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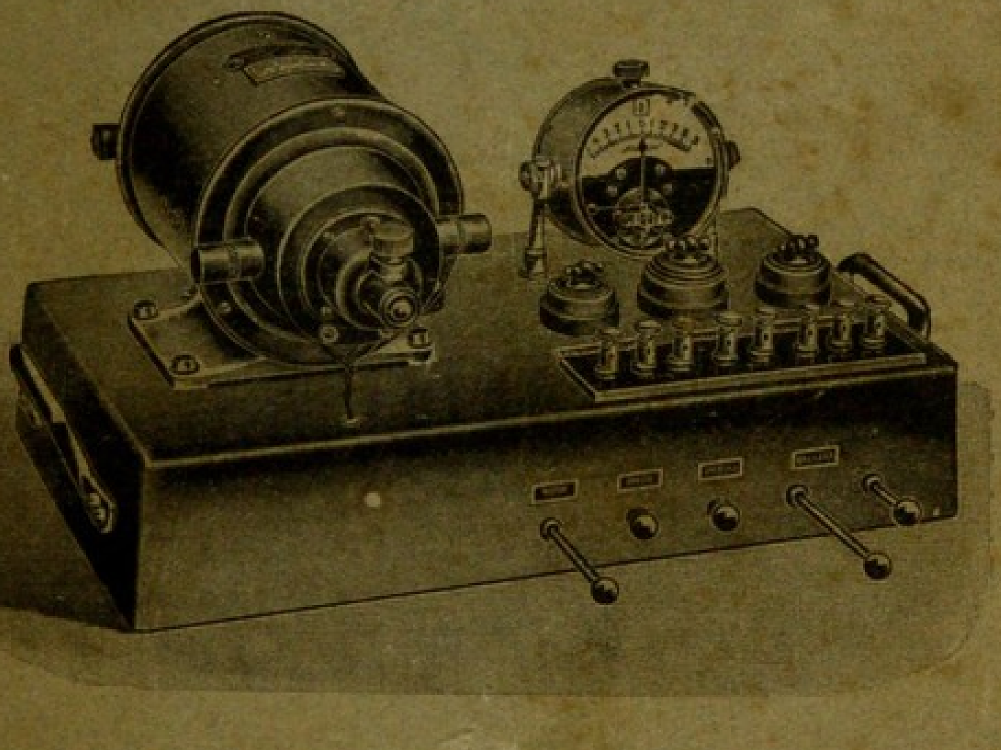
Electro-Medical Instruments and their Management . .

AND

Illustrated Price List of Electro-Medical Apparatus.



BY

SCHALL & SON.

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PRICE ONE SHILLING.

FARADISATION.
GALVANISATION, Etc.

CAUTERY, SURGICAL
LAMPS, MOTORS, Etc.

SWITCHBOARDS for Current
from Main. LIGHT THERAPY

X-RAY
APPARATUS

J. Thomson

ELECTRO-MEDICAL INSTRUMENTS AND THEIR MANAGEMENT.

FARADISATION, GALVANISATION, Etc.

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X-RAY APPARATUS

PREFACE.

The following pages explain as simply as possible the physical laws which are of importance in using Electricity for Medical and Surgical purposes. They describe the necessary apparatus and their construction; they give a few practical hints about the apparatus best suited under special circumstances; they show how faults may be avoided, or, at any rate, how they may be detected and rectified.

Should the reader who lacks time to study larger works on Electricity find the following pages a help in making his electrical instruments familiar to him, thus facilitating their management, this little pamphlet will not have been written in vain.

1892. K. SCHALL.

The pamphlet, "Electro-Medical Instruments and their Management," was published for the first time about twenty years ago. Since that time many Medical Men have assured me that it has been a help to them, and this encourages me not only to republish, but also to enlarge it considerably, hoping that the new chapters likewise may be found useful.

The part about X rays has been entirely rewritten, to bring it up to date.

1911. W. E. SCHALL, B.Sc. Lond.

ELECTRO-MEDICAL INSTRUMENTS AND THEIR MANAGEMENT.

ELECTRICITY is the result of some kind of motion, like heat, light, magnetism, etc. ; it is closely related to these forces and can be easily converted into them.

We possess many means and ways of producing it, such as friction, chemical action, induction, mechanical power, etc. All these methods are used in applying electricity for medical purposes ; but before explaining them, it will be necessary to define a few general expressions.

Positive and Negative.—If we rub a glass bar or a stick of sealing-wax with a dry cloth or fur, and apply the knuckle to the rubbed place, a small spark appears. The friction has electrified the sticks, and the consequence thereof is that they attract light things, such as pieces of paper, electrify these as well, but repel them immediately after having touched them. A glass bar repels a piece of paper after having electrified it ; but a stick of sealing-wax, after having been rubbed, attracts the same paper strongly. This shows that the electricity in the glass bar is not the same as the electricity in the stick of wax. It is the custom to call the kind of electricity produced through rubbing a glass bar *positive* electricity, and the electricity produced by rubbing a stick of wax or india-rubber, *negative* electricity. The above experiment shows that two bodies charged with the same kind of electricity repel each other, and that bodies charged with different kinds of electricity attract each other.

Normal Condition.—It is a mistake to imagine that the friction has charmed some new strange power into the sticks. It will be more correct to suppose that, in their normal (that is to say unrubbed) condition, the sticks contained negative and positive electricity in equal quantities, and as long as this was the case we could not discern the presence of the power at all. The friction, however, disturbed the normal condition by separating the two kinds of electricity contained in those bodies, and under these conditions only can we detect the presence of electricity.

Conductors and Insulators.—The separated kinds of electricity can be united again by means of a conductor. After rubbing a glass bar, or a stick of wax, we find that it has become electrified in the rubbed places only, and remains non-electric where it was not rubbed. Obviously therefore electricity cannot spread equally over glass or wax, but remains localised. Substances which do not conduct electricity, such as glass, oil, *pure* water, air, paraffin-wax, etc., are called non-conductors or insulators. Other substances which allow electricity to pass freely, such as all metals, carbon, some minerals, etc., are called conductors. Between conductors and non-conductors there is a third class of materials, which do not conduct electricity nearly as well as metals do, but which still conduct it to a certain extent; such as acids, salt and alkali solutions, etc. Such fluids are called half-conductors. Now to this class belongs the human body.

It is of the greatest importance that there are bodies which conduct, and others which do not conduct, electricity, for we are thus enabled to direct the electricity exactly to the spot where we desire its action, and to send it along metal wires which are supported by insulators, over any distance we like.

For a long time friction was the only means known to electrify bodies; but about a hundred years ago, Volta and Galvani discovered another and far more convenient method to produce electricity, *i.e.*, the simple contact of two different metals, and chemical action. They thereby gave the first impulse to the wonderful development of electricity which we have witnessed in our day. The electricity produced in this way has been called galvanic electricity, in honour of one of its discoverers.

GALVANIC ELECTRICITY.

Electro-motive Force.—If we immerse a piece of metal in some fluid which has the power of acting chemically on the metal, the two kinds of electricity are separated too. The power which disturbs the normal condition, and separates the positive from the negative electricity, is called *electro-motive force.* The E.M.F. is in some proportion to the intensity of the chemical action, but is *independent of the size or shape of the metal.*

If we immerse zinc in diluted sulphuric acid, the zinc becomes negatively, the sulphuric acid a little positively, electric. Platinum immersed in sulphuric acid gets positively electric, and the acid becomes negative. This shows that different metals react differently with one and the same liquid, and they can be classified in such an order that, in contact with a liquid, always the preceding metal gets negative compared with those that follow. In diluted sulphuric acid, for instance, the most important metals follow one another as follows: Zinc, lead, copper, silver, platinum, carbon.

By immersing at the same time two different metals, the one of which gets negatively, and the other positively, electric, we increase the tension, for in this case we have two E.M.F.'s instead of one. On the exciting liquid much depends too; zinc and carbon, for instance, have twice as high an E.M.F. if dipped in chromic acid than when dipped in sulphuric acid only. Such an arrangement, i.e., two metals, or a carbon and a metal, in an exciting fluid, is called a galvanic element or cell.

Arrangement of Cells.—No single cell possesses an E.M.F. higher than two units, if we take that of the Daniell cell as one unit. A much larger E.M.F. is often needed, and we can obtain it by connecting several cells, so that the zinc of the first cell is connected with the carbon of the second, the zinc of the second with the carbon of the third, etc. In this way we add the

E.M.F.'s of the single cells together, and if, for instance, forty Leclanché cells are connected like this, the E.M.F. between the two end poles (i.e., the first carbon and the fortieth zinc) will be forty times as high as that of a single Leclanché cell. To connect the cells in this manner is called connection "in series." There are other ways of connecting elements, but as these are of importance for cautery only, we shall explain them under cautery.

Current.—As soon as the two metals are connected by a conductor or half-conductor, the two separated kinds of electricity are able to reunite again. While discharging, the electricity accumulated at the poles gets less, but it is replaced immediately by the E.M.F., so that the discharge goes on as long as the electrifying cause (in this case the chemical action) exists, or till the circuit gets broken. There exists, then, in the circuit a *continuous current*, which is generally supposed to start from the positive pole, and to pass through the conductor to the negative pole, and inside the cell from the negative metal through the exciting liquid to the positive metal, thereby forming a complete circuit.

The larger a cell and its store of chemicals is, the longer will it be able therefore to maintain a current, and the constancy of an element, i.e., the length of time for which an even strength of current can be got out of it, is in direct proportion to its size.

If we call the metal *positive* from which the current starts into the conductor; the copper, for instance, is *positive* as far as it projects above the liquid, but is *negative* as far as it is covered by the liquid, and *vice versa* with the zinc.

Resistance.—The free passage of the current depends on the nature of the conductor through which the current has to pass. We have already mentioned that the conducting capacity of various bodies varies widely. Metals are the best conductors, but even they differ much: one yard of copper wire allows ten times as much electricity to pass as one yard of German silver wire. It would be more correct to say that German silver has ten times the resistance of copper. The resistance increases with the length, ten yards of wire having twice as much resistance as five yards of the same wire. If, however, the diameter of the conductor increases, the resistance decreases accordingly. The resistance of the human body is ten times less if we apply electrodes ten inches square than if we apply electrodes one inch square only.

Up to now we have only mentioned the external resistance, that is, the resistance which the current has to overcome outside the element. The current meets, however, some resistance inside the cell, and this is called internal resistance. It depends on the conducting capacity of the exciting liquid and the size of the metal plates. If the external resistance is great, 500 or more ohms, the internal resistance of the battery can be neglected; if the external resistance is, however, as small as in a cautery burner, the internal resistance is of importance.

Polarisation.—There is another obstacle to the rapid discharge of electricity. The electric current decomposes the fluids through which it is passing; for instance, it decomposes water into hydrogen and oxygen. As soon as the current is closed, bubbles of oxygen appear on the negative, and bubbles of

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hydrogen on the positive, metal. The quantity of the produced gas is in proportion to the strength of current. In a cell consisting, for instance, of zinc, sal-ammoniac and silver, the silver becomes covered with gas bubbles very shortly after the circuit is closed, and then the cell consists only of zinc and hydrogen, which has a very much lower E.M.F. than zinc and silver. The strength of current decreases in consequence of this formation of gas, and the first consideration in constructing a cell is to prevent this action, which is called *polarisation*.

Depolarisation.—It can be achieved in different ways: either by shaking off the bubbles mechanically, or by chemical action. The positive metal is then surrounded with materials containing plenty of oxygen, which unites eagerly with the hydrogen and becomes water, annihilating thus the gas bubbles. For this reason some cells contain nitric acid or chromic acid, the Leclanché cell manganese di-oxide, etc.

The *depolarisation*, as we call this process, works perfectly in the chloride of silver or Daniell cell. Such cells are therefore called constant elements, compared with a chromic acid cell, in which the depolarisation is less perfect, and which is called inconstant, because its strength of current decreases after a short time. A Leclanché cell is constant if it is worked for short intervals only or with weak currents; but it is inconstant if it has to yield a current too strong in proportion to its size, or if it remains closed for many hours without rest.

Units.—It became necessary soon to introduce units, in order to be able to express in figures the amount of E.M.F., or the strength of current and the amount of resistance, etc. An International Congress of Electricians agreed to derive the electrical units from the measures for length, weight and time (centimetre, gramme, and second), in order to be able to compare the effects produced by electricity with those produced by other physical forces, and moreover they agreed to name the different units for E.M.F., strength of current, resistance, capacity, etc., after the physicists, who have by their great discoveries, materially developed the knowledge of electricity, such as Volta, Ampère, Ohm, Faraday, etc.

The unit of the **E.M.F.**, or potential, which has been chosen is very near the E.M.F. of a Daniell cell, and has been called **Volt.**

The unit of **resistance** is **Ohm.** It equals the resistance of a mercuric column of 1 square millimetre sectional area, and 1·06 metre length at a temperature of 32° F.

The unit of **strength of current** is called **Ampère.** It is the current which an E.M.F. of 1 volt produces in a circuit, the resistance of which is 1 ohm. 1 ampère is too much for medical purposes, and therefore its one-thousandth part, or 1 milliampère, has been adopted as unit for measures of intensity. A source of electricity with an E.M.F. of 1 volt passing through a circuit, the resistance of which amounts to 1,000 ohms, produces in it a current of 1 milliampère.

Watt is the expression for the product of volt and ampère; for instance, a 16 candle-power incandescent lamp requiring either 100 volts and 0·5 ampère, or 200 volts and 0·25 ampère, consumes 50 watts. 736 watts are equal to 1 horse-power.

In the following pages the expression "ampère hour" is sometimes used; this means a current of 1 ampère for one hour, or 2 ampères for thirty minutes, or 1 milliampère for 1,000 hours, etc.

Ohm's Law.—We have already seen in the previous statements that an E.M.F. of 1 volt produces 1 ampère in a circuit, the resistance of which is 1 ohm. If we increase the E.M.F., say, to 5 volts, we shall find that the strength of current in the circuit has increased to 5 ampères. The strength of current increases therefore in the same proportion as the E.M.F. In increasing the resistance, however, the strength of the current is diminished; 5 volts can send 1 ampère only through 5 ohms, or only ½ ampère through 10 ohms, etc. The strength of current decreases in proportion with the increase of the resistance. This can be expressed by the formula :—

$$\frac{\text{Electro-motive force}}{\text{Resistance}} = \text{Current; or shorter, } \frac{\text{E.M.F.}}{\text{R.}} = \text{C.}$$

The resistance in this case means all the different resistances which are in the circuit, the resistance in the outer circuit as well as the internal resistance of the battery. This law was discovered by Ohm, and has been named after him. It is the foundation stone of electrical measurements, and it is practically the only electrical law which has to be considered in using electricity for medical purposes. We will therefore devote a few more remarks to this subject, and quote a few examples.

1. Thirty Leclanché cells, each of which has an E.M.F. of 1·5 volt, and an internal resistance of 0·8 ohm, will, with an external resistance of 4800 ohms, yield

$$\frac{45 \text{ volts}}{(30 \times 0{\cdot}8) + 4800 \text{ ohms}} = 0{\cdot}0093 \text{ ampère, or } = 9{\cdot}3 \text{ milliampères.}$$

2. If the same battery is used for small incandescent lamps, such as are required for illuminating cavities of the body, the resistance of which varies between 8 and 25 ohms, the current with a lamp of 22 ohms resistance would be

$$\frac{45 \text{ volts}}{(30 \times 0{\cdot}8) + 22 \text{ ohms}} = 0{\cdot}978 \text{ ampère, or } = 978 \text{ milliampères.}$$

3. If the same battery is connected with a platinum burner, such as is generally used for galvanic cautery, and which has about 0·02 ohm resistance, the 30 cells will yield a current of

$$\frac{45 \text{ volts}}{(30 \times 0{\cdot}8) + 0{\cdot}02 \text{ ohm}} = 1{\cdot}8 \text{ ampère,}$$

a strength of current quite insufficient for making the platinum wire even warm, as the burners generally in use require a current of 18 ampères in order to get red hot.

4. A bichromate battery with two *large* cells, however, which have an E.M.F. of 2 volts each, and only 0·03 ohm internal resistance, will give with the same burner a current of

$$\frac{4 \text{ volts}}{(2 \times 0{\cdot}03) + 0{\cdot}02} = 50 \text{ ampères.}$$

5. With the resistance quoted in Example 1, these two large cells would, however, give only

$$\frac{4 \text{ volts}}{0{\cdot}06 + 4800 \text{ ohms}} = 0{\cdot}0008 \text{ ampère, or } = 0{\cdot}8 \text{ milliampère.}$$

This example shows why the current of a battery with 2 or 4 large cells is sufficient to heat or even to fuse platinum wires, which offer a small resistance; whereas it is too weak to be felt at all if it passes through the high resistance of the human body.

Ohm's law does not only help to find out the strength of current if the E.M.F. and resistance are known, it also enables us to find out the resistance if we know the E.M.F. and strength of current. In this case, Ohm's law reads

$$\frac{\text{E.M.F.}}{\text{Current}} = \text{Resistance.}$$

6. For instance, if the strength of current is 9 milliampères, and the E.M.F. of the cells used 41 volts, the resistance will be:

$$\frac{41 \text{ volts}}{0{\cdot}009 \text{ ampère}} = 4555{\cdot}5 \text{ ohms.}$$

Lastly, you can find out the E.M.F. if you know the resistance and strength of current. The formula then reads as follows: Strength of current × resistance = E.M.F. For instance:—

7. If the strength of current is 184·4 milliampères, and the total resistance 244 ohms, as shown in Example 2, you get

$$0{\cdot}1844 \text{ ampère} \times 244 \text{ ohms} = 44{\cdot}99 \text{ volts.}$$

Effects produced by the Electric Current.—Before closing these general remarks, we have to mention the principal effects which the current produces.

A magnetic needle is deflected from its direction towards north if a current circulates in its neighbourhood, a quality which is used to detect the presence of a current, and to measure the strength of it. A piece of steel or iron, round which a current passes, becomes magnetic, and has consequently the power to attract other pieces of iron, steel, or nickel. Fluids are decomposed by the current. If we connect two metal or carbon plates with a battery, and immerse them in water, the current will decompose the water; oxygen gas appears at the plate connected with the positive pole (anode), and hydrogen gas on the plate connected with the negative pole (kathode). If the plates are immersed in a solution of metal oxides—for instance, sulphate of copper—metallic copper will be deposited on the plate connected with the negative pole. If we send the current through the human body, at the negative electrode, potassium, sodium, hydrogen, etc., are liberated; and at the positive electrode, oxygen, chlorine, acids, etc.

If electrodes are placed on the human body, and the current is suddenly closed or broken, the muscles will contract. Flashes appear in the eyes, noises in the ears, and a peculiar taste on the tongue; the irritability of nerves gets diminished near the anode, and increased near the kathode; currents can produce anæsthesia; the circulation of the blood and the nutrition of the tissues gets stimulated, and various chemicals can be introduced into the body through the skin. This is used for cautery burners, incandescent lamps for examining cavities of the body, etc.

APPARATUS FOR GALVANISATION AND ELECTROLYSIS.

The Resistance of the Human Body varies widely. If two small metal electrodes of one centimetre diameter each are placed on the *dry* skin, the resistance will be near 100,000 ohms. If we use, however, larger electrodes, about 5 centimetres diameter, cover them with leather, and place them on the skin, after having well soaked them in warm salt water, the resistance will not be more than about 3,000 ohms, and become less, within a short time, under the influence of the current itself. If we introduce an electrode into the rectum, and place a large electrode, 8 inches diameter, on the abdomen, the resistance will be less than 200 ohms. It is principally the skin which offers the great resistance, whereas the blood, etc., conduct comparatively well. Still, we have in most cases 1,000 to 5,000 ohms resistance to deal with, and therefore a large number of cells is indispensable in order to obtain with these resistances currents varying between 1 and 50 or even more milliampères.

Which are the most suitable Cells ?—It is not my intention to enumerate all the cells which have been invented since Volta till to-day. *Any* cell can be used which is capable of yielding the desired strength of current ; but if we consider convenience, portability, etc., the number of useful cells is limited. In choosing a battery, it is a consideration whether it can be charged by the owner himself, or whether it has to be returned to the maker when exhausted.

The cells most frequently used may be classified in two groups : Cells which contain acids, and where the zincs therefore have to be taken out of the fluid after the battery has been used—Plunge Batteries ; and cells, the exciting fluid of which does not attack the zinc as long as the circuit remains open, and in which the zinc may remain immersed.

Leclanché Cells.—Let us first consider the cell which is more used than all the other cells taken together—the Leclanché cell. For galvanisation and electrolysis, there can hardly be found a cell more reliable and convenient than the Leclanché cell. It is always ready for use, and a well-constructed cell will last for two years without having to be seen to during that time. Moreover, they can be cleaned and refilled without technical aid.

Dry Leclanché Cells.—If portability has to be considered, the dry cells, which belong to the Leclanché type, too, have great advantages over the cells containing fluid, for there is no liquid to be spilled or to corrode the brass parts, and there is no glass, etc., to get broken. They can be sent charged all over the world, and are very suitable for batteries which have to be carried about frequently.

Their only disadvantage is that the cells, after being exhausted, cannot be recharged, but have to be replaced by new ones, and this makes the refilling rather expensive. On the other hand, batteries filled with *good* dry cells will certainly last for fully two years without requiring recharging, and they are less likely to require repairs than those filled with liquid, because accidents like the breaking of glasses cannot happen, so that the difference in the cost of maintaining the batteries is not as great as it appears at first sight.

Acid Cells.—As far as cleanliness and convenience are concerned, the acid cells have disadvantages compared with Leclanché cells. As they must be plunge elements, the vessels cannot be so well closed, and evaporation and spilling cannot be prevented altogether. With daily use an acid battery has to be cleaned and refilled about once in every three months. The refilling, however, may be easily performed even by the most inexperienced. As the acid batteries require less skill to be kept in order than any other battery, they are especially suitable for use in the Colonies. They have a high E.M.F., 2 volts, so that 22 acid cells are even stronger than 30 Leclanché cells.

Number of Cells.—The number of cells a battery ought to have depends on the purposes for which it is required. Specialists for eye, ear, and throat diseases, and general practitioners, will be able to obtain the strongest currents usually applied to the head with 18 to 24 Leclanché cells; that is, with 25 to 36 volts. 40 to 60 volts are necessary for diagnostic purposes, and for the treatment of nervous and paralytic diseases.

A suitable number of cells alone is not yet sufficient for a medical man; there have to be different appliances for regulating the strength of current, for interrupting, reversing, and measuring the current, and for applying it to the body. The strength of current can be regulated in two ways: either by varying the E.M.F., or by means of artificial resistances. The first mentioned method is more frequently used, and is managed with the help of the current collectors.

Current Collectors.—The current collectors help to increase or diminish the number of cells in the circuit, thus changing the E.M.F., and regulating the strength of current. They ought to be constructed so that the current is never interrupted while the number of cells is being changed, as this would give disagreeable shocks.

A number of pegs, equal to the number of cells in the battery, are arranged in a circle, so that a crank can be brought in contact with every one of these pegs. The cells are connected with these pegs; a wire leads from the first zinc to the negative terminal, another wire from the carbon of the first cell to peg 1, another wire from the carbon of the second cell to peg 2, etc., and one wire leads from the crank to the positive terminal. By turning the crank the number of cells connected with the terminals can thus be conveniently increased or diminished. In order to avoid interrupting the current, the pegs are so arranged that the crank touches the next peg before having quite left the former one.

As long, however, as the crank touches two pegs, for instance pegs 5 and 6, *at the same time*, the sixth cell is short circuited, for the current can pass from the zinc of cell 6, which is connected with the carbon of cell 5, on to peg 5, through the crank to peg 6, and from there back to the carbon of cell 6, without finding on its way any resistance worth mentioning. If this state lasts but shortly, it causes no damage, but if it lasted for any length of time, the short circuited cell would be exhausted. It is therefore important, thicker wire, which is wound so as *not* to influence the magnet, and in this way the current will divide itself so that its strength in each branch is inversely proportional to the resistance of the wire. If, for instance, the resistance of the shunt wire is chosen so that its resistance is $\frac{1}{10}$th of the resistance of that wire which makes the needle decline, only $\frac{1}{10}$th of the current will flow through the latter wire and $\frac{9}{10}$ths through the shunt wire. The magnet, therefore, will be influenced by only $\frac{1}{10}$th of the current which actually passes through the galvanometer, and consequently the numbers indicated on the dial have to be multiplied by 10 in order to find the real strength of the current.

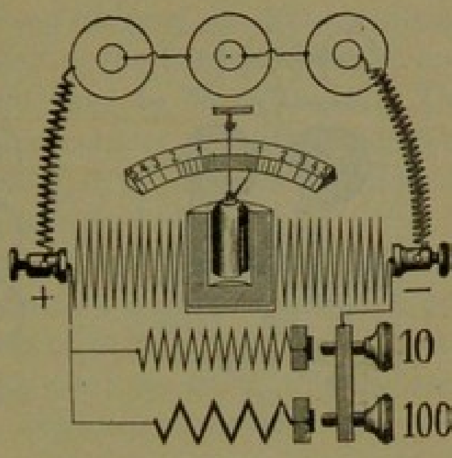

Fig. 5.

Voltmeter.—If the resistance of a milliampèremeter has been increased up to 1,000 ohms, it can be used for measuring E.M.F.'s; for as a current of 1 volt produces 1 M.A. in 1,000 ohms, the number of milliampères is equal to the number of volts *as long as the resistance in the circuit is* 1,000 *ohms*. The body of a patient, or any other unknown resistance, must therefore *not* be in the circuit while the E.M.F. of the cells is being measured.

If the strength of current obtained through a patient is known, and the E.M.F. of the cells which has been used to produce the above strength has been measured in volts in the way just mentioned, the resistance of the patient can be found out with the formula :—

$$\frac{\text{E.M.F.}}{\text{Current}} = \text{Resistance.}$$

(See Example 6, page 6.)

Current Reversers, Current Combiners.—It is important for most physicians to possess an arrangement which makes it possible suddenly to close or interrupt the current, or else to connect with the negative pole the electrode hitherto connected with the positive pole, and *vice versa*. These sudden changes produce contractions of the muscles, the intensity of which depends on the strength of the current, and the sensitiveness of the muscle. They are therefore important for diagnosis. To interrupt and to reverse the current can be managed with one single instrument, of which we add a diagram. The negative pole of the battery is connected with W and N, the positive pole with the metal piece between these two. While the crank points towards N (normal), as the drawing shows, the crank on the right-hand side is connected with the negative pole, and the crank on the left-hand side with the positive pole. By moving the cranks slightly to the left, so that they rest on W and N, both cranks are in contact with the negative pole ; consequently there is no current at all ; but if we move the cranks further, so that they point towards W, the left-hand crank is connected with the negative, and the right-hand crank with the positive pole.

Current Alternator and Combiner.—In order to be able to change the

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continuous or the faradic current without having to connect the electrodes with other terminals, and in order to be able to apply at the same time

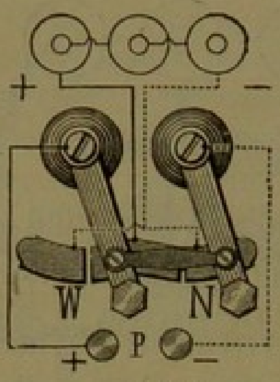

Fig. 6.

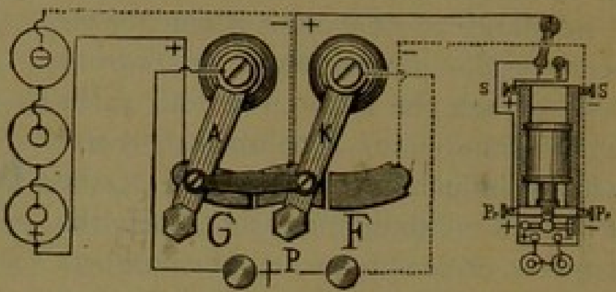

Fig. 7.

continuous and faradic currents combined, Dr. de Watteville has suggested a convenient apparatus, of which we add a diagram, too (Fig. 7). While the cranks point to G, the galvanic current is connected with the terminals; while the cranks point to F, the faradic current is connected with the terminals; and while they stand half way (G F), the galvanic and faradic currents are connected with each other in series, i.e., the continuous current has to pass through the bobbin of the induction coil and the patient, and the faradic current has to pass through the patient and all the cells of the continuous current battery. Thus both currents pass through the patient at the same time.

Cords and Handles.—Two connecting cords of suitable length, covered with some insulating material, are necessary for conducting the current from the battery to the patient. Insulated copper wire, which is bare for half an inch at both ends, is sufficient; but, on account of the greater flexibility, cords made of very fine wires, terminating on both ends in short and thick wires, are mostly used. They are to be fastened in the handles and in the terminals of the battery. The handles are provided with a terminal for the reception of a connecting cord, and with a thread fitting the electrodes. Many handles are provided with a trigger for making or breaking the current.

Electrodes.—There exists a great variety of electrodes: buttons, round and square plates of all dimensions, made of tin, aluminium, or carbon, and covered with flannel, which may be screwed on to the handles, or have a terminal to receive the cords direct. Brushes of fine metal wire are used for exciting the muscles and nerves of the skin; wheel electrodes for conveniently changing the place of application, and for combining massage and electricity. Needles are employed for destroying hairs, nævi, tumours, etc. All these electrodes become polarised, and all electrodes made of common metal are subject to oxidation; they ought therefore not to be placed on the mucous membrane unless they are connected with the negative pole. To be used with the positive pole, the electrodes for electrolysis should be of carbon or platinum, unless it is desired to introduce zinc or copper, etc., oxides into the patient's body.

the current collector, the wires being mostly well protected and all the invisible connections being soldered. The pegs of the current collector, as well as the current reverser, are liable to become oxidised, and have to be cleaned occasionally with fine emery paper ; dust between the pegs should be removed with a brush. The screws which keep the crank of the current collector and reverser on their axes may become loose and have to be tightened. The handles with an interrupter may fail to make contact through oxidation, or through the spring being loose. *Cords, handles, or wet electrodes ought never to be placed on the current collector, as they may cause short circuit.*

We have yet to mention the faults which are caused by false application. Some people believe in being able to test a battery if they touch with dry fingers the varnished terminals, or else the ends of the connecting cords. Of course, in both cases, the current is exceedingly weak on account of the very high resistance, and can hardly be felt even by experienced persons. Currents of a few milliampères are felt by most patients only if they are suddenly closed or broken, and whenever a battery is tested, the only proper way to do it is to soak the electrodes in warm salt water, and to apply them as in real use.

Current supplied from Dynamos.—The apparatus required for utilising the currents supplied for lighting houses, for galvanisation and electrolysis, are explained on pages 30–33.

BICHROMATE BATTERIES FOR CAUTERY, SPARK COILS &c., INSTRUMENTS FOR CAUTERY.

A strong current is required for rendering platinum wires of the thickness needed for cautery operations incandescent, for most of the burners require 10 to 18 ampères (10,000 to 18,000 milliampères), and in order to keep a current of this strength constant, even for one minute only, *large* cells are absolutely necessary. On the other hand, platinum burners have a very low resistance—burner, handles and cords together about 0·06 ohm. If the cells have a small internal resistance too, for instance, 0·06 ohm per cell, two cells of 1·5 volt each are already sufficient for producing the necessary strength of current with these resistances, for

$$\frac{3 \text{ volts}}{0{\cdot}06 + 0{\cdot}12 \text{ ohm}} = 16{\cdot}6 \text{ ampères.}$$

The requirements for cautery are therefore totally different from those for galvanisation and electrolysis. In the latter case many cells are needed to force even a weak current through the high resistance of the human body. The cells, however, can be small, because the strongest current used rarely exceeds 100 milliampères. For cautery, the E.M.F. of two cells is already sufficient on account of the very small external resistance, but the cells have to be of large size, as the current required must be more than 1,000 times as strong as the currents generally used for galvanisation.

Connection of Cells.—Up to now only *one* method of arranging the cells has been mentioned, the connection "*in series*," for high external resistances.

The cells can, however, be arranged so that the carbon of the first cell is connected with the carbon of the second, and the zinc of the first with the zinc of the second cell, etc., and this is called connecting the cells "*parallel.*" The E.M.F. *does not* increase thereby, no matter how many cells are connected in this way, but the surface of the metal or carbon plates increases, and consequently the internal resistance diminishes, with each additional cell.

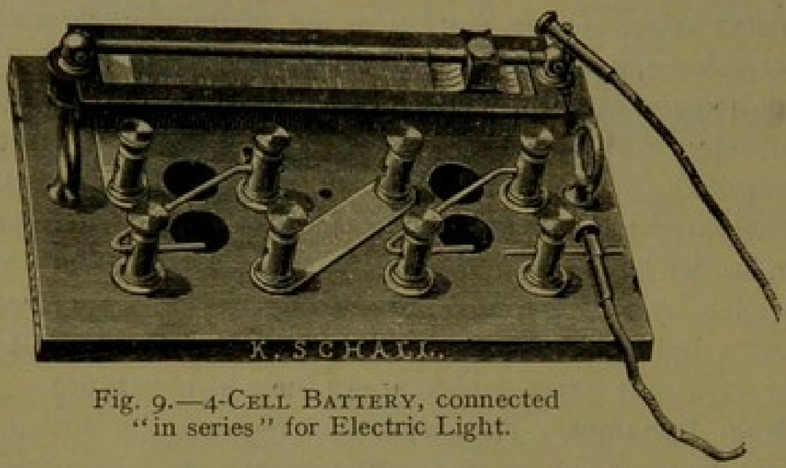

Fig. 9.—4-Cell Battery, connected "in series" for Electric Light.

Two cells connected in this way are equal to one single cell of double size, and this is an advantage for galvanic cautery, for by lessening the internal resistance we enable it to yield, with small external resistance, a stronger current. Moreover, we double the constancy, for large plates do not polarise as quickly as small ones do, and the capacity in ampère hours of two cells connected parallel, is twice as large as the capacity of two cells connected in series. There are yet some other combinations possible. The two diagrams show the two different ways of connecting the 4 cells of a cautery battery. As already mentioned, the E.M.F. of two cells is sufficient to produce with so small a resistance the necessary strength of current; for wire loops, however, 3 to 4 cells are necessary, and the batteries most frequently used for cautery have 4 cells. If batteries are constructed with more than 4 cells, this is partly done in order to be able to connect the cells parallel in the way above mentioned, and partly to use them for surgical lamps or spark coils as well.

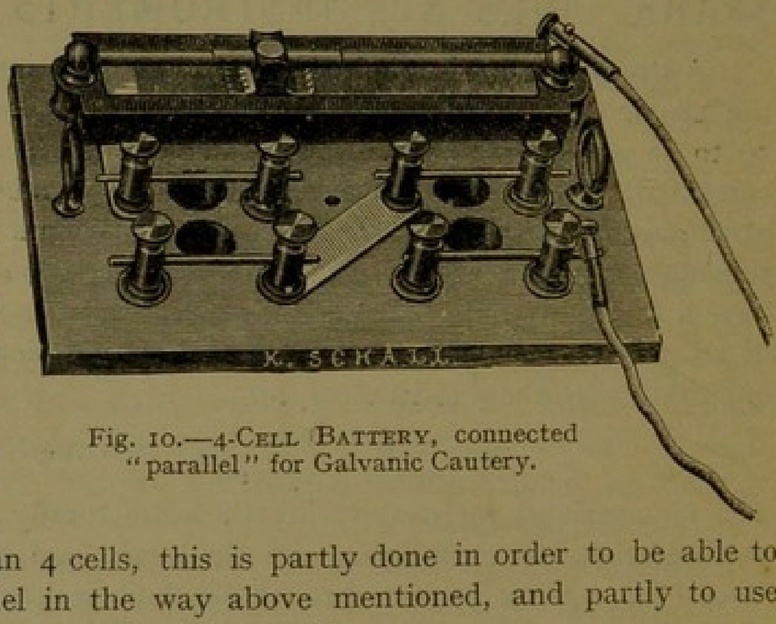

Fig. 10.—4-Cell Battery, connected "parallel" for Galvanic Cautery.

Which are the most suitable Elements? Bichromate Cells.—There is no great variety of cells with a sufficiently small internal resistance. Bichromate elements are most frequently used for cautery. The chief objection to them is their want of constancy. If, however, the cells are not made too small, they are sufficiently constant for all cautery operations; for a cell of 3 by $5\frac{1}{2}$ by $6\frac{1}{2}$ inches will keep a burner requiring 18 ampères incandescent for about twenty minutes. They are powerful, their E.M.F. being 2 volts, and they are easily put in action. They can quickly be re-filled, and can be easily kept in order by anybody, so that they are very suitable for medical men who do not wish to be dependent on the electrician's help. The zincs in bichromate batteries should be well amalgamated, and for this reason the zincs in our batteries consist of an alloy of 10 parts of zinc and 1 part of mercury, and moreover the acid contains some mercury too.

Rheostats for Batteries.—A rheostat is most convenient with every battery for regulating the strength of current for cautery. A bichromate battery, without a rheostat, cannot be plunged in deeper than is necessary for just making the wire red hot; on account of polarisation, etc., the current diminishes pretty quickly, and the battery ought to be gradually immersed deeper, in order to keep the burner at the same temperature. A rheostat, however, enables you to immerse the battery completely from the beginning, and to reduce the current by inserting an artificial resistance. As the cells have a larger surface, the strength of current remains constant for a much longer time, so that the operator can give his whole attention to the patient. Rheostats are quite indispensable for accumulators, as without them all burners would be destroyed at once.

It is best to begin by inserting the whole resistance, and after the circuit has been closed, to diminish it gradually, by moving the spring, until the platinum has reached the proper temperature for operations.

Cords and Burners.—Connecting cords for cautery ought to be thick, because if thin they would either become too warm, or else weaken the current considerably.

The platinum burners are soldered on to copper wires of different lengths, suitable for the nose, larynx, ear, etc. The copper wires are insulated from one another with silk, which is wound round them in the shape of an 8, but where the copper touches the platinum they grow so warm that the silk would become black, and therefore they are for a short distance insulated with shellac varnish only.

Faults.—In order to rectify any fault, it is necessary with these batteries, too, to find the seat of the defect, and it will then be easy to remove it. The burners are apt to fail because the two copper wires may touch at the end near the platinum, so that the current can pass directly from one copper wire into the other without reaching the platinum at all. This is a frequent fault, and can be recognized by the copper wires getting very hot. They should be separated with a finger nail so far that you can see between them all along. If the platinum of a burner has been fused by too strong a current, a new platinum wire must be soldered on. If the battery fails, in spite of the burner being all right, you should take off the handle, and let the two ends of the connecting cords touch each other. If they yield a strong, crackling spark, the fault is in the handle—the place of contact is oxidised, and has to be cleaned with fine emery paper; but if the connecting cords yield but a weak spark, or none at all, the fault lies further back. A weak spark shows that the connections, etc., are in order, but that the battery is too weak. With bichromate batteries, this fault can be easily removed. If the solution has turned green, it is exhausted, and the battery must be cleaned and refilled. If the fluid is still red or brown, a cell has been short circuited by carbon and zinc touching one another, *or else the zincs are covered with a coating of oxide*, which can be best removed if they are screwed off and cleaned under a water tap with an old nail-brush, until the bright zinc reappears. If there is no spark at all, although the battery can hardly be exhausted, you should remove the connecting cords and see whether the cells yield a spark, if the end terminals are connected with a short wire; if this gives a spark, the rheostat or the cords are at fault. A fault in the cords is indicated by excessive flexibility near the broken place. If, however, there is no spark, either the connection amongst the cells is at fault, or the arrangement of the cells is incomplete; this is found out if each element is tested singly at first, and afterwards groups of two or more cells; or the battery is exhausted, and you have to clean and re-charge it as already stated.

For apparatus required to control the current supplied for lighting houses, for cautery or spark coils, see pages 32-35.

ACCUMULATORS.

The Advantages and Disadvantages of Accumulators or Secondary Batteries, compared with primary galvanic cells, are as follows. Their E.M.F. (2 volts) is higher and their internal resistance lower than in all other cells, and for this reason they produce a remarkably powerful current, which, being completely depolarised, is perfectly constant until the accumulator is nearly exhausted. The acid is not used up, and therefore has not to be renewed except to make up for the loss by evaporation. Accumulators are specially suitable for spark coils. They are convenient for motors, cautery burners, and small lamps.

Their Disadvantages are, that they require a more scientific and careful treatment, more frequent attention, and more time for being recharged than primary batteries do; that they are more easily damaged, and that for repairs they have to be returned to the manufacturer.

They consist of lead plates immersed in diluted sulphuric acid; 136 volumes of *pure* strong sulphuric acid are mixed with 1,000 volumes of distilled water. The mixture ought to have a specific gravity of 1·15, or 36 Baumé.

Chemical Process.—The sulphuric acid causes a thin layer of lead to change into sulphate ot lead. An electrical current sent through such a cell produces electrolysis; oxygen appears on the plates connected with the + pole, and converts the sulphate of lead into peroxide of lead. On the plates connected with the negative pole, hydrogen appears, and reduces the sulphate of lead into a porous, spongy mass of metallic lead. If the action of the current lasts long enough, the plates connected with the positive pole are converted entirely into peroxide of lead, and the negative plates into spongy metallic lead. Ultimately, oxygen and hydrogen, finding nothing left to act upon, escape as gas, and it would be waste to let the current act any longer.

In this way, chemical changes have been effected by means of an electrical current. We have two different plates now, and the chemical action of the acid produces an E.M.F. If the plates are connected by means of a conductor, an electrical current is started *in opposite direction* of the charging current. During the discharge, the chemical process gets reversed; the plates which had been covered with oxygen during the charging become, during the discharge, covered with hydrogen, which combines with the oxygen contained in the peroxide, and produces sulphate of lead. The oxygen generated on the negative plates combines with the acid, and changes the metallic lead also into sulphate of lead. As soon as both plates have returned to their original condition, all difference between them has ceased to exist, the E.M.F. stops, and with it the discharging current. The acid too has regained its original strength, and thus the process can be repeated any number of times.

The only difference between primary cells and accumulators is, that primary cells have to be charged with chemicals which have to be prepared beforehand, and which, when used up, have to be removed and replaced by a fresh supply. In the accumulators, it is the action of an electrical current which generates the chemicals required to produce the E.M.F., and a current will regenerate them as often as desired, without a renewal of acid.

Capacity.—The capacity of the accumulators, i.e., the quantity of electrical energy which they can store, in form of chemicals, is in direct proportion to the quantity of lead which they contain. Moreover, the current by which an accumulator is charged or discharged, has to be in proportion to its capacity. If the density of current (the number of milliampères per square centimetre) is too great, the oxygen cannot change the sulphate quickly enough, and therefore part of it escapes as gas unutilised. In discharging too heavy a current, the cell will become polarised in consequence of the same difficulty. There is no fixed rule how many ampères may be used for charging or discharging accumulators; this depends on the capacity of the accumulators, and on the special construction of the plates. As a general rule, the charging current ought not to exceed one-fifth, and the discharging current one-fourth of the capacity; that is to say, a 20-ampère hour accumulator should be charged with not more than 4 ampères, and discharged with not more than 5 ampères. Some kinds are made specially so that they can stand a considerably higher rate of discharge. If the strength of the discharging current is exceeded, the efficiency decreases, and instead of 20, only 15 or 10 ampère hours will be obtained from the accumulator. In extreme cases, when an accumulator is short circuited, the plates are destroyed by crumbling up.

Charged Accumulators have the tendency to Discharge slowly without being connected with a conductor, in consequence of defects in the insulation, and also on account of impurities of the acid. Sulphate of lead is therefore gradually being formed even while the accumulators are standing unused. The sulphate, when freshly formed, is fine and soluble, and can be changed into peroxide by means of a current. After some time, however, it assumes a crystalline form, becomes insoluble, and cannot then be changed any more into peroxide by the current. The capacity of the accumulators decreases therefore in proportion to the increase of the sulphate of lead crystals. Plates which have become defective in this way have to be replaced by new ones.

The following rules can be derived from the above:—

(1) The capacity of the cells must be in direct proportion to the discharging current. If, for instance, the accumulators are intended for working

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spark coils or cautery burners, they should be of a size which can discharge up to 18 ampères without becoming damaged. Cells which are too small for the work required of them will soon be destroyed.

(2) Short circuit must be avoided. Terminals must not be connected with a wire in order to see a spark, as it tends to destroy the plates. The connecting cords should be attached to the spark coil or cautery handle *before* the other ends are connected with the accumulator terminals.

(3) In charging, the + pole of the changing current has to be connected with the + pole of the accumulator. The latter is usually painted red. If by mistake the wrong poles are connected, the accumulators discharge rapidly and are destroyed.

(4) Accumulators must be re-charged frequently, *whether used or not.* If this is neglected their capacity is diminished, on account of the formation of insoluble sulphate of lead. This explains why accumulators give every satisfaction when used in lighting stations, where they are re-charged daily, or at least once a week, but many medical men are under the false impression that the accumulators need no re-charging so long as they still yield a current. The smaller the accumulators, the more frequently have they to be re-charged. Accumulators of 20-ampère hour capacity and more, ought to be re-charged *at least once a month* to keep them in good condition.

The charging of the accumulators is best done by dynamos. Where the *continuous* current is laid on for illuminating purposes, medical men can easily do it themselves. One or several incandescent lamps are inserted in the circuit. By means of pole-finding paper, the polarity is ascertained (the negative pole makes a red stain on the moist paper), and the charging is continued till gas bubbles appear, the acid turns milky and makes a hissing noise. A 20-ampère hour accumulator will take about twenty hours for charging with a 32 candle-power lamp on a 100-volt circuit. If four lamps of this same candle power are connected parallel, the charging will be finished in five hours.

The plates *must be fully covered by the acid,* and if the latter has partly evaporated on account of too prolonged charging, or for some other reason, it has to be brought to its original level by some fresh acid.

A Voltmeter is very convenient for controlling accumulators. While in good condition, each cell gives fully 2 volts. If the E.M.F. falls to 1·8 volt per cell, the charge is nearly exhausted, *and the accumulator should be re-charged at once.*

BATTERIES AND INSTRUMENTS FOR ELECTRIC LIGHT.

Advantages of the Electric Light.—The electric light is white and intense, it develops scarcely any heat, and the lamps need not be held upright, as oil lamps, for instance; they can be used in any position and can be brought close to the object which has to be examined. Moreover, the doctor is independent of the focal length of a reflecting mirror. These facts help to make incandescent lamps most useful for medical purposes, in the consulting room, but more especially in the patient's house, where often a wax candle is the only other available light which might be used. The electric light is, moreover, the only kind of light which can be introduced into the human body, either for examinations of cavities like the bladder, or to make part of the body transparent (antrum) for diagnostic purposes.

Strength of Current.—The filaments of the surgical lamp require a current of 0·3 to 0·7 ampères to become white hot, and the resistance of the lamp is chosen so that 4 to 12 volts can produce this current. The size of the cells employed will depend on the time for which the light is required.

The most suitable Cells are 2 to 4 accumulators or bichromate cells, or 3 to 8 Leclanché cells, connected in series. Accumulators are smaller than any other battery of similar power, but to keep them in good order they must be re-charged regularly about once in every four weeks, and for this reason they are to be recommended only where a continuous current from a dynamo is within convenient reach for re-charging. Full particulars will be found on pages 18–20.

The Leclanché cells, dry or liquid, if not chosen too small, will be found reliable for one or two years, without requiring any attention for re-charging during this time. The liquid cells can be re-charged; the dry cells have to be replaced by new ones, but there is no danger of breaking or spilling with the latter.

The current from the main cannot be used directly, because there is no room for a filament of sufficient resistance in the small bulbs; but the voltage may be reduced either by transformers or rheostats. Full particulars about these will be found on page 35.

Rheostats are most convenient, and the small expense of obtaining one will be made up in a short time, because fewer lamps will be destroyed by using them. The rheostat had best be fixed on the battery, as in this way it may be used for several instruments.

The amount of light which a lamp can yield may not be increased to any extent by increasing the strength of current, without damaging the lamp. The carbon filament should be a little more than yellow. If this degree of incandescence is exceeded, the lamp can certainly give twice as much light as under normal circumstances, but its life is considerably shortened, as the filament evaporates by being over-heated. If the current which the lamp requires is not known, the whole resistance of the rheostat should be inserted, and the current can then be increased by diminishing the resistance until white heat is obtained.

Faults.—If the instrument fails, examine first of all the lamp. The lamps are provided with an arrangement allowing them to be exchanged easily—in most cases they are fitted with a screw, *which has to be well screwed home.* The lamps may become loosened by shaking, heating, etc.; when the light fails, this ought to be seen to first. The carbon filament may be burned through, and this frequently shows itself by the glass looking grey. In this case the lamp has to be replaced by a new one. But if the lamp and its connection with the instrument are in good order, and still there is no light, the fault is likely to be in the battery, and may be found out in the way mentioned already under galvanic cautery; for experience shows that, with the exception of the lamps, the illuminating instrument itself is hardly ever in want of repair. The sparks obtained from batteries for the electric light are not nearly as strong as those yielded by the cautery batteries, and therefore it requires more attention, especially in daylight, to find out whether the battery gives a spark or not.

FARADISATION.

The genius of Faraday taught the world another way of producing electricity. He found out that in a closed circuit a current is induced as often as a magnet is approached to this conductor, or withdrawn from it, or as often as a current is closed or interrupted in the neighbourhood of the closed circuit. This discovery was the first step towards producing electricity by mechanical power—towards the dynamo, telephone, spark coil, and all the marvellous acquisitions of the last fifty years.

Origin of the Induced Currents.—If the two ends of a wire are connected with a sensitive galvanometer, and a magnet is approached to the wire, the needle of the galvanometer declines *as long as the magnet is approaching*, and returns to **0** if we cease to change the distance between wire and magnet. If we *withdraw* the magnet, the needle declines again, *but in the opposite direction.*

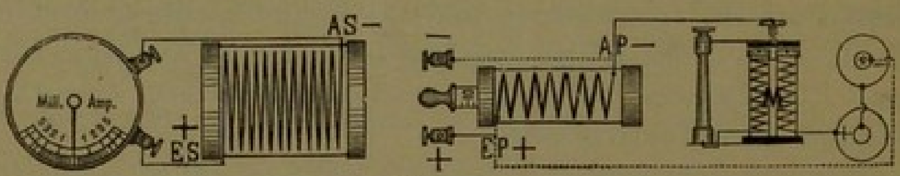

Fig. 11.

If in the neighbourhood of the closed conductor a second wire is drawn parallel to the first one, and the ends of this second wire are connected with a galvanic cell, the needle deflects the moment the circuit is closed, although there is no connection whatever between the two wires; but it returns to **0** immediately afterwards, and remains there, although the galvanic current continues to circulate in the second wire. If we diminish or interrupt the current, the needle deflects again, but in the *opposite direction*. This shows that the approaching and the withdrawing of a magnet, or the making and the breaking of a current in a conductor close by, induces currents in a closed circuit, which, however, are of very short duration only, and which pass in opposite directions.

Alternating Currents.—The currents induced by *closing* a galvanic current pass in the direction *opposite* to that of the inducing current; the currents induced by *breaking* the inducing current pass in the *same* direction as the inducing current. If we make and break the inducing current very often consecutively, we induce each time a momentary current in another conductor;

but the directions of these induced currents keep changing, and for this reason we call them *alternating* currents, in contrast to those currents which keep their polarity.

Wagner's Hammer.—Wagner's hammer (see diagram, page 26) is most frequently used for rapidly making and breaking the current. The current passes through the electro-magnet, through the hammer, the contact screw, and back to the battery ; or else it can be made to pass from the contact screw through the inducing wire, and then back to the battery. As soon as this arrangement is connected with a cell, the electro-magnet becomes magnetic and attracts the hammer, which consequently leaves the platinum point of the contact screw. This, however, interrupts the current, the electro-magnet ceases to be magnetic, and a spring causes the hammer to fly back ; as soon as it touches the platinum point again, the current is closed once more and the hammer attracted, and this play lasts as long as the apparatus is connected with a cell giving a current.

Self-Induction. Extra Currents.—The wire through which the inducing current passes is called the *primary* wire, and the wire in which currents are induced is called the *secondary* wire ; the induced current is called the *secondary* current. For various reasons we do not draw the primary and secondary wires in a straight line, but wind them in spirals on cylinders of ebonite, etc., which are made of such sizes that the primary coil can be pushed into the secondary coil. In a spiral each turn of the wire is parallel with the previous and following turns of the same spiral ; and a current which passes through a turn of the spiral must have, therefore, an inducing influence too on the other turns close by. This effect of the different turns of the same spiral on one another is called *self-induction*, and the current thus induced is called the *extra current*. If the current is made, the extra current, too, has an opposite direction to the inducing current, and thereby *retards and weakens* the inducing current, and consequently the secondary current, too ; but if the inducing current is interrupted, the extra current flows in the *same direction* as the inducing current, and *increases* thereby the latter current very considerably, and consequently the secondary current, too. The shocks which are induced by making and breaking the inducing current are, therefore, of very unequal strength ; those induced by breaking the inducing current predominate very much, and the signs + and − which are near the terminals of some induction coils are intended to show the direction of the currents induced by *breaking* the inducing current. The signs would have no meaning if the currents induced by making and breaking the inducing current had an equal strength, as they follow one another in opposite directions.

Primary Currents.—If we connect one or two galvanic cells with a Wagner's hammer, which is provided with a small electro-magnet only, and connect the cells by means of two further wires with two electrodes, which we hold in our hands, we shall not feel the making or breaking of the current. But if the current has to pass a primary coil with several hundred turns of wire besides the Wagner's hammer, each breaking of the current gives us a decided

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shock, the strength of which, amongst other things, depends upon the number of turns of the coil; this shock is caused by the extra current. This is the *primary* current, which we obtain from medical induction apparatus; it is an *intermittent galvanic current*, very considerably increased by the extra current, but it is *not an alternating current.*

Iron Core.—The inducing effect of a current is considerably increased by letting it act simultaneously with a magnet, and this can be arranged easily if the primary wire is wound round an iron core. The iron core should consist of a bundle of soft iron wires, as these take and lose magnetism much quicker than solid iron. In this way two powers act inducing in the same direction and at the same time, the making and breaking of the inducing current, and the sudden appearance and disappearance of a magnetic field.

E.M.F. of the Induced Current.—The E.M.F. of the induced current depends (1) On the number of turns of wire which a coil has; the more turns the higher the E.M.F. (2) On the strength of the inducing currents; the stronger the latter, the higher the E.M.F. of the induced currents. (3) On the presence or absence of an electro-magnet; its presence increases the E.M.F. of the induced current very materially. (4) On the suddenness of the break of the inducing current. Ultimately the E.M.F. of the secondary current depends on the distance between the secondary and primary coils.

Strength of the Induced Current.—The strength of the induced current depends, too, on Ohm's law. If, for instance, an induced current has 70 volts, and the resistance of the secondary coil is 610 ohms, and the resistance of the patient 2,300 ohms, the strength of the current would be

$$\frac{70 \text{ volts}}{610 + 2{,}300 \text{ ohms}} = 0{\cdot}024 \text{ ampères} = 24 \text{ milliampères.}$$

Chemical Action and Physiological Effect of the Induced Currrent.—The chemical action of faradic currents is small, principally on account of their very short duration, and moreover because they are alternating, so that each following impulse partly neutralises the effect of the preceding impulse. The physiological effect of these suddenly appearing and disappearing currents on the human body, however, is intense, the muscles contract each time the current is made, and much more so when it is broken; so that the muscles can be excited with these currents to a great extent.

Differences in the Effects produced by Primary and Secondary Currents.—The effect produced by the secondary current depends a great deal on the diameter of the wire which is used. Very fine wires (0·1 millimetre, or finer) produce a pricking local pain, but not strong muscular contractions; if we increase the diameter of the wire, the contractions become more powerful; if the secondary coils are wound with thick wire, they produce the same effects as a primary current, i.e., less local pain, but powerful contractions of the muscles near the electrodes, or even in the whole body. The primary, or the secondary current produced in a coil with thick wire, is frequently applied if the deeper lying organs, such as, for instance, the bowels, etc., are to be treated, whereas the secondary current produced by a coil with fine wire is chiefly used for the treatment of muscles and nerves which are near to the skin. This is the practical difference between primary and secondary currents. It is no doubt only due to the great difference in the resistance of the coils and in the E.M.F., but it is impossible to draw a sharp line between them, and to define accurately in what cases the one, and in what cases the other, should be applied. For the electric bath only the primary current, or a secondary coil with thick wire, can be used.

How to Regulate the Primary Currents.—The E.M.F. of the primary current can be regulated in different ways : the simplest method is to regulate the E.M.F. by pushing the iron core in and out. The primary current is weakest if the iron core is drawn out, and becomes stronger the more it is pushed in. Instead of drawing the iron core out, a damper in the shape of a brass tube can be slipped over it with the same effect. If the iron core is entirely covered with the tube, its inducing power ceases to act, but the E.M.F. increases the more the brass tube is withdrawn. The position of the secondary coil has *no* influence on the strength of the *primary* current.

How to Regulate the Secondary Current.—The secondary coil is generally constructed with a large number of turns of wire, about 1,000 to 5,000 turns, for in most cases it is desired to obtain a high E.M.F. The strength of the

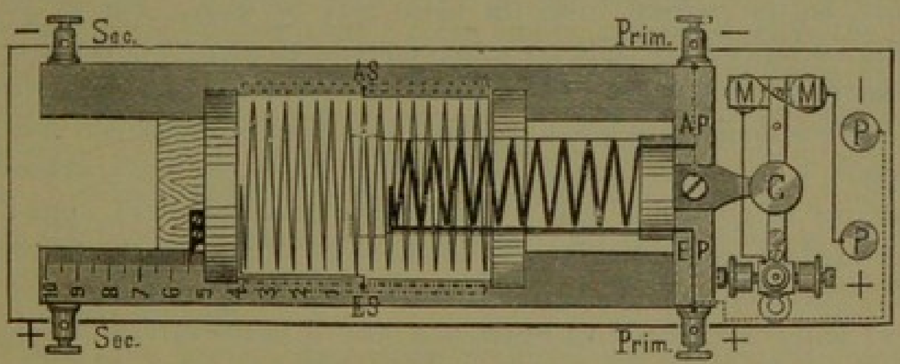

Fig. 12.

secondary current can be regulated in different ways. If the apparatus has a small primary coil, it is sufficient for all purposes of treatment to regulate the strength of the secondary current, merely by pushing the iron core in and out, for a current which is hardly to be felt when the iron core is drawn out can be increased quite gradually to painful strength by pushing it home. The more complete coils are so arranged that the distance between the primary and secondary coil can be easily changed. In this case the secondary coil slides on a sledge, and can be pushed over the primary coil, or be drawn away from it, an arrangement which allows an exceedingly fine regulation of the current. These sledge coils are preferable for diagnostic and for physiological purposes.

Rapidity of Interruptions.—The Wagner hammer of an induction apparatus can be regulated within certain limits, so that the interruptions follow one another slower or quicker. The sooner the hammer meets the platinum point again after having been drawn away from the electro-magnet by the force of

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a spring, the sooner the current is closed and the hammer attracted again. The further we screw this contact screw home, the quicker will be the vibrations; but if we screw it too tightly, the hammer has no room for moving any more, and ceases to work. The more we unscrew the contact screw, the slower will the interruptions follow one another; but we must not unscrew it too far, as the hammer must make good contact with the platinum point in flying back, else it would also cease to vibrate. In order to make the interruptions even slower, the hammer can be lengthened with a bar, on which an aluminium ball can be raised or lowered. The longer this pendulum is, the slower are the interruptions. Slow interruptions produce more powerful and painful contractions than quick ones. If the number of interruptions is very great, anæsthesia can be produced, and special apparatus have been made for obtaining this result.

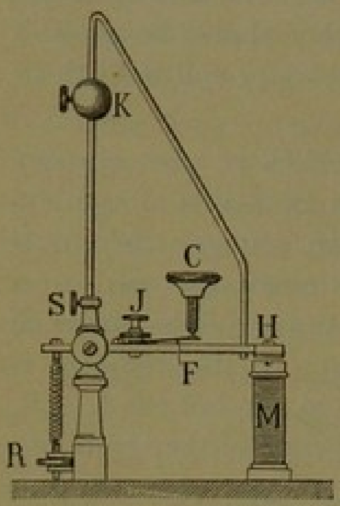

Fig. 13.

What are the most suitable Cells ?—Faradic batteries require a current of 0·3 to 0·8 ampères, and 1·5 to 3 volts. Leclanché cells, bichromate cells, accumulators, or the current from the main may be used. For all portable batteries, the Leclanché dry cells are most convenient, and for this reason they have superseded all the other cells. Good cells of this kind are sufficiently constant; there is no glass to break, no fluid to spill and damage coil or clothes; and the repairs, which were formerly so frequent, have practically ceased since the introduction of good dry cells. Bichromate cells have still some advantages in out-of-the-way places like the Colonies, because they can so easily be re-charged. The continuous current from the main may be used if an incandescent lamp is inserted as resistance, and a shunt arranged across the interrupter. Further particulars of this will be found on subsequent pages.

Faults.—If an induction coil fails, you should see first whether the element is exhausted. If you are sure that the cell is all right and gives the necessary current, you should see whether the interrupter is in order. The interrupter is the most delicate part of the induction coil, and therefore you should be careful not to interfere with the contact screw if it is not strictly necessary; frequently apparatus which were in good order have been spoiled by playing with this screw. The interrupter does not always start of its own account, and has to be put in vibration by being slightly touched with the finger. The hammer should be arranged so that its distance from the electro-magnet is about the 16th part of an inch, and the platinum point of the contact screw should just touch it. If an interrupter has not the proper distance from the electro-magnet, it has to be carefully bent till it keeps the correct distance. The spark on the interrupter attracts dust, and the little platinum sheet should be cleaned occasionally with fine emery paper. Oil should on no account be allowed on the interrupter.

If the apparatus fails, although cell and interrupter are in order, *see* *whether the connecting cords* are in order. We should like to repeat here, that it is of no use to test an apparatus by touching the terminals or the connecting cords with two fingers. An apparatus can only be tested with well soaked and properly connected electrodes.

Faradimeters.—For more than twenty years there has been a desire for some method by means of which the faradic current can be measured like a continuous current. Galvanometers are not satisfactory for this purpose for two reasons: many of the instruments which are capable of measuring the alternating currents (for instance, the "hot wire" galvanometers) cannot yet be made so sensitive that they would indicate a few milliampères. The second, and more important reason, is that galvanometers cannot be used unless all the interrupters of the coils vibrate at a fairly rapid rate, because a galvanometer will register less if there are only 5 interruptions per second than if there are about 20 interruptions in the same time, in spite of the fact that the current may be of exactly the same strength in both cases.

In 1903, Dr. Leduc suggested to use a continuous current with an interrupter (or reverser) worked by an electric motor, for testing the reaction of muscles, and for treatment with the interrupted current. The interrupter or reverser is fixed on the axis of the motor; it is in the circuit of a galvanic battery, and a milliampère meter is also in the circuit. By means of the latter the current flowing through the patient can be measured while the interrupter is at rest; when it is started, the galvanometer will indicate less, and the difference between the two readings can be used to find out the duration of the current. If the galvanometer indicates, for instance, one-fifth of its former reading, it shows that the current is closed for one-fifth, and "off" for four-fifths of the time of a period or revolution. The proportion between the time it is "on" to the time it is "off" can be varied by altering the position of one of the two brushes.

It has been proved that more powerful contractions of muscles, with less pain, are obtained with short contacts and long intervals with no current, i.e., if the brushes are so adjusted that the time during which the current is closed is only about one-tenth of the time during which the current is "off." The number of periods or interruptions per minute can be adjusted by altering the speed of the motor. The E.M.F. used can be regulated by varying the number of cells in the circuit. By means of such apparatus, anæsthesia can also be produced, as has recently been shown by Dr. Leduc. More particulars will be found in "Medical Electrology and Radiology," October, 1904.

These phenomena have been further investigated by Drs. Lewis Jones and E. R. Morton, who speak highly of the advantages of such currents over those of a faradic coil.

APPARATUS FOR USING THE CURRENT FROM THE MAIN.

The electric current for lighting houses is now available in all towns, and even in many rural districts. It is obviously much more convenient to obtain a current of perfect constancy delivered into one's house ready made, by merely turning a switch, than to have to generate it in primary batteries or to store it in accumulators. The transformers or rheostats controlling the current require no charging with corrosive liquids ; most of them are not even subject to any wear and tear, and in consequence they are not liable to get out of order. There are already over 3,000 of such switchboards for medical purposes in daily use, some of them since twenty-one years, and the advantages are so great that I need not waste any more words about this.

There exist two kinds of current which may be used for lighting houses, viz., the continuous or the alternating current.

Continuous Current.—In some towns the continuous or low tension current is supplied. The E.M.F. used in the mains in the street is not higher than that which is being used in the houses, and varies from 100 to 250 volts in different towns. Heavy copper cables are required to distribute such a low tension current, and it is therefore suitable only for thickly populated districts, and for comparatively short distances, not exceeding one and a half miles.

The continuous current is suitable for every purpose for which electricity may be employed in medicine or surgery : as galvanisation, electrolysis, and faradisation ; cautery, surgical lamps, and motors ; X-ray and high-frequency apparatus, lamps for treating lupus, electro-magnets, charging accumulators, etc.

Alternating Current.—In other towns, and in many rural districts, the alternating current is being supplied. This current changes its direction from 50 to 100 times every second. The number of volts and ampères of such an alternating current can easily be raised or lowered ; a high voltage, from 2,000 to 10,000 volts, is being used in the mains, and on entering a house this high tension is transformed down to 200 or 100 volts and a greater number of ampères, so that it can be used for incandescent lamps, etc. The advantage of this system for the electric lighting companies lies in the fact that the copper cables used for the mains have to be only one-tenth to one-hundredth part of the thickness which would be required for the distribution of the same quantity of current at low voltage.

The number of ampères which a cable can carry without becoming hot is limited, and ought not to exceed 1,000 ampères per square inch (cross section) of copper. The number of volts, however, can be raised as far as the safety of the insulation will permit ; as many as 30,000 volts have already been used in wires suspended on porcelain insulators on telegraph poles, and sent over a distance of more than 100 miles. A copper cable with a cross section of one square inch can carry only 100,000 watts with 100 volts, but 5,000,000 watts with 5,000 volts. The clear gain to the electric light co. is not nearly as great as these figures imply, because for cables intended for 5,000 volts a much better insulation is necessary than for cables intended for 200 volts only; moreover, accumulators cannot be used with the alternating current, and the engines have therefore to run all day long, and ultimately there is some constant loss in all the transformers fixed in the consumers' houses, as long as no current is being used in the houses. Nevertheless, the alternating current must be used whenever the current has to be sent over long distances, to reduce the heavy cost of the copper cables.

The alternating current is very convenient for cautery, surgical lamps, motors, and for treatment with sinusoidal currents; it can be used for producing X-rays and high frequency currents, but for charging accumulators it has to be made unidirectional. It cannot be used for galvanisation or for electro-magnets.

For the continuous as well as for the alternating current, it is necessary to employ a rheostat or a transformer of some kind, to control the current's strength, or to reduce the voltage, etc., in order to protect the patient or the apparatus from overdoses or dangerous currents. I was the first electrician who began making such apparatus in my workshop in London in 1890. They vary very much according to the type (continuous or alternating) and the voltage of the current, and according to the purpose for which they are wanted (galvanisation or cautery, etc.), and will be explained more fully in the following pages.

Continuous Current Installations.—For galvanisation and electrolysis we require currents ranging from a fraction of a milliampère up to 50, and in a few exceptional cases even 200 milliampères. There are two ways by means of which a 100-volt current can be reduced so as to produce only a few milliampères through the resistance of the patient's body: either an artificial resistance has to be inserted in the circuit "in series" with the patient, or else a shunt circuit has to be arranged.

In the former case we would require a resistance of 100,000 ohms to reduce a 100-volt current to 0·001 ampère (= 1 milliampère). There is no difficulty in obtaining such high resistances, for instance, with graphite rheostats; they were used to some extent in the earliest attempts to utilize these currents, but the method of placing the patient "in series" with the dynamo has some defects. Even a weak current of, say, 2 milliampères, which would not be felt at all if produced by a battery of a few volts only, causes a peculiar burning sensation. With 200 volts it is worse. In consequence of this we tried the other method, by placing the patient's body in a shunt circuit. This system has proved such a complete success that all switchboards for galvanisation and electrolysis are now arranged on this principle.

Shunt.—Shunt circuits are used not only for galvanisation and electrolysis, but for surgical lamps, X-ray apparatus, arc lamps, etc., as well. I will try to explain the principle of this shunt connection, which is the same in all apparatus.

If a current passes through a resistance A B, and we connect another conductor with two points of this circuit, say, at C and B, a current will circulate in this second conductor as well, and the E.M.F. in this shunt circuit C X B is in the same proportion to the E.M.F. between A and B as the resistance between C B is to that between A B. If, for instance, the E.M.F. between

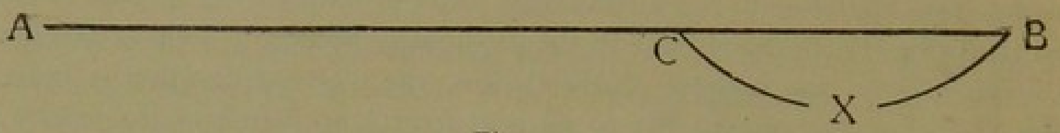

Fig. 14.

A and B is 100 volts, and the resistance in C B one half of that in A B, then the E.M.F. in C X B will be 50 volts, or it would be 10 volts if the resistance in C B were only one-tenth of that in A B. According to the spot where C is connected we can obtain for the shunt circuit any E.M.F. we like, from 0 upwards; only, of course, it cannot exceed the E.M.F. existing between A and B, and if the apparatus is so constructed that C is movable, the E.M.F. in C X B can easily be varied by moving the point C.

With this arrangement we need not employ more volts than are necessary for obtaining the desired strength of current in X. X represents either a patient, a spark coil, or a lamp, etc.

The strength of current in the shunt circuit depends on the E.M.F. and the proportion of the resistance in C X B to that in C B. If these resistances were equal, the current would have an equal strength in both loops; if the resistance in C X B is greater than that in C B, more current will pass through C B than through C X B.

If the current in C X B is interrupted near X there will be no spark, because the current in A B has not been broken, only a part of it has been shunted to another branch: moreover, it has been proved that with such a connection a current from a dynamo can be endured just as easily as a similar current from a battery; the only disadvantage is, that the part of the current passing through C B is wasted. The currents employed for galvanisation, faradisation, surgical lamps, etc., are so weak that this waste is not worth mentioning, it will scarcely amount to one shilling during a whole year; for cautery or spark coils the loss is greater. However, the electricity generated by dynamos is much cheaper than that produced by batteries; we shall refer to the actual cost later on under rheostats for spark coils.

Switchboard for Galvanisation and Electrolysis.—In order to control the currents from the main for galvanisation and electrolysis, we use a special shunt rheostat or volt selector (see No. 327). It consists of a slate core, round which about 500 turns of a fine platinoid wire are wound; the single turns are quite close together, but insulated from one another. The total resistance is about 400 ohms. The sliding spring shown in the diagram Fig. 15 corresponds with the point C in Fig. 14. An incandescent lamp is also inserted in the circuit, partly as a safety resistance, to protect the patient against an overdose, partly to increase the total resistance, so that the fine wire cannot be overheated. The lamp burns with a dull red light as long as the switch is turned on, whether the electrodes are connected or not, and thus acts as a signal to turn the current off when the application is over.

If the sliding spring is on the right-hand side near B, the E.M.F. between the terminals leading to the patient is only a small fraction of a volt. As we move the spring towards the left, the E.M.F. available at the terminals will increase, but only very gradually, on account of the large number of turns; the increase amounts only to about 0·15 volt per turn of wire. When the spring C is on the left-hand side near A, the maximum number of volts has been reached. With a 100-volt supply and a 16 c.p. lamp in circuit, this maximum will be about 65 volts. Such a rheostat allows an exceedingly fine graduation of the current's strength, which can be increased from a small fraction of a milliampère up to the full strength we wish to employ, without the patient feeling any jumps at all. The increase or decrease is much more gradual than that which we obtain with a battery and collector; the latter cannot add less than one cell (= 1·5 volt) at a time, and this may be felt as a shock if the current is applied to sensitive parts like the head.

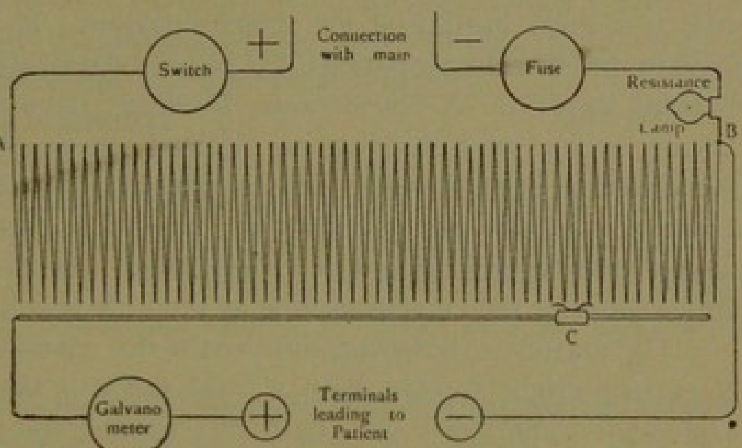

Fig. 15.

The diagram (Fig. 15) shows a galvanometer, which should always be employed with these apparatus. If batteries are used, the number of cells is an unreliable control, but still some sort of a guide to estimate the current; but with a 100-volt current without a galvanometer one works absolutely in the dark.

There are yet other accessories which may be inserted in the shunt circuit, as current reversers, etc., but as they do not differ from those used for batteries, we refer the reader to pages 10–12.

Is it absolutely Safe to use the Currents from Dynamos for Galvanisation?—With a shunt rheostat and a lamp arranged as described, it is not possible that the patient may receive an overdose; of course the current may be applied by mistake, while the spring of the rheostat is at "strong" instead of at "weak," just as easily as this can happen while the current collector of a battery is full on; the result in both cases will be an unpleasant, but not a dangerous shock. With underground cables it is impossible that the E.M.F. of a continuous current may suddenly rise to dangerous proportions.

There is, however, in all installations a certain amount of leakage, i.e., escape of electricity to earth in consequence of defective insulation. In many districts, where the so-called three-wire system is being used, one pole of the dynamo is intentionally connected with the earth. If, for instance, the + pole of the dynamo is in contact with the earth, a patient who is in good electrical contact with the earth may receive an unexpected shock when an

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electrode is applied, even if the sliding spring is close to B, if this electrode happens to be connected with the negative pole of the dynamo. But we never hear of such shocks, and the reason is, no doubt, that patients are nearly always well insulated from earth. A *dry* wooden floor, carpet, linoleum, etc., is a good insulation for these purposes. It is not likely to happen in private practice that a patient will be on a damp stone floor * while the current is being applied. A few doctors, however, have received unpleasant shocks already when, while holding an electrode in one hand, they attempted with the other to open a water tap to moisten the electrodes. *It must be made a rule not to touch gas or water pipes on any account, as long as one hand is in contact with the switchboard or an electrode.* There is really no danger in local applications of the current as long as this rule is adhered to.

The matter is, however, different if the current is to be applied in a bath. A patient might receive even a fatal shock if the necessary precautions are neglected. The water in a bath tub, even if the latter is made of porcelain, is usually in excellent contact with the earth through the waste pipes, etc., which are of metal. If the current is intended to be applied in a bath, it is necessary to insulate the water by replacing the metallic waste pipes by others made of earthenware for a considerable distance ; by enclosing the inlet pipes and taps in wooden cases, so that a patient cannot possibly touch them, and by using a bath tub made of porcelain or wood. If this cannot be done, the metal bath tub has at least to be placed on porcelain tiles. If the leakage is bad, or if one pole of the mains is earthed, a current reverser should not be on the switchboard, and this should be so connected that B of our diagram is connected with the earthed pole. If the current is to be used for an electric bath in a hospital, hydro, etc., it would, under such circumstances, be advisable to transform the current by means of an electric motor driving a small dynamo (see No. 1790) ; this is an absolute protection against any danger.

The above remarks apply to the ordinary water bath ; if the current is applied in small local baths to feet or arms, as, for instance, in the so-called Schnee's 4-cell bath, there is no danger at all, because for these purposes small earthenware or glass vessels are usually employed, which are not connected with the earth by waste pipes.

Apparatus for Faradisation.—A coil for faradisation is frequently connected with the above described apparatus for galvanisation. A current of about 0·5 ampère is required to work these coils, and the easiest way of obtaining it is by inserting an incandescent lamp in the circuit as a resistance. A shunt resistance must be arranged parallel to the interrupter to prevent sparking, which would destroy the platinum contacts.

Apparatus for Cautery.—For galvanisation and electrolysis the maximum current required does not exceed 0·3 ampère ; the most frequently used cautery

* The stone floor of operating theatres in hospitals is occasionally an insufficient insulation ; frequently the difficulty can be overcome by placing a dry linoleum or indiarubber mat under patient and operator. In some large hospitals it will be safer to transform the current before it is being used, because it cannot be avoided that persons may have to handle these apparatus who are quite unacquainted with them.

burners, however, consume 18 ampères. About 200 times as much current is, therefore, wanted for cautery as for galvanisation, and since the requirements for cautery are entirely different from those for galvanisation, the same apparatus cannot be used for both purposes.

It is not possible to attach a cautery burner directly to the main, as it would be fused instantly, but the current may be used if either :—

(1) The current is transformed into a lower voltage.

(2) A suitable rheostat is inserted.

(3) A few accumulator cells are charged.

Transformers.—A continuous current can be transformed into a lower voltage either by means of a motor, or else by changing the continuous current first into an intermittent current by means of an interrupter. The voltage can then be reduced by a transformer similar to those used for alternating currents.

In either case the primary current required does not exceed 1·5 ampères with 200 volts, and the ordinary size cables used in a room are sufficient; these transformers can, therefore, be connected with any existing wall-plug or lamp-holder. They consume less than two pennyworth of electricity per hour.

Motor Transformers consist of a motor, which is driven by the current from the main. This motor may either be combined with a small dynamo which supplies a continuous current of low voltage, or the motor may be used to convert the continuous into an alternating current. In the first case, the motors are provided with a second winding on the armature ; in consequence of this the drum and the whole motor must be comparatively large. The second winding spins round in the magnetic field, and according to the number of turns and the diameter of the wire used, currents of another voltage and ampèrage are induced in it, which are taken off by brushes at a separate collector.

In the second case, the ends of the winding of the armature are connected with two separate collector rings, from which an alternating current is taken off. The armature need then not be larger, but this current has yet to be transformed by means of a small alternating current transformer, so that the volts and ampères are suitable for cautery burners.

These motor transformers have an efficiency of 60 per cent, i.e., a current of 200 volts and 2 ampères may be transformed into a current of 10 to 12 volts and about 20 ampères. They require very little attention ; the bearings must be oiled about once a month, and the resistance contained in the base of the motors must be inserted before the switch is turned on to start it. The speed is then increased by diminishing the resistance in the circuit, till the desired degree of incandescence is obtained in the cautery burner. If these few points are attended to, the motor transformers will remain absolutely reliable for many years without requiring repairs.

As the current is being transformed, it is impossible that the patient or operator can receive any shock, even if they touch water or gas pipes while being in contact with the instrument.

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These motor transformers have the great advantage that, besides for cautery and surgical lamps, they can be used equally well for all surgical operations requiring drills, burrs, saws, trephines, etc. They can be used for massage, rapid vibration, or percussion treatment, for working the air pumps used for pneumatic massage of the ear, or for vaporizing drugs. If they transform into an alternating current, this may be used for applying sinusoidal currents; if they transform into a continuous current of lower voltage, they can also be used for charging a few accumulators.

Interrupter Transformers.—The continuous current can be converted into a pulsating current by means of an interrupter,* and the intermittent current thus obtained can be converted into a current of fewer volts but more ampères by means of a transformer similar to those used for transforming alternating currents. The efficiency of these interrupter transformers is nearly as great as that of the motor transformers, and amounts to about 45 per cent. The interrupter transformers are cheaper than the motor transformers. On the other hand, they are useful only for cautery; other apparatus, like a rheostat for surgical lamps or for galvanisation, can be added, but the transformers cannot be used for drills or massage, like the motor transformers.

Rheostats for Cautery have been superseded by the more efficient transformers, and are scarcely used any more since the voltage of the electric supplies has been raised almost everywhere to 200 or more volts.

Accumulators can be charged and used for heating the cautery burners. They can be connected for charging with almost any wall-plug or lamp-holder, but a resistance has to be inserted in the circuit in order to protect the plates of the accumulator from too heavy a current. Incandescent lamps are usually chosen as resistance; the candle-power of the lamps to be used depends on the capacity of the accumulators and the number of volts of the supply. If the light of these lamps is not turned to any useful purpose, the efficiency is not great, because about nine-tenths of the current are wasted in making the carbon filament of the lamp incandescent. It is, however, frequently possible to arrange it so that the accumulator is inserted in the circuit of lamps, the light of which is used for illuminating a hall, dining-room, etc., and under such circumstances the charging would practically cost nothing, and, what is more important, the accumulators would be charged at frequent intervals, and would thus be kept in good condition for the longest possible time. Accumulators have also the advantage that they can be taken away and used in houses where the current from the main is not available.

Accumulators require some supervision. Care must be taken that the poles are connected correctly, and that they are not left too long without being re-charged. For fuller information about the charging and treatment of accumulators, see pages 18–20.

* An electrolytical interrupter may be used, but it consumes more current and make more noise than a mechanical interrupter.

Surgical Lamps cannot be connected directly with the main. The glass bulbs of lamps used for examining the various cavities of the human body must be small, and carbon filaments capable of standing currents of 100 volts must necessarily be long in order to have a sufficient resistance; there would be no room for them in these small bulbs.

The current from the main can be reduced either by means of a transformer—nearly all the transformers made for cautery are so arranged that they can also be used for surgical lamps—or by means of a rheostat. An incandescent lamp serves usually as the resistance. If the resistance lamp is connected with a small variable rheostat, and the surgical lamp is placed in a shunt circuit to this rheostat, there will be no spark on breaking the shunt circuit, and the amount of light is perfectly under control. Any size lamp, from the smallest which is to be introduced through the male urethra can be used with such a rheostat. Rheostats on this principle can be made in various forms, and can be used equally well on the continuous or the alternating current.

For working **Spark Coils** for X-rays or high frequency currents, the continuous current from the main is the most convenient, and, at the same time, the most efficient source of supply. Particulars will be found under X-rays on page 144.

Arc Lamps for Treating Lupus, etc., require a continuous current of not less than 50, and not more than 65 volts, and from 10 up to 60 ampères, according to the size and the candle-power of the lamps. If the current from the main has 100 volts, rheostats are most frequently used to reduce it to 60 volts; if the E.M.F. is 200 or more volts, a rheostat may be used, provided that not more than 25 ampères are required; but if the lamp is wanted for many hours every day, or if currents of more than 25 ampères are necessary, a motor transformer has to be employed instead of a rheostat.

Some microbes are killed by the light itself; others are killed by the inflammation following the prolonged application of a powerful light. In any case, it is necessary to have the light as powerful as possible, and lenses are invariably used with the arc lamps to concentrate the light of the lamp on the spot which is to be treated. The heat of such a powerful light is very great. The lenses through which it passes would crack, and the patient's skin would be burned, unless precautions were adopted to carry off the heat. The simplest and most efficient remedy is to keep a stream of water circulating between the lenses. This plan is adopted in the optical part of all the arc lamps, whether they are large or small. A stream of water also passes through the compressor, to be mentioned later on. Distilled water has to be used, as ordinary water would absorb the ultra-violet light.

As it is the ultra-violet part of the light which produces the changes, the lenses used have to be made of quartz, which is much more transparent to these chemical rays than glass.

Blood is opaque to the light rays, and in order to reach deeper-lying tissues the parts have to be made anæmic, which can be done either by pressure alone (by pressing a rock-crystal lens firmly against the part to be treated), or by pressure combined with cold (by using a piece of ice as compressor).

Mercury Vapour Lamps.—The mercury vapour lamps have been found to be very rich in rays of a wave length below 400 $\mu\mu$, usually called the ultra-violet rays, and they are therefore suitable for the treatment known under Prof. Finsen's name, provided that the tubes in which the light is generated are pervious to the ultra-violet rays.

Ordinary glass is quite unsuitable, but in the glass-works of Dr. Schott, in Jena, a new kind of glass has been discovered which is pervious to the ultra-violet rays. Two or three tubes of this glass, 20 to 36 ins. long and about 1 in. diameter, are suspended on a stand with a reflector behind. The tubes carry platinum wires with carbon electrodes inside at either end, and contain a certain quantity of mercury. They are connected with a continuous current supply (alternating current cannot be used) of 100 to 250 volts in such a manner that the negative pole is connected with the lower end, which remains covered by the mercury after the light has been started. The tubes are tilted till the mercury flows over and connects both poles for a moment; as soon as the mercury thread breaks somewhere, the mercury vapour is generated by the current, the reflector is brought back to a vertical or inclined position, when a steady light of a peculiar green colour is obtained. The light thus generated is cheaper than that of the electric incandescent lamps with carbon filaments—the latter require about 4 watts per candle power, the mercury vapour lamps only about 0·5 watt.

The rays emitted by the uviol lamps have a deadly effect on small insects; a fly dies within one minute if brought near such a lamp, and bacteria are killed by it as they are by sunlight. The skin of patients exposed to this light becomes bronzed, and if continued long enough the same inflammations and reactions are produced which are obtained with the powerful Finsen or Finsen-Reyn lamps, by burns with X rays, or by sun-burns on the high Alps. The operators have to wear spectacles to protect their eyes.

The light is not only suitable for treating lupus, eczema, etc., but can also be used for light baths for stimulating the skin; very satisfactory and encouraging results have already been obtained in the short time the lamps have been available.

For **Electric Light Baths** it is immaterial whether the continuous or the alternating current is available, as either kind can be used equally well. The candle-power employed in the baths is not strong enough to kill microbes, but the light has a stimulating effect. It opens the pores of the skin, and the heat given off by the incandescent lamps causes strong perspiration, similar to that produced in a Turkish bath. The light baths are, however, more pleasant than the Turkish baths, because the heat is dry and easily under control, and because the patient can breathe air of ordinary temperature, and in consequence heart and lungs are not affected as they are in a Turkish bath.

Electro-Magnets.—The small hand magnets, as well as the giant magnets like Haab's, required to remove pieces of steel or iron from the eye, can be used with the continuous current only. The diameter of the copper wire and the number of turns must be adapted to the voltage of the supply; a magnet wound for 100 volts has fewer turns of a stouter wire than a magnet wound for 250 volts.

ALTERNATING CURRENT.

The alternating current is superior to the continuous current only for cautery; it is equal in efficiency to the continuous current for all illuminating instruments, light baths, motors, etc., but it is less convenient for almost all other purposes, and in some cases—for instance, for galvanisation or for charging accumulators—it cannot be used unless it has first been converted into a continuous current.

Transformers.—Alternating currents can easily be transformed by induction, so that, for instance, 2,000 volts and 1 ampère can be converted into 100 volts and 20 ampères. Transformers are used in all houses where an alternating current is laid on, to transform the high tension current so that it can be used for incandescent lamps.

The transformers are a kind of induction coil. An insulated primary wire is wound round a bundle of soft thin iron sheets, which are insulated from one another; above this primary is wound the secondary wire, in which currents are induced by the alternating current circulating in the primary coil, and by the magnetism of the iron core. The secondary coil must have fewer turns than the primary one if the number of volts is to be reduced, or it must have more turns of a finer wire if the number of volts has to be raised.

Transformers for Cautery and Surgical Lamps.—For this purpose 100 volts and about 2 ampères are converted into about 10 volts and 19 ampères. If we insert a variable small rheostat in the secondary circuit, we can adapt the number of ampères to either small or large cautery burners. In most cases there is another secondary coil of medium-sized wire on these surgical transformers, giving currents of about 15 volts and 2 ampères; with the help of another small rheostat this can be used for surgical lamps. The efficiency and simplicity of these instruments surpasses that of the best continuous current transformers, or of any other source of electricity which may be used for cautery.

Charging Accumulators.—The alternating current has to be made unidirectional before it can be used for charging accumulators. It can be done in three ways: (1) by means of a synchronous rectifier; (2) with the help of aluminium cells (electrolytic rectifier); or (3) with a motor transformer.

In Synchronous Rectifiers a polarised relay is being used. An electro-magnet is connected with the alternating current; it therefore changes its polarity as frequently as the phases of the alternating current change. A permanent steel magnet is fixed like a Wagner's hammer above the electro-magnet; it is attracted by the electro-magnet while the latter has an opposite polarity, and is repelled while it has the same polarity, and in consequence the steel magnet vibrates synchronously with the alternating current dynamo. These movements can be used to close the circuit through the accumulators which are to be charged for a certain time, while the direction of the current is correct and the E.M.F. sufficiently high, and to break this circuit while the alternating current flows in the wrong direction. I have used one of these rectifiers for about eighteen months almost daily (till my supply was changed to the continuous current) for charging accumulators, and during this time it has never gone wrong or given any trouble ; if properly adjusted there is no sparking at all.

Aluminium Cells.—A pulsating unidirectional current can also be obtained with the help of aluminium cells. These cells consist of a large indifferent electrode, and an active electrode of aluminium. The cells are charged with a solution of ammonium phosphate.

Aluminium has the peculiarity that it allows a current to pass freely while it is anode, but when it turns cathode it polarises rapidly, and offers so high a resistance that a current of less than 20 volts cannot pass. An arrangement of this kind is simpler than the mechanical rectifier previously described, but in actual working the aluminium cells have up to now given some trouble. If they are used continuously for a considerable time, they become hot and the polarisation ceases ; moreover, crystals form, and the cells have to be cleaned and scraped thoroughly at fairly frequent intervals. This is, no doubt, the reason why they have not come more into use.

Finally the alternating current can be converted into a continuous current by means of a *Motor Transformer* (see No. 1780). The installation of such a transformer is a little more expensive than that of a rectifier, but it gives no trouble, and the voltage of the continuous current dynamo can be adapted to the number of accumulators to be charged.

Sinusoidal Currents can be applied with the alternating current from the main. Particulars will be found under Sinusoidal Currents on page 43.

The alternating current cannot be used for galvanisation, electrolysis, for the large arc lamps for treating lupus, for electro-magnets required for removing pieces of steel, etc. ; but, with the exception of galvanisation and electrolysis, it will be found more convenient and economical to generate the required continuous current in a dynamo for which an alternating current motor serves as the motive power. This is more convenient than a gas or oil engine, and batteries are out of the question for heavy currents. Motors and dynamos, and the combination of them, are explained in a special chapter (see pages 39–44), and the motor transformers will be found under Nos. 1780–1793.

For galvanisation and electrolysis very weak currents only are required, and for these purposes it is certainly cheaper to use a battery than to use a motor transformer. Good Leclanché cells will give the necessary current with average use for fully two years without requiring re-charging, and the batteries are cheaper to buy and simpler to manage and maintain than a motor transformer, for which a special switchboard would also be wanted to regulate, measure, and reverse the current.

In those cases, however, where a motor transformer exists already (in many hospitals, for instance) for converting the alternating into a continuous current for spark coils or arc lamps, etc., it can of course be used also for galvanisation and electrolysis, if a suitable switchboard is added to control the current.

DYNAMOS, MOTORS, MOTOR TRANSFORMERS.

Electric Motors and Motor Transformers are used so extensively for various medical purposes, that a short explanation of them may be of interest to some of our readers.

A **Dynamo** consists of an electro-magnet, between the two poles of which is an armature which can turn round its axis. The armature consists of iron round which a coil of insulated copper wire is wound. The ends of this copper wire are connected either with two separate copper rings fixed on (but insulated from) the axis, or with a collector ring consisting of many segments. Collecting brushes press against the rings, and if the brushes are connected by a conductor, an external circuit is established.

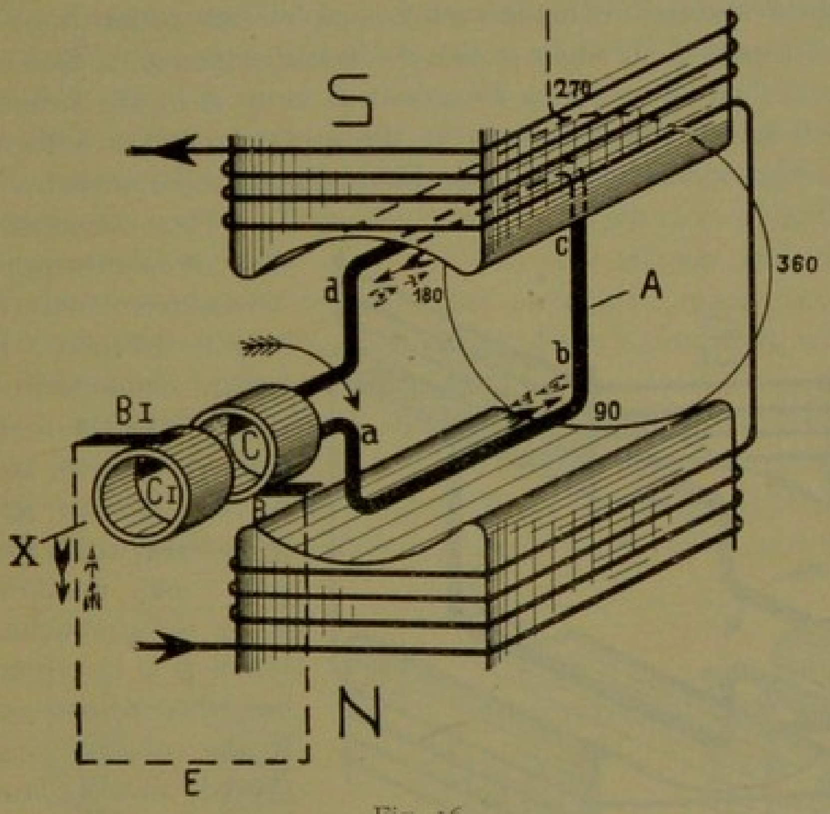

Fig. 16.

The illustration gives a diagram of an alternating current dynamo. Of the electro-magnet only the poles N and S are shown. The armature is represented by one stout coil of wire a, b, c, d ; the ends of this wire are connected with the rings C and C1, which are insulated from one another, and against these rings press the brushes B and B1. The dotted lines from B *via* E to B1 represent the external circuit.

If the armature is driven round the axis A X by mechanical power, its position to the poles of the magnet will vary constantly ; a, b will alternately move over the north pole of the electro-magnet, as shown in the illustration ; after it has made half a turn it will move past the south pole. While a, b approaches the north pole, c, d is approaching the south pole, and an E.M.F. of opposite polarity is induced in each half of the armature (see page 22 about

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induction), as indicated by the black arrows. After the coil has made half a revolution, a, b comes near the south pole, the position of the armature to the poles of the magnet is reversed, the E.M.F. induced has now the opposite polarity, and the current is flowing in the direction of the dotted arrows.

A current produced by such a dynamo describes curves as shown in illustration. While the coil of wire is in a horizontal position (connecting 360 with 180) there is no current; while a, b approaches the north pole the current rises till the coil of wire has reached the vertical position shown in the diagram. When it moves farther on towards 180 the current diminishes, is 0 again when it has reached 180, increases then in opposite direction till it has reached 270, and falls afterwards again till it reaches 360. If the armature has made such a complete revolution from 0 to 360, we call it a "period"; when it has made half a turn only, from 0 to 180, we call it a "phase." If an incandescent lamp is in the external circuit, the light will appear steady as soon as the armature moves with a sufficient speed, *i.e.*, when it has not less than about 40 periods per second.

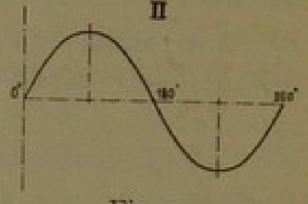


Fig. 17.

The annexed diagram (Fig. 18) shows quite a similar arrangement, only the copper ring is different. Instead of being connected with *two complete, separate* rings, the ends of the wire are attached to *two segments* (C and C1) *of one ring*, which are insulated from one another. When a, b is approaching N, the brush B is in contact with C, but when a, b is approaching S, the collector ring has also moved, and has brought B in contact with C1, In consequence of this the current in the external circuit *retains the same direction*, in spite of the fact that the polarity of the current in the armature changes, and a dynamo provided with such a commutator is called a continuous current dynamo.

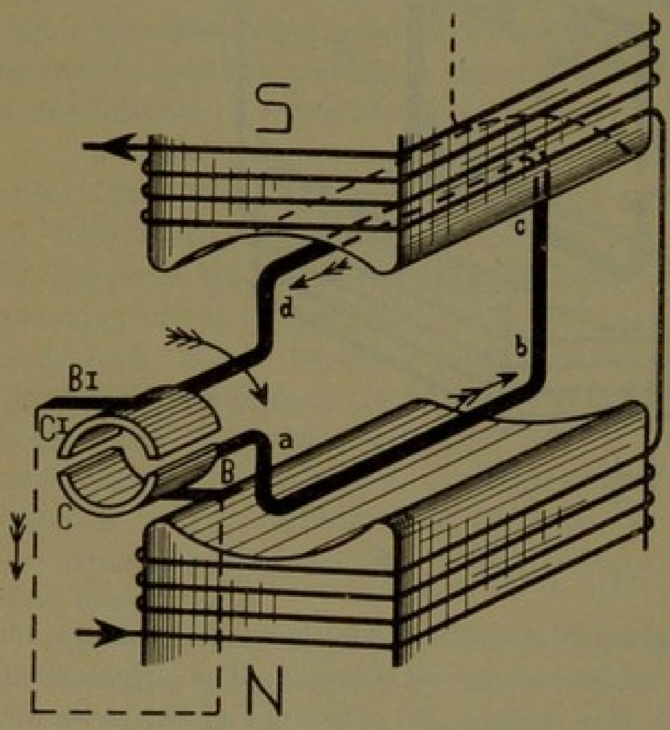


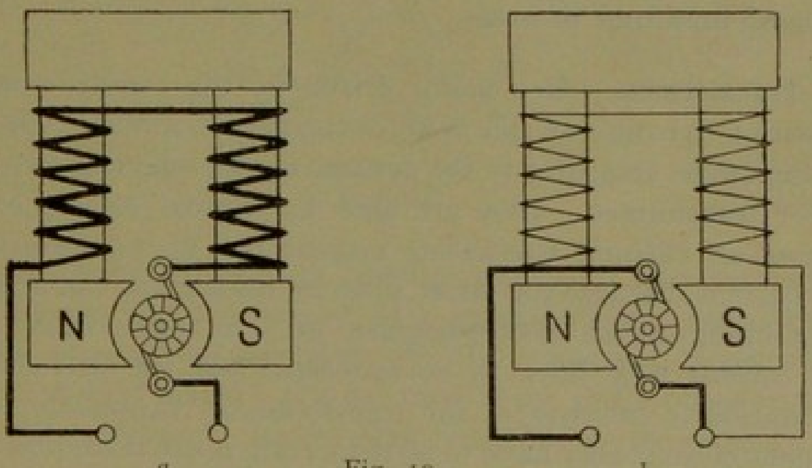
Fig. 18.

The difference between an alternating and a continuous current dynamo is not great—it consists only in the arrangement of the collectors. In the alternating dynamo the brushes remain in contact always with the *same end of the wire*; in the continuous current dynamo one brush takes the currents of the coils while they approach the north pole, the other brush receives the impulses while the coils approach the south pole. One and the same dynamo may even serve to produce both types of current if it is fitted with two separate rings from which the alternating current can be taken off, and, in addition, with a commutating collector from which the continuous current can be taken off This is made use of in some transformers, to be described later on.

Practically there is never one coil of wire only, as shown in the two diagrams. The armature of a dynamo consists of a ring of iron wire, or thin discs of soft iron, and the whole circumference is wound with a continuous coil of wire. The E.M.F. induced in the upper half has the opposite polarity of that induced in the lower half. There is, therefore, no current flowing in the armature as long as the external circuit is open; when it is closed the current is discharging through the brushes and the external circuit.

A continuous current dynamo in no way differs from a continuous current motor—the same machine can serve either purpose.* If it is to be used as a dynamo, the armature has to be driven round by mechanical power, and currents are induced in consequence which are available in the external circuit to produce light, etc. If we wish to use it as a motor, we send a current through it which produces magnetism. Two opposite parts of the armature are made magnetic and attracted by the poles of the electro-magnet. As soon as the armature has moved a little, the collector, which moves simultaneously, sends the current through the next coil. In this manner one part of the armature is made magnetic after the other in regular, rapid succession. It revolves in consequence, and thus mechanical power is produced, which can be taken off a pulley fixed on the end of the axis.

"Series" or "Shunt" wound Dynamos or Motors.—The current which is induced in the armature does not pass only into the external circuit, it is also used for exciting the electro-magnet of the dynamo. If it passes from a brush round the magnets, then through the external circuit and back to the



a Fig. 19. *b*

other brush, as shown in Fig. 19 (*a*), the dynamo is wound "in series." If the current divides itself into two loops, i.e., a weaker current passing from a brush round the magnets and back to the second brush, and the stronger

* There is a considerable difference in the construction of an alternating current dynamo and an alternating current motor. Some of the latter have not even a collector.

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current flowing through the external circuit only, as shown in Fig. 19 (*b*), there are two separate circuits connected parallel to one another, and we say that such a dynamo is "shunt" wound. The latter type has the advantage that the magnetic field retains the same intensity whether the dynamo or motor has to do hard work or whether they run empty, and the E.M.F. or the number of revolutions are not influenced thereby. Most dynamos, and all good motors for surgical purposes and for motor transformers, are therefore "shunt" wound. "Series" wound motors are universally used for traction purposes; in electric carriages, etc., they have special advantages for this work.

Rheostats for Motors.—With all motors it is essential that a rheostat should be used. It is necessary in order to protect the motor from damage in starting, and it is required to control the speed of the motor. As long as the armature does not revolve, there is great danger that it will be damaged if the full current is switched on. This is due to the fact that a considerable E.M.F. is produced in the armature as soon as it revolves in the magnetic field, and the polarity of this E.M.F. is *opposed* to that of the current driving the motor. It acts, therefore, as a powerful resistance to this current, and weakens it, but this resistance is absent as long as the armature does not revolve, and in consequence an artificial resistance has to be substituted. This is necessary for all motors, to protect them from an overdose. As soon as the armature has started, this artificial resistance may be reduced or switched off. Many motors are damaged because this necessary precaution is forgotten. The same rheostats help to regulate the speed of the motors, from the maximum of about 2,400 revolutions per minute down to a few hundred. The amount of resistance in the circuit can be increased or diminished by altering the position of a crank.

The bearings of a motor or dynamo must not be allowed to run dry; they have to be oiled from time to time.

Motor Transformers.—If a motor driven by the current from the main is coupled with a dynamo, we can produce currents of another type, or another voltage or ampèrage, according to the dynamo chosen, and call such a combination a motor transformer. They are used for a great variety of purposes; in some cases an existing alternating current has to be converted into a continuous current, because the latter is better for a spark coil or an arc lamp for treating lupus, or an electro-magnet, etc. In other cases an existing continuous current may have to be converted into an alternating current to obtain sinusoidal currents, or for transformers. Ultimately, the voltage of a continuous current may have to be reduced to make it suitable for cautery burners, arc lamps, for charging accumulators; or else the current may have to be transformed as a measure of precaution, to make the current applied in a bath independent of the main and of leakages, to avoid all possibility of shocks.

Particulars and illustrations of motor transformers for these various purposes will be found under Nos. 1780–1793.

Motor Transformers for Sinusoidal Currents.—Before concluding this chapter, I have yet to mention one particular motor transformer which is being used to produce the so-called sinusoidal currents. This word has been invented to describe a wave-like alternating current, such as is produced by an alternating current dynamo, and to distinguish such a current from the irregular, jerky alternating current produced by a faradic coil. The two illustrations show

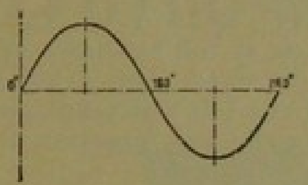

Fig. 20.

Fig. 21.

the curves of a sinusoidal current, and the curve of the secondary current of a faradic coil. The latter type produces painful contractions of the muscles, whereas the smooth sinusoidal currents may cause equally powerful contractions, but they are not so much felt. They are also free from the electrolytic effects of a continuous current.

We distinguish yet between single-phase and polyphase sinusoidal currents. For medical purposes three-phase currents are frequently employed, and to obtain them a peculiar connection of the winding of the armature is necessary. It is arranged in three groups; each of these groups occupies one-third of the circumference of the armature. One end of each group is connected with one of the three collecting rings, and the other ends of the three groups are connected together. Three separate waves are thus generated, and are interwoven, as shown in the illustration.

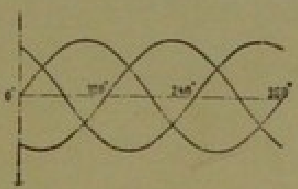

Fig. 22.

The most convenient way to produce sinusoidal currents is to have a continuous current motor provided with extra collector rings, from which the sinusoidal current can be taken off. If it has two rings, single-phase currents only can be obtained; if it has three rings, single-phase or three-phase currents can be employed; in the first case two, in the second case three, electrodes have to be used simultaneously on the patient.

The E.M.F. of the sinusoidal currents thus obtained depends on the E.M.F. of the current used for the motor, and in small transformers is approximately 60 per cent of it. For instance, if a 250-volt current is being used, the sinusoidal current obtained at the brushes will have about 150 volts. This would be too much for a patient, but it can be reduced by a simple transformer resembling a sledge coil. Such a transformer allows a very fine

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regulation of the current's strength, and a current transformed in this manner can be used with perfect safety in a bath, even if there should be a bad leakage to earth in the continuous current installation which is being used to run the sinusoidal transformer.

The number of periods depends on the number of revolutions of the armature, and can be varied by means of the rheostat from about 40 periods down to a few periods per second.

The current should not be switched off while it is at full strength, otherwise the patient might receive a shock similar to that obtained from a faradic coil. The sledge transformer has to be put on weak, and the full resistance should be inserted in the circuit of the motor before the electrodes are removed, or before the switch on the motor is turned off.

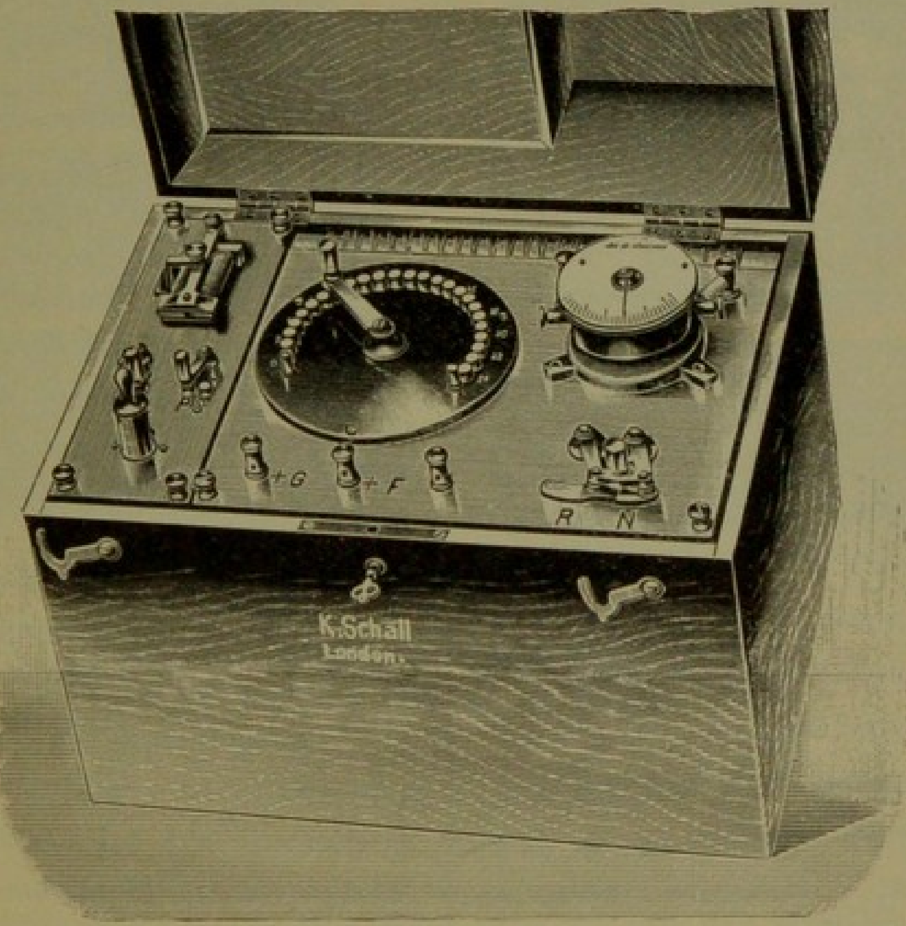
The alternating current from the main can be used for the application of single-phase sinusoidal currents, and the strength can be varied by means of a volt selector similar to those used for controlling the continuous current. If a leakage exists it would not be safe to apply the current in this manner in a bath, but it can be rendered absolutely safe by transformation, either by means of a suitably arranged sledge transformer, or by the combination of a transformer like No. 1928 with a volt selector.

X Ray Apparatus and their Management will be found on pages 138-175.

Illustrated Price List

OF

ELECTRO-MEDICAL APPARATUS.



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LONDON, W.

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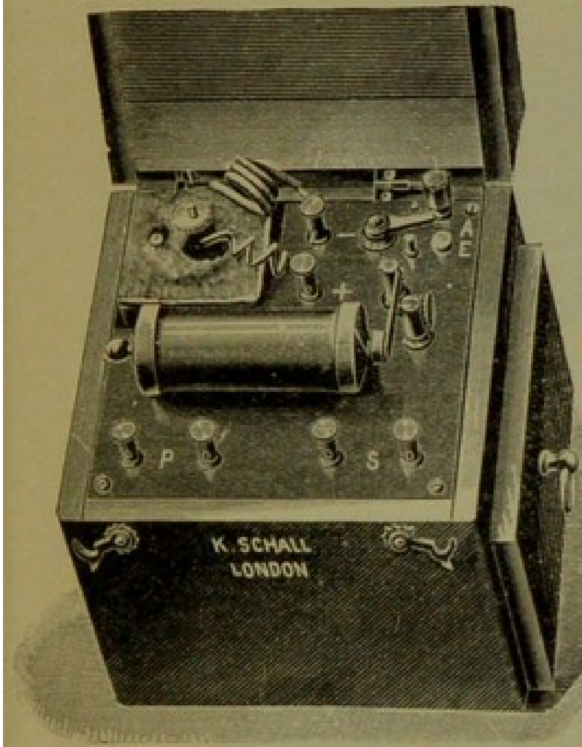
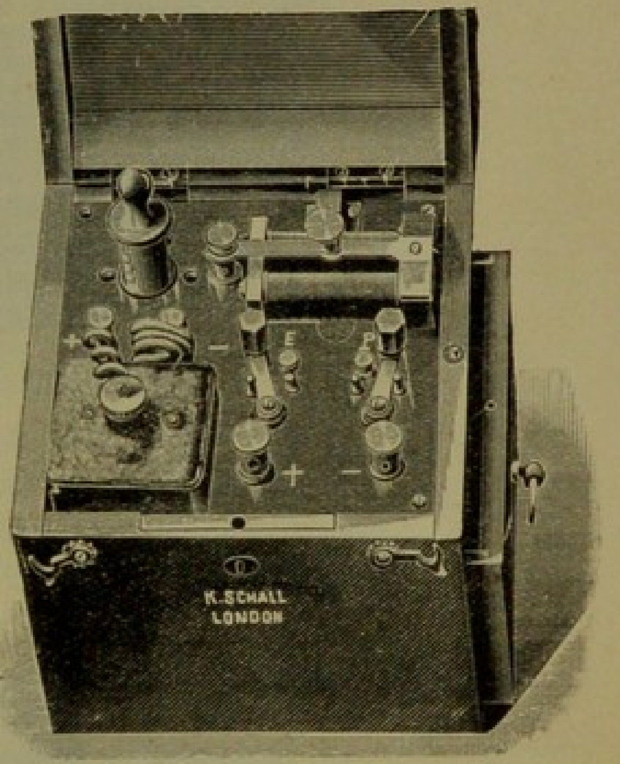
FARADISATION.

(See also pages 22-27.)



No. 5



No. 6.

No. 5. Dr. Spamer's Coil, in polished mahogany case, cheap form, with dry cell, cords, handles, and 4 electrodes (Fig. 5) £1 0 0

Size 5 by 5 by 5½ in., weight 2¾ lbs.

No. 6. Dr. Spamer's Coil, in polished mahogany case, with dry cell, commutator for primary and secondary current, cords, handles, and 5 electrodes (Fig. 6) .. 1 18 0

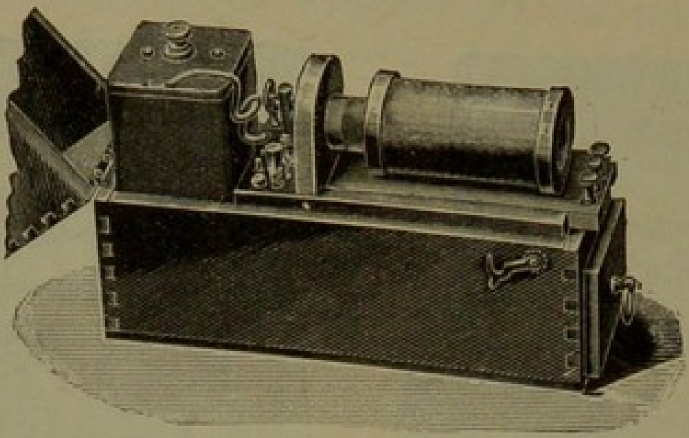
Size 5 by 5 by 5½ in., weight 3 lbs.

This coil is bought more frequently than any other type ; there are several thousands of them in use already.

No. 7. Similar Coil, with two dry cells instead of one .. 2 4 0

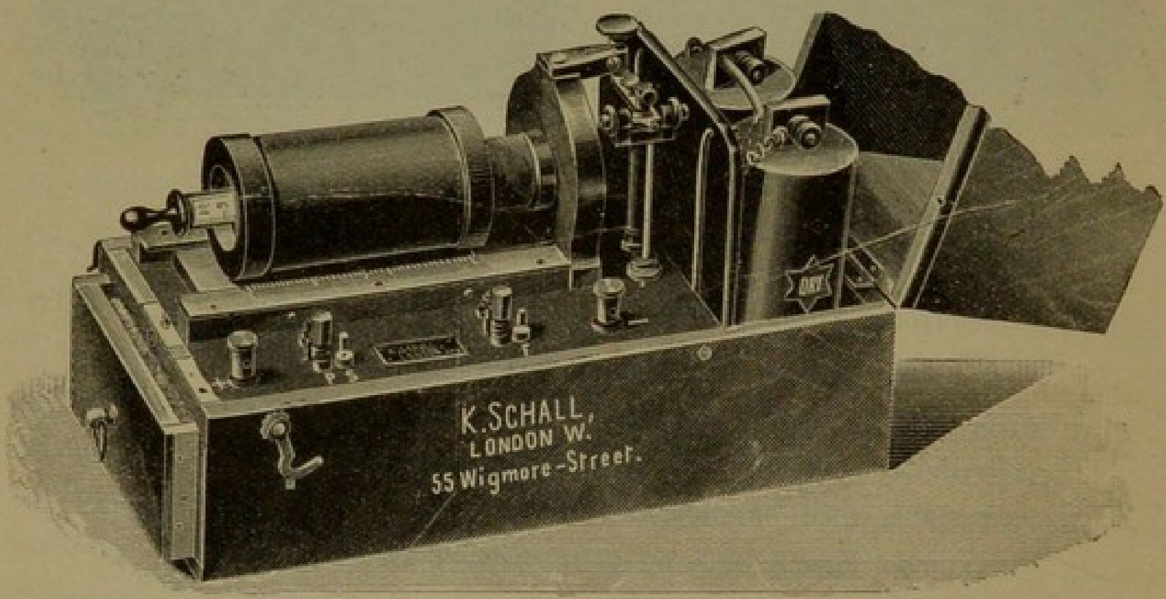
If desired, we can supply the coils Nos. 5 to 7 with bichromate cells instead of the dry cells, but we recommend the acid cells only if the coil is to be used in some part of the world where it is difficult to get the dry cell replaced. The dry cells have great advantages compared with the acid cells : they are more convenient, portable, and clean. It is only the spilling of acid which necessi tated the frequent repairs to coils in former years, and since we began to use dry cells in the year 1891, the repairs have practically ceased.

The size and quality of the cells chosen is such that one cell will work a coil for about 40 hours before it becomes exhausted. With an average use of ten minutes a day, the cell has to be renewed about once in a year. Price of new cell, including postage, 2s. 6d.



No. 19.

No. 19. Dr. Lewis Jones' Sledge Coil, with one large dry cell, working the coil for about 80 hours altogether, cords, handles, and 5 electrodes, in walnut case (Fig. 19) £2 0 0

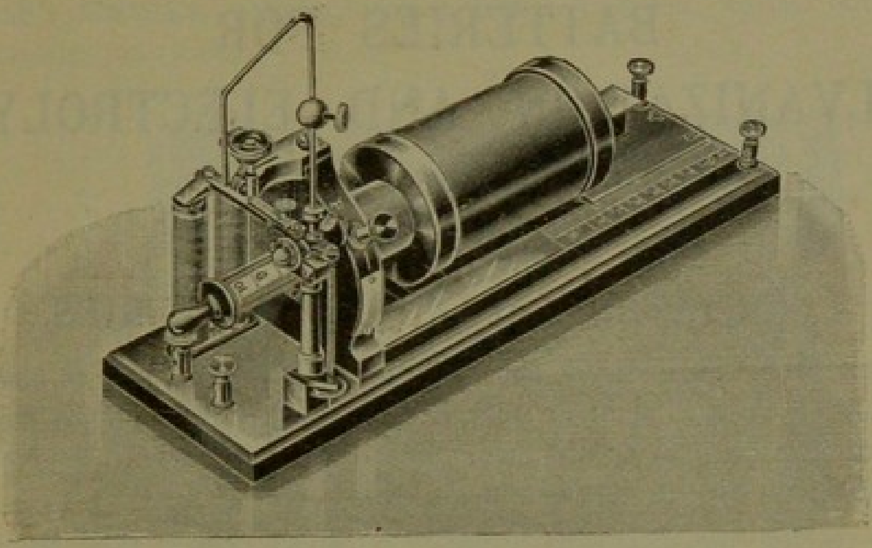


No. 21.

No. 21. Dubois-Reymond's Coil, with two dry cells, in polished mahogany case, commutator for primary and secondary current, cords, handles, and six electrodes, size 5 × 11 × 7 inches, weight 6 lbs. (Fig 21) .. £4 10 0

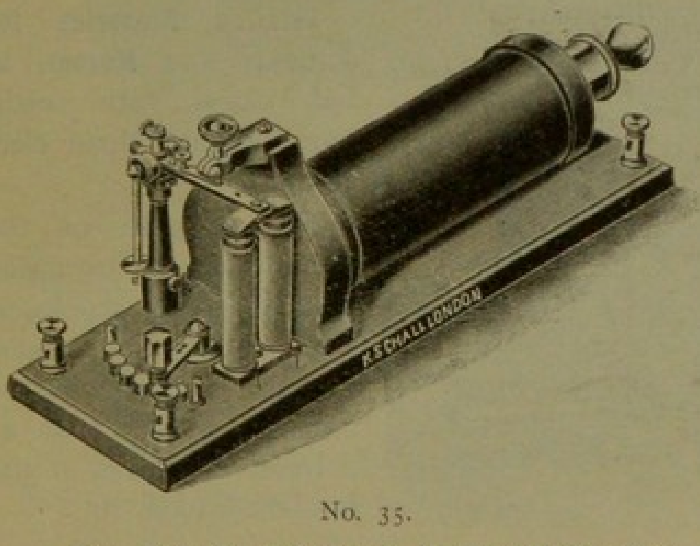
This is the most complete and convenient of all the portable coils for diagnosis as well as for treatment. The rapidity of the interruptions may be regulated by means of a weight, which can be fixed higher or lower. The cells will work the coil for more than 80 hours altogether.

Spare Cells for the Coils No. 19 and No. 21, 2s. 6d. each.



No. 27.

No. 27.	Dubois-Reymond's Coil, with metal scale and adjustable interrupter (for slow or quick vibrations); primary coil 700 turns, secondary coil 5,000 turns ..	£2 15 0
No. 35.	Dr. de Watteville's Coil, for primary current only ..	2 15 0
No. 36.	Same Coil, complete with 2 dry cells, cords, and 2 large bath electrodes	3 7 0



No. 35.

This coil is especially suitable for the electric bath, and for treatment of the abdomen with faradisation. The strength of current is regulated partly by drawing out an iron core, and partly through a crank, by means of which 2, 4, 6, 8, or 10 layers of the copper wire may be thrown in or out of circuit. The number and rapidity of interruptions may be regulated by altering the position of the ball.

For Leduc's apparatus for administering interrupted currents, and for Lewis Jones' Rhythmical interrupter, see No. 245 and 248, pages 57 and 58.

We have supplied coils No. 21, amongst others, to :—

King's College Hospital; Westminster Hospital; Royal Hospital for Women and Children, Waterloo Bridge Road; Victoria Hospital, Chelsea; Westminster Medical School; Seamen's Hospital, Greenwich; London County Asylum, Claybury; Metropolitan Hospital, Kingsland Road, London; Royal Infirmary, Halifax and Derby; Cottage Hospital, Aberdare; Grimsby District Hospital; Eye Infirmary, Newcastle; Royal Berkshire Hospital, Reading; Children's Hospital, Gloucester; Dispensary, Nottingham; South Charitable Infirmary, Cork; General Infirmary, Hertford, etc., etc., and to several hundred medical men.

CAUTERY, SURGICAL LAMPS, MOTORS, Etc.
SWITCHBOARDS for Current from Main. LIGHTTHERAPY
X-RAY APPARATUS

BATTERIES FOR GALVANIZATION AND ELECTROLYSIS.

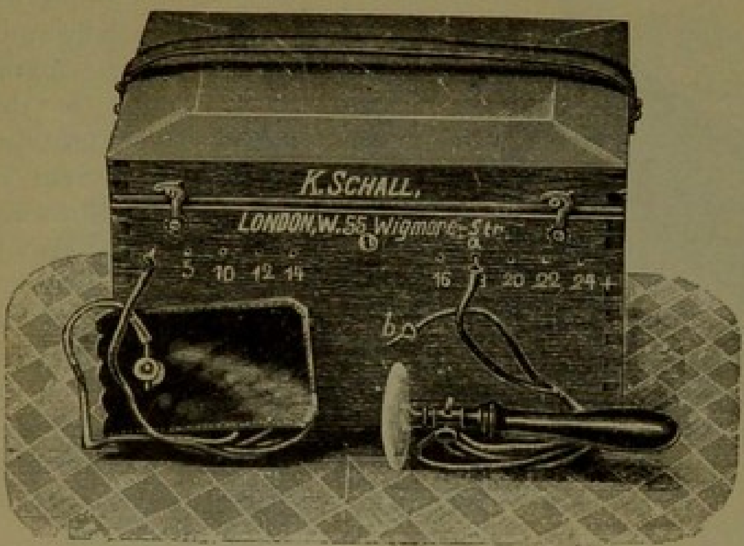
(*See also pages 7-15.*)

PORTABLE LECLANCHÉ BATTERIES.

If not otherwise ordered, the batteries Nos. 99-132 will be charged with liquid cells, if remaining in or near London, but with dry cells if they have to be sent away a greater distance. Batteries charged with dry cells can be sent as ordinary freight all over the world.

The re-charging of the batteries costs 8d. per cell if they are filled with liquid cells, and 1s. 6d. per cell if they are filled with dry cells.

Provided the batteries are not short circuited, batteries Nos. 99—132 are guaranteed to last with average use for two years before requiring re-charging. For combined batteries, the two cells working the coil may require re-charging earlier.



No. 103.

Schall's Batteries for Patients and Nurses, in oak cases, with cords, handles, and three electrodes.

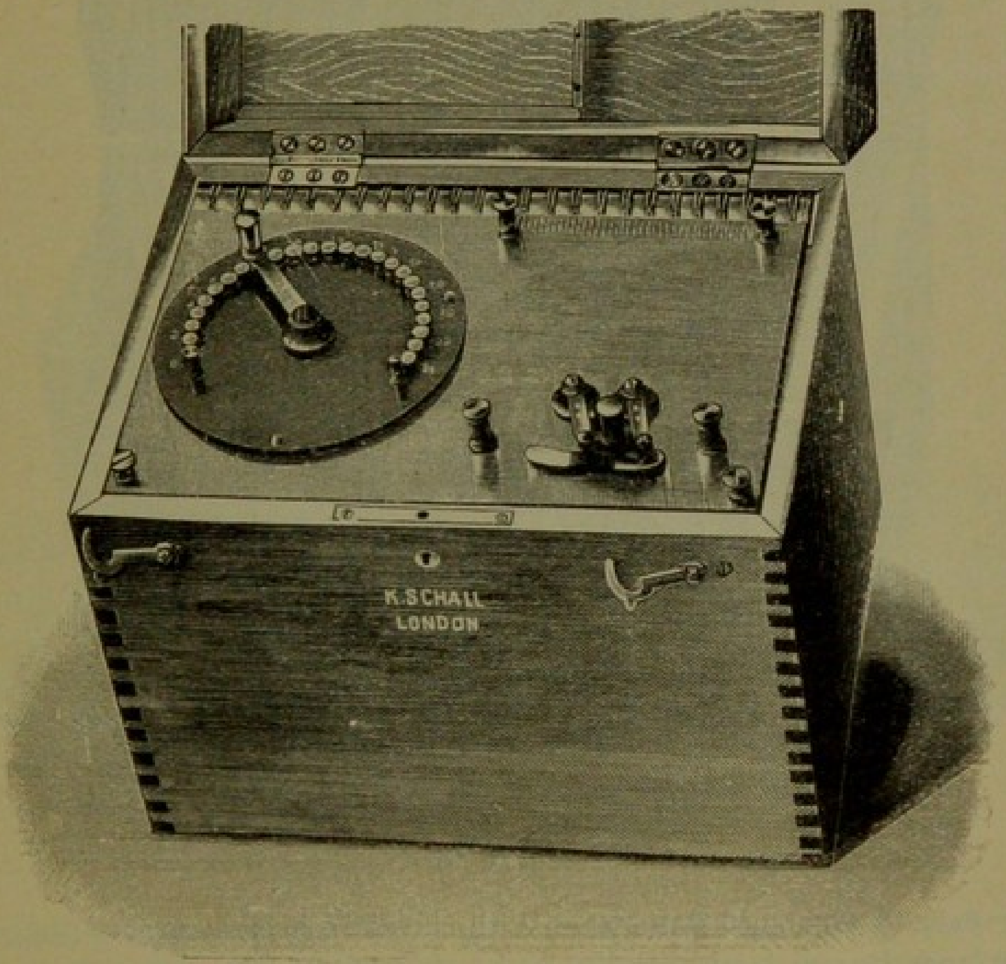
The strength of the current can be regulated without giving shocks to the patient, by increasing or diminishing the number of cells (two at a time) by means of the forked cord *a b*.

*No. 99.	6 cells			..	£1	1 0
†No. 100.	8 ,,	3½×5 ×6½ inches, weight	6 lbs.	..	1	12 0
†No. 101.	12 ,,	5 ×5 ×6½ ,, ,,	9½ lbs.	..	2	2 0
No. 102.	18 ,,	5 ×9½×6½ ,, ,,	12½ lbs.	..	2	15 0
No. 103.	24 ,,	7½×10×6½ ,, ,,	18 lbs.	(Fig. 103)	3	5 0
No. 104.	32 ,,	8 ×14×6½ ,, ,,	24 lbs.	..	4	2 0
No. 105.	40 ,,	8 ×17×6½ ,, ,,	30 lbs.	..	5	0 0

* Suggested by Mr. Cardew, for treating exophthalmic goitre (Graves' disease).

† For throat, ear, and eye diseases; for removing hairs by means of electrolysis, etc.

Schall's Batteries, with current collector, reverser, cords, handles, and four electrodes (oak case).



No. 117

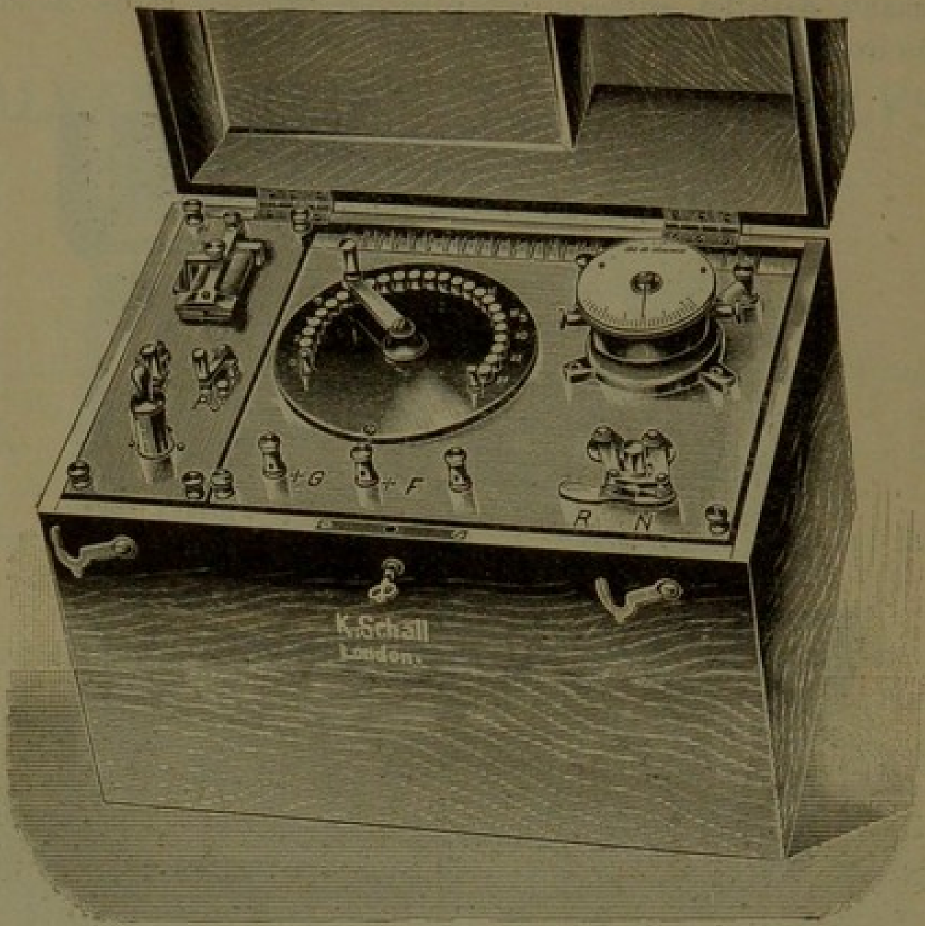
No. 116,	18 cells,	$4\frac{1}{2} \times 9\frac{1}{2} \times 11$ inches, weight	16 lbs. ..	£4	10	0
No. 117,	24 „	$7 \times 11 \times 11$ „ „	21 lbs. (Fig. 117)	5	10	0
No. 118,	32 „	$7 \times 13\frac{1}{2} \times 11$ „ „	29 lbs. ..	6	12	0
No. 119,	40 „	$7 \times 17 \times 11$ „ „	37 lbs. ..	7	12	0

Of the many unsolicited testimonials we have received about batteries Nos. 99–140, we will mention one only.

The late Dr. Milne Murray, of Edinburgh, wrote :—

"The Combined Battery (No. 132) I bought some three or four years ago will soon want re-charging. It has done me splendid service, and I am greatly pleased with it. I have never had any trouble with it, and though I have used it now steadily all these years, and made thousands of applications with it, it is still giving a good current."

CAUTERY, SURGICAL LAMPS, MOTORS, Etc.
SWITCHBOARDS for Current from Main. LIGHT THERAPY
X-RAY APPARATUS



No. 117A.

Schall's Combined Batteries.—With current collector, reverser, coil No. 6, and large dry cell, cords, handles, and 5 electrodes. The galvanometer shown in illustration is 30s. extra.

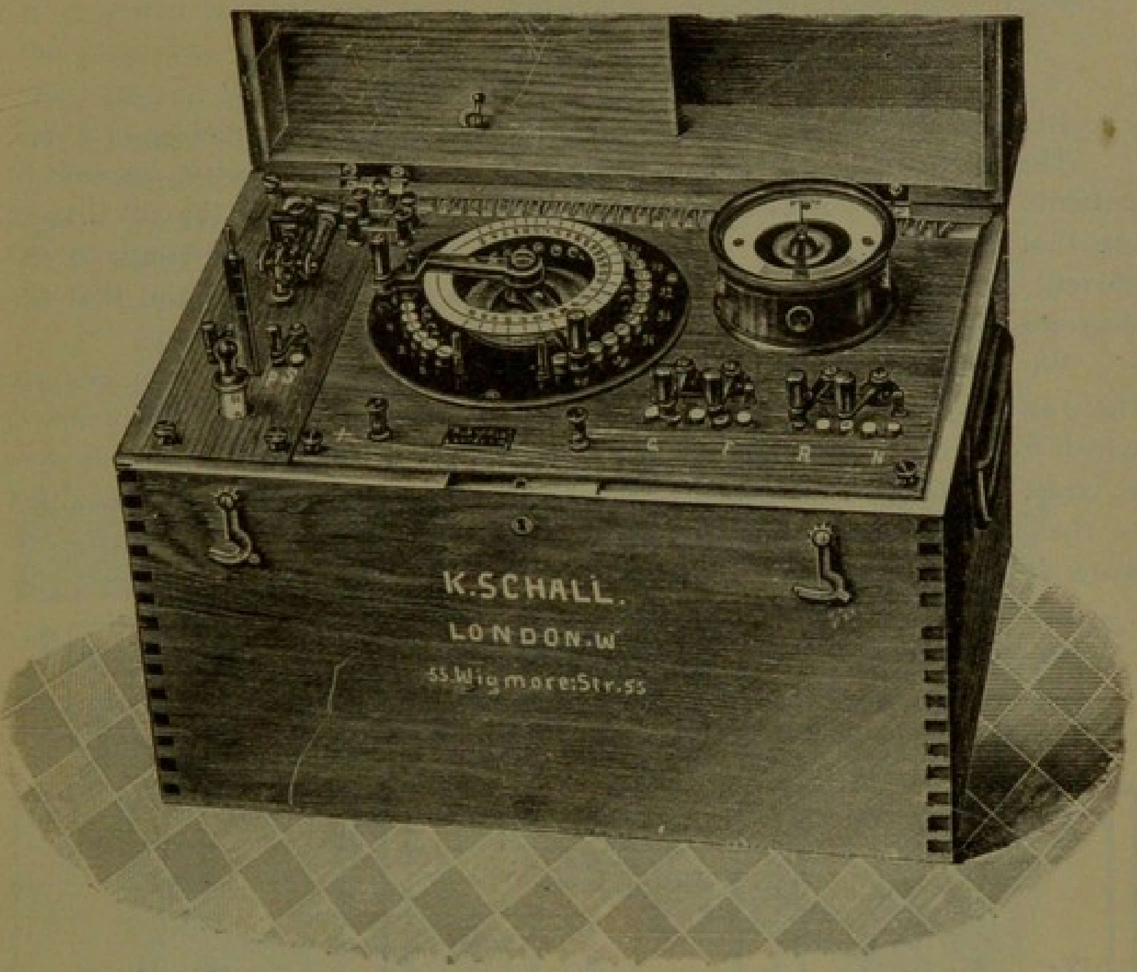
No. 116*a*, 18 cells	£6 10 0
No. 117*a*, 24 ,, (Fig. 117*a*)	7 10 0
No. 118*a*, 32 ,, ...	8 12 0

Schall's Batteries, with double collector, current reverser, galvanometer (No. 271), cords, handles, and five electrodes.

No. 122, 24 cells, 7 ×11 ×11 inches, weight 22 lbs. ..	£10 0 0
No. 123, 32 .. 7 ×13½×11 .. .. 30 lbs. ..	11 0 0
No. 124, 40 ,, 7 ×16 ×11 ,, ,, 38 lbs. ..	12 0 0

Batteries Nos. 122–124 are similar to Fig. 132; the only difference is that the latter is provided with a faradic coil, shown on the left hand side, which is not supplied with batteries Nos. 122–124.

For apparatus for utilizing the current supplied from dynamos for galvanization, electrolysis and faradization, see pages 107–112.



No. 132.

Schall's Combined Batteries, with double collector, current reverser, galvanometer No. 271, coil No. 27, Dr. de Watteville's commutator, cords, handles, and seven electrodes.

No. 130.	24 cells,	7×13 ×11 inches, weight	34 lbs.	..	£12 15 0
No. 131.	32 ,,	7×15½×11 ,, ,,	42 lbs.	..	14 10 0
No. 132.	40 ,,	9×16½×11 ,, ,,	48 lbs. (Fig. 132)		16 5 0

There are over a thousand of our Leclanché batteries, Nos. 116–132, already in use. They have been supplied, amongst others, to :—

The Admiralty, the War Office, H.M. Office of Works, the Crown Agents for the Colonies, Guy's Hospital, King's College Hospital, St. Mary's Hospital, St. Thomas's Hospital, London Hospital, Queen Alexandra Maternity Hospital, University College Hospital, Westminster Hospital, National Hospital for Diseases of the Heart, Victoria Hospital, Central Ear and Throat Hospital, General Dispensary, Marylebone ; London County Lunatic Asylum, Hanwell ; Royal Victoria Hospital, Bournemouth ; Royal United Hospital, Bath ; Army Medical Service, Netley ; Dispensary, Exeter ; Devon and Exeter Hospital, Exeter ; Whitworth Hospital, Mater Misericordia Hospital, Dublin ; Royal Infirmary, Hospital for Sick Children, Aberdeen ; Manchester Southern Hospital ; Infirmaries in Macclesfield, Southport, West Riding, Carlisle, Workington, Dundee, Downpatrick, Greenock, Waterford, and Worcester ; County Asylums, Whittingham, York, and Dorset ; Haywood Hospital, Burslem ; Addenbrooke Hospital, Cambridge ; Grimsby District Hospital ; Manchester Children's Hospital, Birkenhead Children's Hospital ; Cottage Hospital, Shaftesbury and East Cowes, and to over a thousand physicians and surgeons.

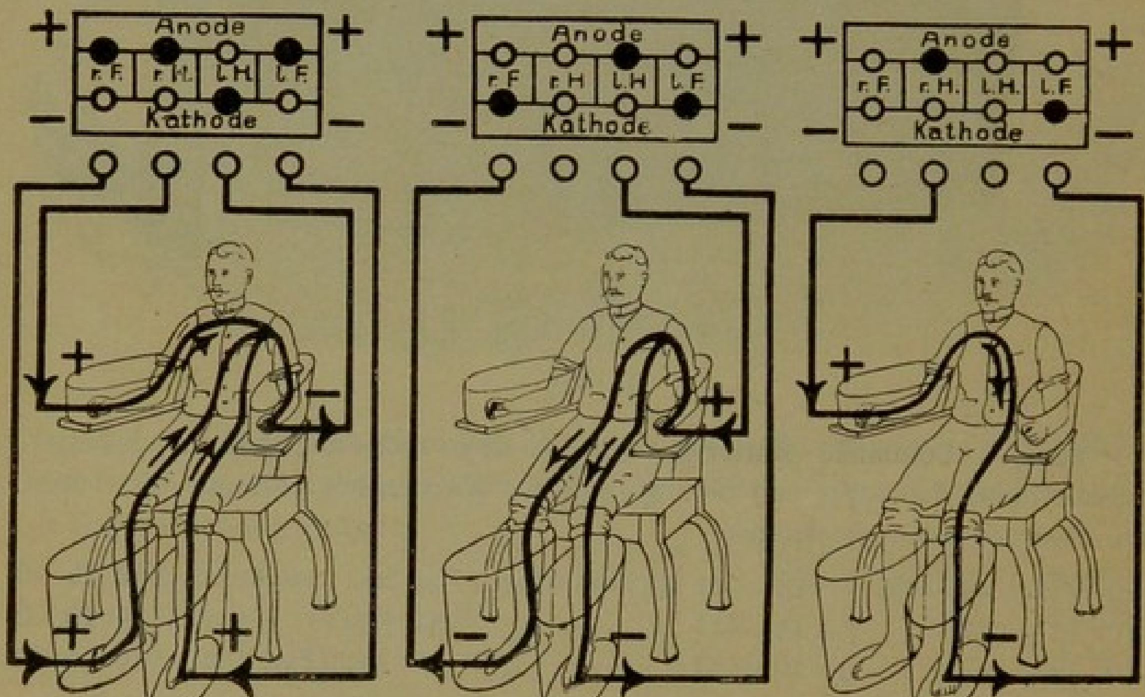
CAUTERY, SURGICAL LAMPS, MOTORS, Etc.
SWITCHBOARDS for Current from Main. LIGHTTHERAPY
X-RAY APPARATUS

DR. SCHNEE'S FOUR-CELL BATH.

In this bath only the arms and feet of the patient are immersed in water.

This is the most convenient method of administering electric currents to patients which we possess. Compared with an electric bath, the advantages are that the patient need not undress completely, that the strength of the current passing through the body can be measured accurately, and that the doctor is not dependent on a bathroom in order to use this method.

We have neither to press the electrodes all the time to the skin, nor are there any fluctuations in the strength of the current owing to uneven pressure, which frequently causes pain. The surface through which the current enters is large, and comparatively strong currents can be used without discomfort to the patient. The resistance of the skin is reduced by the action of the water.



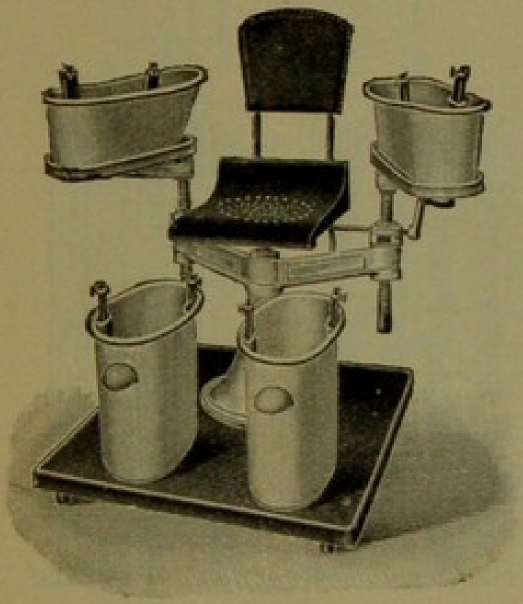
The method is also very convenient for ionic medication, i.e., for the introduction of chemicals through the skin. The advantage of this is that the chemicals remain suspended for a longer time in the cells of the tissues of those parts where their action is desired. If injected hypodermically or introduced through the stomach, they are less active because they are washed away rapidly by the circulation of the blood.

The direction of the current can be varied by means of a commutator; many different combinations are thus possible; three of them are shown in the diagram.

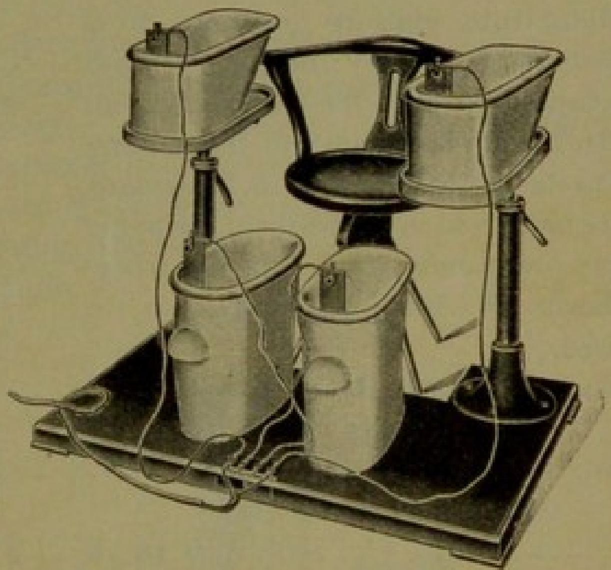
The four-cell bath can be used with the galvanic, faradic, or sinusoidal currents produced by batteries or by dynamos; in the latter case there is no danger of shock, because these porcelain tubs are not connected with the water pipes, and are well insulated from earth. The quantity of water required is not great; the apparatus does not therefore depend on the proximity of a water supply.

No. 180. Complete outfit of Dr. Schnee's Four-cell Bath, consisting of a pantostat No. 2005 for galvanisation, faradisation and sinusoidal currents, with galvanometer, reverser, etc.; commutator to control the direction of the current; and four porcelain tubs with carbon electrodes. The tubs for the arms can be raised or lowered **£33 10 0**

For illustration of the pantostat, *see* Fig. 2005, page 113.



No. 181.



No. 182.

To enable those of our customers who have already a suitable battery or switchboard to use with the four-cell bath, we can supply the following parts separately :—

No. 181. Chair, commutator to control the direction of the current, and four porcelain tubs with carbon electrodes (Fig. 181) **£19 0 0**

The chair shown in Fig. 181 is made of iron in a very substantial manner, with arrangement to raise the seat and adjust the height and the distance of the two supports for the arm-bath by means of a screw gear. This is very convenient, but somewhat expensive. The four-cell bath can also be used by placing the patient on an ordinary chair, and the two arm-baths on separate stands of convenient height, as shown in Fig. 182.

No. 182. Two porcelain tubs for the feet, two for the arms, and stands for the latter (as shown in Fig. 182), four carbon electrodes, and crank commutator to control the direction of the current **£10 0 0**

The chair shown in fig. 182 is not included in this price.

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No. 183. Separate porcelain tub for foot, with carbon, electrode, and terminals 0 16 0

No. 184. Do. do. arm do. 0 14 0

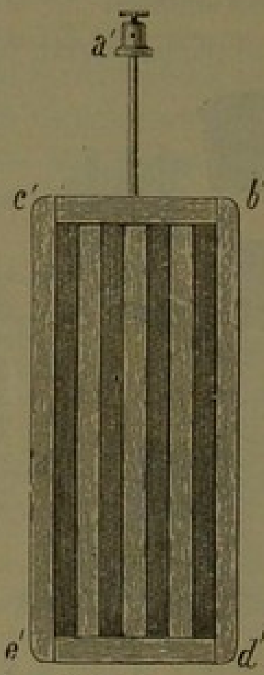
No. 185. Commutator to control the direction of the current, with the necessary terminals, etc., mounted on ebonite 1 15 0

ELECTRIC BATH.

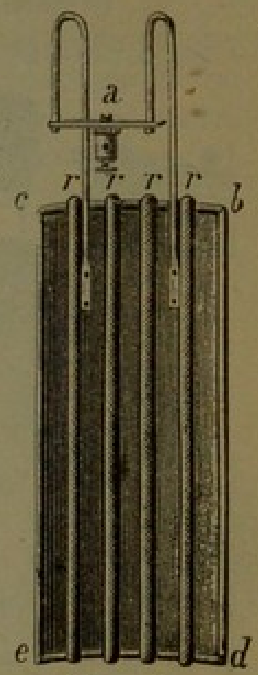
Any wooden or porcelain bath tub is suitable for an electric bath. Metal tubs may be insulated to a certain extent by means of bath enamels, so that the electric current can therein be applied to the patient. Tin electrodes, about 10 inches square, are immersed in the water at the upper and lower ends, or else the electrodes shown in Nos. 195—198 can be used.

No. 195. Large Bath Electrode, Fig. 195 .. £0 16 0

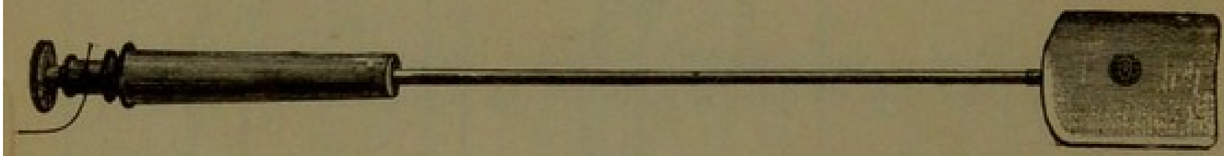
No. 196. The same, bent for the head or foot end of the tub, Fig. 196 .. 0 18 0



No. 195.



No. 196.


No. 198.

No. 198. Paddle Electrode, Fig. 198 .. .. .. £0 14 0

For Tin Electrodes, see Nos. 480—497.

In this way any bath tub can be made fit for the treatment of a patient with the electric current. The Induction Coil No. 35 is specially recommended if the faradic current is used. The Batteries Nos. 116—132 are suitable for applying the galvanic, faradic, or combined currents.

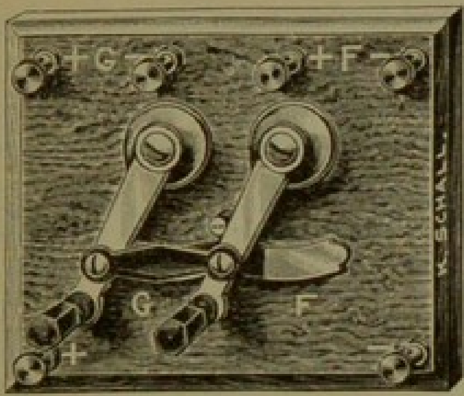
CURRENT REVERSERS, COMMUTATORS, &c.

(*See also pages* 11–12.)

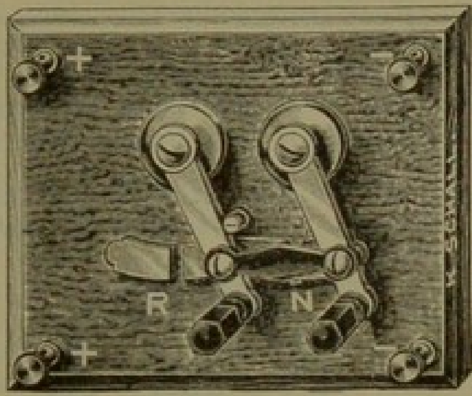
No. 222. **Current Reverser and Interrupter,** Fig. 222 .. .. £0 12 0

No. 232. Dr. de Watteville's Commutator, for the use of galvanic, faradic, or combined currents, Fig. 232 .. .. 0 14 0

No. 240. Metronome Interrupter, with two mercury cups. The number of interruptions can be varied from 20 up to 300 per minute 3 0 0



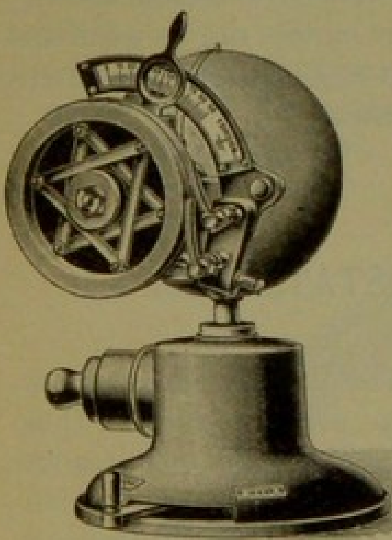
No. 232.



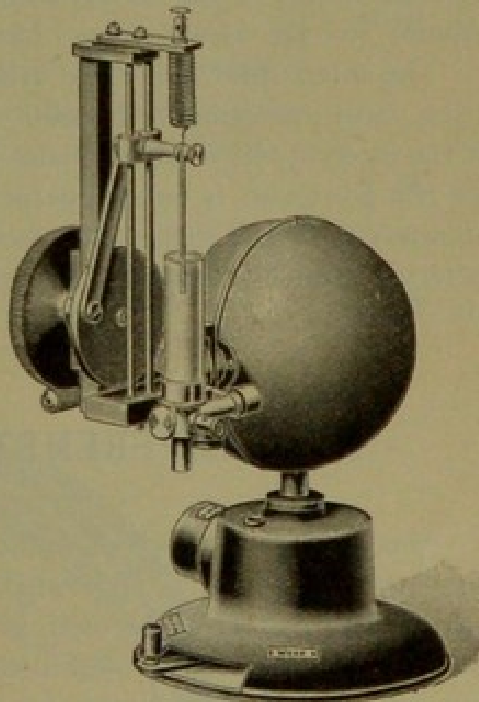
No. 222.

No. 245. Prof. Leduc's Motor Interrupter, with adjustable brushes and scale to vary the duration of the time during which the current is open or closed £3 15 0

No. 246. Prof. Leduc's Motor Interrupter and Reverser. The current can be reversed up to 200 times per second. This apparatus can also be used to produce the electric anæsthesia described by Prof. Leduc (Fig. 246) £6 0 0



No. 246.



No. 248.

This reverser can be attached to any of our motors, or Pantostat. The motor shown in the illustration is not included in the price quoted.

Prof. Leduc has published most interesting results, which he obtained with pulsating unidirectional currents produced by means of an adjustable interrupter as shown above, which has to be attached to an electric motor, and connected with a continuous current battery of 10 to 20 volts and a milliampèremeter.

He found that the human body reacts most powerfully if there are 100 interruptions per second. If this frequency is increased or reduced, the susceptibility diminishes. It is possible by means of this interrupter to produce gradually, *with remarkably weak currents*, single contractions, tetanus, local anæsthesia, general anæsthesia, paralysis of the respiration, of the heart, and ultimately death. The electric sleep can be prolonged for hours, and full consciousness returns immediately after the cessation of the current without any ill effects, or feeling unwell. The method has been used already in laboratory experiments upon animals; the anæsthesia has been prolonged for eight hours, without a single accident or noticeable ill effect, and it can also be used for local anæsthesia for minor operations.

Moreover, the apparatus can be used for faradization, for diagnosis as well as for treatment. It is superior to faradic coils, because dosage is impossible with the latter, whereas Leducs currents can be measured accurately with a M.A. meter. The time during which the current is closed can be varied by altering the position of the handle above the scale, from $\frac{1}{50}$th up to $\frac{9}{10}$th part of the duration of each interruption. The scale shows approximately the time the current is "on" compared with the time it is "off"; with a M.A. meter this proportion can be ascertained quite accurately. Full particulars about this will be given in the directions for use sent with our apparatus.

No. 248. Dr. Lewis Jones' Rhythmic Interrupter (fig. 248) .. **£4 10 0**

By means of this interrupter, galvanic, faradic, or sinusoidal currents can be made to increase and decrease in slow rhythms, about once in every four seconds. The tissues become stimulated, but as time is given for the renewal of the blood supply, no fatigue is produced as is the case in sustained tetanus of the muscles. After the muscles of the hind limb of a rabbit were stimulated for 10 minutes daily for 20 days, it showed an increase of 40 per cent over the weight of the corresponding untreated limb. (See "Rhythmic Interrupters," by Dr. Lewis Jones, *Lancet*, Nov. 13th, 1909.)

The interrupter has to be attached to a motor; the Pantostat No. 2005 is the most convenient, because in addition to the motive power required for the interrupter, it supplies also the necessary galvanic or sinusoidal current. But if a pantostat is not available, any other of our motors can be used, and the interrupter has then to be inserted in the circuit of a galvanic or a faradic battery. Full instructions are sent with the apparatus.

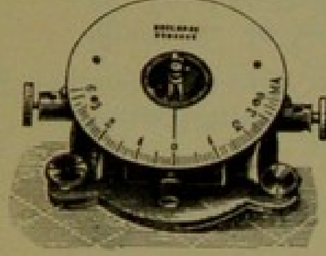
MILLIAMPÈREMETERS, RHEOSTATS, &c.

(*See also pages* 10–11.)

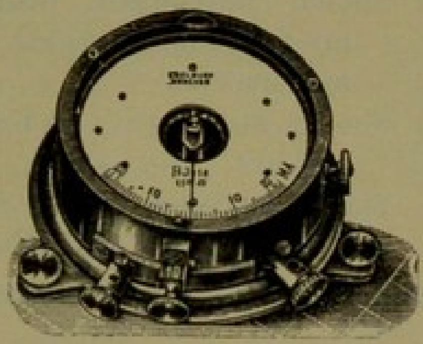
There are two types of milliampèremeters. The older one has a horse-shoe magnet, which is provided with an index pointing north. These instruments can only be used in a horizontal position, and their reading becomes inaccurate while used in the neighbourhood of magnets or the current from the main. Experience has shown, however, that these instruments require practically no repairs; the needle on which the magnet oscillates becomes blunt in course of time, but it can easily be replaced by a new sewing needle by the owner, without having to return the instrument to the manufacturer. In consequence of this reliability we still continue to make these galvanometers, and recommend them especially for portable batteries.

The newer type is provided with a movable solenoid; these instruments can be used in a horizontal or vertical or any other position, and their readings are not affected even when used near dynamos. They are therefore more convenient than the older type, and have superseded them to a large extent;

they have to be used for all switchboards for the current from the main. They are, however, more delicate than the old instruments. The current has to pass through two fine hair springs, and if it is too strong the elasticity of these springs changes, and the index does not point to 0 any more. Such an overdose may be caused if the connecting cords or electrodes touch one another accidentally. They then have to be returned for repairs.

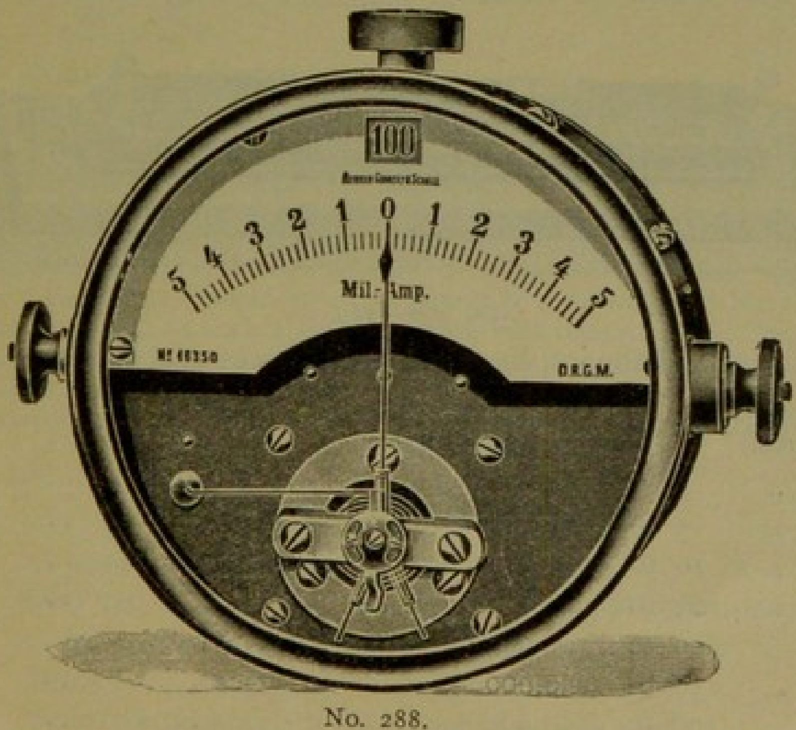


No. 264.



No. 271.

No. 264. Galvanometer, in cardboard box, showing up to 6 milliampères each 10-th part of a milliampère, Fig. 264 ..	£1 10 0
No. 265. The same instrument, showing up to 30 milliampères each single milliampère	1 10 0
No. 270. Galvanometer, in polished mahogany box, showing up to 5 milliampères every 10-th part of a milliampère; or by using the shunt, each single milliampère up to 50 milliampères	2 14 0
No. 271. The same instrument, showing each single milliampère up to 25; or by using the shunt, every 10 milliampères to 250 m.a., Fig. 271	2 14 0



No. 288.

CAUTERY, SURGICAL LAMPS, MOTORS, Etc.
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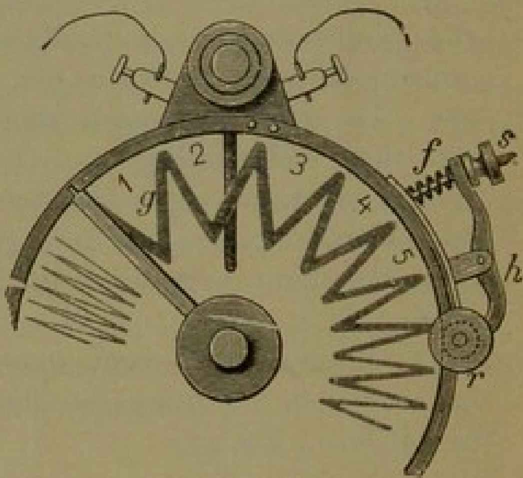
No. 280.	Small d'Arsonval Galvanometer, diameter 2½ inches, reading up to 10 or 25 milliampères without shunt	£2 0 0
No. 281.	Similar instrument, reading up to 25 milliampères, or with shunt up to 100 or 250 milliampères ..	2 4 0
No. 284.	D'Arsonval Galvanometer, diameter 4½ inches, reading up to 10 or 25 milliampères, without shunt ..	2 18 0
No. 285.	Similar instrument, diameter 4½ inches, reading up to 5 milliampères, or with shunt up to 50 milliampères	3 5 0
No. 286.	Similar instrument, reading up to 25 or 250 milliampères	3 5 0
No. 288.	Similar instrument, Fig. 288, with 2 shunts, reading up to 5, 50 and 500 milliampères	3 10 0

For **Amperemeters** and **Voltmeters**, see Nos. 950—980, page 73.

GRAPHITE RHEOSTATS.

No. 306. Rheostat with mercury contact, total resistance about 20,000 ohms, which can be diminished *gradually*, without any jumps, down to about 20 ohms, by turning the glass dial, Fig. 306, **£1 17 0**



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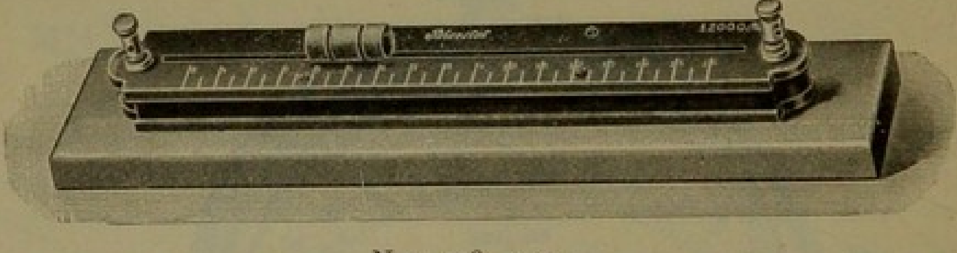
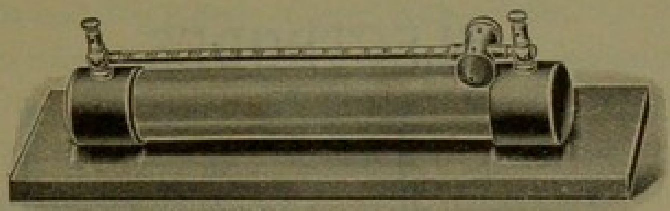


Nos. 308—319.

Rheostats with sliding spring; the resistances can be varied *gradually*, without any jumps.

No. 308.	From	3 to	200 ohms	.. .. ..	£0 18 0
No. 309.	,,	5 to	600 ,,	.. .. ..	0 18 0
No. 310.	,,	5 to	1,000 ,,	.. .. ..	0 18 0
No. 311.	,,	10 to	5,000 ,,	.. .. ..	0 18 0
No. 312.	,,	25 to	10,000 ,,	.. .. ..	0 18 0
No. 313.	,,	50 to	25,000 ,,	.. .. ..	0 18 0
No. 314.	,,	50 to	50,000 ,,	.. .. ..	1 0 0
No. 316.	,,	100 to	100,000 ,,	.. .. ..	1 0 0



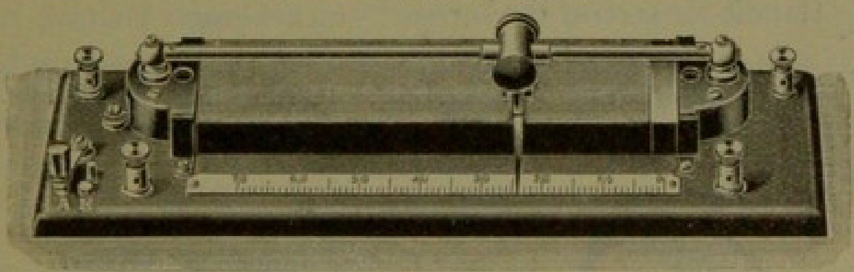
No. 323

No. 323.	**Metal Rheostat,** with about 1,000 contacts, Fig. 323—	
	(*a*) Total resistance, 2,500 ohms	£1 4 0
	(*b*) ,, ,, 5,000 ,, ...	1 4 0
No. 324.	Similar Rheostat, with about 100 contacts—	
	(*a*) Total resistance, about 5,000 ohms ..	1 10 0
	(*b*) ,, ,, ,, 10,000 ,, ..	1 14 0
	(*c*) ,, ,, ,, 20,000	1 17 0
	(*d*) ,, ,, ,, 50,000 ,, ..	2 2 0
	(*e*) ,, ,, ,, 100,000 ,, ..	2 10 0

These Rheostats are only suitable for currents not exceeding 0·2 ampère.

SHUNT RHEOSTAT (VOLT REGULATOR).

(*See also pages* 30–31.)



No. 327.

No. 327.	Volt Regulator, Fig. 327, mounted on board with terminals	£1 16 0
No. 328.	Double Volt Regulator	3 0 0

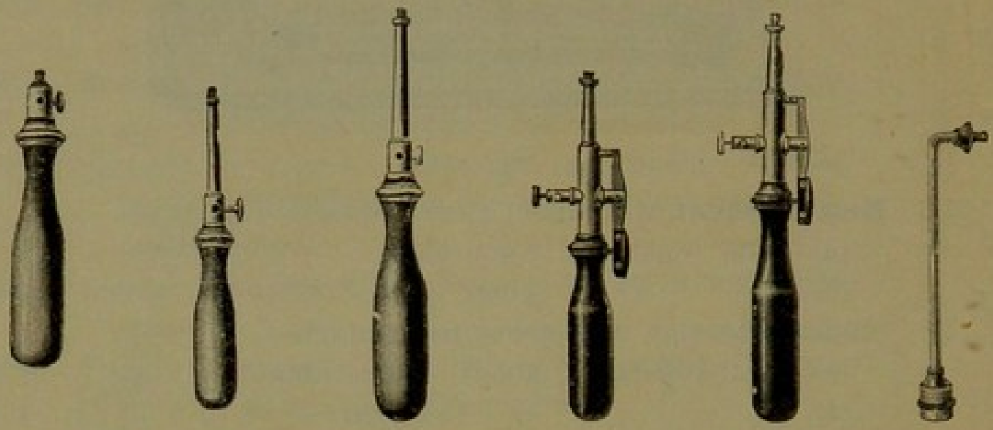
These rheostats consist of a slate core 9½ inches long, round which are wound about 500 turns of a fine insulated wire. The E.M.F. at the terminals can be increased or reduced by small fractions of a volt by moving the sliding contact; for instance, if the E.M.F. of the current passing through the rheostat is 50 volts, the current which is obtained at the terminals of the volt regulator rises or falls 0·1 volt only for every new turn of wire with which the sliding spring is brought in contact. For some laboratory experiments it may be desirable to obtain a still finer graduation, and in such a case a second volt regulator may be added.

These volt regulators are chiefly employed to utilize the current from the main for galvanisation, electrolysis, sinusoidal faradisation, etc. They are also very convenient if a battery of accumulators has to be used for these purposes.

CONNECTING CORDS.

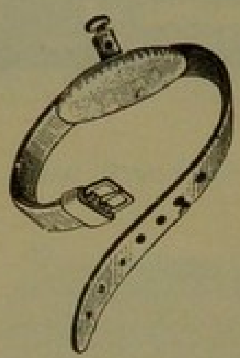
No. 329.	12 yards insulated copper wire	1/0
No. 330.	One pair of cords, for galvanisation, faradisation, or electrolysis, covered with silk, 1½ yards long	2/3
No. 332.	Ditto ditto 2 yards long	3/–
No. 336.	Separate terminals to be attached to silk cords .. each	–/6

ELECTRODES.

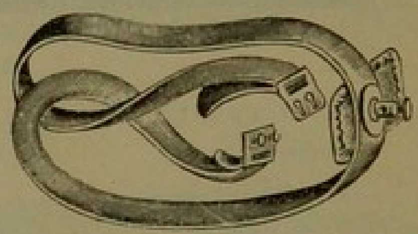


370. 371. 372. 376. 377. 385.

No. 370.	Simple Handle, 3 inches long	1/6
No. 371.	,, 4 ,, ...	2/6
No. 372.	,, 5 ,, ...	3/-
No. 376.	Handle for *interrupting* the current, 5 inches long ..	6/-
No. 377.	,, ,, ,, 6 ,, ...	6/6
No. 381.	Handle for *making* the current, 5 inches long	6/-
No. 382.	,, .. ,, 6 ,, ...	6/6
No. 385.	Connecting piece for fixing the electrodes at a right angle to the handles, Fig. 385	2/-



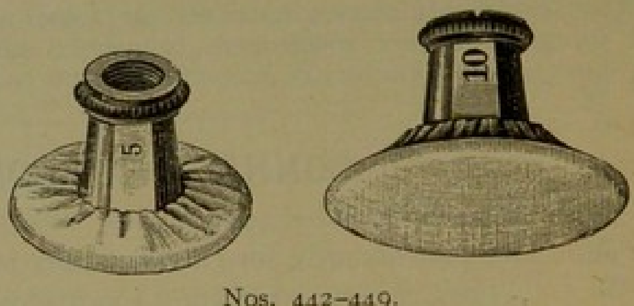
No. 412.



No. 418.

No. 412.	Bracelet for fixing electrodes to the arms or wrists ..	4/6
No. 418.	Belt Electrode, by Beard and Rockwell..	6/6

Nos. 430–432.

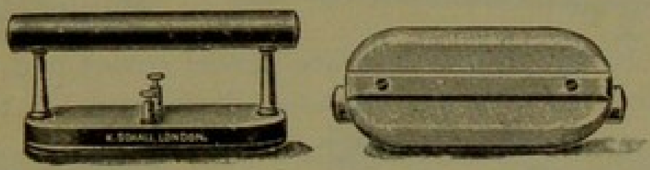


Nos. 442–449.

No. 430.	Button shape Electrodes, small	1/3
No. 432.	,, ,, .. large	1/6

Round Tin Plates, covered with cotton.

No. 442.	¾ inch diameter	**1/4**	No. 445.	2 inches diameter	**2/-**
No. 443.	1 ,, ,,	**1/6**	No. 447.	3 ,, ,,	**2/9**
No. 444.	1½ ,, ,,	**1/9**	No. 449.	4 ,, ,,	**4/-**



No. 395.

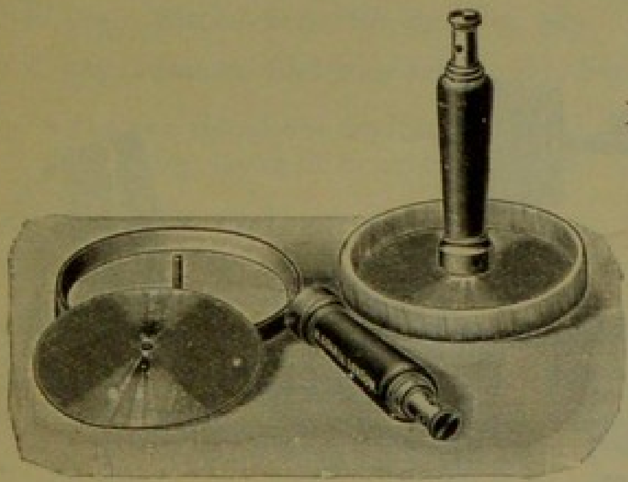
No. 395. Double Pole Electrode (Fig. 395), to combine electric treatment with massage **15/-**

No. 453.

Round electrodes, with an arrangement which makes it possible that for each patient a *new and clean cover* can be fastened over the electrode by means of a celluloid ring.

The illustration on the right shows the ring only, the illustration in the centre shows the electrode with a new cover ready to be slipped over it, and the illustration on the left shows the complete electrode, with cover held in position by the ring.

No. 453.	¾	1¼	1½	2	2½	3¼	4	5 ins. diam.
	1/9	**2/-**	**2/6**	**3/-**	**3/6**	**4/-**	**5/6**	**7/-**

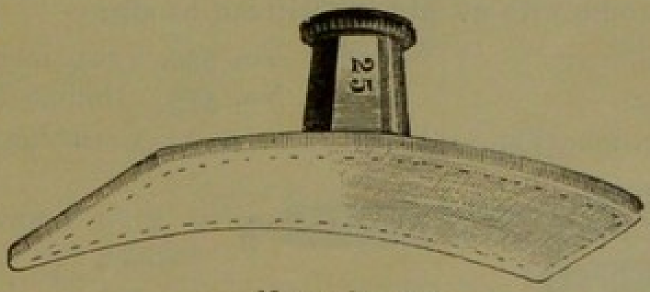


No. 455.

No. 455. New Electrodes, with changeable cover and strong handle, Fig. 455 (recommended by Dr. Lewis Jones), diameter 2½ ins. .. **6/6**

,, 4½ ins. .. **8/6**

,, 5½ ins. .. **9/6**



Nos. 460—470.

CAUTERY, SURGICAL LAMPS, MOTORS, Etc.
SWITCHBOARDS for Current from Main. LIGHT THERAPY
X-RAY APPARATUS

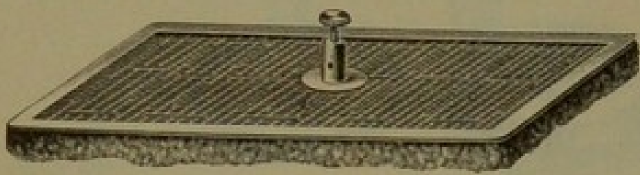
Square Flexible Electrodes, of tin, with leather covers.

No. 462.	2 square inches	1/9	No. 468.	8 square inches	3/9
No. 464.	4 ,, ,,	2/3	No. 470.	12 ,, ,,	4/6

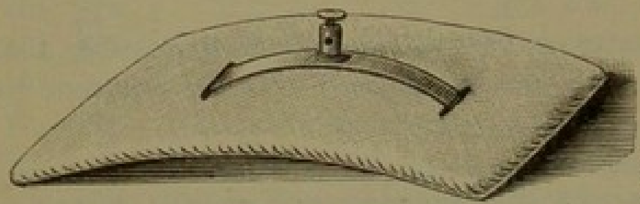
Nos. 442—449 and 460—470, with carbon plates and leather cover, 50 per cent. more.

Flexible tin Electrodes, with white flannel covers and terminals, back of the electrode covered with wax cloth (see illustration No. 103, page 50).

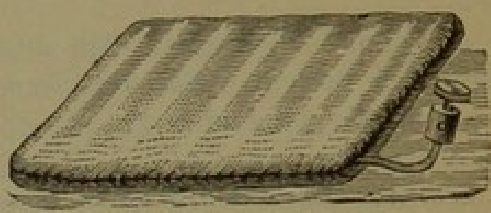
No. 480.	2½×4 inches	1/3	No. 493.	4½×8½ inches..	2/6
No. 483.	2¾×5	1/6	No. 495.	5 × 8½ .. .	3/-
No. 489.	3½×6	1/9	No. 497.	6 ×10	4/-



No. 500.
Flexible Metal Gauze Electrodes, with sponge, according to sizes, 5/- to 12/-

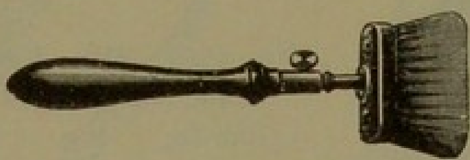


No. 510.



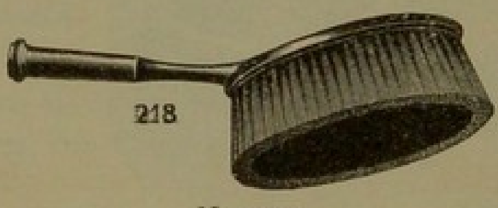
Nos. 525—528.

No. 510.	Large Indifferent Electrode, 3 × 6in.		7/-
No. 525.	Flexible Pillow Electrodes ..	70 square inches	10/-
No. 526.	,, ,, ,, ..	100 ,, ,,	12/-

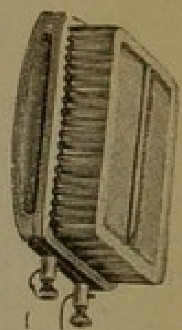


No. 545.

Nos. 540—542.



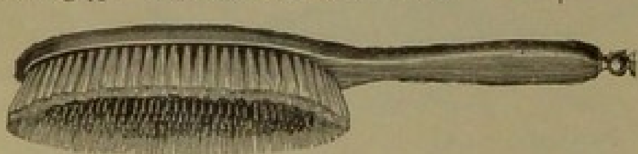
No. 550.



No. 555.

Brush electrodes with metal wire, without handles—

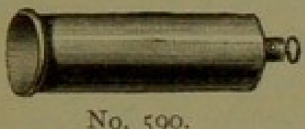
No. 540.	Small	1/6	No. 550.	7 sq. inches Fig. 550	7/-
No. 542.	Large	2/6	No. 555.	Double brush, 9 square inches, Fig. 555	10/6
No. 545.	2½ sq. ins. (Fig. 545)	5/6			



No. 557. Large brush, with handle, Fig. 557 .. 9/6

No. 557.

No. 559. Comb Electrode, Fig. 559 .. .. 3/-

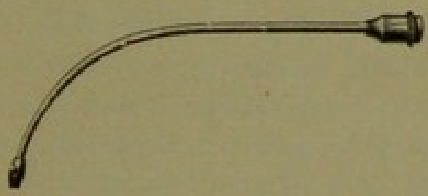


No. 590.

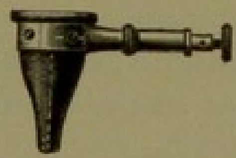
No. 573.

No. 572.

No. 587.

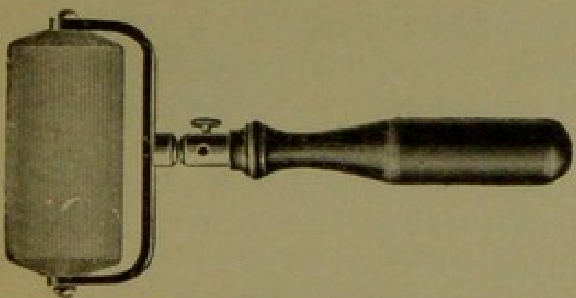


No. 560.

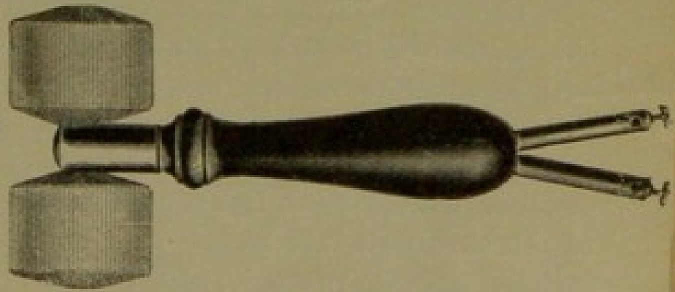


No. 585.

No. 560.	Electrode for larynx, with olive shaped button, shaft insulated with gutta-percha, Fig. 560	2/6
No. 570.	Electrode for rectum, 3 sizes .. .. .. each	4/6
No. 572.	Zinc Electrode for rectum, Fig. 572	3/-
No. 573.	Electrode for rectum, with douche, Fig. 573	6/-
No. 585.	Electrode for the ear, Fig. 585	6/-
No. 587.	Double Electrode for the ear, Fig. 587	12/-
	The two electrodes are insulated from one another, and can be used bipolar or monopolar, as desired.	
No. 590.	Electrode for penis, Fig. 590	8/-



No. 603.



No. 604.

No. 600.	Wheel Electrode, 1½ inch long, without handle	4/9
No. 602.	,, ,, 2½ inches long	5/9
No. 603.	,, ,, 3½ ,, Fig. 603	7/-
No. 604.	Double Wheel Electrode, with handle, Fig. 604	12/6

CAUTERY, SURGICAL LAMPS, MOTORS, Etc.

SWITCHBOARDS for Current from Main. LIGHTTHERAPY

X-RAY APPARATUS

IONIC MEDICATION.

The advantage of introducing drugs through the skin by means of an electric current is due to the fact that the chemicals thus introduced become distributed evenly in the minute cells, and SMALL doses will thus have a more powerful effect near the spot where the application is made, than much larger doses which are swallowed or injected. The latter are washed away and distributed rapidly over the whole body by the stream of blood, and occasionally produce undesired effects elsewhere.

It has been proved that a small dose of cocaine introduced by an electric current produces local anæsthesia for a longer time than a larger dose injected by a syringe, and lithium introduced electrically in small quantities can be traced longer than much larger doses which have been swallowed.

The chemical theory is simple. There is an electro-positive and an electro-negative part in each salt; if a current discharges through a solution, the metals or alkaloids become charged with positive electricity, they are repelled therefore from the positive pole and wander towards the negative pole, they are called the kat-ions; the acid radical becomes charged negatively, it is repelled by the negative, and attracted by the positive pole, and is called an-ion.

If, for instance, we introduce lithium through the skin, we have to connect a solution of lithium carbonate with the positive pole; if we wish to introduce salicylic acid, we have to connect a solution of sodium salicylate with the negative pole.

One or two per cent solutions should be used for ionic medication, and the strength of current should be in proportion to the surface of the electrodes used. Prof. Leduc recommends a current of 2 M.A. per square centimetre surface of the active electrode, and the application should last from ten to twenty minutes. Most patients can bear this strength of current, but in a few cases it is advisable to introduce a little cocaine first.

More information about these matters may be found in "Electric Ions, and their Use in Medicine," by Prof. Leduc. Translated by R. W. Mackenna, M.A., price 2s. 6d.

The electric apparatus required, and the manner of application, are quite simple, too. For the large majority of cases an 18- to 24-cell Leclanche battery, with a milliampèremeter, or a switchboard or Pantostat to reduce the current from the main, will do. Electrodes of the metal to be introduced, or of non-corrosive material (carbon, platinum) are best. If the area to be treated is small or plane, 5 to 10 layers of pure lint, which have been soaked in a solution of the chemicals, are placed on the skin, and carbon or metal electrodes of suitable size are pressed against them; or else the solution may be filled in cups of ebonite or glass, closed at one end with parchment or a disc of porous clay, at the other end with a carbon or platinum terminal to establish the electrical contact. If the area to be treated is large or uneven, like the knee, shoulder, hip, etc., the electrode should be flexible, to insure uniform and good contact. Chain electrodes of copper, zinc, etc., may be used over several layers of lint, or else the arms or legs may be immersed in basins filled with the solutions of the chemicals, and large electrodes of carbon establish the electric contact between the solution and the source of the electric supply.

For the treatment of gout it has been recommended to paint the affected part with liniment of iodine, and to soak the electrode which is to be connected with the positive pole in a solution of carbonate of lithium, and the electrode to be connected with the negative pole in a solution of salicylic acid. A current of 10 to 30 M.A.—according to the size of the electrodes used—should be applied for five to ten minutes.

Excellent results have been obtained by Dr. Lewis Jones in the treatment of rodent ulcer, etc., by this method (see his book, "Medical Electricity," or *Lancet*, Oct. 28th, 1905, or *Brit. Med. Journal*, Feb. 16th, 1907).

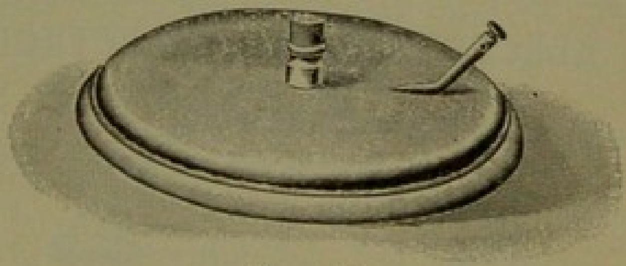
In the *Brit. Med. Jour.* of Aug. 15th, 1908, there is an article by P. L. Fenwick, M.D., recommending this method for the treatment of gonorrhœa.

The cost of a complete set, consisting of an 18-cell battery No. 116, with a milliampèremeter reading up to 30 M.A., cords, and a set of 6 different electrodes suitable for ionic medication, will be £6.

ELECTRODES FOR CATAPHORESIS, OR IONIC MEDICATION.

No. 630.

No. 632.



No. 638.

No. 630. Glass Vessel, with carbon rod, and porous clay cap, diameter 2½ ins., Fig. 630 .. .. 8/-

No. 632. Cup of ebonite, with a spiral platinum wire, to make contact, Fig. 632. .. .. 9/-

No. 638. Large Electrode for cataphoresis, diameter 8 ins., consisting of a disc of aluminium over which parchment or a pig's bladder can be fastened, Fig. 638 .. .. .. 16/-

No. 642.

No. 642. Dr. Meissner's Double Electrode, diameter 2 ins., Fig. 642 .. .. .. 16/-

No. 645. Set of Dr. Lewis Jones' Electrodes, of pure zinc, consisting of 5 needles and 4 larger electrodes of different sizes, for the treatment of rodent ulcer 10/-

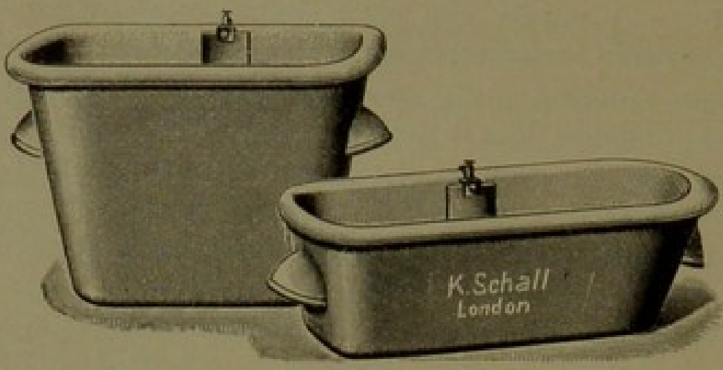
No. 647. Dr. Lewis Jones' Electrode, made of copper rings, to fit the head of a child of about 10 years 16/-

No. 648. 4½ × 6 in. 8/-

No. 649. 5½ × 11 in. 11/-

Other sizes can be made to order.

No. 650. Complete set of Ophthalmic Electrodes by Dr. Wirtz (see *The Ophthalmoscope*, Jan., 1911, "Iontophoresis in Eye Work") £2 8 0



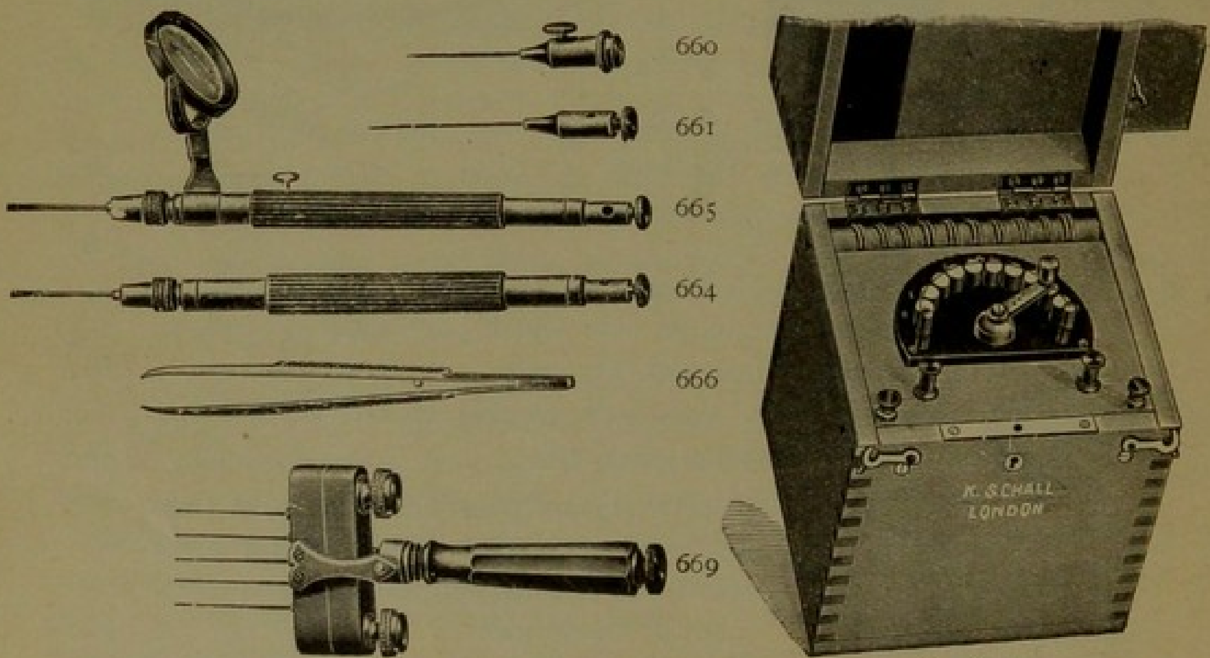
No. 652. No. 651.

No. 651.	Large porcelain tub, for an arm-bath, with carbon electrode, Fig. 651	14/-
No. 652.	Large porcelain tub, for a foot-bath, with carbon electrode, Fig. 652	16/-

These tubs are convenient for ionic medication. See page 67.

ELECTRODES FOR ELECTROLYSIS AND FOR THE TREATMENT OF STRICTURES.

Needles for removing Hairs, Nævi, and Small Tumours.



No. 675.

No. 660.	Steel Needle with terminal, Fig. 660	1/6
No. 661.	Platinum Needle with terminal, Fig. 661	3/9
No. 662.	Gold Needle	3/-
No. 663.	Lens as shown in Fig. 665, for magnifying the hairs; it can easily be attached to our needle-holders Nos. 664 or 665 ..	5/-

No. 664.	Needle-holder for the reception of different needles, Fig. 664	4/-
No. 665.	Needle-holder with interrupter .. „ 665	4/6
No. 666.	Forceps for epilation .. .. „ 666	2/6
No. 668.	25 steel needles (No. 12)	-/6
No. 669.	Dr. Lewis Jones' multiple bipolar needle-holder, for treatment of nævi, Fig. 669	15/-

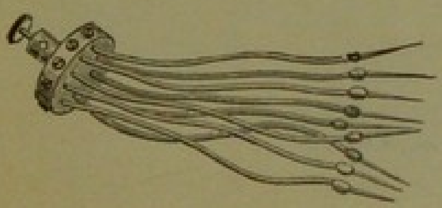
No. 675. Complete set for epilation, consisting of 9-cell battery with collector inserting the cells one by one (see Fig. 675), bracelet electrode No. 412, needle-holder No. 664, forceps No. 666, a packet of needles and connecting wires £3 6 0

Explicit directions for use are sent with this outfit.

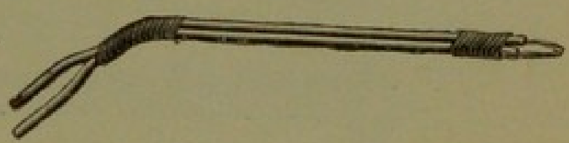
Needles for destroying tumours, etc., with flat platinum points, and shafts insulated with india-rubber.

Nos. 676—679.

No. 676.	Needle, 1 inch long	4/-	No. 678.	Needle, 3 inches long	5/-
No. 677.	„ 2 inches long	4/9	No. 679.	„ 4 „ „	5/9



No. 680.



No. 695.

No. 680.	Electrode, holding 12 steel needles, Fig. 680	8/-
No. 682.	Electrode, holding 12 platinum needles	16/-
No. 695.	Voltolini's double needles, Fig. 695	3/3

No. 710.

No. 710. Bougie electrode, with Brodie's handle, for the treatment of strictures of the urethra, Fig. 710 . .. .. 8/6

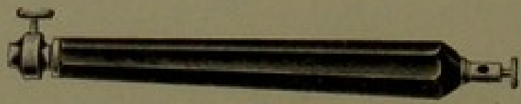
No. 713.

No. 713. Similar electrode, very flexible, in metal case,. Fig 713 .. 18/-

CAUTERY, SURGICAL LAMPS, MOTORS, Etc.
SWITCHBOARDS for Current from Main. LIGHT THERAPY
X-RAY APPARATUS

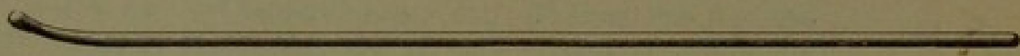
ELECTRODES FOR THE TREATMENT OF UTERINE FIBROIDS ETC.

746



747

747A



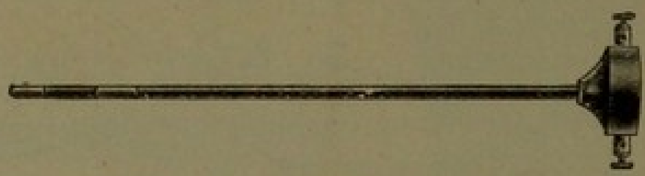
No. 746.	Handle for the reception of uterine sounds, Fig. 746 ..	7/0
No. 747.	Prof. Engelmann's aluminium Sound, Fig. 747	2/6
No. 747*a*.	Dr. Apostoli's Sound, of silver, Fig. 747*a*	9/0

No. 757

No. 760.

No. 757.	Vaginal Electrode, Fig. 757	4/6
No. 760.	Uterine Electrode, Fig. 760	4/6

No. 789.



No. 790.

No. 789.	Dr. Apostoli's double vaginal Electrode, Fig. 789.. ..	15/-
No. 790.	Do., do., Electrode for the urethra and uterus, Fig. 790	10/6

[*Copy of an unsolicited testimonial.*]

"DEAR SIR,

"Will you please send me one of your combined batteries, No. 132, if you consider that this is a good form for general consulting-room use?

"I have had many batteries from various makers, and I think the three I have had from you are much superior to any others I have seen of their kind, and also cheaper considering their workmanship.

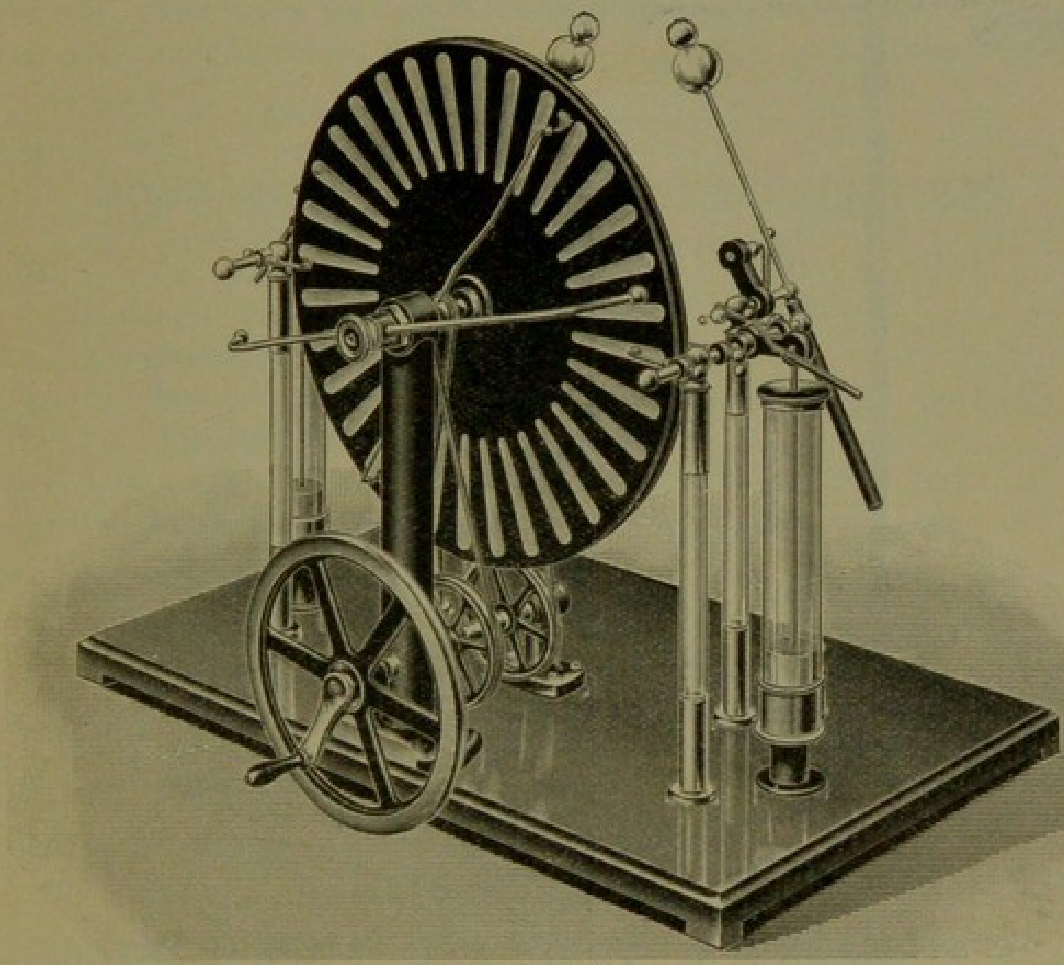
"Yours faithfully,

"FORBES FRASER."

"2, THE CIRCUS, BATH."

APPARATUS FOR FRANKLINISATION.

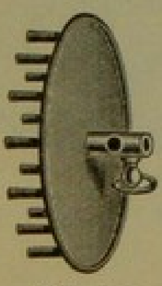
Of all the various constructions of static machines, the Wimshurst machines have been found to be the most reliable.

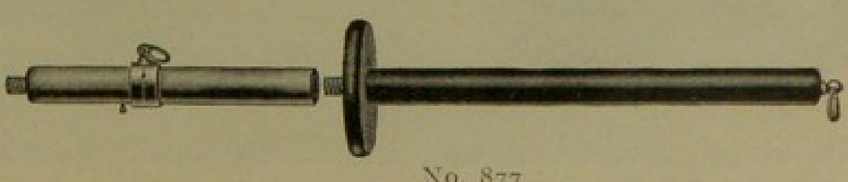


No. 806.

WIMSHURST MACHINES.

No. 806.	With two ebonite plates, diameter 22 in. ..	£13	10	0
No. 807.	,, four ,, ,, ,, ,, ..	20	0	0
No. 808.	,, eight ,, ,, ,, ,, ..	38	0	0
No. 860.	Large insulating platform, 40 × 28 in., on strong feet of glass	2	5	0
No. 870.	Electrode, with wooden ball or point	0	8	6
No. 871.	,, ,, metal ,, ,, ...	0	8	6
No. 877.	Long insulating handle of ebonite, for electrodes for static electricity or high-frequency currents, Fig. 877 ..	0	8	0

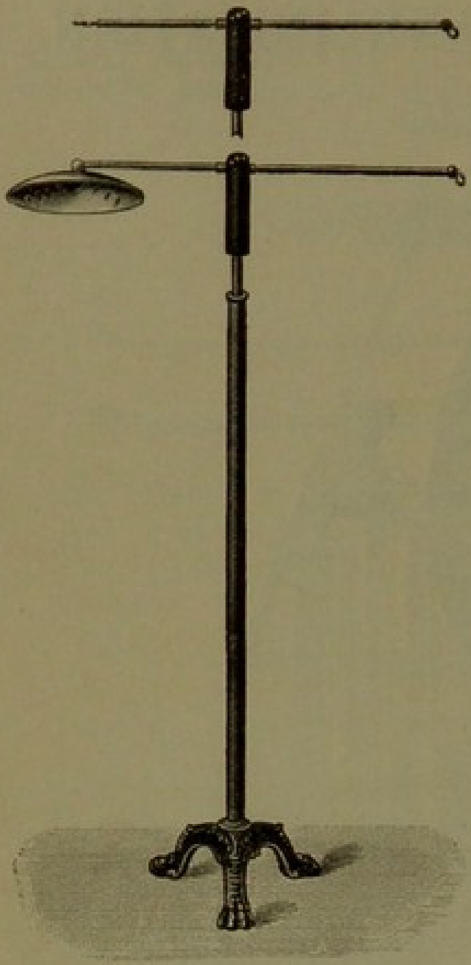




No. 877

No. 879

CAUTERY, SURGICAL LAMPS, MOTORS, Etc.
SWITCHBOARDS for Current from Main. LIGHTTHERAPY
X-RAY APPARATUS



No. 880

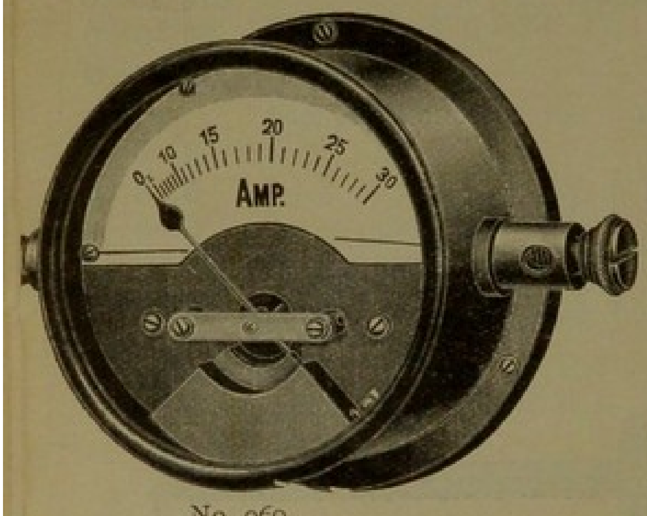
No. 879. Multiple point electrode, Fig. 879 .. .. **12/6**

No. 880. Bowl for the head, on insulated stand, Fig. 880 .. .. .. **50/-**

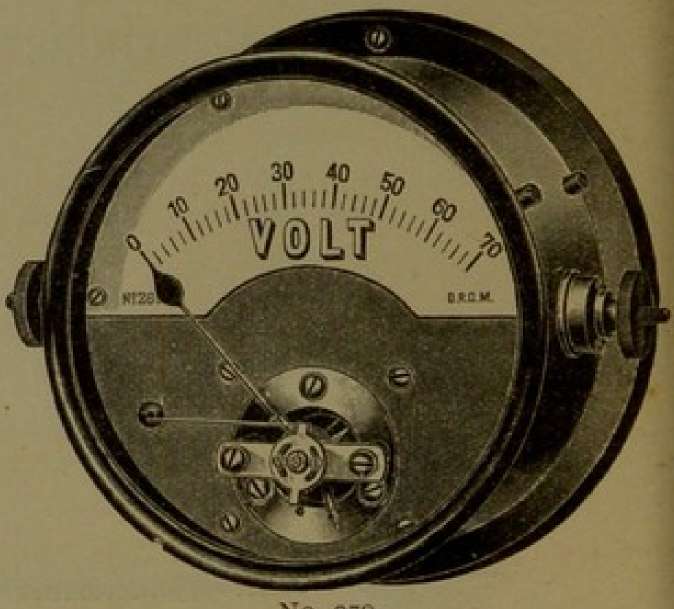
No. 885. Two highly insulated cables, for static electricity or high-frequency currents .. **10/-**

Electric motors suitable to drive static machines vary from £**6** to £**9**, including rheostat.

ELECTRO-MAGNETIC VOLT AND AMPÈREMETERS.



No. 960.



No. 970.

In consequence of the addition of a pneumatic chamber, these instruments are practically dead beat.

Diameter 4 ins.; diameter of the base 5 ins.

Price of volt or ammeter for continuous current	£1	10	0
„ „ „ alternating „	1	8	0

No. 950. Voltmeters are supplied reading up to 3, 5, 20, 50, 100 or 130 volts.
No. 960. Ampèremeters, *Fig.* 960 „ „ 1, 5, 10, 20, 40 or 50 amps.

DEAD BEAT VOLT AND AMPÈREMETERS, for Continuous Current.

(Moving Coil or D'Arsonval Type.)

No. 970. **Voltmeters**, *Fig.* 970—

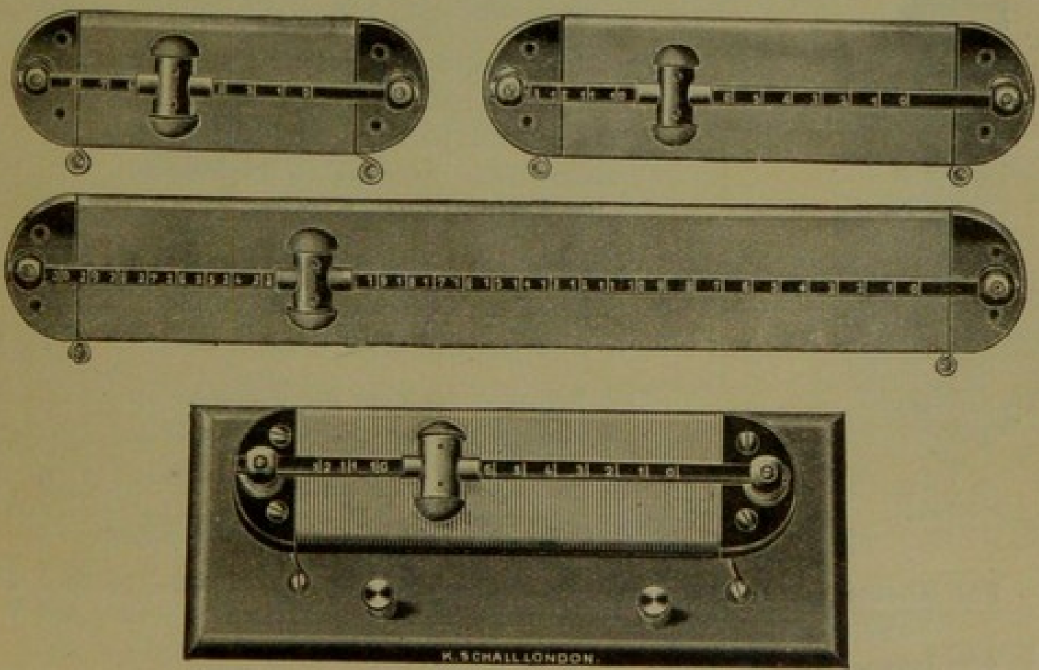
Reading up to	5	30	50	100	130	200	250 volts.
Diameter, 4 ins.	65/-	66/-	68/-	70/-	70/-	—	—
„ 7 ins.	72/-	72/-	73/-	74/-	74/-	78/-	80/-
„ 8½ ins.	86/-	86/-	86/-	87/-	88/-	90/-	92/-

No. 980. **Amperemeters**—

Reading up to	1	5	10	20	50	100 ampères.
Diameter 4 ins.	65/-	65/-	65/-	68/-	70/-	—
„ 7 ins.	70/-	70/-	70/-	70/-	72/-	74/-
„ 8½ ins.	86/-	86/-	86/-	86/-	86/-	86/-

RHEOSTATS.

With Sliding Contact, wound on Slate Cores.



Nos. 982 to 988.

CAUTERY, SURGICAL LAMPS, MOTORS, Etc.
SWITCHBOARDS for Current from Main. LIGHTTHERAPY
X-RAY APPARATUS

	Length	..	5½	7½	9½	14 inches.
No. 982.	Resistance	..	0·3	0·4	0·5	— ohms.
	Current	..	12	17	20	— ampères.
	Price	..	19/-	22/-	24/-	
No. 984.	Resistance	..	4	5	5	7 ohms.
	Current	..	3	4	6	6 ampères.
	Price	..	16/-	18/-	20/-	25/-
No. 986.	Resistance	..	20	60	80	100 ohms.
	Current	..	1	1	1	1 ampères
	Price	..	16/-	18/-	20/-	25/-
No. 988.	Resistance	..	250	500	1000 ohms.	
	Current	..	0·1	0·2	0·1 ampères.	
	Price	..	20/-	27/-	30/-	

If mounted on polished board, with terminals, the prices are increased by 2/9.

None of these rheostats can be connected directly with the current from the main, but many of them can be used with 100 to 250 volt currents if an incandescent lamp or a motor is connected in series with the rheostat.

We have quoted the maximum number of ampères for which the rheostats are suitable; these figures are approximately correct only if the rheostats are not switched on for longer than about fifteen minutes at a time.

RESISTANCES FOR CHARGING ACCUMULATORS FROM THE MAINS.

No. 995.

No. 995. Resistance Lamp-holder, with terminals for connection with accumulators, Fig. 995 .. £0 6 0

This Lamp-holder is inserted into an ordinary Edison lamp-holder, and is suitable for lamps up to 60-candle-power. The poles are ascertained by means of pole-finding paper.

No. 997. Board with 4 lamp-holders, switch, fuse, and terminals to connect with accumulators 1 5 0

This board is suitable for currents up to 5 ampères on a 200-volt supply.

No. 999. Book with pole-finding paper .. 0 1 6

The negative pole makes a red stain on the moist paper.

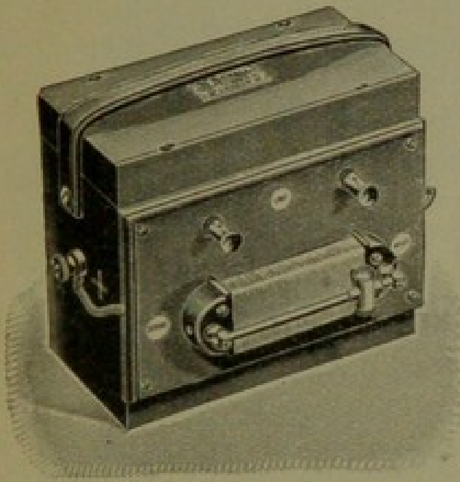
For Rheostats for Galvanisation, etc., see also Nos. 306–328 and 1820–1850.

For Rheostats for Spark Coils, see also Nos. 2672–2678.

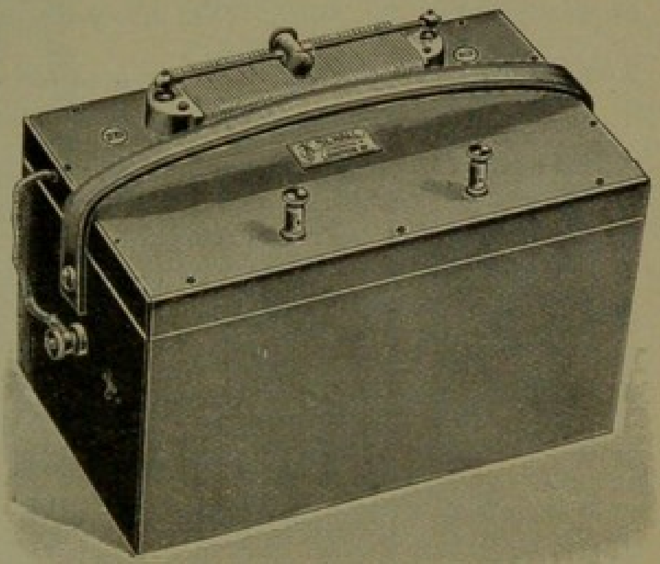
For Rheostats for Cautery, etc., see also Nos. 2000–2050.

ACCUMULATORS.

(See also pages 18–20.)



No. 916.



No. 922.

No. 1010.	4-Volt Accumulator, for surgical lamps only, capacity 15 ampère hours, in leather case .. .. Size $4\frac{1}{2}\times2\frac{1}{2}\times6\frac{1}{4}$ in., weight about 3 lbs.	£1	8	0
No. 1012.	8-Volt Accumulator, for surgical lamps only, capacity 15 ampère hours, in polished mahogany case, **including rheostat,** Fig. 916 .. .. .. Size $4\frac{1}{2}\times8\frac{1}{2}\times6$ in., weight 15 lbs.	3	0	0
No. 1015.	4-Volt Accumulator, for cautery burners, capacity 45 ampère hours, in polished walnut case, **including rheostat** .. .. Size $7\frac{1}{2}\times7\times6\frac{1}{2}$ in., weight 24 lbs.	3	10	0
No. 1018.	8-Volt Accumulator, for cautery or surgical lamps, capacity 45 ampère hours, in polished walnut case, **including rheostat,** Fig. 922 .. .. .. Size $7\frac{1}{2}\times12\times7$ in., weight 45 lbs.	5	12	0
No. 1020.	12-Volt Accumulator, for surgical motors, spark coils, cautery, or surgical lamps, capacity 45 ampère hours, in polished walnut case, **including rheostat** .. Size $7\frac{1}{2}\times18\frac{1}{2}\times6\frac{1}{2}$ in., weight 60 lbs.	7	12	0
No. 1024.	12-Volt Accumulator, in teak case, capacity 50 ampère hours, **without** rheostat	6	9	0

Other sizes or single cells can be supplied to order.

CAUTERY, SURGICAL LAMPS, MOTORS, Etc.
SWITCHBOARDS for Current from Main. LIGHT THERAPY
X-RAY APPARATUS

BICHROMATE BATTERIES FOR GALVANIC CAUTERY & FOR WORKING SPARK COILS.

(*See also pages* 15–18.)

*The Batteries marked * may also be used for lighting Surgical Lamps and driving Surgical Motors.*

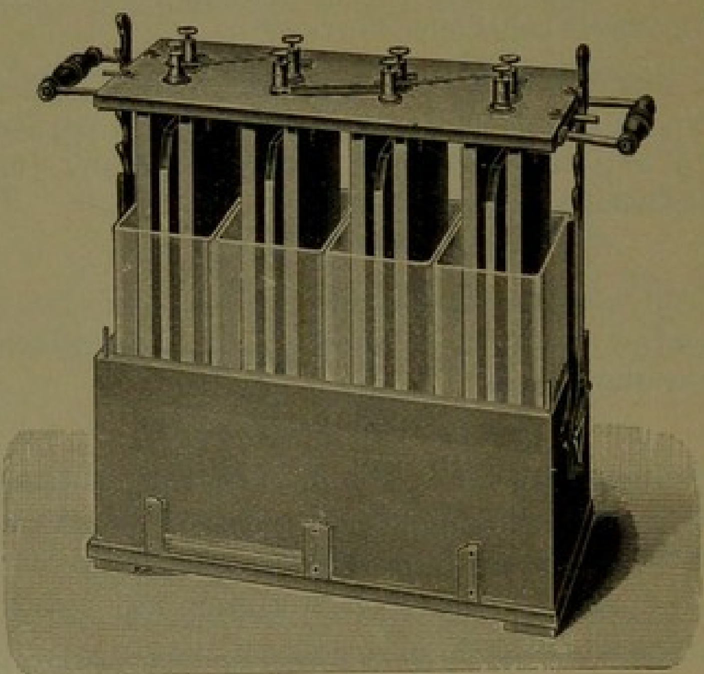
Batteries with two cells suffice for eye operations with galvanic cautery: for all other operations where galvanic cautery may be applied, four cells are required. Batteries with six or more cells are supplied, partly to enable the operator to double the constancy of his cells by connecting them up parallel, and partly for making the batteries useful for surgical lamps and for spark coils.

SIMPLE BATTERIES,

IN OAK CASE, FOR HOSPITALS, &C.

Each cell gives a current of over 30 ampères.

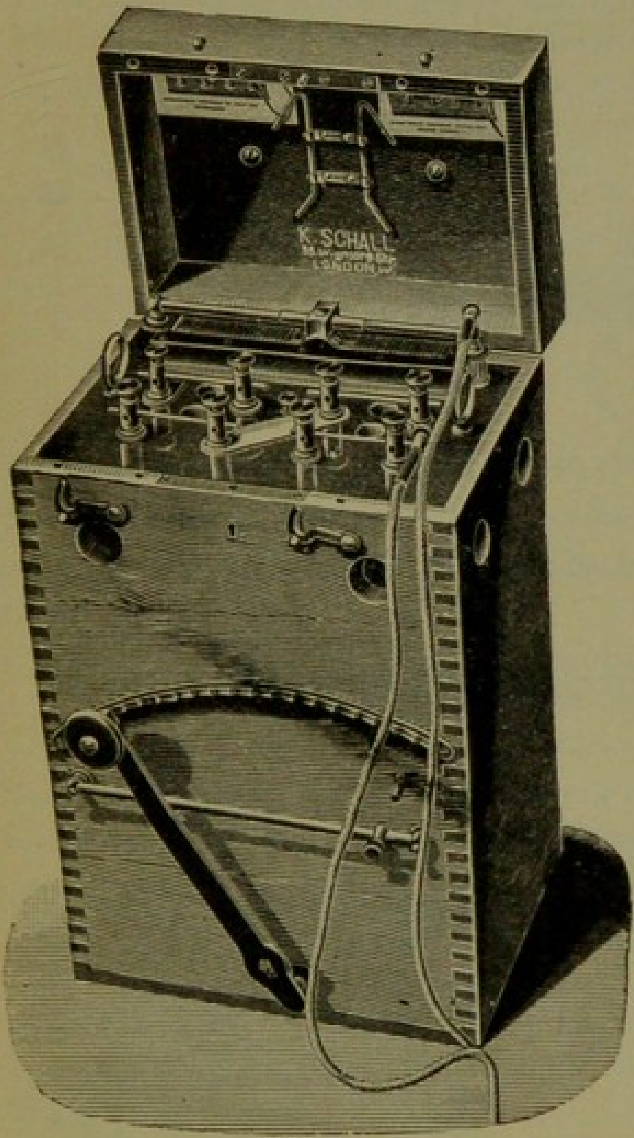
*No. 1035.	4 cells	**£4 0 0**
*No. 1037.	8 „	**6 10 0**
*No. 1039.	12 „	**9 0 0**



No. 1035.

The battery No. 1039 may be used for spark coils, provided that it is supplied with larger glass vessels, measuring 4½ × 7 × 9 ins. each. Price of No. 1039 with larger cells **£11 0 0**

The prices include connecting cords. Rheostat for any of the above batteries, extra **18**/–



No. 1040.

SCHALL'S PORTABLE CAUTERY BATTERY,

In Oak Case, with rheostat and cords.

*No. 1040. 4 cells, 7 × 9½ × 15 ins. Weight, 24 lbs.,
Fig. 1040 .. **£5 15 0**

*No. 1042. 6 cells **8 5 0**

The 6-cell battery is provided with a current collector in addition to the abovementioned accessories.

There are now about 900 batteries No. 1040 and No. 1042 in use in Great Britain and the Colonies, the best proof of their practical construction and reliable working. These batteries can be used equally well for cautery and for light, and they may be used to a limited extent for electrolysis, for removing hairs, destroying nævi, etc.

The acid is contained in strong ebonite vessels, pressed out of one piece. The ebonite cell can be moved up and down by means of a handle on the outside of the battery, and can be fixed at any elevation. A 4-cell battery keeps a platinum burner incandescent for about thirty minutes, and requires for its filling half a gallon of acid solution.

Copy of an unsolicited testimonial :—

Dear Sir,

Please send me six new zincs for the cautery battery (1042) I bought five years ago. It is a first-rate battery, and never has had ''a days's illness''--unlike most electrical plant.

Yours faithfully,

John K. Murray

Whittlesea, Cape Colony.

SWITCHBOARDS for Current from Main. LIGHTTHERAPY

X-RAY APPARATUS

Spare Zincs for batteries Nos. 1040 and 1042, consisting of 10 parts of zinc and 1 part of mercury, weight 1 lb. 12 ozs. ..	..each	3/-
One pair of Carbons	.. "	7/-
Ebonite vessel for 4-cell battery	.. "	21/-
Ditto ditto 6-cell do.	.. "	29/-
Acid, ready mixed, for charging the batteries Nos. 1035–1042, per gall.		3/-

Accumulators for cautery and spark coils will be found on page 75. For Rheostats and Transformers for utilizing the currents from dynamos for cautery and spark coils, see Nos. 2000-2050, and 2672-2678.

We have supplied Batteries Nos. 1040 and 1042, amongst many others, to: –

The War Office, The Crown Agents for the Colonies, to the Governments of India, Natal, New Zealand, etc.

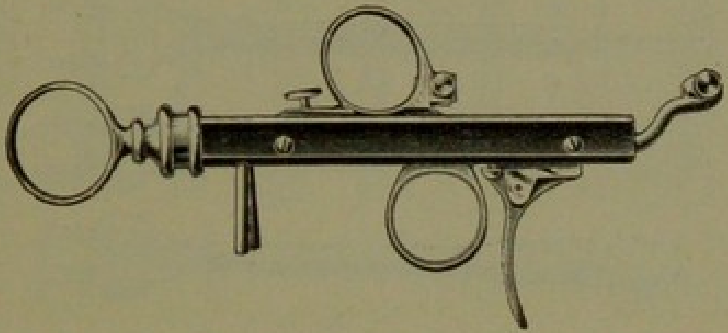
St. Bartholomew's, Charing Cross, Guy's, St. Peter's, St. Thomas's, Great Northern, London, St. Mary's, and Westminster Hospitals; Lock Hospital; Hospital for Diseases of the Heart and Paralysis, German Hospital, Victoria Hospital for Children, Central London Ophthalmic Hospital, Royal Hospital for Diseases of the Chest, etc.

Royal Infirmaries, Bristol, Glasgow, Windsor, Edinburgh; Western Infirmary, Glasgow; Queen's Hospital, Birmingham; Bristol Eye Hospital; Kent County Ophthalmic Hospital, Maidstone; Infirmary, Wolverhampton; Eye and Ear Hospital, Liverpool; Eye and Ear Infirmaries, Southampton and Bath; Ear and Throat Hospital, Birmingham; General Infirmaries, Leeds and Sheffield; Children's Hospital, Pendlebury; Ear Institution, Manchester; Throat and Ear Hospital, Nottingham; Eye Hospital, Shrewsbury; South Devon Hospital, Plymouth; Children's Hospital, Sheffield; Eye Hospital, Oxford; Hospital for Sick Children, Newcastle; Grimsby and District Hospital; Sanatorium, Weymouth; Wolverhampton and Staffordshire Infirmary; Manchester and Salford Hospital; Royal Sussex County Hospital, Guildford; Ripon Hospital, Simla; Medical College, Lahore, etc. And

To over 900 Medical Men.

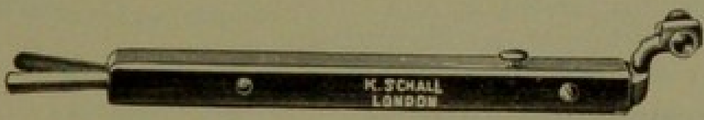
INSTRUMENTS FOR GALVANIC CAUTERY.

The "Universal" Handles can be used for burners *and* snares.
The "Simple" Handles can be used for the burners *only*.



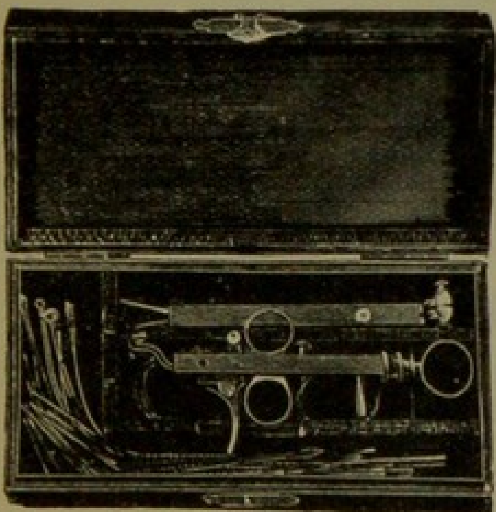
No. 1100.

No. 1100. Universal Handle, by Dr. Schech, Fig. 1100 .. £1 7 0



No. 1101.

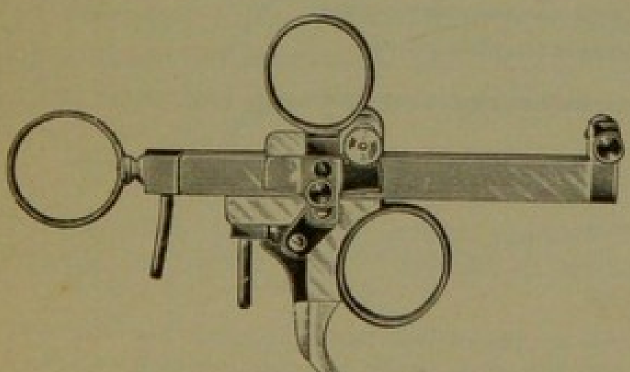
No. 1101. Simple Handle, by Dr. Schech, Fig. 1101 .. .. 0 12 6
No. 1102. Set of Simple Handle and 3 different burners, in case 1 4 0



No. 1104.

No. 1103. Set of Universal Handle, six different burners, two ligature tubes, and one porcelain burner, platinum wire for one loop, and steel wire for twelve loops £3 5 0

No. 1104. Schech's Universal Handle and Simple Handle, with ten platinum burners, two ligature tubes, two porcelain burners, platinum and steel wire, in case, Fig. 1104 .. £4 8 0

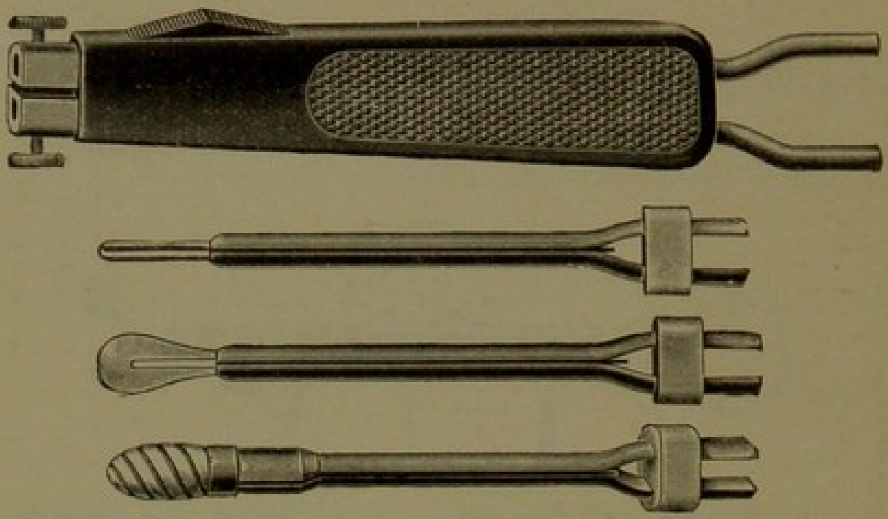


No. 1112.

No. 1112.
Universal Handle,
by Dr. Kuttner.
Fig. 1112 .. £1 16 0

SWITCHBOARDS for Current from Main. LIGHTTHERAPY
X-RAY APPARATUS

No. 1114.

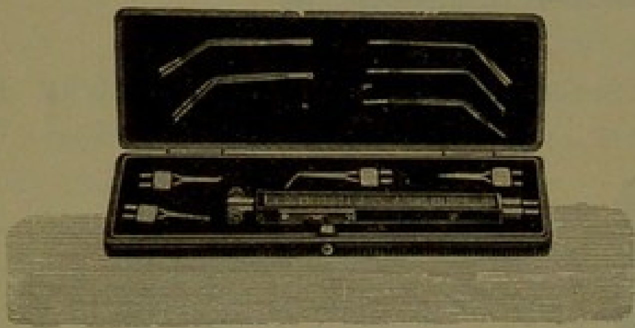


No. 1114. Cautery Handle, Fig. 1114, suitable for burners requiring up to 50 ampères (for gynæcological operations) £1 10 0

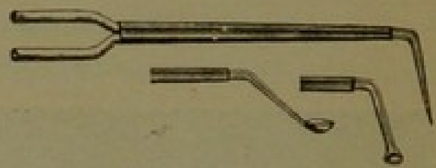
Point or knife-shaped platinum burners for this handle (see illustration) .. .. .. each 0 18 0

Porcelain burner (see illustration) .. ,, 1 1 0

One pair of extra stout cables for handle No. 1114 .. 0 10 0



No. 1116.

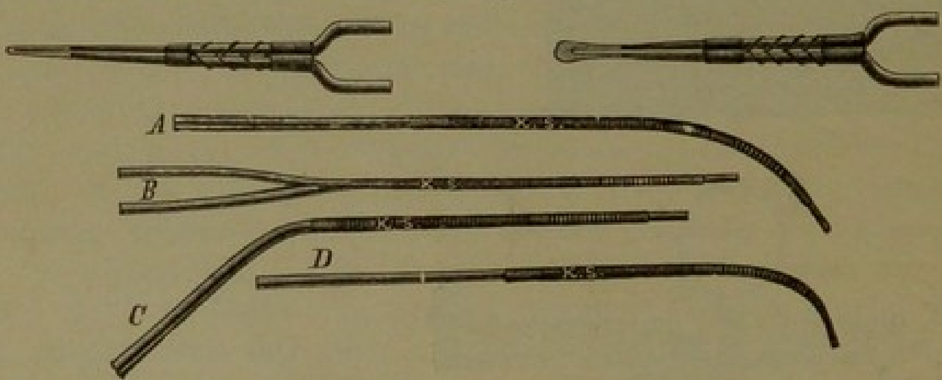


No. 1117.

No. 1116. Handle for eye operations, with five burners, in case, by Prof. Sattler-Nieden, Fig. 1116 .. .. £1 10 0

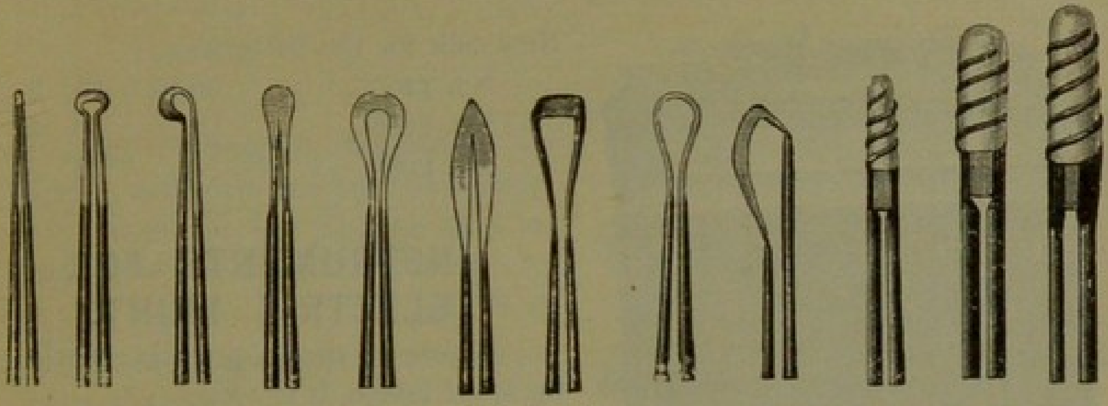
No. 1118.

No. 1118. Handle for small burners, Fig. 1118 .. .. 0 15 0



Shape and description of the ordinary curves of burners and ligature tubes. The length is 4, 6, or 8 inches, as desired. Other curves or burners can be made to order.

In ordering, please state the desired length in inches. and for the curve quote the capital letter printed by the side, and the form of the platinum, with its accompanying figure as shown in Nos. 1120—1150.



1120 1122 1123 1125 1126 1131 1132 1133A 1137 1150 1151 1152

Shape and numbers of the burners: Nos. 1120—1134 platinum, 1150—1151 porcelain.

Prices of the burners: Nos. 1120—1137, 3/3; 1150—1152, 5/- ligature tubes, 3/6.

The burners 1120—1133 require 15 to 18 ampères and 4 to 10 volts

The eye and ear burners require only 8 to 10 ampères.

Platinum wire for one large loop	£0	5	0
Steel wire, 0·3 or 0·4 millimetre thick, for six loops	0	1	0
Cases for cautery instruments	0	4	0

No. 1174.

No. 1174.	Micro hot air burner for dermatological purposes, with two silver nozzles of different sizes, Fig. 1174	1	18	0

BATTERIES FOR ELECTRIC LIGHT.

(*See also page* 21.)

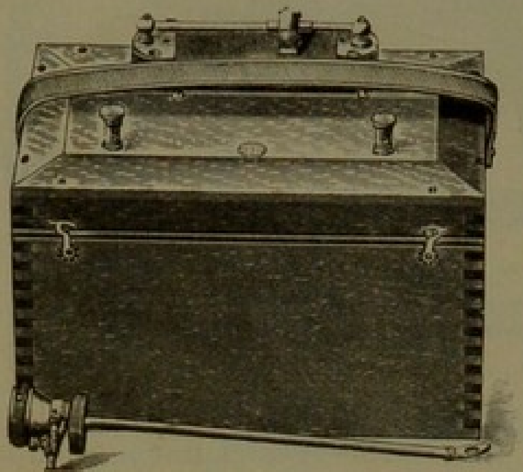
In order to make the lamps which are described on the following pages incandescent, batteries of 6 to 12 volts have to be used, or else the current from the main has to be reduced by means of a resistance or a transformer. About these latter instruments, see page 35, and Nos. 2000—2067.

The most suitable batteries are **accumulators** (see pages 75 and Nos. 1010—1024), or **bichromate batteries** (see pages 15–18 and Nos. 1035—1042), or **dry Leclanché batteries** (see Nos. 1180—1188 below.)

Leclanché Dry Batteries for electric light, with rheostat and cords.

		Volts.	Capacity in amp. hours.	Weight.			
No. 1180.	6 cells, 4 × 5½ × 5½ inches	9	5	4 lbs. ..	£1	10	0
.. 1186.	8 ,, 6 × 9½ × 8 ,,	12	15	15 ,,	2	7	0
,, 1188.	8 ,, 6½ × 13 × 9 ,,	12	30	24 ,, ..	2	14	0

The battery No. 1180 is useful for the so-called "cold" lamps only.



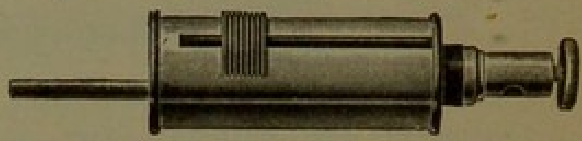
No. 1186.

New cells for the batteries—

No. 1180	..	each	£0	2	0
No. 1186	..	,,	0	2	6
No. 1188	..	,,	0	3	0

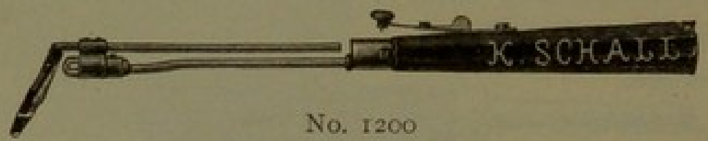
INSTRUMENTS FOR ELECTRIC LIGHT.

Where no special price is mentioned for spare lamps, it is 2/6.



No. 1195.

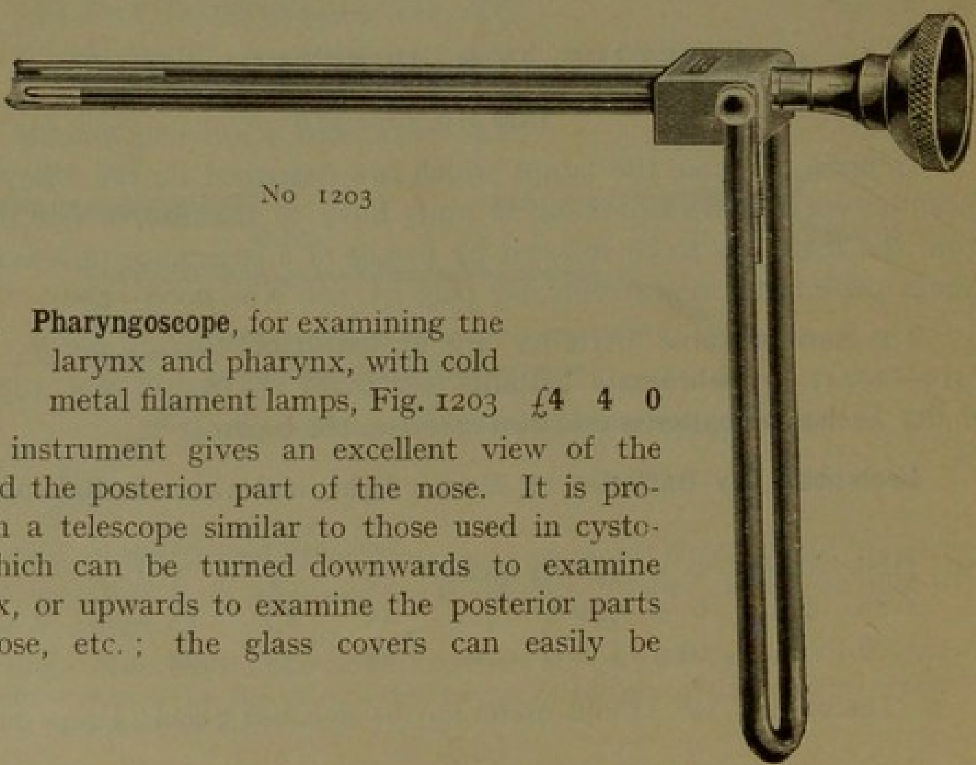
No. 1195. Special Rheostat for very small lamps, Fig. 1195. One end is to be fixed into the terminal of battery or transformer, and a connecting cord is attached to the other end 0 7 0



No. 1200

No. 1200. **Laryngoscope,** by Dr. Semon, with case and one spare lamp, Fig. 1200 .. .. 1 16 0

This instrument can also be very advantageously used in dental operations. Further, the mirror can be removed, and the lamp, which has a very thin handle, can be used for the illumination of other cavities of the body.



No 1203

No. 1203. **Pharyngoscope,** for examining the larynx and pharynx, with cold metal filament lamps, Fig. 1203 £4 4 0

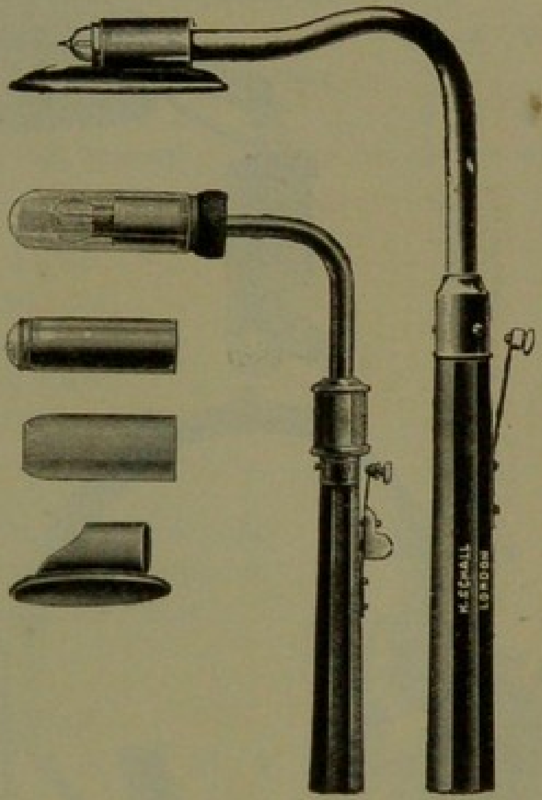
This instrument gives an excellent view of the larynx and the posterior part of the nose. It is provided with a telescope similar to those used in cystoscopes, which can be turned downwards to examine the larynx, or upwards to examine the posterior parts of the nose, etc.; the glass covers can easily be sterilised.

No. 1206. **Tongue depressor,** by Schall, with case and one spare lamp, Fig. 1206. It can also be used for making the antrum transparent. £1 18 0

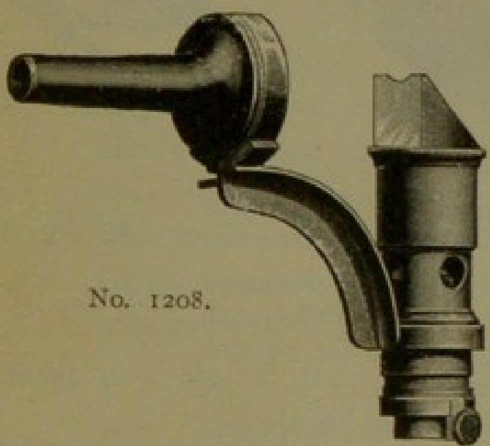
The ebonite spatula can be removed to be cleaned.

No. 1207. Hand lamp, Fig. 1207, £2 8 0

This lamp can be used as a hand lamp, or as a tongue depressor, or, with a bull's-eye lens, for making the antrum transparent.



No. 1207. No. 1206.



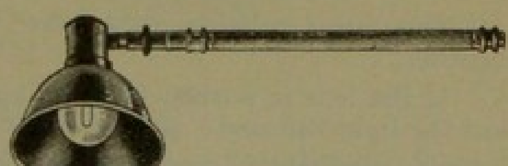
No. 1208.

No. 1208. Schall's **Otoscope,** fitted with incandescent lamp, case, spare lamp, and three ear funnels in case, Fig. 1208 £2 16 0

Extra spare lamps, 2/6 each.

This apparatus gives a brilliant light, and allows free movement for the operating instrument.

No. 1210.



No. 1211.

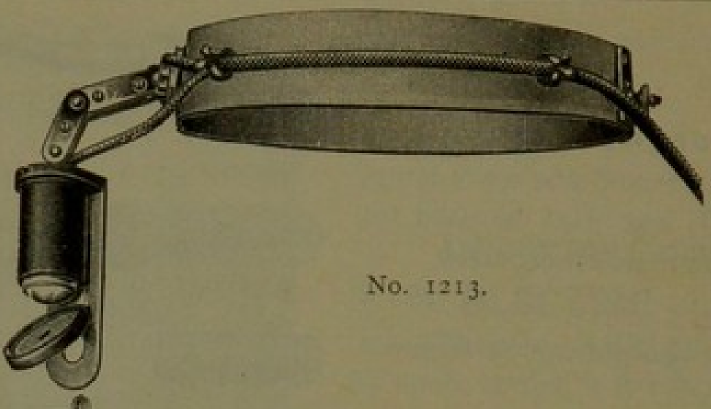
No. 1210. **Incandescent lamp,** for vaginal speculum, with one spare lamp, Fig. 1210 .. .. .. £1 5 0

The lamp can be clamped to any speculum.

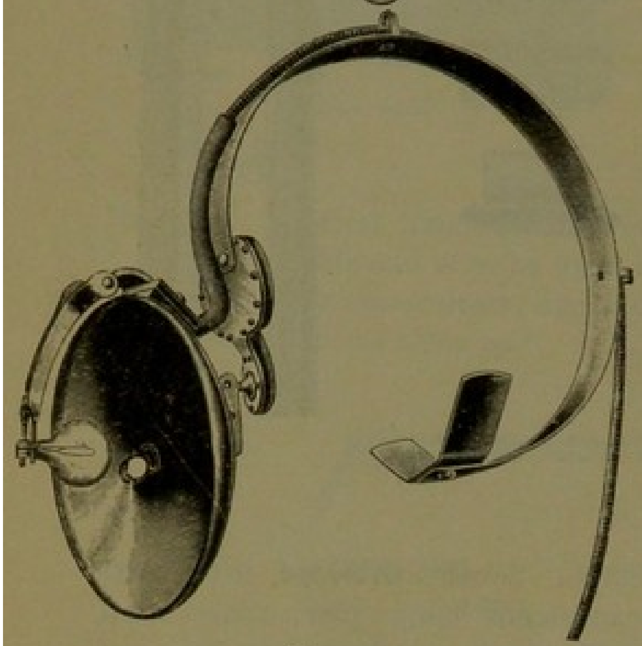
No. 1211. **Hand lamp with platinized reflector,** for abdominal and other operations, in case, with one spare lamp, Fig. 1211 .. .. 2 0 0

SWITCHBOARDS for Current from Main. LIGHT THERAPY

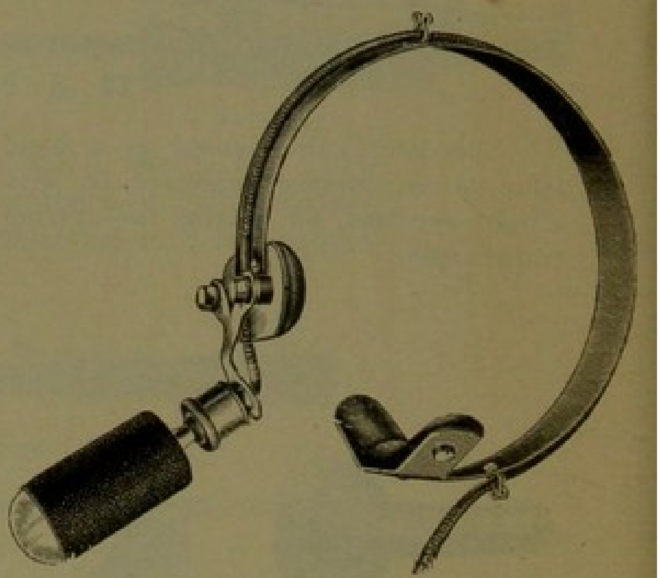
X-RAY APPARATUS



No. 1213.



No. 1212.



No. 1214.

No. 1212.	Forehead lamp, with concave mirror and lamp, with case and spare lamp, Fig. 1212	£2 6 0
No. 1213.	Dr. Kirstein's head lamp, Fig. 1213, with perforated concave mirror, so that the eye looks parallel with the ray of light. This is of advantage for narrow passages like the ear or male urethra	1 18 0
No. 1214.	Forehead lamp, with steel band, spare lamp and case, Fig. 1214	1 14 0

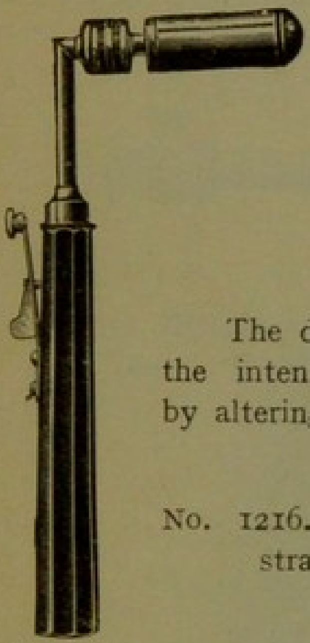
This lamp is being used more frequently than all the other patterns taken together.

If the lens is pushed back as far as it will go, the illuminated area is large, and the light diffused ; if it is drawn out the diameter gets smaller, but the light is more concentrated and intense. A parallel beam of light can be obtained with the lamp if desired. The light is bright and homogeneous.

The head lamps can be provided now with bulbs with metal filaments, requiring 4 volts only. The light is as intense as that obtained by carbon filament lamps of 8 volts.

The advantage of these low voltage lamps is that batteries with fewer cells can be used, 2 accumulator or 3 Leclanché dry cells are sufficient. The batteries are therefore cheaper and lighter. They can even be carried on the back by an Operator, and allow him a freedom of movement round an operating table, which is a little impeded when cords lead from a forehead lamp to a stationary battery or switchboard.

Price of 4 volt accumulator, 15 ampère hours capacity, in leather case	£1 8 0
Price of 3 dry Leclanché cells (Obach Q size), including strong cardboard case, with terminals	0 9 6
Leather strap and handle for carrying this battery ..	0 4 0

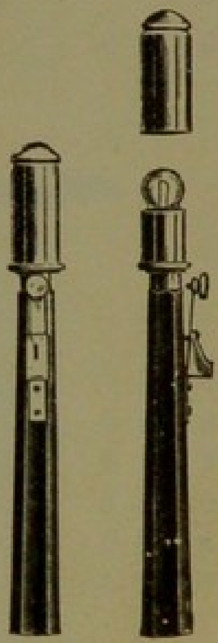


No. 1215. Hand Lamp, with bull's-eye, for surgical operations, with case and spare lamp, Fig. 1215 .. £2 2 0

The diameter of the illuminated area and the intensity of the light can be regulated by altering the distance of lamp and lens.

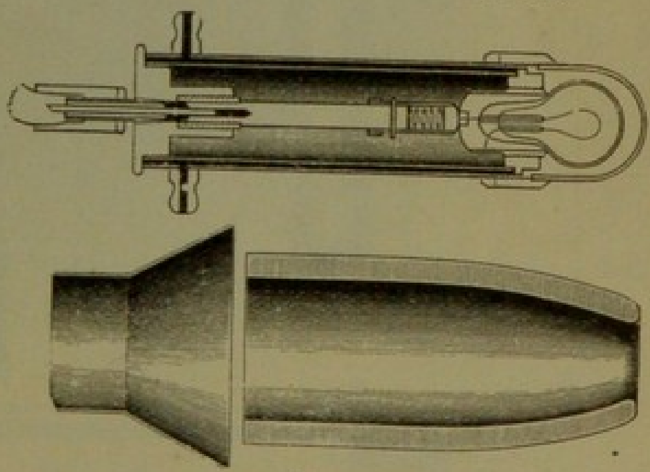
No. 1216. The same instrument, straight, Fig. 1216 .. .. £1 18 0

No. 1215.



No. 1216.

No. 1220. Lamp for trans-illumination of larynx, nose, temple, ear, etc., with india-rubber funnel and water cooling arrangement, Fig. 1220. £2 2 0



No. 1220.

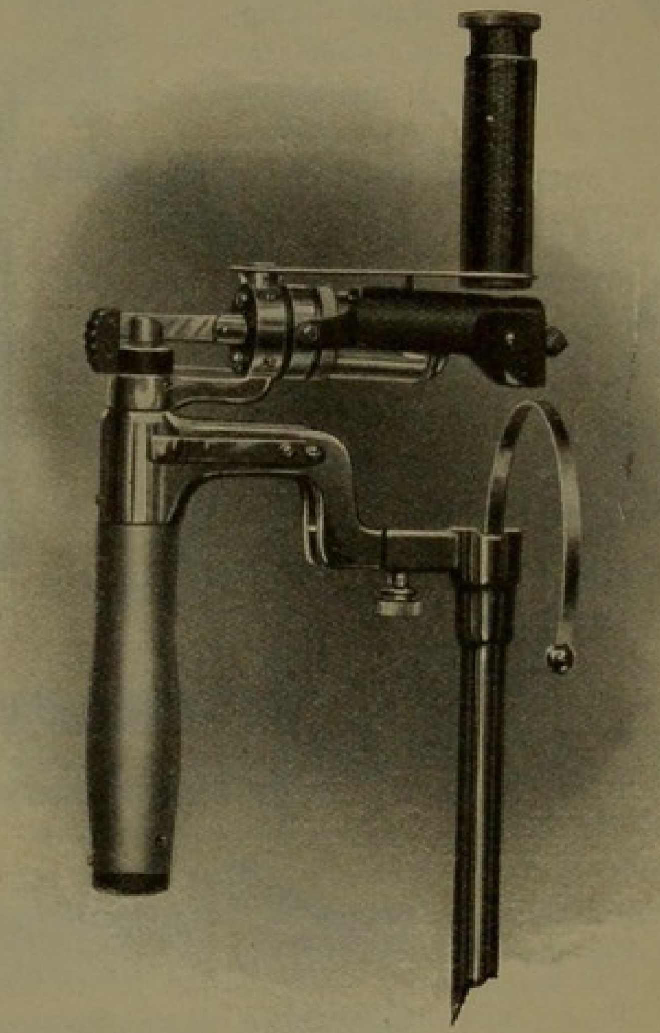
BRUENINGS' INSTRUMENTS
for direct Laryngo- Tracheo-Bronchoscopy and Œsophagoscopy.

A full description of this new method and its advantages, by M. H. Tilley, of University College Hospital, appeared in the *Lancet* of Nov. 7th, 1908: "Direct Examination of the Larynx, Trachea, and Œsophagus by Bruenings' Instrument."

The Apparatus consists of: (1) *The illuminating instrument.* (2) *Various bronchoscopic tubes.* (3) *Some forceps, etc., for operating through these tubes.*

SWITCHBOARDS for Current from Main. LIGHTTHERAPY
X-RAY APPARATUS

No. 1225. Complete set of instruments, as described below	£15	0	0
The set consists of a wooden case, covered with calico and lined with sailcloth, which can be washed, including stand with four glass bottles marked "Adrenaline," "Cocaine 10 %," "Cocaine 20 %," and "Paraffin"	1	6	0

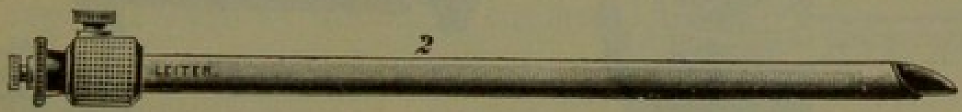


No. 1226.

This case contains :—

The illuminating instrument, with wires and one spare lamp	4	4	0
5 double tubes of 5, 7, 8, 10 and 12 mm. diameter	5	0	0
1 inner tube for œsophagoscopy, 10 mm. diameter	0	10	6
3 special bougies as cannulas	0	11	0
1 extensible forceps for foreign bodies, with 5 interchangeable blades of various sizes for bronchoscopy	1	16	0
1 ditto, with two blades for œsophagoscopy	1	1	6
1 saliva pump, with three india-rubber tubes of different sizes	0	13	0
2 small hooks for foreign bodies	0	2	6
1 dozen cotton-wool carriers	0	5	0

No. 1230. Prof. Killian's **Bronchoscope,** diam. 9 mm., and 18, 25 or 35 cm. long, with window	£0 9 0
No. 1230B. Similar instrument, for children, diam. 7 mm. and 13, 18, or 25 cm. long	0 9 0
No. 1230D. Telescopic conductor, with channel for allowing the air for respiration to circulate	0 6 0



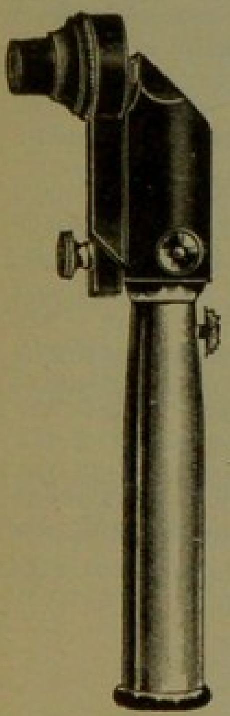
No. 1235.

No. 1235. **Œsophagus Tubes,** with conductor :—

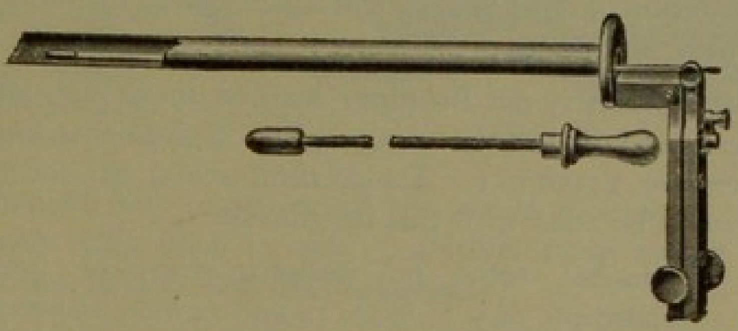
(*a*)	Diam. 9 mm.,	length 30 cm.	0 12 6
(*b*)	,, ,,	,, 50 ,, ...	0 14 9
(*c*)	,, 11 ,,	,, 30 ,, ...	0 14 9
(*d*)	,, ,,	,, 50 ,, ...	0 17 0
(*e*)	,, 13 ,,	,, 30 ,, ...	0 17 0
(*f*)	,, ,,	,, 50 ,, ...	0 19 0

No. 1251. Dr. Casper's Illuminating Apparatus, *Fig.* 1251, with spare lamp and case 2 8 0

The urethral tubes, Nos. 1261 to 1266
The rectal tubes, Nos. 1277 and 1289
The ear and nose tubes, Nos. 1281 and 1282
The œsophagus tubes, No. 1235 *a* to *f*
The bronchoscope, No. 1230 and
The instrument for examining the female bladder,
} *Can be attached to No. 1251.*



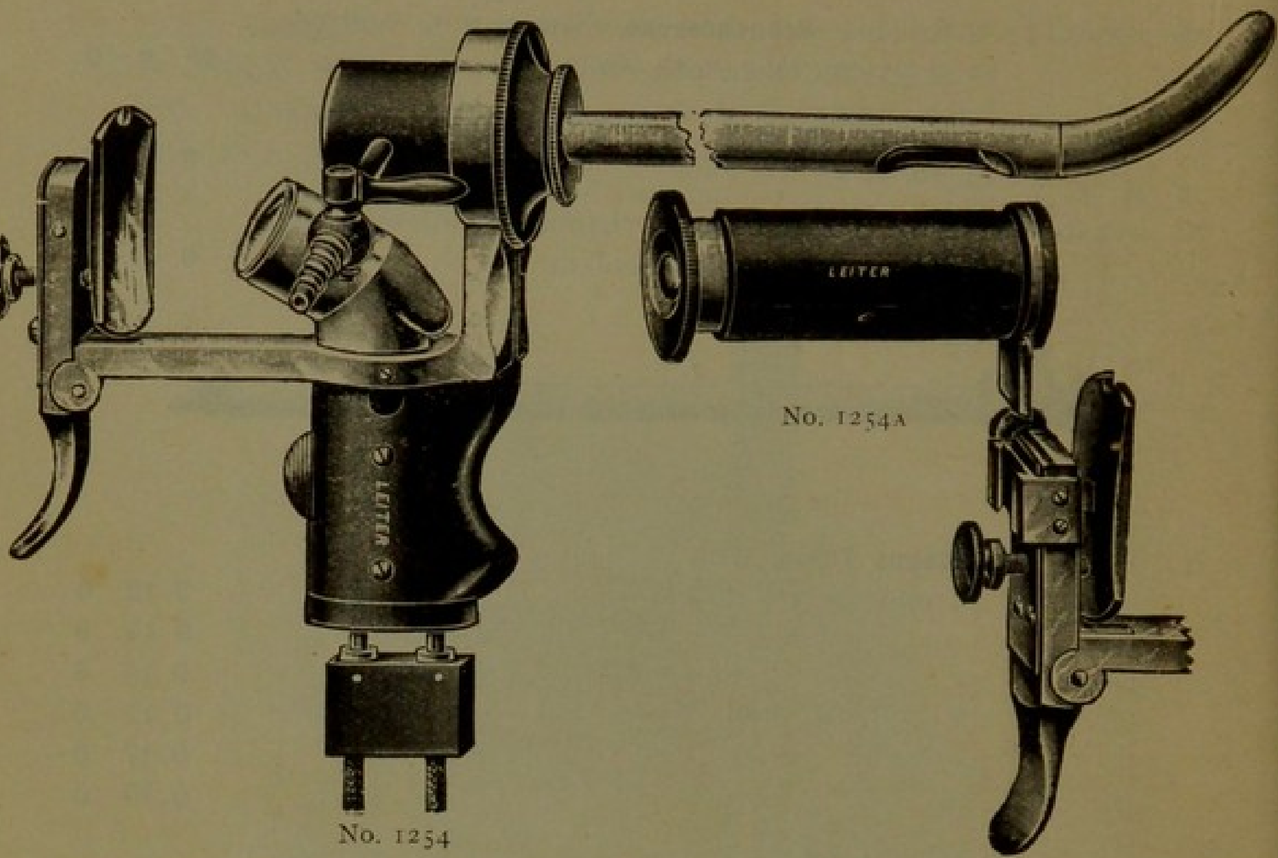
No. 1251.



No. 1253.

No 1253. Dr. Valentine's **Urethroscope,** *Fig.* 1253, with small "cold" incandescent lamps, which are introduced through the urethral tube, with tube, spare lamp, cords, and case 2 8 0

SWITCHBOARDS for Current from Main. LIGHT THERAPY
X-RAY APPARATUS



No. 1254A

No. 1254

No. 1254.	New Fenwick Leiter **Panelectroscope**, Fig. 1254 ..	£3 5 0
No. 1254A.	A telescope fitting this instrument, to magnify the picture 3 to 4 times	1 1 0

Metal filament lamps, giving a brilliant light, are used for this instrument, and a lens concentrates the rays in the most economic manner.

The instrument is equally useful for the examination of the œsophagus, bronchial tubes, urethra, and prostate, rectum, vagina, etc. It can be used with or without inflation, and operating instruments can easily be introduced.

The illustration shows it with a tube for examining the colliculus seminalis. Even the posterior part of this can be clearly seen by means of the mirror contained in the bent tubes.

Instruments to carry out Brünings' method of examination of œsophagus, etc., are mentioned under Nos. 1255A to E; instruments for examining the rectum under Nos. 1255R to T. The urethral, rectal, ear and nose tubes, 1261 to 1282, can also be used with this instrument.

No. 1255A.	Extensible tubes for œsophagoscopy or bronchoscopy, of 5, 7, 8, 10, 12 and 14 mm. diameter, each	£1 0 0
No. 1255B.	Saliva pump, with three tubes, 25, 35, and 50 cm. long	0 13 0
No. 1255C.	Extensible forceps for foreign bodies, with 7 interchangeable blades, 5 for adults and 2 for children	3 0 0
No. 1255E.	Cocaine spray	0 6 0

This Panelectroscope can be used equally well for Rectoscopy, Rectomanoscopy, and Urethroscopy.

The price of tubes for Rectoscopy is :—

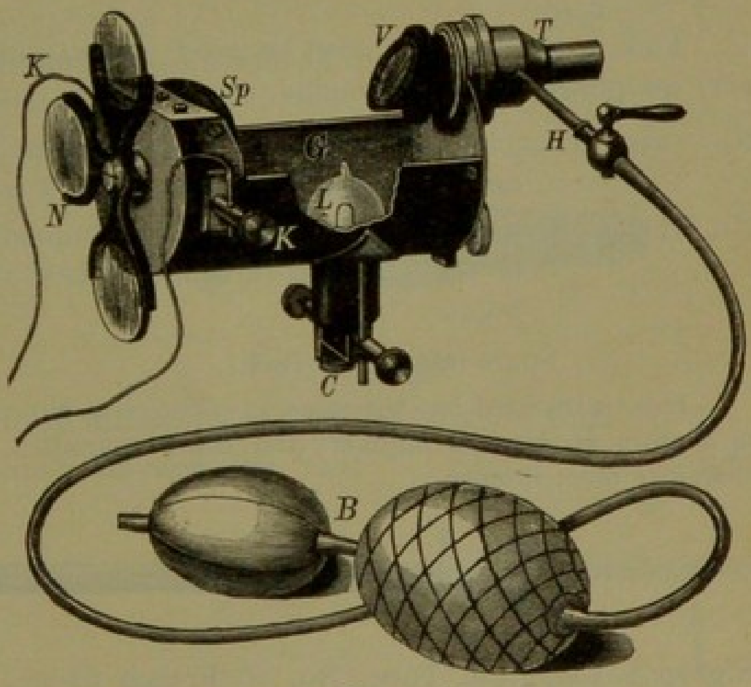
No. 1255R.	Tube, 10 cm. long, 23 mm. diameter, with inflating arrangement	£0 12 0
No. 1255S.	Tube, 30 cm. long, 20 mm. diameter	0 15 0
,,	,, 20 cm. long, 15 mm. diameter, for children	0 12 6
No. 1255T.	Forceps for rectum, 40 cm. long	2 8 0

The tubes for examining urethra, etc., will be found under Nos. 1261 to 1274.

No. 1256.	**Fenwick's urethroscope,** with one spare lamp and inflating arrangement, Fig. 1256	3 14 0
	Large double bellows, as shown in illustration ..	0 7 0

This instrument can be used equally well for the rectum, ear, œsophagus, nose, vagina, etc.

In the mode of reflection this instrument is a distinct innovation. A mirror is placed behind the lamp, and its concavity permits of the concentration of the rays of the light coming from the lamp upon the object, the operator looking over the upper edge of the mirror into the tube fixed to the instrument. In this way he is enabled, even in the case of narrow canals like the male urethra, to observe and to use the operating instruments at the same time. It is chiefly employed for lighting up the male urethra, the ear, nose, œsophagus, rectum, and vagina.

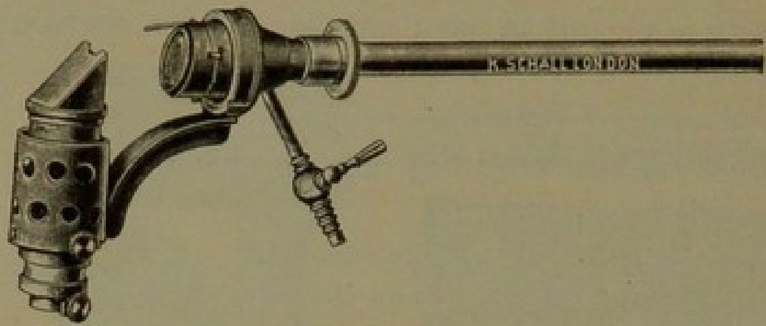


No. 1256.

No. 1257.	Complete set, consisting of the above instrument, with spare lamp in case, 5 urethral tubes and 2 cotton holders, and double bellows	£5 10 0

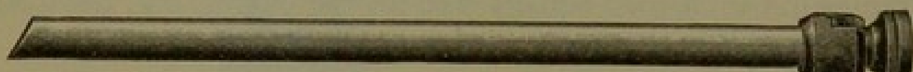
With the urethroscopes it is essential that the lamp should be exactly in the focus of the mirror or lens, as otherwise no light will be obtained at the end of the tube. This must be borne in mind in placing new lamps in their position. After exchanging the lamps, a piece of white paper is placed on a table, and the end of the tube directed upon this paper. Now, while the lamp burns, it is moved up and down, until an intense and circular light falls on the paper, and when in this position it is fixed to the body of the instrument by means of a screw.

SWITCHBOARDS for Current from Main. LIGHTTHERAPY
X-RAY APPARATUS



No. 1258a.

*No. 1258.	**Schall's Urethroscope,** with spare lamp and cords ..	£2 0 0
No. 1258*a*.	The same instrument, with the inflating arrangement and double bellows in addition, Fig. 1258*a* ..	2 18 0



This instrument can also be used for examining nose, ear, œsophagus, rectum, vagina, etc.

No. 1259.	Complete set, consisting of instrument No. 1258, in case, with 3 urethral tubes and 2 cotton holders	3 0 0
No. 1259*a*.	Complete set, consisting of instrument No. 1258*a*, in case, with 3 urethral tubes and 2 cotton holders	3 16 0

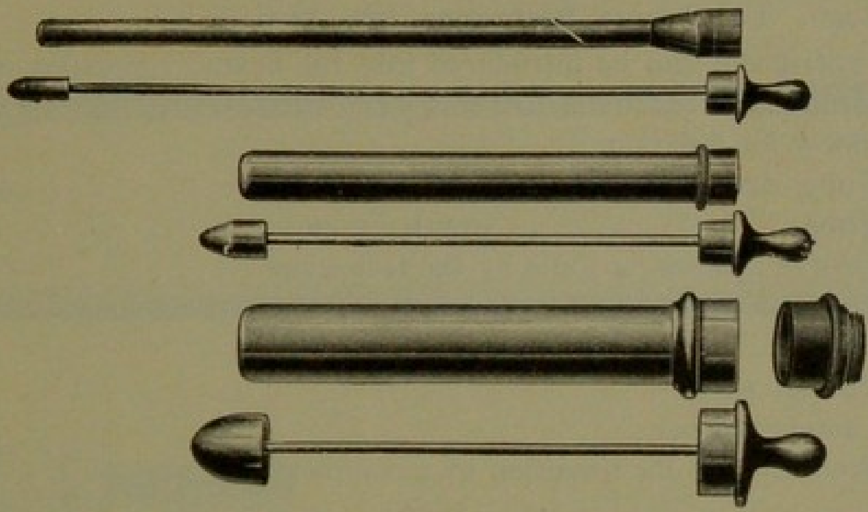
Spare lamps, 2/6 each.

This instrument has the same advantages as No. 1256, but the light is utilized in a more economical manner, and the illumination at the end of the tube is therefore more intense.

No. 1261.

No. 1261.	Urethral Tube, No. 16 French gauge, 3½ inches long, Fig. 1261	4/-
No. 1262.	Do. No. 18 French gauge, 4 ins. long	4/-
No. 1263.	Do. No. 20 ,, .. 4½ ,, ...	4/-
No. 1264.	Do. No. 22 ,, .. 5	4/-
No. 1265.	Do. No. 24 ,, .. 5 .. , ...	4/-
No. 1266.	Do. No. 26 ,, ,, 5 ,, ,, ...	4/-
No. 1272.	Tubes for the prostate, with conductor	8/-
No. 1274.	Cotton holders for the urethra	2/-

* As supplied to St. Bartholomew's Hospital, London Hospital, St. Peter's Hospital, Mr. Hurry Fenwick, and over 160 hospitals and surgeons.



No. 1277.

No. 1277. Rectal tube, with conductor, in three different sizes, Fig. 1277 .. .. each 4/6

No. 1278. Metal ring, to connect these tubes with the urethroscope .. .. each 3/-

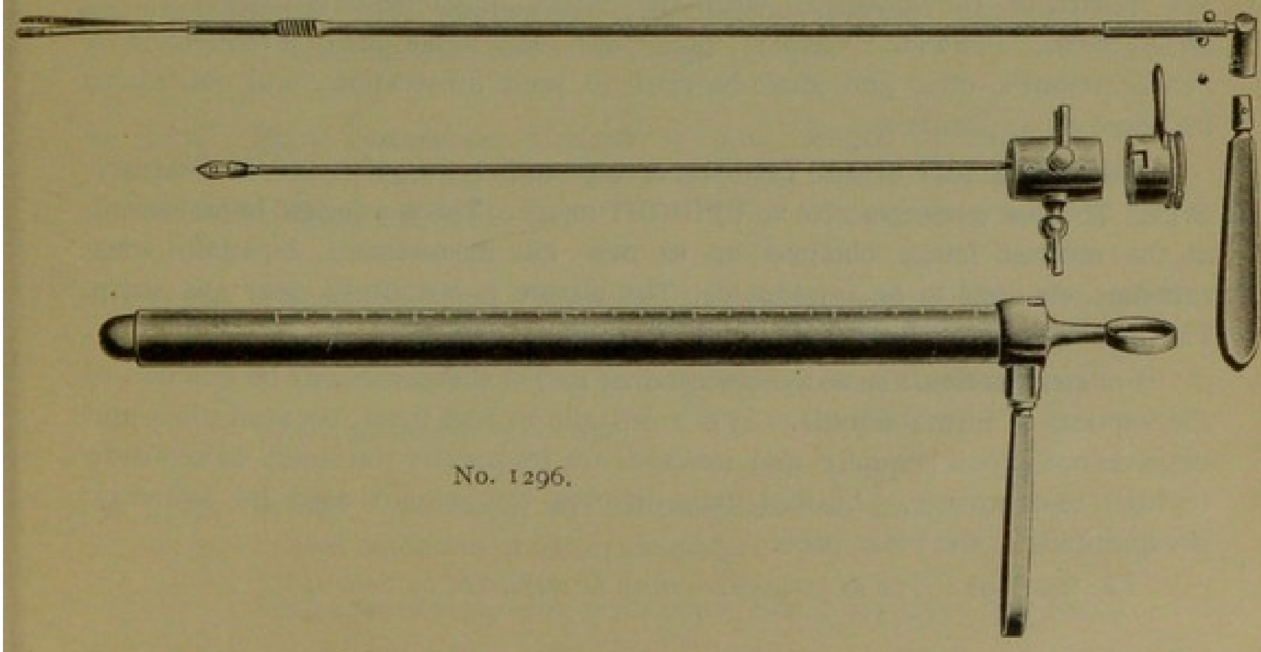
For illuminating the ear and nose, funnels of different diameter can be screwed on to the instrument.

No. 1281.

No. 1282.

No. 1281. Ear funnel, in three different sizes, Fig. 1281 .. each 2/-

No. 1282. Tube for examining the nose, Fig. 1282 .. ,, 3/6



No. 1296.

No. 1296. Dr. Strauss' **Rectoscope.** Fig. 1296.

This instrument can be introduced into the flexura sigmoidea while the lamp is burning, so that its *direction is under control*. The tube is provided with a window for inflation.

A.	Tube, diameter 20 mm., length 30 cm.	£1	15	0
B.	Tube ,, ,, length 35 cm. .. .	1	17	0
(*a*).	Double bellows for inflating the rectoscope	0	7	6
(*b*).	Cotton-wool carriers, with handle	0	11	0
(*c*).	Brush	0	1	0
(*d*).	Powder spray	0	9	0
(*e*).	Cautery burner	0	7	9
(*d*).	Wooden case for reception of a complete set ..	0	11	0

CYSTOSCOPES.

Cystoscopes were made originally at the suggestion of Prof. Nitze by J. Leiter, of Vienna. The first instrument was finished in 1880. Incandescent platinum wire had to be used at that time as source of light, and this made the instruments complicated; they came into practical use only after small incandescent lamps were available in 1886. The Cystoscopes were introduced in Great Britain by us in 1887, and Mr. Hurry Fenwick used them first, and described them in his work, *The Electric Illumination of the Bladder and Urethra.*

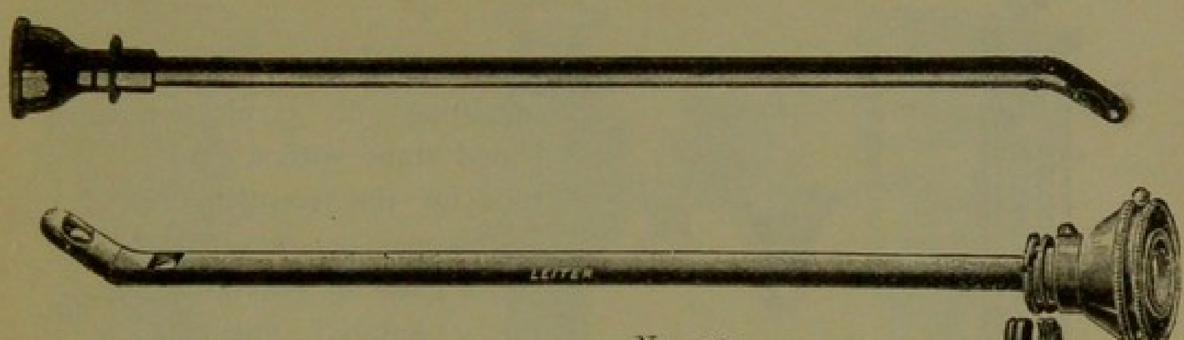
Since that time the value of the instruments has been generally recognised, and their usefulness increased as further improvements made it possible not only to examine the bladder, but to introduce catheters into the ureters to draw samples of urine of the kidneys, and to perform operations through cystoscopes.

The various types have become rather numerous during the last years. We illustrate the patterns with the latest improvements suggested by Drs. Nitze, Fenwick, Caspar, etc., but we make also Freudenberg's, Schlagintweit's, etc., and shall be glad to send illustrations and quotations for these on application.

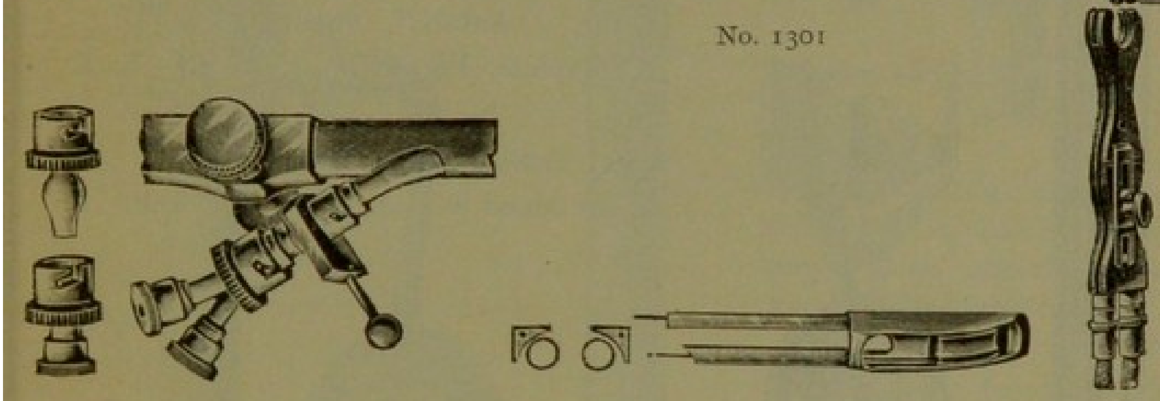
The optical part of our Cystoscopes was entirely reconstructed in February, 1911. The new telescopes give an UPRIGHT image. This is a decided improvement, as the reversed image obtained up to now was inconvenient, especially when catheters, etc., had to be introduced. The picture is beautifully clear and sharp. The new optical part is certainly the best existing at present.

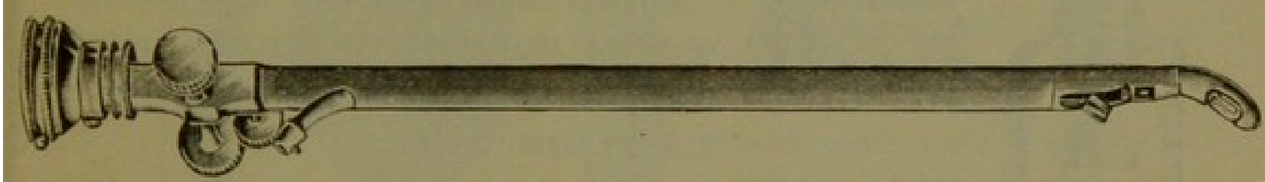
For **sterilization,** the older cystoscopes and catheters should be exposed to the vapours of formaldehyde. It is a mistake to boil them, because glass and brass do not expand equally, and leakages are frequently the result of exposure to high temperature. Alcohol may dissolve the cement used for fastening prism or lens in the brass tube.

The new 1911 *type of cystoscopes may be sterilised by boiling.*



No. 1301

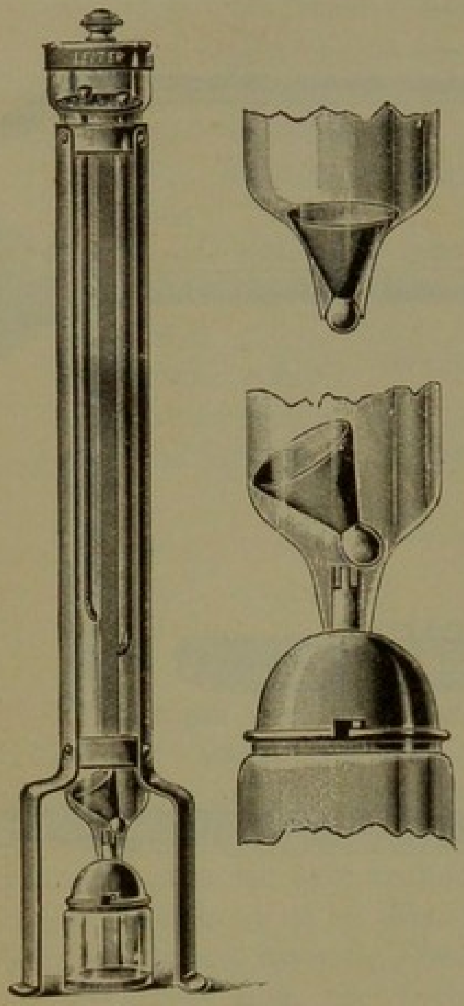




No. 1315

No. 1301.	Hurry Fenwick's cystoscope, for the anterior wall, Fig. 1301, diameter 7 mm. (No. 22 French gauge), with telescope, one spare lamp, a pair of cords, and a wooden case	£4 16 0
No. 1302.	Ditto, with window for the posterior part of the bladder, with one spare lamp	4 16 0
No. 1304.	Baby cystoscope, diameter 5 mm., length of the part to be introduced 21 ctm., with spare lamp and cords	4 12 0
No. 1315.	Cystoscope, with irrigation and arrangement to introduce one or two catheters into the orifice of the ureter, Fig. 1315, with spare lamp and cords..	10 0 0
	Spare catheters, 5/- each.	
No. 1317.	Similar cystoscope, with arrangement to introduce two catheters of larger diameter	11 5 0

Extra spare lamps for cystoscopes Nos. 1301–1315, 4/- each.

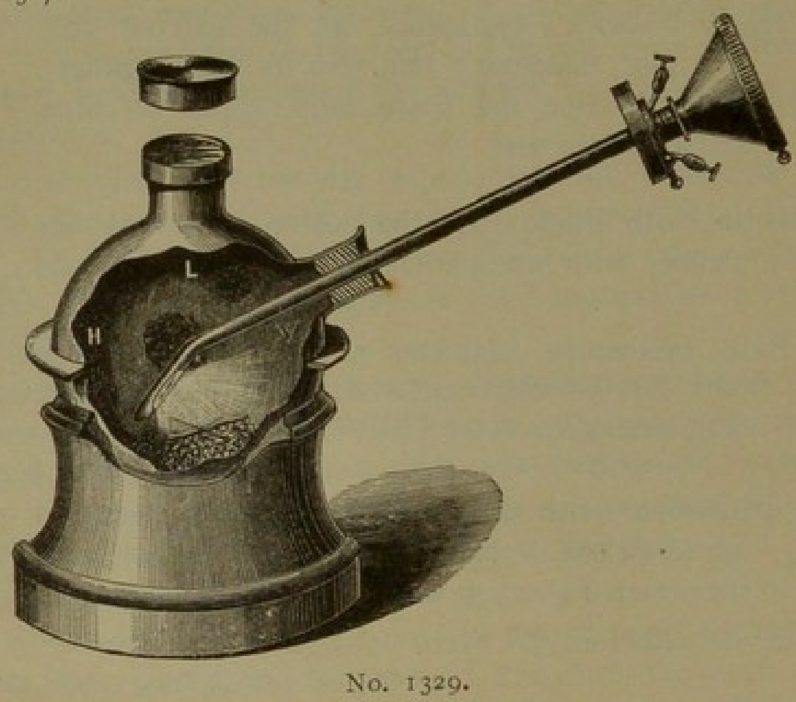


No. 1327.

No. 1327. Sterilizing apparatus, consisting of a nickel-plated stand with a glass tube for the reception of cystoscopes or catheters, and a glass for generating the "Autan" vapours, complete, Fig. 1327 .. £1 5 0

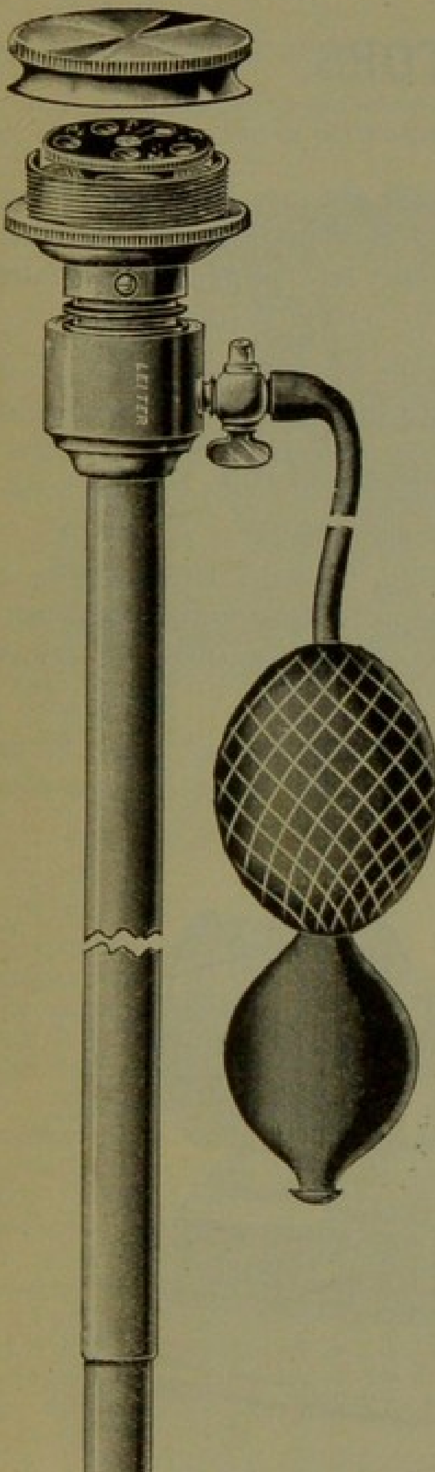
Fifty doses of Autan powder, contained in glass tubes .. 0 10 0

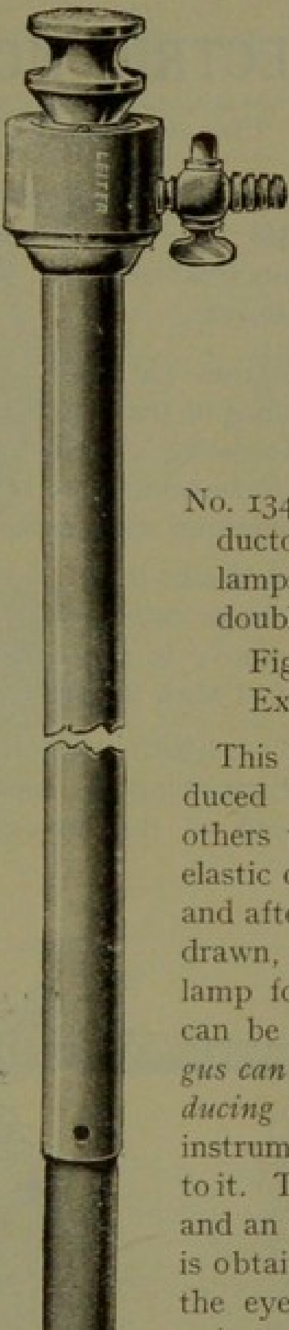
Surgical Lamps to be used in connection with the 100 to 250 volt currents supplied from dynamos will be found under Nos. 2090–2165 on pages 120-123.

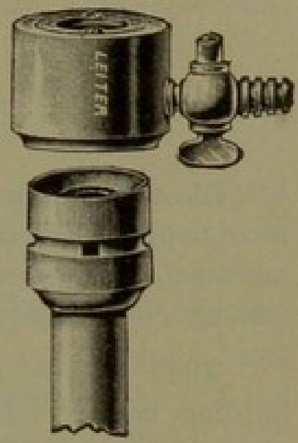


No. 1329.

No. 1329. For practising with cystoscopes, and for demonstrations, a phantom, as shown in Fig. 1329, exhibiting artificial tumours, stones, and foreign bodies, etc., is very convenient £0 18 0



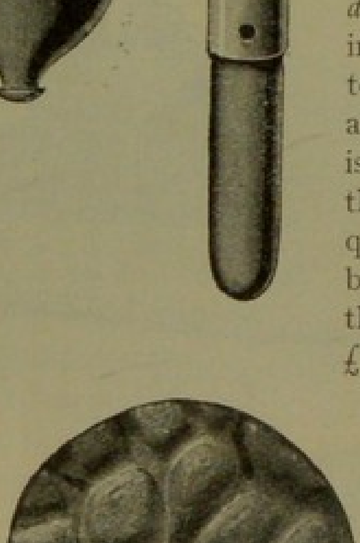


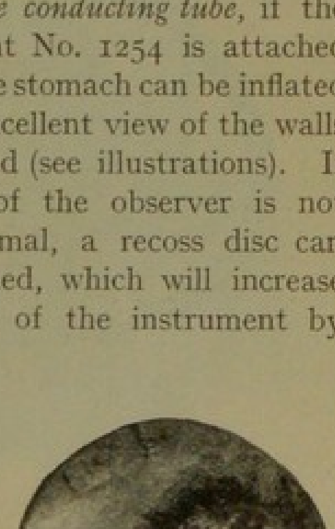


No. 1340. Gastroscope, with conductor tube, cords, 2 spare lamps with metal filament, double bellows and case,

Fig. 1340 ..	£12 10 0
Extra spare lamps	0 5 9

This instrument can be introduced directly in some cases, in others the conducting tube with elastic conductor has to be used, and after the latter has been withdrawn, the optical part with the lamp for examining the stomach can be introduced. *The œsophagus can be seen clearly while introducing the conducting tube,* if the instrument No. 1254 is attached to it. The stomach can be inflated and an excellent view of the walls is obtained (see illustrations). If the eye of the observer is not quite normal, a recoss disc can be attached, which will increase the price of the instrument by £1 10s.





No. 1340.

ELECTRIC MOTORS.

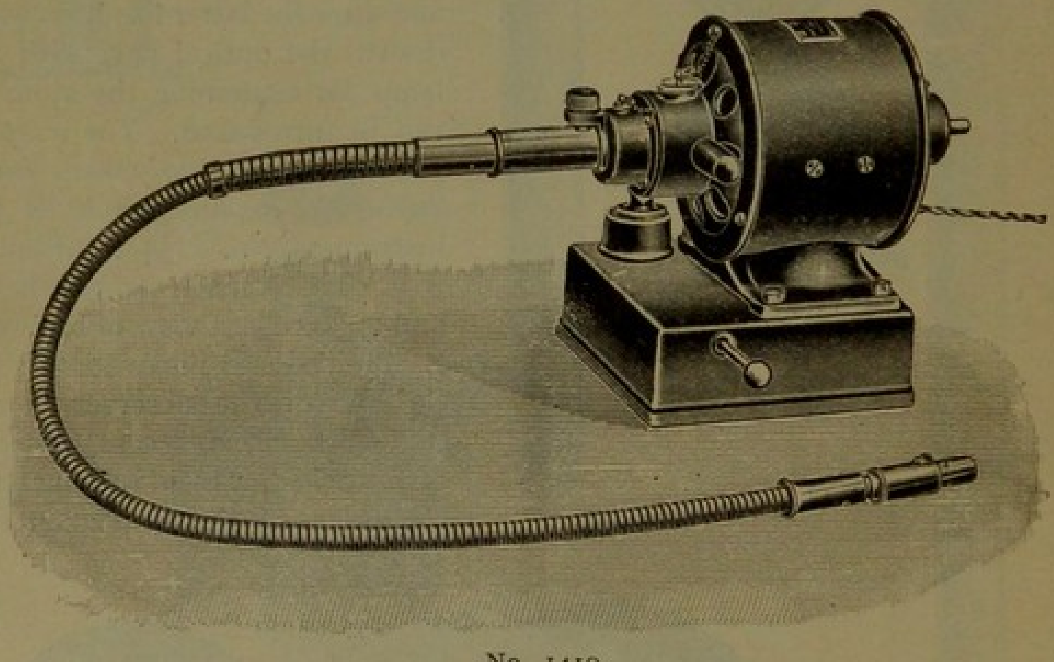
(*See also pages* 39–43.)

Electric motors have come into general use, and are very convenient for driving drills, saws, and trephines for surgical operations, for applying massage and rapid vibration treatment, for working air-pumps for pneumatic massage, for centrifuges, etc., etc.

They can be worked from batteries or from the current supplied for lighting houses. The winding of the motors has to be adapted to the special conditions present, and in ordering a motor, please state the number of volts, and whether the supply is continuous or alternating current; in the latter case it is also necessary to mention the number of periods.

If the current from the mains is not available, a 6-cell accumulator or a bichromate battery with large cells will work a 12-volt motor very well. Our motors are shunt wound; in consequence of this the speed is almost independent of the amount of work they have to perform.

A rheostat should be used with every motor. The current ought to be turned on gradually by diminishing the resistance. The same rheostat also serves to control the speed of the motors.



No. 1410.

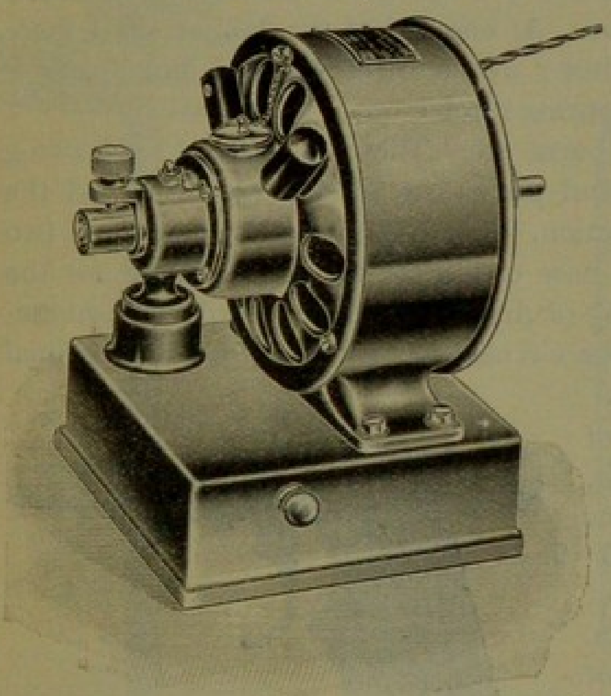
CONTINUOUS CURRENT MOTORS.

For surgical operations, for massage, etc., with connecting plug, switch, and rheostat on cast-iron base, Fig. 1410.

The motor transformer Nos. 2000–2005, and the sinusoidal motors Nos. 1900 and 1901 can also be used for surgical operations and for massage.

		12	100	200-250 volts
No. 1411.	1-8th horse-power ..	£7 0 0	£7 15 0	£8 14 0

The motors are powerful enough for all surgical operations in the nose and ear, on the skull, and for all purposes of massage.



No. 1420.

No. 1420. **Alternating Current Motor** for surgical operations and for massage, with connecting plug, switch, and rheostat, in cast-iron base, Fig. 1420—

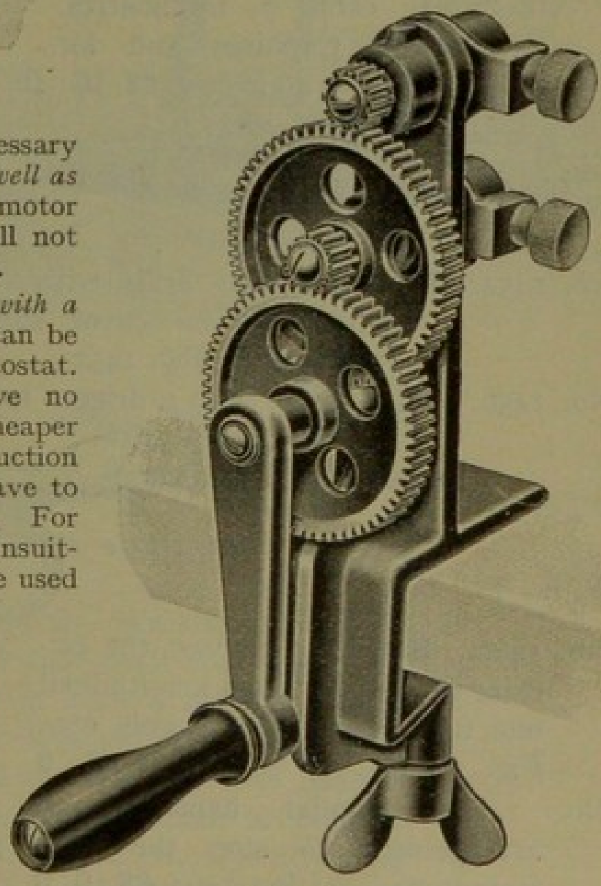
(*a*) For 100 volts, £10 10 0

(*b*) For 200 volts, £10 16 0

In ordering this motor it is necessary to mention the number of volts *as well as the number of periods* of the supply ; a motor which is arranged for fifty periods will not run with eighty periods, and *vice versa*.

The motor No. 1420 *is provided with a collector and brushes*, and the speed can be varied in wide limits by means of the rheostat. The so-called induction motors have no collector, and are therefore much cheaper in price, but the speed of these induction motors is not under control, they have to run synchronously with the dynamo. For this reason they are, in our opinion, unsuitable for surgical work, but they can be used for various other purposes.

No. 1430. **Strong Transmission Gear,** Fig. 1430, to work any of the following drills, saws, massage appliances or air pumps by hand instead of electro-motor £1 15 0



No. 1430.

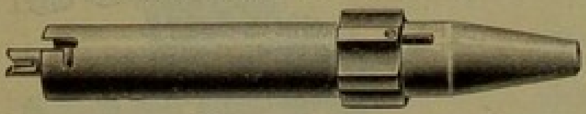
FLEXIBLE SHAFTS AND HAND PIECES FOR THE SURGICAL MOTORS.

The flexible shafts connect the motor with the hand piece; they are made of thin steel wires twisted together to a cable, and this cable is enclosed in a flexible, nickel-plated metal tube. At one end of the flexible shaft there is a connecting piece fitting the motor; at the other end the hand piece is slipped on and held in position by a spring catch.

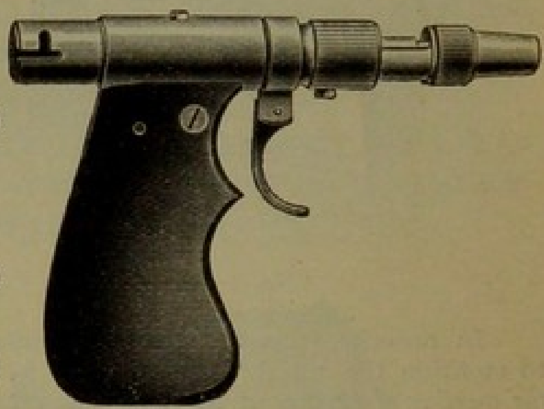
The hand pieces hold the drills, burrs, etc. They are released by drawing back a spring. The axles of our hand pieces run in ball bearings, and the covers can be taken off for sterilization. The hand pieces are made in two sizes, either for small operations in nose or ear, or for the trephines for the skull; some are provided with a ring or drigger to stop the drills instantaneously; other hand pieces convert the circular movement into a longitudinal one for operations with *straight* saws.

No. 1432. **Flexible shaft,** diameter of the steel cable 5 millimetres, length 40 inches, for operations in nose and ear .. **£2 0 0**

No. 1433. **Flexible shaft,** diameter of the steel cable 7 millimetres, suitable for trephines and for massage, length 40 inches **£2 10 0**



No. 1452.



No. 1456.

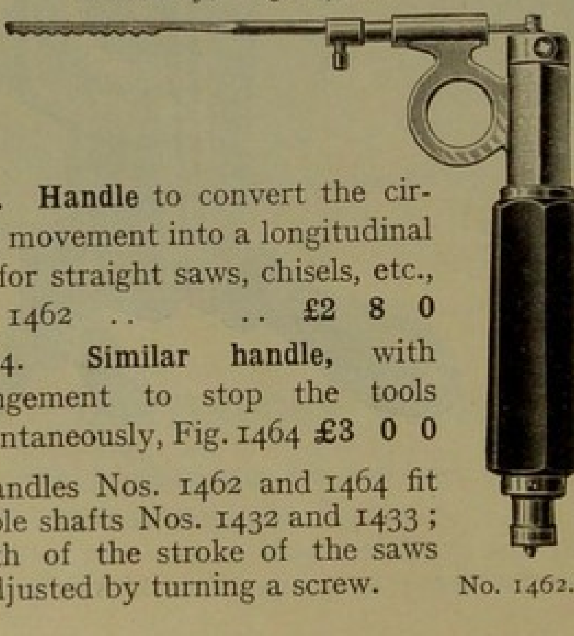
No. 1452. **Hand piece,** for drills, with a shaft of 5 millimetres diameter. The cover can be taken off for sterilization, Fig. 1452 .. .. .. **1 12 0**

No. 1456. **Hand piece,** with a drigger to stop the tools instantaneously, Fig. 1456.. .. .. .. **3 3 0**

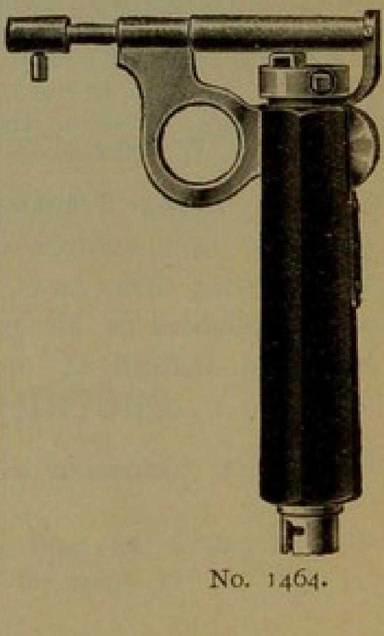
No. 1462. **Handle** to convert the circular movement into a longitudinal one, for straight saws, chisels, etc., Fig. 1462 .. .. **£2 8 0**

No. 1464. **Similar handle,** with arrangement to stop the tools instantaneously, Fig. 1464 **£3 0 0**

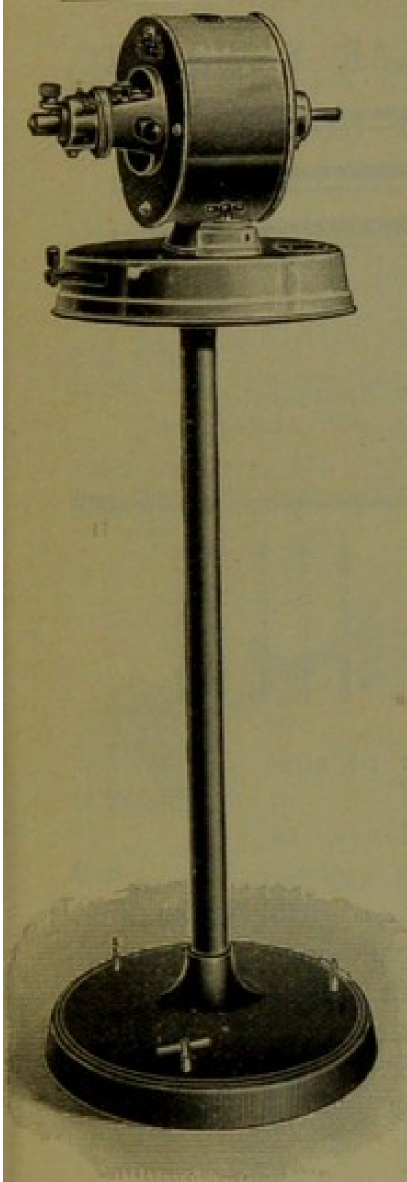
The handles Nos. 1462 and 1464 fit the flexible shafts Nos. 1432 and 1433; the length of the stroke of the saws can be adjusted by turning a screw.



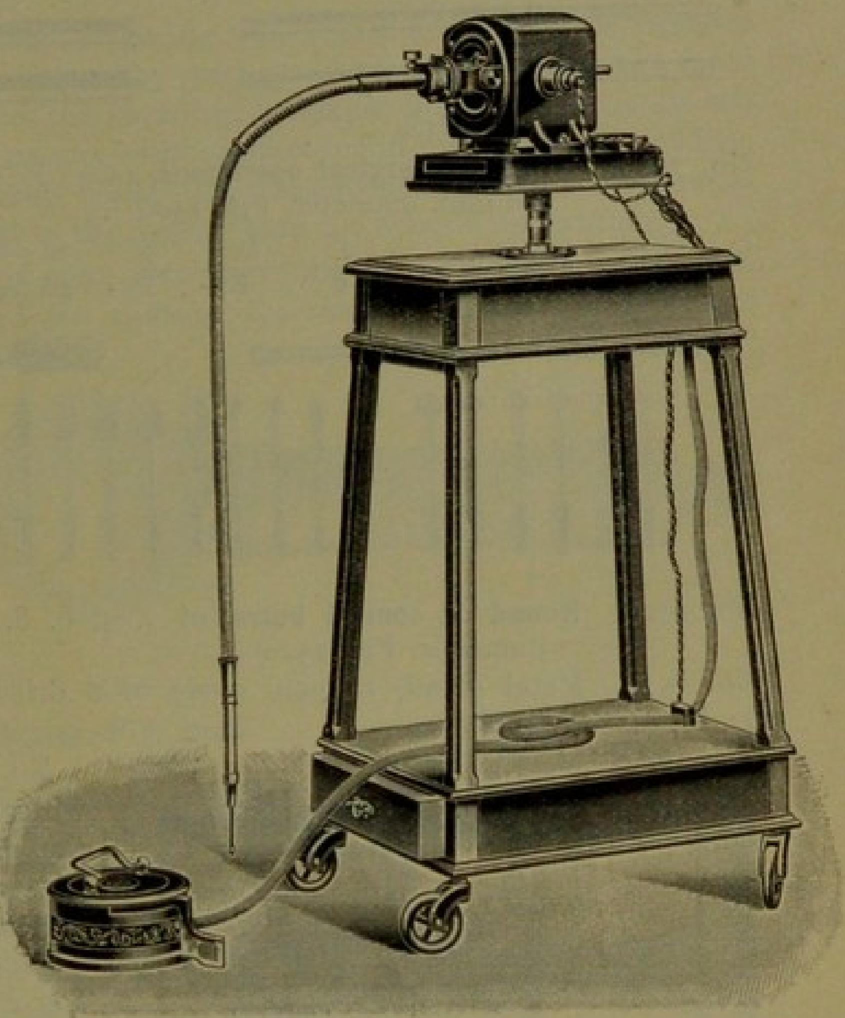
No. 1462.



No. 1464.



No. 1484.



No. 1496.

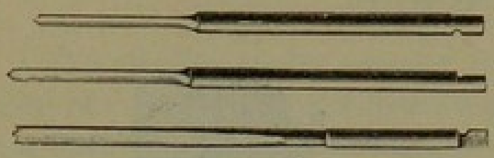
No. 1484.	**Plain stand** for surgical motors, Fig. 1484, with castors (the motor shown in illustration is not included in the price)	£1 14 0
No. 1485.	**Similar stand,** with telescope arrangement to raise or lower the motor	3 8 0
No. 1496.	**Complete outfit** for Hospitals, consisting of a motor of $\frac{1}{8}$ of a H.P., with flexible shaft and hand piece, mounted on a stand in such a manner that it turns round its axis; foot switch, to start, stop, and control the speed of the motor with the foot of the operator. The stand, made of polished oak, is provided with large castors, with india-rubber tyres, and with a drawer for the reception of shaft and hand piece, Fig. 1496	22 0 0

Without foot switch it will be **£5** less.

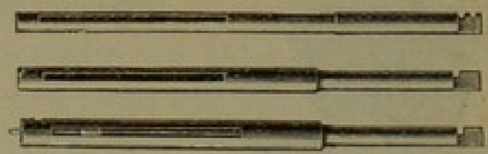
As supplied to St. Bartholomew's Hospital, Grantham Hospital, etc.

SWITCHBOARDS for Current from Main. LIGHT THERAPY
X-RAY APPARATUS

DRILLS, BURRS, TREPHINES, CIRCULAR SAWS, ETC.



No. 1500.

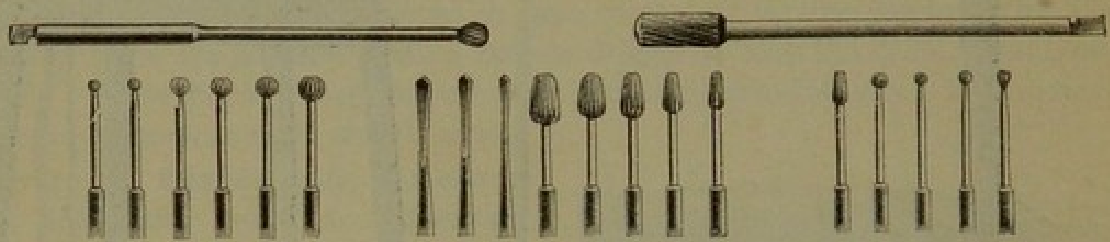


No. 1510.

No. 1500. **Drills for surgical operations,** of 1, 2, 3, 4, 6, 8, or 10 mm. diameter, Fig. 1500 .. .. .. each **3/0**

No. 1510. **Trephines,**

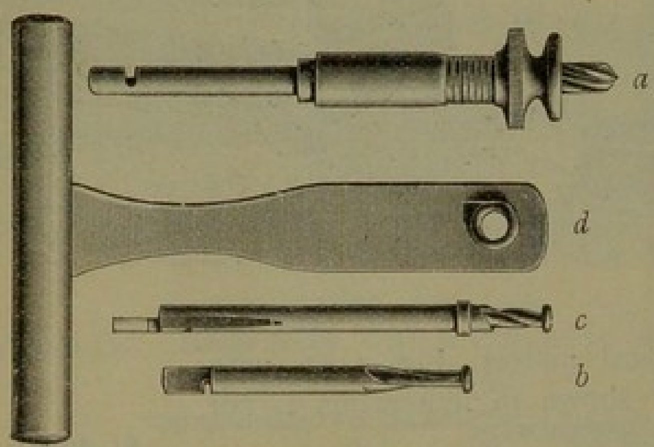
4	6	8	12 mm. diameter.
5/-	**6/-**	**7/-**	**10/-** each.



No. 1520.

No. 1520. **Round or conical burrs,** of 3, 4, 6, 8, or 10 mm. diameter, Fig. 1520 .. .. **3/9 to 6/0**

No. 1530. Metal stand, to hold a set of 8 drills, burrs, or trephines **5/0**



No. 1540.

No. 1540. **Drill for the skull,** with adjustable guard to control the depth of the hole, Fig. *a* .. **17/-**

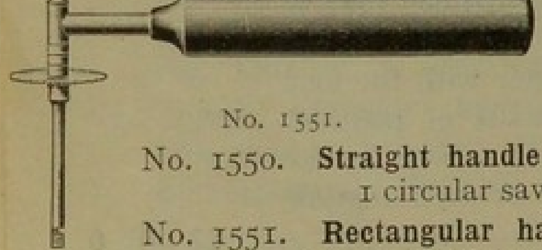
Reamer with guard, to enlarge a circular hole sideways, Figs. *b* or *c* **3/9**

Handle, to guide the reamers, Fig. *d* **2/9**

No. 1548.

No. 1548. **Dr. Lassar's multiple needle.** Fig. 1548, for the treatment of red noses **16/-**

This multiple needle fits into one of the handles, No. 1462 or 1464.



No. 1551.

No. 1550.

No. 1550. **Straight handle for circular saws,** Fig. 1550, with 1 circular saw and 2 keys to fix the blades .. **£0 18 6**

No. 1551. **Rectangular handle for circular saws,** Fig. 1551, with 1 circular saw and 2 keys to fix the blades .. **1 2 0**

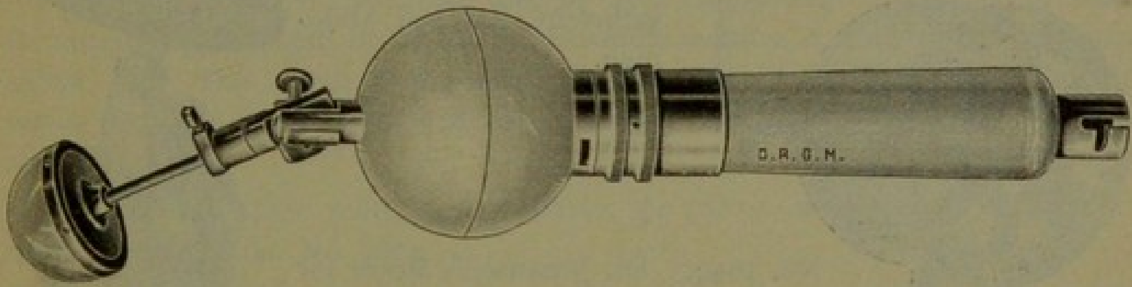
No. 1553. **Circular saws,**

¾ in.	1 in.	1¼ in. diameter.
5/-	**5/6**	**6/-** each.

INSTRUMENTS FOR APPLYING MASSAGE AND RAPID VIBRATION with the help of Electrical Motors.

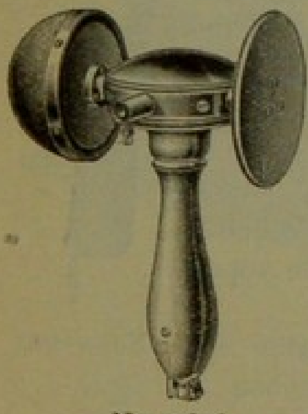
The manual applications of massage and kneading can now be replaced efficiently with the help of motors by mechanical power. Massage and rapid vibration (the latter replaces the kneading, knocking or percussion treatment) can be applied with these motors with absolute regularity and great rapidity, and the force can be accurately dosed—the consequence is that the mechanical application is more pleasant to the patient than the manual application.

The motors Nos. 1410–1420, 2000–2008, or the sinusoidal motors Nos. 1900 or 1901, are required for working the massage handles or vibrators illustrated below.

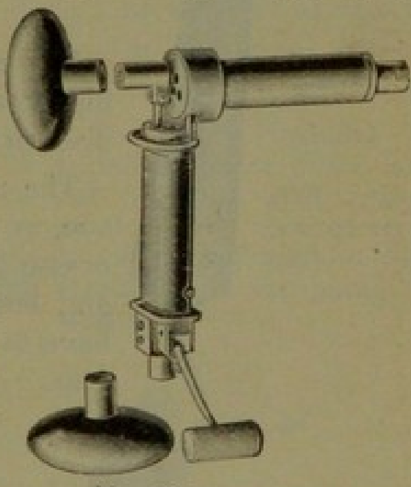


No. 1640.

No. 1640.	**Centrifugal Vibrator,** Fig. 1640	£3 7 0



The centrifugal power can be *varied and graduated* by altering the respective positions of a heavy weight and a light body, which revolve inside the cup, but the instrument need not be opened to make these alterations. The plates or sounds can be fixed to the instrument at any desired angle, or they can be removed altogether so that the instrument alone may be used.



No. 1646.

No. 1650.

No. 1646.	**Oscillator,** Fig. 1646 for general massage ..	£2 16 0
No. 1650.	**Dr. Johansen's Universal Vibrator,** Fig. 1650 ..	3 18 0

The Johansen's vibrator is the most powerful, and should be used when the liver or other deep-lying parts have to be treated. Its power is, however, completely under control, and can be reduced to a pleasant, gentle vibration.

The discs make either a circular movement to produce vibration if attached on the left-hand side, or a striking movement if attached near the hammer; the length of the stroke can be varied in wide limits.

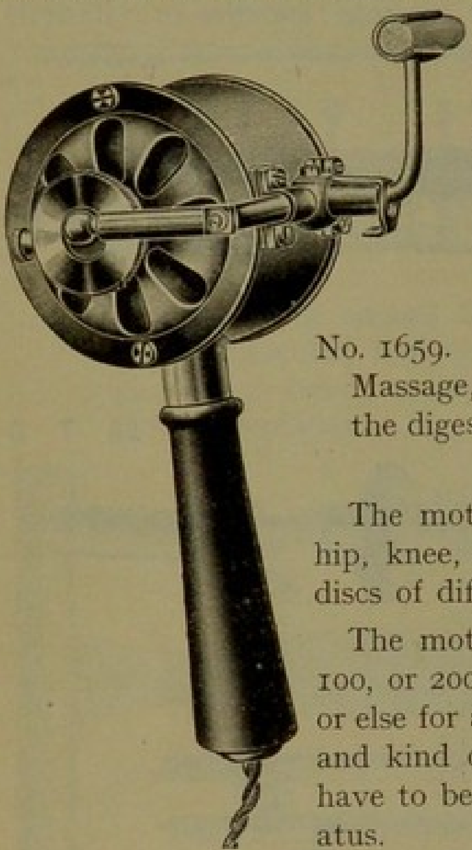
No. 1652.	Round vibrating disc, diameter 3 centimetres ..	£0 4 0
No. 1653.	,, ,, ,, 4½ ,, ..	0 4 6
No. 1654,	,, ,, ,, 6 ,, ..	0 5 0
No. 1656.	Hammer, lined with indiarubber	0 6 0

DR. JOHANSEN'S VIBRATORS.

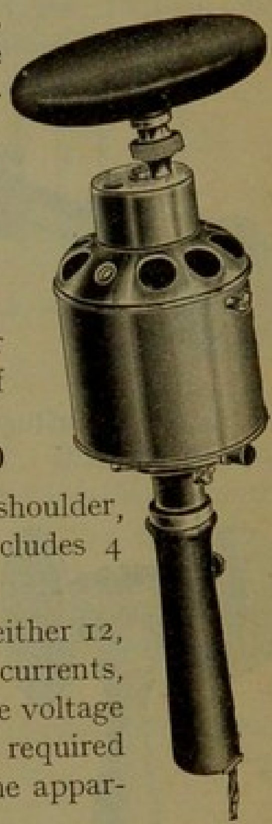
No. 1658. Dr. Johansen's Vibrator, for rapid vibrations and tapotement, Fig. 1658 .. .. .. £4 10 0

This apparatus can be supplied for either 12, 100, or 200 to 250 volt continuous currents, or else for alternating currents. The voltage and kind of current for which it is required have to be stated when ordering the apparatus.

Owing to an ingenious but simple construction, this motor is the most perfect of the numerous types of hand motors existing. The intensity of the stroke can be varied in the widest limits, from a very gentle vibration suitable for the head, larynx, etc., up to a powerful stroke sufficient for the abdomen.



No. 1658

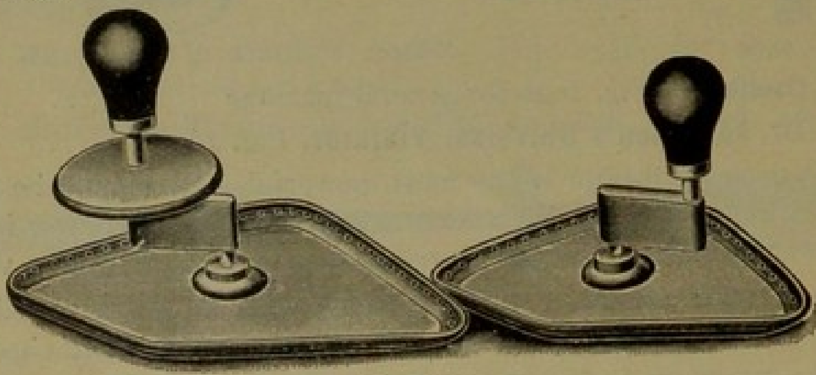


No. 1659

No. 1659. Dr. Johansen's Motor for Massage, especially for massage of the digestive organs, Fig. 1659 £5 12 0

The motor can be used for the shoulder, hip, knee, etc., too. The price includes 4 discs of different sizes.

The motor can be supplied for either 12, 100, or 200 or 250 volt continuous currents, or else for alternating currents. The voltage and kind of current for which it is required have to be stated when ordering the apparatus.



No. 1677.

No. 1677. Dr. Johansen's apparatus for abdominal massage, *Fig.* 1677 .. .. £0 16 0

The price includes one weight.

Price of extra weight 0 2 0

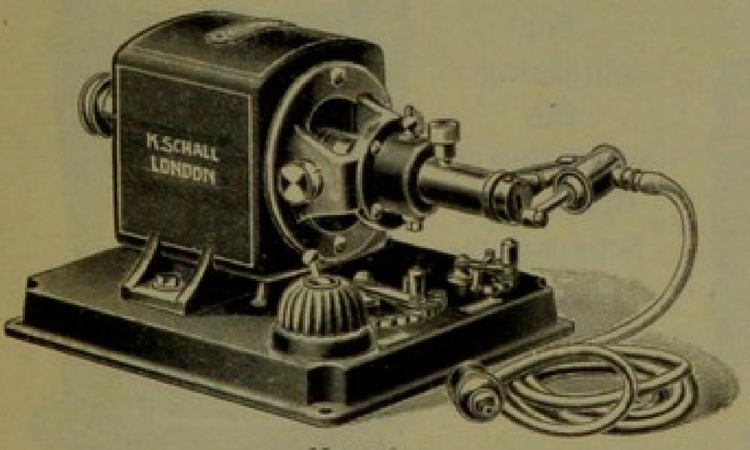
This apparatus is used chiefly for treating constipation, flatulence, atonic and anæmic conditions. *It can be used by the patients themselves*: the handle has to be turned round with one or both hands, and the power of the stroke can be varied by altering the eccentricity of the crank, or by adding one or two weights below the handle.

AIR PUMPS FOR PNEUMATIC MASSAGE OF THE EAR, ETC.

The air pumps can be attached either to one of the motors Nos. 1410–1420, 2000, 2005, or the sinusoidal motors Nos. 1900 or 1901.

The air pump No. 1672 can also be used for massage of the eye or face, for supplying a current of air for the Eustachian tube, or for sucking out pus, saliva, etc. The length of the stroke of the piston (*i.e.*, the quantity of air which is being compressed) can be varied in wide limits while the pump is working.

If none of these motors is available, see prices of air pump *with motor*, quoted below under No. 1675.



No. 1670.

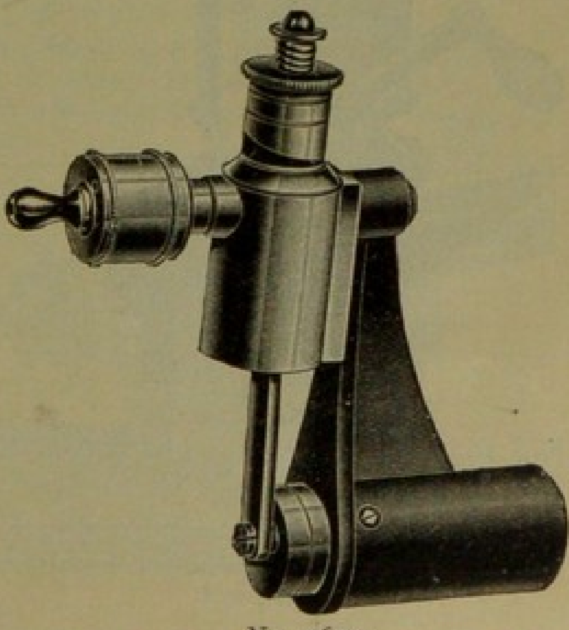
No. 1670. **Air pump,** for pneumatic massage of the ear, as shown in Fig. 1670, **£2 2 0**

The price includes a suitable rubber tube, an ear funnel with glass window, and arrangement to vary the length of the stroke while the pump is working.

No. 1672. **Air pump,** with three taps, for pneumatic massage of the ear or the Eustachian tube, for hot air syringes, or for removing pus, etc., Fig. 1672 .. .. **£2 15 0**

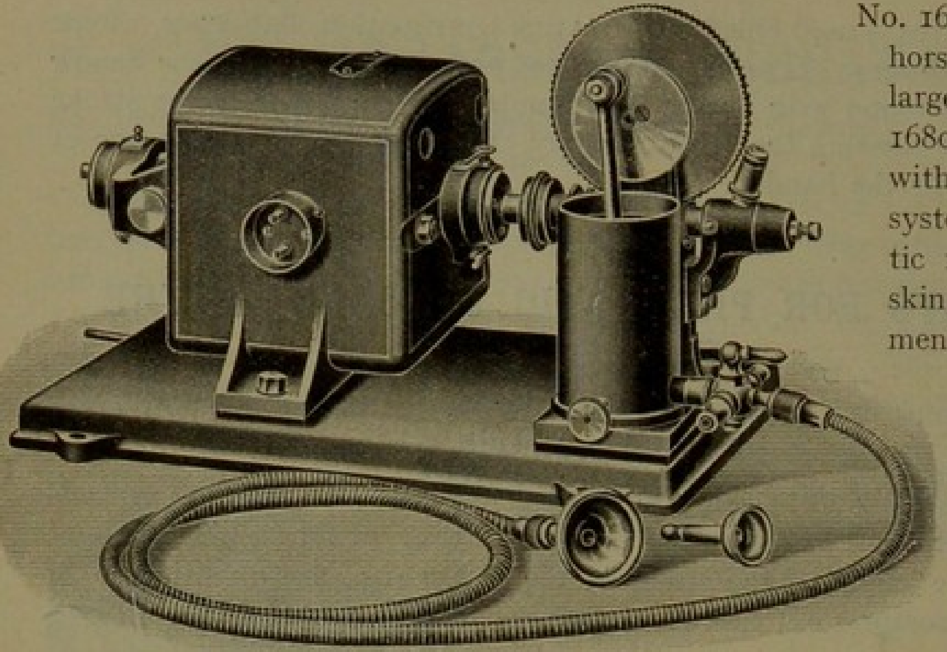
No. 1675. **Air pump,** No. 1670, *with motor, including rheostat for varying speed of motor,* switch and fuse. Motor wound for 12 volts .. **£7 15 0**

Motor wound for 200 to 250 volts **£8 10 0**



No. 1672.

SWITCHBOARDS for Current from Main. LIGHT THERAPY
X-RAY APPARATUS

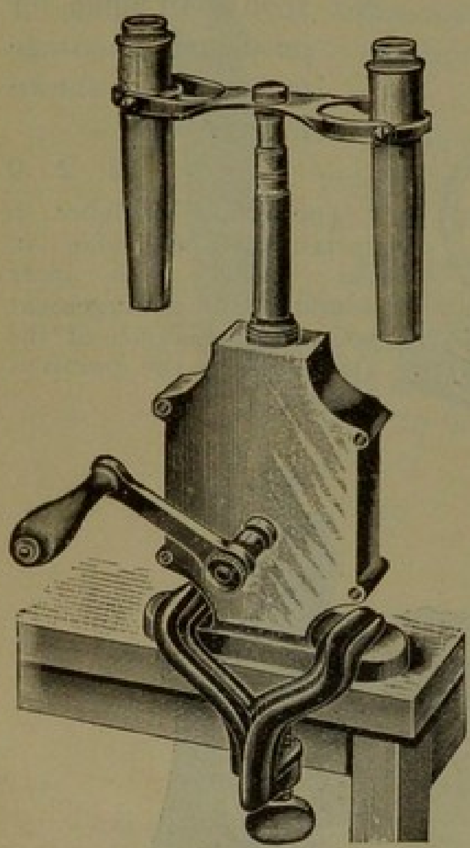


No. 1680. **Motor** of $\frac{1}{8}$ horse-power, with large air pump, Fig. 1680, for treatment with Professor Bier's system, for pneumatic massage of the skin, and for treatment of impotence, for vibratory massage, and for spraying drugs by means of compressed air, for continuous current, etc. **£20 0 0**

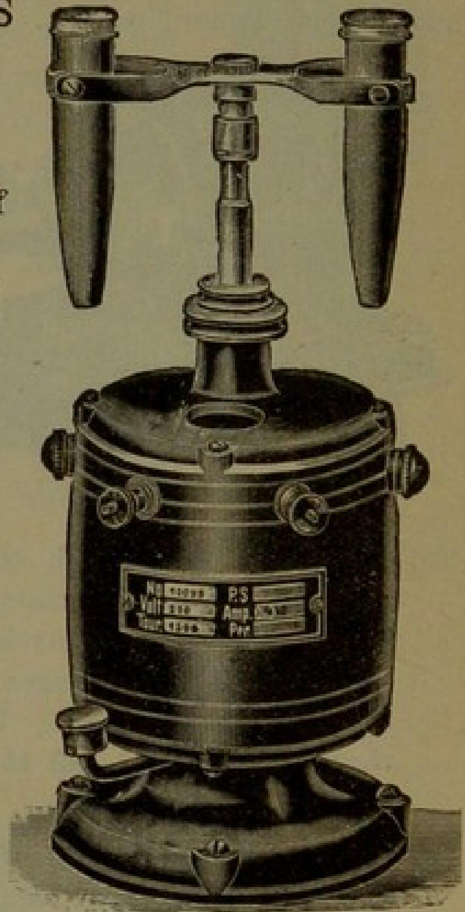
No. 1680.

CENTRIFUGES

For obtaining the Sediments of Urine, for Separating Blood, Milk, etc.



No. 1684.

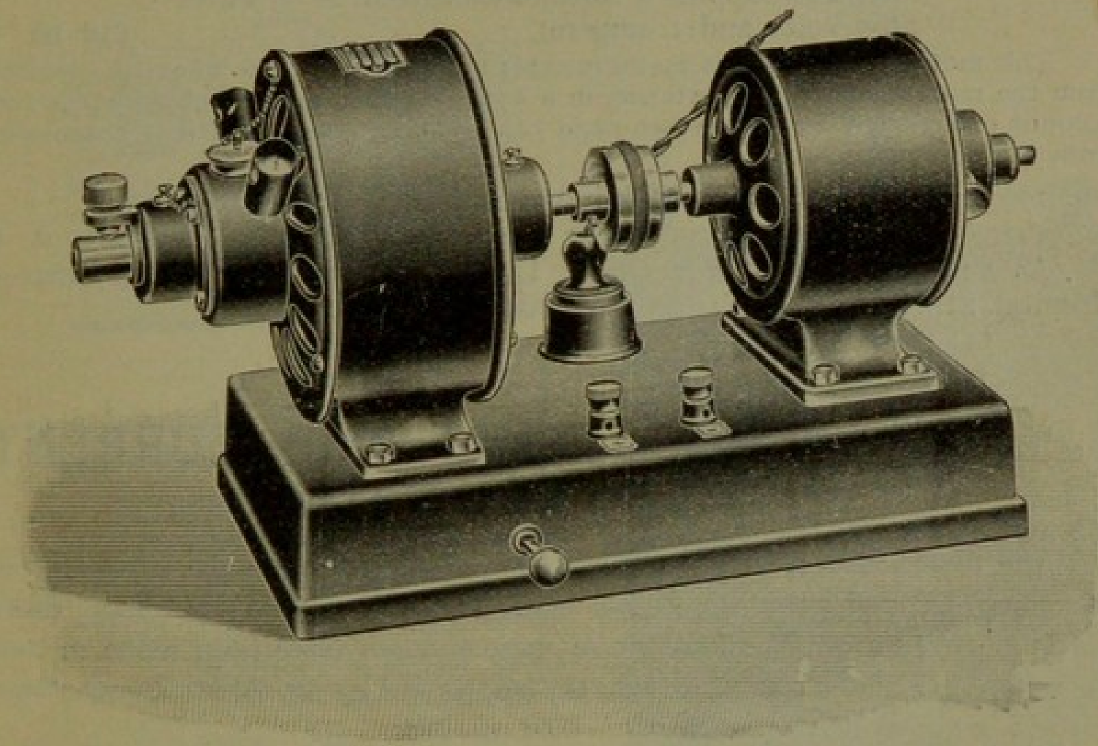


No. 1686.

No. 1684.	**Centrifuge**, to be driven by hand, Fig. 1684 ..	£1 7 0
No. 1686.	**Centrifuge**, with electric motor for 220 volt continuous current, Fig. 1686	4 16 0
No. 1688.	**Fork**, of aluminium, to be inserted in a surgical hand-piece	1 0 0

MOTOR TRANSFORMERS.

(*See also pages* 39-44.)



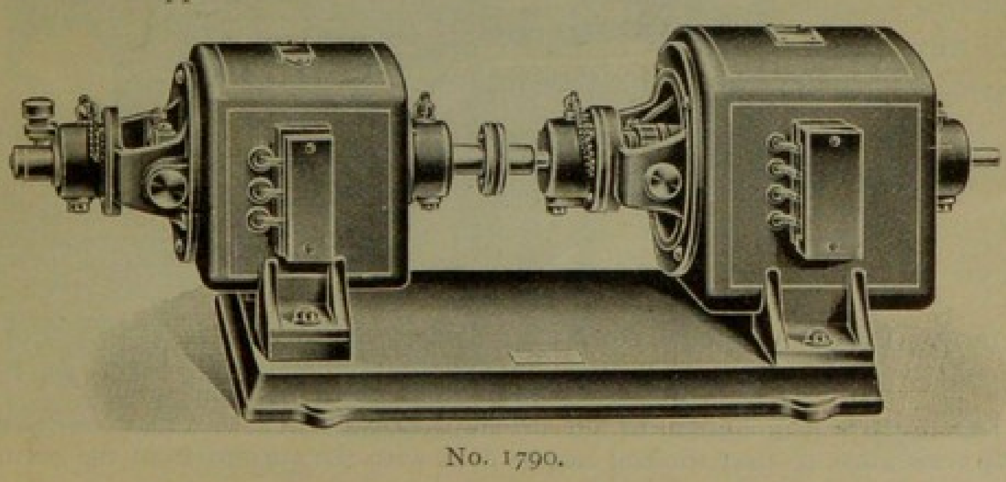
No. 1780.

No. 1780.	**Motor transformer,** to convert an alternating current into a continuous current, for galvanisation and electrolysis, Fig. 1780. The continuous current dynamo supplies 70 volts and 1 ampère ..	£20 0 0
No. 1782.	**Similar transformer,** for charging accumulators. The continuous current dynamo supplies 65 volts and 2·2 ampères	24 0 0

These prices *include the necessary rheostats.*

Larger motor transformers, suitable to give from 700 to 2,000 watts, for spark coils, arc lamps, etc., will be found under Nos. 2680–2687.

In ordering motor transformers of this kind, it is necessary to mention the *number of periods*, as well as the number of volts. If the number of periods is below 50 or above 70, the prices mentioned will have to be increased. Estimates will be sent on application.



No. 1790.

SWITCHBOARDS for Current from Main. LIGHT THERAPY
X-RAY APPARATUS

No. 1790. **Continuous current transformer,** for galvanisation, electrolysis, or surgical lamps, Fig. 1790. The dynamo supplies a continuous current of 65 watts (65 volts and 1 ampère) **£16 10 0**

This motor transformer is useful in cases where it is not safe to use the current from the main directly (for instance, in a hydro-electric bath, or in a hospital) on account of deficient insulation (see page 32). The dynamo is efficiently insulated from the motor.

No. 1793. **Similar transformer,** suitable in addition for cautery burners requiring up to 18 ampères **£21 0 0**

As supplied to the War Office, University College Hospital, Cottage Hospital, St. Andrew's, Infirmary, Aberdeen, etc., etc.

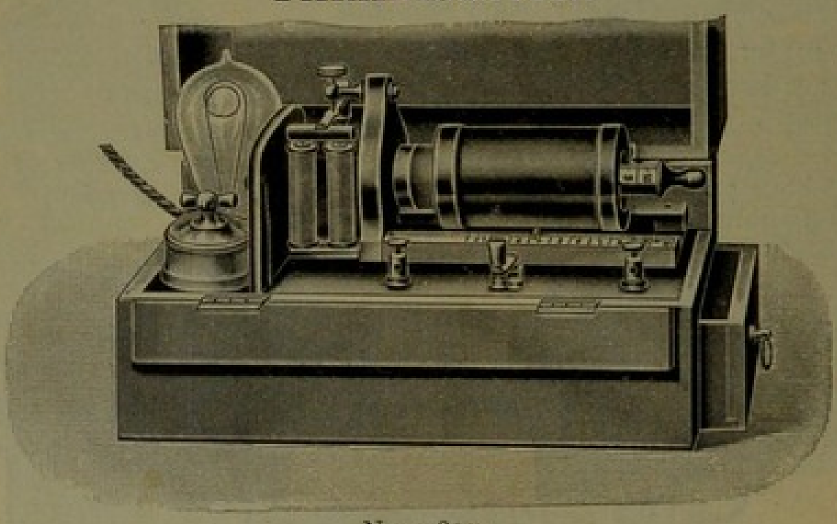
APPARATUS FOR USING THE CURRENT FROM THE MAIN.

The first Switchboard which was ever designed to use the current from dynamos for medical purposes was made by us in London in 1890. Since that time over 2500 switchboards of various types have been made in our workshops in London; we have thus the *longest* and by *far the largest experience* in this kind of work.

The compliment has been paid us that all our switchboards have been copied by competitors, which proves that more practical constructions have not been found up to now.

SWITCHBOARDS for Galvanisation, Electrolysis, and Faradisation. (*See also pages 28–31.*)

FARADISATION.

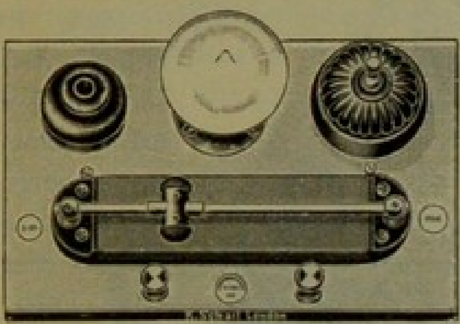


No. 1807.

No. 1807. **Portable sledge coil,** in polished mahogany case, with electrodes, cords, and handles, Fig. 1807 .. **£4 12 0**

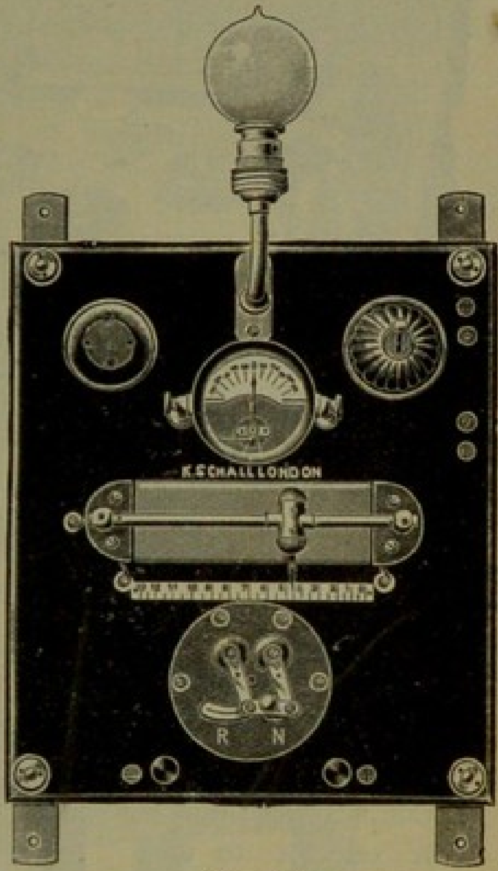
This apparatus is similar to No. 21, but instead of the two dry cells there is a lamp resistance, so that the coil can be used with the current from the main.

GALVANISATION, ELECTROLYSIS, AND FARADISATION.



No. 1820

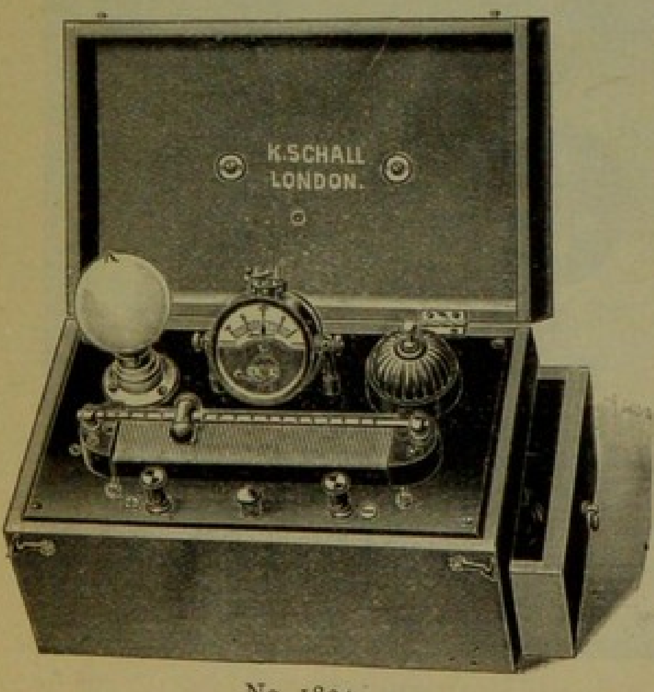
No. 1820. **Switchboard,** with volt selector, to vary the current from the main from 0·1 volt gradually up to about 70 volts, lamp, switch, and fuse, mounted on enamelled slate. Size, 6 in. by 10 in.; weight 4 lb. Fig. 1820 **£2 16 0**



No. 1822.

No. 1822. **Similar apparatus,** with a current reverser, galvanometer No. 281, cords, handles, and 4 electrodes in addition, Fig. 1822 .. .. **£6 12 0**

Size of slate, 11 in. by 12 in.



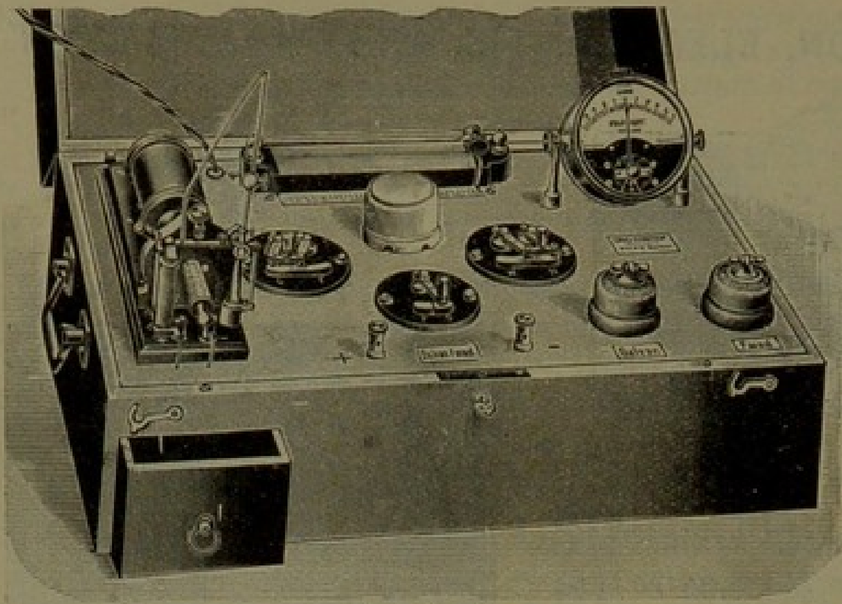
No. 1824.

No. 1824. Dr. E. R. Morton's **portable switchboard,** Fig. 1824, for galvanisation and electrolysis, in polished walnut case, with volt-selector, milliamperemeter, handles, cords, and four electrodes **£7 0 0**

Size 8 in. by 13 in. by 9 in., weight 15 lb.

SWITCHBOARDS for Current from Main. LIGHT THERAPY

X-RAY APPARATUS

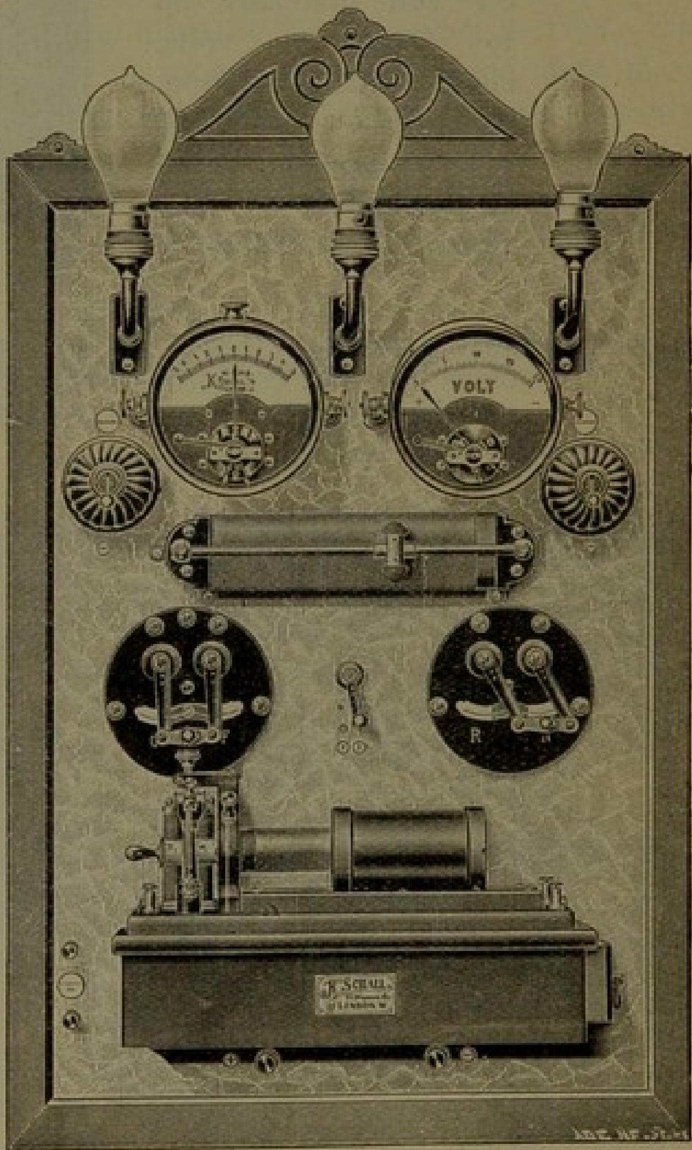


No. 1828.

No. 1828. **Switchboard,** with accessories as specified under No. 1830, but arranged in a portable polished walnut case. Fig. 1828 **£15 0 0**

Size, 15 in. by 22 in. by 12 in.

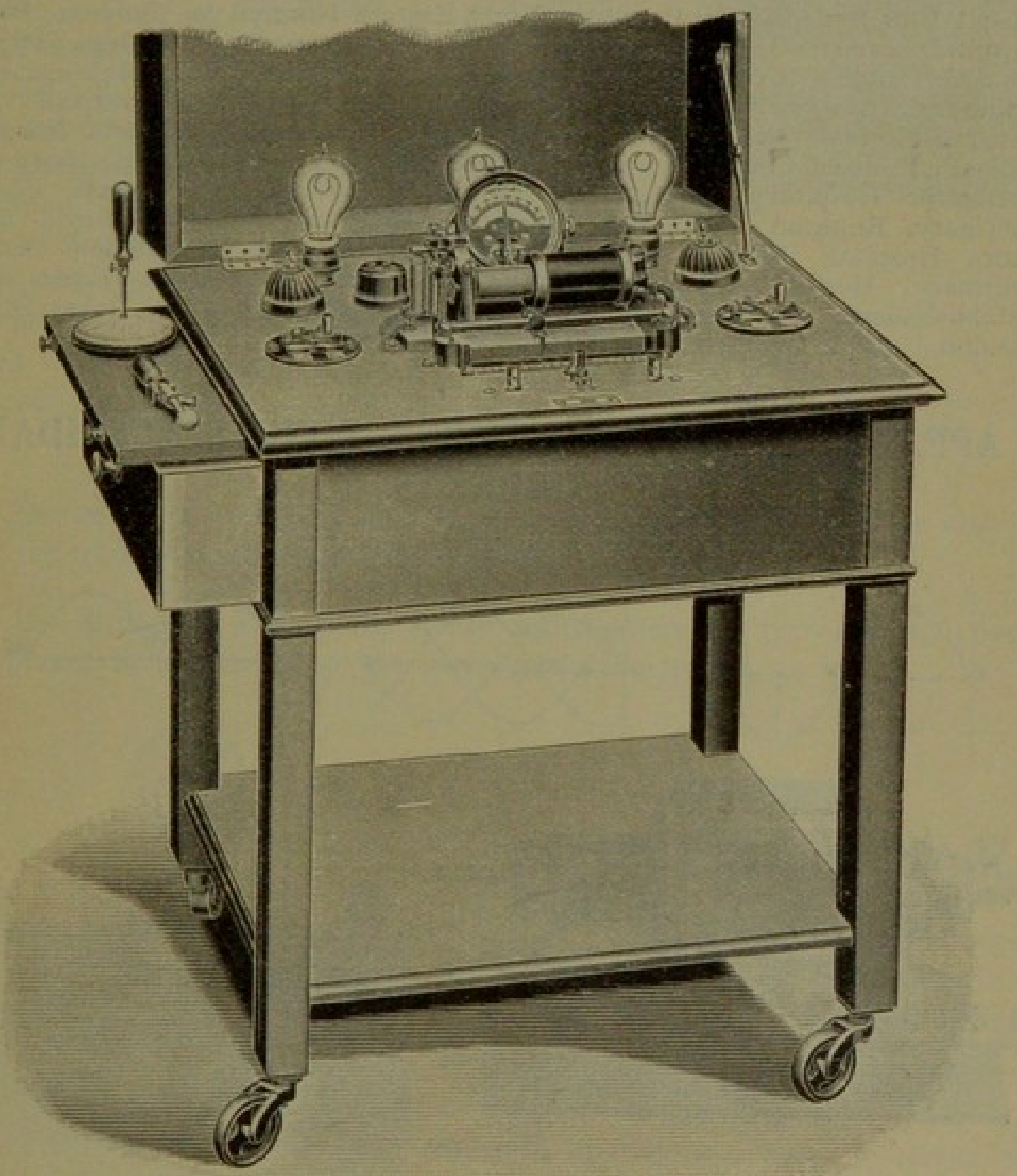
No. 1830. **Switchboard,** for galvanisation, electrolysis, and faradisation, consisting of volt selector to vary the current from the main from 0·1 volt gradually up to about 70 volts; sledge coil No. 27, galvanometer No. 288, with 2 shunts; current reverser and Dr. de Watteville's key, three lamps, switches, and fuses, mounted on enamelled slate or marble, cords, handles, and six electrodes. (The apparatus is similar to Fig. 1831, but is not provided with the voltmeter shown in the illustration) **£15 0 0**



No. 1831.

No. 1831. **Similar apparatus,** with a voltmeter in addition, Fig. 1831 .. .. **£18 10 0**

The apparatus Nos. 1830 and 1831 can be enclosed in a polished mahogany case with glass door and lock, to protect it from dust and interference by servants. Price of the case, **£2 10s.**



No. 1837.

No. 1837. **Switchboard,** with accessories as specified under No. 1830, arranged on a trolley of oak, with castors covered with indiarubber, for hospital use, Fig. 1837 .. .. **£18 10 0**

X-RAY APPARATUS

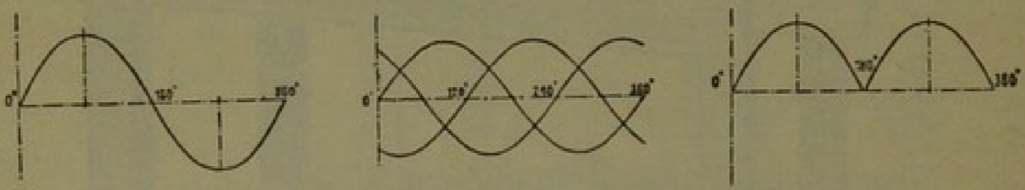
No. 1840. **Switchboard,** with accessories as specified under No. 1830, and with a voltmeter in addition, arranged in a desk-like mahogany case, with glass lid (suggested by the late Dr. M. Murray) **£21 0 0**

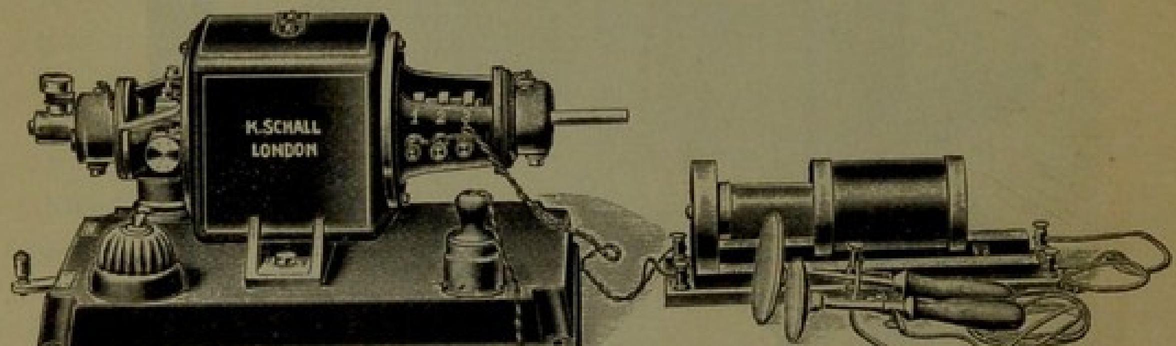
Estimates for other combinations of apparatus will be sent on application.

Apparatus Nos. 1830–1840 have been supplied to the War Office, the Crown Agents for the Colonies, St. Bartholomew's Hospital, Queen Alexandra Hospital, London Hospital, King's College, St. Mary's, Westminster, and St. George's Hospitals; London County Asylum, Claybury; National Hospital for the Paralysed; Hospital for Epilepsy and Paralysis; North Eastern Hospital for Children; Poplar Hospital, Seamen's Hospital, Greenwich; Victoria Hospital for Children, Hospital for Sick Children, Great Ormond Street, etc., in London. Royal Infirmaries in Edinburgh, Glasgow, Aberdeen, Halifax, Hull, Manchester and Liverpool; New General Hospital and Queen's Hospital in Birmingham; Victoria Hospital, Belfast; Lincoln County Hospital, Norfolk and Norwich Hospital, Essex and Colchester Hospital; St. Andrew's Hospital, Northampton; Sussex County Infirmary, Brighton; Infirmary, Lancaster; Infirmary, Norwich; Royal Alexandra Hospital, Rhyl; West Kent General Hospital, Maidstone; General Infirmary, Hertford; Stanley Hospital, Liverpool; Smedley's Hydropathic Establishment; Harrogate Hydropathic Company; Bath Club, Dover Street, London; and to over 300 Medical Men.

APPARATUS FOR TREATMENT WITH SINUSOIDAL CURRENTS.

(*See also pages* 43–44.)





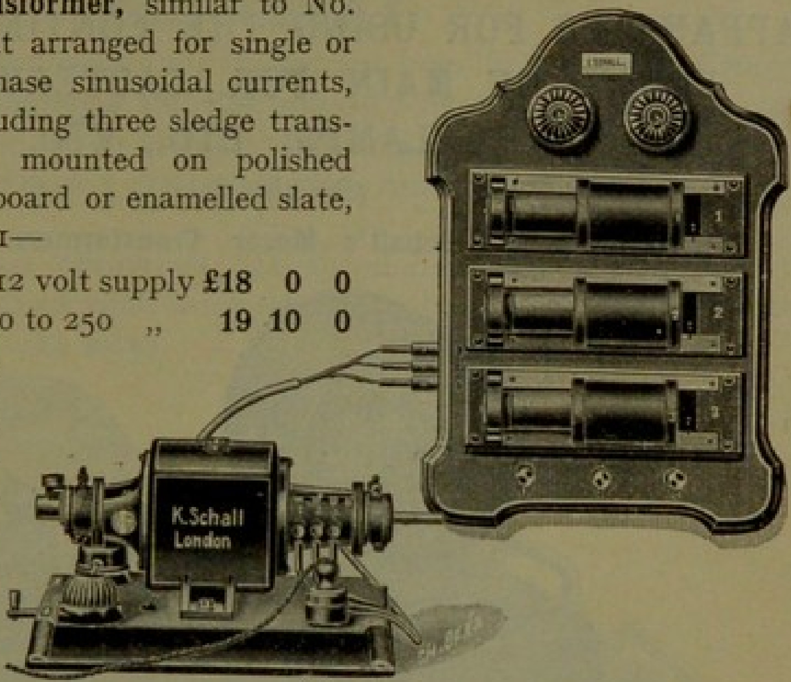
No. 1900.

No. 1900. **Motor transformer,** to convert a continuous current into a single phase sinusoidal current, including rheostat to control the motor and the number of periods, and a sledge transformer to vary the E.M.F. of the sinusoidal currents gradually from a few volts up to nearly 100 volts, Fig. 1900—

(*a*) Motor wound for 12 volt supply .. **£12 5 0**
(*b*) „ „ 200 to 250 volt supply .. **13 15 0**

No. 1901. **Motor transformer,** similar to No. 1900, but arranged for single or three phase sinusoidal currents, and including three sledge transformers, mounted on polished walnut board or enamelled slate, Fig. 1901—

(*a*) Motor wound for 12 volt supply £18 0 0
(*b*) „ „ 200 to 250 „ 19 10 0

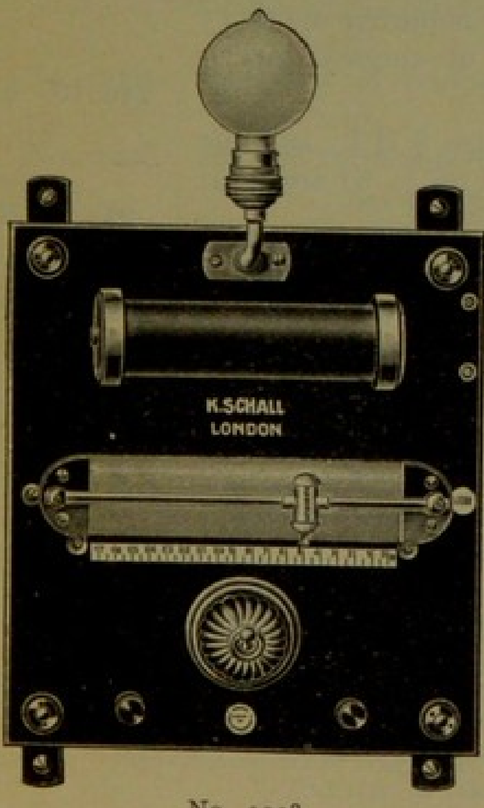


No. 1901.

The motor transformers Nos. 1900 and 1901 can also be used for massage and rapid vibration treatment, and for surgical operations with drills, etc., or they can be provided with a Leduc's reverser (see No. 245), or a rhythmical interrupter, No. 248.

The motor transformers Nos. 2000 to 2008 for cautery etc., can also be used for treatment with sinusoidal currents.

The secondary coils of the sledge transformers are provided with rack and pinion, though this is not yet shown in the illustration.



No. 1928.

No. 1928. **Transformer,** with volt regulator, to apply the alternating current from the main as sinusoidal current *in a bath*, Fig. 1928 .. £4 4 0

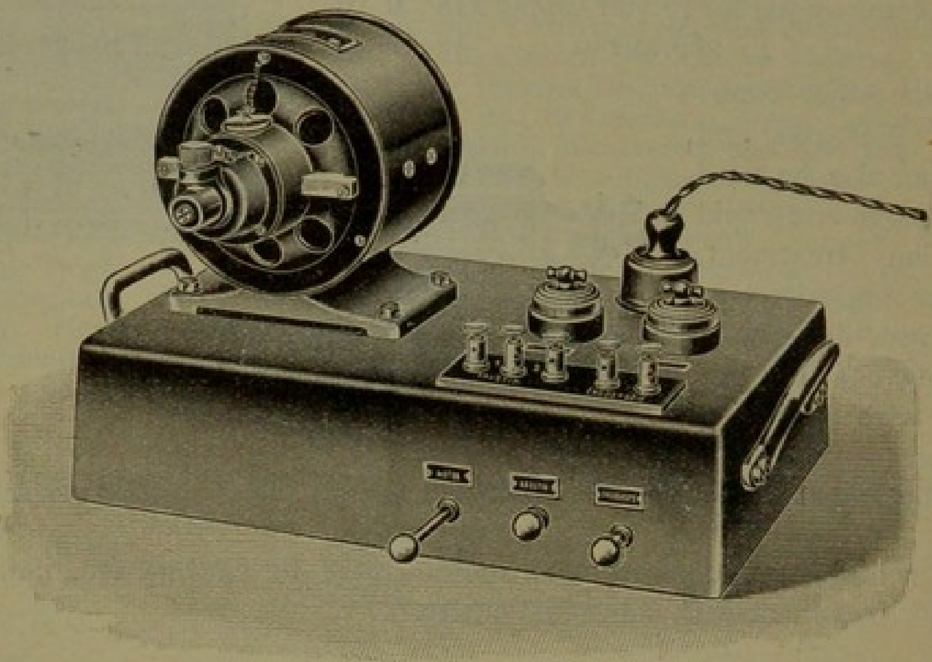
Before the alternating current from the main is applied in a bath, it should be transformed in order to protect the patient from shocks due to leakage (see pages 31 and 32).

X-RAY APPARATUS

APPARATUS FOR USING THE CONTINUOUS CURRENT FROM THE MAIN FOR CAUTERY, SURGICAL LAMPS, ETC., ETC.

(*See also page* 33.)

Schall's Motor Transformers.



No. 2000.

No. 2000.	**Motor Transformer,** Fig. 2000, $\frac{1}{16}$th of a H.P., suitable for cautery burners requiring up to 25 ampères, and for all sizes of surgical lamps. Wound for 200 to 250 volts	**£16 10 0**
No. 2002.	**Similar Transformer,** but larger size, ¼ H.P., suitable for cautery burners requiring up to 60 ampères, wound for 200 to 250 volts	**21 0 0**

In addition to cautery and light, transformers Nos. 2000 to 2002 can be used equally well as motors for surgical operations with drills, for massage and rapid vibration, for air pumps, for sinusoidal currents, Leduc's interrupter, etc.

[*Copy of an unsolicited testimonial.*]

"IPSWICH, *March 21st* 1910.

"DEAR SIR,

"I have received authority from the board of Management of the Suffolk and Ipswich Hospital to place an order for a universal apparatus for electrical treatment. Your competitors are most anxious to secure the order, but we have had one of your motor transformers No. 2000 in our operating theatre since about 1904; it has served us well, and we prefer to deal with you.

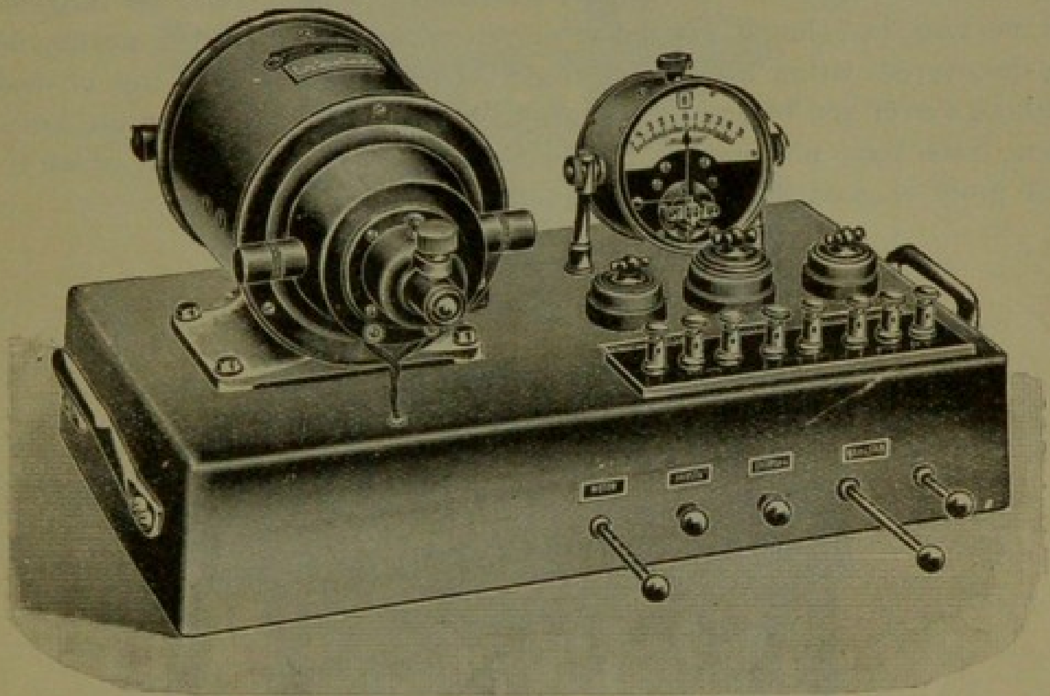
"Yours faithfully,

"P. E. RIPLEY."

PANTOSTAT.

A *Universal Apparatus* for using the current from the main for: *Cautery, Surgical Lamps, Galvanisation* and Electrolysis, Sinusoidal *Faradisation*; for Rhythmic Currents and for Leduc's Currents; for *Air Pumps, Massage*, and rapid *Vibration*; for Surgical *Operations* with drills, trephines, burrs, saws, etc.

All the currents are *transformed*; it is therefore impossible for patient or operator to receive a shock while using this apparatus, even if one pole of the dynamo is connected with earth.



No. 2005.

No. 2005.	**Pantostat** for *continuous* current of 200 to 250 volts, Fig. 2005	£23 10 0
No. 2008.	Similar apparatus, for *alternating* current, 100 volts	28 10 0
	Ditto, 200 to 250 volts	30 0 0
No. 2009.	**Pantostat,** with 6 accumulator cells of 50 amp. hour capacity, on trolly, Fig. 2009	35 0 0
	Cords, handles, and 4 electrodes are included in these prices.	
No. 2010.	Stand, made of enamelled steel tubes, and provided with casters covered with india-rubber tyres ..	3 0 0
A Drawer	for the reception of instruments, cords, etc., can be added to the Stand, price	0 12 0

(Copy of an unsolicited testimonial.)

December 23rd, 1910.

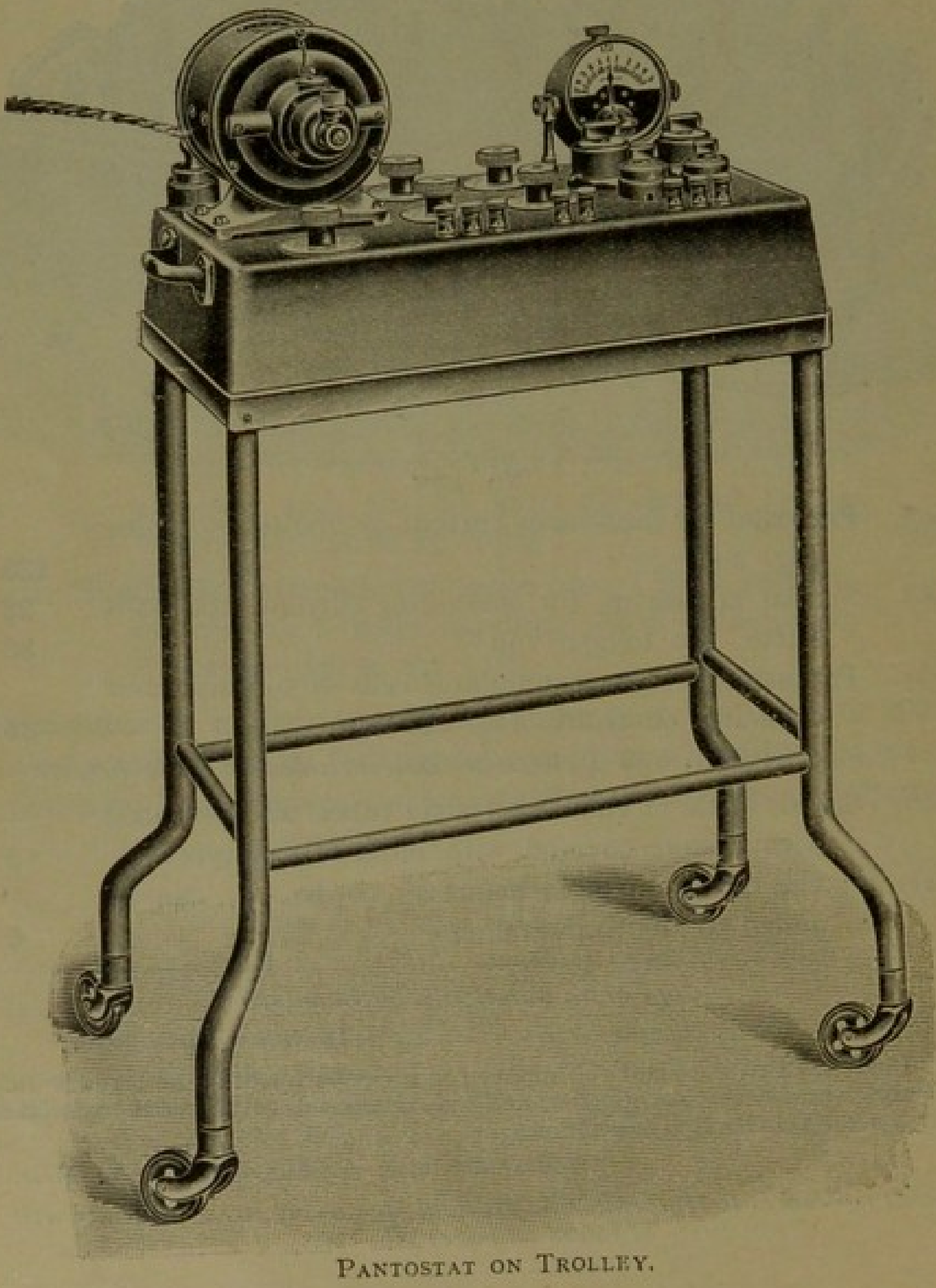
"I may say that the plant you supplied to my department in the Dundee Royal Infirmary gives me every satisfaction, and I am anxious to get the same material and quality for the Dundee Eye Institution.

"Yours faithfully, A. McGILLIVRAY, M.D."

Some references to Hospitals and Medical Men using our Pantostats will be found on pages 116, 117.

These Motor Transformers were invented and brought out by us in London in 1903. They are the most useful electro-medical apparatus which has been constructed up to now, because they supply *all* the various currents and motive power which are required nowadays in medical and surgical practice, with the only exception of X rays. On account of their great convenience they are already being used by a large number of Hospitals and medical men (see references on pages 116, 117).

These instruments have been copied by many other firms, but we have the *longest and by far the largest experience with these apparatus,* and this enables us to supply the *best quality obtainable. We guarantee our instruments for one year,* i.e., should any defect due to imperfect material or workmanship be discovered within a year, we undertake to make it good free of charge. Although over 400 of our Pantostats have been in regular daily use, some of them since 1904, not one has required serious repairs up to now, which is the best proof of good design, materials, and workmanship.

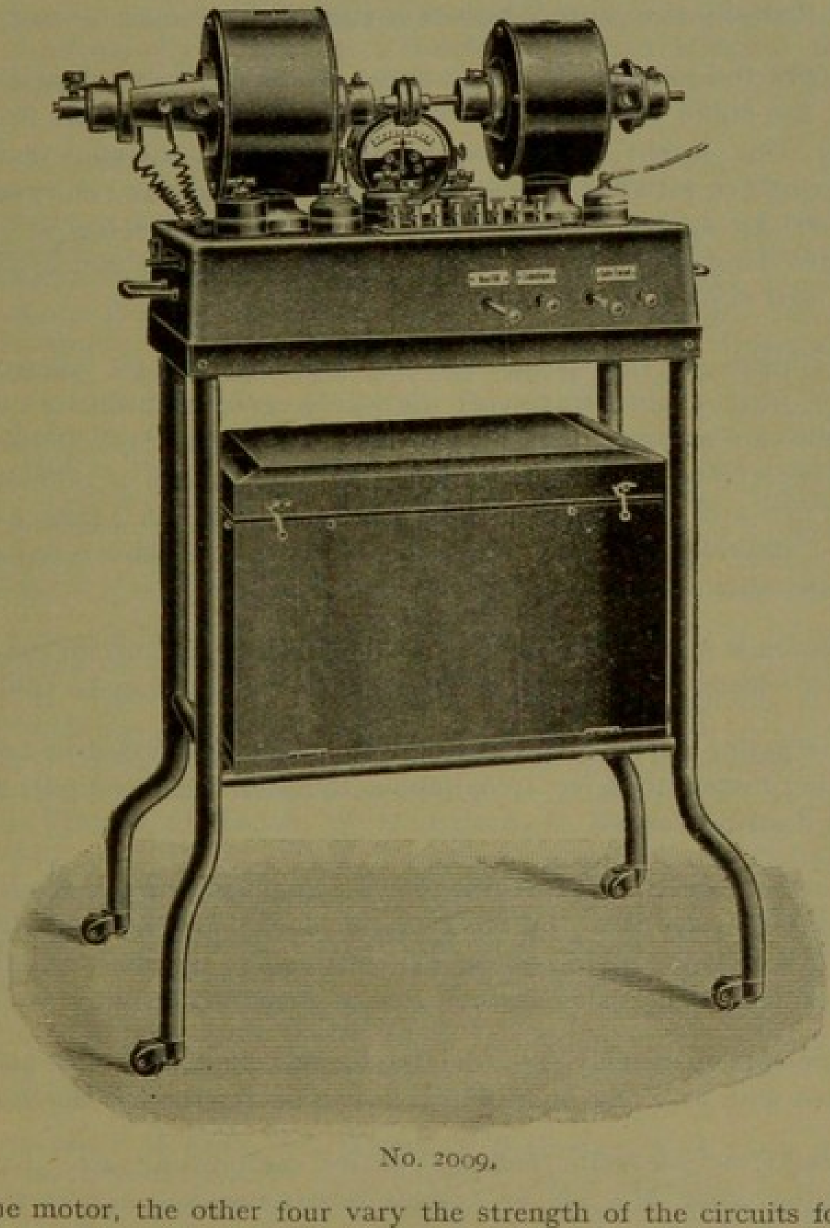


PANTOSTAT ON TROLLEY.

The motors consume less than one ampère on a 200 volt continuous current supply, and can be attached to any wall plug or lamp holder *without altering the size of the cables and fuses.*

The terminals are mounted on an ebonite plate, on which the words : Cautery, Light, Galvanization, Faradisation, are engraved, so that no mistake can be made in connecting the cords.

The Apparatus No. 2005 consists of a motor of 1-eighth of a H.P. mounted on a base of cast iron, which contains five variable rheostats ; one of these controls the



No. 2009.

speed of the motor, the other four vary the strength of the circuits for cautery, surgical lamps, galvanisation, and sinusoidal faradisation.

The sliding contacts of these rheostats can be shifted either by the steel rods (as shown in Fig. 2005), which have to be drawn out to increase the strength of the current, or by cranks fitted with large ebonite knobs, which have to be turned round (as shown in illustration with pantostat on trolley, page 114). We can supply either type ; as far as gradual increase or decrease of the current-strength is concerned, both are equally convenient, but the rods are preferable because the apparatus can be dusted and kept clean more easily, and moreover, the cranks may be left by mistake on "strong," whereas it is less likely that it will be forgotten to push the sliding rods home to "weak" after the application is over.

For *cautery, surgical lamps, and sinusoidal faradisation*, the motor converts the continuous into an alternating current (see page 41), which is transformed by means of an alternating current transformer, so that at the secondary terminals of this transformer about 30 ampères and 10 volts are available for cautery, and 2 ampères and 20 volts for surgical lamps. Two sliding rheostats control these circuits, so that any size cautery burner or surgical lamp may be used.

To supply the current for *galvanisation, electrolysis and cataphoresis or ionic medication*, the motor is provided with a second winding, so that it acts also as a dynamo. The current which reaches the patient is therefore not connected at all with earth or with the current supplied by the main, and our pantostats can safely be used for applying currents even in a bath, without fear of exposing the patient to the dangers of a shock, which would be possible if the current from the main were used directly in a bath.

The terminals of the special wire for galvanisation are connected with a volt selector, which enables us to vary the voltage gradually from 0·1 up to about 70 volts; the current passes through a reverser, and a dead beat milliampèremeter indicates the current reaching the patient. The M.A. meter is provided with two shunts, and indicates up to 5 M.A., every tenth part of a M.A.; from 5 to 50 every single M.A.; and from 50 to 500, ten by ten, M.A. A condenser is provided in this circuit to neutralize the pulsations of some dynamos.

For *sinusoidal faradisation* the transformed alternating current passes through a similar volt selector. Sinusoidal and continuous currents may be used combined.

For alternating circuits the Pantostat No. 2008 is provided in addition with an alternating motor, to drive a continuous dynamo, which supplies the various currents as described above.

If no current from the main is available, 6 *accumulator cells*, of about 50 ampère hours capacity may be used to drive a 12 volt motor, as shown in *Fig.* 2009, this is coupled to a dynamo giving about 100 volts and 2½ ampères, and this current is used for cautery, light, galvanisation, etc., as described above.

Drills, trephines, circular saws, or the various appliances for massage, etc., are connected with a flexible shaft which has to be attached to the motor.

Air pumps for pneumatic massage, or for compressing air; Lewis Jones' Rhythmic Interrupter, No. 248, or *Leduc's Interrupter*, Nos. 245 or 246, etc., are attached directly to the axle of the motor.

Explicit directions for use are sent with the apparatus.

We have supplied our Motor Transformers amongst others to :—

The Admiralty ; the War Office ; the India Office ; the Crown Agents for the Colonies ; the Governments of Egypt, India, and Ceylon ; the Cairo Sanitary Department.

St. Bartholomew's Hospital (3 Transformers), the Charing Cross Hospital, St. George's Hospital, Westminster Hospital, New Hospital for Women, Central London Throat and Ear Hospital, Victoria Hospital for Children, German Hospital, Queen Alexandra Hospital, Throat Hospital (Great Portland Street), Samaritan Free Hospital, Metropolitan Throat, Nose, and Ear Hospital, London Homœopathic Hospital, Central London Ophthalmic Hospital, Hospital of St. John and St. Elizabeth, National Eye, Ear, etc., Hospital, Queen's Hospital for Children, Brompton Hospital, Orthopædic Hospital (Great Portland Street), Willesden Board of Guardians, Bath Club (Dover Street), etc., etc.

Royal Infirmary, Edinburgh ; Royal Infirmary, Glasgow ; Hospital for Diseases of the Ear, etc., Glasgow ; Cancer and Skin Institution, Glasgow ; General Hospital, Northampton ; General Hospital, Wolverhampton ; East Suffolk and Ipswich Hospital (2 Transformers) ; York County Hospital ; Batley Hospital ; Salop Infirmary ; Victoria Hospital, Hull ; Victoria Hospital, Burnley ; Royal Buckinghamshire Hospital, Aylesbury ; Leigh Infirmary, Leigh ; Swansea General and Eye Hospital ; Radcliffe Infirmary, Oxford ; General Hospital, Calcutta ; Stanley Hospital, Liverpool ; Royal South Hants and Southampton Hospital ; Birmingham and Midland Skin Hospital ; General Infirmary, Gloucester ; Royal Hamadryad Seamen's Hospital, Cardiff ; British Hospital, Colombo ; Royal Infirmary, Hull ; Royal Infirmary, Dundee ; Dumfries and Galloway Royal Infirmary ; Victoria Hospital, Folkestone ; Kidderminster Infirmary ; Civil Hospital, Rangoon ; New General Hospital, Rangoon ; Cork Eye, Ear, and Throat Hospital ; Royal Infirmary Liverpool ; The Royal Baths, Harrogate ; Croydon General Hospital ; Sir Patrick Dunn's Hospital, Dublin ; etc., etc.

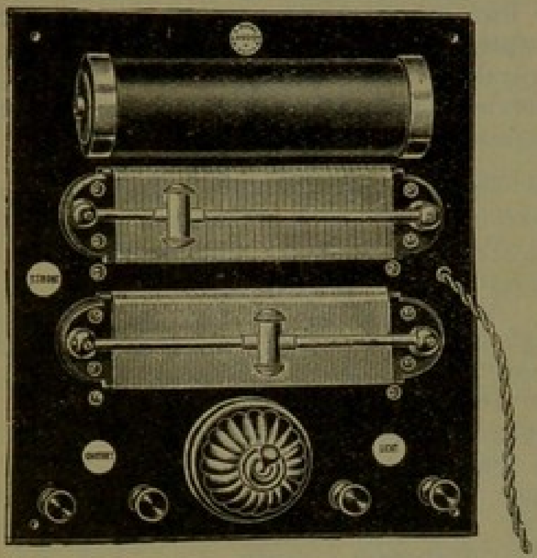
P. H. Abercrombie, M. F. Agar, H. S. Barwell, A. E. Bridge, R. W. Brimacombe, G. W. Badgerow, R. M. Beattie, J. W. Bond, G. L. Cheatle, G. L. Cathcart, A. H. Cheatle, H. H. Clutton, E. E. Cornaby, E. H. Crisp, B. Dawson, R. W. Doyne, F. S. Eve, W. Edmunds, R. J. Ferguson, R. H. Fox, J. D. Grant, L. Galsworthy, F. Green, E. C. Greenwood, W. S. Hedley, H. T. Herring, G. E. Haslip, G. Herschell, G. W. Hill, W. J. Horne, W. G. Howarth, F. H. Humphris, P. S. Jakins, H. M. Jones, G. J. Jenkins, D. Judah, W. H. Kelson, E. Kingscote, R. Lake, E. Law, W. Stuart-Low, A. Lawson, W. M. Leslie, W. Lloyd, H. D. McCulloch, H. J. Macevoy, J. D. P. McLatchie, G. W. Mackenzie, J. McGregor, W. McQuibban, H. H. Mills, C. W. M. Moullin, W. J. C. Nourse, A. Orwin, B. Pollard, J. Pollard, H. W. F. Powell, C. A. Parker, L. H. Pegler, A. F. Penny, F. H. Preston, W. Rose, H. B. Robinson, E. W. Roughton, J. Russell Ryan, M. Rees, A. W. Read, P. Rendall, A. Q. Silcock, J. Startin, B. H. S. Spicer, F. Spicer, J. Shaw, Sir F. Semon, C. J. Symonds, A. H. Tubby, Inglis Taylor, St. C. Thompson, H. Tilley, H. F. Tod, H. F. Waterhouse, W. H. White, A. Whitfield, A. Wylie, D. Wright, T. O. Wood, C. A. Wright, A. Westerman, A. Wilson, F. C. Wallis, etc., etc.

J. Macintyre, P. McBride, A. L. Turner, P. S. Hichens, B. S. Jones, A. P. Parker, F. C. Hitchins, E. M. Hainworth, V. T. Greenyer, W. L. Griffiths, T. D. Griffiths, T. Guthrie, H. E. Gamlen, G. W. C. Hollist, C. T. Holland, O. S. Gogarty, N. E. Aldridge, H. E. Bateman, A. F. Blagg, T. C. Squance, G. S. MacGregor, W. F. Brook, E. J. Fox, W. L. Muir, N. Davies, P. J. McGinn, J. E. G. Calverley, R. H. Woods, D. Neu, J. D. Rawlings, R. A. Bickersteth, Th. H. Bickerton, W. J. Turrell, A. W. Sandford, T. O. Graham, etc., etc.

L. A. Beck, A. M. Moll, and J. Petersen, Cape Town ; Dr. Pettavel, and G. E. Murray, Johannesburg ; G. V. Lockett, Vancouver ; A. Doyle, Brisbane ; L. A. Gagnier, Montreal ; N. G. Munro, Yokohama ; J. Murphy, Melbourne ; Dr. Irwin, Tien-tsin : E. C. Long, Maseru ; Dr. Truhart, St. Petersburg ; Medical College, Calcutta ; A. W. Munro, Sydney ; Dr. E. Reytter, Bangkok, etc., etc.

TRANSFORMERS TO USE THE ALTERNATING CURRENT FROM THE MAINS FOR SURGICAL LAMPS, GALVANISATION, ELECTROLYSIS, ETC.

(*See also page 37.*)



No. 2050.

No. 2050. **Schall's portable transformer** for cautery and surgical lamps, on enamelled slate plate. The current for cautery can be varied gradually between 8 and 20 ampères, and the current for surgical lamps from 4 to 15 volts, Fig. 2050 .. £4 0 0

Size, 9½ by 9½ by 2¼ inches.

No. 2052. **Similar transformer,** but for cautery only £3 0 0

When ordering, please state the number of volts and the number of periods of your supply.

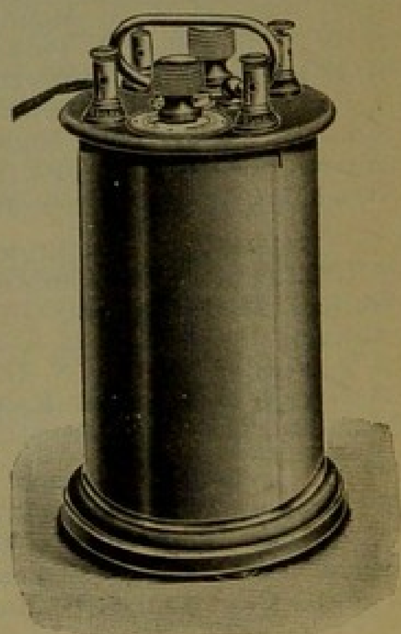
Polished wooden frame with glass door, to protect the transformer from dust, etc. £1 5 0

Our transformer No. 2050 is now used by over 1000 medical men and hospitals, which is the best proof of its convenience and reliability.

A Universal Apparatus, to use the **alternating** current for cautery, surgical lamps, galvanisation and electrolysis, sinusoidal faradisation; for operations with drills, for massage, air pumps, etc., will be found under No. 2008, page 113.

No. 2054. **Portable transformer,** for cautery, surgical lamps, and sinusoidal faradisation, Fig. 2054 .. £6 0 0

Motor Transformers, to convert the alternating into a continuous current, will also be found under Nos. 1780-1782 and 2682-2687.

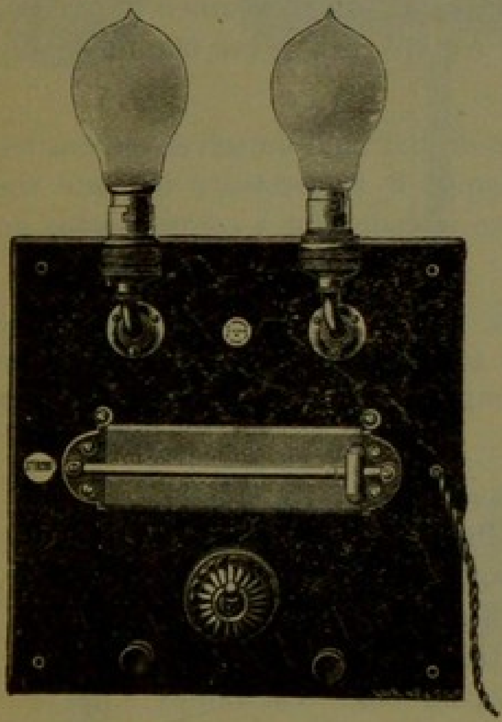


No. 2054

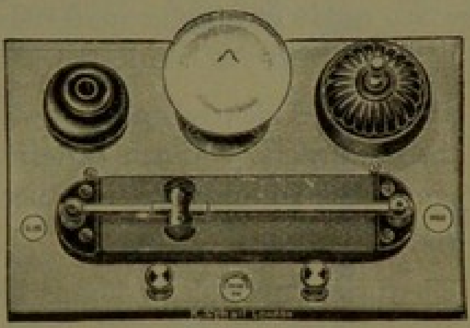
RHEOSTATS FOR SURGICAL LAMPS.

(*See also page* 35.)

These rheostats can be used equally well on a continuous or an alternating current. In ordering please mention the E.M.F. of the supply.



No. 2060.



No. 2066.

No. 2060. **Rheostat,** consisting of two lamps, sliding rheostat, switch, and terminals, mounted on enamelled slate, suitable for all sizes of surgical lamps, Fig. 2060 .. .. £3 0 0

No. 2063. **Rheostat,** for the same purpose as No. 2060, but with a wire resistance instead of the two lamps—
For 200 to 250 volt supplies 4 0 0

If the antrum, etc., has to be made transparent, the room must be kept dark, and in such a case the resistance lamps used in No. 2060 have to be replaced by a wire resistance.

No. 2066. **Portable rheostat** for surgical lamps, Fig. 2066 .. £2 10 0

ILLUMINATING INSTRUMENTS TO BE USED WITH THE CONTINUOUS OR ALTERNATING CURRENT SUPPLIED FROM DYNAMOS.

In ordering these instruments it is necessary to state the voltage of the supply, and in some cases also whether it is a continuous or alternating current.

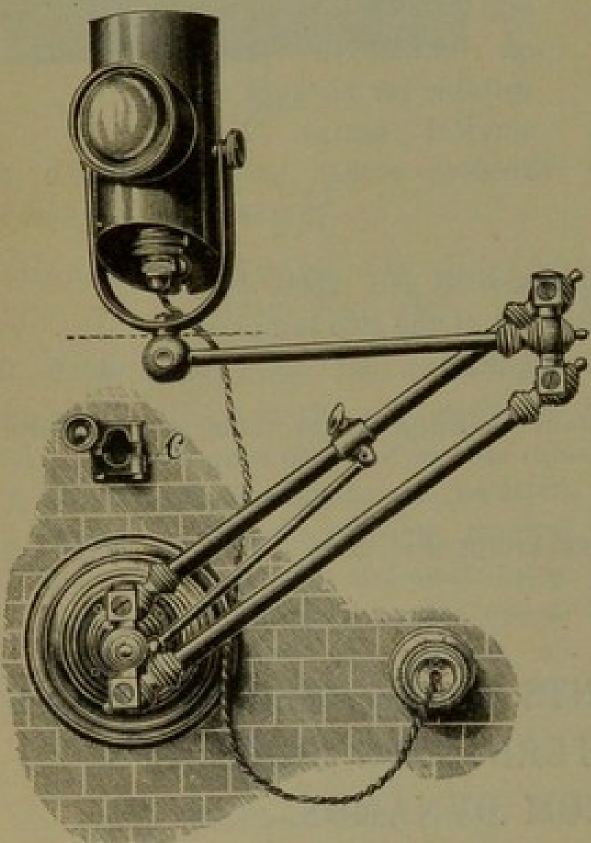
The Lamps Nos. 2090—2101 can be provided either with incandescent lamps, which have a carbon filament arranged in a zig-zag in the centre of

X-RAY APPARATUS

the glass bulb (so-called focus lamps), or else they can be provided with Nernst lamps, which give a whiter light of 60 to 100 candle-power. As far as homogeneous illumination, *i.e.*, absence of bright or dark parts, is concerned, the light of these Nernst lamps is as good as the limelight, and the candle-power comes nearer the limelight than any other lamp which may be used. The disadvantage of the Nernst lamps is that, after turning on the switch, one has to wait nearly a minute till the light appears, and the burners are fragile (they are made of similar materials as the Auer-Welsbach gas mantles), only lasting for 200 to 300 hours.

It must be clearly understood that we do not hold ourselves responsible for these burners. When ordering the lamps it is necessary to state the voltage of the supply, and whether they are intended for a continuous or an alternating current.

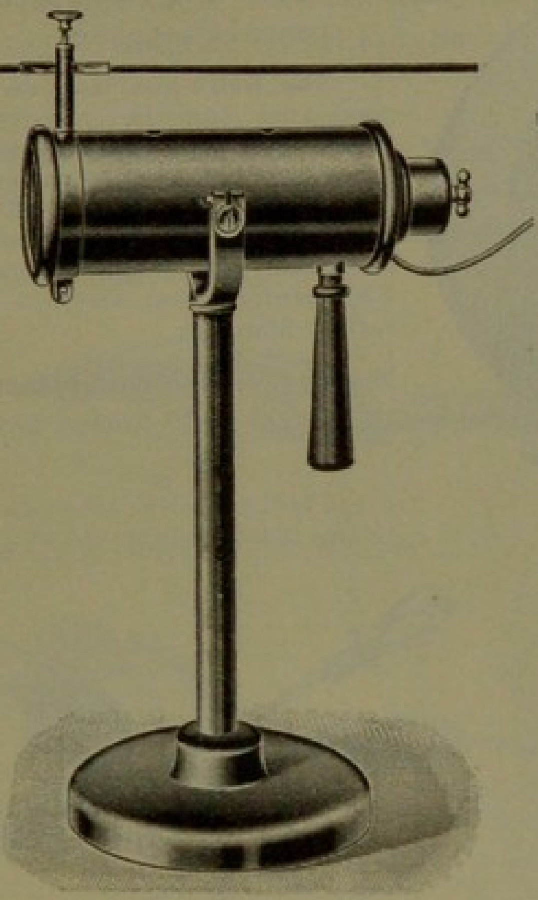
The prices quoted for lamps Nos. 2090, 2095, 2098, and 2101 are for the bull's-eye lanterns fitted with incandescent focus lamps; if it is desired that they should be provided with Nernst lamps, **5**/– has to be added to the prices.



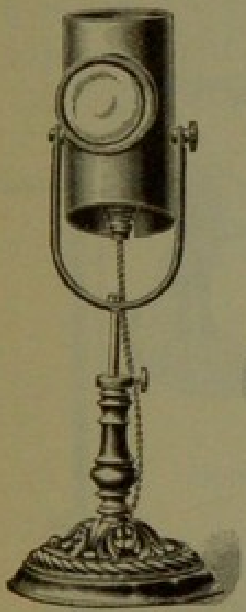
No. 2090

No. 2090. **Dr. MacDonald's lamp,** with bull's-eye, for throat, nose, and ear examinations, and for surgical operations. The lamps are movable in any direction, and can be taken off the bracket and used as hand lamps. Price, with parallel bracket, as shown in illustration, and with a 32 candle-power focus lamp, Fig. 2090 .. **£4 6 0**

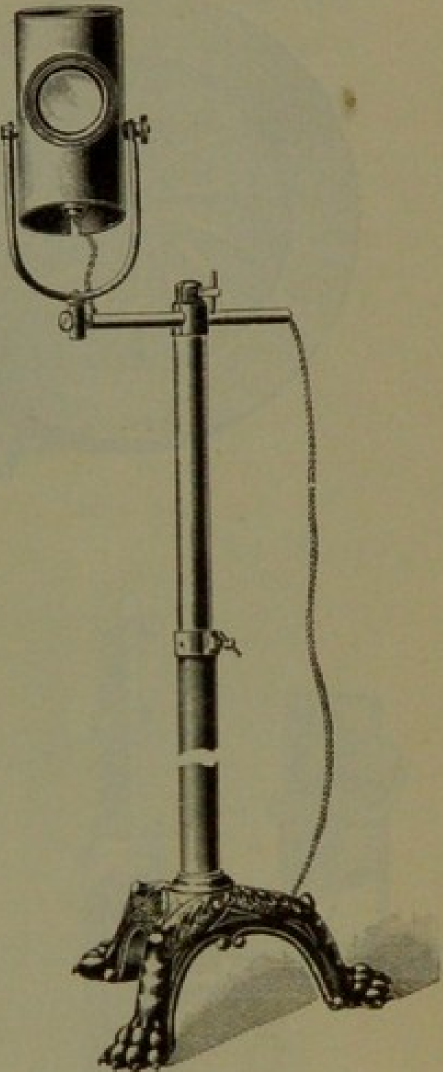
No. 2095. **Dr. MacDonald's lamp,** as shown in Fig. 2090, but without the parallel bracket. A clamp (*c*) is supplied with it, by means of which it can be attached to an existing gas bracket .. **1 15 0**



No. 2104.



No. 2098



No. 2101.

No. 2098.	**Dr. MacDonald's lamp** on a stand, to be put on a table, Fig. 2098	£2 5 0
No. 2101.	**Dr. MacDonald's lamp** on a telescopic stand, as shown in Fig. 2101	3 10 0
No. 2104.	**Nernst lamp,** with lenses and concave mirror, on stand, Fig. 2104	3 15 0

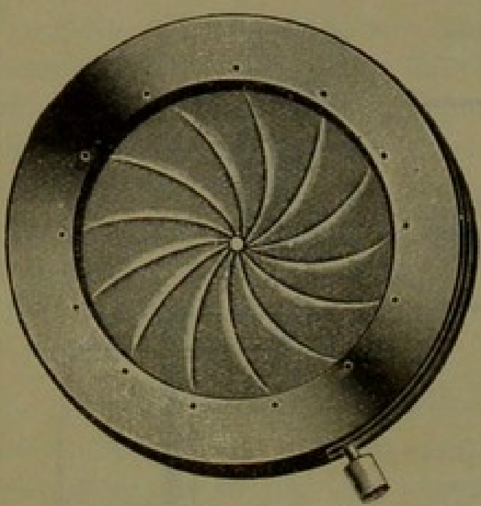
This lamp supplies a parallel or converging beam of light of great intensity, and is excellent for examination of larynx, ear, nose, etc.

The Lamps Nos. 2090—2101 have been supplied by us, amongst many others, to :—

Dr. Greville MacDonald, Sir Francis Laking, Sir Victor Horsley, Sir Felix Semon, Dr. J. Macintyre, Prof. Ogston, and over 400 other surgeons.

Guy's Hospital, London Hospital, Royal Free Hospital, Poplar Hospital, Throat Hospital (Great Portland Street) ; to the Royal Infirmaries in Glasgow, Manchester, Aberdeen, Halifax, Wigan, Belfast, Newcastle-on-Tyne ; Queen's Hospital and New General Hospital in Birmingham ; Manchester Ear Hospital, Lincoln County Hospital, Royal Victoria Hospital (Bournemouth), etc., etc.

To the Governments of Natal, India, etc., etc.



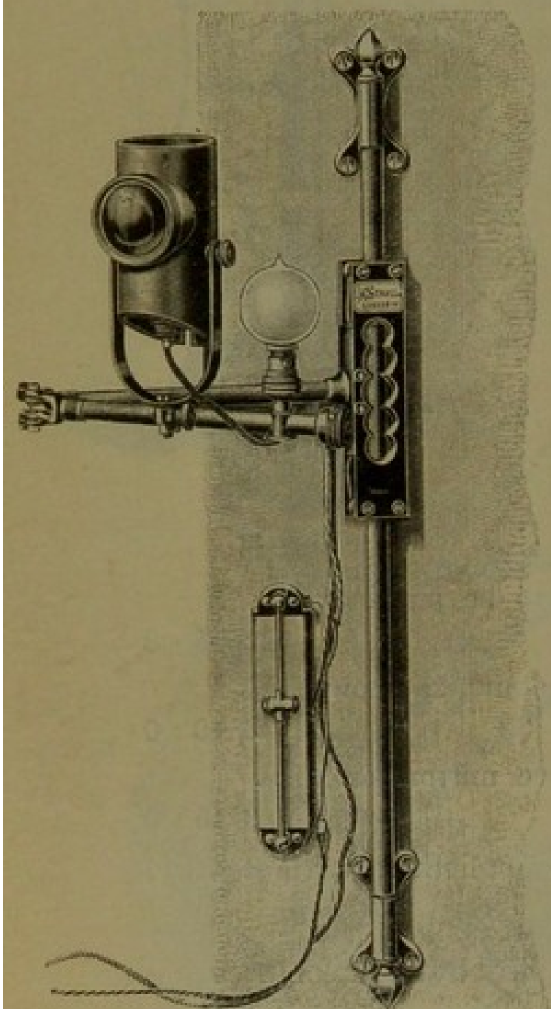
No. 2108.

No. 2108. **Iris diaphragm,** Fig. 2108, with frosted glass plate **£1 0 0**

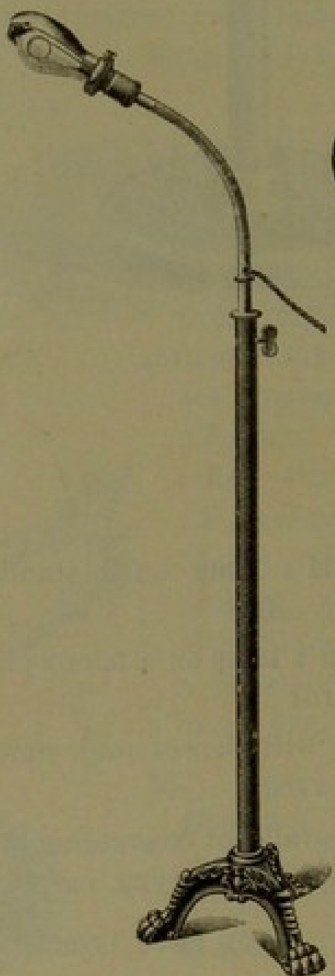
The bull's-eye lens of the Lamps Nos. 2090–2101 can be removed and the iris diaphragm can be inserted instead. The intensity of the light can be varied gradually by means of this diaphragm, *without varying the colour of the light,* which is important for ophthalmoscopic purposes. The frosted glass destroys any trace of the carbon filament.

No. 2114. **Ophthalmoscopic bracket,** Fig. 2114, with frosted lamp and switch, **£4 0 0**

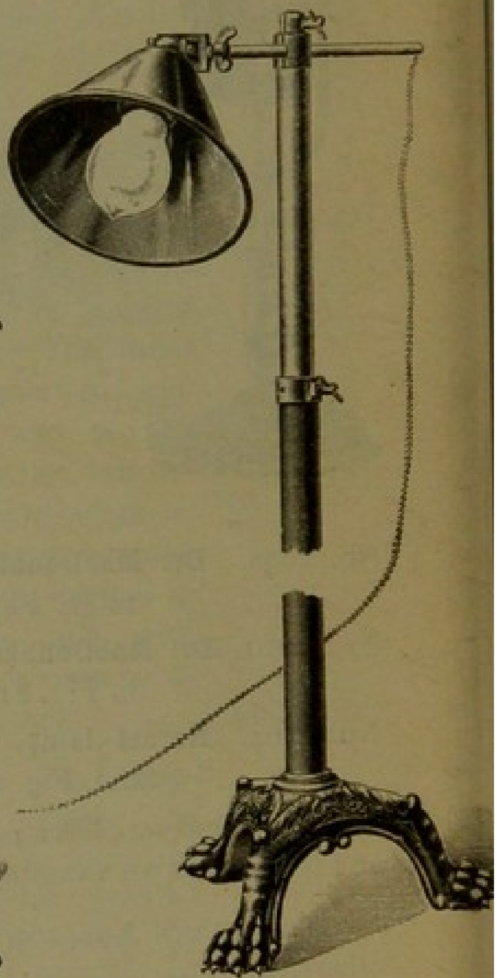
The Lamp No. 2095 can also be attached to this bracket, as shown in illustration.



No. 2114.



No. 2125.



No. 2127

No. 2125. **Lamp on telescopic stand,** and mounted on a flexible metal spiral, movable in any direction, with reflector, Fig. 2125 .. .. **£2 7 0**

This is a very convenient lamp for an operating table; it gives a good light, can be brought close to the patient, occupies little space, and the reflector protects the eyes of the operator from the glare of light.

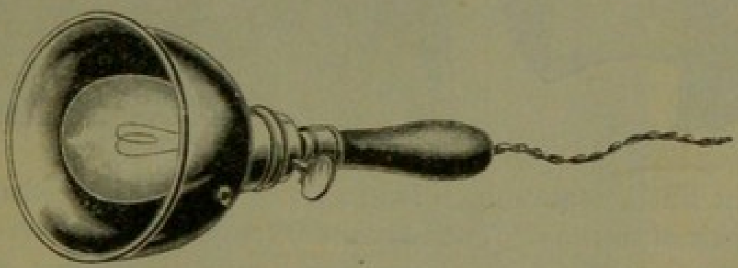
About fifteen of these lamps have been supplied by us to the new operating theatres of the London Hospital, and already many other hospitals are using them.

No. 2127. **Large lamp on telescopic stand,** with reflector, Fig. 2127 .. .. £3 0 0

This lamp can be used either for illumination, for keeping exposed parts warm, or for small local light baths.

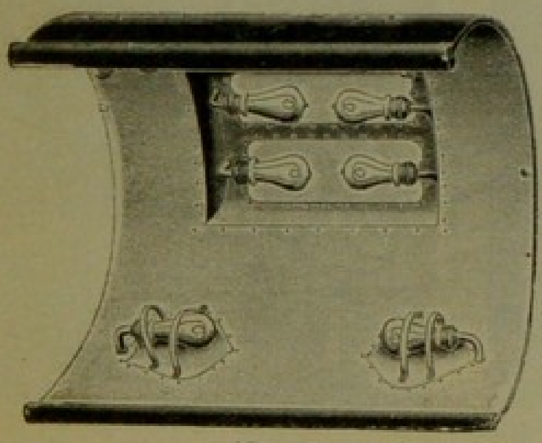
No. 2131.

No. 2131. **Hand lamp,** with reflector and switch, Fig. 2131 .. £0 18 0



No. 2132.

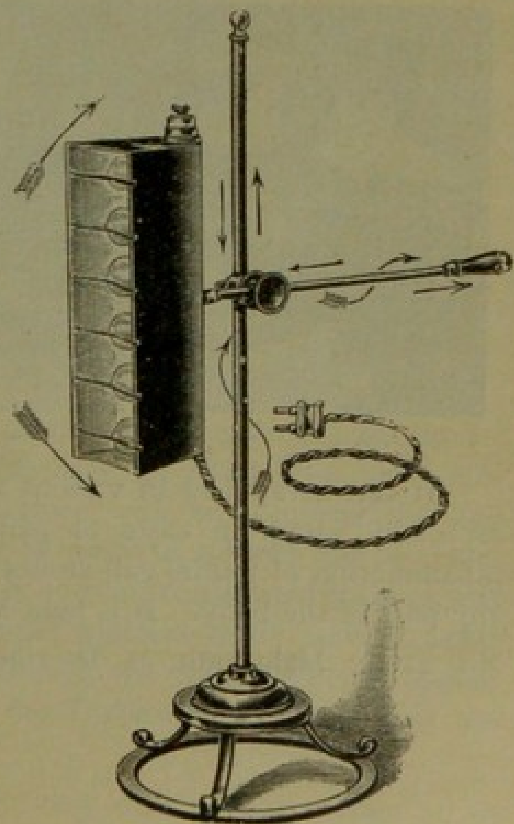
No. 2132. **Hand lamp,** with reflector and switch, Fig. 2132 .. £0 18 0



No. 2165.

No. 2165. **Frame,** with twelve lamps, suitable for placing over a patient lying in bed, Fig. 2165 .. £9 0 0

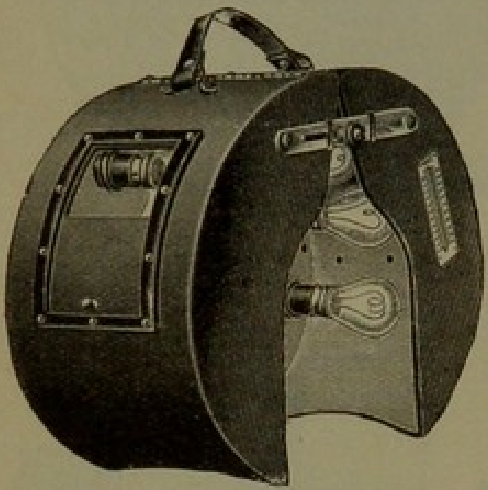
No. 2157. **Reflector,** with six lamps, movable in any direction. Switch to turn on either three or six lamps, Fig. 2157 £7 10 0

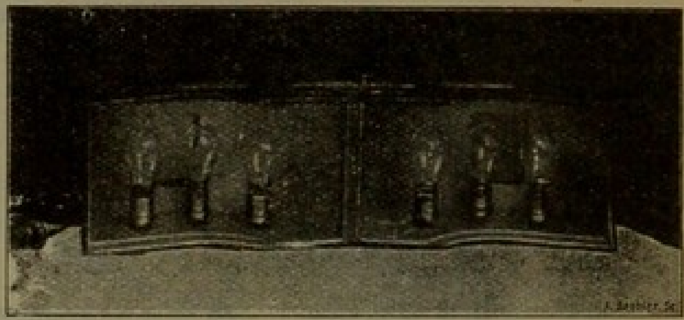


No. 2157.

SMALL LIGHT BATH FOR LOCAL APPLICATIONS.

By Dr. Miramond de Laroquette.





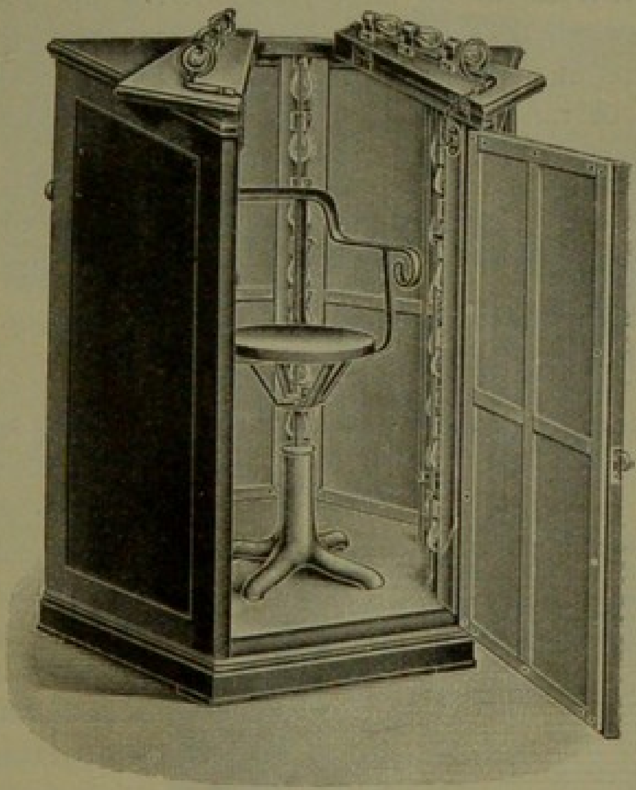
The Light Bath, containing 6 lamps, consists of a drum-shaped box which opens like a pair of scissors. The maximum temperature which can be reached depends on the candle power of the lamps used; with 100 candle lamps it can be raised up to about 200 degrees.

It can be applied in various ways, as shown by the illustrations, and is especially useful in cases of pain due to rheumatic or gouty conditions, inflammation of joints, gall stones, stiffness, etc. It can easily be applied to any part of the body. It is light and portable.

No. 2169. **Light bath**, as described and illustrated **£5 15 0**

ELECTRIC-LIGHT AND HOT-AIR BATHS.

Light has an animating and exhilarating influence on human beings; it causes the pores of the skin to open, stimulates circulation, and kills bacilli. For these reasons sunlight is being used for therapeutical purposes in southern climates, but in our latitudes this is not possible, sunlight being too scarce and not reliable. Several medical men—Dr. Kellogg, of Battle Creek, Michigan, seems to have been the first—have, therefore, tried whether sunlight could not be replaced by electric light, and the result of these experiments was so favourable that apparatus for this kind of treatment have come into general use.



No. 2176—OPEN

Perspiration is produced by the light and the heat of incandescent lamps, a method which is preferable to the Turkish bath for several reasons: The perspiration sets in at once; the temperature can be conveniently and accurately regulated by varying the number of lamps in action; the temperature of the air which the patient breathes is normal, consequently lungs and heart are not affected, and the depression under which so many patients suffer in the Turkish bath does not appear. Although the temperature is higher, and the perspiration more profuse than in the Turkish bath, the patient has an agreeable sensation in the dry heat.

These light baths can be used equally well with a continuous or an alternating current. In ordering, it is necessary to state the number of volts of the supply, and, if arc lamps are desired, it is necessary also to mention whether the current is continuous or alternating.

All the light baths are lined with white enamelled plates, because they reflect the light and heat rays better than mirrors can do.

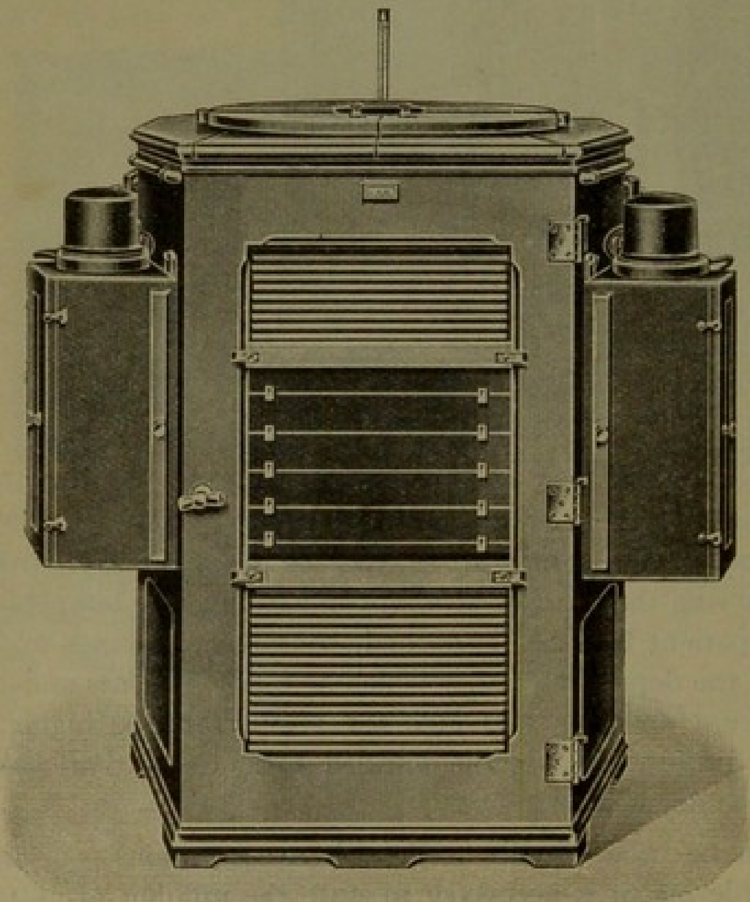
Most of the baths are fitted with incandescent lamps only, but some are provided with arc lamps as well. These arc lamps give a higher candle-power, but it is a mistake to suppose that their light is sufficiently powerful to kill bacteria; the apparatus required for the latter purpose will be described later under Nos. 2315—2398.

No. 2176. **Prof. Winternitz's light bath,** Fig. 2176, with forty-eight incandescent lamps, six switches, and fuses to switch the lamps on or off in groups of eight lamps at a time; thermometer and chair, which can be raised or lowered. The sides are lined with enamelled plates, the floor is enamelled .. **£38 0 0**

Size: Diameter 4 ft.; height 4 ft. 4 in. The bath can be taken to pieces so that it will pass through any door, and it can easily be cleaned.

The switches are arranged so that they can be turned on or off from the outside or the inside of the bath.

If coloured screens are added, so that white, blue, or red light can be used, the price will be increased by £18.



The door can be provided with a roll shutter, if it is desired to use a search lamp placed outside the bath; the extra cost of this, including blue glass screen, is £2 15s.

No. 2180. **Light bath,** to receive the patient in a recumbent position. The cabinet is lined with white porcelain plates, is fitted with thirty-six incandescent lamps divided into six groups, six switches and fuses, thermometer, etc. Illustrations on application **£46 0 0**

Many combinations of light baths with arc lamps alone, or arc lamps combined with incandescent lamps, colour filters to be used with powerful search lamps placed outside the bath, are possible. The illustration shows a light bath with 4 arc lamps, and door with roll shutter. Estimates and illustrations will be sent on application.

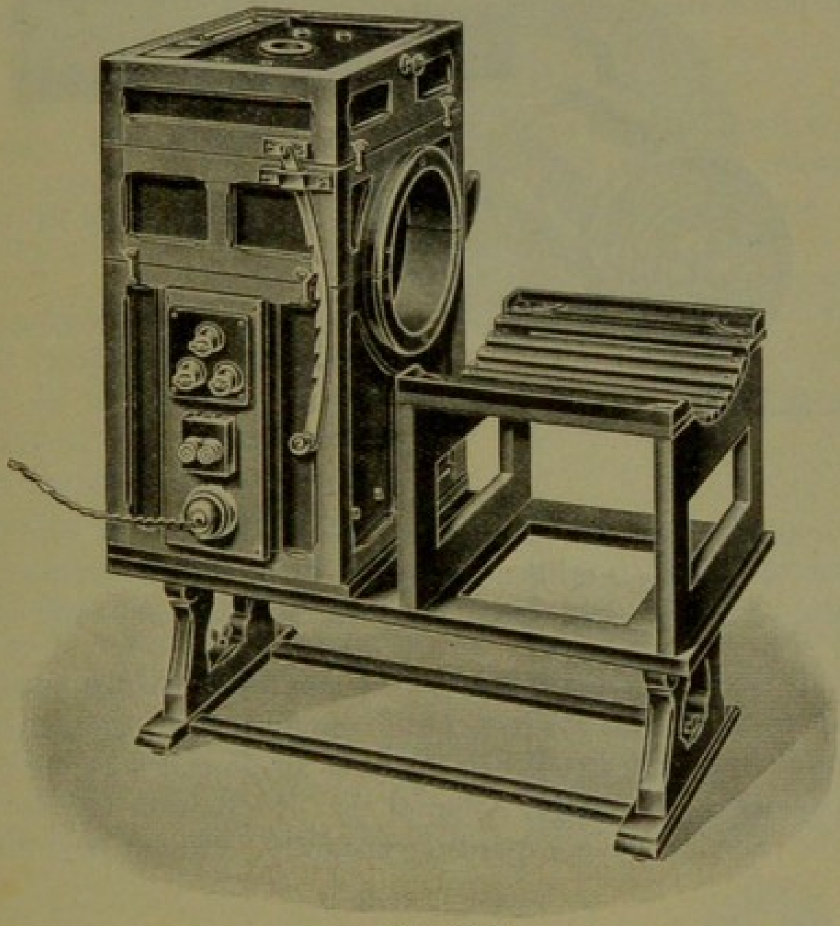


Fig. 2240.

No. 2240. **Hot-air bath,** for arm, elbow, knee, etc., Fig. 2240 .. £20 0 0

The apparatus consumes a current of 6 ampères with 220 volts.

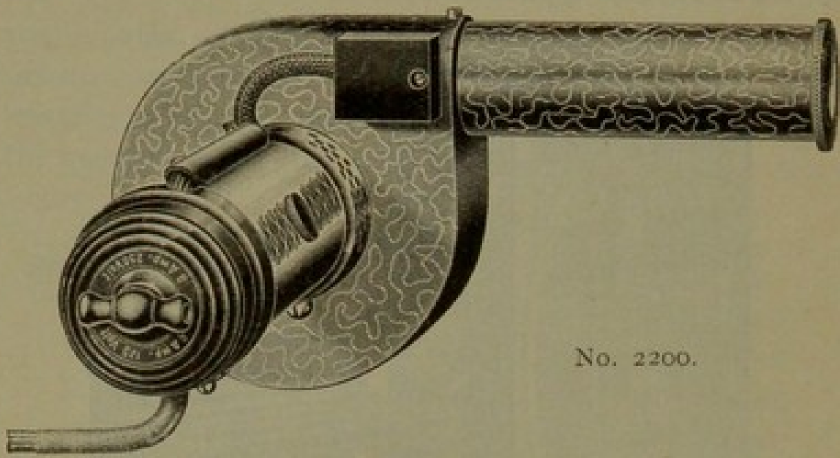
In the hot-air baths, the temperature can be raised *gradually* up to 300, or even 400 degrees, by means of resistance wires arranged inside the bath. The illustrations show the apparatus which is being used most frequently for arms, knees, etc. Illustrations and estimates of other types of apparatus, suitable for the whole body, will be sent on application.

We have supplied the Light Bath No. 2176, amongst others, to:—

H.R.H. the Princess Royal, H.G. the Duke of Portland, Lord Rothschild, Lord Clan-William, Lord Farquhar, Lord Bentinck, Lord Kenyon, Prince Hatzfeld, Sir J. Ellis, Sir Alfred Hickman, the Hon. G. Lambton, Drs. Abbot, Anderson, F. Little, F. Mackenzie, J. Shaw, Messrs. Wertheimer, Singer, etc., etc.

To Guy's Hospital, the Bath Club in Dover Street, the Turkish Baths at Earl's Court, Wolverhampton, Birmingham; Hydropathic Establishments in Peebles, Rothesay, Tunbridge Wells, Helouan, and Sydney; the Corporations of Keighley, Dover, etc., etc.

HOT-AIR DOUCHES.



No. 2200.

The hot air is generated by propelling air by means of a ventilating fan past a resistance which can be made incandescent by the current from the main. The apparatus consumes little current, and can be attached to any wall plug.

The temperature of the air close to the mouthpiece of the apparatus can be raised up to about 300 degrees, but it diminishes as the distance from the mouthpiece is increased. The quantity of air propelled by our apparatus is so great (about 300 litres per minute) that it produces the sensation of massage; the perspiration is carried off instantly. Hot or cold air can be obtained.

The hot air produces local hyperæmia, and is of great value in treating abscesses, erysipelas, and some infected and discharging wounds and skin diseases. The hot air dries up such wounds, the secretion ceases, and healthy new granulations soon appear. It is also most useful in many cases for relieving pain.

The hot air douches are most convenient for drying hair, airing and warming linen or beds, etc.

In ordering, please state the voltage of your supply, and whether it is a continuous or an alternating current, in the latter case the periodicity of the supply should also be mentioned.

No. 2200	**Plain hot-air douche**, Fig. 2200, with small motor serving as hand-piece, ventilating fan, and connecting cords, 3 yards long	£2 12 0
No. 2205.	**Douche** for changing suddenly hot or cold air, Fig. 2205, to be attached to our flexible shafts ..	4 4 0

ELECTRO-THERMAL COMPRESSORS.

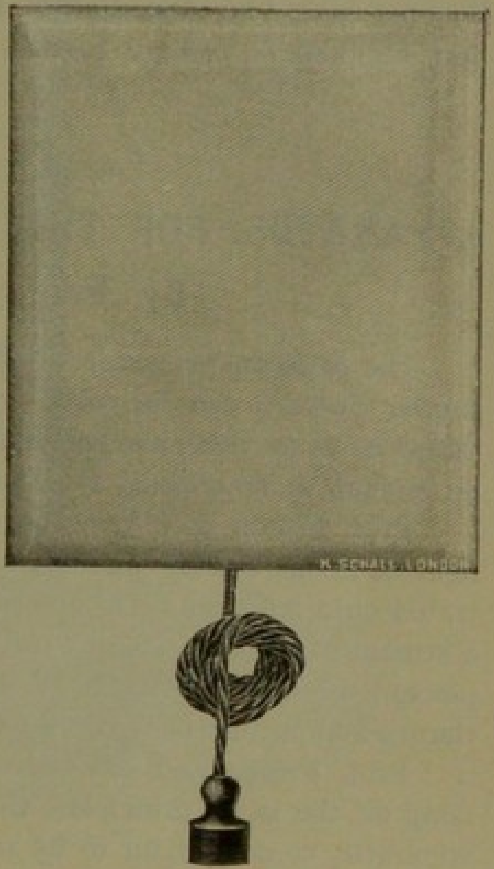
Dry heat, in the shape of radiant heat or electric-light baths, is being used so frequently, and with such great success, that it does not require any more special recommendation in many cases of cold, and in cases of a rheumatic or gouty nature, such as lumbago, sciatica, neuralgia, gout, rheumatism, etc. It relieves pain, reduces swelling, stimulates exudation and the circulation, etc.

Hot-air or Electric-light Baths are available in many hydros and special institutes; but in the majority of cases it will be more convenient, and cheaper, if the treatment can be applied in the patient's own home.

The apparatus required are neither costly nor cumbersome, but they can be used only in houses where the electric light is laid on. The Compressors consist of strings made of asbestos. Round these strings a fine resistance-wire is wound, and the strings are arranged in spirals between asbestos pads, which are enclosed in an outer cover, which can be removed for cleaning or renewal.

A switch is in the circuit to control the heat, which can be raised up to about 300 degrees Fahrenheit as maximum.

The Compressors can be made in various sizes and shapes; below is a list of those used most frequently :—



No. 2285.

FLAT COMPRESSORS.

For the Eye	..	.. .. ..	£0 10 0
" Throat	..	2½ins. by 14 ins. ..	0 14 0
" Heart	..	8½ins. by 12½ins. ..	0 17 0
" Stomach	..	8 ins. by 10 ins. ..	0 17 0
" "	..	12ins. by 14 ins.	1 4 0
" Abdomen	..	7 ins. by 17 ins. ..	1 4 0
" Lungs	..	.. .. ..	1 4 0

For the lungs, two flat Compressors of this size may be used *simultaneously*, one on the chest and the other at the back.

X-RAY APPARATUS

HOLLOW COMPRESSORS.

Hand Bags	£1 7 0
Bags for Elbow or Knee	1 8 0
Bags for the Shoulder	2 0 0

Other sizes and shapes can be made to order.

Rheostat for any of these Compressors, with switch, giving three different degrees of heat 1 18 0

The Compressors can be used on any current, but in ordering it is necessary to state the voltage for which the apparatus is required.

If the Compressors are covered with a blanket, or something similar, the heat cannot be carried off by the air, and the temperature will rise so high that blankets, etc., may become damaged.

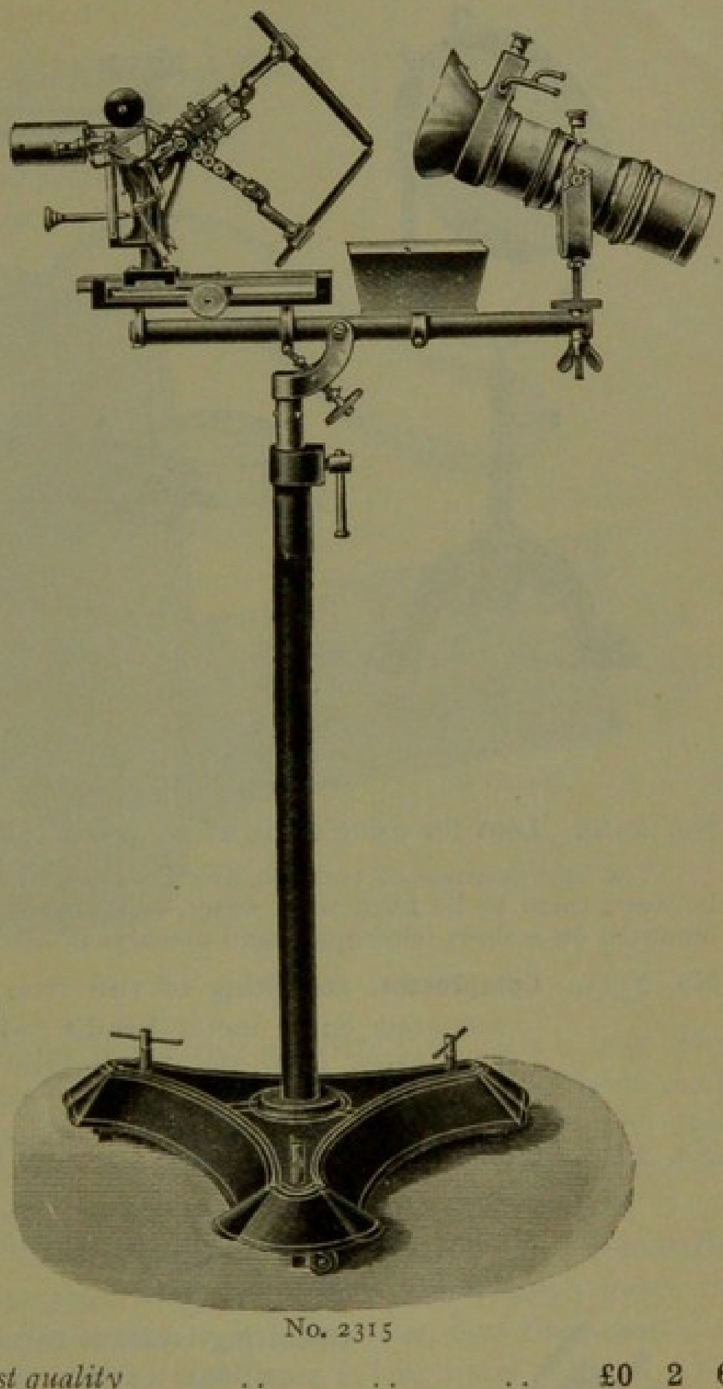
APPARATUS FOR THE TREATMENT OF LUPUS, ETC., By Prof. Finsen's Method.

The experiments made by Professor Finsen have shown that lupus and similar diseases can be cured by a very powerful light, provided that the tissues to be treated have been rendered anæmic, so that the light can penetrate far enough without being absorbed by the blood.

Prof. Finsen used large arc lamps consuming 50 ampères, and giving a light of about 10,000 candle-power. By means of lenses the light is concentrated on a small circle of about ½in. diameter, and to exclude the heat rays a stream of water circulates through the tubes which hold the lenses in their places. Four patients can be treated at the same time with one lamp, but the original pattern is a little wasteful.

Prof. Finsen and his assistant Reyn constructed, therefore, a smaller lamp on the same principles, the Finsen-Reyn lamp. The arc lamp of this apparatus consumes 20 to 25 ampères, is self-adjusting, and a concentrator provided with quartz lenses and water circulation, similar to the concentrators used in the larger lamps, but shorter, is in front of the arc lamp. Only one patient can be treated at a time. This type of lamp is being used most frequently now. The light of sparks from large Leyden jars can also be used; these condensers have to be charged either from spark coils, or from the alternating current from the main, with a step-up transformer. The light of these sparks is rich in ultra-violet rays. Ultimately, the light of mercury vapour lamps has been found to be very rich in ultra-violet rays, they are therefore suitable for this treatment, provided that the tubes on which the light is generated are pervious to the ultra-violet rays.

Whatever lamp is being used, the tissues must be made anæmic by pressure, and for this purpose the compressors (lenses of quartz, or pieces of rock salt or ice) are pressed firmly against the skin, either by bandages or with the hand.



No. 2315

No. 2315. ***Finsen-Reyn Lamp,** consisting of arc lamp with automatic regulator, consuming 20 ampères, concentrator with rock crystal lenses and water cooling arrangement, mounted on telescopic stand, Fig. 2315. The arc lamp and concentrator can be moved in any direction **£32 0 0**

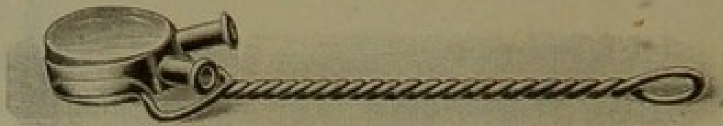
12 pairs of **spare carbons,** *best quality*	.. .. ..	£0 2 6
100 ,, ,, ,, ,,	.. .. ..	0 18 0

Variable Rheostats, to use this lamp with the continuous current from the main, vary from **£3** to **£7,** according to the voltage.

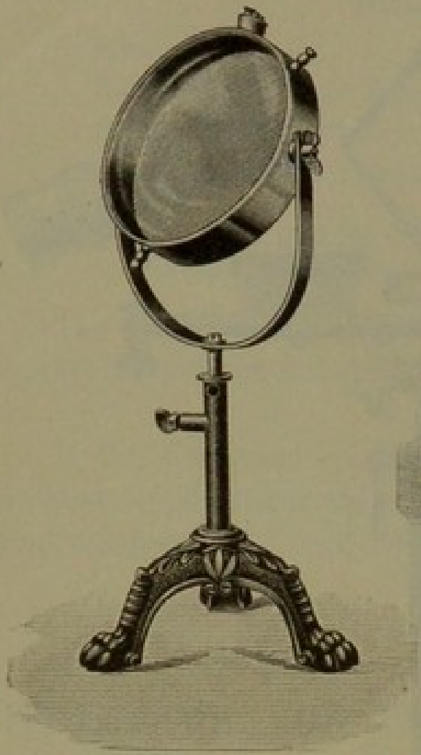
It is possible to use the lamp No. 2315 on an alternating supply if an electrolytic rectifier is inserted in the circuit. In such a case the arc lamp makes a slight humming noise.

* We have supplied our Finsen-Reyn Lamp, amongst others, to :—The War Office, the Crown Agents for the Colonies ; Charing Cross Hospital, Queen Alexandra Hospital, Skin Hospital, Stamford Street, London ; Royal Victoria Hospital, Belfast ; Infirmary, Cardiff ; Essex and Colchester Hospital, Colchester ; Skin Hospital, Birmingham ; Infirmary, Bradford ; Royal Infirmary, Glasgow, etc., etc.

No. 2326.



No. 2327.



No. 2319.

No. 2319. **Lens** for using sunlight for treating lupus, Fig. 2319 **£6 10 0**

The lens consists of two concave glasses mounted on a brass ring, the space between them to be filled with water. The optical part is suspended in a fork, mounted on a short telescopic stand movable in any direction.

No. 2325. **Compressor,** consisting of two rock crystal lenses, mounted on a metal handle, with nozzles for connection with the indiarubber tubes for the water circulation **£1 15 0**

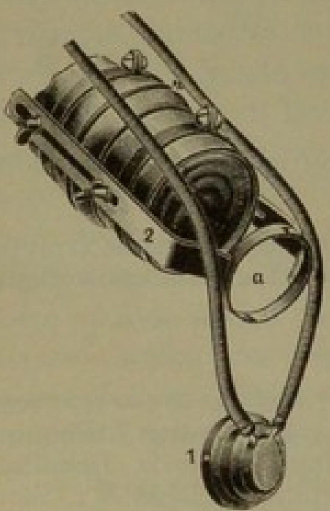
No. 2326. **Similar Compressor,** made specially for treating the eye, Fig. 2326 .. .. **1 10 0**

No. 2327. **Similar apparatus,** made specially for treating the lips and mouth, Fig. 2327 .. .. .. **1 10 0**

Operating-tables or couches, to give the patients a comfortable position and adjust them to correct height, from **£4 10s.** to **7 0 0**

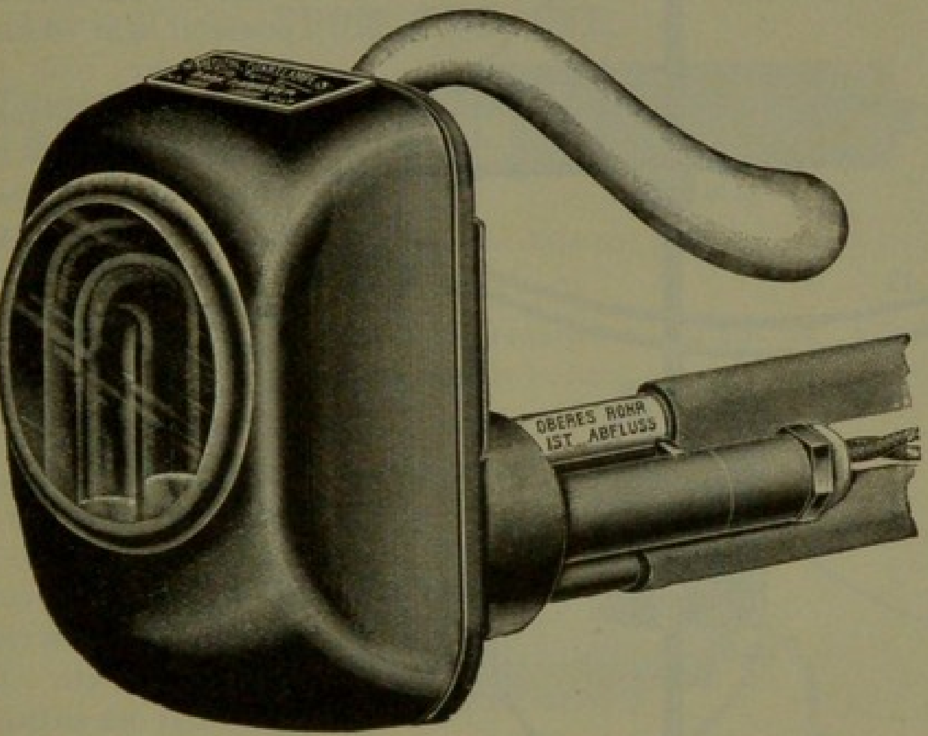
No. 2328. **Dr. Wichmann's Holder** for automatic compression, Fig. 2328 .. .. **1 18 0**

This arrangement does away with the necessity of applying the compressors by hand all the time—it is a great convenience and saving of time and money, as one nurse can attend several patients simultaneously. The apparatus is so constructed that the weight of the concentrator presses the compressor lens against the patient.



No. 2328.

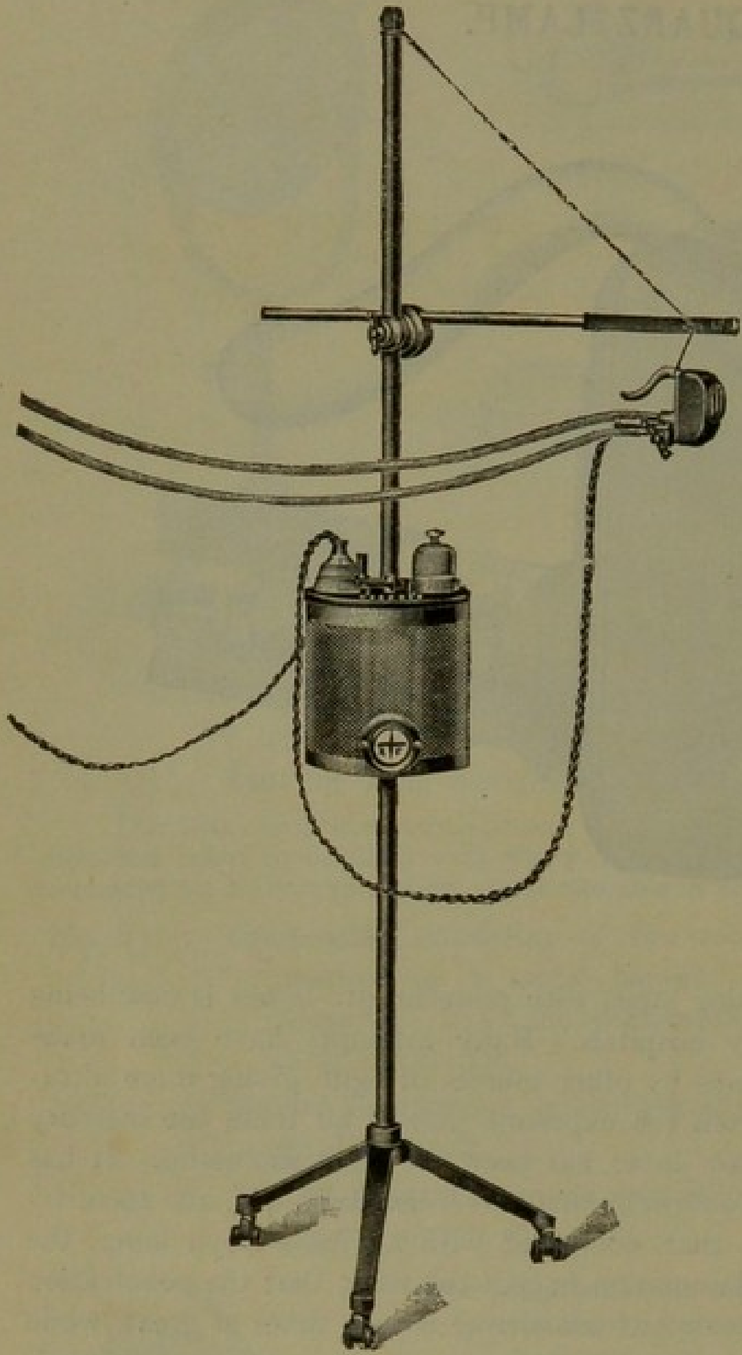
QUARZ LAMP.



Finsen's method of treating lupus with powerful arc lamps is now being employed regularly in many hospitals. Many attempts have been made to replace these large arc lamps by other sources of light, giving more ultra-violet rays, in order to shorten the exposure, and of all these the mercury vapour lamp enclosed in quarz tubes has been the most successful. It has first been described in the *Deutsche medicin. Wochenschrift*, No. 10, 1906, by Prof. Kromayer. He claims that, compared with a Finsen-Reyn lamp, the Quarz lamp produces the inflammation in half the time, that the penetration is greater, and as the area treated at one sitting is four times as great, while the current consumed is only 4 ampères, it is a great advance compared with the Finsen lamp.

Since then other authorities—in this country the London Hospital and Dr. Heaton, of the Royal Sea Bathing Hospital, Margate—have tried the lamp and made comparative tests. All agree that the action on the surface is more rapid, that the penetration is great provided that a blue colour filter is interposed between lamp and skin to protect it from an overdose of the ultra-violet rays of short wave length. In the *Berliner klinische Wochenschrift*, Nos. 4 and 5, 1907, Prof. Kromayer reports good results obtained with this lamp in cases of nævi, lupus, eczema, etc., in which the Finsen lamp had previously been tried without success.

The chief advantages of the Quarz lamp are :—



No. 2380.

The mercury vapour contained in quarz tubes can be raised to a high temperature, and gives a powerful light which can be kept quite cool by the water circulation. The light is remarkably rich in ultra-violet rays, so that comparatively short exposures are sufficient. The lamp can be used at a distance of about 10 centimetres for treating the surface, or can be used as a compressor for affecting deeper lying parts. With the help of quarz rods of various sizes, it can be used to treat the mucous membrane of nose, rectum, vagina, urethra, etc. The area treated at one sitting is four times as large as that treated with a Finsen-Reyn lamp, and it consumes only one-fifth of the current.

These advantages will certainly procure for this lamp a permanent position in photo-therapeutics.

It can be used on continuous current supplies of 70 or more volts.

The prices of the apparatus are :—

No. 2380. **Quarz Lamp,** on floor stand, including variable rheostat, galvanoscope, cords, and india-rubber tubes, complete (Fig. 2380) . . **£28 0 0**

VARIOUS INSTRUMENTS.

ELECTRO-MAGNETS FOR REMOVING IRON, ETC. FROM THE EYE.

No. 2400.

No. 2404.

No. 2400. **Small Electro-Magnet,** with five different points, Fig. 2400 .. .. **£1 0 0**

This magnet is wound for 8 volts, requires a current of 4 ampères, and can carry a weight of about 10 lbs.

No. 2404. **Medium-sized Magnet**—

(*a*) Wound for 8 volts and 5 ampères **1 4 0**

(*c*) Wound for 200 to 250 volts and 0·2 ampère .. **1 16 0**

No. 2406.

No. 2406. **Large Electro-Magnet** (Prof. Hirschberg's), Fig. 2406, with five points—

(*a*) Wound for 8 volts and 7 ampères **3 10 0**

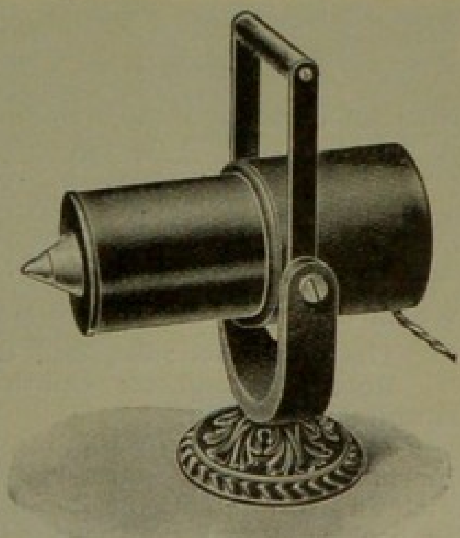
(*c*) Wound for 220 volts and 0·25 ampère .. **4 4 0**

This size magnet can carry a weight of about 30 lbs.

No. 2412. **Prof. Schloesser's Electro-Magnet.** This powerful magnet is suspended in a fork as shown in Fig. 2412; it is movable in any direction, and can carry a weight of about 40 lbs. with the currents mentioned below—

(*a*) Wound for 12 volts and 15 ampères .. **£6 6 0**

(*c*) Wound for 220 volts and 1 ampère **£8 10 0**

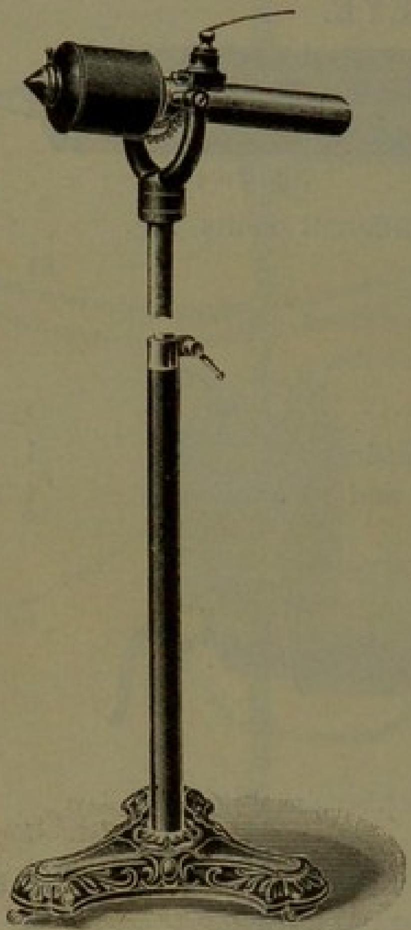


No. 2412.

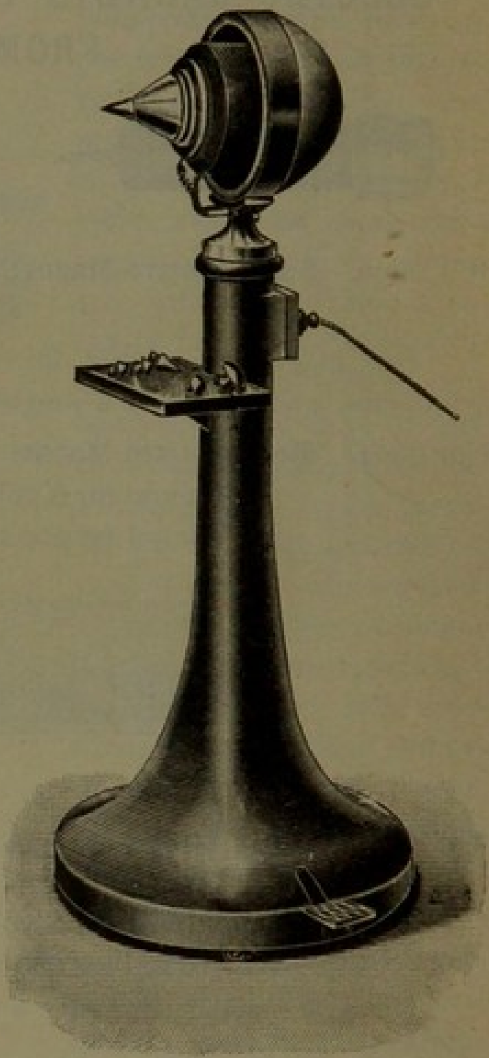
This size magnet can carry a weight of about 80 lbs.

No. 2416. **Large Electro-Magnet** on telescopic stand, with a long iron core suspended in a fork, movable in any direction—

Wound for 220 volts and 1 ampère **£11 11 0**



No. 2416



No. 2420

No. 2420. **Large Haab's Magnet,** latest type, Fig. 4020—
Wound for 220 volts and 8 ampères **£29 0 0**

The prices include 3 different points. The magnet can carry a weight of over 600 lbs. The current has to be switched on or off with the foot.

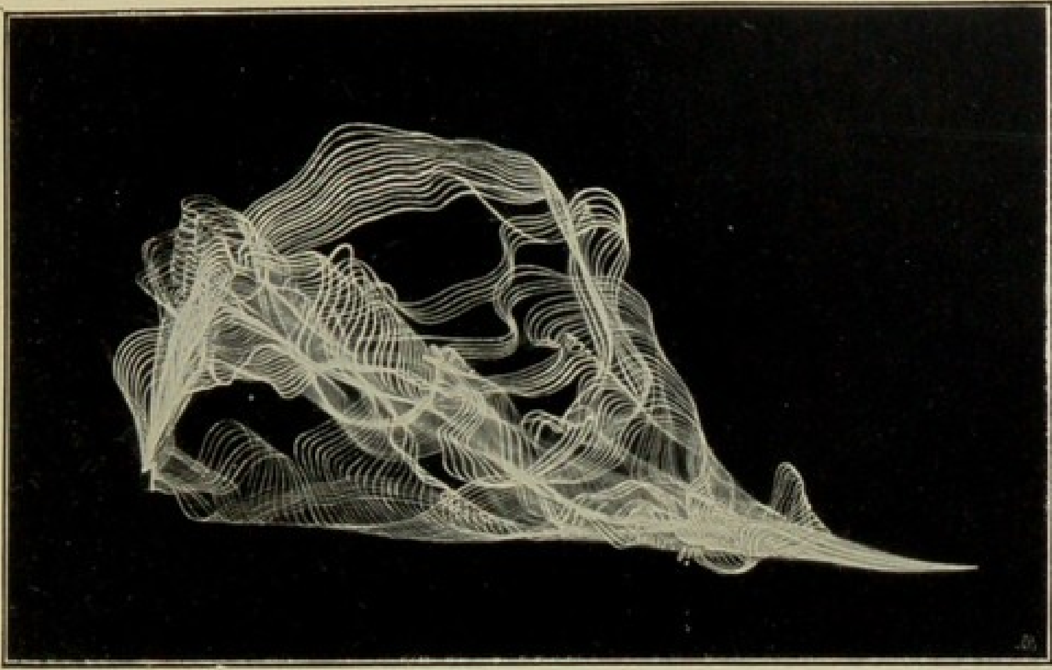
We have supplied our Electro-Magnets amongst others to :

The War Office ; the India Office.

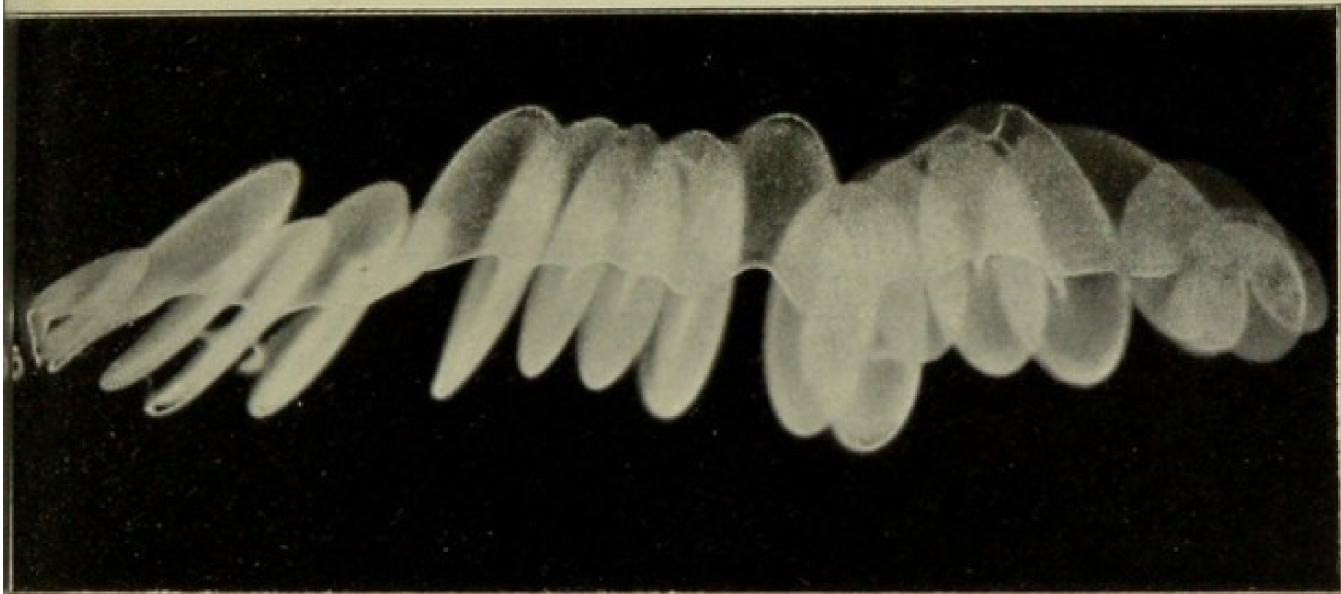
Royal Westminster Ophthalmic Hospital ; Central London Ophthalmic Hospital, etc., etc.

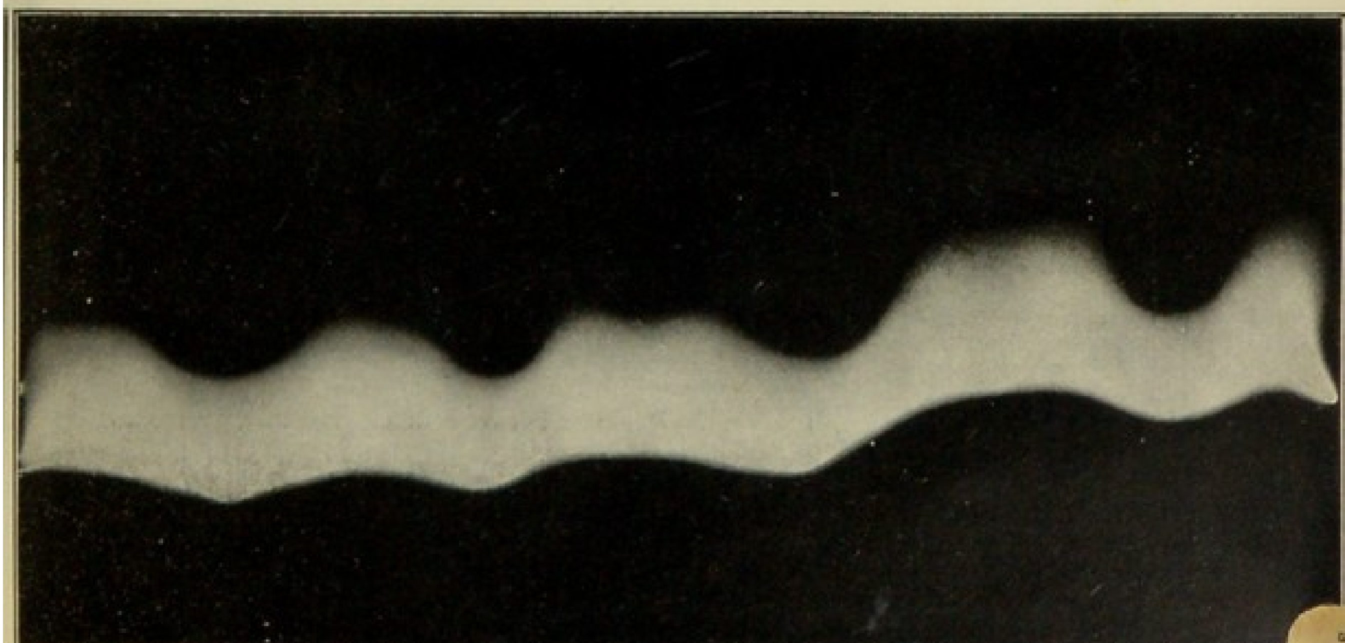
Royal Infirmary, Edinburgh ; Royal Infirmary, Dundee ; Dundee Eye Infirmary ; Cardiff Infirmary ; Swansea General and Eye Hospital ; Royal Victoria Hospital, Belfast ; Sunderland and Durham County Eye Infirmary ; Derbyshire Royal Infirmary ; Bolton Infirmary and Dispensary ; Launceston Infirmary and Rowe Dispensary ; Dunedin Hospital ; New Royal Naval Hospital, Chatham ; Grimsby and District Hospital, etc., etc.

J. R. Rolston, E. J. Fox, Randle Leigh, W. H. De Silva, Ceylon, etc., etc.



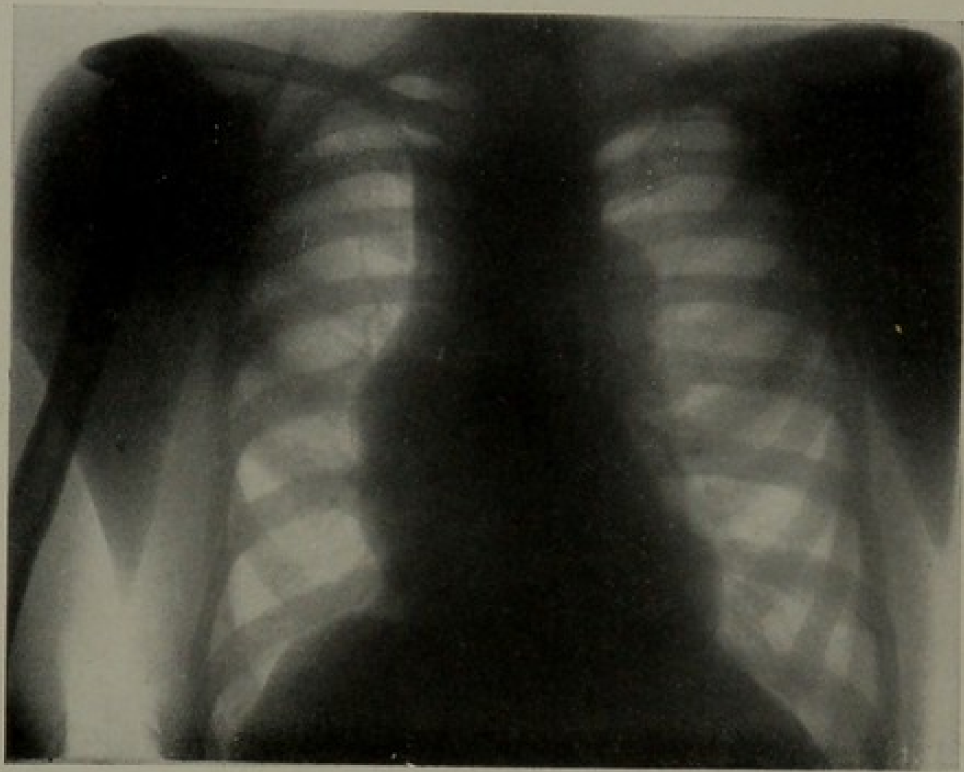
Discharge obtained with an Electrolytic Break.



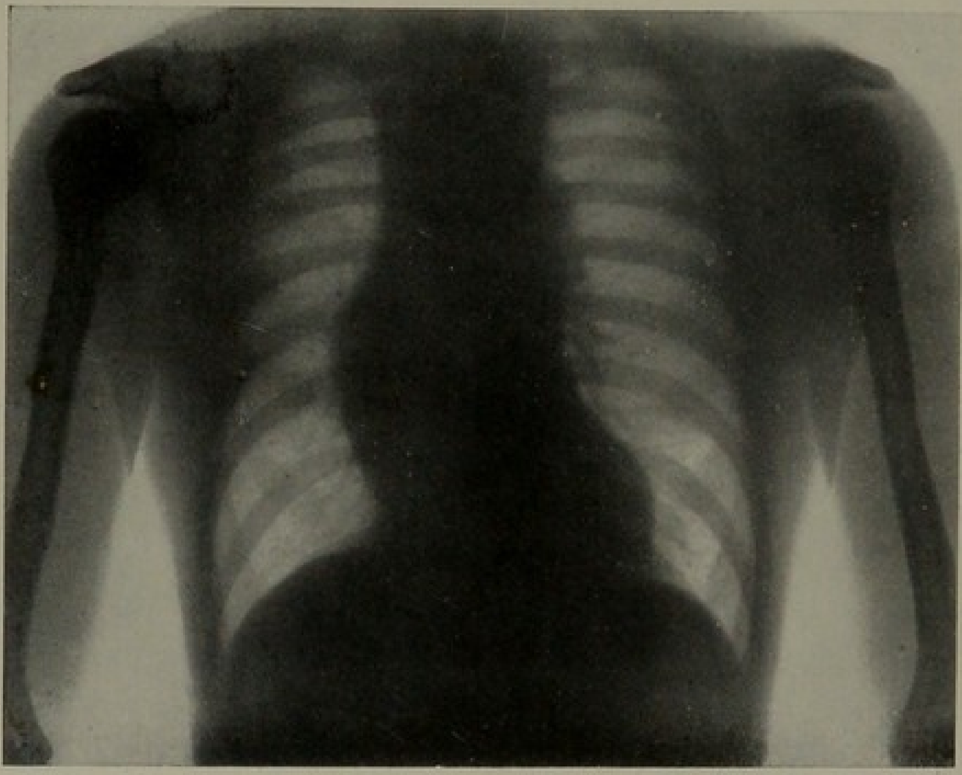


Single sparks obtained with mercury breaks, sufficiently powerful to give good negatives of the stomach of an adult with one single flash (exposure about $\frac{1}{100}$th part of a second).

X-RAY APPARATUS

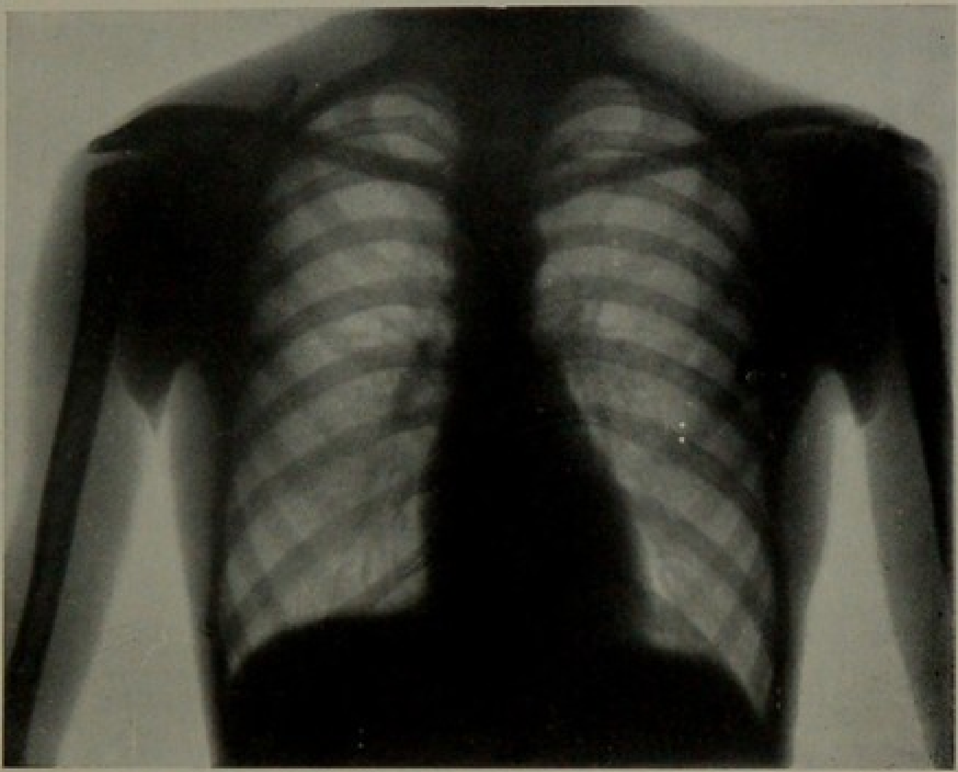


1908. Exposure, $\frac{1}{5}$th of a second. Distance between tube and plate, 25 inches.

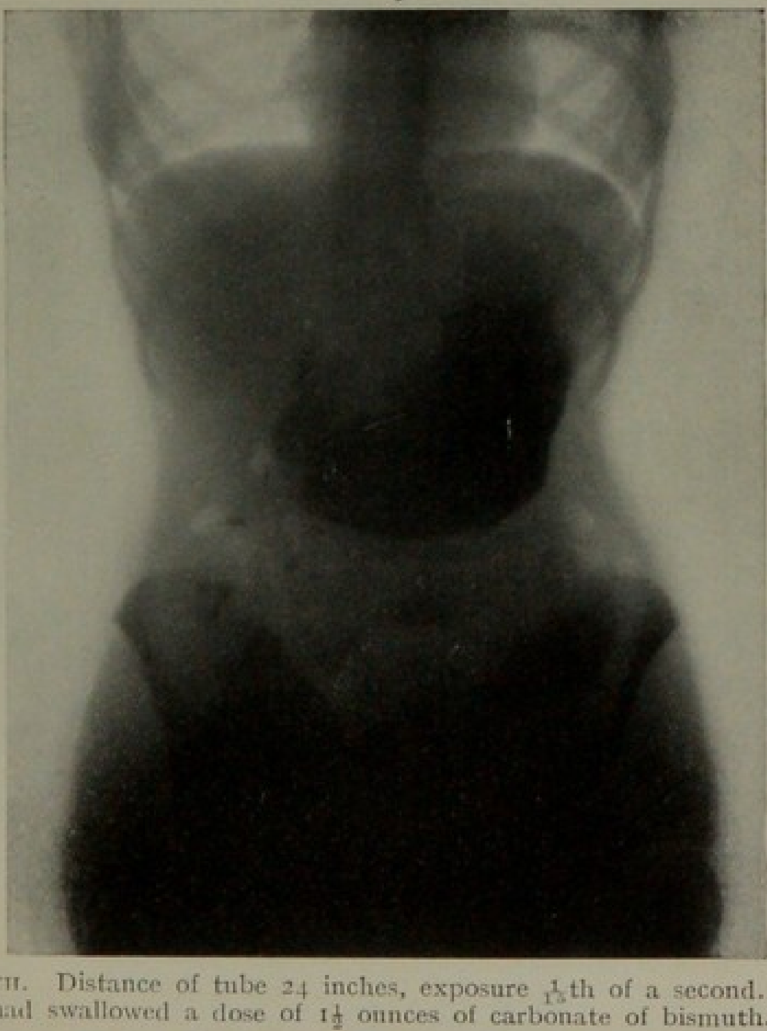


1908. Same patient. Exposure, 1 second. Distance between tube and plate, 80 inches.

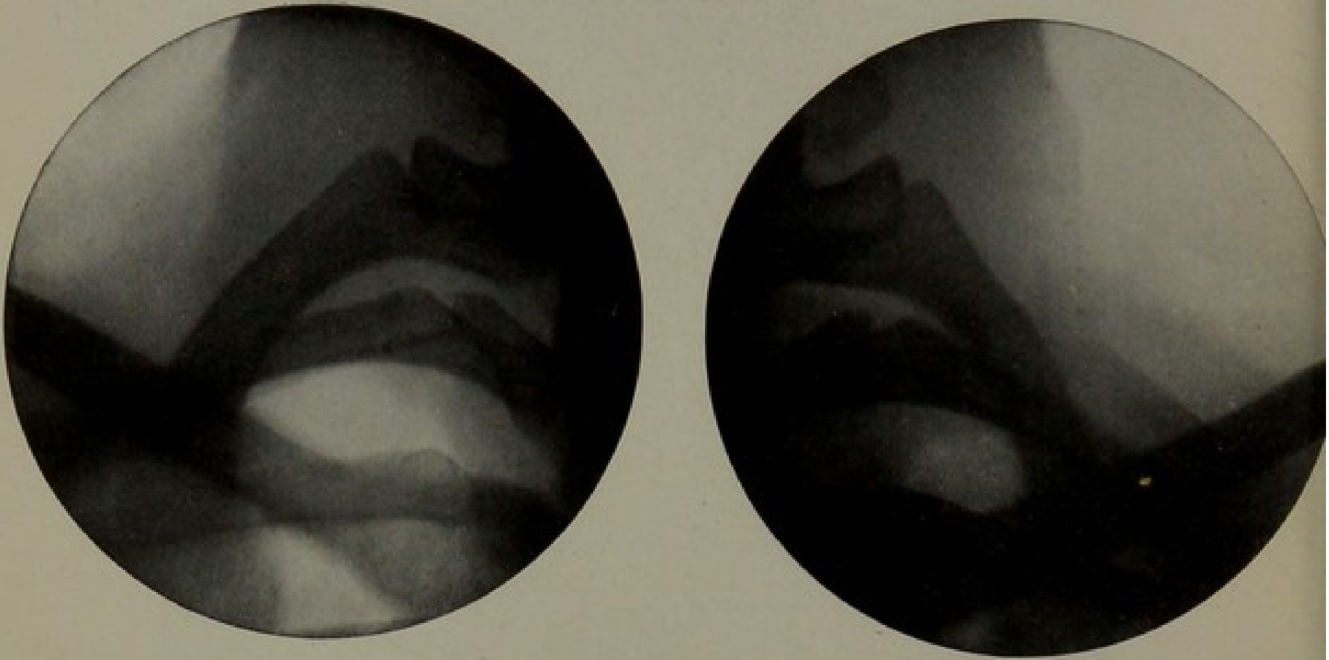
The two negatives were obtained at a demonstration of instantaneous and tele exposures given at the London Hospital in May, 1908. 200 volts and 55 ampères were available. The two illustrations show the difference in the size of the heart and ribs if taken with a distance of 25 or 80 inches between tube and plate.



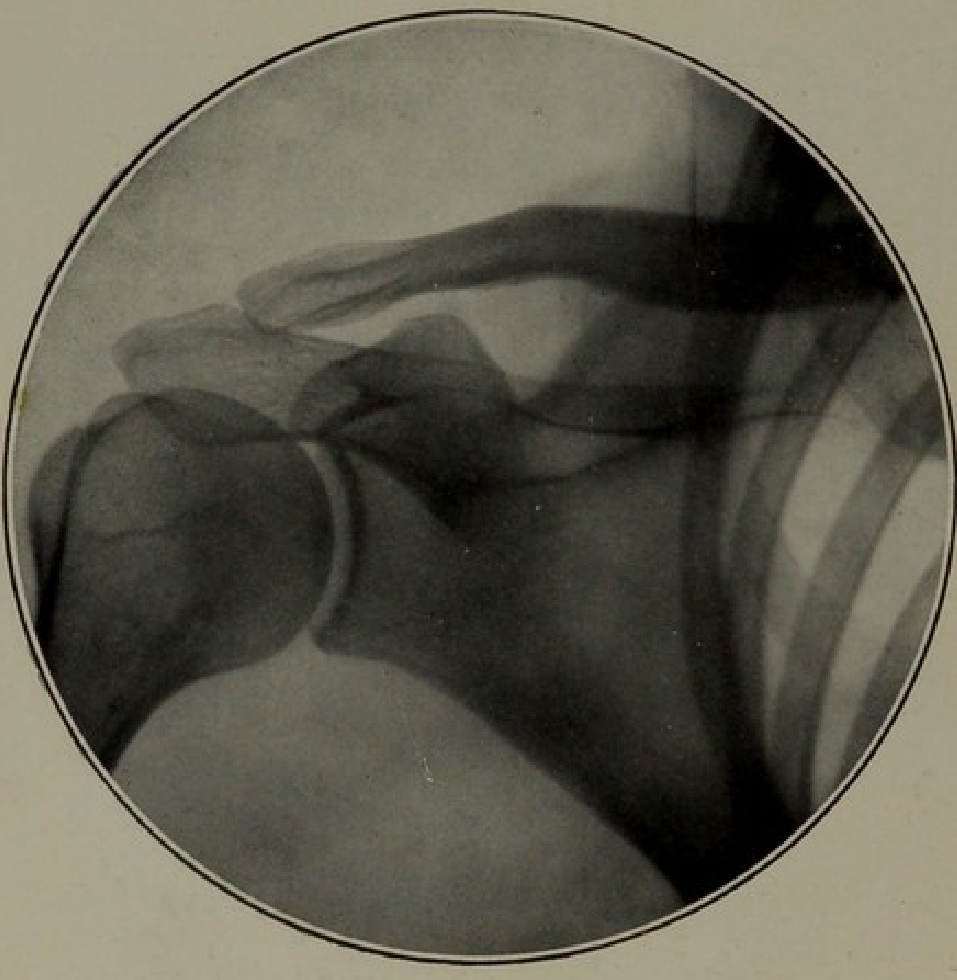
1908. Exposure, $\frac{1}{25}$th of a second. Distance between tube and plate, 30 inches. Ilford plate: one accelerating screen.



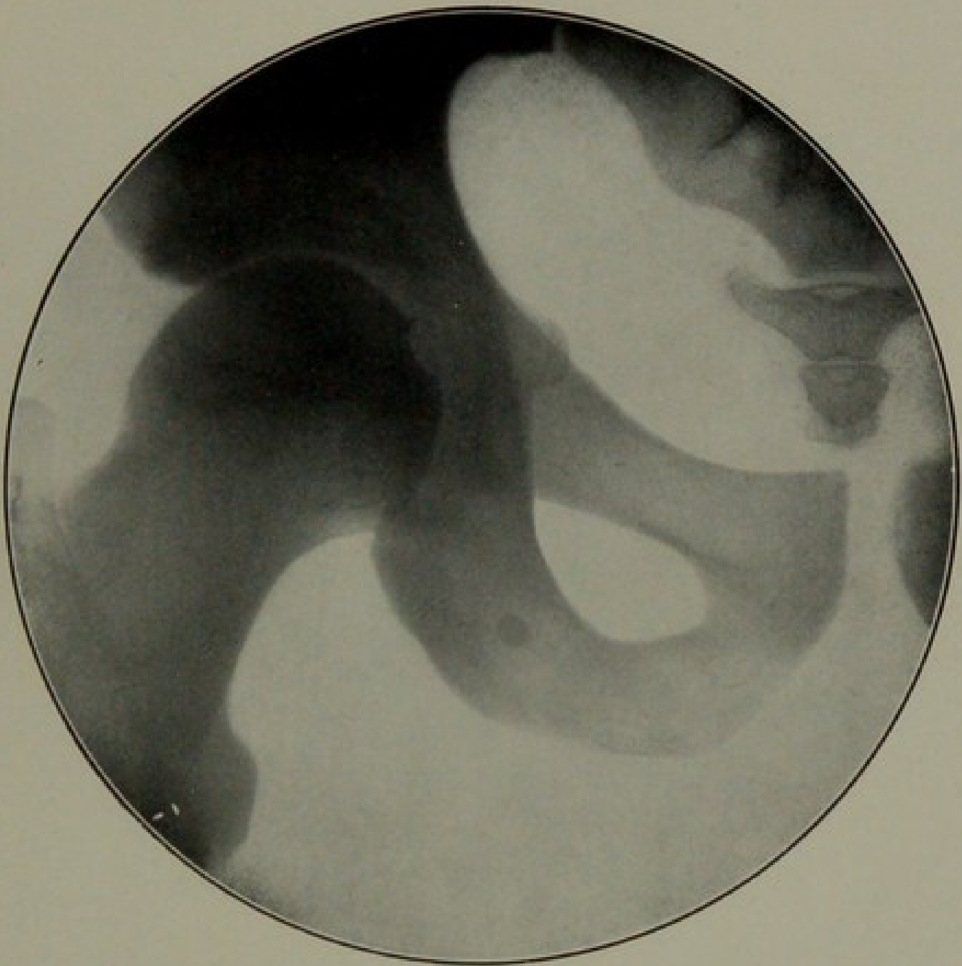
1907. STOMACH. Distance of tube 24 inches, exposure $\frac{1}{15}$th of a second. The patient had swallowed a dose of $1\frac{1}{2}$ ounces of carbonate of bismuth.

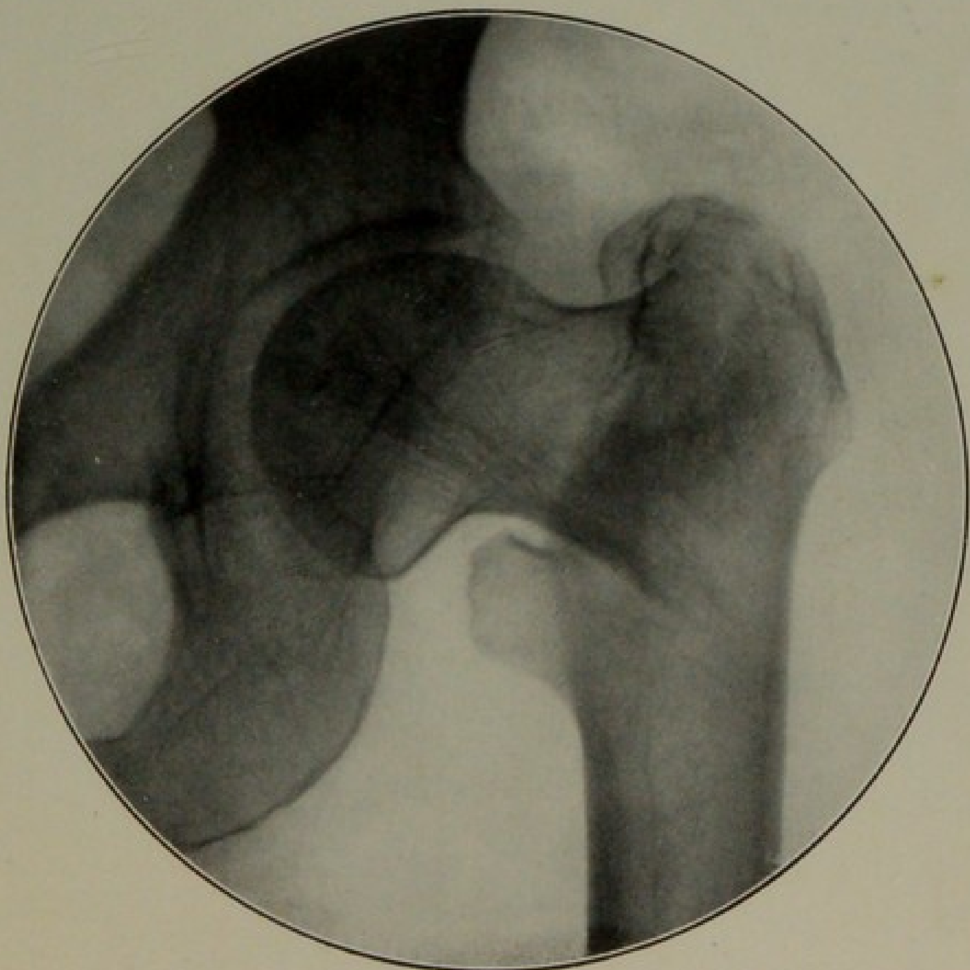


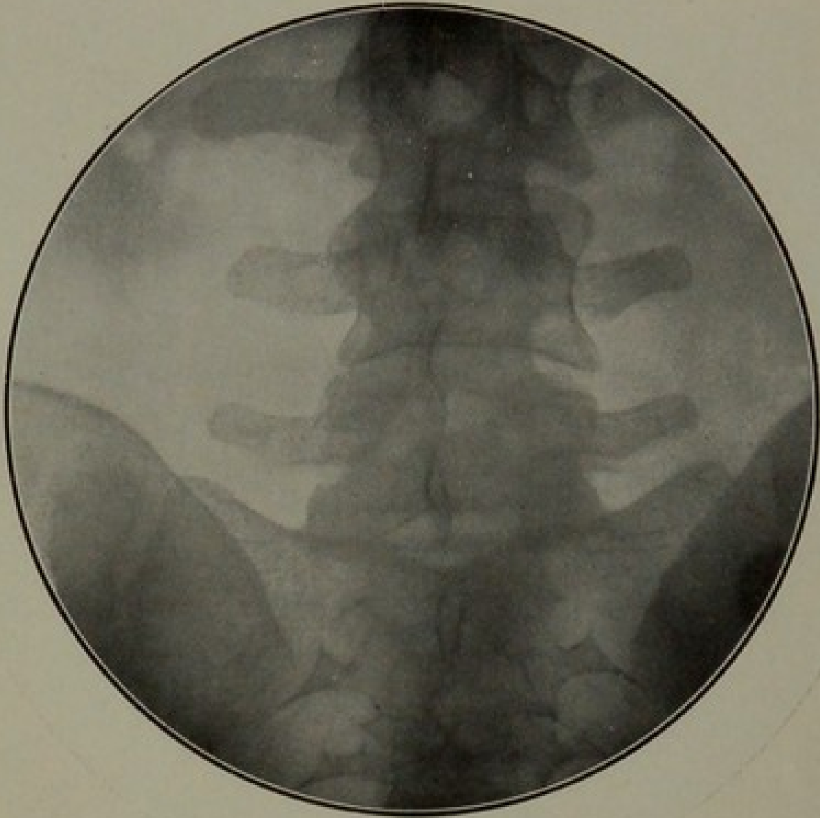
Exposure, $\frac{1}{25}$th of a second. Negative shows beginning of tuberculosis



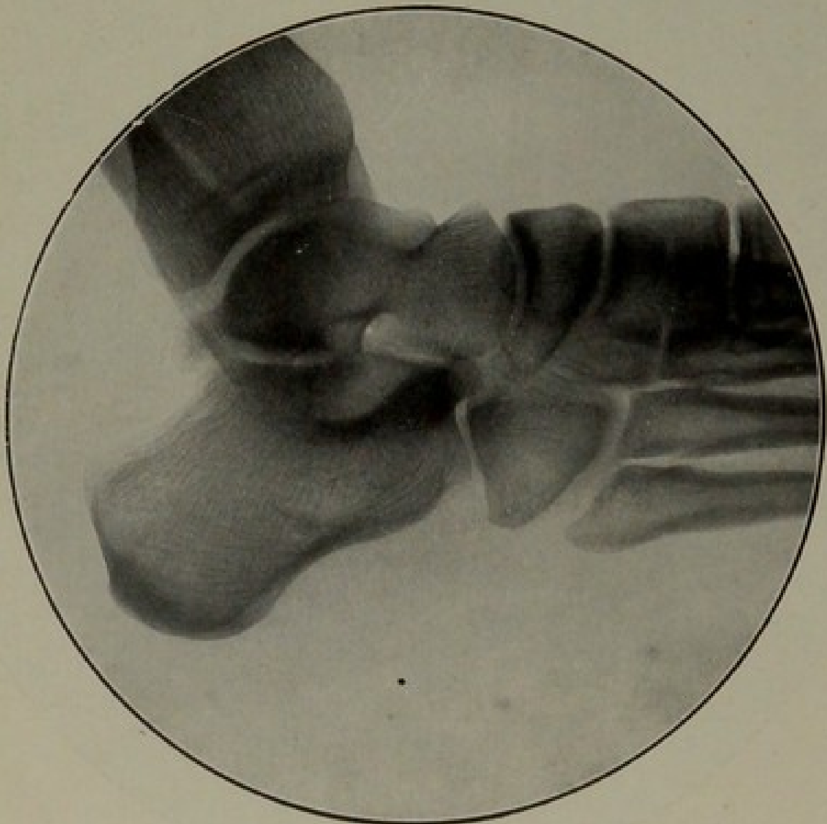
Exposure, 30 seconds.
1903.

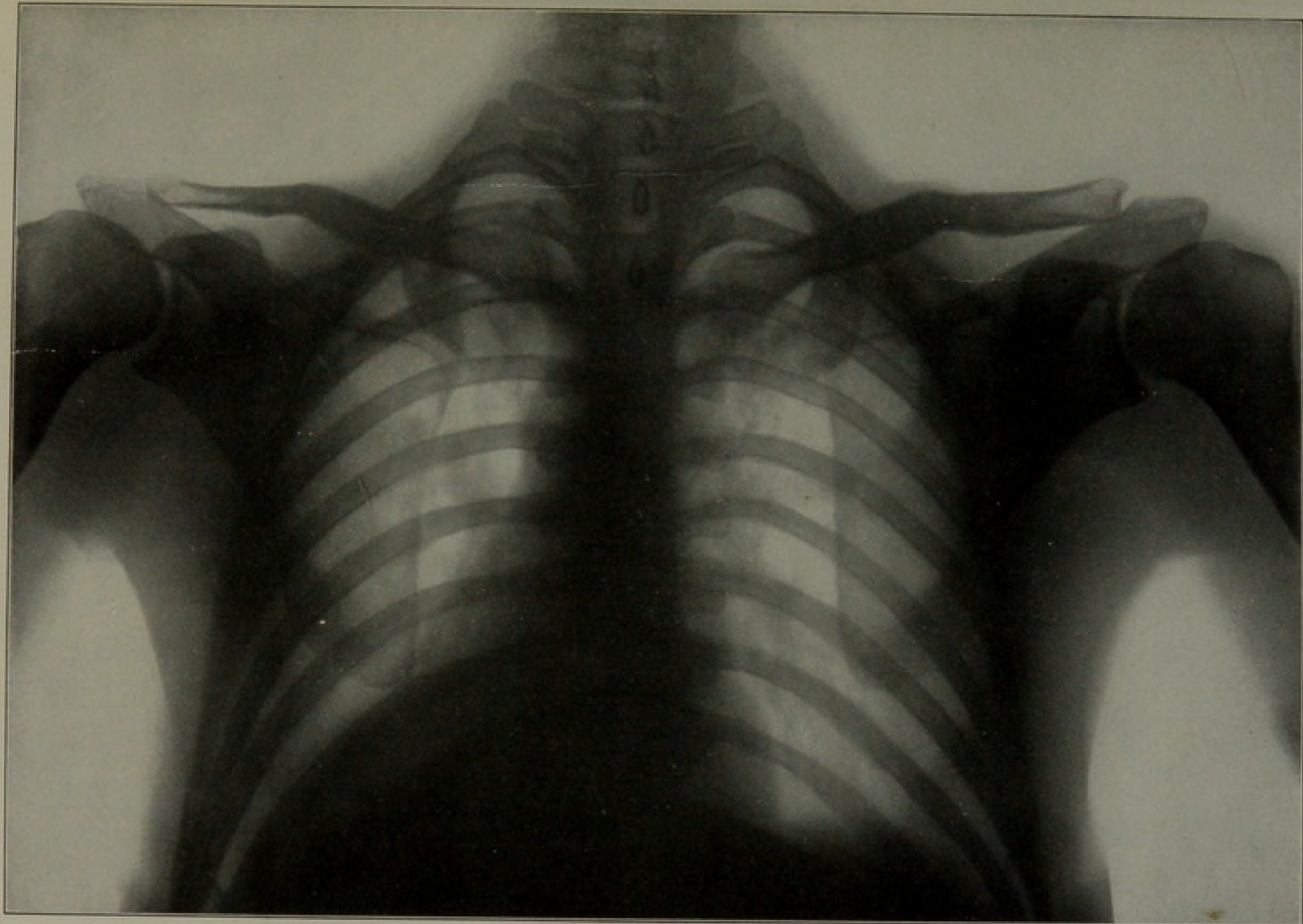




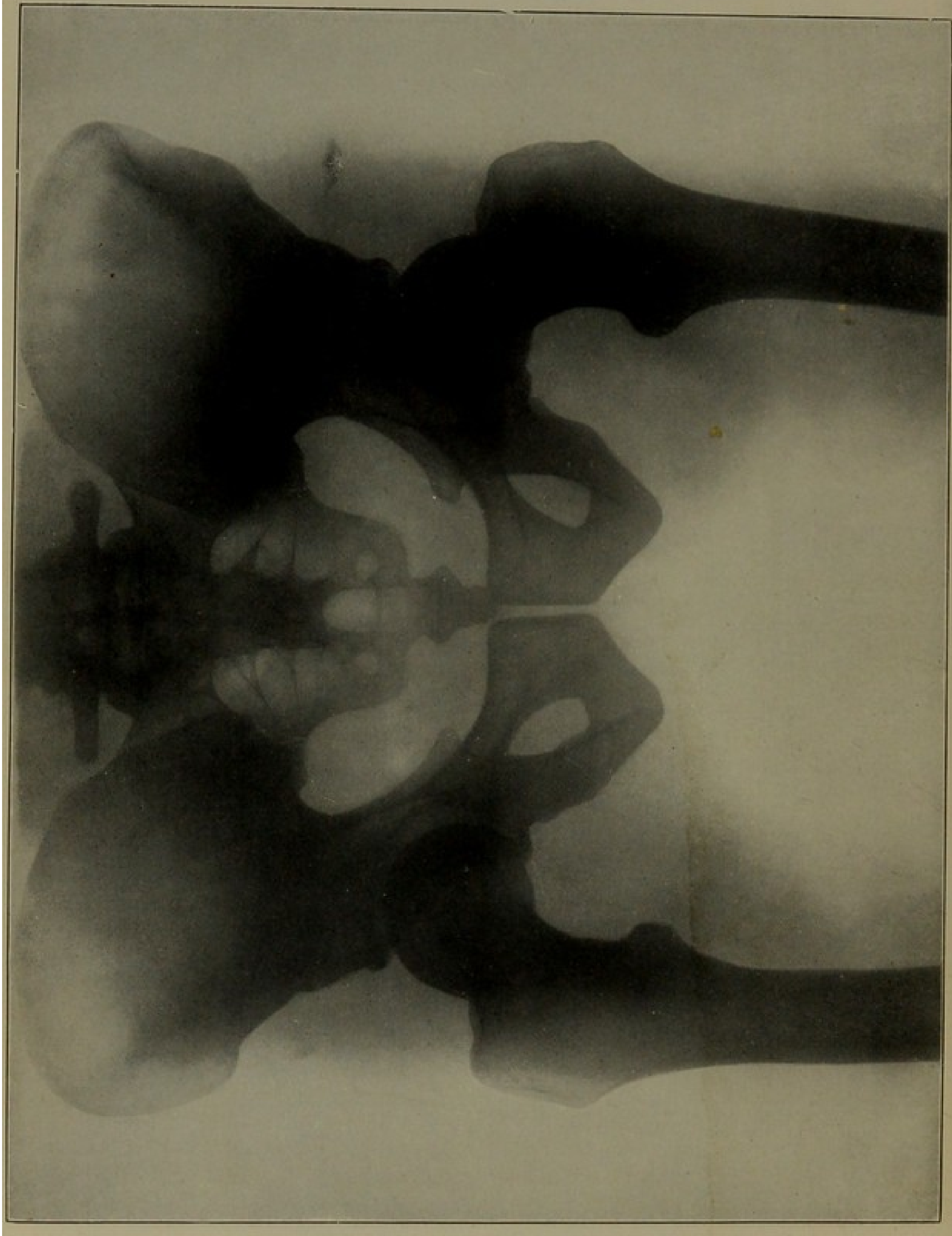


1909.





1902



X-RAY APPARATUS

AND THEIR MANAGEMENT

BY

K. SCHALL

AND

W. E. SCHALL, B.Sc. Lond.

ENTERED AT STATIONERS' HALL,
JANUARY, 1911.

X-RAY APPARATUS.

In December, 1895, the scientific world was startled by the news of a discovery made by Professor Roentgen, of Wuerzburg. While experimenting with Crookes' tubes and fluorescent salts, he found that from these tubes there emanate rays which, though invisible to the eye, act like ordinary light on photographic plates, and moreover, that these rays penetrate substances through which ordinary light cannot pass,—for instance, wood, flesh, etc.,—while other substances, like bones or metals, are less transparent or quite opaque.

The apparatus required to produce X-rays consist of :—

(1) An electrical apparatus capable of supplying currents of a very high E.M.F., from 100,000 volts upwards, such as spark coils, transformers, or static machines.

(2) A focus tube.

(3) A fluorescent screen or a photographic plate.

SPARK COILS.

Spark coils are used almost exclusively. The essential parts of a spark coil are —

A primary coil, consisting of a number of thin sheets of a special magnetic iron, round which about 100 turns of thick copper wire are wound. This is placed in a stout ebonite tube, to insulate it from the secondary coil. The latter consists of many thousand turns of thin copper wire wound in some 100 thin vertical sections.

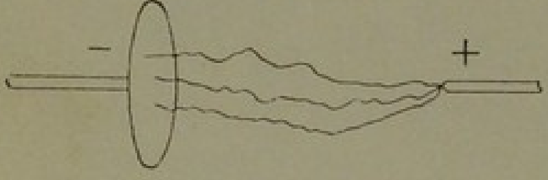


Fig. 1

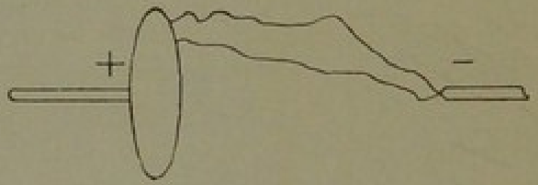


Fig. 2

In the base of the coil is the condenser, whose function will be explained later on. The coils are provided with discharging rods ; one of these ends usually in a point, the other is provided with a plate, this arrangement helping to detect the polarity. The sparks can discharge easily from the point to any part of the plate while the latter is the *negative* pole or cathode, and the point the anode, or positive pole, as shown in *Fig.* 1. If the point were the negative pole, the sparks would invariably discharge between the *edge* of the plate and the point, as shown in *Fig.* 2, and would then be shorter than when discharging the correct way.

If we send a current through the primary wire, the iron becomes magnetized, and a magnetic field is created. The appearance or disappearance of this field, or any change in its intensity, induces currents of short duration in the secondary coil. Their intensity depends on the intensity of the magnetic field, and the *suddenness* of its appearance or disappearance.

There is a great desire to be able to give *short* exposures, as in many cases a *reliable* diagnosis is impossible if the exposure lasts longer than the patient can conveniently keep his breath. If an X-ray installation is wanted chiefly for therapeutic purposes, or to find fractures, dislocations, or a foreign body in arms, legs, etc., the quality and reliability of the picture need not be affected even if the exposure has to last five minutes, because an arm or foot can be kept quiet, and comparatively small coils will be sufficient. But if the apparatus is wanted for proving the presence or absence of stones in the kidney, of calcifications, tumours, tuberculous lesions, aneurysms, etc., the excursions due to respiration may make small objects disappear entirely, or cause the outlines to become so blurred, that the negative would be insufficient for diagnosis, unless we can finish the exposure in a few seconds ; in some cases it is certainly a great advantage if the exposure need not exceed a small fraction of a second, to avoid even the movements due to the beating of the heart, the arteries, etc. To obtain X rays of sufficient intensity for such short or instantaneous exposures, powerful coils have to be used.

Size and Power of the Coils.—The intensity of the X-rays generated in a tube depends on the strength of the current which we can send through the tube. The length of exposure depends, other things—like the distance between tube and plate, and the thickness of the object—being equal, entirely on the intensity of the X-rays. With a current of 1 milliampère only, we have to expose twenty times as long as when we can use 20 milliampères with the same tube.

Spark coils are classified up to now only according to the *length* of the spark which they can give. This is almost useless ; it means only that a coil has a sufficient *voltage* to overcome the resistance of an air gap 10 or 20, etc. inches long, but just as the power of a water-fall is not determined by the head of the water alone, but by the head × the *quantity* of water which is available, so for X rays the power depends on the number of volts × milliampères which the coil can give. To overcome the high resistance of an X-ray tube it is necessary to have a voltage not smaller than that required to overcome the resistance of an air gap 8 inches long, and as some spare power is desirable, coils giving sparks 12 to 16 inches long are most frequently used, and some prefer even coils giving 20-inch sparks ; but it must be clearly understood, that with a 20-inch coil which gives 2 milliampères only through a tube, the exposure will have to be ten times as long as, for instance, with a 12-inch coil which is capable of giving 20 milliampères through the same tube. Differences quite as great as this exist between various types of coils. They are due to the fact that in the better coils the size and proportion of the iron core, condenser, diameter and number of turns of wire, have been chosen more correctly than in the less efficient coils. This is generally admitted, and is the reason why all manufacturers claim that their coils give a "heavy" or "intensified" discharge; but unless we have some means to measure and compare the output we do not know at all which is a heavy, a heavier, or the heaviest discharge.

Measuring the Intensity of the Discharge.—Although it is not yet possible to measure the intermittent currents of high voltage obtained from spark coils as accurately as we can measure the currents from batteries or dynamos, it can be done, and it is of great importance that in addition to the spark length, the number of M.A. which a coil can give should be stated.

There are no convenient voltmeters for these currents available up to now, but even without a voltmeter we may obtain some information about the volts used. If we measure the M.A. obtained through a resistance of *known value*, we can calculate the voltage with the help of Ohm's law, e.g., 1000 volts produce a current of 1 M.A. in 1,000,000 Ohms resistance. If the actual number of Ohms is unknown, we cannot express the output in volts and ampères any more; but provided that we use for comparison a suitable *standard resistance, which remains uniform, the number of M.A. obtained shows which coil and interrupter gives the largest output.*

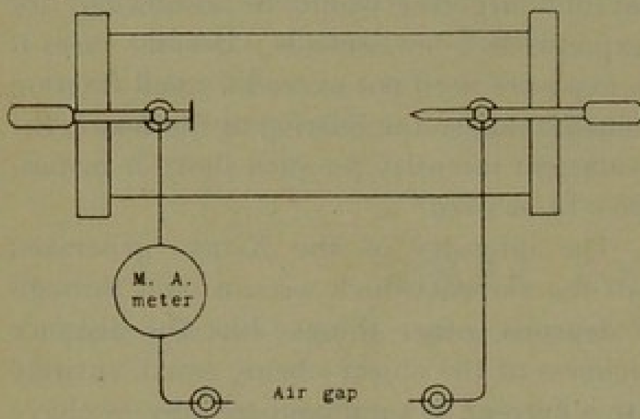


Fig. 3

The most natural thing would be to measure the number of M.A. obtainable through an X-ray tube, but as a standard of comparison this is impossible for several reasons, the chief of which is that there is too great a difference in the resistance of various tubes: the hard ones, suitable for examination on the screen, have over five times as much resistance as the soft ones, which are suitable for making negatives of hands, etc. We can, however, measure the number of M.A. obtained through an air gap. Its resistance depends on its length, and we have to adopt, therefore, a definite length as standard. I would suggest 8 in. or 20 ctm. as suitable, because this is the length of the equivalent spark gap of the hardest tubes, and the smallest coils used in X-ray practice still give 8-in. sparks. Atmospheric conditions, or the shape of the electrodes (point, ball, etc.), do not affect the result as long as the latter are less than 10 mm. in diameter. The M.A. meter is not to be inserted in the air gap on the coil, it would be damaged if this were done; it is to be connected as shown in the sketch. If a separate spark gap is not available, a temporary one can be arranged easily with the help of two empty bottles, the corks of which serve to hold the wires.

I have found that coils giving 10 milliampères through such an air gap give nearly twice as much current through a tube as coils which give only 5 milliampères, and although this proportion may change, *those coils which give the highest number of milliampères through the air gap always give the highest number of milliampères through a tube.* The air gap acts also as a valve, and excludes the reverse current, so that the reading is not disturbed by it.

This method gives us fair information about the real power of a coil, and is infinitely more accurate than the mere statement of the spark length. It is so simple that every owner of a spark coil and M.A. meter can use it.

It is also desirable to know the primary current required to produce a certain number of milliampères through the air gap. A difference of a few hundred Watt more or less in the primary current is unimportant as far as the bill for electricity is concerned, because the coils are required for a short time only. But coils which require a weak primary current only to give say 50 milliampères in the secondary circuit, enable us, in consequence of their better construction, to reach a larger maximum output than those coils in which a heavier current is required in the primary circuit. Moreover, with the latter coils the interrupters become hot, and the mercury has to be cleaned after a shorter time than with the former coils.

INTERRUPTERS.

The function of the interrupter is to close and open the primary circuit in regular succession. It should keep the primary current closed just long enough to allow the iron core to reach the maximum of magnetization ; the break should be as rapid as possible, and there should be a sufficient interval to allow the iron core to be demagnetized before the current is closed again. The more or less perfect manner in which these conditions are fulfilled influences the intensity of the secondary discharge which can be reached with various types of interrupters.

The condenser is connected in parallel with the interrupter ; it helps to reduce the spark appearing in the interrupter on breaking the primary current, and to demagnetise the iron core rapidly. It is of great importance for all coils connected with mercury breaks.

The first interrupters were of the hammer type, well known from faradic batteries or electric bells. Owing to their low efficiency they have been superseded, but on account of their great simplicity they are still used in some portable coils worked by accumulators.

Mercury Interrupters. — The motor-driven mercury interrupters are most frequently used. There is a large variety of them. The interruptions take place under alcohol or paraffin oil, in order to extinguish more rapidly the spark which appears at the breaking point than air would do. In some interrupters coal gas is used for the same purpose. Those interrupters in which a copper rod plunges into the mercury, as in the centrifugal, or Mackenzie Davidson interrupters, have a higher efficiency than those in which the mercury is raised and ejected by a pump. The best frequency is about 40 interruptions per second ; less than this would cause the light on the screen to be unsteady, and a higher frequency is bound to increase the amount of reverse current, and is an unnecessary strain on and waste of tubes.

I should like to mention here, too, that it is impossible to obtain the *best* results, unless the size of the iron core, the capacity of the condenser, and the frequency of the interrupter are adapted to one another.

Electrolytic Interrupters.—An interrupter based on a totally different principle was invented by Prof. Wehnelt, in Berlin, in 1899. In this interrupter a thin platinum wire and a large lead electrode are immersed in diluted sulphuric acid, 1 oz. acid to 5 oz. water, of 20 to 25° Beaumé. When a current of at least 50 volts and 5 ampères is passing through this in such a manner that the platinum is the anode, the density of the current is so great near the small anode that it becomes very hot, and steam is formed. In addition, electrolysis causes hydrogen and oxygen to appear, and these gases form an insulating mantle round the anode, which interrupts the current. If there is sufficient amount of self-induction in the circuit, a spark appears at the breaking point, i.e., the anode, ignites the gases, and the explosion gives the acid access to the platinum, thus closing the current again. This process takes place with extraordinary rapidity and regularity. The intensity of the discharges and the frequency of the interruptions can be varied in the widest limits by varying the E.M.F. used in the primary circuit, the surface of the platinum anode, and the amount of self-induction.

The electrolytic interrupters are undoubtedly very good in every way; they are the simplest interrupters, and require no cleaning and less attention and repairs than any others. They were used almost exclusively on the Continent and in America for over ten years, but there was an undeserved prejudice against them in this country. It was due to the fact that they were connected with coils which were not suitable for them. The self-induction and the voltage in the primary coil must be variable in order to have an efficient control over an electrolytic interrupter, and this makes two extra switches necessary on the switchboard. This is a disadvantage in some hospitals, where the Staff using the apparatus changes frequently; but I am certain that every medical man who attempts to do so is able to learn the management of an electrolytic interrupter in half an hour.

One great advantage, however, offered formerly by the electrolytic interrupters has disappeared. Up to a few years ago the shortest exposures could be reached only with electrolytic interrupters; but they remained stationary, whereas the mercury interrupters, and the coils wound for them, have been improved steadily, so that at the present time good negatives of any part of the body can be obtained with either type of interrupters, even in a small fraction of a second.

Interrupters for Alternating Current.—There are numerous interrupters, mechanical and chemical, which enable us to use the alternating current directly. None of them is as efficient as an interrupter on a continuous current, and the maximum intensity which can be reached even with the best alternating current interrupter is much weaker than that obtainable with a continuous current. But where the X rays are chiefly required for therapeutic purposes, or examination on the fluorescent screen, or if time exposures lasting up to two or three minutes can be given, several of the mechanical interrupters will be found satisfactory, provided that the supply has not more than sixty periods. With a higher periodicity than sixty most of these interrupters become impossible.

The chemical rectifiers consist of large cells containing aluminium plates, and iron, lead, or carbon plates as indifferent electrodes, in a solution of bicarbonate of soda. A current can pass freely through such a cell while the aluminium is the anode ; but if the direction is reversed, a thin layer of aluminium hydroxide is formed instantly in consequence of electrolytic action, and this may offer a resistance of over 1000 Ohms to the passage of the current. This is used to convert an alternating into a pulsating unidirectional current. If the aluminium is quite clean, and while the cells are new, the rectifying effect is good, and for this reason this method has been tried again and again ; but to maintain the oxide in good condition the cells should be used *every day*, they require thorough cleaning from time to time, and nearly all the installations in which these cells were used for X rays proved unsatisfactory after a few months.

Motor Transformers.—We can, however, obtain with an alternating current, exactly the same results as with a continuous current, if we convert it into a continuous current by means of a motor transformer. A motor driven by the alternating current is coupled to a dynamo, which delivers a continuous current ; the size ought to be chosen so that about 1000 Watt can be obtained from the latter. These dynamos are reliable, and require scarcely any attention.

High Tension Transformers without Interrupter.—There is yet another way of utilizing alternating (or transformed continuous) current for X-ray purposes. It can be transformed into a suitable high voltage by means of an alternating transformer, and a motor makes the phases unidirectional.

This method was invented and described by a Mr. Koch, in 1904 but for peculiar reasons it remained dormant for some years, but has been taken up again lately. It looks at first sight as if we could employ currents of almost unlimited intensity. Practically the exposures are not shorter than those obtained with good coils. The reason of this is due to the different character of the discharge obtained from transformers connected with an alternating current, or from coils connected with interrupters. With the latter we have a sudden break, an intense discharge of high voltage but short duration, followed by a comparatively long period of rest before the next discharge takes place (*Fig.* 4). With the alternating current we obtain waves which are gradually rising and falling, but with almost no period of rest between two succeeding waves (*Fig.* 5). As X rays of sufficient

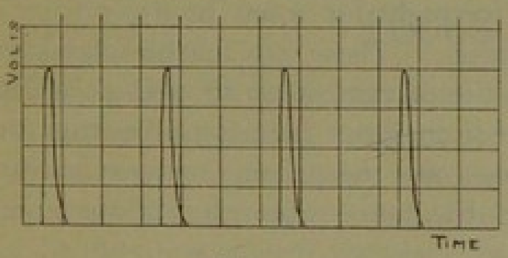


Fig. 4

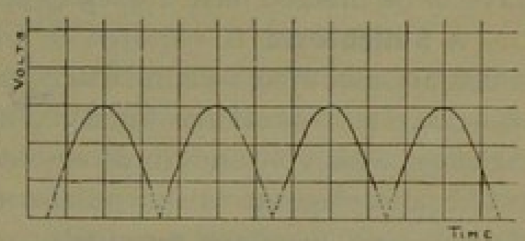


Fig. 5

penetrating power to pass through the glass of the tubes are generated only *while the voltage has a high value*, the beginning and end of these waves are lost for X rays ; but owing to the longer duration of the waves, the heat in the tubes is much greater than that generated with spark coils, and this is the stumbling-block, and prevents us from using more energy. There is no kind of tube existing which will stand, even for a second, the full discharge of a good transformer connected with a 4 H.P. dynamo.

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ELECTRIC SUPPLY.

We have yet to mention the sources of electrical energy which are necessary to work the spark coils. Wherever the continuous current is laid on this should be used; it is the most convenient, and also the most efficient current. For mercury interrupters we require up to 10, for electrolytic interrupters up to 20 ampères.

If an alternating current with a periodicity of 40 to 60 is laid on, and the X rays are not wanted for short exposures, it may be used directly with mechanical interrupters. If the periodicity exceeds 60, or if short exposures are desired, it is necessary to transform the alternating into a continuous current by means of a motor transformer, as has already been explained on page 143.

Accumulators.—If no current from the main is available, accumulators may be used, provided there is an opportunity of getting them recharged easily; but it must be understood that the time of exposure required will be somewhat longer, because with twelve 2-volt accumulators we cannot produce the same intense discharge which can be obtained with a 100- or 200-volt supply. If there is no opportunity of getting accumulators recharged, 12 *large* bichromate cells may be used too; but if the apparatus is required frequently, the recharging of bichromate cells will be too troublesome and expensive. In such cases—

Gas or Oil Engines can be used very well to drive a dynamo. The oil motors are similar to those which are used in automobiles; they can easily be started, and are small and portable, so that they can be used also in field hospitals. For a coil with a mercury break, engines of 1½ or 2 H.P. are sufficient; for electrolytic breaks 3 to 4 H.P. will be required. These engines may be used also for lighting small hospitals, or private houses. Some 30 metal filament lamps of 25-candle power can be used simultaneously with such an installation. A battery of 27 accumulator cells of about 75 ampère hour capacity, and a switchboard, are necessary in such cases. According to the number of lamps and the time for which they are used, the accumulators have to be charged once a week or once a fortnight for a few hours.

A Switchboard is required in most cases. These are marble plates, on which are mounted a main switch to turn the current on or off, and a variable resistance to control the intensity of the discharge. In most cases they are provided with volt and ampèremeter to measure the primary current, with a switch and rheostat to control the motor of the interrupter, and always with the necessary fuses and terminals.

In more elaborate installations the switchboard can be provided also with a switch to insert either a mercury or an electrolytic break, and to use the anodes of the latter separately or connected in parallel, with a switch to change the degree of self-induction of the primary coil, and with a switch and clockwork to break the primary current automatically after a previously set time of from 0·01, up to 10 seconds.

Shunt or Series Rheostat.—The switchboards can be so arranged that the coil is " in series " or " in shunt " with the dynamo. In the former case the full voltage of the supply has to be used, and can be reduced a little only by inserting resistance ; in the latter case, the voltage can be reduced and varied gradually. This has decided advantages, because the variable voltage gives a better control over the discharge. For instance, with a 16-in. coil a mercury break and a resistance of 35 ohms on a 240 volt supply, the shortest spark I could obtain " in series " was 5½ in. long, i.e. the discharge rods had to be separated 5½ inches to prevent the sparks from discharging ; whereas, the shortest sparks obtainable with the same resistance arranged in a " shunt " were only 1½ in. long. With a shunt the discharge can therefore be varied in wider limits, and it can better be adapted to medium and soft tubes than this is possible with the series connection.

As the amount of reverse current generated is in direct proportion to the voltage used in the primary coil (see page 152), we obtain less reverse current with the lower voltage available with a shunt than with the higher voltage which is inseparable from the series connection. Long practical experience, and the fact that the quality of the X-ray pictures obtained in the early days, when 12-volt accumulators only were used, has never been exceeded, is a proof that a low voltage in the primary coil is preferable to a high one as far as the quality of the negatives and the lifetime of the tubes is concerned.

The objection to shunt rheostats is that they are wasteful. They are a little more expensive, and the rheostats, while in shunt, consume twice as much current as they will do while in series ; but everybody who uses X rays for a short time only knows that the bill for the current is a negligible quantity compared with that for the tubes, and the latter is most decidedly heavier with a series than with a shunt rheostat. The better switchboards are so arranged that the coil can be placed in " shunt " or " in series " at the will of the operator, by closing or opening an additional switch.

FOCUS TUBES.

The quality of the focus tube is all important for success in X-ray work : if the tube is unsuitable, too hard or too soft, it is impossible to obtain a good negative, even if the tube were connected with the very best electrical apparatus. On the other hand, if the tube used is a good one, a fair negative may be obtained even if the electrical apparatus is not quite perfect. Focus tubes are worn out by use, and are expensive, but those which are properly treated will last for hundreds of exposures, whereas with carelessness or want of skill and knowledge, a tube may be damaged or even destroyed during the first exposure made.

It is therefore well worth while to devote a little more space to a description of the construction, working, and management of the tubes.

Cathode Rays.—If the secondary terminals of a spark coil or other source of electricity of *high voltage* are connected with electrodes which are fixed in a glass tube from which the air has been exhausted, a current will discharge through such a tube rather than through the surrounding air. The current passing between the two poles takes the form of a stream of very numerous and very small negatively-charged particles. These particles are believed to be finite quantities of electricity separated from all other matter. They are called electrons, and the stream of these electrons is called cathode rays. They travel in a straight line with a velocity almost as great as that of light. This velocity increases with the E.M.F. with which the cathode is charged, and with the degree of exhaustion. If this is great, we call the rays "hard," if it is comparatively low, we call them "soft."

The cathode rays can be deflected from their path by a magnet. If they are arrested in their flight by a hard substance, like the glass wall of the tube, they produce in consequence of their great velocity intense heat, in spite of the fact that they must be smaller yet than even the atoms of hydrogen. They cause fluorescence of the glass, but do not penetrate through the glass.

Roentgen Rays.—When the cathode rays strike a hard substance—for instance, a piece of metal placed in their way,—they are converted into X rays, and, provided that the E.M.F. used and the degree of exhaustion of the tubes is high enough, the X rays penetrate through the glass wall of the tube. They spread from the point of origin all round in straight lines, but they cannot be reflected, or refracted, i.e., be focussed by a lens, and they cannot be deflected by magnets.

Their intensity diminishes in inverse proportion to the square of the distance, and though invisible to our eyes, they affect bromide of silver like ordinary light. They make some substances—for instance, barium platino-cyanide—fluorescent. They can penetrate through substances through which ordinary light cannot pass, the amount of penetration depends on the hardness of the rays, and on the atomic weight of the substances through which they pass: cardboard is more transparent than wood or ebonite, flesh more than bones, aluminium is fairly transparent, but the heavy metals are opaque. These properties make the X rays useful for medical and surgical purposes.

Construction of the X-ray Tubes.—The illustration shows the arrangement of an X-ray tube. The cathode, consisting of aluminium, is placed in the cylindrical part of the tube, and is given the shape of a concave mirror, in order to concentrate the cathode rays to one point. This is necessary in order to obtain sharp outlines of the shadows projected on the fluorescent screen or photographic plate; if the X rays were to emanate from several points, or from a large surface, the image would be unsharp or blurred. In the centre of the tube, and in the focus of the cathode, is a piece of metal called the anti-cathode. The surface of this consists of platinum. Comparative tests have shown that the largest quantity of X rays is obtained when the target for the cathode rays consists of platinum. Metals with a higher melting point, like osmium, tantalum, etc., have been tried, but have proved a failure. As solid blocks of platinum are out of the question, owing to the price, thin sheets of it are fused in intimate contact with a solid block of another metal, like nickel, copper, silver, etc., which can carry the heat off rapidly and disperse it by radiation. In some tubes water is used for carrying off the heat.

The anode shown in the illustration is a third electrode, which is required during the process of exhaustion. It is not necessary when the tube is being used, but usually anticathode and anode are connected by a wire outside.

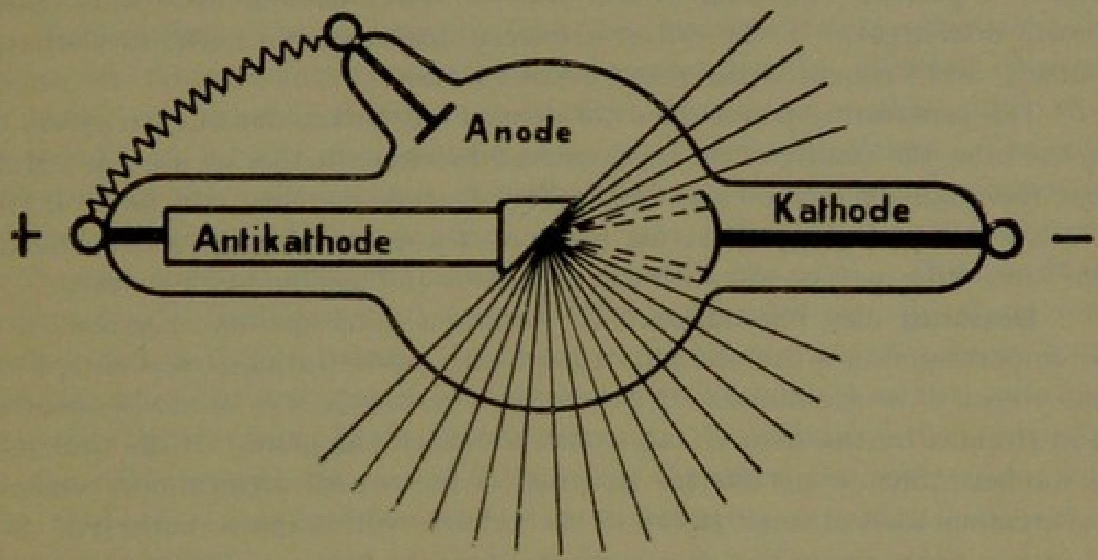

Fig. .6

Connecting the Tubes.—The cathode, i.e., the concave aluminium mirror of the tube, has to be connected with the *negative* pole, and the anti-cathode or anode with the *positive* pole of the coil. On page 138 it has been explained how the polarity of a coil can be found out by watching the behaviour of the sparks. If the X-ray tube is connected correctly, one-half of the tube—the space between cathode and anticathode—looks as if it were filled evenly with green air, the other half of the tube behind the anticathode remaining dark, because the latter acts as a screen. If connected wrongly, there is an irregular patchy fluorescence on the glass walls of the tubes ; rings appear, and in such a case the connection should be altered immediately, as the tubes are damaged if the current discharges in the wrong direction for any length of time.

Penetration : Soft and Hard Tubes. — If we hold a cardboard screen coated with barium platino-cyanide in front of the anticathode, and turn the current on, the screen will fluoresce with a green-yellow light. If we hold a hand between the tube and the screen, so that it is close to the back of the screen, and 10 to 20 inches in front of the anticathode, a shadow of the hand appears on the screen. If the degree of exhaustion is comparatively low, the whole hand appears as a black mass, the tube is " very soft." If the vacuum is somewhat higher, the flesh of the hand becomes somewhat transparent, the bones appear as black shadows, and the wrist bones as a compact black mass ; such a tube is called " soft." With " medium " tubes, the wrist bones become clearly visible. If the vacuum is high, the bones are transparent too, and

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appear as grey shadows only, the flesh seems to have disappeared, the rays have a high penetration, and such a tube is called " hard."

In soft tubes the fluorescence is intensely green, with some tendency to blue light near the cathode. Medium tubes show a steady green colour, with usually sharp division between luminous and dark part, no violet light nor rings or irregular patches. In hard tubes the light is thin, grey-green, there are some irregular flame-like green spots on the walls of the glass, the tube makes a peculiar crackling sound, and the wires leading to it show lively brush discharges. If the tubes are very hard, sparks begin to discharge outside, and frequently pierce and destroy a tube.

The penetrating power does not depend on the amount of current we use in the tube, the quality of the rays remains the same whether we use 1 or 5 M.A., but the quantity increases as we employ stronger currents. If, however, the voltage is raised, the penetrating power increases, and for this reason one and the same tube may be soft with one apparatus and medium with another.

Measuring the Penetration.—To obtain a good quality negative, it is all important that a tube should be used with a penetrating power suitable for the object to be examined. If it were too low, the X rays would be absorbed and stopped by the tissues, and would not reach the plate. If the tube used is too hard, fine details like the structure of the bones, calcifications, tumours, tuberculous lesions, small stones in the kidney, will disappear entirely. It is therefore necessary to test the condition of a tube before making an exposure; we have seen already how the hand may be used, but it is dangerous to expose one's hand frequently for fear of dermatitis. There are other means to measure the degree of penetration.

Equivalent Spark Gap.—If we connect a tube with a coil in the manner shown in the illustration, the discharge will take place through the path which offers least resistance. The resistance between the discharging rods is in proportion to the length of the air gap between them, and can easily be altered. If we put these dischargers so closely together that there is only a distance of about 2 inches between point and plate, the discharge will most likely take place through the air gap only, and the tube will remain dark. If we increase the length of the air gap gradually, a point will be reached when the current suddenly prefers to discharge itself through the tube instead of between the dischargers, and if this point is reached when the dischargers are for instance 4 inches apart, we say that the equivalent spark gap of the tube is 4 inches. A tube is very soft if the equivalent spark gap is 2 inches;

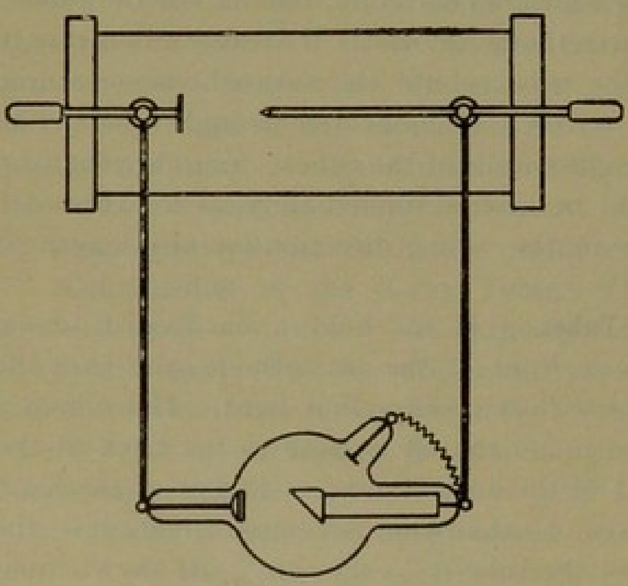


Fig. 7

soft if it is 3 inches; medium if it is 4 to 6 inches; and hard if it is 7 inches or more.

The equivalent spark gap is a convenient, but not an accurate or reliable, indication of the condition of the tube; it depends on the amount of current used, on the shape of the electrodes of the dischargers, on the frequency of the interrupter, etc. One and the same tube may have for instance an equivalent spark gap 4·5 centimetres long if measured with a current of 0·3 M.A., but 10·5 centimetres if measured with a current of 1 M.A.

Radiometers.—The penetration can be measured more accurately by means of the radiometers, which were constructed by Benoist, Walter, Wehnelt, and others. Benoist's instrument consists of a thin silver disc surrounded by a circle of aluminium steps of increasing thickness. The only objection to this instrument is that the thickness of the steps increases in arithmetical progression, 2, 4, 6, 8, etc., mm.; the increase is too rapid at the thin end, and too slow at the thick end of the scale. This has been corrected in Wehnelt's modification of the Benoist radiometer; the aluminium wedge used in this instrument increases in a geometrical progression, 1, 2, 4, 8, 16 mm. The transparency of silver is less affected than that of other materials by any change in the penetrating power of the tubes; the luminosity of the field covered by the silver is used, therefore, for comparison, like the light of a standard candle. The radiometers are placed behind a fluorescent screen.

The luminosity of the part of the screen covered by the aluminum changes according to the condition of the tube and the thickness of the aluminium, and if for instance with the tube we are using the aluminium field No. 3 has the same luminosity as the silver, we say that the tube has a penetrating power equal to No. 3 on the Benoist, or the Wehnelt scale, as the case may be.

It is thus possible to obtain an accurate comparison of the degree of penetration of different tubes; and the radiometers enable us to measure it conveniently, and independent of the strength of current used.

COMPARISON OF DIFFERENT RADIOMETERS.

Benoist	2	2½	3	4	5	6	7	8
Benoist-Walter ..	1	2	3	4	4½	5	5½	6
Walter	2–3	3–4	4–5	5–6	6	6–7	7	7–8
Wehnelt	1·8	3·3	4·9	6·5	7·2	8	8·8	9·6

Changes taking place in the Tubes.—While currents are discharging through tubes, changes take place which influence and vary the penetrating power. If the current used is strong enough to heat the anticathode, gases which are embedded in the pores of the metal become liberated, and diminish the degree of exhaustion, and so make the tubes softer. New tubes, in which

X-RAY APPARATUS

the metal parts are full of the amount of gases normally contained in the metals, have a great tendency to become softer, and with new tubes prolonged exposures, or short exposures with strong currents, have to be avoided carefully. If serious mistakes are made in this respect, the tubes may become so soft within a few seconds that they show a blue colour, and are useless ; such tubes have to be re-exhausted before they can be used again. If an exposure requiring intense X rays has to be made with a new tube, because an old-seasoned one is not available, the only possible way to do it is to use a weak current, and give a long exposure, if possible with a few intervals of rest in between. A strong current would most likely make the tube useless before the required exposure has been given.

After some exposures with moderate currents the tubes gradually become fit to stand stronger currents and longer exposures. They can be "ripened" to stand strong currents by connecting them repeatedly, at intervals of five minutes or more, for a second or two with a moderate current, which must not be so strong as to make the tube softer. With some patience tubes can thus be "trained" to stand currents of even 20 M.A. for over 30 seconds at a stretch without suffering harm.

If the anticathode has been raised to a high temperature during or before the process of evacuation, the gases are expelled by the heat, and tubes thus treated have no tendency to become softer even with fairly strong currents. The same is the case with old tubes, which have become too hard by use, and have been opened to be re-exhausted ; they have no gases left in the metal of the anticathodes either. But as such tubes are bound to become harder rapidly, it does not pay to re-exhaust tubes which have been used a good deal already.

Owing to another process, the gases left become gradually less ; some of the electrons are driven into the glass of the tube, others stick to the surface of the glass in consequence of static charges and attractions. This process is a slow one, but it tends to make the vacuum gradually higher and the rays harder, and finally all tubes are bound to become too hard to be of any use. Very weak currents, which do not warm the anticathode perceptibly, therefore make the tubes hard prematurely. Such weak currents are not at all an economy, and do not tend to prolong the life of the tubes, as so many imagine ; but, on the contrary, they are wasteful, as they tend to reduce the lifetime of the tubes, and are to be avoided.

It is an advantage to use tubes with bulbs of fairly large diameter. As the cubic capacity of a tube with an 8-inch bulb is four times as great as that of a 5-inch bulb, the changes which are bound to occur will affect the vacuum of a small tube much more than that of a large one ; and the latter are, for this reason, more constant, and become also less heated.

Normal Current.—The vacuum will remain constant if the quantity of gas which is liberated is as great as the quantity which is being used up, i.e. if the tube is worked with its normal current. A M.A. meter is most convenient to find out whether a tube has its correct load. If the index of the M.A meter has a tendency to fall, the tube is getting harder, the current used is too weak, and should be increased ; if the M.A. meter has a tendency to rise, the current is too strong for the present condition of the tube, it is becoming softer, and the current should be reduced. If these indications of the M.A. meter are ignored, the vacuum will change, failures owing to wrong penetration and exposure will be frequent, and the lifetime of the tubes will be shortened.

Regeneration.—If a tube is too soft for the purpose for which we require it, it can be made harder, as explained on page 150, by sending quite a weak current through it for some twenty or thirty minutes. If this is not yet sufficient, repeat it after a rest of an hour or more. The process is sure to succeed ultimately, but tubes which are much too soft require, of course, greater perseverance than those in which only a little hardening is wanted. Tubes become harder fairly quickly if the current is allowed to discharge in the wrong direction, either in consequence of wrong connection, or by allowing the reverse current to reach the tubes. This should never be done, for reasons which will be explained under "Reverse Current."

If the tubes are too hard, they can be made softer. If the temperature is raised slightly, by forcing a strong current through them, or by moving a spirit flame under the glass, some of the gases held in the glass-wall become liberated; but this effect lasts usually only as long as the tube keeps warm; after it has cooled down it is hard again.

Most of the tubes used now-a-days are provided with a regenerating arrangement. Some have a small palladium tube projecting through the neck of the tube. This has the peculiarity that it allows hydrogen to pass while it is hot, a process which is called osmosis. In others, the current can be made to pass and heat mica, marble, or similar substances enclosed in the tube, thus liberating some gases contained in these materials. Care must be taken not to over-do the regeneration.

REVERSE OR CLOSING CURRENT.

The current which is induced on breaking the primary circuit has the *same* direction as the inducing current ; the current which is induced on closing the primary current has an *opposite* direction, and is called the closing or reverse current. Its existence is a great inconvenience in X-ray practice, and a source of expense. Happily it is bound to be weaker than the current induced on breaking the primary current, for the following reasons : When the magnetic field appears, it induces a current not only in the secondary coil, but in the primary as well. As this current has an opposite direction to the primary current, it forms an obstacle to the passage of the primary current and retards the latter. As each turn induces a current in the adjoining turn, this is called self-induction—the obstruction increases with the number of turns of wire on the iron core. In closing the primary current, some little time is bound to elapse before the current and magnetism can reach its maximum. Such an obstruction does not exist on breaking the primary circuit, because the current induced has then the same direction; the break is thus more rapid than the make, and the sparks produced on breaking are therefore always more intense than those induced on making, but under unfavourable circumstances the closing current may reach fully 25 per cent of the E.M.F. of the current induced on breaking the primary circuit. Professor Walter obtained, for instance, from a coil which gave sparks 23 in. long on breaking the primary current, sparks

	¾	2½	5½ in. long
with	37	110	220 volts

on closing the primary circuit. The same number of ampères was used in all cases. The E.M.F of the currents induced by closing the primary current *rises in direct proportion with the E.M.F.* used in the primary circuit, and *in inverse proportion with the self-induction of the primary coil.* Though it is impossible to prevent the creation of reverse current, we can influence its strength considerably; to keep the intensity of the closing current low, the E.M.F. used in the primary circuit should be low and the self-induction high.

If the E.M.F. of the reverse current is sufficiently high to overcome the resistance of the tube, a current discharges in the wrong direction, some irregular rings and patchy spots appear on the glass wall of the whole tube, the fluorescence shows some milkiness and some violet light in the part behind the anticathode which ought to remain dark. There is not any more a sharp division between the luminous and the dark half. A more sensitive indicator of reverse current are the—

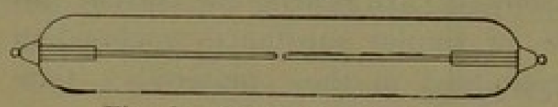


Fig. 8.—Oscilloscope Tube.

Oscilloscope Tubes.—Two aluminium wires, separated only by a small gap, are enclosed in an evacuated glass tube, and the wire connected with the negative pole becomes surrounded by a purple fluorescence. If the current discharges in one direction only, one of these wires only shows the violet light. But if each wire is alternately + or − pole, both become fluorescent, and the length of the fluorescence band indicates the intensity of the current; so that we can also compare the relative strength of the closing and the breaking currents. *Fig.* 10 shows the appearance of the oscilloscope tube with plenty of reverse current, *Fig.* 9 with very little reverse current.

Deterioration of Tubes through Reverse Current.—If a current is allowed to discharge through a tube in the wrong direction for any length of time, the platinum of the anticathode becomes disintegrated, and is deposited as a fine grey dust on the walls of the glass. It is generally supposed that this platinum dust combines with the remaining gases, thus making the tubes harder. At any rate, long practical experience has proved beyond doubt that tubes through which current is allowed to discharge in the wrong direction become unreliable, inconstant, hard, and useless much sooner than those tubes which are protected against reverse currents. In the latter case the tubes assume gradually a pretty violet or amethyst colour, whereas in the former case they become smoky grey.

The reverse current interferes also with the reading of the M.A. meter; it makes a correct measurement impossible; this will be explained later on under "M.A. METERS." Finally, the majority of the—

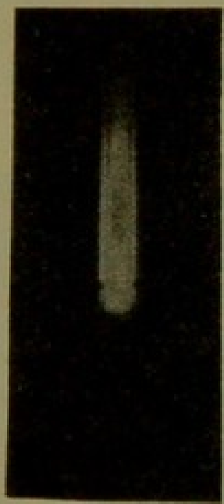


Fig. 9

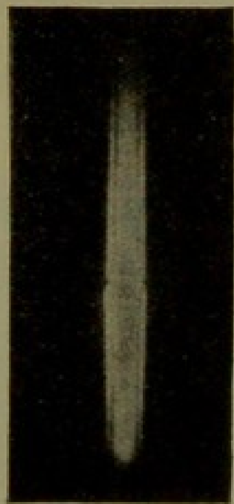


Fig. 10

Secondary Rays are produced by the reverse current. The cathode rays start from the anticathode or anode, they strike the glass wall of the tube and are converted there into X rays. All those X rays which do not emanate from the focus of the anticathode are called secondary rays. They have the same penetrating power as the primary rays, and are especially plentiful in hard tubes. They project the outlines of the objects in other directions than the primary rays do, and on account of this the sharpness of the outlines and the contrasts of the picture are reduced, some fogginess is caused in which fine details, which would be so valuable in more difficult cases, get lost. Some secondary rays are also started, or else diffusion of the primary rays take place, in the thicker parts of the patient's body.

The X rays *a a*, emanating from the focus of the anticathode, project a shadow B B of the object O on the plate. If there were no secondary rays, this shadow would be of uniform darkness from B to B, and the space B C D would be free from any shadow. But if any current discharges in the wrong direction, the so-called secondary rays are generated on the glass bulb; they are indicated by the dotted lines *b b*. Although weaker in intensity, they project nevertheless shadows of the object, and in another direction than the primary rays will do; the shadows overlap, and the part between A B will not be as dark as that between A A, and the space between B C will not be as clear as that between C D. The effect of the secondary rays is therefore to make the outlines less sharp, and to cause a general fogginess. In consequence of this, some details will become indistinct and the finer ones will disappear entirely.

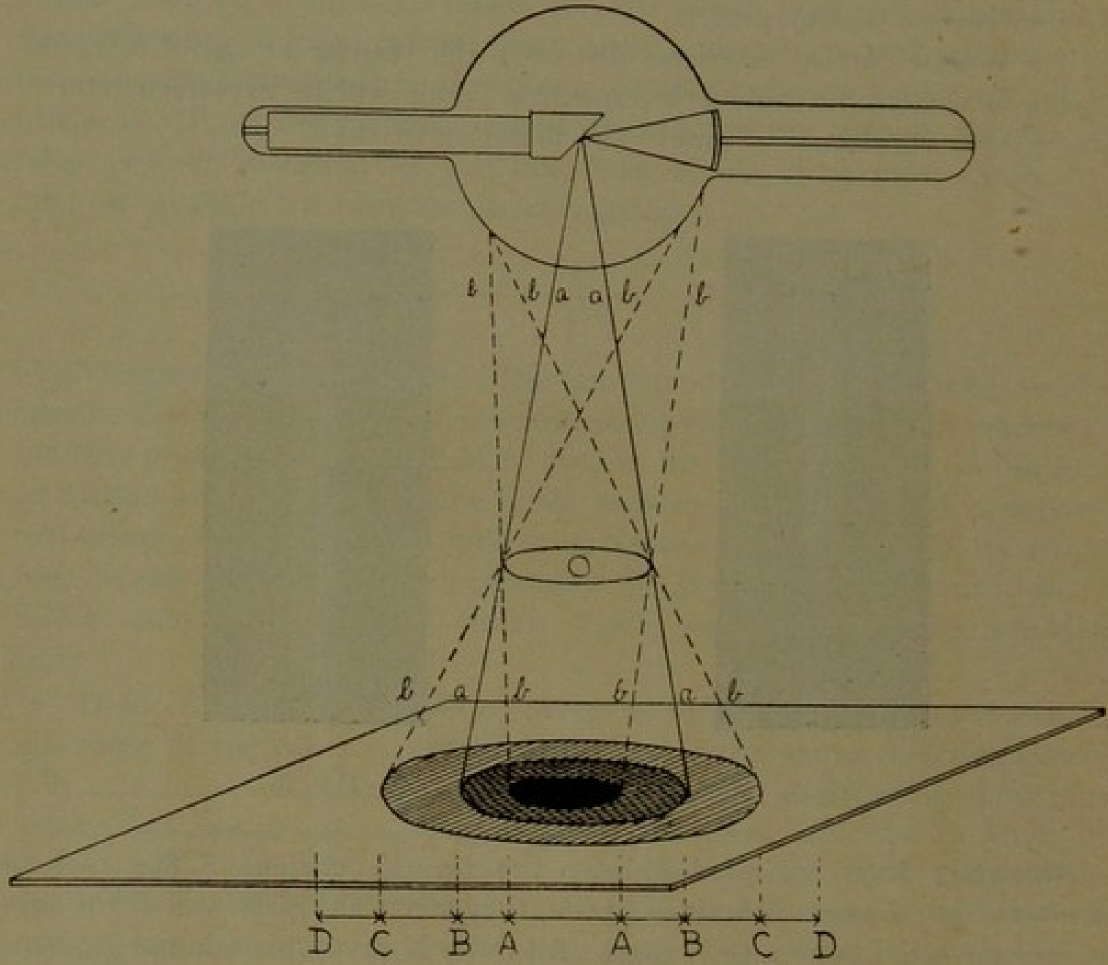


Fig 11

The reverse current is therefore a great inconvenience in every way. It causes waste of the usefulness and lifetime of the tubes, makes the dosage by means of the convenient M.A. meters inaccurate, and starts the secondary rays which cause fogginess in the negative, and loss of fine details. We try, therefore, to reduce or suppress the reverse current as far as possible. On page 152 it has already been explained that by using a low voltage and a high self-induction in the primary coil, the intensity of the reverse current will be kept low ; but if intense discharges are used, we cannot suppress it entirely in this way, and other means are available to minimise its ill effects.

Valve Tubes or **Spark Gaps** are frequently connected in series with the X-ray tubes. Both act on the same principle ; the current can discharge easily between a point and a plate if the point is the + pole, but it does not do so if the point becomes the — pole. It is thus possible to create an impediment or high resistance to the current in *one direction only*, whereas the passage is left free in the other. There are various types of valve tubes ; I have compared several of them ; the appearance of the oscilloscope tube proves that there is no difference in the rectifying effect and the resistance of the three types examined.

The first picture (*Fig.* 12, A) shows the appearance of the oscilloscope tube, while the X-ray tube was used alone without any valve tube in the circuit.

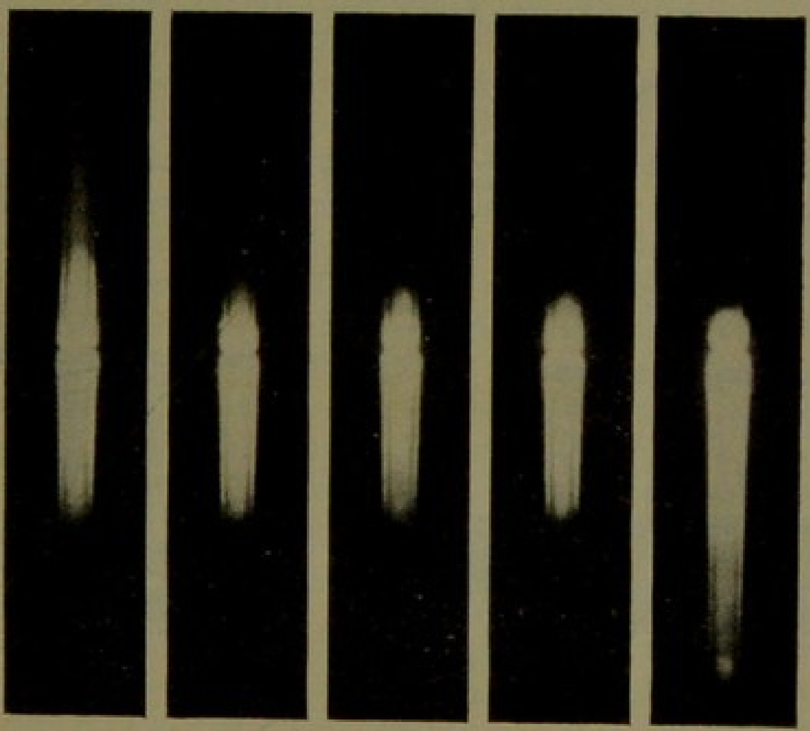
B shows the effect of a Gundelach valve tube.

C shows the effect of a Sir Oliver Lodge valve tube.

D shows the effect of a Villard valve tube.

E Villard tube, with coil in shunt, high self-induction.

It will be seen that there is no difference in the rectifying power of the three valve tubes which have been compared. None suppresses the reverse current entirely under the conditions, which were arranged *intentionally*, so



A B C D E

Fig. 12

that plenty of reverse current should be produced. But if the closing current is limited, by using a lower voltage and a higher self-induction in the primary, the proportion of the closing current to the breaking current will be much smaller, and even with double the number of M.A. passing through the X-ray tube, any of the three valve tubes will suppress the closing current under such conditions almost completely, as shown in Fig. 12 E.

Valve tubes or spark gaps should always be in the circuit if *new* or *soft* tubes, or if very strong currents are being used. Many X-ray tubes are also so constructed that the reverse current finds some obstruction.

If a fairly low voltage, a high self-induction, and a moderate frequency of the interrupter are being used in the primary circuit, and a valve tube in the secondary, it is possible to reduce the reverse current with a weak or moderate discharge almost to nil, and to obtain sharp division between the luminous and the dark half in the X-ray tube. If strong currents are being used for instantaneous exposures, we are compelled to use a fairly high voltage in the primary, and in such cases some reverse current may be present in spite of the precautions mentioned above. To prevent it deteriorating the quality of the negative—

Diaphragms are used. The illustration (*Fig.* 13) shows the primary or principal rays *a a* emanating from the anticathode A ; the dotted lines *b b* indicate secondary rays emanating from the glass wall of the tube. If we place a diaphragm between tube and plate, some of these secondary rays are stopped,

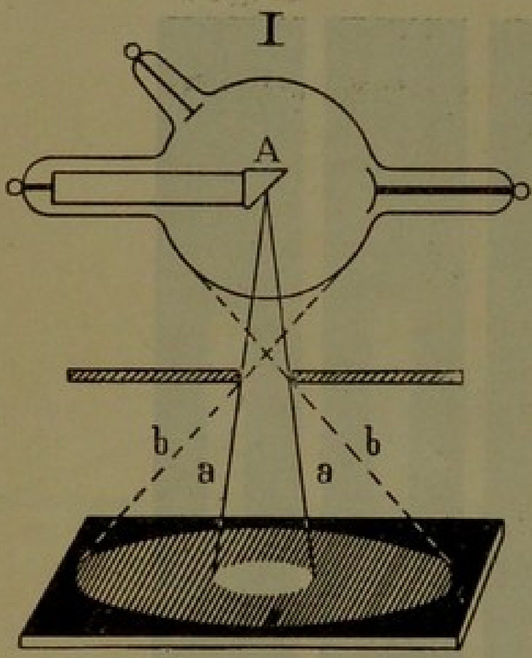


Fig. 13

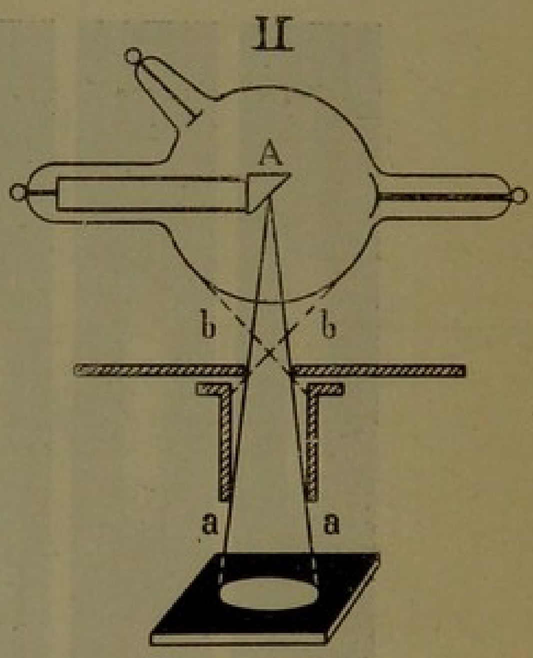


Fig. 14

and the nearer the diaphragm to the tube, and the narrower its aperture, the more efficient will it be. But as metal plates cannot be brought quite close to the tube, some secondary rays will still reach the plate unless a *cylinder diaphragm* is employed, as suggested by Dr. Albers Schoenberg. *Fig.* 14 shows why a cylinder diaphragm is bound to exclude more secondary rays than a flat diaphragm can do ; the cylinder diaphragm can be used with advantage also for compression, which is a great help, and will be explained later on.

The importance of the diaphragms is equally great whether negatives are to be made or whether the patients are examined on a fluorescent screen, and it is rather surprising that some Hospitals and Surgeons continue to ignore their advantage. All those who have only once had the opportunity of comparing, for instance, the appearance of a heart with and without a diaphragm, will agree with me. Some details, like small foreign bodies, calcifications, small tubercular lesions, cracks in the bones, etc., cannot be discovered at all without a diaphragm, whereas they appear clear with one. I was present once at a demonstration where the patient was known to have a few gunshot pellets in the chest, but nobody could see them, not even the expert specialist giving the demonstration. He doubted their presence, and I was at last allowed, by way of experiment, to place a diaphragm before the tube. The pellets then appeared quite clear to everybody present, but disappeared again when the diaphragm was withdrawn.

MEASURING THE X RAYS.

To determine the correct length of exposure and dosage, it is necessary to know the intensity of the light we are using. The intensity of the X rays leaving a tube depends on the number of volts and milliampères used. The latter can be measured by means of a reliable M.A. meter, which will be described later on, but we have not yet a satisfactory voltmeter. We know, however, that a greater voltage is necessary to force a current through a hard tube than through a soft one ; according to Bergonié 40,000 volts are required in the former, 16,000 volts in the latter case. The voltage required to overcome the resistance of the tubes increases in about the same proportion as the vacuum and the penetrating power increase ; we can therefore substitute the latter for the unknown voltage. The practical use of this will be described under "EXPOSURE." How the penetrating power or the quality of the X rays can be measured has been explained already on page 149.

Milliampère Meters are being used to measure the strength of the current discharging through the tubes. It was found, about ten years ago, that if an M.A. meter of the d'Arsonval type was inserted in the circuit of an X-ray tube, a current of 0·1 to 1 M.A. was registered by these instruments, and that the effect produced on a photographic plate was in proportion to the current × time used, i.e., plates exposed with a current of 0·5 M.A. for 60 seconds, or with 1 M.A. for 30 seconds, or with 5 M.A. for 6 seconds, and developed simultaneously, showed the same amount of density, provided that the same tube was used in each case.

Quite different results, however, were obtained if either tubes of different penetrating powers, or different types of M.A. meters were used, and this created doubts about the reliability of M.A. meters for measuring X rays. The influence of the penetrating power was overlooked at first, but it has been recognized since. As to other types of M.A. meters, besides the d'Arsonval moving coil instruments, the voltameter, in which water is decomposed by the current, is useful too ; but other types, like the hot-wire instruments, have been found to be useless and misleading for X-ray purposes, though they are correct for continuous currents or for alternating currents with phases of equal strength.

The chief objection which is usually made against the M.A. meter is that it does not register the actual strength of the current, but indicates only an *average value* between the strength of the single discharges and the number of discharges in unit time (or in other words, the frequency of the interrupter).

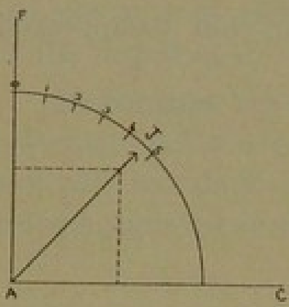


Fig. 15

It is undoubtedly true that this is so. The position of the index (*Fig.* 15) depends on the parallelogram of forces. Along A C is measured the maximum value of one impulse, and along A F the time which elapses between two succeeding impulses, i.e., during which no current flows into the M.A. meter. This time is given by the expression $\frac{1-NX}{N}$ where N is the number of impulses per unit time, and X is the duration of one impulse. A J is the position of the index.

It is a decided *advantage* that these instruments indicate the resultant between the frequency and the current. If they were to indicate the maximum value of each discharge, without regard to the frequency, as certain kinds of instruments do, it would be necessary to measure the number of M.A. × the number of discharges used, and this would be inconvenient with some, impossible with other, interrupters ; but as the M.A. meters indicate an average, depending on the current and the number of impulses, we have only to measure the number of M.A. × the time used. They make us independent of the size of the spark coil and of the type and frequency of the interrupter used.

There is, however, an objection against these instruments. They become inaccurate if reverse current is present. They do not indicate alternating currents at all if both phases are of equal strength. If one phase preponderates, as is always the case with spark coils, they indicate the *difference* between the two phases, i.e., between the strength of the closing and the breaking current. All coils must give some closing current, but the amount varies a good deal. As long as the E.M.F. of it is small, the resistance of the X-ray tubes or of an air gap acts as a valve and suppresses it, so that only pulsating currents of uniform direction reach the M.A. meter. But when the E.M.F. of the closing current becomes sufficiently high, it begins to discharge through the tubes in the wrong direction, and it is therefore necessary to ascertain whether any reverse current is present or not, and if so, a valve tube or some other device must be inserted to suppress it, and so keep the M.A. meter accurate.

With this precaution the d'Arsonval M.A. meters are reliable for measuring the discharges through X-ray tubes, and when these facts have been more generally recognized, the M.A. meters are sure to be considered as necessary in X-ray practice as they are in galvanisation, ionic medication, etc.

The word milliampère has, however, not yet the same meaning of a definite dose, to which we are accustomed elsewhere. In electrolysis, for instance, it means a current capable of decomposing water into 0·62 cctm. of gas per hour, but in X rays the distance between tube and object, and the penetration, have also to be taken into account before we arrive at the dose.

The M.A. meters are also very convenient for watching the tube during exposure. If a tube has its proper load, the index of the M.A. meter keeps steady. If more current has been turned on than the tubes will stand for any length of time without changing, the needle rises gradually, and it does so long before even the most experienced operator can notice any change in the colour of the light. If the hint given by the M.A. meter is followed, and the current reduced a little, the tube can be kept constant ; if it is disregarded, it will soon become softer, and the exposure may have to be stopped for a little while. On the other hand, if the needle of the M.A. meter shows a tendency to fall, more current is wanted to prevent the tube from becoming harder. There are no other means as reliable, sensitive, and convenient to control the condition of the tubes, and a M.A. meter indicating from 0 to 5, and with a shunt to 50 M.A., is a great convenience, and a saving of tubes and time.

EXPOSURE.

Selecting a Tube.—Before making an exposure, we must select a tube with a suitable degree of penetration for the object of which we wish to obtain a negative. Please remember that the difference in the density of the shadows is due to a difference in the atomic weight of the objects. Between a bone and the surrounding muscles, or between a foreign body like a bullet or a steel needle and the flesh, there is a great difference in atomic weight, and for this reason fractures, dislocations, and some foreign bodies are easily diagnosed by means of the X rays, and the degree of the penetration of the tube used does not matter so much in such cases, provided that the tube is not so soft that the rays are stopped and absorbed by the surface already and cannot reach the plate at all. But differences between the atomic weight of small stones, calcifications, tumours, etc., and the surrounding flesh are very small, and if the tube is only a little too hard, fine details are bound to disappear entirely.

If a *reliable* diagnosis of small stones in the kidney or bladder is wanted, or of small tuberculous lesions, cracks in bones, tumours, etc., a suitable degree of penetration is all important ; if the tube should be a trifle too soft, we can correct the fault by exposing a little longer, if it is too hard the fine details get lost. The majority of failures in X-ray negatives is due to the fact that the tubes used were too hard, and that no diaphragms have been employed.

Many surgeons are under the impression that it is sufficient to have one tube only ; if it is wanted chiefly for finding fractures or bullets, it may do, but if wanted for finer work, the vacuum has to be corrected too frequently ; the better way, and the more economical one, is to have three to five tubes : one soft, two or three medium, and one hard. The new tubes are usually soft, and should be used only for thin objects, like hands, etc., requiring a weak current and a short exposure. After they have been used for a number of exposures on such objects, they are advanced a step, and are used for knees, shoulders, lungs, the heart, etc. When they have become medium hard, they are used for the head, spine, and for examination on the screen. After they have become hard, they are regenerated, as described on page 151, or in the directions for use received with the particular tube, and take a lower place again ; although softer, they can now stand fairly strong currents or longer exposures, and are used for exposures for stones in the kidney, etc. If tubes are used in this manner better results will be obtained, less time is wasted, and the bill for tubes will be smaller than when one tube has to do everything, and has to be made harder or softer too frequently.

To obtain good negatives of various parts of the body, the tubes should show the following degrees on the Wehnelt Radiometers :—

For teeth, with the film in the mouth	60 to 70
For fingers, hands, nose, or eye	65 to 80
Stones in the kidney or bladder	75 to 85
Arms, knees, shoulder, lungs, heart	80 to 95
Spine, head, pelvis	85 to 100

For thin and juvenile patients, the lower figures ; for stout or elderly ones, or if the exposure has to be very short, the higher figures should be used.

If there is no tube with a suitable degree of penetration available, the nearest one can be made a trifle softer or harder, as the case may be, in the manner described on page 150. If a tube is only a little too soft, there is no need to correct it, but we have to expose a little longer.

How the degree of penetration can be tested has been already explained under Radiometers, on page 149.

When the tube has been selected, it is suspended in the stand so that the axis of the tube is *parallel* to the plate ; it is a mistake to incline it towards the plate. The wires must be attached to the terminals of the tube securely, that they cannot possibly fall off and come near the patient, that they do not cross one another, and that they do not pass too near the bulb of the tube, as otherwise there would be some risk of perforation. The tubes should be free from dust or dampness, and should not be placed too near the coil, as otherwise the cathode rays would be deflected by the magnetism of the iron core. The focus would not then be always on the same spot, and the outlines on the negative might become unsharp. The distance should not be less than 5 feet to either end of the iron core. It is also frequently desirable that the patient should see the tube working for a moment before the actual exposure is made, because some of them may be frightened and move when they suddenly see the green light in the tube or hear a little noise for the first time.

The Distance between Anticathode and Plate is important. The intensity of the X rays is in inverse proportion to the square of the distance. If we have to expose for a certain object 3 seconds with a distance of 10 inches between the anticathode and the plate, the time of exposure required with

	10	12	16	20	25	30	40	50	60	80	inches.
will be	3	4·32	7·68	12	18·75	27	48	75	108	192	seconds.

The distance to be chosen depends on the thickness of the object. If the distance is too small, the distortion will be great, as is apparent from *Fig.* 11. To obtain, for instance, the shadow of the heart in natural size, the distance between anticathode and plate ought to be 80 inches. Distances as large as this cannot be chosen unless we have an apparatus capable of giving very intense currents, otherwise the exposure would be too long. The distances most frequently used are :—

For teeth, toes, fingers, or hands	10 to 12	inches.
Arms, neck, leg, or foot	12 to 15	,,
Nose, head, shoulder, knee	20 to 22	,,
Chest, kidney, pelvis	22 to 25	,,

When the connections have been made, the current is switched on for a moment, to see that the apparatus is working properly, that the tube is connected correctly, that it gives a steady, intense green light with sharp division between the luminous and the dark half, and to measure approximately the M.A. of the " normal " current (see page 159) which can be used, as this is one of the items which determines the length of the exposure to be given.

Plates.—The special X-ray plates which are being made now by many manufacturers are decidedly superior to the ordinary portrait or landscape plates, in consequence of a thicker coating of bromide of silver, which makes them more sensitive to X rays, and likely to give more fine details. Ordinary plates are less sensitive, and give fewer details ; they should be used only if it is impossible to obtain the special plates. It is not advisable to keep the films or plates packed in envelopes stored for too long a time, as all materials, except glass, deteriorate the emulsion. The stock of plates must not be kept near the place where the exposures or experiments are being made, as all the plates may be affected and rendered useless.

The plates are placed in suitable casettes, or red and black envelopes, in the dark room, in such a manner that the rays will reach the sensitive emulsion *without having to pass through the glass of the plate.* Casettes lined with a sheet of lead at the bottom are decidedly better than only paper envelopes, because the lead efficiently stops any X rays after they have reached the plate, so that no secondary radiation can affect the plate from below, and the negatives are less foggy.

The photographic plate has to be adjusted under or above the patient, so that the part to be taken comes in the *centre* of the plate, and the anti-cathode of the tube should be above (or below) the centre of the plate, so that the principal ray from the focus of the anticathode reaches the object to be taken and then the centre of the plate.

The Patient.—That part of the body which is to be examined should be as near as possible to the plate. If the spine or the kidneys are to be examined, the plate must be on the back of the patient, and the tube in front ; if the heart or the front ribs are to be examined, the plate must be on the chest, and the tube behind the back. The part to be examined should be naked to avoid shadows of buttons, clothes, etc.

For examining the heart, stomach, etc., it is desirable that the patients should be standing, and the plates are suspended on an upright stand against which the patient presses ; for other parts they may be sitting ; for examining kidneys, the spine, a knee, etc., the patients are placed on a couch ; but in whatever position they are, they should be *comfortable, so that they can easily keep quiet.* Small pillows or cushions will frequently be a help to keep them quiet in the desired position. If, for instance, the left shoulder has to be taken, a cushion should be placed under the right shoulder, so that the chest is inclined, and the left shoulder as flat and close on the plate as possible.

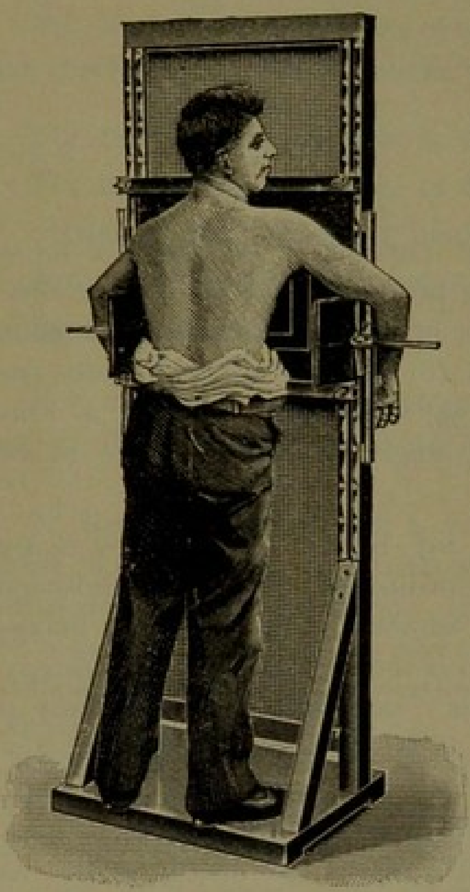


Fig. 16

If the kidneys are to be examined for stones, the knees of the patient should be raised somewhat, to make sure that the spine presses against the plate. The plate should be so arranged, that part of the spine will appear on it, to act as a criterion whether the condition of the tube, exposure, and development have been correct. When the lumbar region or the pelvis are to be examined, the patient should be given an aperient previously.

If a stomach, œsophagus, or the bowels have to be examined, a bismuth meal has to be given to the patient. For this purpose $1\frac{1}{2}$ to 2 oz. of carbonate of bismuth are mixed with raspberry syrup, and added afterwards to some porridge, mashed potatoes, or something similar. Bismuthum subnitricum must not be used. It has caused the death of several patients already when given in such large doses. Oxide of zircon, though a trifle less opaque than bismuth, is a good material too, but some preparations of iron, etc., have proved failures, some are too repulsive for a meal, and others are not opaque enough.

Compression.—In many cases it will be a help to fix the parts to be exposed either with a broad strap or binder (*Fig.* 17), which can be made tight with clamps, or with weights, or a few small sacks filled with sand. A cylinder diaphragm, described on page 156, can very well be used as a compressor. In

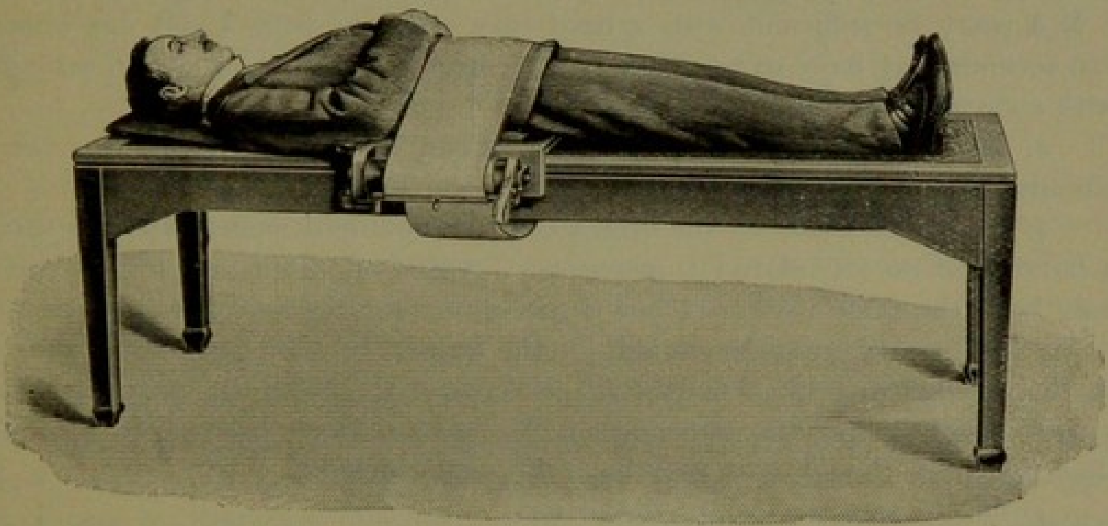


Fig. 17

making exposures of the kidneys, this is a great advantage, as it helps to reduce the thickness of the body, but it is useful for many other parts too, as it prevents movement of the patient, and excludes the secondary rays. An inflated rubber cushion can also be used for compressing the abdomen, as shown in *Fig* 18.

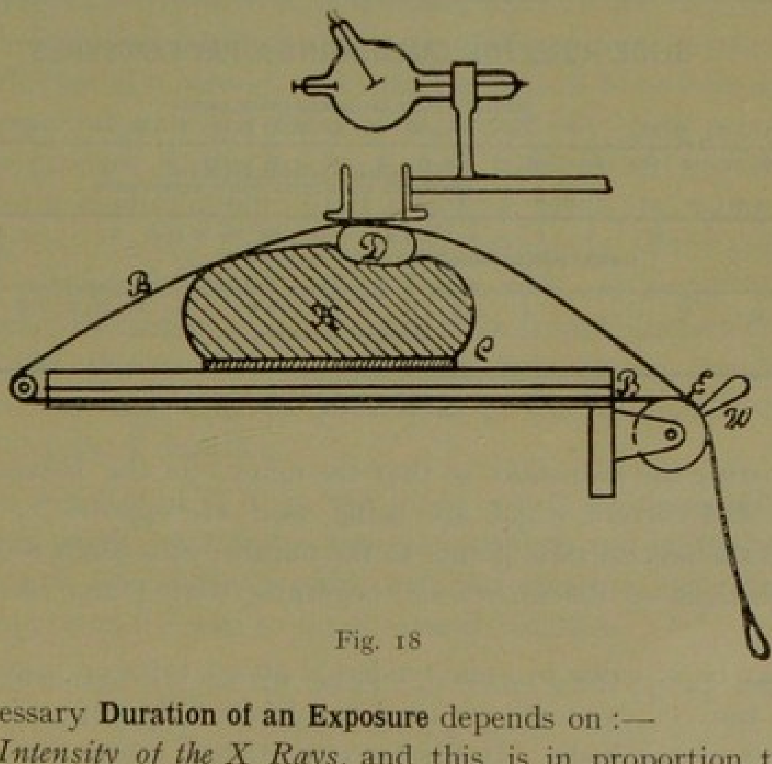


Fig. 18

The necessary **Duration of an Exposure** depends on :—

1. *The Intensity of the X Rays,* and this is in proportion to the penetrating power of the tube × the number of M.A. used. With one and the

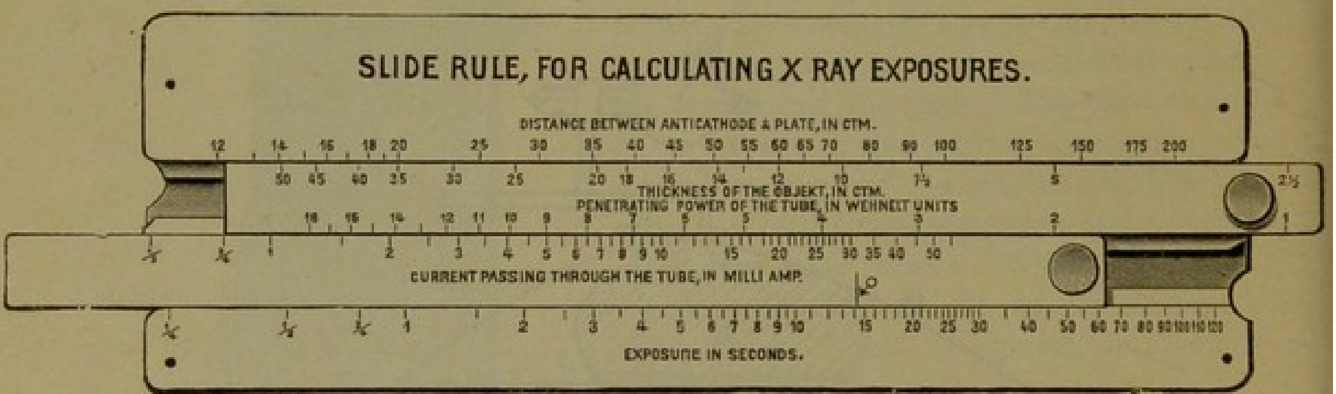
same tube, 1 M.A. for 60 seconds, or 2 M.A. for 30 seconds, or 10 M.A. for 6 seconds will produce the same effect on a plate. If tubes of different penetrating power are used, the number of M.A. seconds required with a soft tube may be three to five times as great as that required with a hard one. To produce a certain density on a plate 30 seconds' exposure with a current of 2 M.A. may be sufficient with a hard tube, whereas with a soft one either 150 seconds may have to be given with a current of 2 M.A., or else 30 seconds with a current of 10 M.A.

2. On the *distance* between anticathode and plate. This has been already explained on page 161.

3. On the *thickness* of the object (a knee requires a longer exposure than a hand) and on its relative transparency. Chest and abdomen, for instance, may have the same thickness, but if the latter requires 200 M.A. seconds, 50 to 80 M.A. seconds may be enough for the former, because the chest contains the lungs filled with air, whereas the contents of the abdomen have a greater atomic weight. For the same reason the head requires more M.A. seconds than the chest, though both may have the same thickness.

4. On the sensitiveness of the plates.

A *slide rule* enables us to find these figures easily. The first scale contains figures for the distance between anticathode and plate, varying from 12 up to 200 ctm. On the second scale, figures for the thickness of the object, varying from 2½ up to 50 ctm., will be found. On the third scale is the penetrating power of the tube in Wehnelt units, from 2 up to 18; and the fourth scale contains the figures for the M.A. used, and rises from 0·5 up to 50 M.A.



No. 19

By adjusting the two slides so that the figures for the distance, thickness, penetration, and current which are being used, are opposite to one another, the index on the second slide points to the number of seconds required for the exposure, which is on the fifth scale, beginning with ¼ and rising up to 120 seconds.

As it may be of value to some readers, I give a table on page 166 showing the average time of exposure required to obtain fully exposed negatives of different parts of the body. It has been mentioned before that, other things like distance, penetration, and thickness of the object being equal, the duration of the exposure depends on the number of milliampères used. For a shoulder, for instance, of a normal adult, 90 M.A. seconds are required with a tube with a penetrating power equal to 9 degrees on the Wehnelt scale. If the apparatus and tube allow us to use a current of—

10 M.A., the exposure will have to last	9 seconds.
8 ,, ,, ,,	11 to 12 ,,
5 ,, ,, ,,	18 ,,
3 ,, ,, ,,	30 ,,
1 ,, ,, ,,	90 ,,

It is best at first to attempt time exposures with moderate currents. When they have been mastered, and if the apparatus available gives the currents required for rapid or instantaneous exposures (from 50 to several 100 M.A.), the latter will not be found difficult, but they should not be attempted at the beginning.

Instantaneous Exposures have been made as early as 1896 by Dr. Macintyre, and later on by Rieder and others, and since 1908 they have become practical for everyday use. The advantage of very short exposures is, that the movements due to respiration and to the pulsation of the heart and the arteries do not interfere with the sharpness of the image. Other advantages are the saving of time and the greater convenience to the patient. The acceleration of exposure is due to the fact that coils and interrupters have been so far improved that over twenty times more current can be obtained now than was the case up to about 1906. The powerful currents can be reached with 100 to 250 volts and up to 40 ampères, and either with electrolytic breaks, or else with mercury interrupters and a new type of coils specially adapted for them. Good negatives of the heart of an adult can then be obtained with exposures down to about the $\frac{1}{10}$th part of a second, and with the best of these coils and a special mercury interrupter, *one single flash*, lasting about the $\frac{1}{100}$th part of a second, is sufficient to produce X rays intense enough to give good negatives, even of the stomach of a normal adult ; and, of course, of all the thinner parts like the head, heart, etc., too. The pelvis of *stout* adults is, at the time of writing this, the only part which cannot yet be taken with one single flash, but two or three such discharges can be given in rapid succession in about one second, and this is sufficient even in such cases. Besides this, the apparatus can be used with an interrupter in the ordinary way for time exposures of very short duration.

The exact number of M.A. in the tubes cannot be measured with these short exposures, partly because the time is too short, and partly because some reverse current is frequently present, but the currents generated with the single flash apparatus are sure to reach several 100 M.A.

It is strange that almost all tubes can stand such strong currents for a fraction of a second easily, without suffering harm. Only a part of the heat generated seems to enter the anticathode, whereas with much weaker currents

EXPOSURE TABLE.

	Dist.	Penet.	M.A. Seconds
Head, sideways	CD	9	110
Head, occipito-frontal ..	CD	9	160
Head, eye and nose	CD	7·5–8	100
Head, teeth, plate outside ..	CD	7·5–8	100
Head, teeth, film inside ..	16″	7–8	15–20
Cervical vertebræ	CD	8–9	75
Lumbar ,, ...	CD	9	200
Sacrum	CD	9	200
Stones in kidney or bladder ..	CD	7·5	250
Stomach, bowels	24″	9	80
Stomach, with accelerating screen	24″	9	20
Pelvis	24″	9	200
Hip joint	CD	9	150
Chest, ribs	24″	9	80
Sternum	CD	8	120
Heart or lungs	20″	8	60
Heart, Tele-exposure ..	80″	9	120
Shoulder	CD	8	90
Arm	CD	7	30
Hand	20″	7	12
Knee or upper leg	24″	8	75
Lower leg or foot	24″	7	50
Foot	CD	7	35

If you divide the number of M.A. seconds given in the column on the right-hand side by the number of M.A. you are using, you will obtain the number of seconds the exposure should last.

Dist.—The distance given in inches means the distance between anticathode and plate.

C.D.—Cylinder diaphragm. The distance is then composed of (1) The thickness of the part of the body to be taken ; (2) The length of the cylinder diaphragm, which is 6 in. ; and (3) The distance from the upper edge of the cylinder to the anticathode, which is 3 to 5 in.

Penet.—Penetrating power of the tube, as given in Wehnelt units.

M.A.—Milliampères.

M.A. Seconds.—The time given is for medium-sized adults and a current of 100 volts. With 200 volts the exposures will be somewhat shorter, with accumulators it will be longer.

If a tube turns softer during an exposure, it has to be prolonged, and the current has to be reduced. If a tube turns harder during an exposure, it has to be shortened, and the current increased.

If softer tubes are used the exposure has to be prolonged 40-50 % for every additional degree of softness.

passing for some 30 seconds only, there is greater risk of the tubes turning soft, though the total number of M.A. seconds used must be the same in either case. It is essential for instantaneous exposures that tubes should be used with a fairly thick piece of platinum and a heavy block of metal behind it. Tubes with a thin anticathode, or water-cooled tubes, will not do for this purpose; they would be pierced instantly. A suitable degree of penetration is even more important, if this is possible, with instantaneous than with time exposures; with the latter we can expose a little longer if the tube is somewhat too soft, but with instantaneous exposures such a correction is impossible—if too soft the negative will be under-exposed, and if only a little too hard it will be foggy and the fine details will disappear. The penetration must, therefore, be tested before the exposure is made, and, if necessary, must be corrected, to avoid a failure.

As it is not well possible to close the primary current with an ordinary knife switch, and open it within $\frac{1}{10}$th or $\frac{1}{4}$th of a second afterwards, and as the sparking on these knife switches is excessive, another type of switches is preferable for instantaneous exposures. The automatic switches with horn-shaped contacts enable us to open the circuit rapidly, and the sparks are much smaller than with ordinary knife switches, and they can also be released automatically by a clockwork, which is started by closing the switch. This clock can be adjusted so that the switch will be released within $\frac{1}{100}$th, $\frac{2}{100}$th, $\frac{1}{10}$th, etc., of a second, up to 10 seconds.

Intensifying Screens.—By the use of the new accelerating or intensifying screens, the exposure can be reduced to $\frac{1}{10}$th or $\frac{1}{20}$th of what would be required without a screen. Their use means, therefore, a great saving in tubes, because the latter have to be switched on only for about $\frac{1}{10}$th the time which would be required without them.

The new screens have been so far improved over the older ones, that grain is practically invisible, and fine details, like the structure of bones, come out quite well. With most negatives it is impossible to detect afterwards whether a screen has been used or not. They are, therefore, of great advantage to the owners of older apparatus, which are not capable of producing the strong currents required for short exposures; but even with the powerful modern apparatus they are a great help, because in some heart, stomach, etc., cases, it is a decided advantage to be able to make an exposure in such a short time, that even the pulsation of the heart and arteries cannot interfere any more with the sharpness of the outlines.

It is important that the fluorescent side of the screen should be in *close* contact with the sensitive side of the plate; if there were any air space between, a blurred patch would be the result. The screen must be kept scrupulously clean, and must be dusted with a camel-hair brush; any dust which may be left on screen or plate will appear as pinholes on the negative. The screens should not be removed from the plates for fully five minutes after the exposure is over, because a bluish phosphorescent image remains on the screen, and continues to act on the plate for a few minutes after the exposure is over.

Over-exposure should be avoided. When intensifying screens are being used, there is no need for the expensive special X-ray plates. Some rapid portrait or landscape plates are faster with the bluish light produced by these screens.

Tele Exposures are made in order to obtain shadows of the heart, stomach, etc., in natural size. As some organs of the body cannot be brought quite close to the plate, they are bound to appear enlarged, the reasons of this are apparent from *Fig.* 11 on page 154. The greater the distance between object and plate, and the smaller the distance between tube and object, the greater will be the distortion. A normal heart, for instance, may appear on the negative fully 40 mm. larger than it really is if the distance between tube and plate is only 25 inches, whereas it cannot appear more than 2 mm. larger than actual size when the distance used was 80 inches.

As the intensity of the rays diminishes as the square of the distance, powerful currents have to be employed to finish an exposure at such a distance in a reasonable time, but the intense X rays mentioned under instantaneous exposures will do well for tele exposures, with a distance of 2 metres between tube and plate. The necessary duration of exposure need not exceed 1 second, and can easily be made with the patient standing.

Stereoscopic X-Ray Exposures.—Negatives or prints show us everything in one plane; we cannot therefore judge of the relative position of the bones in cases of fracture, or in dislocation of the hip, etc., nor the exact distance between the skin and a foreign body. But if we make two negatives of one object, and change the position of the tube a certain distance between the two exposures (as indicated in *Fig.* 20), we can examine all the details in stereoscopic relief, and this is a great help in many cases. No complicated apparatus are required to make stereoscopic exposures.

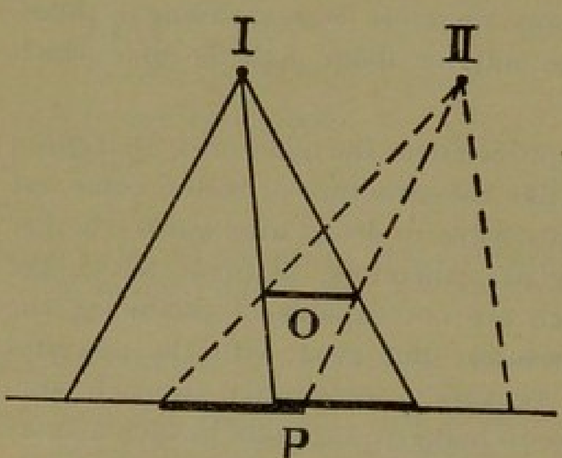


Fig. 20

It is necessary *that the first plate can be withdrawn after exposure and a fresh plate put in its place without disturbing the position of the patient, which must remain the same for both exposures.* Special cassettes enable us to do this.

The distance for which the tube is to be shifted depends on the thickness of the object and on the distance between tube and skin; if the object is thick, or the distance small, we have to shift the tube only a little; if the object is thin, or distance great, we have to move the tube a greater distance. Marie and Ribaut have given us a table about this :—

Thickness of the object : Centimetres.	If the distance of the Anticathode from the surface of the object is—			
	20	30	40	50 ctms.
	The Tube has to be shifted			
2	4·4	9·6	16·2	—
4	2·4	5·4	8·8	13·5
6	1·7	3·6	6·1	9·3
8	1·4	2·8	4·1	7·3
10	1·2	2·4	4·0	6·0
15	—	1·8	2·9	4·3
20	—	1·5	2·4	3·5
25	—	1·3	2·1	3·0
30	—	1·2	1·9	2·7

The tube-holders are provided with a scale ; the tube is first fixed so that the anticathode is above the centre of the object to be taken, and the position is noted ; if the tube has to be shifted 6 ctm. altogether, we move it first 3 ctm. to one side of its original position, and after the first plate has been exposed, we move it to a distance of 3 ctm. on the other side, and when the plate has been changed make the second exposure. The plane in which the tube is to be moved must be parallel to the plane of the plate, so that the distance between the anticathode and the plate is the same in both instances. The direction in which the tube is being moved must be rectangular to the longest side of the object ; if we take an elbow, for instance, the tube must be moved across, not parallel with, the arm.

Large plates are examined in stereoscopes with reflecting mirrors, or else reductions of the plate can be examined in ordinary stereoscopes.

EXAMINATION ON THE SCREEN.

The part to be examined must be between tube and screen, as near to the tube as this can safely be done without being exposed to sparks, and the fluorescent screen is held close to the other side of the part to be examined. A diaphragm, with a fairly narrow aperture, should be used between tube and patient, as more details become visible, and the contrasts increase, if the secondary rays are prevented from reaching the screen too. It is convenient if tube, diaphragm, and screen are suspended in a frame in such a manner that they can easily be moved up and down together. The greenish light of the platinum screens seems to affect the eyes unfavourably, and we cannot detect as many fine details on the screen as on a good negative ; partly for these reasons, and partly to obtain a permanent record, a negative has to be taken in all the more difficult cases.

PROTECTION FROM X RAYS.

Some years after the X rays had been discovered, severe burns and several sad deaths after much suffering taught us that these rays produce dangerous inflammations, and later on it was proved that they may cause also sterility. It has to be remembered that all the serious cases were contracted at a time when nobody suspected the dangerous nature of the rays ; the victims exposed themselves at demonstrations, which had frequently to be given while the invention was new, for hours quite close to the tubes. No sensible person would dream of doing such a thing now, but precautions have certainly to be taken by all those who come frequently in the neighbourhood of tubes.

The first rule is : Whenever possible, do not stand in front of the luminous part of the tube, but keep behind it. By following this rule, many specialists have avoided any ill-effects, though they have employed X rays daily for many years. But it is not always possible to do it ; for instance, in examining a patient with the fluorescent screen, the operator is exposed to the rays too. Whenever a fluorescent screen is used frequently, it ought to be covered with a sheet of lead glass, to protect the face and eyes, and the frame of the screen ought to be provided with metal shields for the hands, or else the operator ought to wear X-ray-proof gloves. The backs of the hands are either the most exposed, or the most susceptible parts, and for this reason the hands ought not to be used too frequently for testing the penetrating power of a tube. People handling dangerous appliances daily are apt to become careless, and the operators and assistants in an X-ray department of a hospital, therefore, require special protection.

An excellent plan is to enclose the tube completely in a box lined with a rubber impregnated with oxide of lead. It does not conduct electricity, and is opaque to the X rays, so that neither X rays nor the green light of the tube can reach the room ; and operator, nurses, and patient are well protected, without having to wear aprons, spectacles, gloves, etc. These boxes can be fitted on tube stands, compressors, couches, etc.

It has been suggested to make a kind of cabinet in which the switchboard, etc., is to be placed, so that the operator must be there to control the current. These cabinets can be lined with sheet lead, and lead glass, and if properly made give thorough protection to the operator as long as he is inside ; but surely nurses and patients are entitled to protection too, and partly for this reason, and partly to have a diaphragm, the tubes, or at any rate the luminous part of them, should be enclosed in an X-ray proof box as described above. If this is properly done the expensive cabinets are superfluous.

It is desirable for another reason that the tube, or at any rate that part of it which looks towards the patient, should be enclosed in a box. If it were unprotected, there is some slight risk that while adjusting tube or patient, especially while working in a dark room, for examination, a rash movement on the part of the operator or patient, a sudden jerk on the cords, might smash a tube, and glass splinters might become dangerous if the explosion took place near the head. But if the part of the tube near the patient is surrounded by a box, the risk of breakage is much smaller, and the diaphragm would stop glass splinters.

If an examination of chest or abdomen is likely to last some time, it is desirable that the testicles of boys should be protected by a piece of rubber impregnated with oxide of lead.

Patients should not be exposed too frequently on one day ; if an examination prove a failure, it may be repeated once or even twice on the same day without risk, but if still unsuccessful, a few days should elapse before it is attempted again. Patients should also be asked whether they have been already examined recently with X rays by somebody else.

DEVELOPMENT.

All the care and trouble and expense bestowed on correct exposure may be wasted unless the development is carried out with intelligent skill, so that all the details which may be in a plate are really brought out. The contrasts are frequently very slight, and may disappear entirely by careless development.

It is easy to control the development in the case of hands, feet, arms, etc., because the picture can be seen fairly well by holding the plate against the ruby lamp, but it requires more experience to develop a thorax or pelvis. In these cases the picture is visible only at the beginning, and it is difficult to know when to stop. The development has to be continued in most cases till the plate looks fairly grey if examined from behind.

The name of the developer is less important than the fact that the operator understands it thoroughly. In consequence of the great thickness of the emulsion it takes several minutes before the developer can penetrate to the deeper parts near the glass ; the rapid developers, which have frequently a tendency to cause chemical fog, are therefore unsuitable. It is also generally admitted that it is more difficult, or even impossible, to bring out the finest details with the rapid developers as well as they can be brought out with *slow* development ; it happens occasionally that 15 to 25 minutes may have to be spent in developing a negative of a pelvis.

Of the older developers, hydroquinone has an advantage because it gives the greatest density, and soft or hard negatives can be obtained at will by diluting it with water or by adding bromide of potassium. It is very susceptible to the addition of bromide, whereas other developers, like rodinal, are scarcely affected by it, and cannot therefore be modified as much. Unfortunately, hydroquinone has the disadvantage of being very sensitive to changes in temperature ; it cannot be used very well in winter, unless the dark room, as well as dishes and solutions, have been warmed. Of the modern developers, glycin is strongly recommended by many X-ray workers. It is less sensitive to changes in temperature, and has the advantage that it gives the *clearest* negatives and most details. Development can be prolonged very much with glycin without producing fog.

Glycin is also the most suitable developer for the so-called tank development, which offers great advantages for our purposes if it is not important to examine a plate at once.

Place the plate in a clean tank, preferably in an upright position, cover it with glycin developer, to which 20 times the usual quantity of water has been added, cover the tank with a lid to exclude the light, and leave the plates in for about an hour, and then examine them. All the details which can possibly be brought out will then be visible, and there is no danger that the plates will be too dense; on the contrary, they will frequently be too thin. In this way it is easier to bring out all the details which are in a plate; the most beautiful or perfect negatives which it is possible to obtain can be got with the tank development; it is the best method of bringing as much as possible out of a rather under-exposed plate, and as no long experience is required if done in this manner, it can be left to assistants who are not yet experts in photography, without fear that good plates will be spoiled by unsuitable development.

Intensification.—Many X-ray negatives will be thin and wanting in contrasts. If there are details, however faint, such plates can be greatly improved by subsequent intensification. It is quite an easy process, which can be carried out in daylight. The intensification does not only increase the density, it considerably alters the character of the plate by increasing the contrasts and making the picture harder. If, however, the details are wanting on account of under-exposure or unsuitable development, subsequent intensification cannot bring them out, and will be of no help. If the plates are to be intensified, it is very important that they have been *thoroughly fixed and washed*, otherwise stains might be produced.

As most medical men have experience in photography, it is not necessary to give lengthy instructions as to the development, printing, etc., here; they can be found in the numerous books on photography.

Examining the Plates.—If negatives are compared carefully with prints, it will be seen that some of the finest details are invariably lost by the process of printing on paper. The plates ought to be examined directly. This can be done either by placing them against a window covered with a ground glass, or better still the plates are examined by artificial light in a dark room. Two to four incandescent lamps are placed in a box behind a thin porcelain plate, and the negatives are placed in front of this plate. It is desirable to have a rheostat to control the amount of light, because *thin* negatives show to best advantage with a *weak* light behind, whereas for dense negatives a strong light is necessary.

EXPOSURES FOR THERAPEUTIC PURPOSES.

It has been the custom for some time to recommend for therapeutic purposes soft tubes, and to use them as close as possible to the skin. This is a mistake, unless the action of the rays is desired on the surface only. In the large majority of cases, in treating eczema, lupus, rodent ulcer, etc., with X rays, it is necessary that the rays should penetrate to deeper parts, and the success depends in many cases on whether sufficiently strong doses can be applied to the deeper-seated parts without burning the skin and causing painful inflammations. For this reason it is necessary to select a medium hard tube, because the rays have then a much greater penetrating power, and the percentage of the rays which will be stopped and absorbed by the skin will be smaller. As the intensity of the rays diminishes rapidly with the distance, it is necessary to have the tube 10 inches or more away to prevent too great a difference between the distance of the skin and the deeper parts. The skin can also be protected somewhat by covering it with a thin leather; this will act as a filter by stopping the softest rays. Sheets of aluminium 1 mm. thick are very good filters for obtaining a particular quality of X rays. It has also been found that X rays affect those parts most in which metabolism is active; if it is reduced, for instance, by pressure sufficiently intense to make the parts anæmic, larger doses can be applied without undue risk for the skin. In some cases the direction of the rays may be changed, so that for part of the dose the tube is in front, for another part behind, or at a right angle, so that the whole dose for a deeper part need not pass through the same piece of skin.

It is desirable to use the tubes always at the same distance; it will thus be easier to judge the doses given, than when another distance is used each time. Partly for this reason, and partly because protection of the parts not to be treated is absolutely necessary in all these cases, the tubes for therapeutic treatment should be suspended in boxes or diaphragms, enclosing the luminous part, and at the lower end of these diaphragms lead-glass tubes of various diameters can be attached, which press against the parts to be treated. Protection and a uniform distance are thus maintained.

For therapeutic purposes a *correct dosage* is of more importance than when making negatives. In the latter case the exposure can be repeated if a mistake has been made, but an overdose in therapeutic application may have serious results to the patient, and under-exposure means great waste of time. The dosage depends on :—

1. The penetrating power of the tube × the number of M.A. used.
2. The distance between the anticathode and the skin.
3. The time for which the X rays are applied.

The first can be measured with the help of a radiometer (Wehnelt, Benoist) and a milliampèremeter. The following table made by Prof. Walter may be found useful. It holds good under the condition that the X rays reach the skin fairly perpendicularly, and that there is no filter between tube and skin, and that the thickness of the glass of the tube is 0·6 mm.

An Erythema Dose will be reached in :—

Penetration / Distance between anticathode and skin in ctms.	3·3	4·9	6·5	7·2 Wehnelt Units
10 ..	20	9·5	6·4	4·6 M.A. minutes
15 ..	44	21·5	14·5	10·4 ,,
20 ..	81	38	25·5	18·6 ,,
25 ..	128	60	40	29 ,,
30 ..	184	86	58	41·5 ,,
35 ..	250	117	79	57 ,,
40 ..	328	153	102	74·5 ,,

Like Sabouraud's pastilles or Kienboeck's quantimeter, this method does not take into account any idiosyncrasy, if such a thing exist.

The **Total Quantity of X-Rays** emitted in a given time may be measured by the various methods suggested by Holzknecht, Sabouraud, Kienboeck, Bordier, and others. They are based on the effect which the X rays have on certain materials, and are called chromoradiometers, because the chemicals used change colour gradually, and the exposure is continued till they assume the colour of the standard tints supplied with the instrument for comparison. Sabouraud's pastilles are small discs of barium platino-cyanide, the same material which is used for fluorescent screens. The discs have to be exposed on a metallic support at a distance from the anticathode, which is one-half of the distance between the latter and the skin of the patient.

According to Walter, Sabouraud's pastilles, exposed at a distance of 13 ctm. from the anticathode, will assume the B tint in

	97	48	33	25·7 minutes
if the penetration is	3·3	4·9	6·5	8 degrees on Wehnelt scale,

and if the thickness of the glass is 0·4 mm. and the current used 1 M.A.

They are useful in many cases, but are open to various objections. The discs discolour in the same way, whether exposed near an X-ray tube or near an incandescent electric lamp, or to sunshine, or to a temperature of about 100° in an oven. Moreover, the difference in colour between the unexposed disc and the standard tint for the maximum permissible dose is small, and errors of over 50 per cent are made if the tints are compared either by daylight or by artificial light.

The most accurate and sensitive instrument is *Kienboeck's Quantimeter.* It is also the only instrument which gives us accurate information about the dose administered during one exposure, about the total dose of various exposures given at different days, or about the dose received by the patient's skin, or at a depth of one or two centimetres *below* the skin. Tints have to be compared too in this instrument, and though some differences exist if various operators compare the results, these errors are sure to be small, because the range between the white colour of an unexposed strip, and the nearly black tint of the maximum dose is great, and the scale shows many intermediate tints between. It is certainly a disadvantage of this instrument that the results cannot be ascertained until a strip of bromide of silver paper has been developed, but this can be done in the same room in which the exposure takes place, and need not occupy more than two minutes. This inconvenience appears to me small compared with the risk of an over-exposure, or compared with the waste of time of repeated under-exposures.

COMPARISON OF DIFFERENT QUANTIMETER UNITS.

Sabouraud ..	—	—	—	1	—	—	—	—	—
Holzknecht ..	—	3	4	5	6	7–8	10–12	15	20–22
Kienboeck ..	3	6	8	10	12	14–16	20–24	28	40–44
Bordier ..	1	1·8	2·7	3·8	4·7	5·8	8	10	15

Illustrated Price List

OF

X-RAY APPARATUS.

"X-RAY APPARATUS AND THEIR MANAGEMENT," will be found on pages 138–175.

Practical Instruction in making X-ray negatives can be given by appointment, to Medical Men only, *in our new X-ray Laboratory at No. 71, New Cavendish Street, London, W.*

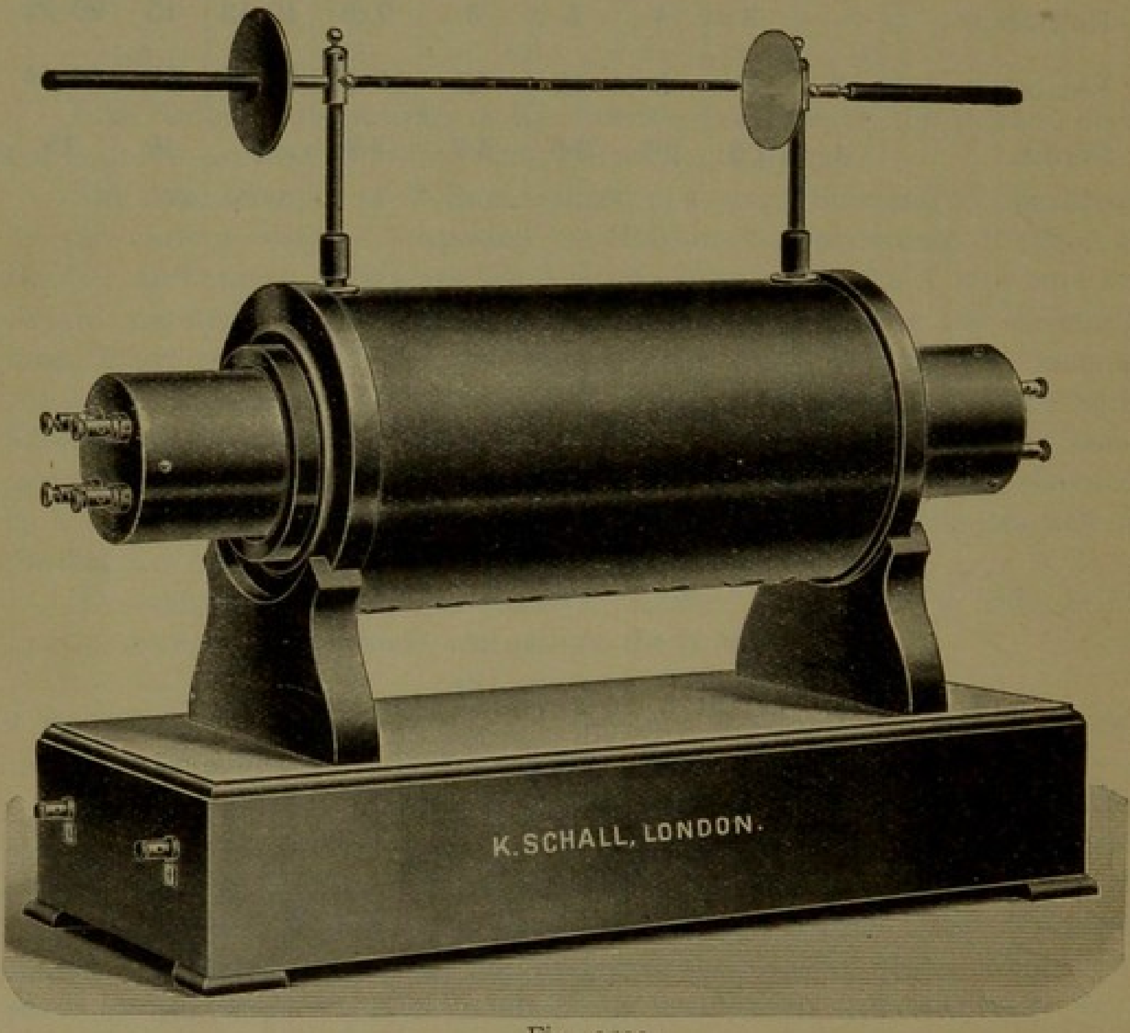


Fig. 2509.

Experts can be sent at moderate charges to any part of Great Britain to connect apparatus and to give our customers **practical instruction in the use of X-ray Apparatus.**

Hints about the selection of Spark Coils will be found under "Size and Power of the Coils," on pages 139–140.

The mere spark length which a coil can give does not determine its value. The power of a coil for X-ray purposes depends on the spark length × the *number of milliampères* which it can give, and before deciding on a particular make it would be wise to ascertain :—

1. How many milliampères the coil is guaranteed to give through an air gap 8 in. long.

2. How many volts and ampères are required to reach the discharge (see pages 140, 141).

Spark Coils are guaranteed against breaking down for three years.

IMPROVED SPARK COILS.

		Without condenser, for electrolytic interrupters only.	With condenser, for mercury or electrolytic interrupters.
No. 2506	10 ins.	£18 0 0	£21 0 0
,, 2507	12 ,,	22 0 0	26 0 0
,, 2508	14 ,,	29 0 0	34 0 0
,, 2509	16 ,,	36 0 0	41 0 0
,, 2510	18 ,,	45 0 0	50 0 0
,, 2511	20 ,,	54 0 0	60 0 0

The prices quoted for spark coils include: polished oak base and discharging pillars.

A current reverser or commutator is 20s. extra. It may be fitted on the base of the coil, but in most cases it will be more convenient to fix it on the switchboard.

Variable self-induction for four different degrees is £3 extra. This is necessary for the proper working and control of *electrolytic* interrupters, but it is of no advantage for mercury breaks.

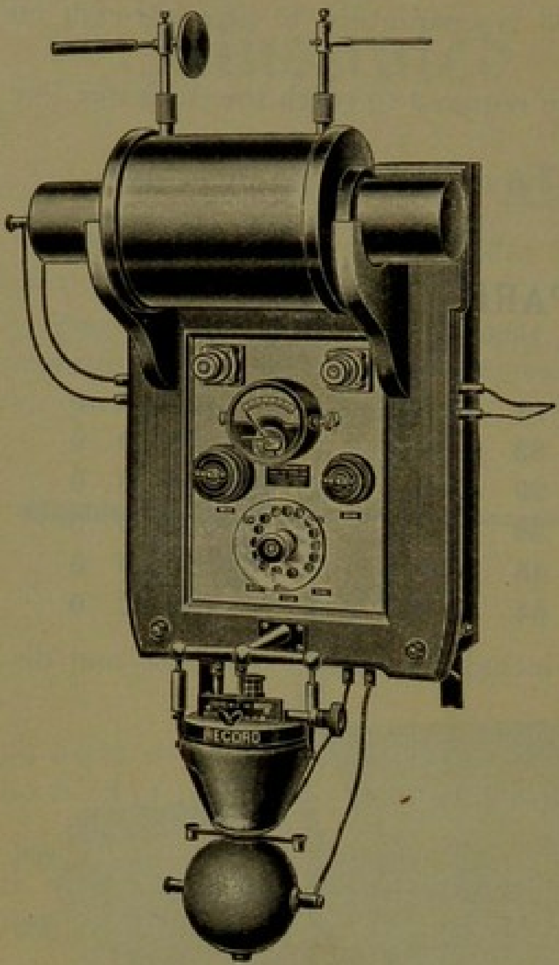
Special insulation for tropical climates will be 3 per cent extra.

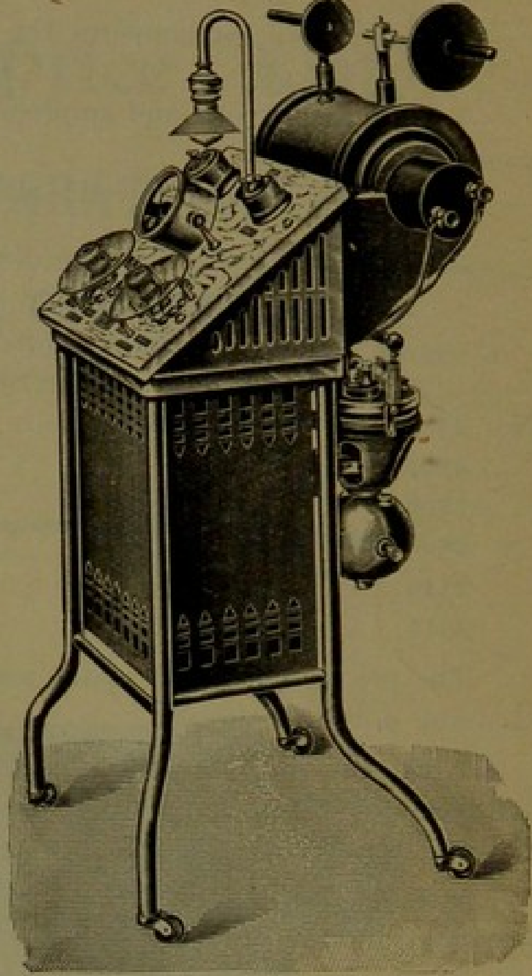
10 or **12-in. Coils,** with an improved platinum break, reverser, discharger, rheostat, and tube holder, can be arranged in a portable box. Prices and photographs can be had on application.

In ordering a coil, please mention whether it is to be used with accumulators (20 to 30 volts) or with the current from the main (100 to 250 volts); and whether it is to be used with a mercury or an electrolytic interrupter, to enable us to choose the wire for the primary coil correctly.

The iron core of our coils consists of thin sheets of magnetic iron, and is of large diameter in order to give the *heaviest possible discharges.* The coils are wound in 80 to 200 separate sections, and the primary is insulated from the secondary by an ebonite tube ¾ to 1½ in. thick, according to spark length Our coils are tested with heavy currents before they are sold. Any current, from 0·1 up to the heaviest current which any focus tube will stand, can be obtained.

Instead of mounting the coils on a base to be placed on a table, as shown in Fig. 2509, they can be mounted on a bracket to be fixed on the wall, or on a trolley of steel tubes, as shown on page 178, or on a cupboard, with switchboard and interrupter, etc., below. They occupy less space in a room if thus arranged.





Our larger Coils (12 to 20 inch sparks) are being used, amongst others, by:—

Westminster Hospital, St. Mary's Hospital, National Hospital (Queen's Square), German Hospital, and St. Pancras Infirmary, in London. Royal Buckinghamshire Hospital, Aylesbury; Edinburgh Hospital for Women; Royal Victoria Hospital, Belfast; Queen's Hospital, Birmingham; Kent and Canterbury Hospital, Canterbury; Grimsby Hospital; Kidderminster Infirmary and Children's Hospital; Stanley Hospital, Liverpool; Tilbury Hospital; Ramsgate General Hospital; Elder Cottage Hospital, Govan, near Glasgow, etc.; the Royal Infirmaries, Glasgow, Derby, Edinburgh, Dumfries, Truro; General Infirmary, Burton-on-Trent; Carnarvonshire and Anglesey Infirmary, Bangor; Sunderland and Durham County Eye Infirmary, Sunderland.

War Office, Cairo; Crown Agents for the Colonies; India Office; High Commissioner for New Zealand; British Seamen's Hospital, Constantinople; Dispensary in Jeypore; Hospitals in Gibraltar, Ceylon, Auckland, Maseru, Lahore and Calcutta Medical Colleges; New General Hospital, Rangoon; General Hospital, Tongkah, Siam; Simmer and Jack Hospital, Germiston; Hospital in Dunedin, etc., etc.

Drs. W. Ironside Bruce, E. S. Worrall, J. Mackenzie Davidson, D. H. Freshwater, C. M. Hinds Howell, H. D. McCulloch, A. B. Roxburgh, and Mr. Coldwell, in London. Drs. J. Macintyre, Glasgow; Prof. Ogston, Aberdeen; E. J. Fox, Warrington; H. E. Gamlen, West Hartlepool; J. Halliwell, Winchcombe; E. H. Howlett, Hull; C. E. B. Kempe, Salisbury; A. C. Norman, Sunderland; L. C. Panting, Truro; A. G. Paterson, Ascot; A. E. Rayner, Preston; G. W. Shipman, Grantham; Mr. C. J. C. Street, Lyme Regis; etc., etc.

A. A. Doyle, Brisbane; R. M. Gibson, Hong Kong; Dr. Harris, Sydney; Kh. Hekimyan, Trebizonde; A. Mackenzie, Durban; N. G. Munro, Yokohama; V. H. Topalian, Diabekir; H. C. Highet, Bangkok; etc., etc.

[*Copies of some unsolicited testimonials.*]

ROYAL BUCKINGHAMSHIRE HOSPITAL,
AYLESBURY.

We are extremely satisfied with the coil. We gave it a thorough trial in all branches of X-ray work, and the results are far better than anything I have yet seen as far as current consumption, output, and absence of reverse current are concerned. We can get 5 M.A. through tube, without a trace of reverse current showing in the oscillograph.

A. C. NORMAN.

TRURO, *Dec.* 23*rd*, 1910.

I am delighted and astonished to find that I can get on 52 volt with 10 to 12 amps. 30 M.A. in an 8-in. air gap.

L. C. PANTING.

(This result is obtained with 52 volts; with 100 volts the coil gives 60 M.A. already.)

WARRINGTON, *Jan.* 12*th*, 1911.

I decided to have your apparatus, as everything I have had from you has been most satisfactory.

EDWARD FOX.

WEST HARTLEPOOL.

The large coil and Wehnelt break are perfection. I never have any trouble with them, and I find I can do much better and quicker work.

H. E. GAMLEN.

With the 12-inch coil which you supplied I obtain better results and shorter exposures than with the 20-inch coil I used up to now.

A. E. RAYNER.

AUCKLAND, NEW ZEALAND,
Jan. 26*th*, 1911.

My new X-ray outfit has arrived, and I am very pleased with its appearance and efficiency. I find that I can get much better abdominal pictures with this new outfit than I can with the one at the Hospital (where I am Hon. Radiologist), although the Hospital coil is larger.

Yours very faithfully,
A. CLARK.

SYDNEY, *Jan.* 28*th*, 1911.

I am delighted with my apparatus. I must compliment you on the explicit instructions you sent out. They are perfect in detail.

A. HARRIS.

The *British Medical Journal* of June 6th, 1908, says :—

A most successful demonstration of a method of making instantaneous X-ray exposures of the chest was lately given before a number of medical men in the electrical department of the London Hospital. Four consecutive exposures of the thorax and abdomen were made upon as many patients; the tube was one of heavy anticathode, and although it had something like 40 or 50 milliampères driven through it several times for a fraction of a second, it appeared at the end to be indifferent to the strain. It is difficult to estimate the actual time of exposure, which was given as one-fifth of a second ; in any case it was momentary. The distance of the anticathode from the plate varied from 20 to 80 inches. With the maximum distance a slightly longer exposure, not exceeding a second, was necessary ; in this case also the shadow of the heart was reproduced on the plate in almost exactly its natural size.

The results generally were all that could be desired, and the detail of the thorax was more clearly rendered than in radiographs of the same subjects taken in the ordinary way with 45 seconds' exposure.

The *Lancet* said :—

INSTANTANEOUS RADIOGRAPHY.—An interesting demonstration was given on this subject at the London Hospital, when very satisfactory radiographs were made of some cases of aneurysm. While so-called instantaneous radiographs were made some years ago by several workers, it was not until quite recently that the method has been so far perfected **that it can be adopted as regular procedure, and that it has been brought within the sphere of everyday radiography.**

While **excellent results** are obtained with the tube say 24 ins. from the plate, good results are also obtained at a distance of 80 ins., and in this case **there is so little distortion that the parts are represented at almost exactly their natural size.** This, and the convenience of dealing with fretful and fidgety patients such as children, **make this modification one of considerable value.**

Mr. C. Thurstan Holland reports about a demonstration given at the Royal Infirmary in Liverpool, in the *Lancet* of July 4th, 1908 :—

A film was exposed on a patient in the Infirmary suffering from aneurysm, and a **most beautiful result** was obtained with an exposure of a fraction of a second.

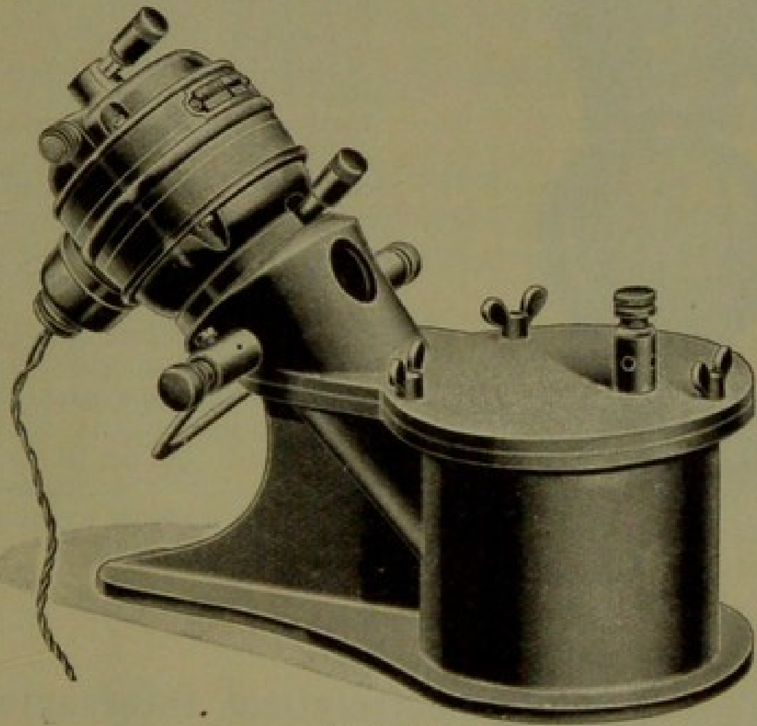
INTERRUPTERS.

(*See also pages* 141–143.)

No. 2530. **Mercury Hammer Interrupter,** suitable for coils giving sparks up to 20 inches long **£1 10 0**

No. 2540. **Mackenzie Davidson Interrupter** (*Fig.* 2540) .. **5 10 0**

This well-known interrupter has been reconstructed by us, *with the consent and approval of Mr. Mackenzie Davidson.*



No. 2540.

Several important improvements have been made. The dipper has been replaced by a wheel, the mercury rotates rapidly in a groove, so that the small drops raised become united again immediately; alcohol can be used to extinguish the breaking sparks, instead of the less efficient and dirty paraffin oil. In all our numerous experiments the intensity of the discharge obtained compared favourably even with that of the more expensive interrupters of the centrifugal type. The frequency is 40 to 45 per second. The construction is simple, so that the interrupter can be opened easily. There is no belt.

The motors can be wound for 24, 50, 100, 200 or 250 volt.

No. 2542. **" Record " Mercury Interrupter** (Fig. 2542) including 10 ozs. of mercury **£10 0 0**

These breaks can be used with any voltage, from 24 up to 250, but in ordering please state the voltage of the supply with which the interrupter is to be used, so that a motor suitable for the voltage will be sent with the break.

The duration of contact can be adjusted while the interrupter is working, and the frequency of the interruptions can be varied in wide limits; the discharges can, therefore, easily be adapted to the individual tubes. The sparks obtained are uniform, the light in the tubes is steady. There is no flickering, no noise, and no smell, and no attention or repairs are required. Compared with the jet breaks it gives a brighter light on the screen, and the

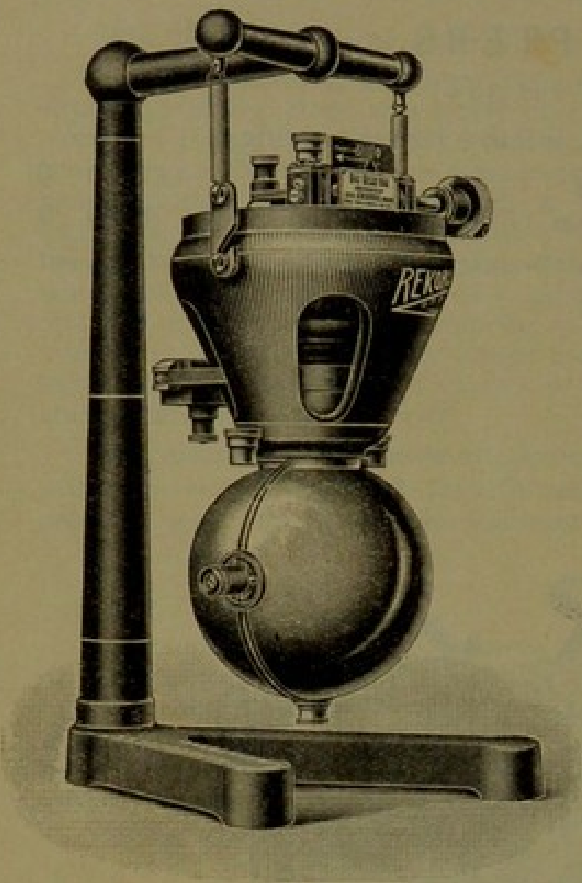


Fig. 2542.

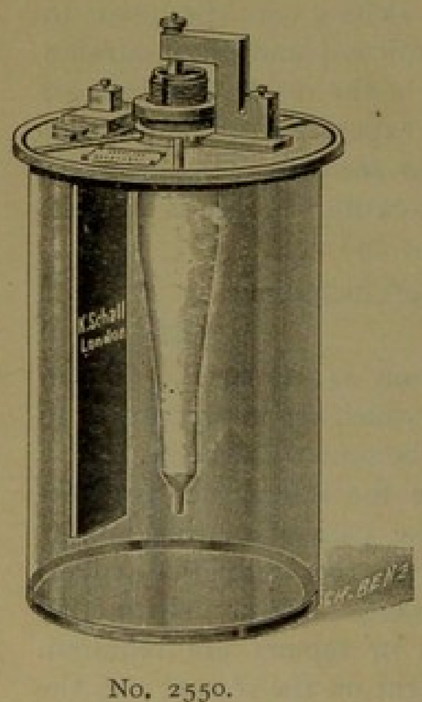
time of exposure can be reduced. **It is the most perfect mercury break existing at present.**

In this break there is no jet of mercury. Instead, a small drum is put in rotation by a motor; 20 ccm. of mercury are being centrifugated in this drum, and a copper segment makes and breaks the current once during every revolution. This allows a more perfect contact to be established than is possible with the jet, and in consequence a more intense discharge is obtained. The mercury is no longer split up in thousands of small drops, forming an emulsion, and the oxide which is unavoidably produced by the breaking sparks is separated from the mercury by the centrifugal action.

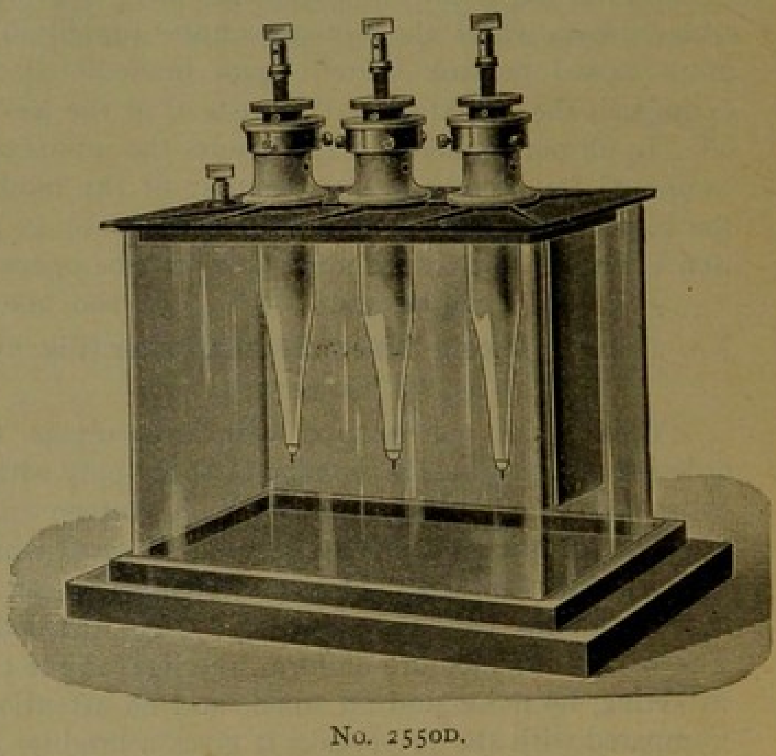
Mercury breaks give the **most intense discharges** which can be obtained at all from a coil, **with a weak primary current,** and are therefore undoubtedly the best if the supply of the primary current is limited, i.e., if accumulators, primary batteries, or **small** dynamos have to be used.

Dr. Wehnelt's Electrolytical Interrupters.

(*See also page* 142.)



No. 2550.



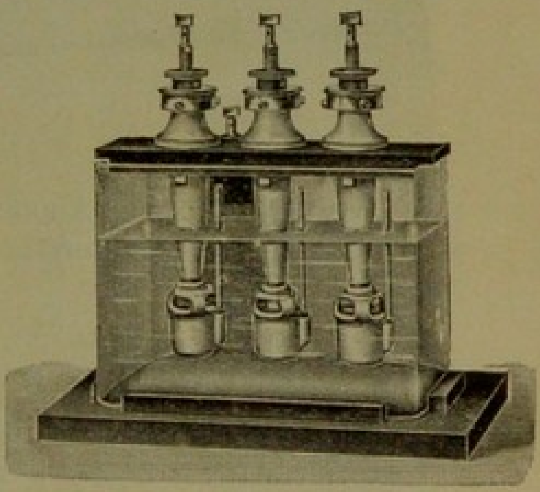
No. 2550D.

No. 2550.	**Platinum,** 1 mm. thick, 40 mm. long	£2 18 0
No. 2550A.	„ 2·5 mm. thick, 40 mm. long, Fig. 2550 ..	3 15 0

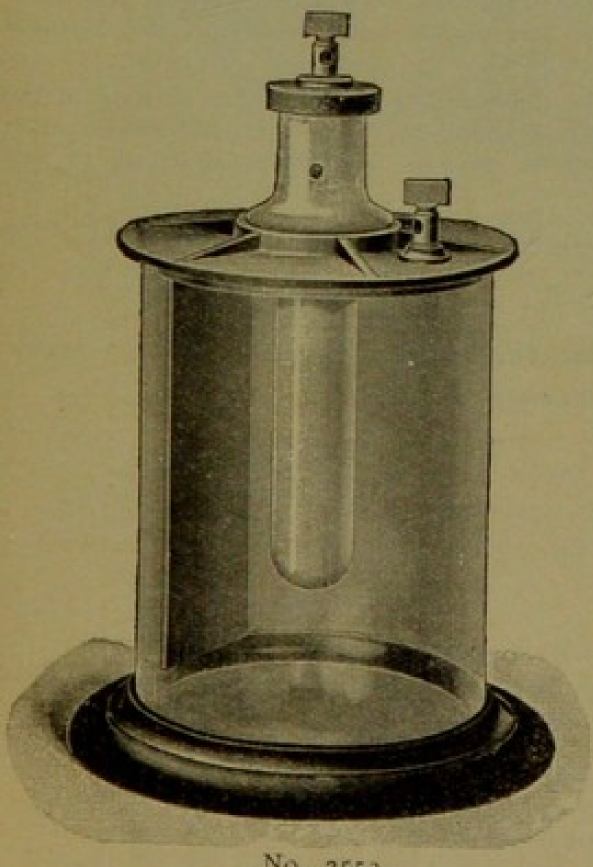
Diameter of the glass jar 8 ins., height 10½ ins. The screw for varying the length of the exposed part of the platinum is of stout ebonite, and cannot stick or corrode. If some oil is poured over the acid, no vapour can escape.

No. 2550D.	**Similar Interrupter** with 3 anodes, one with 1 mm. and two with 2·5 mm. platinum wire, Fig. 2550D..	9 0 0
No. 2550F.	**Similar Interrupter,** with 3 thick anodes, for instantaneous exposures	10 0 0
No. 2550G.	**Similar Interrupter,** with 4 anodes; 3 with thick wire for instantaneous exposures, and one with thin wire for examination on the screen.. ..	11 0 0

No. 2550Z. Our **Wehnelt Interrupters** can be made *perfectly silent* by adding our rubber air cushion over the porcelain tube, near the anode (see Fig. 2550Z), price **£1 2 0** each



No. 2550Z.

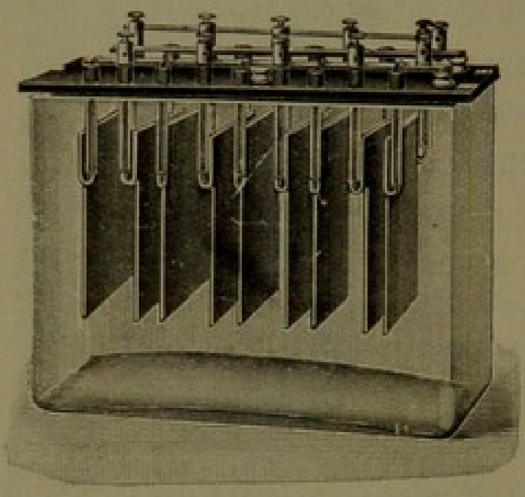


No. 2552.

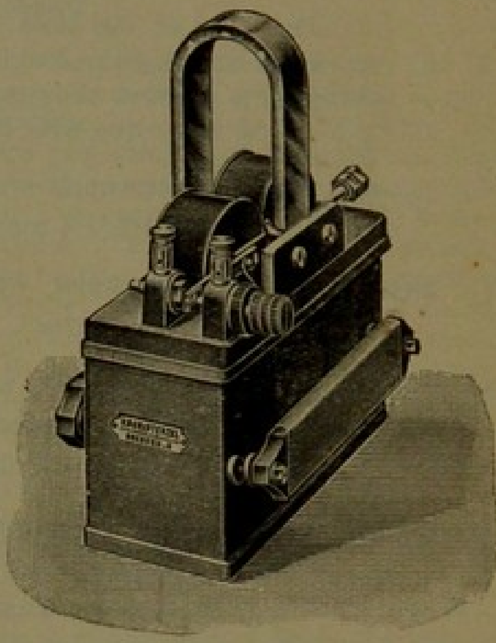
No. 2552.	**Simon or Caldwell Interrupter,** *Fig.* 2552	£2 5 0
No. 2553.	**Similar Interrupter,** with 3 tubes for instantaneous exposures	3 14 0
No. 2553B.	**Similar Interrupter,** with 3 tubes for instantaneous exposures, and a fourth tube for time exposures, or examination on the screen ..	4 0 0

Interrupters for Alternating Current.

(See also pages 142–143.)



No. 2554.



No. 2556.

No. 2554.	Price of large **Aluminium Cell,** *Fig.* 2554	£3 0 0
No. 2556.	**Alternating Current Interrupter and Rectifier,** *Fig.* 2556	12 0 0

This is an efficient, reliable, and convenient interrupter, suitable for spark coils of any size. A hammer swings synchronously with the periods of the alternating current within a polarised relay, and makes contact only at the moment when the E.M.F. has reached its highest point.

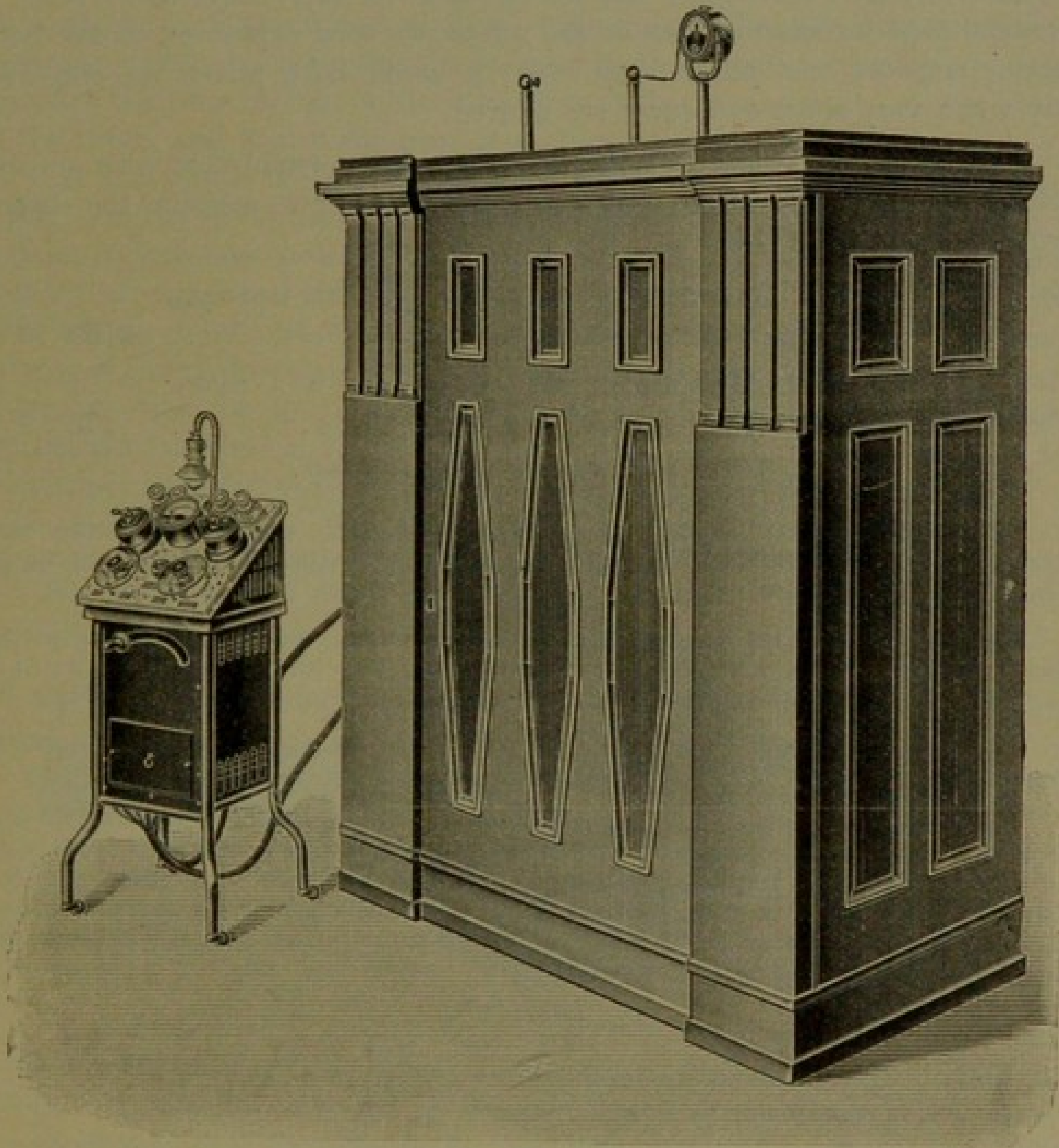
In ordering it is necessary to state the number of volts and periods of the supply with which it is to be used, because the capacity of the condensator must be in correct proportion to the number of periods to prevent sparking of the interrupter.

An apparatus similar to this can be supplied to utilize the alternating current for charging accumulators.

Motor Transformers, *to convert the Alternating into a Continuous Current,* will be found under Nos. 2680–2684, on *pages* 207, 208.

TRANSFORMER,

For producing X Rays without Interrupter.



No. 2518.

In this apparatus an alternating current is transformed to a voltage sufficiently high for X-ray purposes, and the waves are made unidirectional by means of a current reverser driven by a synchronous motor.*

Its advantages are:—

There is no reverse current, the control of the apparatus is simple, no interrupter, no valve tubes, no cleaning is necessary.

* The apparatus was invented by Mr. Koch, and described in 1904 in *Annalen der Physik*, *Engineering*, *English Mechanic*, and *Fortschritte auf dem Gebiet der Röntgenstrahlen*. Five years later Mr. Snook, of Philadelphia, constructed a similar apparatus, and its present size and appearance are due to him.

The current through the tubes can be varied easily, from 0·1 up to as many milliampères as the best tubes will stand. The time of exposure is very short.

Our apparatus is enclosed in a cabinet, which effectually deadens the unpleasant noise caused by the motor and rectifier. Moreover, it is so arranged that for examination on the screen, for time exposures, or for therapeutic purposes, one phase only may be used; both phases are employed only when very short exposures are desired.

The price of a complete apparatus, including switchboard with ampèremeter to control the output, and a milliampèremeter to measure the current through the tube, is :—

No. 2516.	For an **alternating** current supply, with two synchronous motors to work the rectifier	£165 0 0
No. 2518.	For a **continuous** current supply, with a motor transformer of 4 H.P., Fig. 2518	170 0 0

Other sizes can be made to order.

The tubes become warmer than when used with a current of the same intensity from a spark coil. This is due to the fact that the single discharges from a transformer are of longer duration than those from a spark coil.

The large tubes with heavy antikathodes, No. 2593, made specially for instantaneous exposures, have given the best results. They have stood currents of 30 M.A. for 10 seconds without any change in the penetrating power taking place.

Where the **alternating** current is laid on, this new apparatus is undoubtedly more convenient than any interrupter, electrolytic rectifier, valve tubes, etc.

Where the **continuous** current is laid on, it cannot honestly be claimed that the new transformer gives better results than those obtained with *good* spark coils, but no interrupter is required, the exposures can be made very short and it is simple to manage. Its disadvantage is the price, which is twice as much as that of a complete installation with a coil giving the same power, and the tubes do not last as long as they do with spark coils.

FOCUS TUBES.

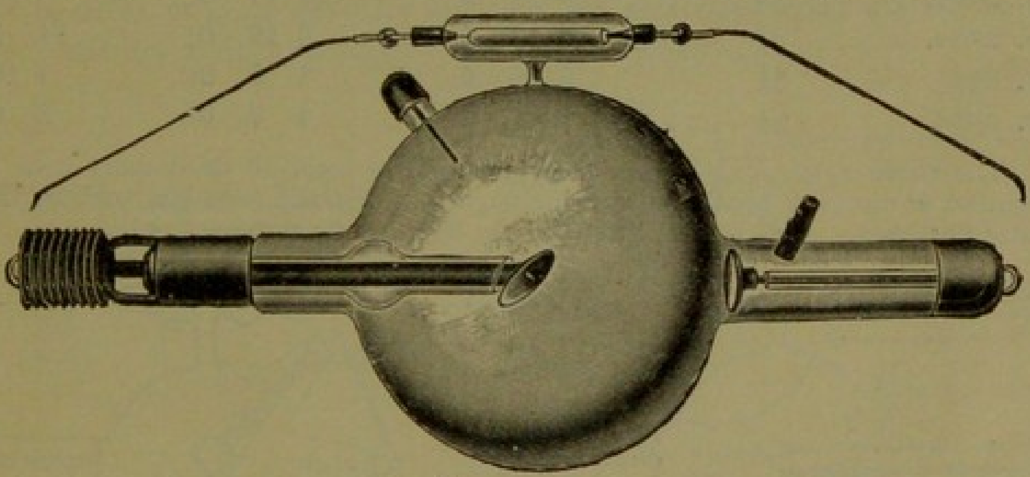
(*See also pages* 145-157.)

Good quality and suitable penetrating power of the focus tubes are *all important* for obtaining good negatives. The rays should be of such a quality that they can be stopped by the object of which we wish to see the shadow on the negative, but that they can penetrate yet through the surrounding tissue of smaller atomic weight. If the penetrating power is too small, the X rays are absorbed and stopped before they reach the plate, and the negative will show clear glass patches. If it is too great, the X rays will penetrate not only the soft parts, but bones, etc., as well, and the result will be a foggy negative, without contrasts and fine details.

The penetrating power can be measured by means of radiometers Nos. 2664. On page 151 it is explained how tubes can be made harder or softer.

It is *economical* to have several tubes in use to suit the various parts of the body: one soft one for hands, arms, etc., two medium for chest, kidneys, knee, etc., and one hard one for pelvis and for examination on the screen. If all exposures are attempted with *one* tube only, either the quality of many negatives will be poor, or else the vacuum has to be altered pretty frequently to adapt the tube to thin or thick parts, and this means waste of the lifetime of the tubes, and loss of the time of the operator.

For every tube there is a "normal" current, with which it will keep constant. In new tubes this is comparatively small, but if the tubes are properly treated it increases steadily, and tubes which have become seasoned by a number of exposures will stand a much stronger current than new tubes. This is more fully explained on pages 150–151. If *less* than the "normal" current is given, the tubes become *harder*. If *more* than the normal current is given, the tubes become *softer*. For a very short time, fractions of a second, the normal current can, however, be exceeded even fifty times without fear of damage, provided tubes with heavy anticathodes are being used.



No. 2590A.

Milliamperemeters No. 2660, are the most convenient and reliable help to find out whether a tube has its normal current, or too much or too little.

Reverse current shortens the lifetime of the tubes, deteriorates the quality of the negatives, and should be carefully excluded; see page 151–154.

Focus tubes are gradually worn out by use, but those which are properly treated will last for hundreds of exposures, whereas with carelessness or through want of skill and knowledge, even the best tube may be damaged or destroyed during the first exposure.

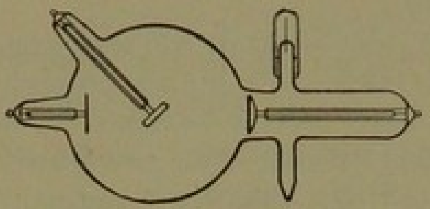
Tubes should be placed fully 5 ft. away from either pole of the spark coil. The glass should be dry and free from dust.

Tubes which have been used already for many exposures are not worth repairing, because after re-exhaustion they become hard too rapidly. The metal parts of some of the tubes are of some value, and will be credited when a new tube is taken instead.

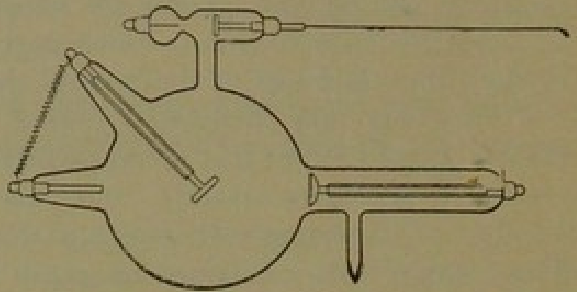
For the length of exposure required for making negatives, or for the dosage for therapeutic purposes, see pages 165 and 174.

If not otherwise ordered, tubes will be delivered which have an equivalent spark gap of 3½ to 4 in. *All tubes are tested carefully* by us before they are delivered, and the equivalent spark gap and the penetration in Wehnelt units are written on a label attached to the neck of the tube.

Plain Tubes, anticathode, made of nickel, with thin platinum cover.



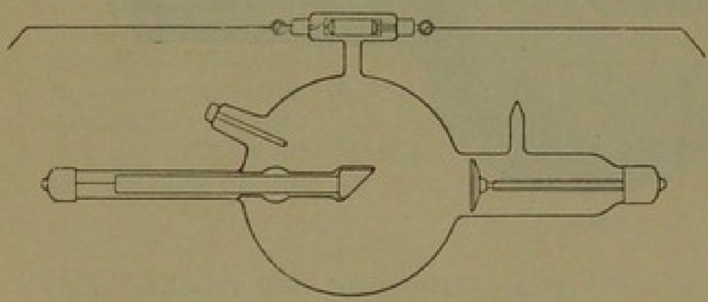
No. 2583B.



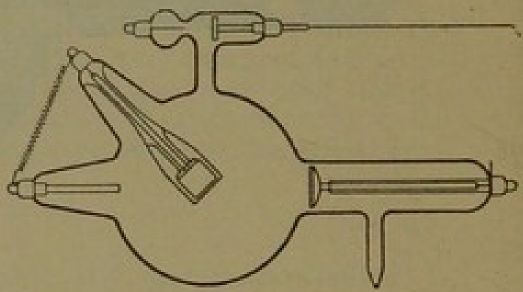
No. 2583C.

	Diameter of bulb in inches	A Without regulation	B With "Osmo" regulation, Fig. 2583B	C With Automatic regulation, Fig. 2583C
No. 2581.	3½	£0 11 6	£0 17 0	—
No. 2582.	4½	0 12 6	0 19 0	£1 5 0
No. 2583.	5½	0 16 0	1 2 0	1 10 0
No. 2584.	6½	1 1 0	1 7 0	2 0 0

The tubes 2582–2584 are suitable for small or medium sized spark coils with platinum or mercury breaks, for taking negatives of arms, feet, etc., and for therapeutic purposes. No. 2581 is intended for therapeutic purposes only.



No. 2590A.



No. 2590B.

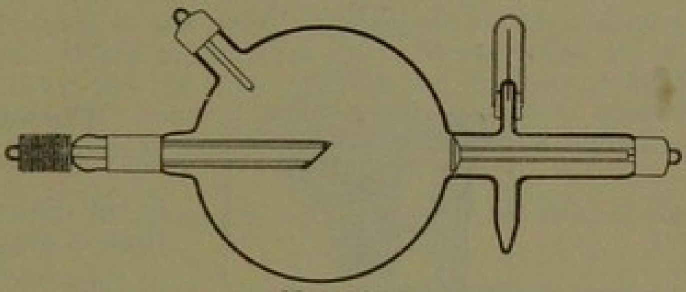
Tubes with "Heavy" Anticathodes, to carry off the heat by radiation.

	Diameter of the bulb in inches	A With Condenser or "Osmo" regulation, Fig. 2590A.	B With Automatic regulation, Fig. 2590B
No. 2588.	4¾	£1 15 0	—
No. 2589.	5½	2 0 0	£2 7 6
No. 2590.	6½	2 10 0	2 12 6
No. 2591.	8	3 8 0	3 2 6
No. 2592.	8	4 2 0	—

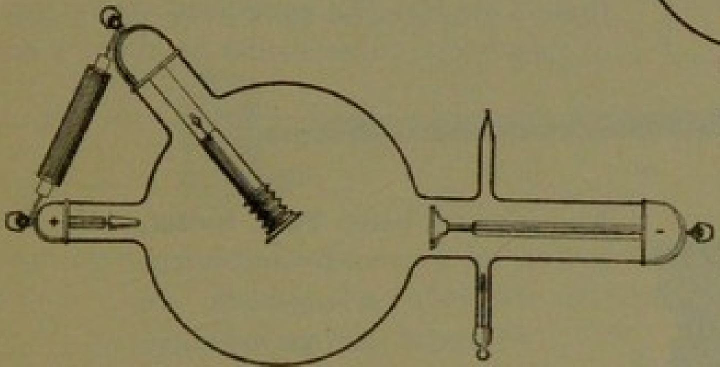
Tubes No. 2592 are specially made for instantaneous exposures. They bear the word "Moment" on the glass, to distinguish them from the tubes No. 2591, which are otherwise similar in size and appearance. The higher price of the moment tubes is due to the fact that they have to be exhausted for a longer time, and that the anticathodes of No. 2592 are covered with a disc of platinum.

Tubes with Air-cooled Anticathodes.

No. 2594. Diameter of bulb 8 in., with special cooling arrangement of anticathode, *Fig.* 2594 **£5 10 0**



No. 2594.



No. 2595.

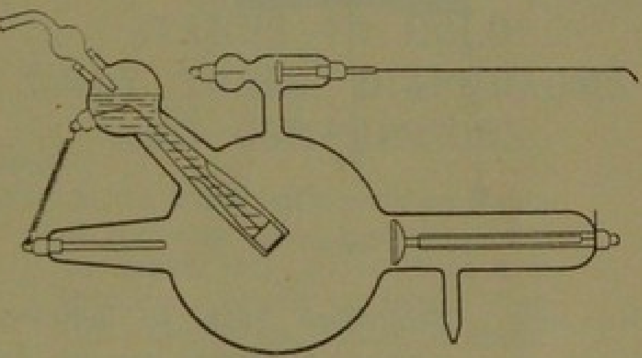
No. 2595. **Bauer Tube,** diameter of bulb 8 in., with choking coil **4 0 0**

No. 2596. Ditto, for instantaneous exposure **£5 0 0**

The tube 2594 is specially suitable for prolonged examination on the screen, and for time exposures with heavy currents.

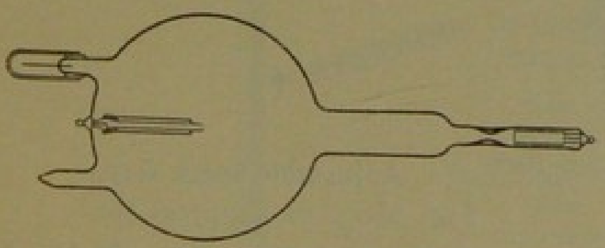
Water-cooled Tubes.

	Diameter of bulb in inches.	With automatic regulation (Muller).
No. 2597.	6¾	**£5 0 0**
No. 2598.	8	**5 15 0**

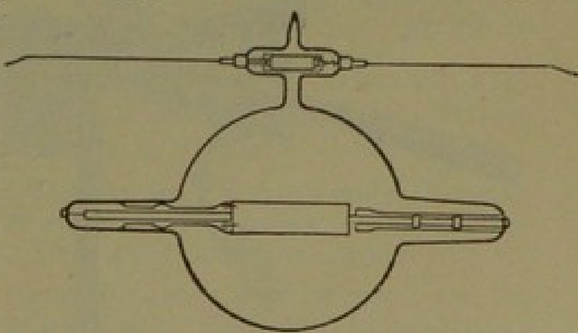


No. 2597A.

Valve Tubes and Spark Gap, to suppress the "Closing Current."



No. 2600.

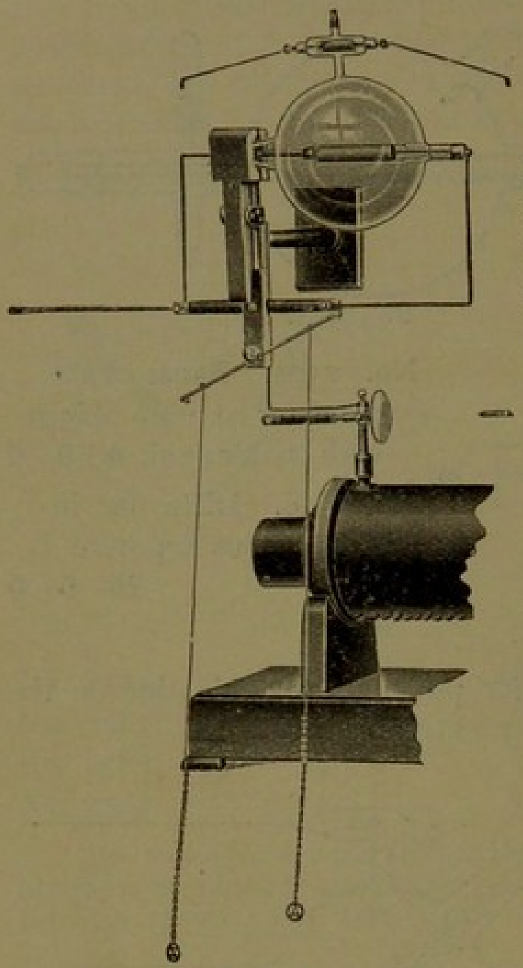


No. 2601.

No. 2600. **Valve Tube,** with regulation, *Fig.* 2600 .. .. **£0 19 0**

No. 2601. **Valve Tube,** with regulation, *Fig.* 2601 .. .. **1 8 0**

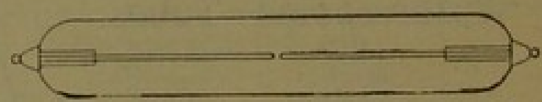
The inner tube has to be connected with the + pole (point) of the spark coil, the outer tube with the X-ray tube.



The valve tube has to be suspended near the coil, and the distance between it and the X-ray tube should not be less than 2 yards. The equivalent spark gap of these valve tubes should be about ¾ in

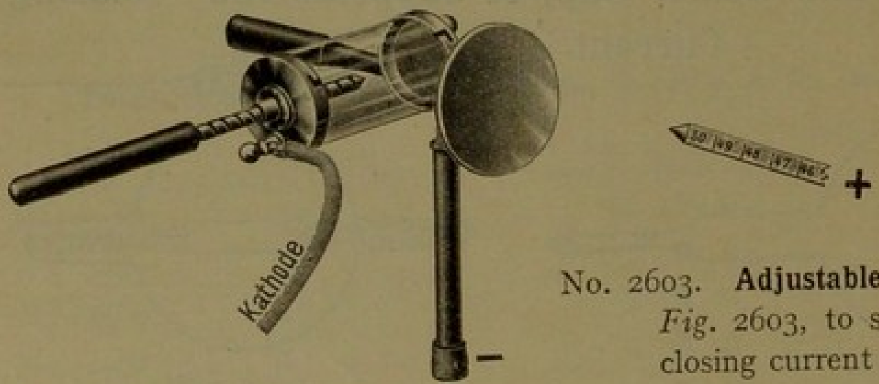
No. 2601H. **Valve Tube Holder,** with convenient arrangement to switch the valve tube on and off, *Fig.* 2601H .. £1 12 6

No. 2601H.



No. 2602.

No. 2602.	**Oscilloscope Tube**, to indicate the presence and amount of reverse current (*Fig.* 2602)	£0 15 0
No. 2602A.	**Similar Tube**, but larger size and better quality, filled with helium	1 10 0



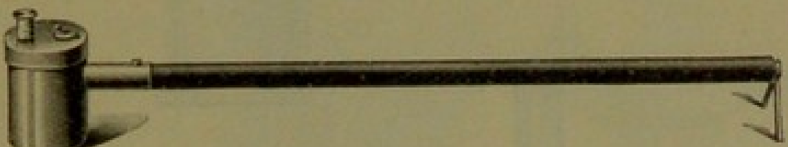
No. 2603. **Adjustable Spark Gap,** *Fig.* 2603, to suppress the closing current £0 16 6

No. 2603.

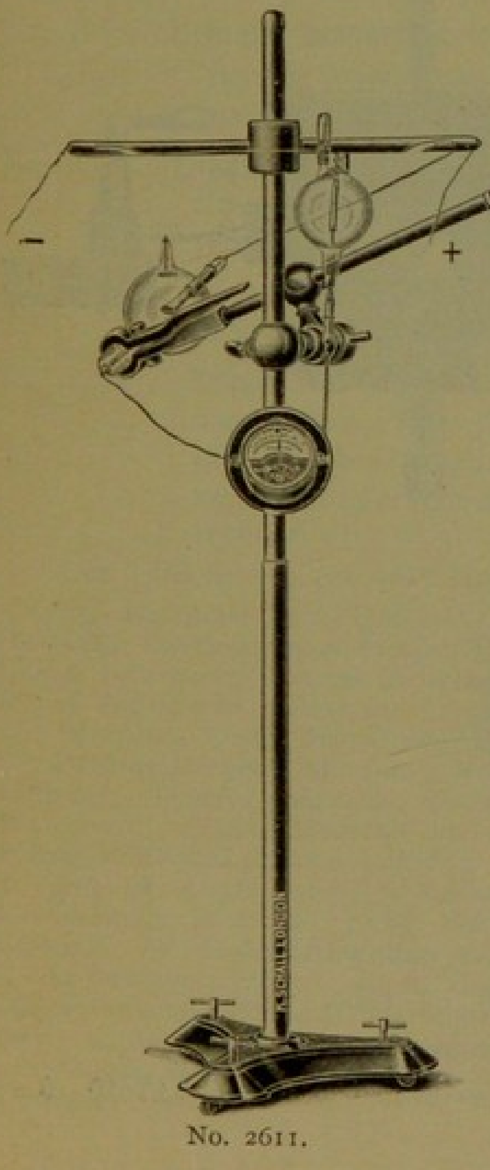
A spark gap or a valve tube ought always to be in the circuit, especially when new tubes are being used. A good valve tube suppresses the closing current more completely than a spark gap will do, but the valve tubes become gradually harder and useless like the X-ray tubes, and have to be replaced. A spark gap is more convenient and economical, as it does not become used up. Its action in suppressing the closing current is quite satisfactory unless very strong currents are being used. It has to be attached to the negative terminal of the coil, and can be left permanently inserted. When not wanted it can be switched off by screwing the point home so that it touches the plate. When the fluorescent light of the tube indicates the presence of "closing current," the screw is opened and the spark-gap increased till the tube appears sharply divided into a luminous and a dark half.

The plate of the spark gap must be connected with the negative pole of the coil, the point with the cathode of the tube.

No. 2605.



No. 2605. **Spirit Lamp,** fixed on a long insulating handle of ebonite, *Fig.* 2605, for warming focus tubes *while the current is turned on* £0 12 0



No. 2611.

STANDS TO HOLD X-RAY TUBES, DIAPHRAGMS AND COMPRESSORS.

No. 2610. **Stand** with polished clamp to hold the tubes, insulating arm 28 inches long, movable in any direction, height 20 inches (the total height obtainable is about 40 inches) £1 11 0

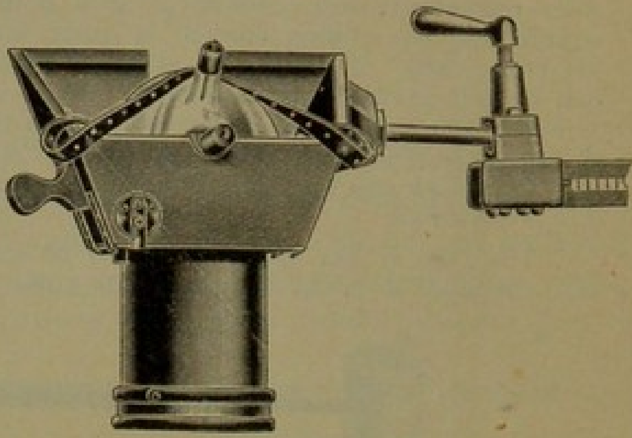
The stand is provided with a heavy cast-iron foot filled with lead.

No. 2611. Large stand, *Fig.* 2611, 5 feet high from floor .. £2 10 0

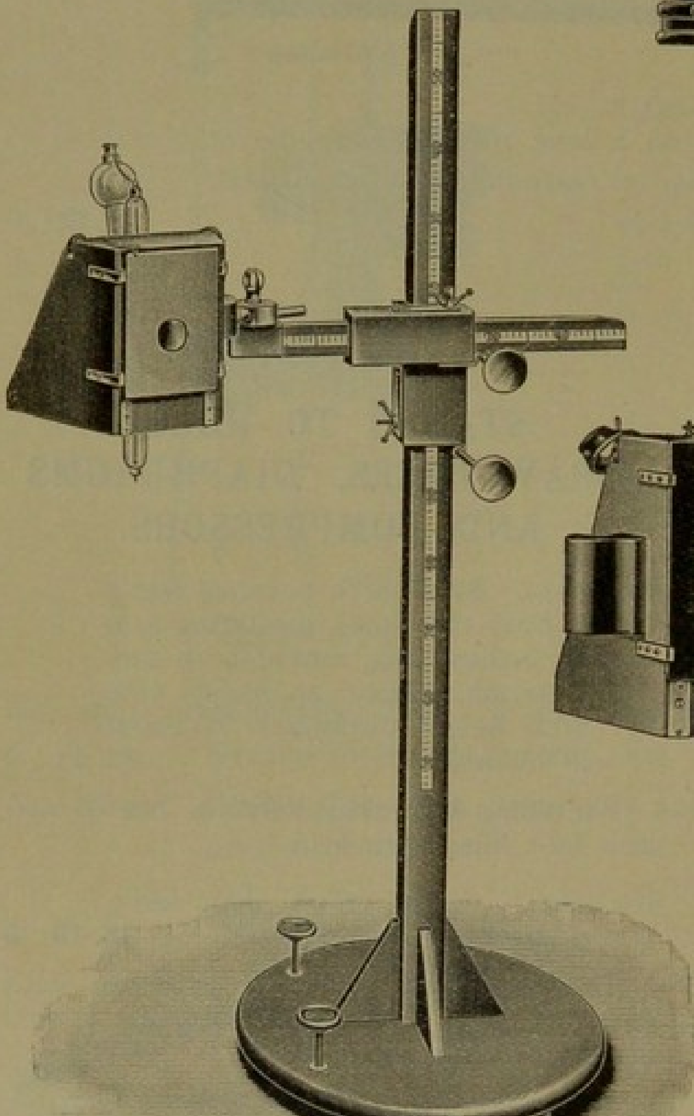
The heavy iron base is provided with castors as well as with screws to fix it in a certain position, if desired.

(As supplied to St. Bartholomew's Hospital, Royal Infirmaries in Edinburgh, Glasgow, Belfast, etc., Dr. Lewis Jones, etc., etc.)

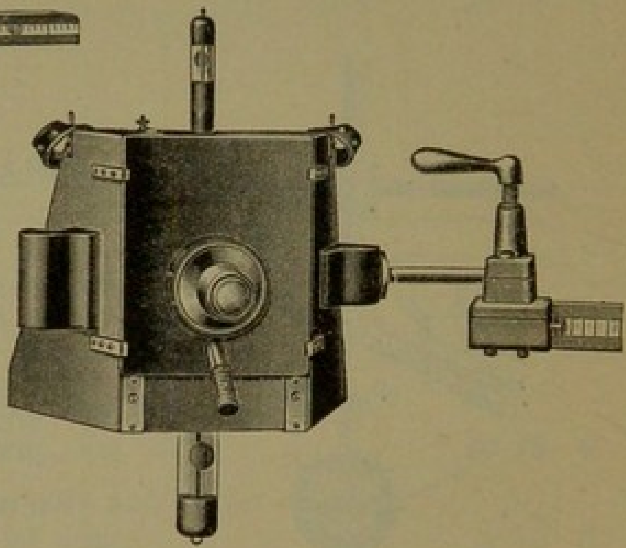
The stand No. 2611 can be used for the suspension of X-ray tubes, and in addition a valve tube and a galvanometer for measuring the currents can easily be fixed on it, as shown in Fig. 2611 (this convenient arrangement was first suggested by Dr. Lewis Jones). The connections are also shown; the wires marked + and - lead to the corresponding terminals of the spark coil.



No. 2613.



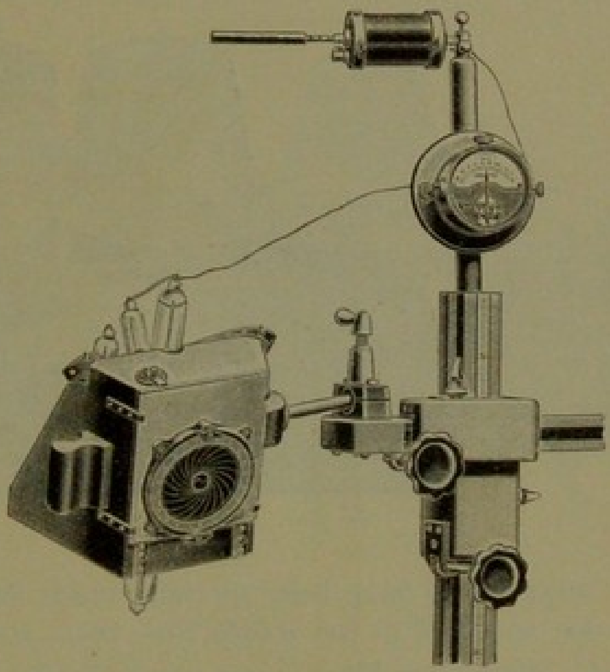
No. 2612.



No. 2614

No. 2612. **Tube Stand**, *Fig.* 2612, made of strong oak, with rack and pinion to adjust position of tube, with X-ray-proof box to cover luminous part of tube and 3 diaphragms of different aperture . . £7 10 0

A milliampèremeter and spark gap No. 2603 can be fixed on the stand, as shown in illustration.



Sheets of aluminium can easily be inserted as filters, for therapeutic purposes.

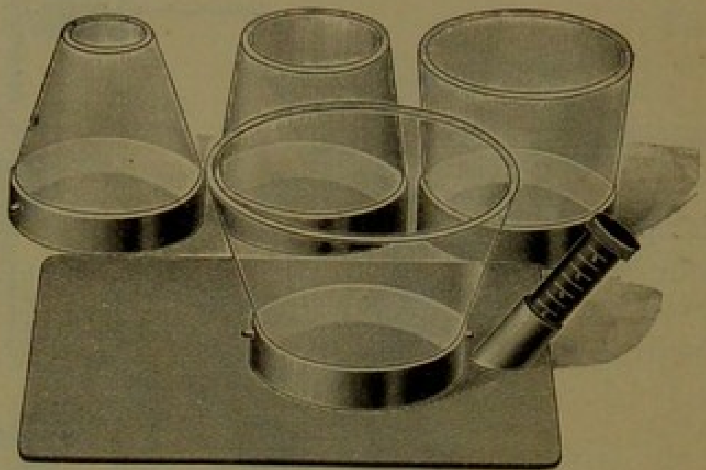
No. 2613.	**Cylinder Diaphragm** for 2612, as shown on *Fig.* 2613	£0 10 6
	An **Iris Diaphragm,** No. 2627, can be used with this stand, price .. .. .. extra	1 15 0
No. 2614.	**Diaphragm** (*Fig.* 2614) with a pastille holder, to expose Sabouraud's pastilles at distances varying from 6 to 12 cm. from the anticathode	1 2 6
No. 2614A.	Four lead glass funnels, with apertures of 1, 2, 3, and 4½ ins., for treating ringworm (*Fig.* 2614A) ..	1 5 0
No. 2614C.	**Tripod** with ebonite rods, to keep the head at a fixed distance from the anticathode, for epilation of the *whole* head, with 4 exposures only. The tripod fits the diaphragm 2614	0 9 0

Our Tube Stands No. 2612 have been supplied, amongst others, to :—

St. Bartholomew's Hospital, Westminster Hospital, University College Hospital, Charing Cross Hospital, St. Pancras Infirmary, London. Kingston Union Infirmary, General Hospital, Ramsgate ; Radcliffe Infirmary, Oxford ; Royal Infirmaries, Glasgow, Liverpool, Dumfries ; Infirmary, Kidderminster ; The Hospital, Diss ; Royal Bucks Hospital, General Hospital, Stroud ; Royal Sea Bathing Hospital, Margate ; Royal Alexandra Hospital, Paisley ; Cumberland Infirmary, General Infirmary, Stafford ; County Hospital, Ayr ; City Infirmary, Waterford ; Poplar Hospital for Accidents, Edinburgh Hospital for Women, Principal Medical College, Lahore ; The Hospital, Dunedin, etc., etc.

Drs. H. Lewis Jones, J. Mackenzie Davidson, E. S. Worrall, Reg. Morton. H. Walsham, London. J. W. White, J. G. Grahame, Rob. Morton, S. Sloan Glasgow ; W. Furlong, Dublin ; W. F. Brook, Swansea ; W. Coleman, Reading ; V. J. Greenyer, Hove ; A. R. Hallam, Sheffield ; C. J. Heaton, Margate ; J. Hussey, Farnham ; A. G. Paterson, Ascot ; W. K. Wills, Clifton ; E. Gairdner, Ayr ; E. Fox, Warrington ; A. E. Cox, Watford.

Drs. R. St. M. Dawes, S. Australia ; R. M. Gibson, Hong Kong ; V. H. Topalian, Diarbekir ; etc., etc.



No. 2614A.

Nos. 2614–2614C have been specially made for the convenient treatment of *ringworm,* and fit into the stands Nos. 2612, 2615, and 2620.

No. 2614f. **Aluminium Filter,** 1 mm. thick, fitting into the stand No. 2612 .. .. £0 3 0

X-RAY TUBE STAND,

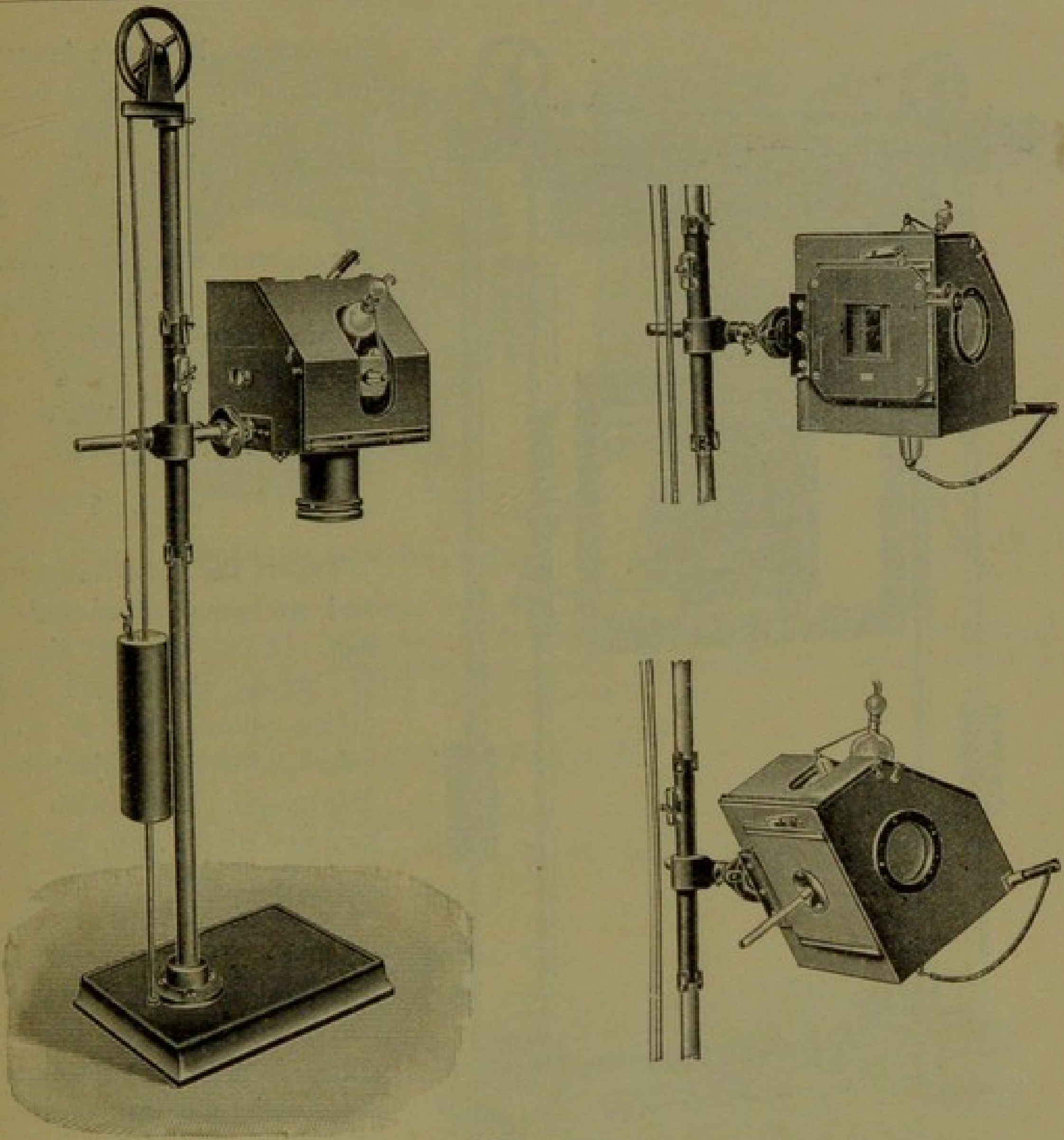
With Flat Diaphragm, Cylinder Diaphragm, and Compressor.

The **Stand** shown in illustration is 6 feet high, and is mounted on castors The tube is suspended in *our New Self-centering Tube Holder,* which enables the operator to fix a tube in correct position above the cylinder diaphragm without losing any time in centering it, without having to keep the tube alight for this purpose, and without having to expose his hands. Tubes of different penetrating power can thus be exchanged easily.

Below the tube is a flat diaphragm, the aperture of which can be adjusted with rack and pinion. The stand can either be used for photographic exposures without a compressor, or for examination on the fluorescent screen, or for therapeutic purposes. Tube and diaphragm can easily be raised or lowered, and can be used in vertical, horizontal, or any other position.

A cylinder diaphragm can be slipped in below, to make exposures with compression. The cylinder diaphragm can be provided with a pneumatic ring as cushion ; it can be inflated by means of a rubber bellows, and grasps the skin of the patient firmly, without giving pain.

No. 2615. Price of Stand, including box, lined with X-ray-proof rubber, to prevent any X rays or green light reaching the room (the box encloses the tube entirely, and gives *perfect protection to operator and assistants*), self-centering tube holder, flat diaphragm, No. 2628, and cylinder diaphragm, *Fig.* 2615 .. £17 0 0



No. 2615.

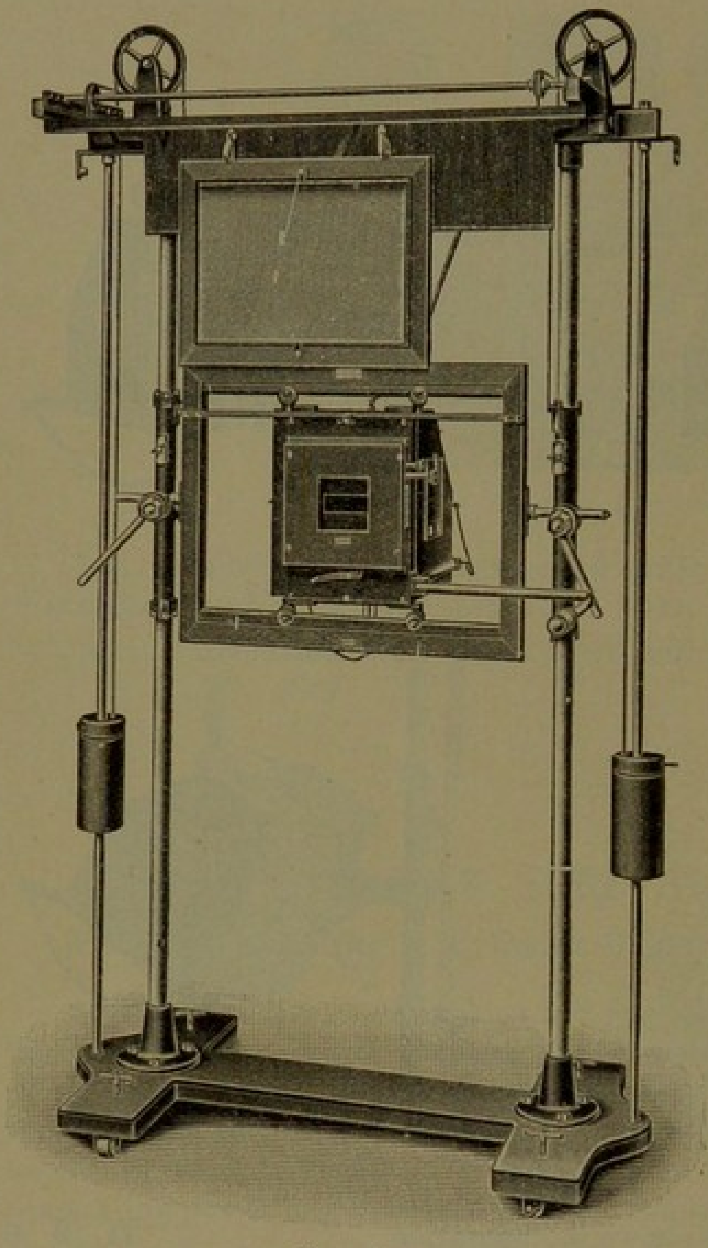
Price of **Pneumatic Cushion**, as shown in illustration £1 9 0

The box can be so arranged that it can be moved up to 7 ctm. each way from the centre, *without disturbing the position of the patient, or interfering with the cylinder compressor.* It is then suitable for exposing plates to be examined with a stereoscope. The extra cost of this arrangement, including scale, is £3 3s.

Our Tube Stands No. 2615 have been supplied, amongst others, to :—

St. Bartholomew's Hospital, Charing Cross Hospital, St. George's Hospital, National Hospital, Queen's Square ; Victoria Hospital for Children, Chelsea ; Royal Infirmaries in Manchester, Liverpool, Glasgow, Derby ; General Hospital, Bristol ; Grantham Hospital ; Cottage Hospital, St. Andrew's, Infirmaries, Burton and Wrexham ; Monkwearmouth and Southwick Hospital, Sunderland ; British Hospital, Constantinople ; Jeffrey Hale Hospital, Germiston ; Medical College, Lahore ; Hospital, Dunedin ; Crown Agents for the Colonies.

Drs. C. M. Hinds Howell, D. F. Wright, London. D. Judah, Bombay ; P. J. S. Bird, Southsea ; H. E. Gamlen, West Hartlepool ; C. B. Kempe, Salisbury ; L. C. Panting, Truro ; A. F. Cole, Ningpo ; G. P. Jordan, Hong Kong ; N. C Munro, Yokohama ; H. C. Highet, Bangkok ; etc., etc.



No 2617

No. 2617. **Beclere's Stand,** Fig. 2617 including box, to prevent the escape of X rays and green light **£30 0 0**

Arrangement that *stereoscopic* pictures can be taken also with the cylinder diaphragm, extra **£3 6 0**

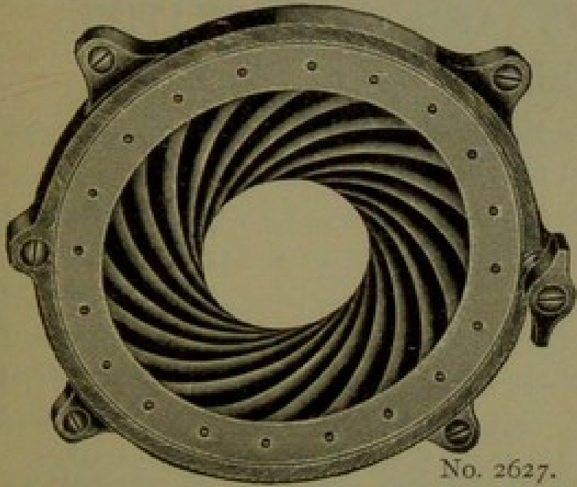
Pneumatic Cushion extra **1 12 0**

This is the most complete and universal stand existing. It can be used above or below the couch for taking photographs, is provided with flat, adjustable diaphragm, and with a cylinder diaphragm, can be used for ordinary or for stereoscopic exposures. (The arrangement for taking stereoscopic pictures with the *flat* diaphragm is included in the price; if stereoscopic pictures are desired also with the *cylinder diaphragm*, a special addition is necessary.)

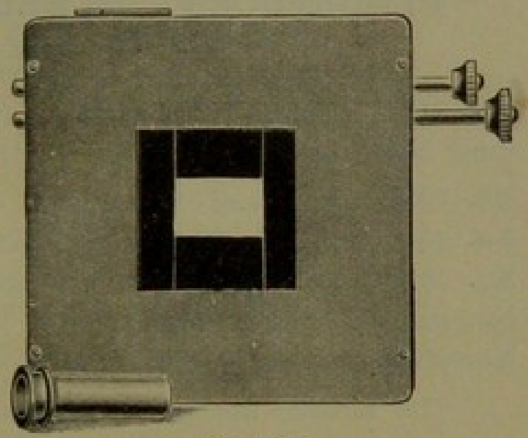
It can be used equally well for examination on the screen, or for therapeutic purposes. The fluorescent screen can be suspended at any height, and a black curtain can be drawn in front of the tube.

The tube is completely enclosed in a box lined with X-ray proof rubber; neither X rays nor green light can reach the room, and operator and assistants are *thoroughly protected*, so that they require neither aprons nor spectacles. Owing to perfect mechanical construction, the friction is so small in our model of this stand, that the tube box can be moved up or down or sideways with the greatest ease with one hand only.

As supplied to Dr. Worrall, Mr. Coldwell, Dr. Ironside Bruce, London; Dr. Harris, Sydney; Stanley Hospital, Liverpool; Grimsby Hospital; General Hospital, Ramsgate, and others.



No. 2627.



No. 2628.

No. 2627. **Iris Diaphragm** for X-rays, Fig. 2627 .. .. **£1 15 0**

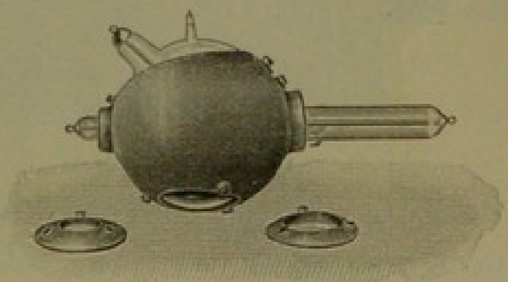
This diaphragm can be used with stands Nos. 2612 and 2712b.
It may also be used with stands Nos. 2615 and 2617. If the iris diaphragm is chosen to replace the adjustable rectangular diaphragm, the prices quoted for the stands Nos. 2615 and 2617 will be *reduced* by 20s.

No. 2628. Rectangular diaphragm (Fig. 2628) .. **£2 15 0**

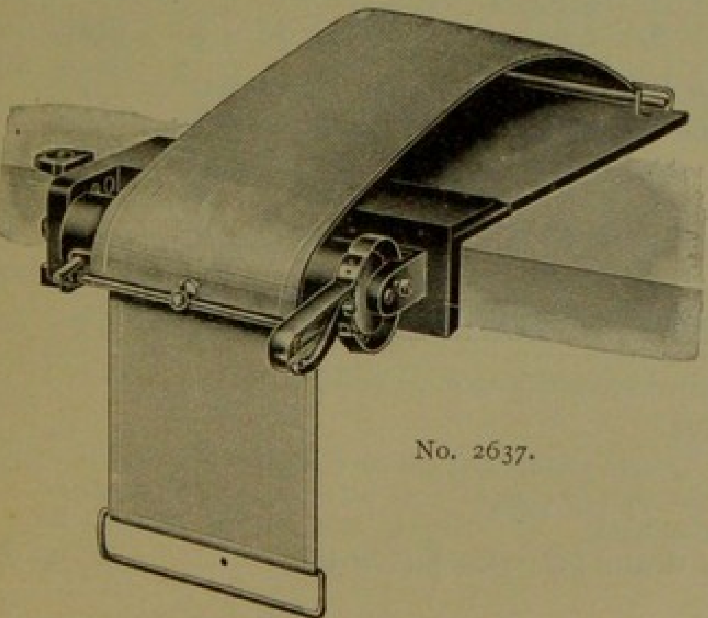
The size of the rectangular opening can be varied by means of the two projecting screws. This diaphragm is supplied with, and included in the prices of, stands Nos. 2615 and 2617.

No. 2634. Dr. Kaiser's **India-Rubber Diaphragm**, with 2 exchangeable discs, with apertures 4 and 6 ctm. wide.

A. for tubes 5½ ins. diam.	**£1 1 0**
C. for tubes 6½ ins. diam.	**1 7 0**
E. for tubes 8 ins. diam.	**1 12 0**



No. 2634.



No. 2637.

No. 2637.

Compressor, consisting of stout canvas band to be stretched across the patient, with clamp to fix it, Fig. 2637 .. **£5 10 0**

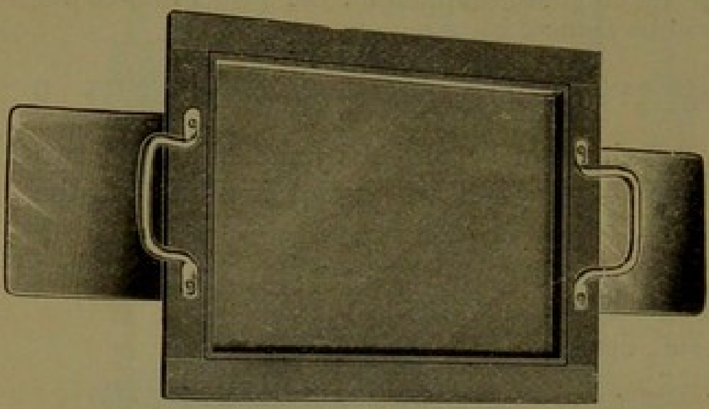
FLUORESCENT SCREENS AND ACCELERATING SCREENS.

FLUORESCENT SCREENS, for direct observation, coated with two thick layers of large crystals of barium platino-cyanide.

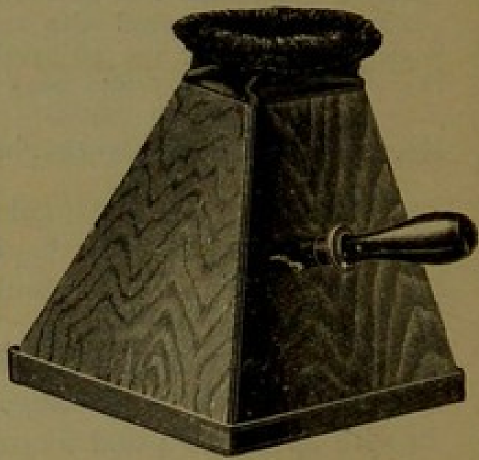
No. 2641.	5 × 7 in.	£1 14 0
No. 2642.	7 × 9½ in.	2 16 0
No. 2643.	9½ × 12 in.	4 12 0
No. 2644.	12 × 16½ in.	7 10 0
No. 2645.	16 × 20 in.	12 0 0

The screens are the best quality obtainable.

At the time when this is being printed (March, 1911), the oz. of platinum costs more than twice as much as an oz. of gold, and the screens are therefore rather expensive at present. The price of platinum has fluctuated a good deal, and if it goes down again, the prices will be reduced.



No. 2652.



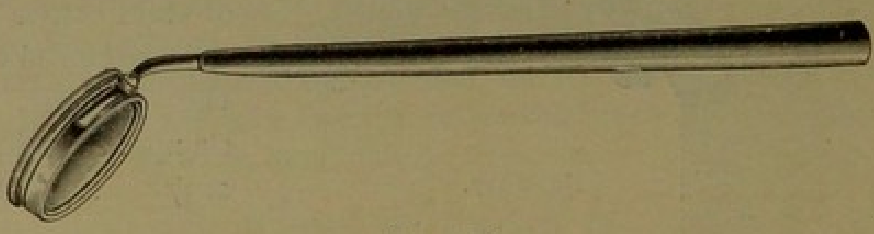
No. 2654.

Plates of lead glass, to cover the screens, to protect the operator against the X rays passing through the screen.

No. 2650.	5 × 7 in.	7 × 9½ in.	9½ × 12 in.	12 × 15½ in.
	2/6	4/-	6/6	10/6

No. 2652. **Metal handles,** to be screwed on to the fluorescent screens, for the protection of the hands of the operator, Fig. 2652 .. .. per pair £0 7 0

No. 2654. **Cryptoscope,** Fig. 2654, with screen No. 2642 .. 4 6 0



No. 2656

No. 2656. **Screen Holder,** for dental purposes, Fig. 2656 .. 1 2 6

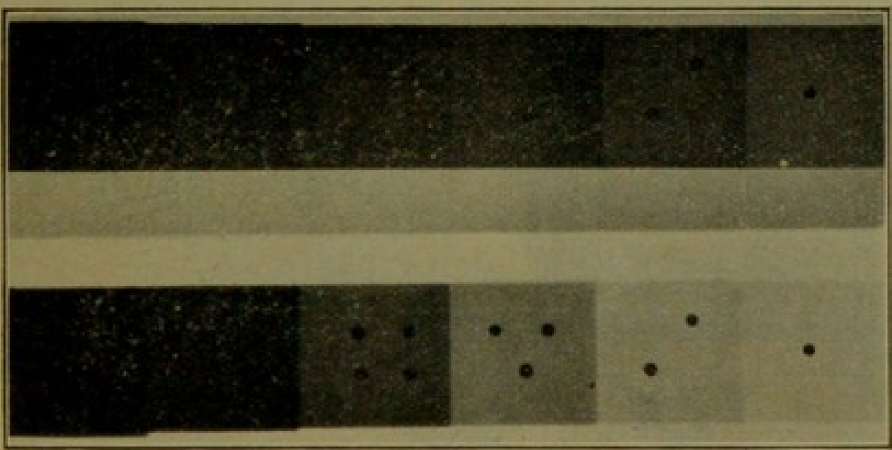
"GRAINLESS" INTENSIFYING OR ACCELERATING SCREEN FOR X-RAY NEGATIVES.

An important improvement has been made in Accelerating Screens. A new type has been invented, which enables us to obtain the finest details free from grain on the negative.

The time of exposure is reduced to between one-tenth and one-twentieth that which would be necessary without the use of such a screen. As the tubes have to be switched on only about one-tenth part of the time, they will last for ten times as many exposures, and the expense for new X-ray tubes will be reduced to one-tenth of the amount which has to be spent when these screens are not being used.

Moreover, it enables the owners of medium-sized coils to make successful exposures of even the most difficult parts of the body in such a short time that patients can keep their breath, and want of sharpness due to the movements during respiration is thus avoided.

The illustration shows two test objects (aluminium ladders) of the same thickness, exposed *simultaneously* on one plate, half of which was covered with one of these screens.



Without Screen.

With Screen.

PRICES.

No. 2658A.	6½ × 8½ ins.	.. ..	£1 8 0
No. 2658B.	8 × 10 ins.	.. ..	2 2 0
No. 2658C.	10 × 12 ins.	.. ..	2 10 0
No. 2658D.	12 × 15 ins.	.. ..	3 10 0
No. 2658E.	16 × 20 ins.	.. ..	5 10 0

It is important that the film side of the photo plate should be in **close contact** with the screen; the casettes No. 2855 of our list are convenient for this purpose. See also page 167.

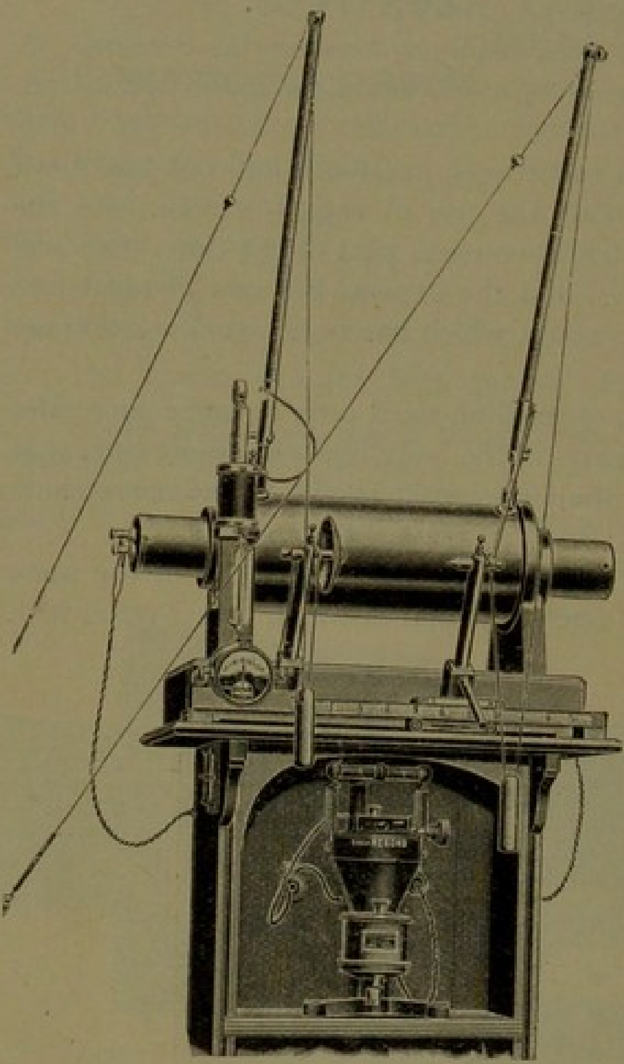
[*Copy of an unsolicited testimonial.*]

SUNDERLAND, *Mar. 3rd*, 1911.

I am very pleased with the accelerating screen. It has solved the problem of Cranial Radiography for me. I can get a fully exposed negative of the orbit or accessory sinuses in 10 seconds. Faithfully yours,

A. C. NORMAN.

INSTRUMENTS TO MEASURE X-RAYS.



The illustration shows a convenient combination of measuring instruments ; a Spark Gap, with scale, to measure either the equivalent spark length, or else the number of milliampères which can be obtained through an air gap 20 ctm. long.

A Milliampèremeter for X-rays.

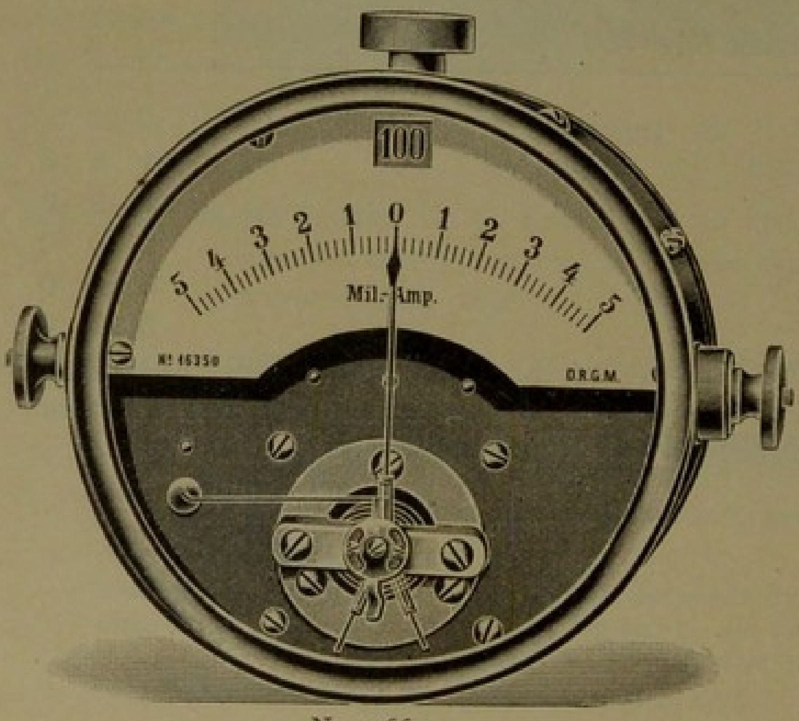
An Oscilloscope tube, and

A Spark Gap, No. 2603, to suppress the reverse current, are arranged on the cabinet on which the spark coil and interrupter are placed.

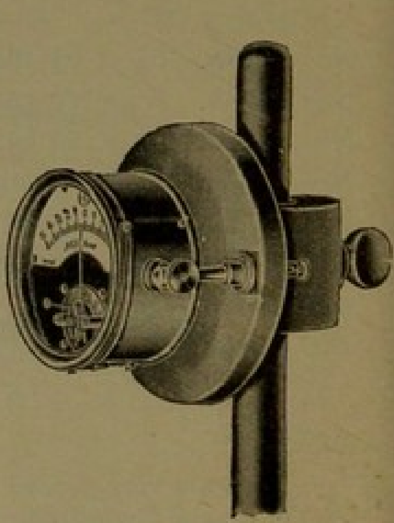
A pair of wooden masts carry the secondary wires leading to the tube safely over the head of the operator, and running weights keep these wires stretched.

Milliamperemeters of the d'Arsonval type to Measure the Current passing through X-Ray Tubes.

(*See also page* 157–159.)



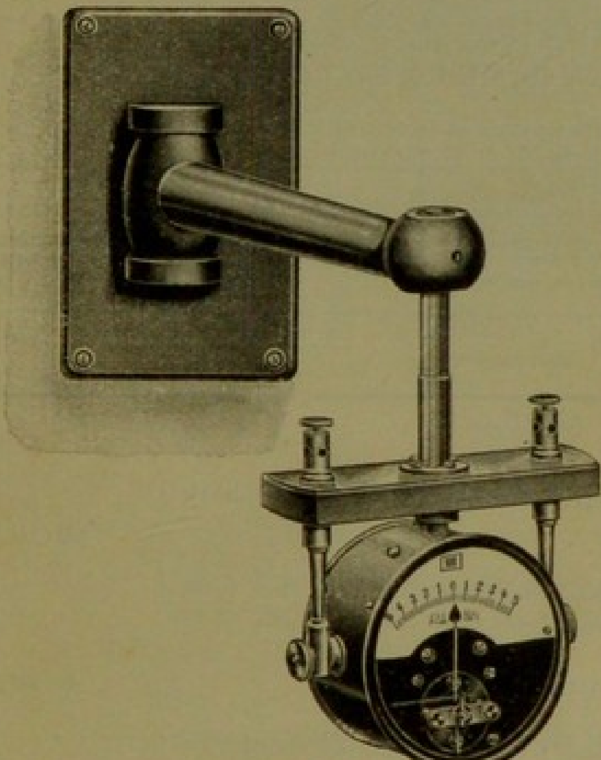
No. 2661.



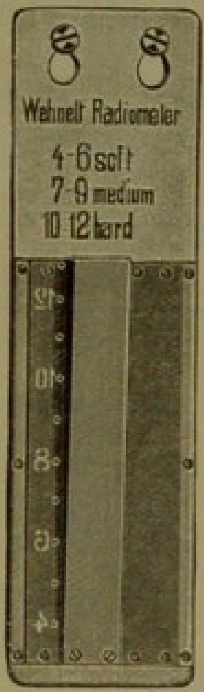
No. 2661A.

These instruments are provided with a condenser, are dead beat, and can be used in any position. Diameter 4½ ins.

No. 2660.	**Milliamperemeter,** indicating up to 5 milliampères, every tenth part of a milliampère	£3	3	0
No. 2661.	Similar instrument, provided with a shunt, reading up to 5 or up to 50 milliampères	3	7	0
No. 2661A.	Similar instrument, with 2 shunts, reading up to 3, 30, or 300 milliampères	3	12	0
No. 2661B.	Small board, fitting stands Nos. 2610 to 2612, with terminals to carry the M.A. meter, Fig. 2661A ..	0	8	0



No. 2662.

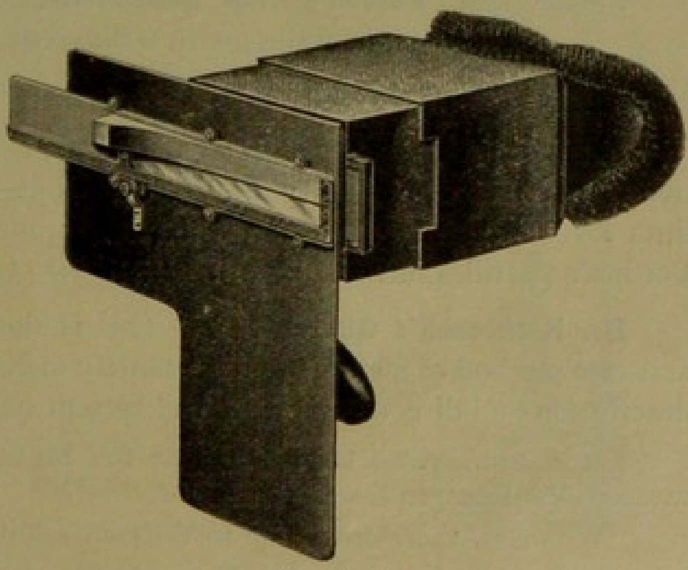


No. 2663.

No. 2662. Milliampère-meter 2661, with bracket as shown in Fig. 2662 £4 2 0

No. 2663. Dr. Wehnelt's small Radiometer, Fig. 2663 .. £0 10 0

No. 2664. **Dr. Wehnelt's Crypto-Radiometer,** Fig. 2664 £3 3 0

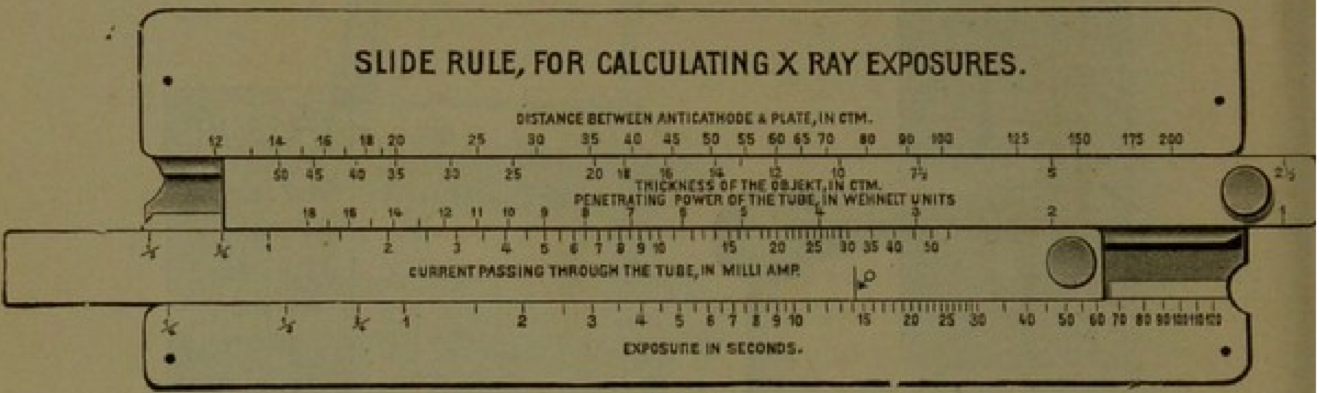


No. 2664

14

This is a modification of the Radiometer of Benoist. A parallel silver strip and a wedge-shaped piece of aluminium (7 inches long) are mounted side by side, and can be moved by means of a rack and pinion behind a narrow strip of a fluorescent screen, so that the lower half of the screen is covered by silver of uniform thickness, the upper half by aluminium of variable thickness.

The luminosity of the field covered by the silver remains uniform, and is used for comparison, like the light of a standard candle. The luminosity of the part of the screen covered by the aluminium changes according to the condition of the tube and the thickness of the aluminium.



No. 2666

No. 2666. **Slide Rule**, for finding the correct time for X-ray exposures, Fig. 2666	£0 10 0

Explanation of this convenient instrument will be found on page 164.

No. 2667. **Sabouraud's Booklet**, with 24 pastilles	0 13 9

The pastilles are to be exposed on a metallic support, at *half* the distance existing between anticathode and skin (see No. 2614).

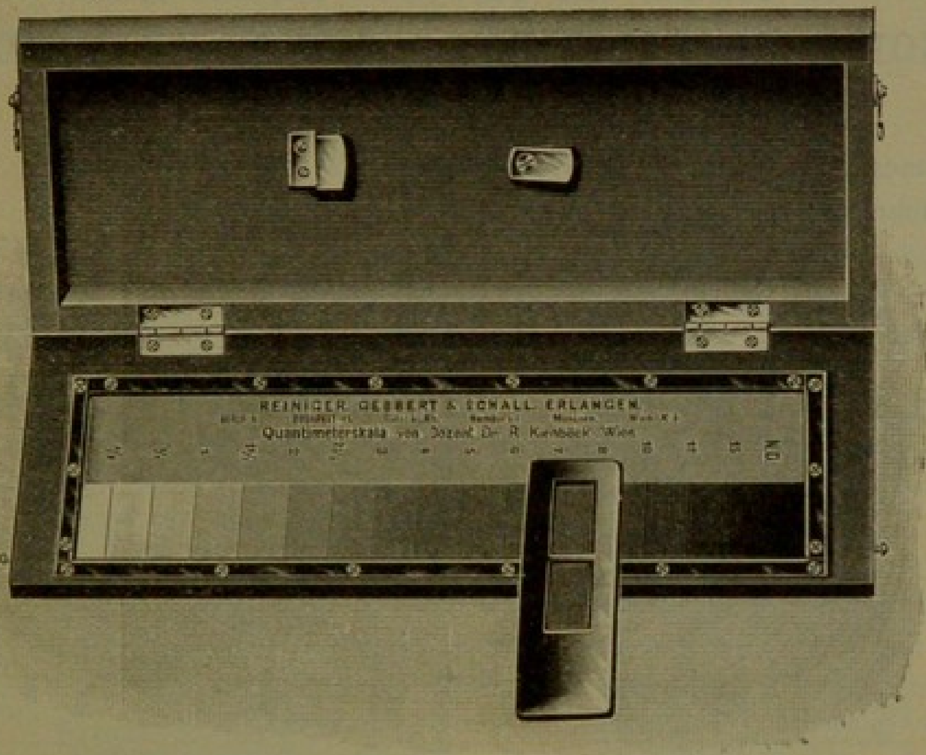
No. 2667 B. **Dr. Bordier's New Chromo-Radiometer**, Standard Scale, in frame, with 6 different tints	1 1 0
No. 2667 C. 100 Pastilles for Dr. Bordier's scale	1 1 0

This new Chromo-Radiometer depends, as Sabouraud's, on the discoloration of pastilles of barium platinocyanide, but the scale shows five different tints for comparison, instead of the single one of Sabouraud's instrument. Bordier's pastilles have to be attached *to the skin* of the patient.

Dr. Kienboeck's Quantimeter.—This is the most sensitive and the most accurate method of measuring the quantity of X rays existing up to now. Full description and directions for use will be sent on application.

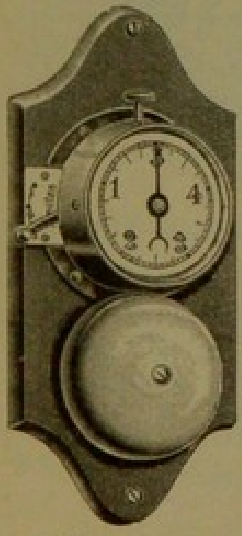
The instrument has been tested at the Blythswood Laboratory. The report made to the Röntgen Society says :—

"We must, therefore, come to the conclusion that although this instrument is open to the errors inseparable from the comparison of tints, it is a great improvement on others of its kind. We have no doubt that the scale is correct, and its ratio to others (Sabouraud, Holzknecht) is as stated."



No. 2668.

No. 2668. Dr. Kienboeck's Standard Scale, *Fig.* 2668, in polished walnut box	£1	14	0
No. 2668A. Fifty strips of bromide of silver paper, in dark envelopes, with labels and numbers	0	9	6
No. 2668B. Stand with four test tubes	0	9	6
No. 2668D. Three aluminium strips	0	2	6
No. 2668E. One aluminium strip with three different degrees of thickness	0	2	6



No. 2669.

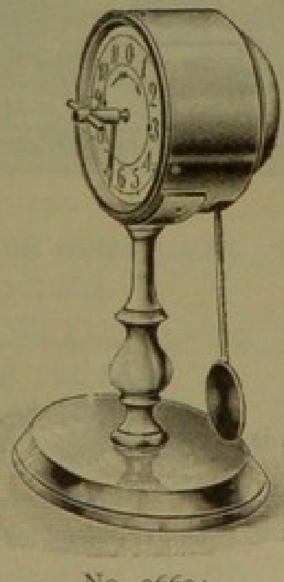
No. 2668K. Dark box to develop the strips in daylight £1 16 0

No. 2668N. ½ litre developer A, ½ litre developer B, and 1 litre fixing solution, in glass-stoppered bottles .. £0 5 9

No. 2669. **Clock,** with adjustable arrangement to ring after three, four, or five minutes .. £0 9 6

These clocks are very convenient for showing the length of the exposure or the development.

No. 2669A. **Pendulum Clock,** to run up to ten or up to twenty minutes, Fig. 2669A .. £0 18 6



No. 2669A.

SWITCHBOARDS,

to control the Current from the Main.

MOTOR TRANSFORMERS, ENGINES, DYNAMOS.

(*See also pages* 144–145.)

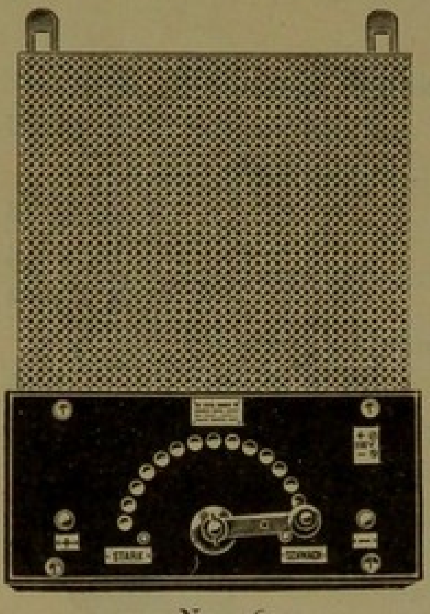
Accumulators suitable for Spark Coils will be found on page 108.

Bichromate Batteries for Spark Coils will be found on page 109.

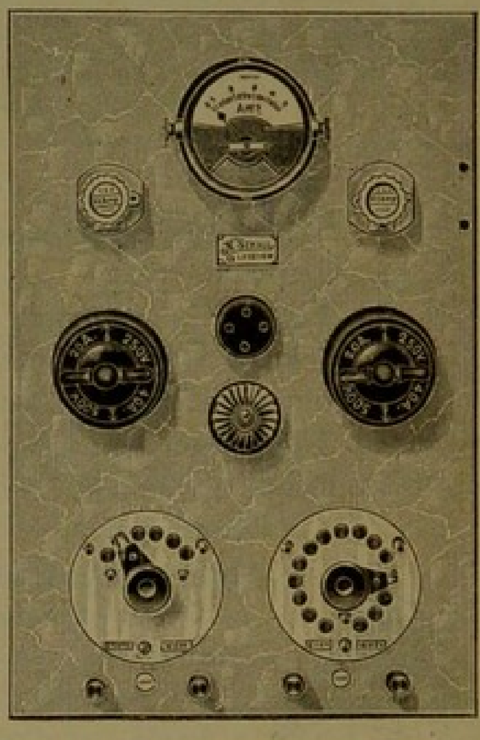
Switchboards are made in great variety, to suit the individual requirements. On the following pages are described and illustrated the types which are most frequently used, but *other combinations can be made within a few days.*

The *first* switchboards ever made for utilizing the current from dynamos for medical or surgical purposes were designed and made by us in our workshop in London in 1890. Since that time we have made over 2000 switchboards; amongst this number are several hundreds made for X-ray purposes.

We have therefore the longest and *by far the largest experience* in this work, and this enables us to supply the *best quality obtainable.*



No. 2672.



No. 2674.

No. 2672. **Series Rheostat,** *Fig.* 2672, to control the primary current for a spark coil.

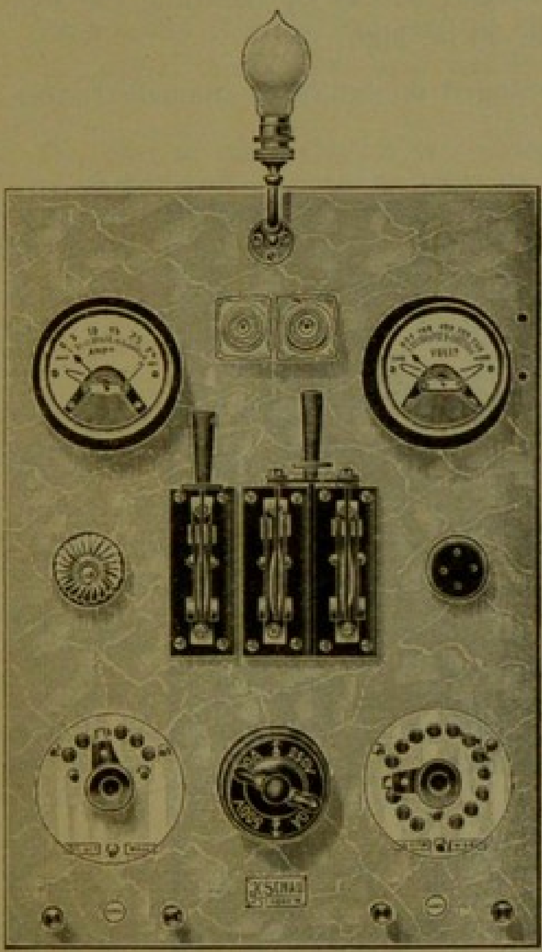
A, for 12 to 30 volt (accumulators)	B, for 100 volt currents	C, for 200 to 250 volt currents
£2 10 0	£3 12 0	£6 0 0

No. 2674. **Series Rheostat** for spark coils, on slate or marble, with switch, fuse, ampèremeter, current reverser, and rheostat to control speed of mercury break, Fig. 2674.

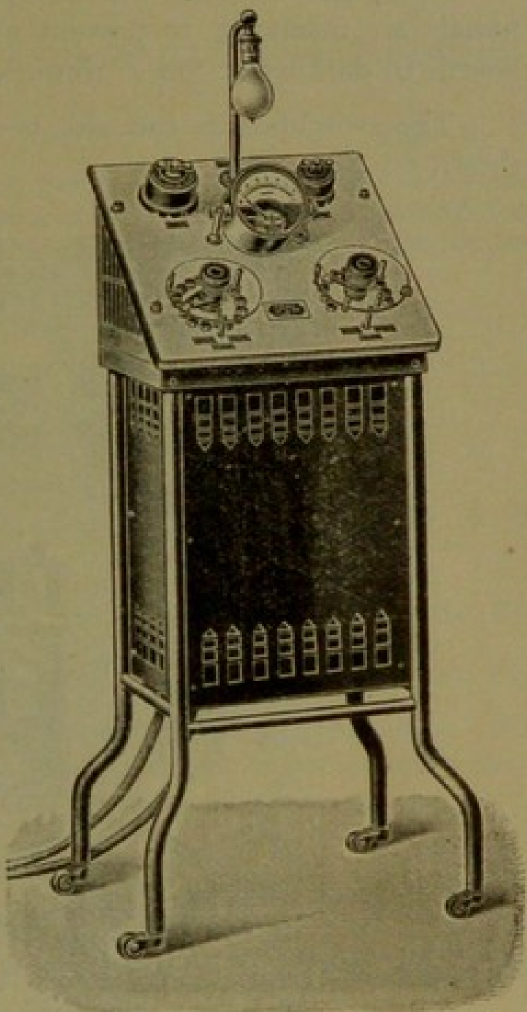
A, for 12 to 30 volts	B, for 100 volts	C, for 200 to 250 volts
£7 15 0	£10 0 0	£12 0 0

IMPROVED SWITCHBOARDS.

Allowing the spark coils to be used in a " shunt " or " in series," at the will of the operator (see page 145).



No. 2675.



No. 2675A.

No. 2675. **Switchboard,** Fig. 2675 .. .. .. £17 0 0

This Switchboard can be used as *Series* rheostat for *instantaneous or tele exposures,* or as *Shunt* rheostat for *time exposures, examination on the screen,* or for *therapeutic purposes.*

On an enamelled slate or polished white marble slab are mounted :

Mr. Mackenzie Davidson wrote us the following letter about the shunt rheostat No. 2675 :—

Dear Mr. Schall, March 27th, 1899.

I am very pleased with your volt selector. I tried it with the new interrupter with most excellent results.

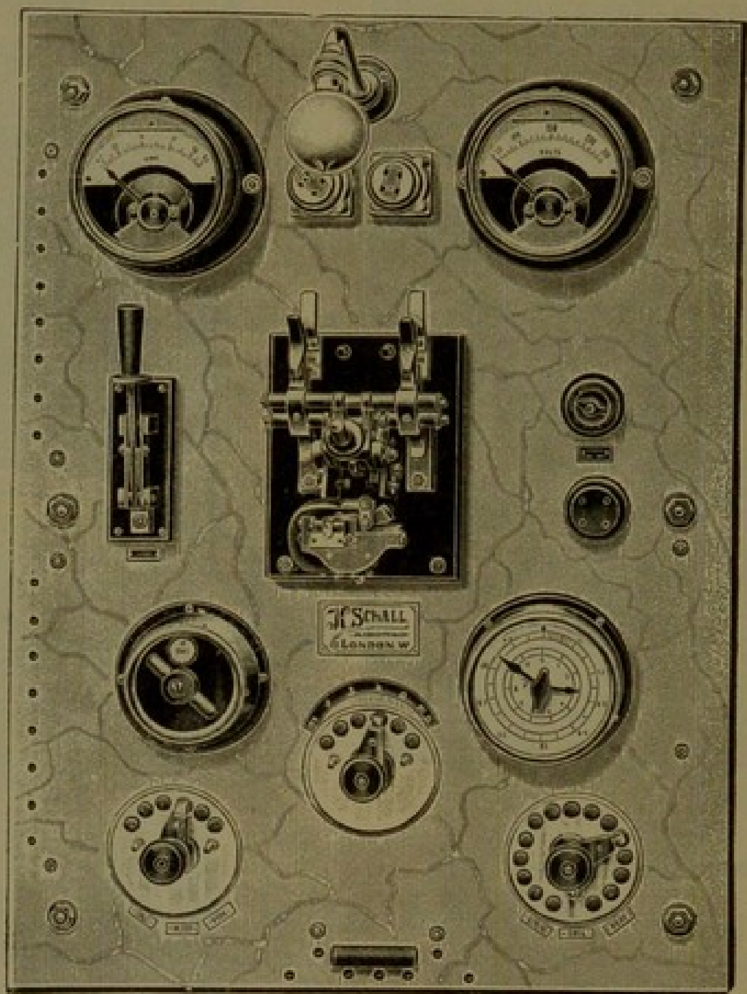
Yours sincerely,

J. Mackenzie Davidson.

current reverser, volt and ammeter, double-pole and single-pole switch, variable resistance for the spark coil, switch and variable resistance for the motor of the mercury interrupter ; signal lamp, fuses, and terminals.

The pegs of the rheostat are protected by glass plate discs, and the terminals are insulated, to prevent unpleasant shocks by handling the switchboards in darkness. Size : 16 in. wide, 23 in. high.

The switchboards can also be arranged on tables of enamelled steel, as shown on *Fig.* 2675A.



No. 2678.

No. 2677. **Large Switchboard,** provided with : a variable *Series Rheostat,* for instantaneous or tele exposures ; and a variable *Shunt Rheostat,* to vary the voltage from the main gradually from 40 up to about 140 volts, for time exposures, examination on the screen, or for therapeutic purposes ;

[*Copy of an unsolicited testimonial.*]

SYDNEY, *Jan.* 28*th*, 1911.

The switchboard (No. 2678) is a dream, the finest piece of work I have ever seen.

DR. HARRIS.

Automatic Double Pole Switch and Clock Work, which can be adjusted so that the primary current is broken automatically after a previously arranged time, which can be set at any fraction of a second, from $\frac{1}{100}$, $\frac{2}{100}$, etc., to 10 seconds.

Dead Beat Volt and Ammeter;

Switch and Rheostat, to control the motor of the mercury interrupter, signal lamp, fuses and terminals.

£27 0 0

The pegs of the rheostats are protected by glass covers, and the terminals are insulated with ebonite, to prevent unpleasant shocks while handling the switchboard in darkness. The switchboard is similar to *Fig.* 2678. Size, 24 in. wide, 34 in. high.

No. 2678. Similar **Switchboard,** but provided in addition with a switch to insert either a mercury, or an electrolytic break; to use the anodes of the latter either separately, or connected parallel, and with a commutator to insert four different degrees of self-induction of the primary coil, *Fig.* 2678 .. £33 0 0

Switchboards No. 2678 have been supplied, amongst others, to :—

Drs. Ironside Bruce, Worrall, Coldwell, London. Dr. Harris, Sydney; Dr. Judah, Bombay.

Grimsby Hospital; Stanley Hospital, Liverpool; Hospital, Dunedin; etc., etc.

Estimates for other types of Switchboards will be sent on application. We can make almost any combination in our workshop in London within one week.

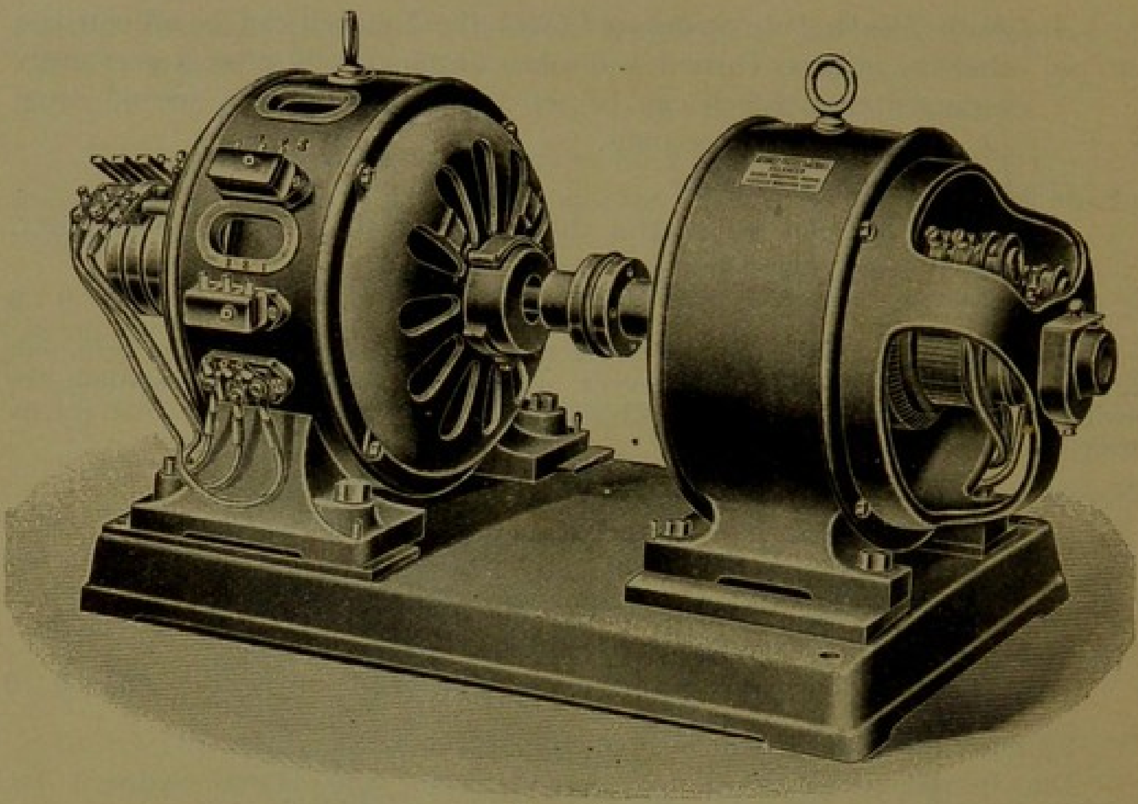
MOTOR TRANSFORMERS, to convert an ALTERNATING into a CONTINUOUS CURRENT.

No. 2680. **Motor Transformer,** consisting of an alternating current motor and a continuous current dynamo, *including* shunt rheostat for dynamo and starter for the transformer, for 40 to 60 periods .. £30 0 0

The dynamo is of 1 H.P. size, but it is so wound that it will give a continuous current of 110 *volt with* 10 *ampères for short periods, not exceeding* 10 *minutes at a time, without any fear of damage.*

No. 2682. **Motor Transformer,** consisting of an alternating current motor and a continuous current dynamo, mounted on cast-iron plate. The latter supplies a current of about 1100 watts (for instance, 10 ampères and 110 volts), Fig. 2682 .. .. £34 0 0

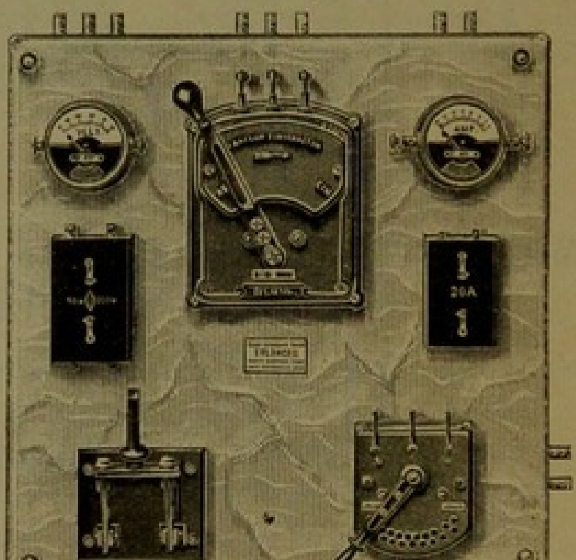
No. 2682A. **Switchboard,** provided with double-pole switch, starting resistance, regulating resistance, fuses and terminals, Fig. 2682A 8 10 0



No. 2682.

No. 2684. Similar **Motor Transformer,** but larger size, continuous current dynamo supplies over 2000 watts, Fig. 2684 **£46 0 0**

No. 2684A. **Switchboard,** for this size transformer, Fig. 2684A **£9 9 0**

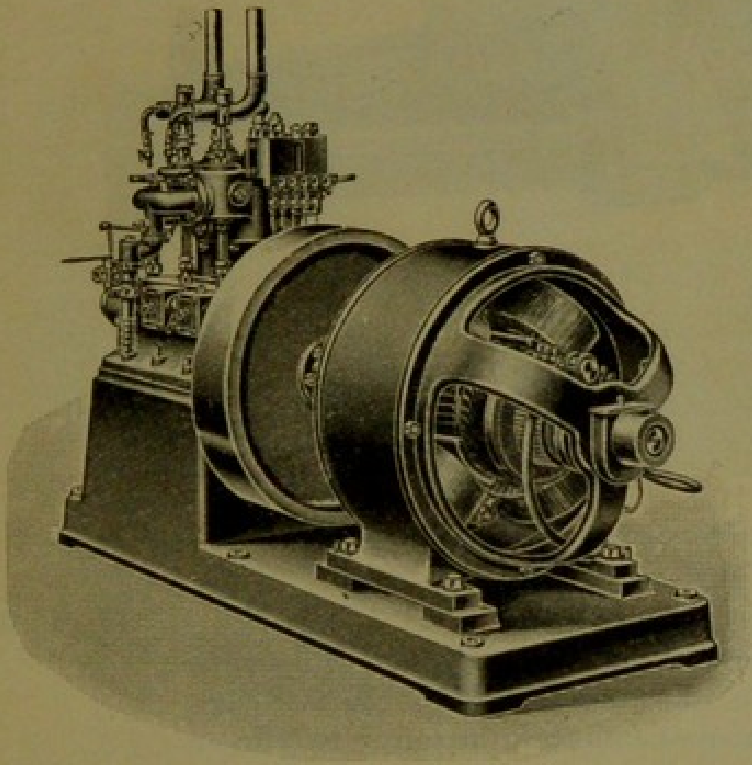


No. 2682A.

Transformer No. 2682 is sufficient for working 10 to 16 inch spark coil with mercury break, or to charge a battery of accumulators (up to 30 cells).

No. 2684 is sufficient for working any size spark coil with a mercury or with an electrolytic break, or to supply the current for mercury vapour lamps, Finsen lamps, or for a Haab magnet.

ENGINE WITH DYNAMO.



No. 2691.

For producing the currents for Röntgen rays, high-frequency currents, arc lamps for treating lupus, and for illuminating small hospitals, etc.

No. 2691. 2 H.P. **Engine** with heavy flywheel and dynamo, complete, Fig. 2691 .. **£60 0 0**

The dynamo gives a current of about 900 watts. It can also be used for supplying the current for about forty 16 candle-power lamps.

No. 2693. **Similar Engine and Dynamo,** but larger size, 4 H.P., complete with tank, tubes, etc. **£90 0 0**

The dynamo supplies 110 volts with 20 to 25 ampères.

The dynamos are shunt wound, and can therefore be used for charging accumulators ; in this case a larger number of incandescent lamps can be used.

The engines make about 1000 revolutions per minute. They are easily started, and require little attention for cleaning, etc.

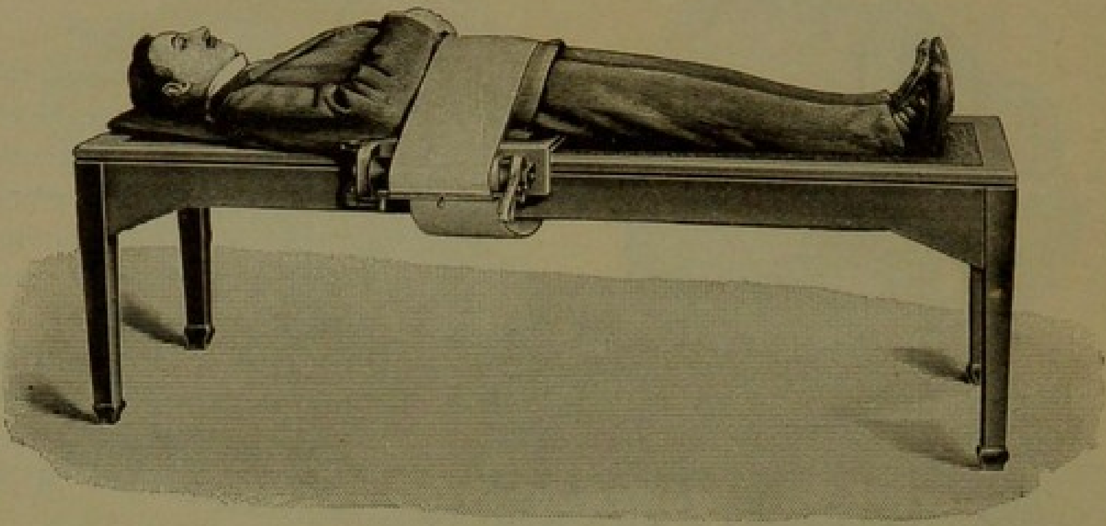
The engines can be used with methylated spirit, benzine, or petrol. They require 24 ozs. of spirit, or 16 ozs. of benzine, or 18 ozs. of petrol per H.P. in one hour, and are therefore cheap to work (less than 2d. per hour).

The size is : Total height, 27 inches ; width, 14 inches ; length, 16 inches ; diameter of the flywheels, 16 inches ; weight, complete, 1½ cwt.

Estimates for larger engines and dynamos can be had on application.

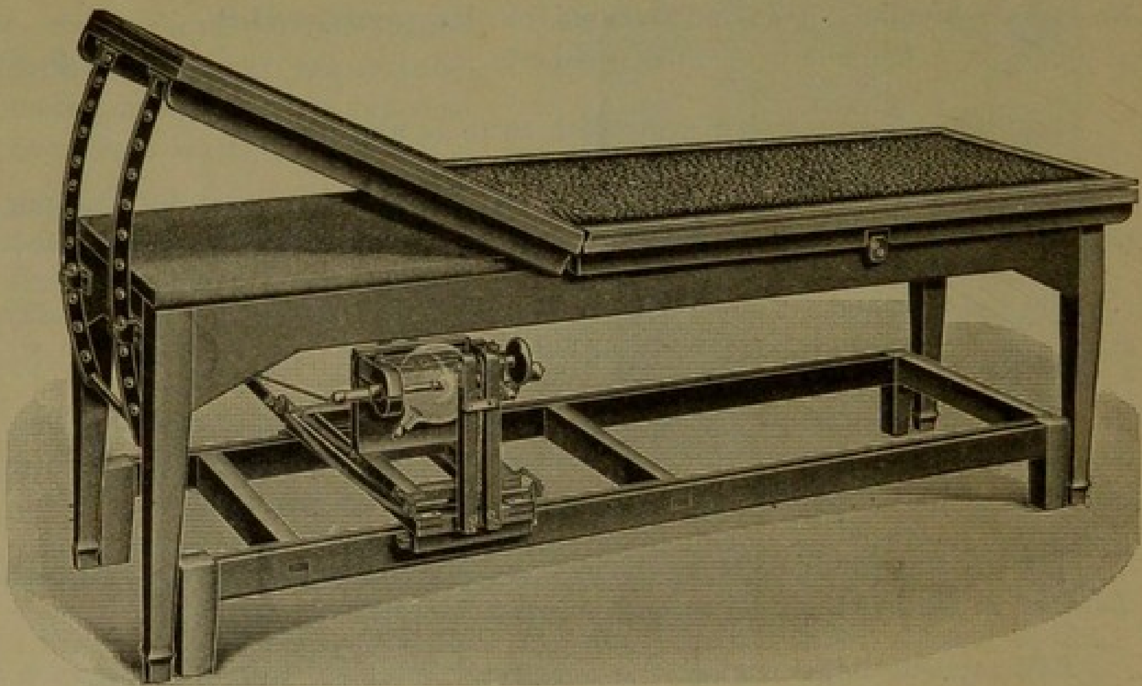
We have supplied these engines amongst others to : The Government of India, for the Agra Medical School ; the Crown Agents for the Colonies ; for Maseru Hospital, Basutoland ; Major Sunder, Pilgrim Hospital, Gaya ; Dr. Ingram, Teneriffe, Dr. Topalian, Diabekir, etc., etc.

COUCHES.



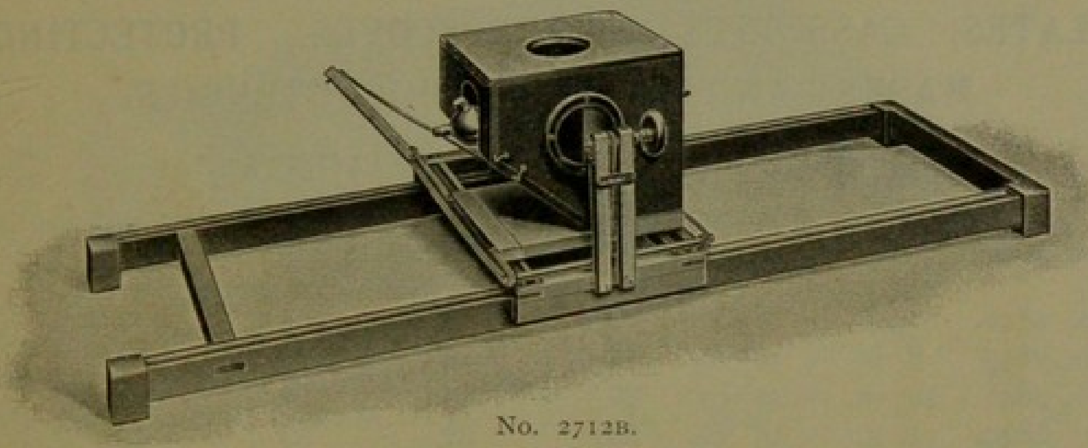
No. 2711.

No. 2711.	**Plain Table,** with canvas cover	£3 3 0
No. 2712.	**Table,** with canvas cover, and in addition with a felt-covered plate, which can be raised at the head end, or can be removed entirely if the tube is to be used below the couch	6 10 0



No. 2712.

The frame with the tube holder below couch, shown in illustration, is not included in this price.



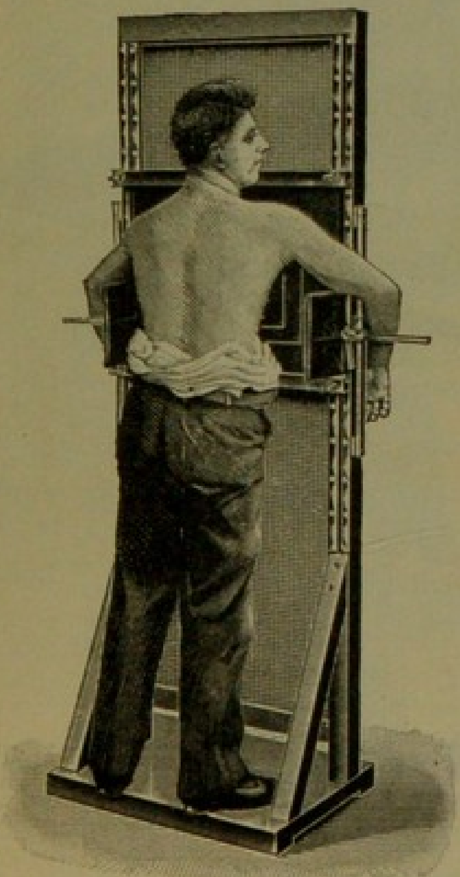
No. 2712B.

No. 2712B. **Frame,** with tube holder, to fit under the couch, as shown in Fig. 2712B. Tube is enclosed in box lined with X-ray proof rubber. There is an arrangement by which the position of the tube can be conveniently adjusted £9 5 0

The frame carrying the tube holder can be arranged so that it is suspended between the four legs of the table, instead of resting on the floor as shown in illustration. The price will be the same.

No. 2712C. **Couch,** Fig. 2712, complete, with frame, tube holder, and box to enclose tube £15 15 0

No. 2715. **Dr. Ironside Bruce's Couch,** latest model, 1910 .. 22 0 0



No. 2720

This is an excellent couch. We made the model with the latest modifications to the order of Dr. Ironside Bruce.

Illustrations and Prices of the Haenisch, Gilmer, etc., couches can be had on application.

No. 2720. **Upright Frame,** to make exposures or examinations with the patient standing, Fig. 2720 £7 10 0

PLATES, CASSETTES, STEREOSCOPES, PROTECTING MASKS, AND PHOTOGRAPHIC UTENSILS.

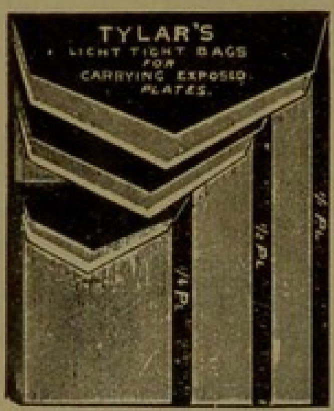
PHOTOGRAPHIC PLATES FOR X RAYS.

The prices are per dozen. Plates of 8 in. × 10 in. or larger can also be had in half-dozen boxes.

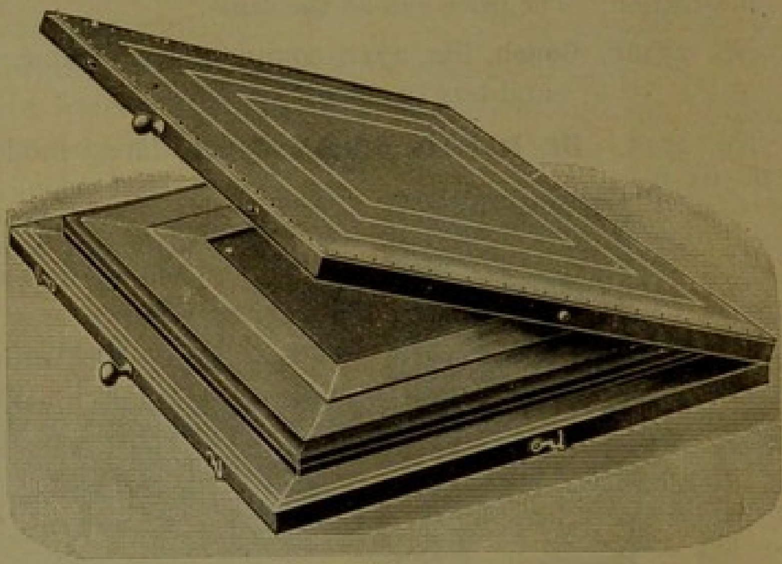
		Lumiere	W.A.H.	Wratten	Ilford
No. 2846.	6½ in. × 8½ in.	**8/6**	**6/9**	**8/6**	**7/6**
No. 2847.	8 in. × 10 in.	**13/6**	**10/–**	**13/6**	**12/6**
No. 2848.	10 in. × 12 in.	**20/–**	**16/–**	**20/–**	**17/6**
No. 2849.	12 in. × 15 in.	**33/–**	**22/–**	**33/–**	**30/–**

Plates can be supplied packed already in separate envelopes. This is to be recommended only if the plates are to be used within the next few months, they deteriorate if stored too long in envelopes.

No. 2853. **Light-tight yellow and Black Envelopes,** for protecting plates against daylight during exposure, 6½ × 8½ in., **2/–**; 8 × 10 in., **3/6**; 10 × 12 in., **6/–**; 15 × 12 in., **10/–** per dozen.



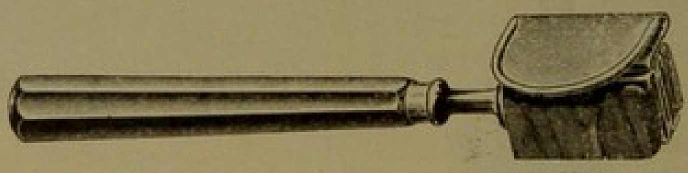
No. 2853.



No. 2856.

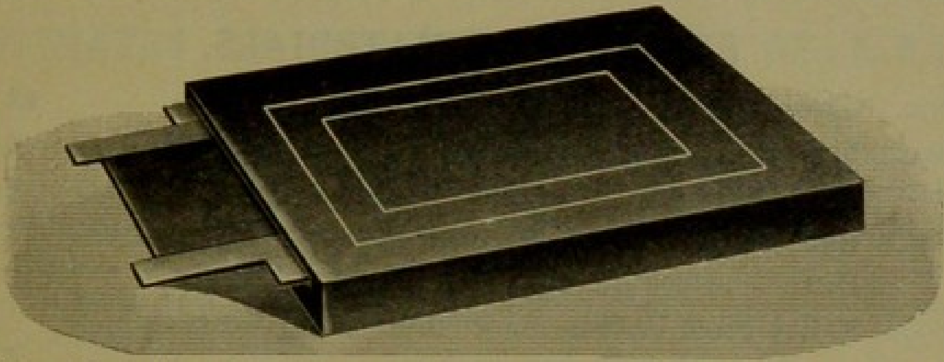
No. 2855.	**Light-tight Cassette,** for the reception of plates up to 10 × 12 in.	£1 8 0
No. 2856.	Similar **Cassette,** for plates up to 12 × 15 in., Fig. 2856	1 14 0

These cassettes are strong, light-tight, and the backs are lined with a sheet of lead to exclude secondary rays from below.



No. 2589.

No. 2589. **Film Holder,** for dental exposures, *Fig.* 2589 .. £0 12 0

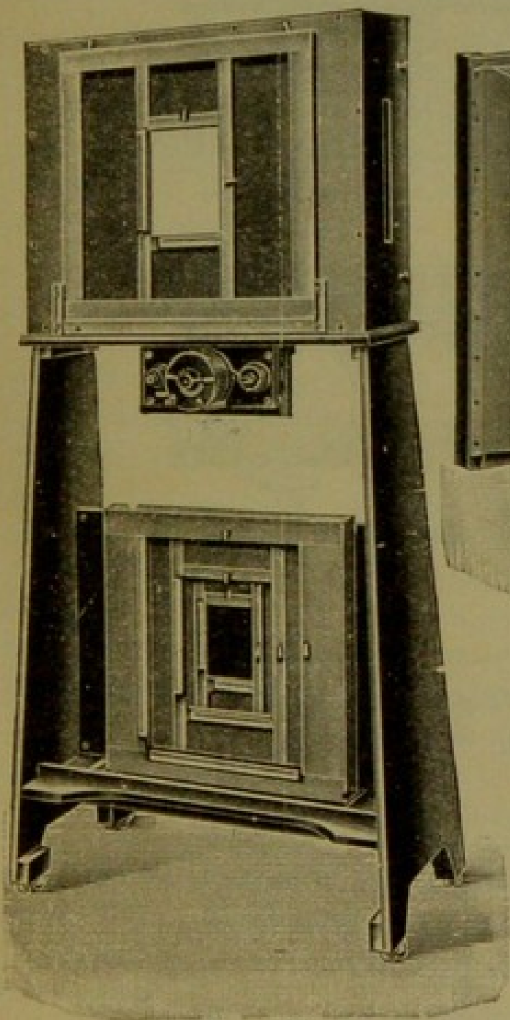


No. 2860

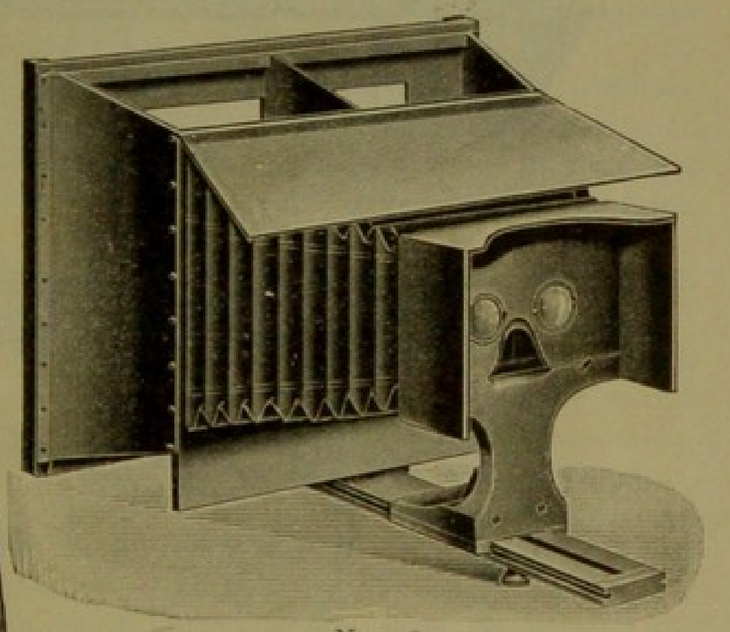
No. 2860. **Cassette,** for stereoscopic exposures, Fig. 2860, for plates up to 10 × 12 in. **£1 7 0**

No. 2861. Similar **Cassette,** for plates up to 12 × 15 in. .. **1 16 0**

These cassettes are lead lined, and so arranged that a plate can be exposed, withdrawn, and a new plate can be inserted instead *without disturbing the patient at all.* If the tube is shifted between the first and second exposure (see page 168) stereoscopic effects will be obtained if the plates are examined in the stereoscope described later on.



No. 2888.



No. 2870.

No. 2870. **Stereoscope,** Fig. 2870, for plates up to 12 × 16 in. .. **£3 0 0**

No. 2871. Similar Apparatus, for plates up to 16 × 20 in. .. **£4 0 0**

Plates or prints can be examined in this apparatus.

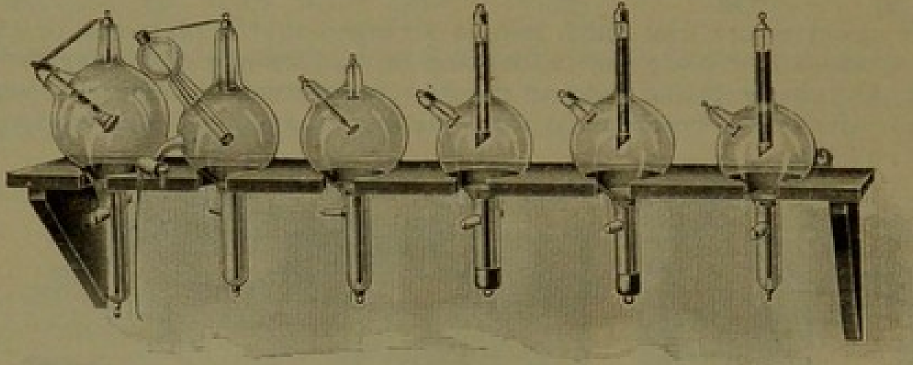
No. 2876. **Wheatstone Reflecting Stereoscope,** with mirrors for examining negatives up to 10 × 12 in. **£5 0 0**

No. 2888. **Case,** with frames for the reception of negatives, to examine them with day or artificial (incandescent) light, including switch, fuse, and rheostat for the incandescent lamp, Fig. 2870 .. .. **5 10 0**

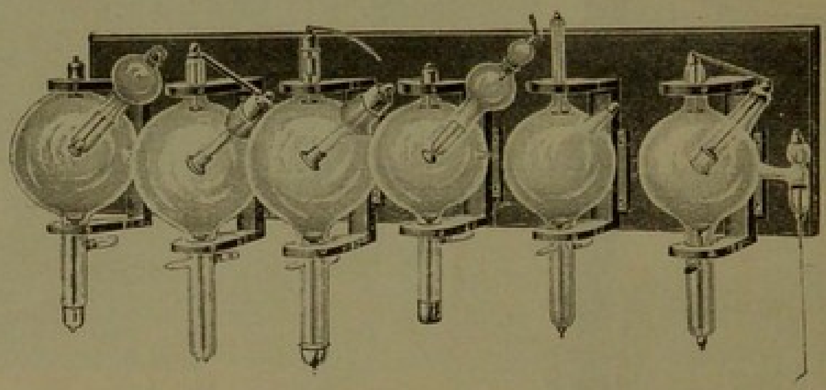
PROTECTIVE MATERIALS.

		£	s.	d.
No. 2890.	**Gloves,** X-ray proof, per pair	£1	4	0
No. 2892.	**Spectacles** of X-ray proof glass	0	6	9
No. 2894.	**Head Mask** of X-ray proof rubber	1	15	6
No. 2896.	**Rubber Apron,** 24 in. wide, 38 in. long, best quality	3	0	0
	Ditto, cheaper quality	2	10	6
No. 2899.	**X-Ray Proof Rubber,** non-conducting, in sheets 24 in. wide, 40 in. long, best quality	2	14	6

WALL BRACKETS, to suspend 6 X-Ray Tubes.



No. 2920.



No. 2921.

		£	s.	d.
No. 2920.	**Bracket,** to suspend 6 tubes, (Fig. 2920) ..	£1	5	0
No. 2921.	,, ,, 6 tubes in self-centering holder, Fig. 2921	1	0	0
No. 2940.	**Cabinets for Storing Negatives,** for holding up to 1000 plates of various sizes in conveniently accessible drawers .. .. from £6 to	10	0	0

Illustrations will be sent on application.

		£	s.	d.
No. 2947.	**Set of Photographic Utensils** for plates up to 8 × 10 in., consisting of 1 xylonite and 2 porcelain dishes, 10 oz. graduated measure, ruby lamp, and 1 dozen light-tight envelopes..	1	5	0
No. 2947A.	Similar set, but for plates up to 12 × 15 in. ..	1	15	0

ESTIMATES OF COMPLETE OUTFITS OF X-RAY APPARATUS.

The combination of the apparatus on the following pages are being ordered frequently, but as individual requirements vary a good deal, alterations and additions may become necessary, and in all such cases we shall be glad to prepare special estimates on application.

The Outfits mentioned below can be seen working in our X-ray Laboratory at 71, New Cavendish Street.

The **Outfit No. 2977** is used by medium or small hospitals, and by many medical men in general practice. It is amply powerful enough for making first-class negatives of any part of the body, for examination on the fluorescent screen, and for all X-ray work for therapeutic purposes. Instantaneous exposures cannot be made with this apparatus, but good negatives of the heart of a normal adult can be obtained with exposures of about 5 seconds, and the *most difficult* parts, like stones in the kidney, etc., will require exposures from 50 to 100 seconds as maximum. With an accelerating screen, this time can be reduced to less than 10 seconds.

The **Outfits Nos. 2980 and 2983** are used most frequently by Hospitals, Surgeons, and many Specialists for X-rays. With these apparatus good negatives of the heart of adults can be obtained in about two seconds and exposures of the pelvis need not exceed 30 seconds, even in difficult cases, *without an accelerating screen.*

A great advantage of the sets Nos. 2977 to 2983 is the simplicity in working, the great efficiency, and the convenient arrangement.

If the apparatus Nos. 2977 or 2980 should be required in different wards of a Hospital, the shape of the cabinets can be arranged so that the apparatus can be wheeled about conveniently. Illustration can be had on application.

The **Outfit No. 2990** is used in the X-ray departments of large Hospitals, and by Specialists for X-rays. It is sufficient for instantaneous exposures; negatives of the stomach of an adult can be obtained in a fraction of a second.

We make a yet larger apparatus, which is powerful enough to give good negatives of the heart, stomach, head, etc., of adults, with *one single flash*, i.e., with an exposure lasting only about the 1/100 part of a second. The lack of sharpness due to the movements of the heart is thus entirely avoided.

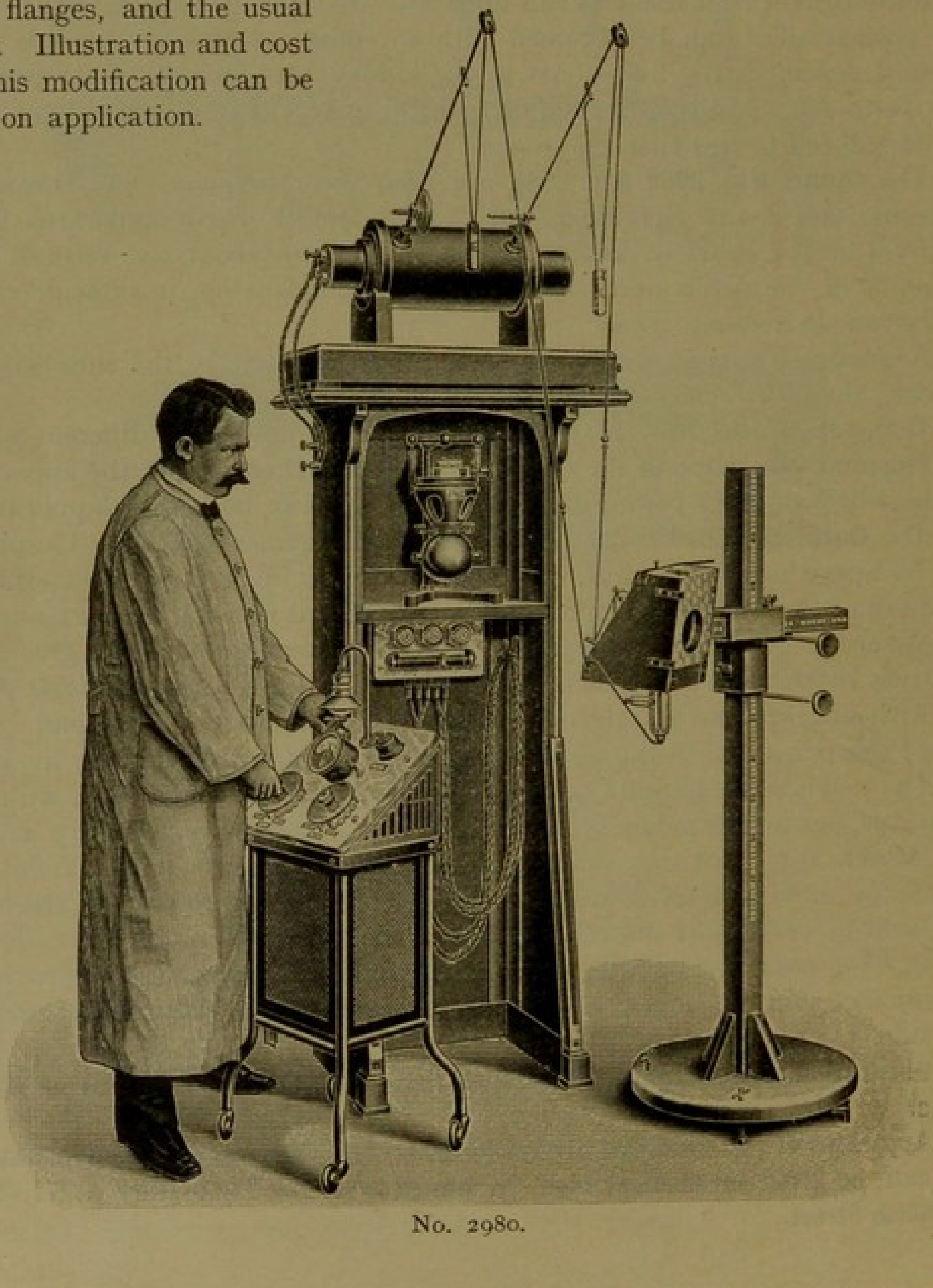
The pelvis of *thin* adults can also be taken with one single flash with the apparatus, but for the pelvis of *stout* adults 2 or 3 flashes are necessary at present (March, 1911), but they can be given in rapid succession, within about one second, by moving a lever of the special mercury interrupter; or else time exposures of very short duration can be made by switching on the ordinary mercury (or electrolytic) interrupter with which the apparatus is provided Examinations on the screen, and exposures for therapeutic purposes, can also be made.

Illustration, prices, and full details of these apparatus will be sent on application.

Apparatus of this kind can always be inspected, and practical demonstrations of it can be given to medical men, in our New X-ray Laboratory at 71, New Cavendish Street.

No. 2977. **Complete Outfit,** consisting of: 12 in. Spark Coil, No. 2507. Mackenzie Davidson Interrupter, No. 2540. Switchboard, on marble, provided with variable rheostat for coil, ampèremeter, switches for coil and motor, fuses, etc. Bracket to be fixed on the wall, to hold coil, interrupter, and switchboard. Tube Stand No. 2612, with box lined with X-ray proof material to enclose the luminous part of the tube, and 3 diaphragms, 2 Tubes, No. 2583, Cables and connecting wires **£48 10 0**

The cost of Outfit No. 2977 can be reduced by £5 if the tube stand No. 2612 is replaced by No. 2611; the price can be further reduced somewhat if the spark coil is enclosed in an oak case, instead of having an ebonite mantle and flanges, and the usual base. Illustration and cost of this modification can be had on application.



No. 2980.

No. 2980. **Complete Outfit,** *Fig.* 2980, consisting of: 16 in. Spark Coil, No. 2509. Record Interrupter, No. 2542. Switchboard, on trolley, with variable rheostats for coil and for motor of interrupter, ampèremeter, lamp, switches, fuses and terminals. Cabinet, 19 in. deep, 36 in. wide, and 69 in. high, as shown in illustration. The switchboard, while not in use, is placed in the lower part of the cabinet. Tube Stand, No. 2612, with box lined with X-ray proof material to enclose luminous part of the tubes, 3 flat diaphragms, and 1 cylinder diaphragm, No. 2613. 2 Tubes, No. 2589, with automatic regulation. Cables and connections **£75 0 0**

No. 2982. **Complete Outfit,** as specified under No. 2980, but *with the following instruments added*: Fluorescent Screen, No. 2643, 9½ × 12 in., with lead glass plate and protecting handles. Accelerating Screen, No. 2658D, 12 × 15 in. Cassette, No. 2856, 12 × 15in. Milliampèremeter, No. 2661, with Bracket, No. 2661B, to suspend it on tube stand. Wehnelt Radiometer, No. 2663. Slide Rule, No. 2666, for calculating duration of exposure. Two Focus Tubes, No. 2589, with automatic regulation. Spark Gap, No. 2603. Bracket, No. 2920. Couch, No. 2711 .. .. **£100 0 0**

If the apparatus Nos. 2977 to 2982 are required for an *alternating* current, the addition of a Motor Transformer, No. 2680, is recommended. This transformer converts the alternating into a continuous current of 110 volts and 10 ampères, which is ample for this coil and interrupter. The prices quoted for Nos. 2980 and 2982 will then be increased by £**30**.

If no current from the main is available, either 12 to 15 accumulator cells, or an engine with dynamo may be used, prices will be sent on application.

No. 2990. **Complete Outfit,** consisting of: 16 in. Spark Coil, with variable self-induction. Mercury Record Interrupter, No. 2542. Multiple electrolytic Interrupter, No. 2553B. Switchboard, No. 2678, *with automatic time release.* Three X-ray Tubes, No. 2590. Two X-ray Tubes, No. 2592. Six self-centring Tube Holders. One Valve Tube, No. 2601. Bracket to suspend valve tube, No. 2601H. Tube Stand, No. 2617, with stereoscopic arrangement. Couch, No. 2711. Fluorescent Screen, No. 2643, 9½ × 12 in., with lead glass plate. Accelerating Screen, No. 2658D, 12 × 15 in. Casette, No. 2856, for plates up to 12 × 15 in. Milliampèremeter, No. 2661. Wehnelt Radiometer, No. 2664. Slide Rule, No. 2666. Bracket, No. 2921. Cables and connecting wires **£150 0 0**

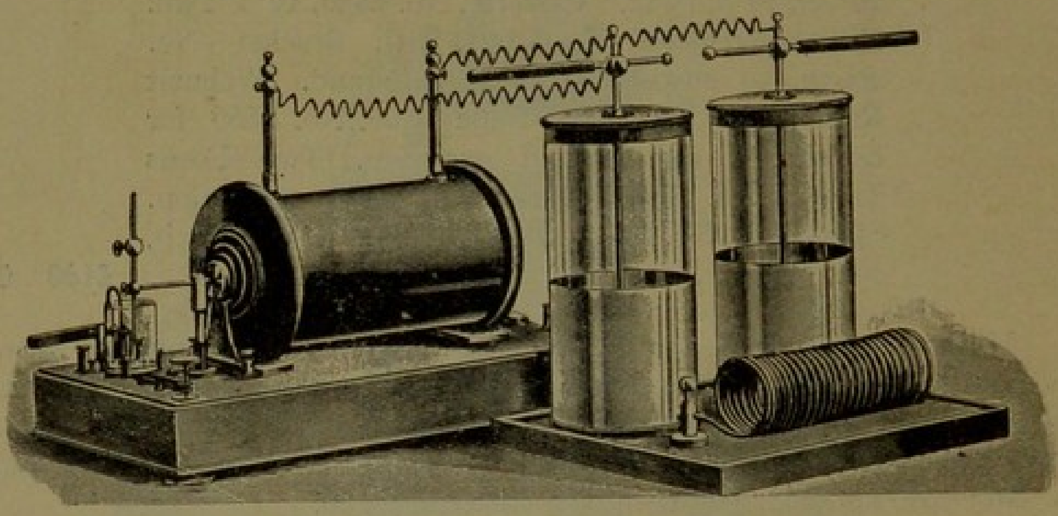
As supplied to Dr. Ironside Bruce, London; Dr. Harris, Sydney; Mr. Coldwell, London; Grimsby and District Hospital, Grimsby; Stanley Hospital, Liverpool; The Hospital, Dunedin; etc., etc.

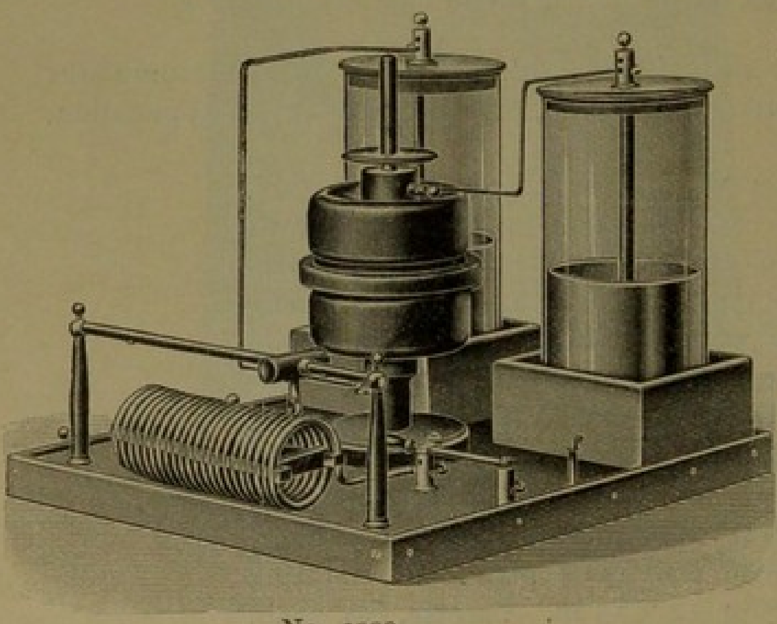
Estimates for Other Outfits will be sent on application.

Experts can be sent at moderate charges to any part of Great Britain, to connect the apparatus, and to give our customers Practical Instruction in making X-ray negatives.

Medical Men can receive Practical Instruction in making X-ray Negatives, by appointment, in our new X-ray Laboratory at 71, New Cavendish Street, London.

APPARATUS FOR HIGH-FREQUENCY CURRENTS.

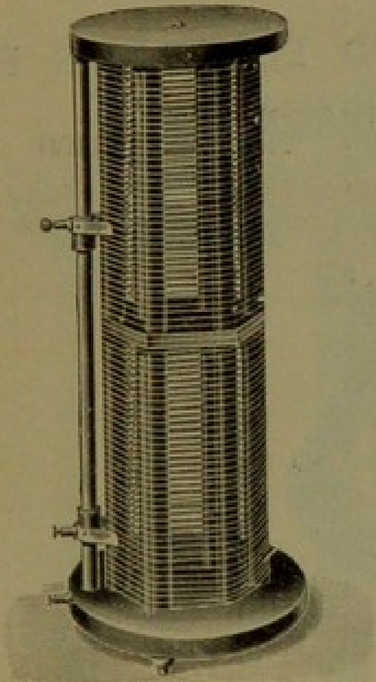




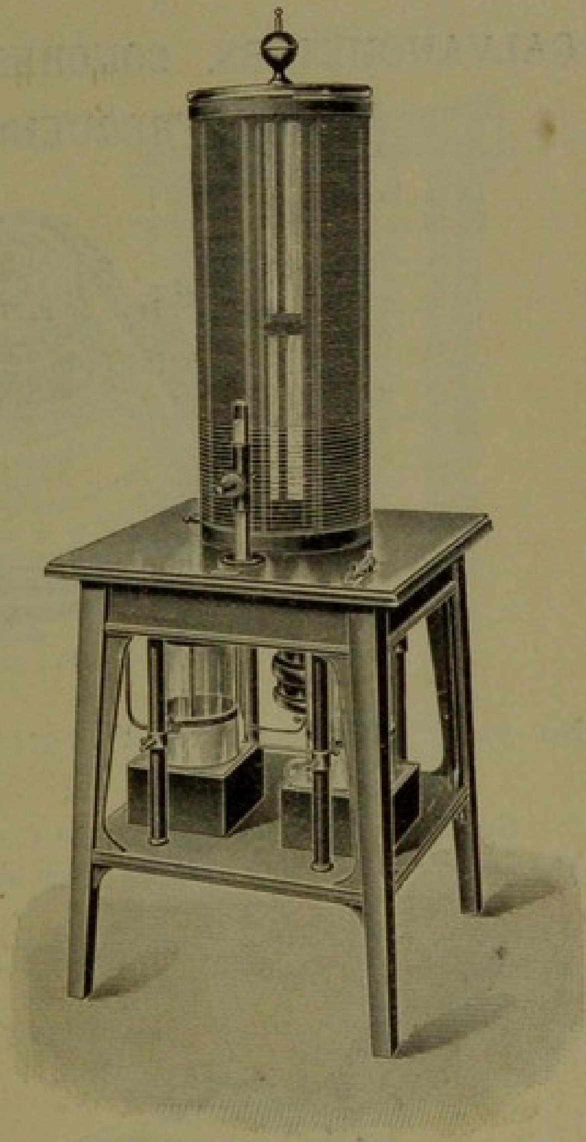
No. 3000.

No. 3000. **D'Arsonval's Transformer,** Fig. 3000, consisting of two large Leyden jars, adjustable spark-gap enclosed in a case with glass windows, solenoid of stout copper wire with sliding contact to insert more or less turns, switch and terminals .. **£6 0 0**

Size of the Leyden jars: Diameter $6\frac{1}{2}$ ins., height 14 ins.



No. 3012.



No. 3032.

No. 3010. **Oudin Resonator,** wound on a wooden frame, with one fixed and two adjustable terminals; diameter of the resonator 9 inches, height 20 inches .. **£3 15 0**

No. 3012. Similar resonator, but larger size, Fig. 3012; diameter 12 inches, height 34 inches .. **£4 9 0**

No. 3032. **Apparatus,** consisting of d'Arsonval transformer, No. 3000, with large Leyden jars, spark-gap, and resonator, No. 3014, arranged on a table of polished mahogany, as shown in Fig. 3032 .. **£16 10 0**

Size of the apparatus: 21 in. by 21 in., total height 62 in.

(As supplied to H. Lewis Jones, M.D., E. R. Morton, M.D., W. Tyrrell, W. M. A. Anderson, F. Little, F. W. Morison; Royal Infirmary, Edinburgh; London Hospital; St. George's Hospital, Royal Victoria Hospital, Belfast, etc., etc.)

If a separate small tuning spiral is added, the price of the apparatus will be **£17.**

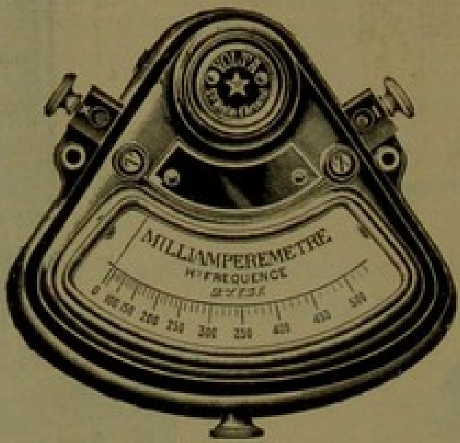
[*Copy of an unsolicited Testimonial.*]

SUNDERLAND, *Sept. 27th*, 1910.

I bought a High-Frequency Installation which you supplied to the late Dr. Daglish, of this town. Allow me to congratulate you on the workmanship.

JAMES B. WATERS, M.A.,
(*In charge of the Electrical Department*).

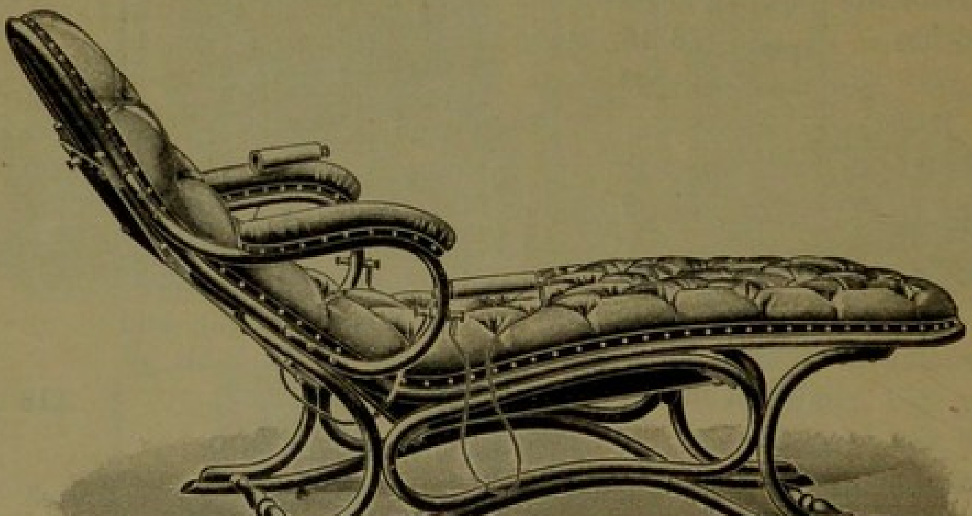
GALVANOMETERS, COUCHES, AND ELECTRODES FOR HIGH-FREQUENCY CURRENTS.



No. 3041.

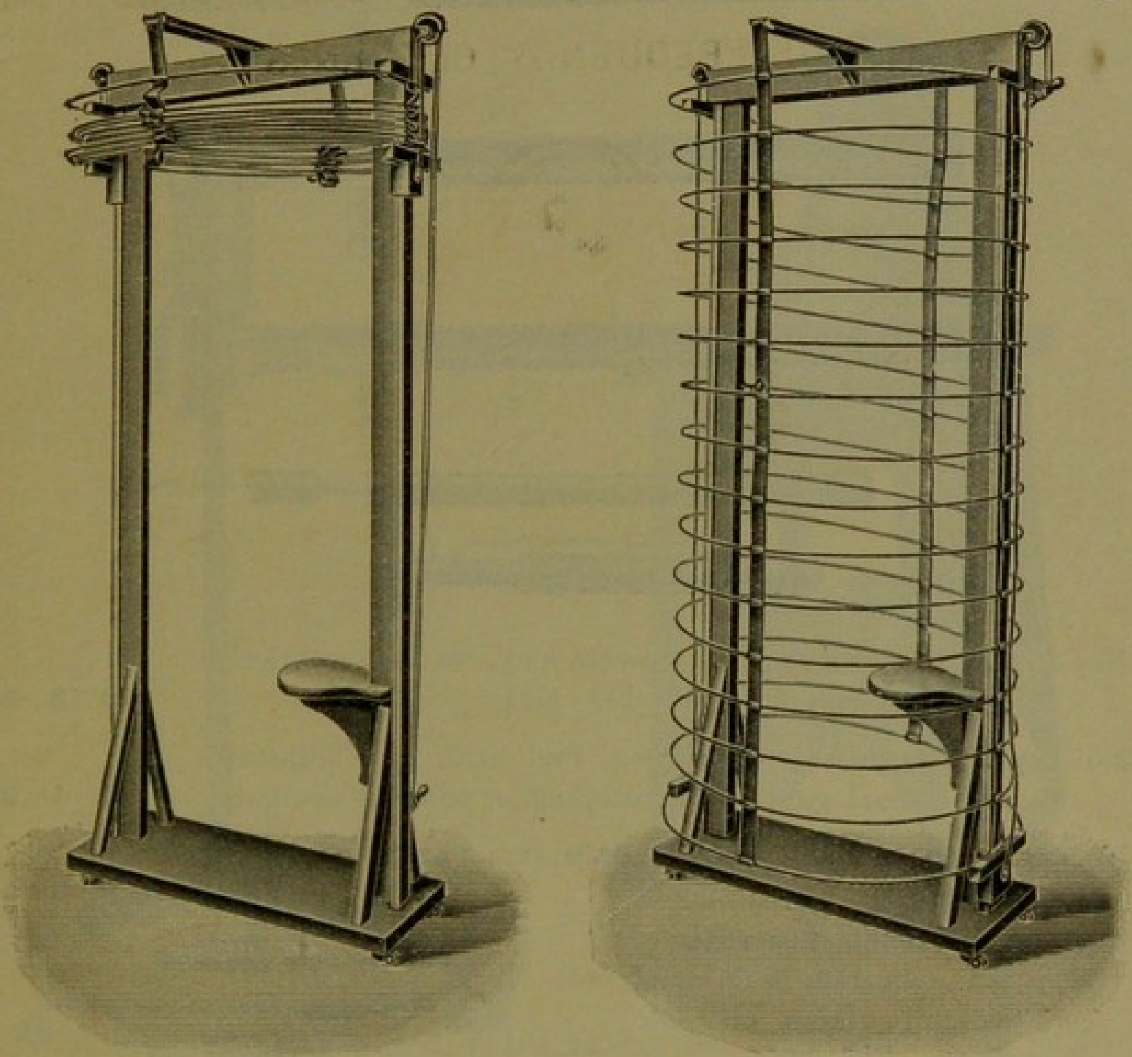
No. 3041. **Milliamperemeter,** Fig. 3041, registering up to 500 milliampères **£4 4 0**

Galvanometers registering up to 1,000 milliampères can be made to order. The prices are the same as those given above.


No. 3051.

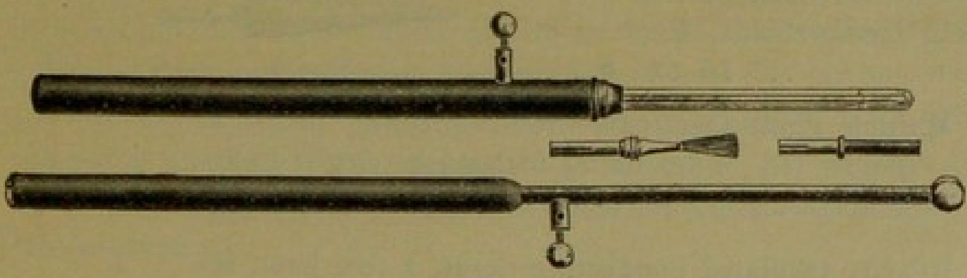
No. 3051. **Condensating Couch,** of Austrian bentwood, thick horsehair mattress covered with dark leather, insulated zinc sheet, and two large electrodes, Fig. 3051 .. .. **£9 0 0**

If covered with cloth only, the couch will be **30/-** cheaper.



No. 3055

No. 3055. **Solenoid**, Fig. 3055, to enclose the patient. It can be raised or lowered like a Venetian blind £12 6 0

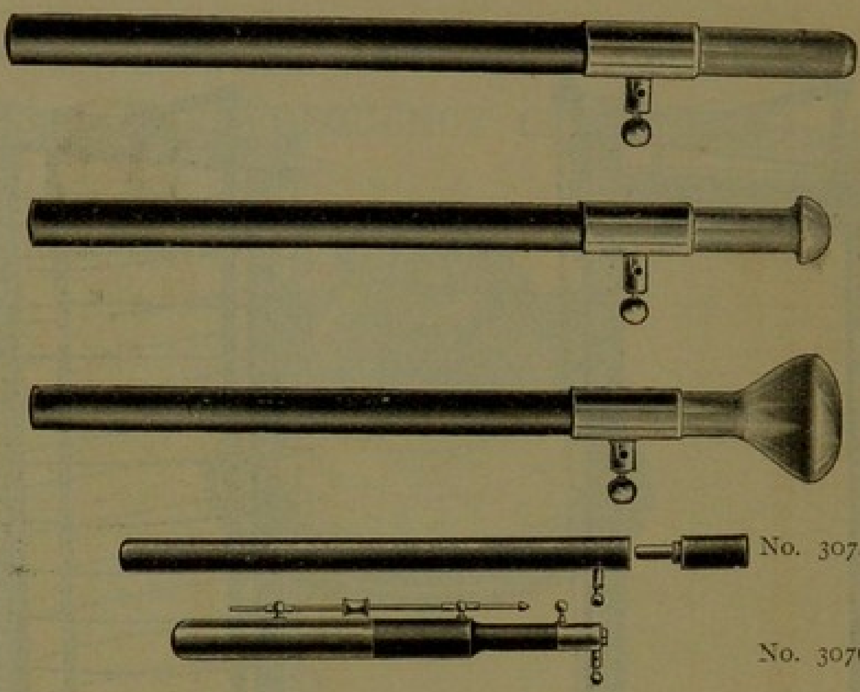


No. 3070.

No. 3072.

No. 3070. **Oudin's Condensator Electrode,** Fig. 3070 .. .. 0 15 0

No. 3072. **Ebonite Handle,** Fig. 3072, for the reception of brush, point, ball, etc., electrodes 0 12 0



No. 3074.

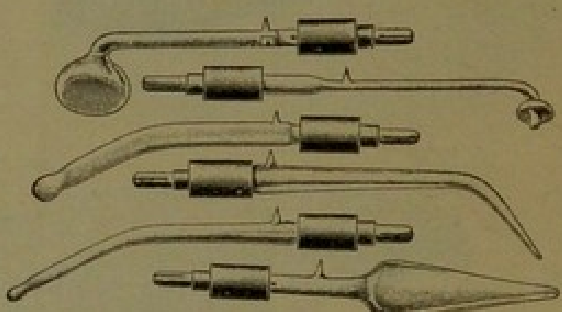
No. 3076.

No. 3074.	**Similar Handle,** 12½ inches long, for the reception of vacuum electrodes, Fig. 3074	£0 12 0
No. 3076.	**Handle,** 12 inches long, Fig. 3076, with adjustable spark-gap, for the reception of different electrodes	1 1 0
No. 3080.	**Metal Points, Brushes, Balls,** etc., for handle No. 3072, each	0 2 6

No. 3084. **Vacuum Electrodes** of glass, for application to the skin, ear, rectum, uterus, etc. (see illustrations, Fig. 3084) each £0 7 0

No. 3085. **Complete Set of Six Vacuum Electrodes,** including handle No. 3074 .. £2 12 0

No. 3090. **Conical Electrode** of thin hollow metal, nickel-plated, for treating hæmorrhoids, Fig. 3090 .. .. .. £0 12 6



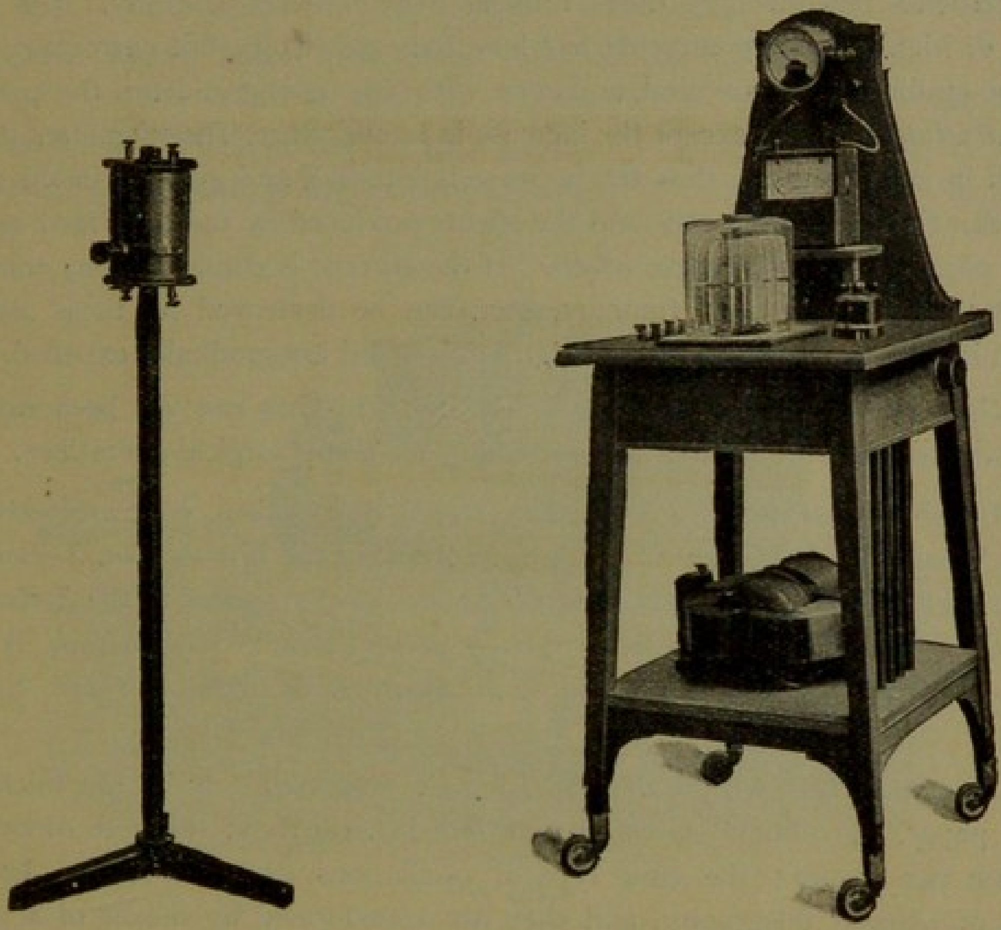
No. 3084.

No. 3090.

No 3092.	**Multiple Point Electrode,** with twenty-five points in ebonite cup, diameter 2½ inches (the electrode fits handles Nos. 3072—3076)	0 18 0
No. 3140.	**Heavily Insulated Conducting Cords,** 5 feet long, for high-frequency currents .. .. per pair	0 14 0

Estimates for complete installations, including spark coil, interrupters and switchboards, and references to literature about this subject, will be sent on application.

THERMO PENETRATION, OR DIATHERMY.



No. 3200

A new method has been found of raising the temperature of the human body. It is well known that pain is relieved, some micro-organisms are killed, and some deposits of urates, etc., dissolved, if the temperature is raised above the normal. For this reason, and by natural instinct, heat has long been employed in cases of a rheumatic or gouty nature, in neuralgia, sciatica, etc. The hot-air or electric-light baths, the hot-water bottle, etc., do *not*, however, affect the *internal* temperature. If the temperature of a patient sitting in a hot-air bath is examined, it will be found that under the arm-pit it is increased, but in the rectum it is normal or actually below normal, because the heat has drawn the blood towards the skin, and makes the internal organs somewhat anæmic. The perspiration produced by any of these methods acts as a wet blanket, and protects the internal organs against an increase of temperature.

It has been found that with the help of electricity we can raise the *internal* temperature, we can artificially produce *fever, and can localize it, control its intensity and duration.* It can be done by means of a peculiar type of high-frequency currents, which differ materially from those which have been known and used during the last ten years. In the latter we employ over 100,000 volts and from 100 to about 500 milliampères, and the the patients feel stronger doses unpleasantly or even painfully. The new type of high-frequency currents has less than 3000 volts, but currents of 500 to 5000 milliamperes are used, and even with the strongest doses the patient *feels absolutely nothing* except the increase in temperature. Thermometers introduced in animals prove that the increase is internal, and greatest in the path between the electrodes. Beyond the effects produced by the heat, *there are no other physiological or chemical effects.* If the current is employed long enough, albumen coagulates, and tumours, etc., can be destroyed by these means. Coagulated tissues behave like foreign bodies, and are gradually expelled.

Deep local anæsthesia can be produced ; this has not yet been further investigated, but may prove of great utility for many surgical operations.

Excellent results in cases of gonorrhœal rheumatism, etc., are reported from Vienna, by Prof. von Zeyneck and others, in the *Wiener klin. Zeitschrift*, No. 15, 1908, and No. 34, 1909. Other papers have appeared in the *Zeitschrift für Physikal. u. Diaet. Therapie*, Heft 3 und 5, 1909 ; *Med. Klinik. Wien.*, No. 35, 1910 ; *Annales et Bulletin de la Société de Médecine de Gand*, No. 3, 1910.

In a spark-gap where the electrodes are separated only by the thickness of a paper, the undamped oscillations are generated at the rate of over a million per second ; the same type of oscillations are used in von Lepel's type of wireless telegraphy, and they are transformed by means of a small transformer.

As electrodes, the copper-chain electrodes used for ionic medication are very convenient.

COLD CAUTERY.

The same apparatus can be used for the " cold " cautery, which has already been described by Dr. Manders. If one pole is connected with a needle, a small spark, about 0·5 mm. long, discharges if the needle is brought close to the body. A scar forms immediately, so that deep incisions may be made and large tumours can be removed WITHOUT ANY HÆMORRHAGE. This is of advantage in operations on cancer or lupus, etc., where it is of importance that the blood should not carry infected material to healthy parts. By adjusting the spark-gap the length of the spark can be increased, so that fulguration can also be applied with this apparatus.

See v. Czerny, *Deutsche med. Wochenschrift*, No. 11, 1910 ;

No. 3200. Complete Apparatus for Thermo Penetration and for Cold Cautery (Fig. 3200) **£45 0 0**

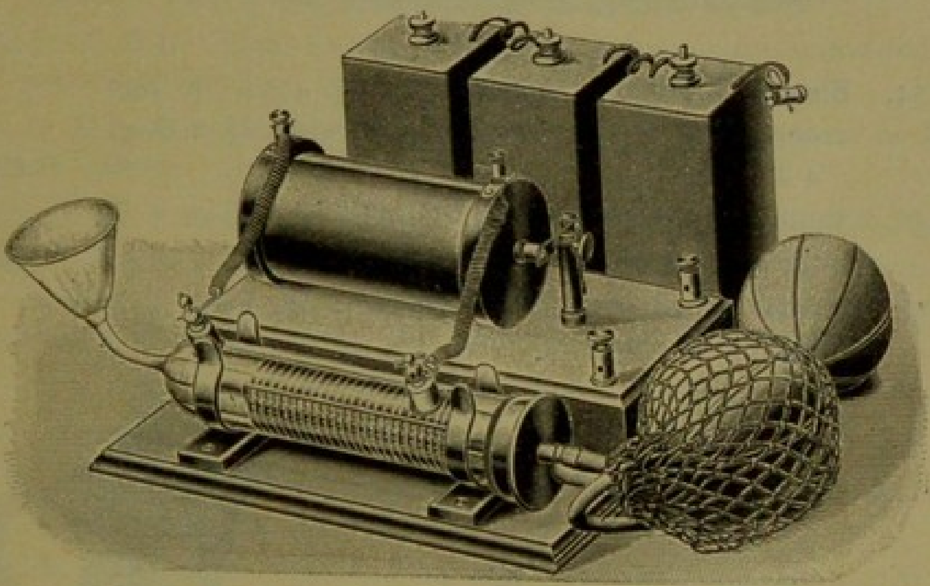
No. 3202. Apparatus for Cold Cautery only **28 0 0**

APPARATUS FOR PRODUCING OZONE.

No. 4200. **Ozone Tube,** with inhaler and double bellows, as shown in Fig. 4212 .. .. £2 2 0

No. 4206. **Spark Coil,** giving sparks of ¼ in. 1 9 0

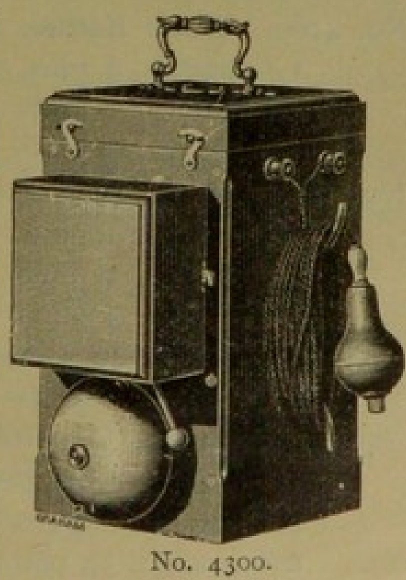
No. 4208. **Spark Coil,** giving sparks ¾ in. long 2 0 0



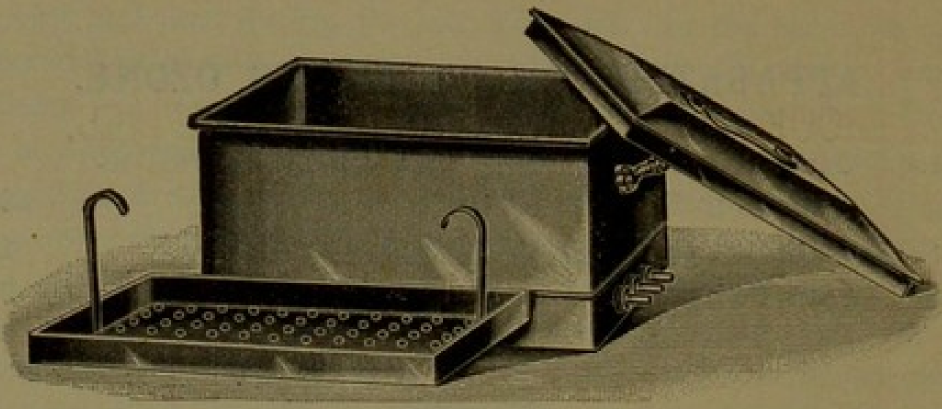
No. 4212.

No. 4212. **Complete Apparatus,** consisting of ozone tube No. 4200, with bellows, spark coil No. 4208, three large Leclanché cells with connecting cords, Fig. 4212 .. .. £4 15 0

No. 4300. **Invalid's Bell,** Fig. 4300, with 12 yards of flexible silk cord, pear push, and dry cells £0 15 0



No. 4300.

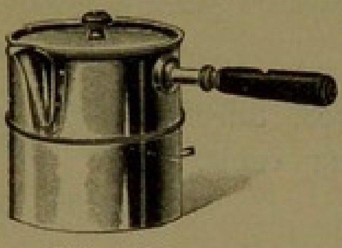


No. 4154.

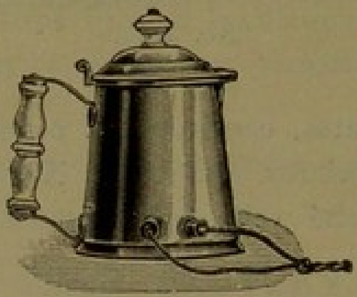
No. 4154. **Electric Sterilizing Apparatus,** Fig. 4154, in rectangular form, size 8 in. long, 4 in. wide, $2\frac{3}{4}$ in. deep; 4 ampères £2 10 0

No. 4156. Similar Apparatus, 12 in. long, 8 in. wide, 5 in. deep; 8 ampères 5 5 0

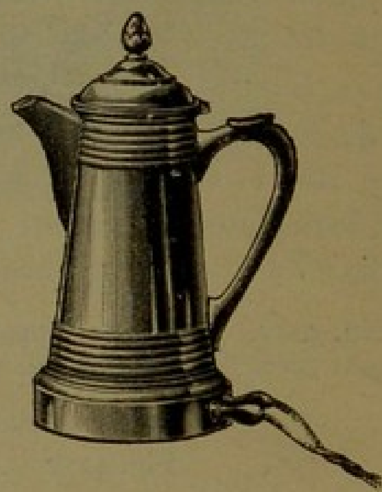
No. 4158. Similar Apparatus, 20 in. long, 8 in. wide, 5 in. deep; 12 ampères 6 5 0



No. 4160.



No. 4163.



No. 4166.

No. 4160. **Water Kettles**, nickel plated, with cables :—

A Capacity, ½ pint	£0 17 0
B Capacity, 1 pint..	1 3 6
C Capacity, 2 pints	1 8 6

No. 4163. **Water Jugs**, nickel plated outside, enameled inside, with cables :—

A Capacity, 1 pint	1 16 0
B Capacity, 2 pints	2 3 0
C Capacity, 3 pints	2 12 0

No. 4166. **Water Jugs**, nickel, with cables :—

A Capacity, 2 pints	1 14 0
B Capacity, 3½ pints	1 19 0
Antique Copper, with cables :—	
D Capacity, 2 pints	1 19 0
E Capacity, 3½ pints	2 6 6

BOOKS ON ELECTRO-THERAPEUTICS.

The books marked (*) can be supplied by us.

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*BRUCE, W. IRONSIDE, M.D. A System of Radiography, with an Atlas of the Normal. 1907. 15s.

CLEAVES, M. A., M.D. Light Energy: its Physics, Physiological Action and Therapeutic Application. 1905. 811 pages. £1 1s.

*DOWSE, T. S., M.D. Massage and Electricity in the Treatment of Disease. 4th edition. 1907. 7s. 6d.

*FENWICK, E. H., F.R.C.S. The Electric Illumination of the Bladder and Urethra.

*FREUND, L., M.D. Elements of General Radiotherapy for Practitioners. Translated by G. H. Lancashire, M.D. With an Appendix by C. A. Wright, F.R.C.S. 1904. 600 pages. £1 1s.

*HARRIS, W., M.D. Electrical Treatment. 1908. 7s. 6d.

*HEDLEY, W. S., M.D. Therapeutic Electricity. 1900. 8s. 6d.

*JONES, LEWIS, M.D. Medical Electricity. A Practical Handbook for Students and Practitioners. 5th edition. 1906. 12s. 6d.

*LEDUC, STEPHANE, Prof. Electric Ions, and their Use in Medicine. 2/6.

*LUKE, THOMAS D., M.D., F.R.C.S. ED. A Manual of Natural Therapy. 1908.

*MORTON, REGINALD, M.D. Essentials of Medical Electricity. 2nd edition. 1909. 7s. 6d.

MORTON, W. J., M.D. Cataphoresis, or Electric Medicamental Diffusion. 1898.

*PUSEY-CALDWELL. The Roentgen Rays in Therapeutics and Diagnosis. 2nd edition. 1904. 600 pages. £1 1s.

*ROCKWELL, A. D., M.D. Medical and Surgical Uses of Electricity. 1904. £1 10s.

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*WALSHAM, H., and ORTON, C. The Roentgen Rays in the Diagnosis of Diseases of the Chest. 2nd edition. 1906. 6s.

*ALBERS-SCHOENBERG, DR. Die Roentgen Technik. 1908. 3rd edition.

*BORDIER, H., DR. Précis d'Electrothérapie. Preface de Mons. le Professeur d'Arsonval. 2nd edition. 1903. 8s.

*BOUCHARD, C. Professeur à la Faculté de Médécine. Traité de Radiologie. Médicale. Paris. 1904. 1,100 pages. £1 6s.

*GUILLEMINOT, H. Electricité Médécale. 1905. 620 pages. 10s.

TERMS FOR LENDING OUT BATTERIES.

The more frequently-used batteries and instruments can be had on hire, on the following conditions :—

If you desire an apparatus on hire, you must mention this clearly when sending the order. When you have finished with it, return it carefully packed, or, if in London, send us notice that we may send for it.

Carriage both ways has to be paid by the customer. *Patients and Nurses are requested to pay half the value of the battery as a deposit.* This money, less the hire, will be repaid when the battery is returned.

If you desire to hire a battery with the option of purchasing it, a *new* instrument will be sent, but the price charged per month will be higher than the prices mentioned below. If you decide to keep it, the amount paid for hire will be deducted from the price of the instrument.

Freshly-charged batteries for Galvanisation, Electrolysis and Faradisation, are lent out for one month or longer. The terms depend on the value of the battery, number of cells and accessories, and vary between 10s. 6d. and 30s. per month.

Batteries and Instruments for Electric Light, and Galvanic Cautery, are lent out at the rate of 10s. 6d. per week, or less ; £1 5s. for a month. For destroyed lamps and platinum burners there will be an extra charge.

In returning batteries, *please put name and address of sender inside* the battery, to avoid mistakes.

TERMS.

Guarantee.—We guarantee our Apparatus for **one year**; i.e., should any defect due to imperfect material or workmanship be discovered within one year from time of delivery, we undertake to make it good free of charge.

Not included in this guarantee are goods which deteriorate even with fair wear and tear, such as cells, lamps, focus tubes, cords, etc.

As references, we have given the names of many well-known members of the medical profession and hospitals using the more elaborate of our apparatus.

The prices mentioned in this Catalogue are subject to 5 per cent discount for cash with order, or on delivery; the prices are net afterwards, and 5 per cent per annum interest is charged on all accounts not settled within six months after delivery.

In ordering, please mention the list number of the apparatus to avoid mistakes. *Detailed printed directions for use are sent with each instrument.*

Orders from abroad from unknown customers will be executed only if a remittance covering at least 25 per cent of the value of the goods is sent with the order. The remainder has to be paid on delivery.

Packing is most carefully carried out, and charged at cost price, but empty boxes cannot be allowed for; the delivery is at cost and risk of consignee. All the frequently-used apparatus are kept in stock, others can be supplied within a reasonable time.

The woodcuts are made from photographs taken from the instruments, but we cannot guarantee every detail to remain as the illustrations show them now. Additional lists of newly constructed apparatus are issued from time to time.

Electro-medical apparatus of every description are promptly repaired. In returning batteries for re-charging or repair, *please put name and address of sender inside* the battery to avoid delays and mistakes.

Second-hand apparatus can occasionally be obtained at considerably reduced prices.

Hospitals and other charitable institutions can obtain special prices on application.

Competent assistants can be sent at moderate charges to any part of the country to erect the apparatus and instruct the owners in their management.

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