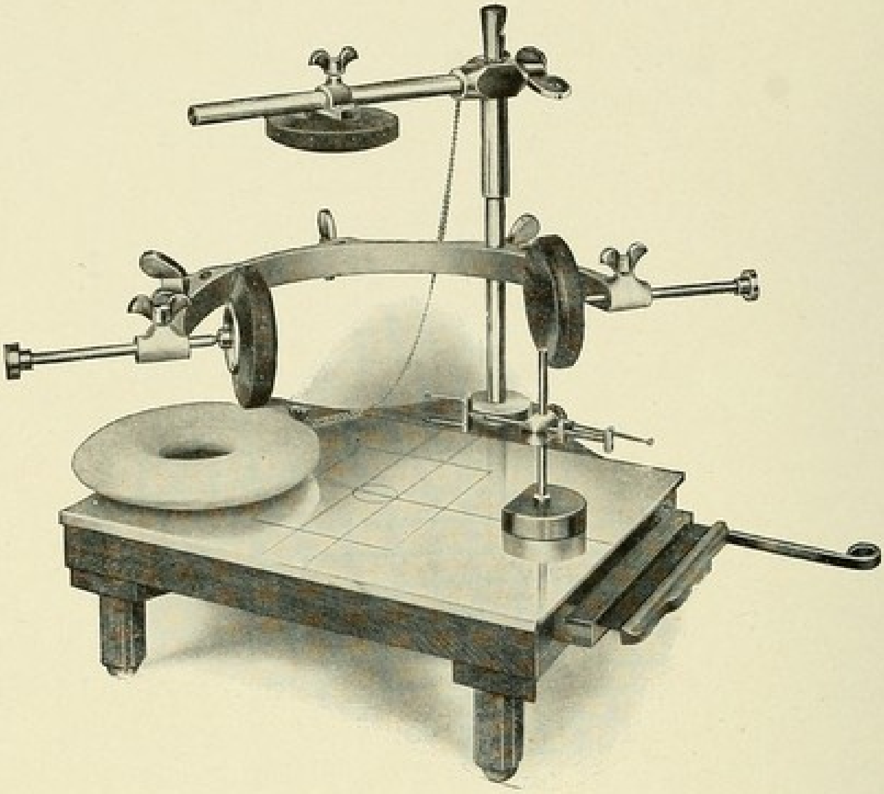


Fig. 205.—Keleket localizer and head-rest.

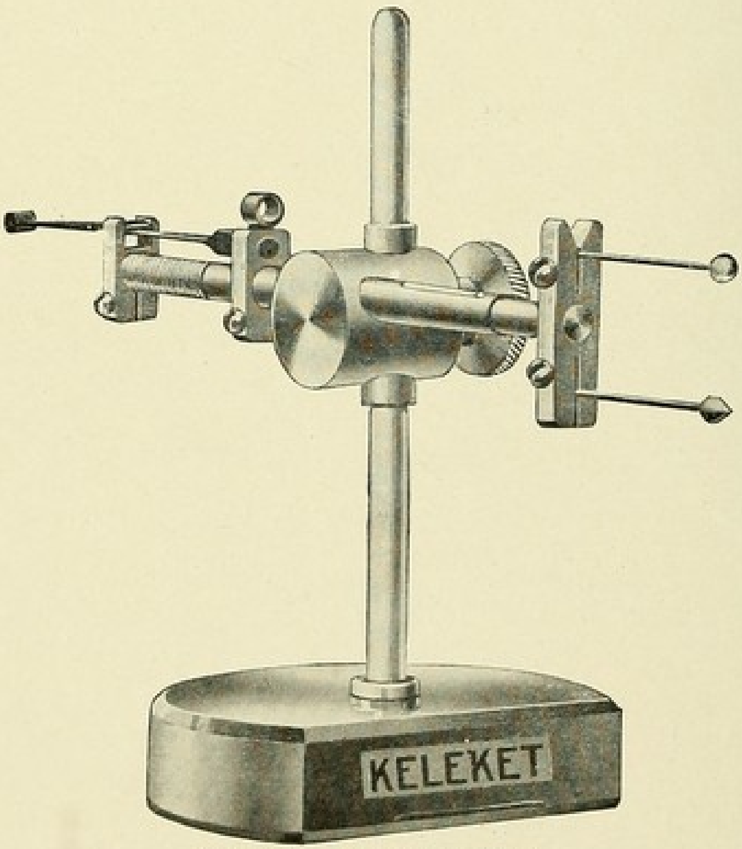


Fig. 206.—Keleket localizer.

In order to use the Doctor Sweet method, it is necessary to have a specially constructed localizer. The one shown in Fig. 205 is known as the Keleket, and will be described in the language of its manufacturers.

The apparatus consists of two general parts:

(A) The base, or head-rest (Fig. 205).

(B) The localizer (Fig. 206), shown in detail in diagrammatic drawing (Fig. 207).

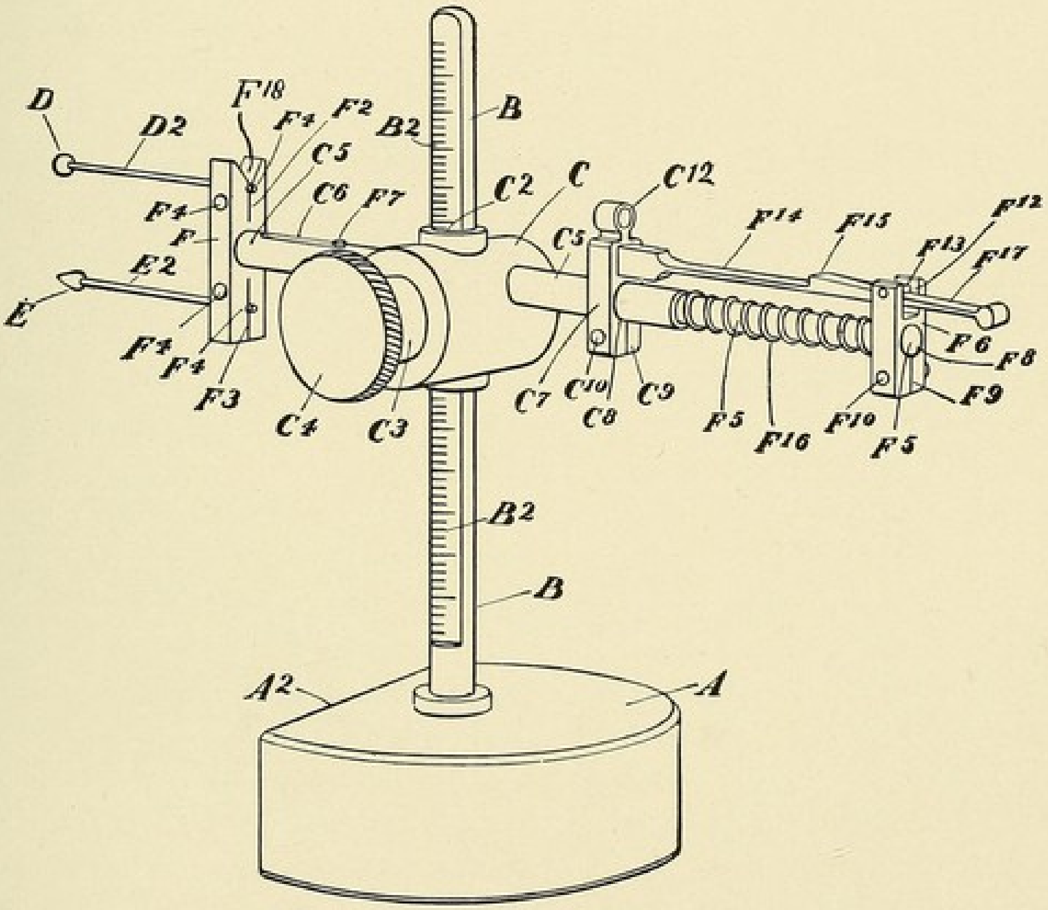


Fig. 207.—Keleket localizer. Diagrammatic view.

The head-rest base is composed of the following parts:

(1) A plate slide tunnel, so constructed as to protect one-half of a 5x7-inch photographic plate while the other half is being exposed, and to further protect the exposed half while the second exposure is being made.

(2) Four rubber-tipped legs, to raise the tunnel so that it will act as a pillow to hold the patient's head level when lying on his side.

(3) A plate-holder, having a slide that will protect the plate from ordinary light, but offer no resistance to the x-rays.

(4) An arm or handle attached to the plate-holding slide, to enable the operator to shift the plate the right distance for each exposure, and to withdraw the same when both exposures have been made.

(5) A pneumatic cushion, for the comfort of the patient.

(6) A double clamp, to hold the patient's head to prevent any horizontal movement.

(7) A single vertical clamp, to press the head downward upon the pneumatic cushion, thereby obviating any necessity for the unsanitary sand bag.

(8) A thin aluminum removable covering for the stand, having alignments that indicate the size and shape of the part of the plate being exposed to the rays, as well as a central indication which shows the position the eye should occupy and the point at which the central rays should be directed by means of the centering rod, as shown in accompanying illustrations.

The localizer proper, as shown in Figs. 206 and 207, consists of:

(1) A heavy metal base (Fig. 207).

(2) An upright standard *B*, to support the localizer and permit the same to be adjusted and held firmly at any desired height.

(3) The indicator ball *D*, with its needle supporting stem D^2, which, when properly adjusted to the center of an eye, will cast a shadow on the photographic plate and serve as a landmark indicating the center of the cornea.

(4) The metal tip *E* of stem E^2 is made cone-shaped, so as to more easily differentiate its shadows from that of ball *D*. These indicators are permanently adjusted a known distance apart (15 millimeters), so that when an x-ray picture is made of them obliquely, when adjusted to an eye, as above stated and as indicated in the front view on the chart, we are enabled by the shadows to definitely locate the source and course of the rays of light (in relation to the chart) that caused the shadows, and, in turn, the position of any foreign body that may show on the same plate can very easily be determined by the position of its shadow in relation to that of the ball and cone, because the exact position of the latter with reference to the chart is known and indicated (front view).

(5) Tube C^{12} and notch F^{18} are sights similar to those used on a rifle, with which the operator can accurately align the center of

the cornea of the afflicted eye with ball D and its supporting stem D^2. F^{14} is a spring trigger, which presses upward against pin F^{13}. F^5 is the end of the rod, to which the indicator ball and cone D E are attached by bracket F, the whole being supported by passing through tube C^5. Spring F^{14} being attached to stationary tube C^5 by means of bracket C^7, rod F^5 with bracket F^6 can be pressed forward until pin F^{13} is engaged by notch F^{15}.

(6) By loosening set screw C^4, the bracket C can be raised or lowered until ball D, with its supporting stem D^2, is in exact alignment with the center of the cornea of the affected eye, and the screw then tightened.

(7) The patient is instructed to close his eyes, and the entire instrument, with its base, is slid forward until indicator ball D presses into the eyelid approximately its own thickness. The trigger F^{17} is then depressed to disengage notch F^{15} from pin F^{13}, when spring F^{16} will cause the rod F^5 and indicator ball and cone D and E to rebound exactly 10 millimeters, being restricted by knob F^7 in slot C^6. The subject and localizer are now in correct position for making the two necessary exposures.

Place patient's head on the plate-holder base, with inflated cushion in position as shown in Fig. 208, being careful that the inflated cushion does not extend over the marked lines on the aluminum cover, as otherwise it may cast a shadow on the photographic plate. Should the subject show a disposition to move about, the horizontal clamps shown in Fig. 205 should be adjusted to the base of the head and forehead; otherwise the vertical clamp shown in Figs. 208 and 209 will be sufficient. The double horizontal clamp (Fig. 205) can be adjusted for either eye by means of its two off-center holes and clamp screws, the center hole being for frontal sinus work. Operators will bear in mind that the patient's afflicted eye must be nearest the photographic plate. Place the diaphragmed tube in such position that its central rays will exactly parallel the front vertical plane of the patient's eyes, as shown in Fig. 208.

A fresh 5x7 plate having previously been placed in the plate-holder, take it from the dark-room and place it in the tunnel, with its outer flange protruding, as shown in Fig. 208. This will expose one-half of the plate to the action of the rays, while the other half will be protected for the second exposure. The localizer (Fig. 206) is now placed on the stand in front of the affected eye, its trigger is "set," as already described, and, after the indicator ball has been adjusted to the plane of the cornea, the entire instrument is pushed forward on its base until the ball presses into the patient's closed eyelid approximately its thickness; the trigger spring is then released, and the indicator ball and cone recede exactly 10 millimeters, thereby permitting the patient to open his eyes and wink them in a natural manner. By referring to the localizer chart it will be ob-

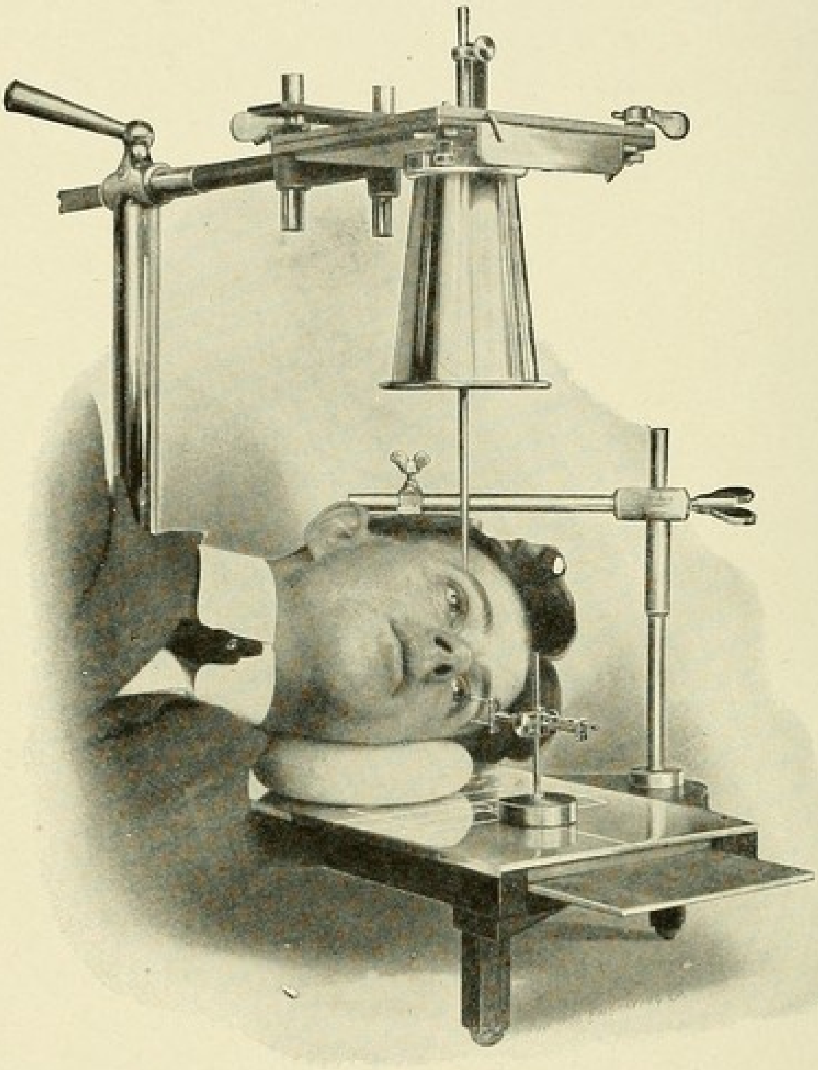


Fig. 208.—X-ray in eye surgery. Centering the tube.

served that due allowance of 10 millimeters has been made by placing the indicator ball and cone just that far removed from the front plane of the cornea, and it should be borne in mind that the front of the cornea is 10 millimeters in front of the shadow of the indicator ball, as shown in the negatives.

Some object, such as a candle or a piece of white paper, that can be readily seen by the patient, should be placed in alignment with the sights of the indicator, but several feet removed therefrom, and the patient should be instructed to look constantly at this object while the two exposures are being made. The first exposure should be made with the light perpendicular to the plane of the plate and parallel with the patient's eyes, thereby superimposing the shadows of the indicator ball and cone and their supporting stems, as shown in Fig. 210 (1). The x-ray tube is then shifted toward the patient's feet 4 or 5 inches, and tilted so that the indicator rod points to the ball of the localizer, thereby causing the central rays to pass

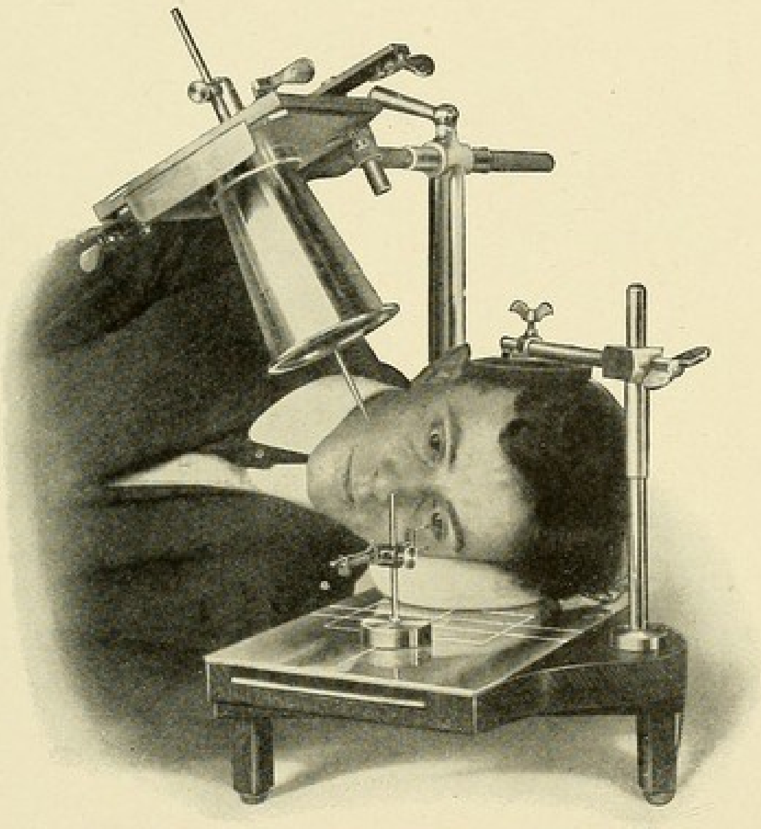
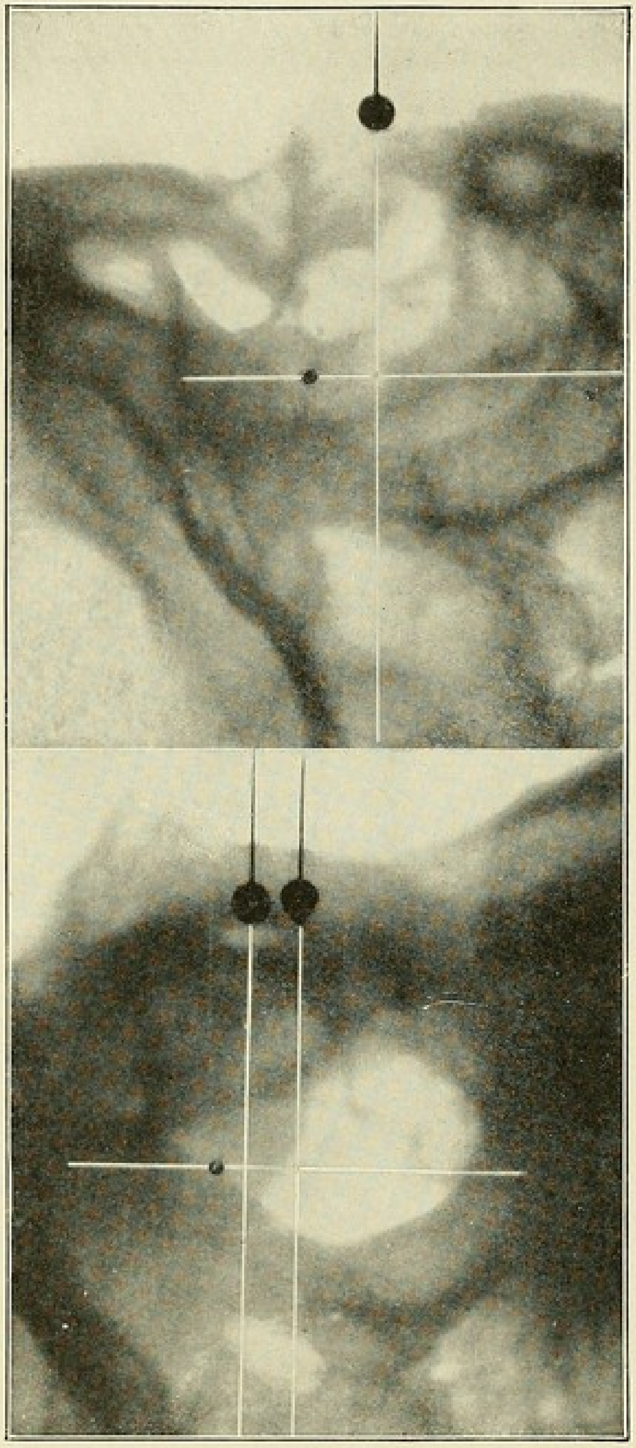


Fig. 209.—X-ray in eye surgery. Oblique position.

obliquely through the center of the cornea of the patient's affected eye, as shown in Fig. 209. The photographic plate must now be shifted by pushing the plate-holder inward by its handle as far as it will go, thereby protecting that portion that was acted upon by the rays in the first exposure, and bring its unexposed half in proper position to receive the rays from the second exposure. In this position the second exposure is made, with the rays falling obliquely upon the indicators, separating their shadows as seen in Fig. 210 (1).

The exposures need not be made with the light at any specific distance from the plate, or even the same distance for the two ex-



1. 2.

Fig. 210.—X-ray in eye surgery. Double skiagraph. Horizontal section.

posures, and neither is it important that the tube be shifted an exact or known distance for the second exposure, as by the use of the charts and Doctor Sweet's method the course of the rays are automatically established, as is shown by lines F^1-P and P^1-P^2 in Fig. 211.

The two exposures having been successfully made as directed, the plate-holder can now be removed and taken to the dark-room, where it should be opened and the plate developed, and, if found to be correct, the patient should be released.

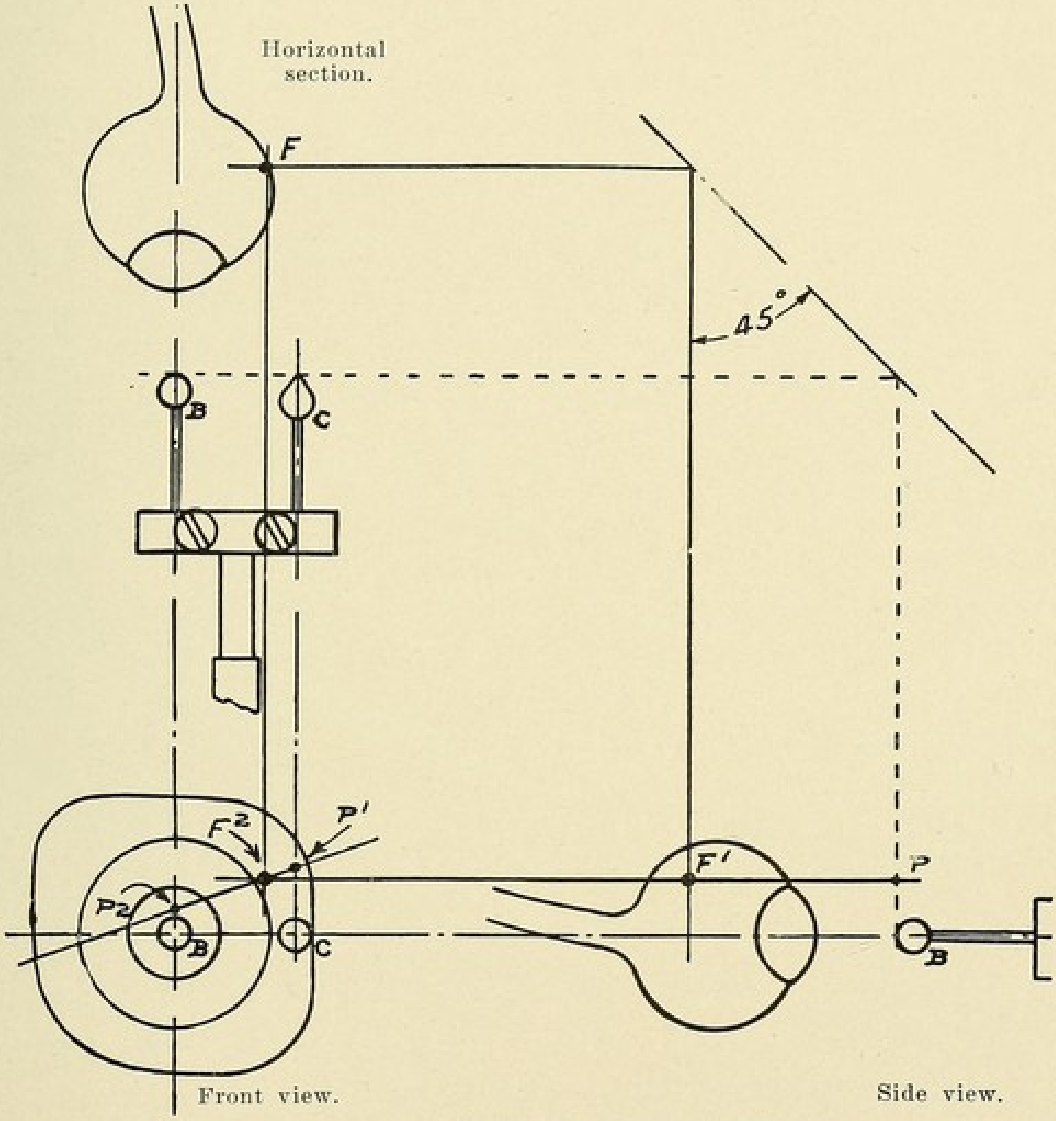


Fig. 211.—X-ray in eye surgery. Sectional view of the eye.

To enable the student to have a thorough understanding of the correct method of making the charts for the Röntgen localization of foreign bodies in the eye or orbit, an example is here presented. 1 and 2 in Fig. 210 show a shot correctly localized by this method, as seen in Fig. 211. On negative 2 in Fig. 210, which represents the first exposure, a line is drawn through the horizontal axis of the indicator ball and cone, which are here superimposed, thereby projecting their supporting stems and establishing the visual axis of the eye. A second line is drawn at right angles to the first through the center of the shadow of the foreign body. With a small pair of dividers, such as draughtsmen use, step the distance from the edge of the indicator ball to the intersection of the horizontal and vertical lines that have been drawn, then step the distance off on the diagram chart, making a dot with a pen or a very sharp pencil to represent the exact distance. On the vertical line that has been drawn through the shadow of the foreign body (2 in Fig. 210) measure the distance of the foreign body above the horizontal line and indicate it on the chart above the first dot, as is represented by dot F^1 in Fig. 211, side view. Place another dot on the same horizontal plane at point P, and draw a line through these two dots, projecting it into the front view, as shown. Since the position of localizer ball B, as shown on the chart, is the same as when the first picture was made, the location of the foreign object must be at point F^1, side view.

But we have yet to establish the location of the foreign body relative to the nasal or temporal side. Project a line vertically through point F^1 to the 45-degree angle, and thence horizontally through horizontal section. On negative 1 in Fig. 210, which represents the second or oblique exposure, a line is drawn through the horizontal axis of both the ball and cone, thereby projecting their supporting stems and establishing the relative relation of their horizontal planes to that of the foreign body. A third line is drawn at right angles to the first two through the center shadow of the foreign body. With the dividers measure the distance of the shadow of the foreign body above the horizontal plane of the shadow of the ball, and mark it by a dot on the front view of the chart just above the center B, as indicated by arrow P^2, because that was the relative position of the ball when it cast the shadow. Measure the distance of the shadow of the foreign body above the horizontal plane of the shadow of the cone, and mark it on the chart at the point above C indicated by arrow P^1, because that was the relative position of the indicator cone when it cast the shadow.

A line drawn through dots P^1 and P^2 will represent the true course of the rays in the second exposure, and its intersection with the projected line from the side view through points P and P^1 will be the position of the foreign body when viewed from the front, while a vertical projection of a line through this point intersecting with the projected line through the horizontal section shows the

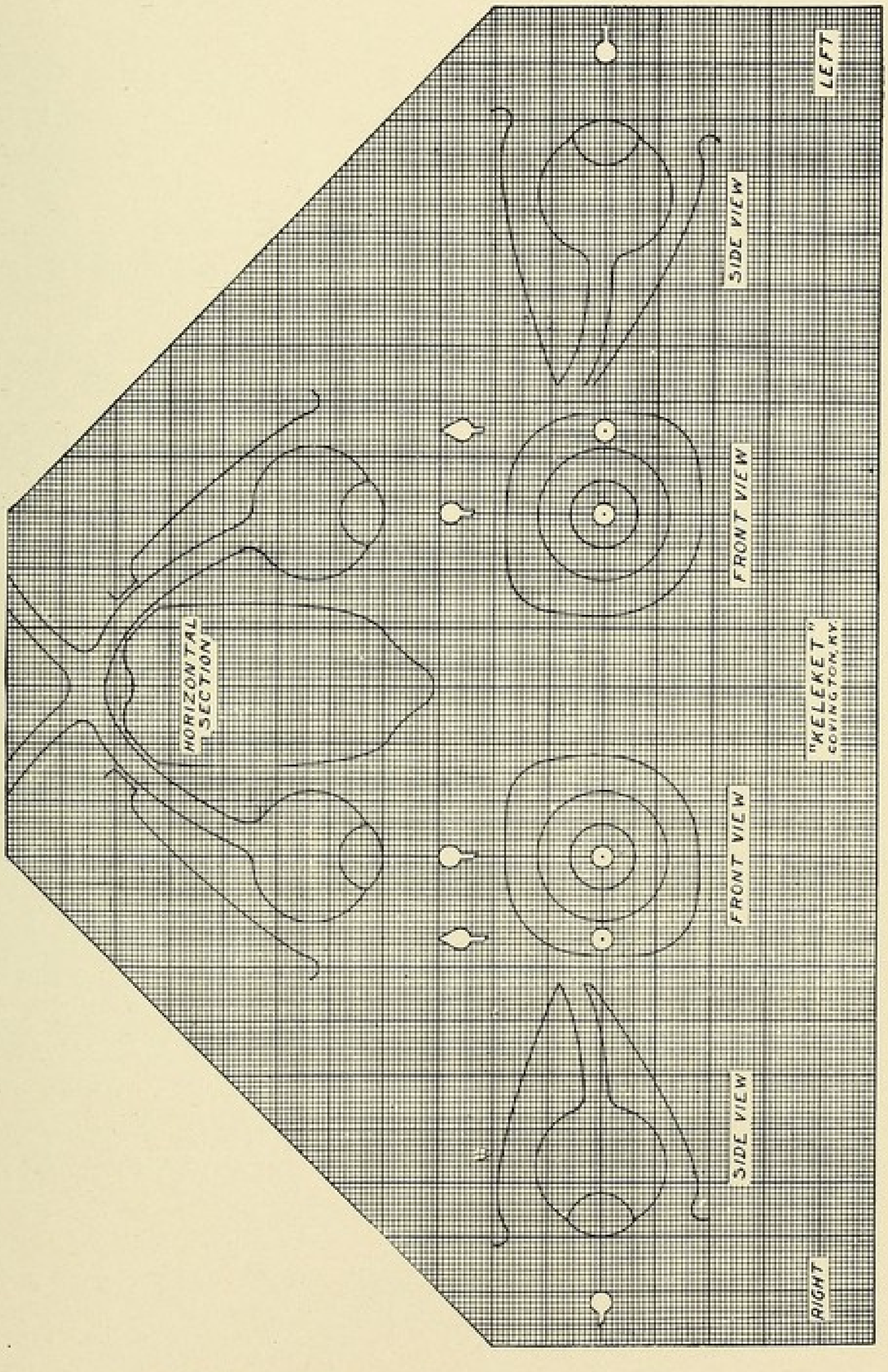


Fig. 212.—X-ray in eye surgery. Chart for locating foreign body in the eye. Reduced.

position of the foreign body to the temporal side at point F, horizontal section.

The reader will readily understand the first picture, lateral exposure, shown in 2 in Fig. 210 and charted in side view in Fig. 211. The method of determining the position of a foreign body relative to the nasal or temporal side will be quite as easily understood by bearing in mind that the circles *B* and *C* in the front view in Fig. 211 represent the ball and cone of the localizer, and that the distance of the shadows of the foreign body shows either above or below the plane of their shadows (as shown in Fig. 210), and must be represented by a dot on the vertical lines in the front view, either above or below their centers, while the joining of these two dots by a straight line will indicate the ray of light passing through the foreign body, the position of which will be indicated by the intersection of this line with that projected through the foreign body from the side view.

Fig. 212 illustrates a reduced chart on which may be indicated the exact position of any foreign body that will cast a shadow on a photographic plate.

Stereoscopic Pictures.—Stereoscopic pictures of foreign bodies in and about the orbit are made with this instrument, the ball and cone of the localizer acting as landmarks—the former indicating the center of the cornea and the latter the temporal side. The pictures are viewed through an ordinary parlor stereoscope. These stereoscopic exposures must be made obliquely, as in Fig. 209, so as to show both arms of the indicator and the relation of the foreign body.

In addition to the localization features of this instrument, its plate slide base can be used most successfully for a great many other purposes, among which may be mentioned stereoscopy of the frontal sinuses, the antrums, the mastoid (obliquely), the teeth, and all other areas not larger than 2½x3½ inches. With it two exposures are made on the same plate for comparing the normal with the pathological, etc. The plate-holder base, cushion, and clamps may be supplied without the localizer, if so desired.

CHAPTER XXI.

X-RAY IN DENTISTRY.

The skiagraph in dentistry has, as elsewhere, maintained its well-earned reputation. The careful and painstaking dental surgeon who is desirous of knowing the exact condition of the teeth may have them revealed from crown to root through the medium of a skiagraph. The position, structure, and evolution of the teeth, from the germ to the time of eruption, may be studied in the living subject. Foreign bodies—as fillings and broken broaches in root canals—fractured roots, root and alveolar abscesses, deformed and displaced teeth, disease of the antrums, fractures, and diseases of the maxillary bones are among the things that are possible to reveal by means of a well-made skiagraph.

The equipment necessary for dental skiagraphy is in no way different from that used for skiagraphing other portions of the body. The coil will do better work than the static machine, and the tubes should range from medium to high vacuum.

Fluoroscopic examinations in dental conditions are not satisfactory. The dental skiagraph may be made in two ways—extra-oral and intra-oral. The intra-oral method is generally preferable where the examination is confined to two or three teeth located together. The method consists in inserting small well-protected sensitized celluloid films inside the mouth, which are supported firmly against the side to be examined. The tube is placed about 12 inches from the teeth, and in such a position that the rays are at right angles to them. During the exposure the patient, if old enough, may be taught to support the films with a finger firmly against the gums and teeth on the inside of the mouth. The films should be heavier than the ordinary kodak films, and of the "triple process" variety, which are 4x5 inches in size. They may be cut to any size, usually about $1\frac{1}{4}$x$1\frac{3}{4}$ inches. The films should be wrapped in oiled or waterproof paper, and then in heavy black paper, with the ends folded toward the back of the film, leaving the smooth surface on the sensitized side. The exposure should be from five to ten seconds, after which the film is taken to the dark-room and developed in the usual way. A number of exposures—say, three or four—may be made in this way without any danger of causing a dermatitis.

In skiagraphing the antrums and the inferior maxillary, the extra-oral method should be used, always placing the affected side nearest the plate. The vacuum of the tube should be higher, and the length of the exposure must be a little longer.

Stereoscopic views of the face may be made with the Doctor Sweet localizer, provided the diseased or injured parts can be shown on a plate 2½x3½ inches.

The method of making extra-oral skiagraphs is not different from that of other parts of the body. The accompanying skiagraphs of the teeth are fair illustrations of the intra-oral method, and readily show the superiority of this method over the extra-oral.

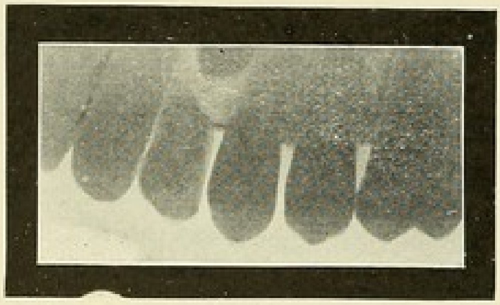


Fig. 213.—X-ray in dentistry. Permanent tooth showing under milk tooth.

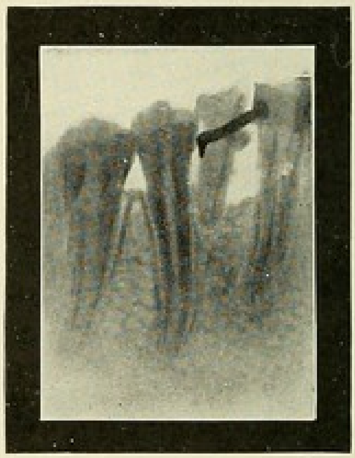


Fig. 214.—X-ray in dentistry. Shows absence of the germ of the permanent tooth.

Fig. 213 is a skiagraph taken from the mouth of a boy 10 years old. He had shed all of his milk teeth, except the left upper canine. This tooth was a little loose, but his dentist did not want to pull it unless the permanent tooth was coming on. The skiagraph revealed the presence of the permanent tooth.

Fig. 214 was made from a case referred to the author by Doctor T. G. Bradford. There is an absence of the permanent left lower canine. The temporary tooth had been wired to its fellow some time before the skiagraph was made, and the wire is plainly seen in the picture. In this case the germ of the permanent tooth is wanting. Without a skiagraph the dentist was at a loss to know what course to take to give the child the benefit of correctly shaped teeth.

In cases of this kind the skiagraph is of the greatest possible diagnostic value by preventing the dentist from making errors that often lead to distressing results.

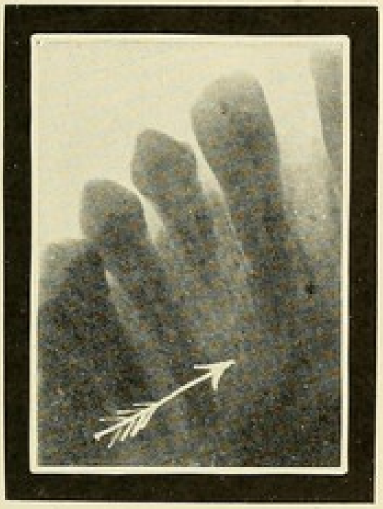


Fig. 215.—X-ray in dentistry. Shows absence of the germ of the permanent tooth.

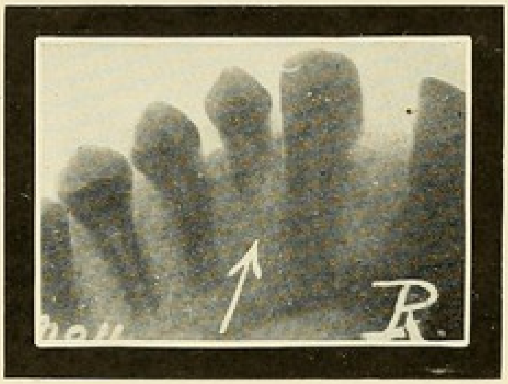


Fig. 216.—X-ray in dentistry. Shows absence of the germ of the permanent tooth.

Fig. 217.—X-ray in dentistry. Shows lower wisdom tooth impacted against its fellow.

Figs. 215 and 216 show the absence of the left lower canine in subjects past the age where there should be any doubt of the presence of permanent teeth. The absence of the germ of permanent teeth occurs more frequently than the author would have believed possible without such positive evidence.

Fig. 217 was made from a case with a very interesting history. The subject had been under observation for some time, and had been seen by several eye, ear, and nose specialists. The case was that of a young lady about 17 years old, who had suffered severe pain on the right side of her face for several months. She finally came to Dallas and consulted Doctors Taber and Arnold. Her symptoms simulated mastoiditis, but were not typical. Doctor Taber referred her to the author for a skiagraph of the molars on the affected side. It will be noticed that the upper wisdom tooth (A) had not erupted, but was descending in a normal direction, while the lower wisdom tooth (B), the offending one, was firmly impacted against its fellow in front. So firmly was this tooth impacted against the second molar that it was necessary to extract the second molar before the third could be removed. The mastoid symptoms disappeared with the pulling of the impacted tooth.

This skiagraph, while it appears to be all one and made at one exposure, was really made on separate films at two exposures and afterward joined together during the process of reproduction. This method of skiagraphing the teeth gives clear and distinct pictures, without being marred by intervening structures. The method is not difficult, but requires some practice to obtain the correct angles, in order to prevent distorting the shadows.

Dentists, like physicians, frequently neglect skiagraphic investigations because it requires some time and trouble, and entails a necessary expense to the patient. Usually people are willing to go to considerable trouble and expense for that which they need, and it only remains to assure them that skiagraphic examinations are necessary in order to obtain their consent.

CHAPTER XXII.

X-RAY BURNS—DERMATITIS.

Overexposure to the x-ray may produce conditions in the skin that are indicated by a degree of tissue changes which may be anywhere between a mere exfoliation of the epithelial layer to a deep necrosis, or a chronic hyperkeratosis. During an exposure the rays produce no sensation whatever to the patient—neither of warmth nor discomfort. A dermatitis may be the result of a single exposure or the accumulated effect of a number of exposures. Some people show a marked susceptibility to the action of the x-rays. This fact is confirmed by the operators of experience in all parts of the country. A few cases of dermatitis have been recorded where the exposure was only one minute.

During the evolutionary stage of the x-ray, before its possibilities were known and its dangers unavoidable, exposures were frequently made lasting from twenty minutes to an hour and a quarter. During this period many severe burns occurred. At a later period, with a more improved technic and better equipment, the length of exposure was reduced, at the same time and in corresponding proportion reducing the liability to x-ray dermatitis. Only occasionally, probably once in 5,000 exposures, did a dermatitis of any consequence occur. During the early period long exposures were frequently necessary to get full-timed pictures, and, as the surface of the tissues bore no evidence of the amount of x-radiation they would stand, the operator, working for results in the skiagraph, sometimes caused a dermatitis.

Many cases of x-ray dermatitis were of so slight an extent that they would have readily healed within a very short time had they not been greatly aggravated by careless infection on the part of the subject, or because of irritating drugs and chemicals prescribed by physicians and druggists who were unfamiliar with the nature of such skin affections. A case that came under the author's observation was that of a young man who had been skiagraphed for a diseased hip. Two exposures of two minutes each were given at a distance of 18 inches. He developed a dermatitis, and a little later contracted a virulent gonorrhea, from which he conveyed the infection to the dermatitic area, resulting in an inflammatory ulceration that lasted several months, leaving markings that will go with him through life. Other cases of like nature have been reported from time to time, for which the x-ray has been made to bear the burden of the blame.

Cause.—The direct cause of an x-ray burn is as yet unknown. The main factors in the process are (1) proximity of the tube to the parts exposed, (2) degree of vacuum of the tube, (3) and length and number of exposures.

For the purpose of treatment, it is customary to divide x-ray dermatitis into acute and chronic stages. These stages have been discussed under x-ray dermatitis, page 240.

Treatment.—The treatment of x-ray dermatitis, acute and chronic, has been mainly by means of drugs, and has been more or less a failure; in fact, a large number of cases so treated have been made much worse instead of better. Ichthyol, carbolic acid, bichlorid of mercury, silver salts, and many other drugs and chemicals, made into washes and ointments, seem to aggravate a large majority of cases. All solutions containing alcohol in any proportion must not be used. In the acute form, if the epidermis is removed, the surface should be thoroughly cleansed with a warm normal salt solution and covered with dry sterile gauze. For the intense itching, Kassabian recommends immersion of the parts in hot water, followed by dilute solutions of cocain. In the treatment of the chronic form, Kassabian's advices should be considered as particularly valuable, as he was a sufferer for many years, having contracted extensive x-ray burns on his hands and other parts of his body, from which he finally died, a martyr to the cause of the science. He recommends the application of picric acid in solution, and ointments containing boric acid, zinc oxid, aristol, and orthoform in a lanolin, cold cream, or vaselin base.

Where the ulceration is the result of external infection, as is often the case, local escharotics are indicated. In one case of slight dermatitis over the inguinal region the author had reason to believe that there had been a secondary infection from chancroidal virus. Fuming nitric acid was applied over the entire surface of the denuded area, with almost magical results.

Fulguration and the ultraviolet rays are of great benefit in a large number of cases. The pain and itching are sometimes entirely relieved after a single treatment.

The belief that cancer will follow an x-ray dermatitis is wholly unfounded. Cancer has followed a few cases of chronic x-ray burns, but there is no evidence that cancer is any more liable to follow an x-ray burn than any other irritation.

The chronic form of dermatitis is seen, almost entirely, in x-ray operators and manufacturers who work daily in the x-ray field. They finally develop a condition that is chronic and incurable. Both gentlemen of the firm of Green & Bauer, tube manufacturers, Hartford, Connecticut, were badly burned while making and de-

Fig. 218.—X-ray dermatitis.

veloping their excellent tubes. In conversation with Mr. Green recently he informed the author that when Mr. Bauer discovered that he was dangerously burned he gave up the business in order to get away from the x-ray influence, but lived only a few months. Mr. Green advanced the belief that if Mr. Bauer had remained in the work, with a lessened exposure to the rays, he would probably be living. As evidence he showed me the remaining effects of his terrible burns, stating that they were more severe than those of his associate, Mr. Bauer, and he believes that had he, also, discontinued the work he would likewise be dead. He explained that he personally tests every tube that leaves his factory, and that for at least two seconds he is in the active field of each. Should Mr. Green be correct in his views, mild x-ray exposures will benefit all cases of x-ray burns. This would agree with the homeopathic theory, and will bear earnest investigation.

With our present knowledge of the action of the x-ray, chronic dermatitis will soon be a thing of the past, and, with the advent of the more powerful generators and the sinegran, accidental dermatitis, even in the most susceptible subjects, need not occur.

CHAPTER XXIII.

MEDICO-LEGAL ASPECT OF THE X-RAY.

The reliability of the skiagraph as evidence in court has been both denounced and defended from almost the very date of its discovery by Röntgen in 1895. Well-made skiagraphs are of inestimable value to the physician who understands their interpretation in explaining to the court and jury the presence and location of shot, bullets, and other dense foreign bodies in the tissues, and in describing fractures and dislocations—their location, extent, and condition—at the time the examination was made.

By means of a correctly made skiagraph an experienced operator may interpret the true extent of any bony injury even months after the accident. If every man or woman who contemplates appearing as a principal in a damage suit, claiming a fracture or other injury to the bones, were forced to have skiagraphs made of their alleged injuries, to be used as evidence at the time of trial, a large number of such intended claimants would be discouraged from bringing suit.

Because of the fact that few lawyers have any conception of the skiagraphs or how they are made, it is necessary that the physician making the pictures be allowed to show them to the court and jury, and to explain them in terms which they can understand. It is frequently necessary in complicated cases that the physician provide himself with a skeleton, or the particular bone or bones involved in the controversy. In describing the bones and pictures (skiagraphs), the witness should use the plainest language, as technical terms frequently confuse the members of a jury, causing them to lose the train of reasoning that would lead to a true verdict. The physician, when asked to skiagraph a subject, should ascertain for what purpose his services are wanted. If the case is likely to result in a damage suit, he should go into the case thoroughly, taking notes of the general appearance of the subject and making a careful record of all objective symptoms. The plate is the property of the operator, and should be kept in his possession, but prints from such plates may be made and delivered to the parties for whom the examination was made. The plates should, however, be taken to the witness stand, as also an electrically illuminated examination box, in case a demand should be made for an examination of the original plates. The plates should remain in the possession of the operator, as they are of delicate construction, and, if thrown on tables, if not broken, the delicate film is likely to become marred by scratches and finger marks, completely spoiling them for future use. The plates are the record of facts on which the x-ray operator bases his judgment, and is valuable only through his interpretation. They belong to neither side, and present the case as found at the time the examination was made. The plates and skiagraphs may be submitted to the examination of experts who are competent to make such examinations. Such a course may, at times, be necessary to determine if the exposures were properly made with regard to distance, time, and direction of the rays during the exposure. Competent operators will have no difficulty in agreeing as to the reliability of a skiagraph as evidence in proof of a certain point.

The physician, when called to the witness stand as an x-ray expert, should be thoroughly familiar, not only with all modern x-ray apparatus, but he should be able to recognize skiagraphs of the various bones of the human body at any stage of growth from infancy to old age. This is sometimes quite difficult—for example, when only a portion of a long bone is shown in the picture. Unless he is, from experience, competent to qualify as a surgeon, the witness may decline to answer questions pertaining to the surgical aspect of the case.

When asked to examine and pass on skiagraphs and plates made by other x-ray operators, the x-ray witness should demand the notes of the physician who made the plates and skiagraphs, in order that he may be in a position to give an intelligent opinion of the value of the evidence found in such plates and skiagraphs. If, however, as too often happens, there are no notes of explanation with the plates and skiagraphs, the witness should be allowed the time and opportunity to make such measurements of the pictures as will enable him to give an opinion as to the method by which they were made. In arriving at his conclusions, he must take into consideration the age of the subject, the shape and size of the bones, and the position of the plate and tube with relation to the parts examined.

It is true that fractures that have been correctly reduced may be skiagraphed in such a position as to appear out of apposition on the plate. The presence of well-developed sesamoid bones in both the hand and foot have caused a great deal of controversy between physicians whose education and experience should have avoided such disagreement. These bones frequently make very clear and distinct shadows, and have been mistaken by inexperienced x-ray operators for foreign bodies, as bullets, shot, etc. Some time ago the author had occasion to skiagraph a foot that was thought to contain a bullet, but no bullet was found. A few days later the foot was examined by a general practitioner with a fluoroscope, who was very positive that he saw the bullet opposite the metatarso-phalangeal joint of the great toe. How he failed to find "two bullets" at this point is more than he was able to explain, as in this particular case there were two well-developed sesamoid bones at that point, making two clear and distinct shadows on the plate. Errors of this kind should not occur, as every physician should know that these bones are present in various parts of the body, and especially at this point in the foot.

On cross-examination the witness should learn to keep his temper, and not become angry and thereby be confused, as it is through such confusion that an examiner hopes to gain a point and break down or destroy the influence of the witness' testimony. The witness should be respectful to the examiner, no matter how absurd his questions may be, so long as he confines himself within reasonable bounds, but, should he persist in asking absurd and irrelevant questions, the competent and well-trained x-ray specialist will, as long as he stays in his own domain, have the examiner at a great disadvantage.

A short time ago the author was serving as an x-ray witness in a damage suit. An old attorney in the case, who is known for his learning and his propensity to terrorize a witness, had evidently attempted to prepare himself for the author's examination by studying kodaks to the extent that he had learned that there is a wide range of difference in lenses. Feeling assured that he had acquired the necessary amount of technical knowledge, this attorney asked very suddenly and with a great deal of emphasis, "With what kind of a lens do you make these pictures?" He also asked if the plates, which were lying on the table before him, had not been retouched.

Such questions indicate to what extent ignorance is encountered in such examinations.

Some attorneys seem to want to engage in a long description of the technic of the method of making a skiagraph, not for the purpose of enlightening the jury, but for the sole purpose of confusing both the witness and the jury by obscuring the main facts for which the skiagraph was shown. Lawyers who make a business of either prosecuting or defending damage suits for personal injuries should familiarize themselves with modern x-ray methods. X-ray operators would be pleased to explain their methods to both sides of the case, as the x-ray operator is dealing with facts as he finds them, and he should have no more interest in the result of a suit than the desire to have justice done to all parties concerned.

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