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Electro-Medical Instruments And their Management,

AND

ILLUSTRATED PRICE LIST OF ELECTRO-MEDICAL APPARATUS,

BY

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CONTENTS OF "ELECTRO-MEDICAL INSTRUMENTS AND THEIR MANAGEMENT."

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 fourteen years ago. Since that time many Medical Men assured me that it has been a help to them, and this encouraged me not only to republish, but also to enlarge it considerably, hoping that the new chapters may be found useful too.

1905. K. SCHALL.

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 çan 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 one by one, 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 very strongly. This shows that the electricity in the glass bar is not the same as the electricity in the stick of wax; that is to say, there are two kinds of electricity. 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, silk, ivory, 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, however, a third class of materials, which do not conduct electricity nearly as well, as, for instance, metals do, but which still conduct it decidedly 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 and convenience 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.

By rubbing a glass stick, we have separated the positive and the negative electricity contained in the stick: the positive electricity remained in the glass bar; the negative passed through the rubbing cloth and the body of the rubbing person into the earth. In rubbing a metal stick we separate the two kinds of electricity in the same way; but we can prove this only by insulating one end of the metal stick, for instance, by cementing it into a glass tube, and holding the glass tube in our hand while rubbing the metal. If we were to touch the non-insulated metal stick, the separated negative and positive electricity would get re-united again immediately through the body of the rubbing person, and would leave no trace at all.

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. Copper immersed in sulphuric acid becomes negatively electric, but not so strongly as zinc. 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. This order changes slightly with various liquids, but not very much. In diluted sulphuric acid, for instance, the most important metals follow one another as follows: Zinc, iron, lead, nickel, bismuth, copper, silver, platinum, carbon.

By immersing at the same time two different metals, the one of which gets negatively, and the other positively, electric, in the exciting liquid, 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. Some special kinds of cells will be mentioned later on. The following list shows the different metals and exciting liquids of which the cells mostly used in medical electricity are composed, as well as their respective E.M.F.'s.

If the E.M.F. of a Daniell cell, *i.e.*, zinc in diluted sulphuric acid, and copper in saturated solution of sulphate of copper, is equal to 1, the following combinations would be equal to :—

Chloride of silver, diluted chloride of ammonium, or chloride of zinc solution, zinc (De la Rue's cell) . . .	1·0
Manganese and carbon, saturated chloride of ammonium solution, zinc (Leclanché cell)	1·5
Carbon, bichromate of potassium, diluted sulphuric acid, zinc (Grenet cell)	1·8
The same element with bisulphate of mercury instead of bichromate	2·0

Arrangement of Cells.—The above list shows that no single cell possesses an E.M.F. higher than two units, if we take that of the Daniell cell as one unit. For reasons, however, which we shall explain later on, 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"; it is the most frequently used method of connecting cells. There are, however, 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. For instance, one yard of copper wire allows ten times as much electricity to pass as one yard of German silver wire under otherwise equal conditions. It would be more correct to say that German silver has ten times the resistance of copper. The following table shows the resistance of some materials; wires of one metre length and one millimetre sectional area have the following resistance :—

Copper	0·056	Units
Iron	0·24	"
Platinum	0·35	"
German silver	0·47	"
Carbon, as used for incandescent lamps	76·0	"
Salt water	950000·0	"
Diluted sulphuric acid, 1 to 11	2800000·0	"
Distilled water	100000000·0	"

The resistance of a body depends on its length and diameter.

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, for instance, 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. The internal resistance depends on the conducting capacity of the exciting liquid, and, moreover, if the size of the metal plates gets increased, the resistance gets diminished accordingly, and *vice versa.* If the external resistance is great, 500 or more ohms, the internal resistance of the battery can be practically neglected; if the external resistance is, however, as small as, for instance, in a cautery burner, the internal resistance is of great importance. Some examples will follow later on.

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 metals of a cell are connected by a conductor, or to express it shorter, as soon as the current is closed, bubbles of oxygen gas appear on the negative, and bubbles of hydrogen gas on the positive, metal.

The quantity of the produced gas is exactly in proportion to the strength of current. In a cell consisting, for instance, of zinc, sal-ammoniac and silver, the silver gets 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 very considerably in consequence of this formation of gas, and therefore 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 the metals, or blowing air into the fluid, in order to get rid of the bubbles mechanically, by simply shaking them off, 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 the Bunsen or Grove cell contains nitric acid, the Grenet cell chromic acid, the Leclanché cell manganese di-oxide, and the chloride of silver cell chlorine.

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, for instance, in which the depolarisation is slower and 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. In order to get a current of even strength out of an inconstant element, the size of the cell should be made rather large in proportion to the current it has to supply, in order to have always a spare surface which is not yet covered with gas.

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. These measures were at first arbitrary and varied in different countries; an International Congress of Electricians, however, decided this matter in Paris in 1881. It was agreed there to derive the electrical units from the generally recognised measures for length, weight and time (centimètre, gramme and second) in order to be able to compare the effects produced by electricity with those produced by other physical forces, such as magnetism, heat, light, etc., 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 and usefulness 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 E.M.F. of a Daniell cell is = 1·07 volt).

The unit of **resistance** is 1 **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 1 **Ampère.** It is the current which an E.M.F. of 1 volt produces in a circuit, the resistance of which is 1 ohm. A current of 1 ampère deposits 4·08 grammes silver per hour, or develops 171·9 cubic millimetres mixed gas per second, if sent through water. 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, in accordance with a proposal made by Dr. de Watteville. 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.

There exist other units besides these; for instance, 1 coulomb is the work 1 ampère can do in one second; 1 farad is the unit for electrical capacity. For our purposes, however, there are only volts, ampères and ohms of importance.

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 current is diminished; 5 volts can send 1 ampère only through 5 ohms, or only $\frac{1}{2}$ 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, which is as simple as it is important, 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. No knowledge of higher mathematics is needed in order to understand it, and he who takes the trouble to grasp and learn to use it, will be amply rewarded for his small pain by finding hardly any more theoretical difficulties afterwards in using and regulating his batteries. 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.—Should the same battery be used for electrolysis, a method where the resistance of the body is generally much smaller in consequence of the different size and application of electrodes, say 220 ohms, the current it would yield would be

$$\frac{45 \text{ volts}}{(30 \times 0{\cdot}8) + 220 \text{ ohms}} = 0{\cdot}1844 \text{ ampère or} = 184{\cdot}4 \text{ milliampères.}$$

3.—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

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

4.—This current is sufficiently strong to render many of these little lamps incandescent, but if in consequence of polarisation, or of small crystals which cover zinc and carbon gradually, the internal resistance has increased up to 1·6 ohm, the battery would be too weak to bring the carbon filament to white heat, for

$$\frac{45 \text{ volts}}{(30 \times 1{\cdot}6) + 22 \text{ ohms}} = 0{\cdot}642 \text{ ampère or} = 642 \text{ milliampères.}$$

5.—If the same battery is connected with a platinum burner, such as are generally used for galvanic cautery, and which have 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 9 to 18 ampères in order to get red hot.

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

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

7.—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.

8.—Two very small bichromate cells, which have the same E.M.F., but ten times more internal resistance, would give exactly the same amount of current as the two large cells with a *high* external resistance, for :

$$\frac{4 \text{ volts}}{0{\cdot}6 + 4800 \text{ ohms}} = 0{\cdot}0008 \text{ ampère or } = 0{\cdot}8 \text{ milliampère.}$$

We shall refer to some of these examples later on.

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 as follows :

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

9.—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 :—

10.—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, gets 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. Electrolysis has been chiefly investigated by Faraday, but its theory is very complicated, and not at all sufficiently solved yet. As far as we know, the chemical changes take place *at* the poles only, but ***not between them***.

If electrodes are placed on the human body, and the current is suddenly closed, or suddenly 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 ; alternating currents of very high frequency produce local anæsthesia ; the circulation of the blood and the nutrition of the tissues get stimulated.

The current heats metallic conductors, carbons, etc., in passing through them. Bad conductors get more heated than good ones. If a current of 12 ampères passes through a platinum wire of about 0·6 millimetre diameter, the wire gets red hot, so that it can be used for burning away tumours, etc. ; and if a current of about 0·75 ampère passes through the thin carbon filament of an incandescent lamp, the lamp gives a brilliant white light, which we use for illuminating our houses, and for examining cavities of the body.

APPARATUS FOR GALVANISATION AND ELECTROLYSIS.

The Resistance of the Human Body varies widely. If two small metal electrodes of one centimètre diameter each are placed on the *dry* skin, the resistance will be near 100,000 ohms. If we use, however, larger electrodes, about 5 centimètres 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 get less, within a short time, under the influence of the current itself. If we introduce an electrode into the rectum or vagina, and place a large electrode, 8 inches diameter, on the abdomen, the resistance will be about 150 ohms, or even less. The same result is obtained by pricking the skin with a few needles, for it is principally the skin which offers the great resistance, whereas the blood, etc., conduct comparatively very well. Still, we have at any rate 100, and 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 100, or even more milliampères.

Which are the most suitable Cells?—It is not our intention to enumerate all the cells which have been invented since Volta till to-day. On the other hand, it is impossible to give the preference to one certain cell under all circumstances, as the wants and wishes differ very much. *Any* cell can be used which is capable of yielding the desired strength of current, but if we consider convenience, the time necessary to keep a battery in working order, its portability, etc., the number of useful cells will be reduced to very few indeed, and these few only will be mentioned here.

In choosing a battery, it is a consideration whether it can be charged by the proprietor himself, or whether it has to be returned to the maker when exhausted. In the latter case, the battery would be suitable for those medical men only who live in convenient reach of the manufacturer. The capacity of the battery, *i e.*, the amount of current which it will yield before having to be recharged, the cost of recharging, the price of the battery, and its size and weight, are important.

E.M.F. of the Cells.—It stands to reason, that cells with high E.M.F. and small internal resistance have a considerable advantage over cells with low E.M.F. and high internal resistance ; for 50 chloride of silver cells with 1 volt and 8 ohms internal resistance each, will yield with an external resistance of 2,500 ohms,

$$\frac{50 \text{ volts}}{(50 \times 8) + 2500 \text{ ohms}} = 0{\cdot}0172 \text{ ampère, or } = 17{\cdot}2 \text{ milliampères,}$$

whereas 22 bichromate cells of 2 volts and 0·3 ohm each would yield in the same case

$$\frac{44 \text{ volts}}{(22 \times 0{\cdot}3) + 2500 \text{ ohms}} = 0{\cdot}0175 \text{ ampère, or } = 17{\cdot}5 \text{ milliampères.}$$

In order to obtain 17 milliampères with 2,500 ohms external resistance, we should therefore require 50 cells of 1 volt each, whereas the same result could be obtained already with 22 cells of 2 volts each ; and, of course, with this latter kind of cells, the batteries are smaller and less expensive in every way, on account of the smaller number of cells.

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, consequently, the zinc may remain constantly immersed in the exciting fluid.

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 in every way more convenient than the Leclanché cell, provided that its size be not reduced too much for portability's sake. Its E.M.F. is good, 1·5 volt, and the internal resistance is moderate, 0·1 to 1 ohm, according to the size of the cell. As long as the circuit is not closed, there is theoretically none, and, practically, very little local action. It is always ready for use, and a well constructed cell will last for over two years without having to be seen to during this time. Moreover, every part of these cells is so easily accessible that they can be cleaned and refilled without technical aid. In order to clean Leclanché cells, the crystals which stick to the carbons and zincs have to be scraped off with a knife, carbon and glasses should be washed, and after the cells have been put together again, they are refilled with a saturated solution of pure sal ammoniac.

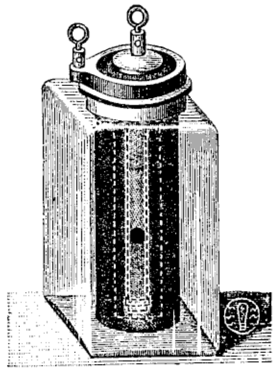


Fig. 1.

With Leclanché cells, as with most other cells, it is of the greatest importance not to select them smaller than absolutely necessary, for the smaller they are made the less satisfactory they get. Many attempts have been made to make them as small as 1 by 1 by 4 inches, but they have invariably failed up to now. The constancy of such small Leclanché cells is insufficient, and for various reasons the local action is greater in the small cells than in the large ones.

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 liquor to be spilled or to corrode the brass parts, and there is no glass, etc., to get broken. Their internal resistance is a little lower, and their E.M.F. a little higher than that of the liquid Leclanché cells. They can be sent charged all over the world, and are very suitable for all 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 to four years without requiring recharging, and they are less likely to require repairs than those filled with liquor, because accidents like the smashing of glasses, and spilling of corrosive fluids cannot happen, so that the difference in the cost of maintaining the batteries is not quite as great as it appears at first sight. The new cells can be sent by post, and can easily be put into the place of the old ones, so that the battery itself need not be returned to the maker.

It is an important question which of the many dry cells at present on the market are the best. Comparative tests of various types have been published in electrical papers, but though we have no doubt that the experiments were made by competent men in good faith, we nevertheless consider most of these experiments as misleading, for they refer only to *new* cells, while for our purposes it is of little interest what the cells will do while they are *new*, whereas it is all important how they will *keep* and what they will do when one, or two, or more years old. We have had samples of most of the existing dry cells, but as far as our experience as to *durability* is concerned, Hellesen and Obach's cells seem to surpass all the others. An example will show this best. We have taken 6 new Obach cells (S size) and 6 cells of another frequently used type, of the same size and shape, which we will call the C cells. The cells gave the following results :—

External Resistance.		October, 1895.	October, 1896.	January, 1899.
Obach cells 1,000 ohms	...	1·5 M.A.	1·4 M.A.	1·2 M.A.
„ „ 100 „	...	15·0 „	14·0 „	10·0 „
„ „ 10 „	...	140·0 „	125·0 „	65·0 „
C „ 1,000 „	...	1·5 „	1·1 „	0·0 „
„ „ 100 „	...	14·0 „	10·0 „	0·0 „
„ „ 10 „	...	140·0 „	50·0 „	0·0 „

This shows that the Obach cells have lost not more than about 3 per cent. in one year, while the C cells have lost 60 per cent. and are practically useless.

If another proof were wanted it is this : we have sold, during the last fifteen years, over 100,000 Hellesen and Obach cells, and not a single complaint has reached us about batteries charged with these cells. (N.B.—We refer here to batteries for *galvanisation and electrolysis only*.)

Acid Cells.—As far as cleanliness and convenience are concerned the acid cells have decided 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; although lately these defects have been considerably improved by means of suitably shaped vessels and india-rubber floats. 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 those countries where technical help is difficult to be had, such as the Colonies, and, moreover, for those medical men who do not use their batteries regularly. It takes no more than an hour to clean the battery and put it in working order again, even if it has stood unused in a corner for years. They have, moreover, the advantage of being very powerful. They have a very high E.M.F., 2 volts, and less than 0·05 ohm internal resistance, so that 22 acid cells are even stronger than 30 Leclanché cells. They are specially suitable for the strong currents required for electrolysis. The zincs last several years with average use, and can be easily replaced without technical help, so that the owner of such a battery is really independent of the maker. All acid cells consist of carbon and zinc, and various solutions are recommended for them ; we prefer a solution of 1 oz. of bichromate of potassium, 20 ozs. of water, 2 ozs of strong sulphuric acid, and 1 oz. of bisulphate of mercury. In order to clean the cells, the vessels have to be filled with water, and the elements should be left soaking in them, over night, to dissolve crystals, etc.

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 will be able to obtain the strongest currents usually applied to the head with 18 to 24 Leclanché cells ; that is, with 25 to 35 volts. General practitioners, surgeons and specialists for gynæcology use as a rule batteries of about 40 volts, and 50 to 80 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. This demand is often the cause why elements are destroyed, as we shall see later on. Moreover, the cells should be put in the circuit one by one, not five by five, etc., as this would also cause shocks.

Crank Collectors are most frequently used. 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 very 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 with all crank collectors, not to let the crank rest so that it can touch two pegs at the same time, as Fig. 2 shows; the crank should always touch one peg only, as shown in Fig. 3. The number next to the peg on which the crank rests shows the number of cells in action. This kind of collector is convenient, but they have one drawback yet especially if used with batteries containing a great number of cells, viz., that by being always put in the circuit, the first cells of the batteries get used up quicker than the last ones.

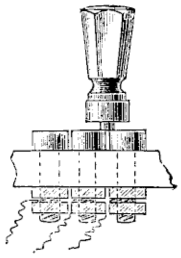


Fig. 2.

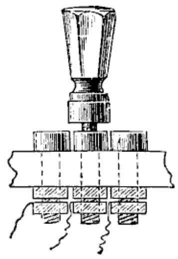


Fig. 3.

Double Collector.—In order to avoid this drawback, I have constructed the double collector. It has two cranks, which are placed on the same axis, but are insulated from one another, and the zinc of the first cell is not connected any more with a terminal, but with an additional peg 0. One crank is connected with the positive, and the other with the negative terminal. By means of these two cranks any batch of cells may be inserted, and thereby the whole battery can be used up evenly. An index fitted to one of the cranks points to a division, thus showing the number of cells in action. Finally, by means of the double collector, each single cell can easily be connected with a galvanometer, and tested, so that damaged or exhausted cells may be found out without trouble. In this way the double collector is a great convenience in testing the battery, and no doubt it is the best current collector known up to now.

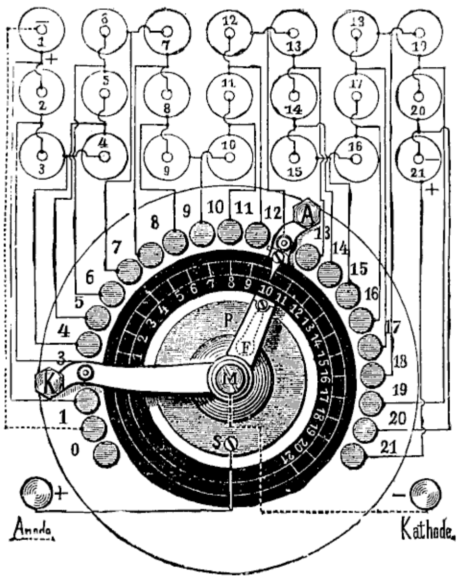


Fig. 4.

Rheostats.—Batteries provided with a good current collector need no rheostat as a rule, but for eye, brain, ear, and dental purposes a rheostat may be wanted. Rheostats may be used instead of the current collector as a means of regulating the strength of current. In order to reduce the current of a battery of 45 volts to about ½ milliampère, the resistance required would be, according to Ohm's law :—

$$\frac{45 \text{ volts}}{0{\cdot}0005 \text{ ampère}} = 90000 \text{ ohms},$$

and it should be possible to diminish this resistance *gradually*, in order to avoid all shocks in increasing the currents.

Liquid Rheostats.—Liquid rheostats have the advantage of cheapness. They consist generally of a glass tube, the lower end of which is closed with a piece of platinum, which acts as one electrode. The second electrode is a piece of zinc, which may be moved up and down in the glass tube. If the tube is filled with some badly conducting liquid, and the piece of zinc is drawn out as far as possible, the resistance is greatest. The number of ohms depends on the length of the tube, the diameter of the electrode, and the conducting capacity of the liquid. The resistance gets diminished by moving the zinc downwards. As decomposition must take place in these rheostats too, small gas bubbles form on the electrodes, changing the surface of the electrodes and the resistance continually. In order to prevent this, a depolarising substance, for instance, chloride of zinc, is mixed with the water. A weak solution of chloride of zinc, however, depolarises only a little, and would therefore prevent the gas bubbles only with very weak currents ; but a strong solution of chloride of zinc conducts pretty well, and in order to obtain, nevertheless, a high resistance, the glass tube would have to be very long, a thing which is impossible with portable batteries, and on account of these difficulties the use of liquid rheostats will always be limited.

Metal Rheostats.—Metal rheostats are most frequently used. They are the only suitable ones for measuring purposes, as they are the most accurate and the least subject to changes. The metal rheostats for medical purposes are provided with a crank like the current collectors ; each peg is connected with its neighbour's with long and fine German silver wire, through which the current has to pass, till it reaches the peg on which the crank rests. In order to obtain high resistances without making the number of ohms between the various pegs too great, a good many pegs are necessary. As a rule, several crank rheostats are arranged so that the first increases the number of ohms 10 by 10 up to, say, 200 ohms, the second 100 by 100 up to 2,000, &c. Such rheostats are convenient, but they are big and costly. They are, as a rule, used for the more expensive office batteries only.

Graphite Rheostats.—Convenient and inexpensive rheostats of low or high resistances may be made of graphite, and they can be so arranged that the current can be varied without giving any shocks. The only disadvantage of graphite rheostats is that the conducting capacity of the graphite varies ; this makes these rheostats quite unfit for measuring purposes, but it is of no importance for rheostats required only for regulating the strength of currents, and certainly the graphite rheostats are up to now the most suitable resistances for portable batteries. They are best made of lead pencils ; the length which the current has to pass through can be varied conveniently by a spring gliding on the pencils as shown in the illustration.

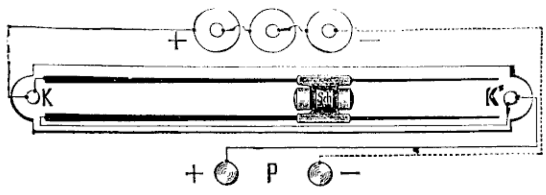


Fig. 5.

Galvanometers.—The great value of galvanometers for medical purposes has been so universally recognised in recent years, that it will hardly be necessary now to say much in their favour. Their purpose is to measure the strength of the current *while it passes through the patient*, and to enable the physician to dose the current accurately, notwithstanding the great difference in the resistance and the sensation in different patients, and notwithstanding the changes and differences of batteries. For administering electricity properly, they are about as important as a scale is for administering drugs; and there is good reason to say, that their introduction through Drs. v. Ziemssen, de Watteville, Edelmann and Gaiffe, mark a turning-point in electro-therapeutics.

Horizontal or Vertical Galvanometers?—When galvanometers first came into use, the vertical form was preferred because it is certainly easier to read from a vertical scale than from a horizontal one. But it was soon discovered that vertical galvanometers with *permanent* magnets are unreliable, in consequence of the changes in the magnetism of the needles. The magnetism of the needles changes, but the directing power of the weight (or magnet) which causes the needle always to return to the o point, does not change. The changes of magnetism occur certainly in horizontal galvanometers too, but here they have no influence on the accuracy of the division, for, if the amount of magnetism in the needle were to change after the graduation, the directing influence of the earth's magnetism, and the deflecting influence of the current, change in exactly the same proportion, and thus the angle of deflection remains the same. The horizontal galvanometers came therefore into general use. For about ten years they were the only reliable instruments known; in these last years, however, a new kind of galvanometer has been constructed which can be used in any position. These instruments will be described later on as d'Arsonval's galvanometers.

Suspension of the Magnet.—The inertia is slightest in the case of instruments the magnet of which is suspended on a cocoon fibre, and in this case the friction also remains always the same. Such instruments have therefore the great advantage, that in the case of their graduation being correct for a certain locality, this graduation will always remain correct and reliable.* These are, no doubt, the most sensitive instruments, as currents up to $\frac{1}{10}$th or even $\frac{1}{100}$th of a milliampère can be measured. In all cases where perfect accuracy is required, only such apparatus should be used. As these instruments are somewhat delicate and expensive, we employ for portable batteries, galvanometers the magnets of which are suspended on a steel point, as in a compass. Ordinary sewing needles are used now for this purpose, which can be easily replaced by new ones from time to time in order to keep them sharp and the instrument sensitive.

D'Arsonval Galvanometers.—The galvanometers described up to now are provided with a movable horse-shoe magnet, which is deflected

* This is not literally correct, as the terrestrial magnetism also varies and gradually increases. For instance, in London the earth-magnetism at the present time is about 1·82, and, if the increase of the latter continues at the same ratio as hitherto, it will be about 1·86 in ten years. A galvanometer, which now shows with perfect accuracy a current of 10 milliampères, would then with the same current, at this increased ratio of intensity of earth-magnetism, not indicate more than 9·97 milliampères, thus being 2 per cent. wrong.

from its direction toward the north pole by an electrical current circulating in its neighbourhood. Lord Kelvin suggested to replace this permanent magnet by a solenoid, and other scientists made practical use of this idea. Many turns of a fine insulated wire are wound on a frame of aluminium which is suspended between two points so that it can move freely. Two hair springs keep the frame in a certain position, and at the same time conduct the current to the solenoid. As long as a current passes through the solenoid it is attracted or repelled according to the polarity, by a current circulating in the neighbourhood, and the elasticity of the hair springs is the power which has to be overcome and which brings the frame back to its original position as soon as the current ceases. These galvanometers are therefore quite independent of the terrestrial magnetism, and can be used in horizontal, vertical, or any other position. Moreover, they are protected by a horse-shoe magnet which acts as a screen against disturbing influences from outside. The galvanometers with a magnet dependent on the north pole are so much influenced by the currents supplied for lighting houses, that it is impossible to take exact measurements in houses lit by electricity, whereas these new galvanometers remain correct even near dynamos.

These advantages render the d'Arsonval galvanometers specially useful for all apparatus utilizing currents from the main ; they are, however, equally convenient for batteries, their only drawback is that the hair springs are easily damaged if too strong a current is sent through the galvanometer.

Shunt.—According to Dr. de Watteville's suggestion, all medical galvanometers are divided into milliampères. In order to be able to measure weak currents for galvanisation as well as strong currents for electrolysis with the same instrument, most galvanometers are fitted with one (or two) shunt, which can easily be switched on and off. As long as this shunt is not used, the whole current has to pass through a long fine wire, which is arranged so as to make the magnet decline from the magnetic meridian. If, however, the shunt is brought into action, by screwing a screw marked 10 home, the current finds another passage through a short and thicker wire, which is wound so as *not* to influence the magnet, and in this way, two paths being open to the current, it will divide itself among both, 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

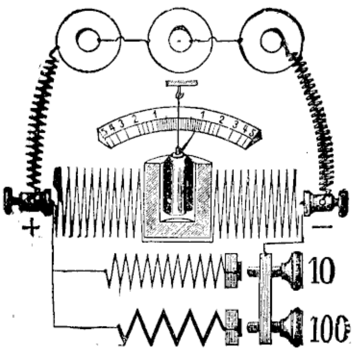


Fig. 6.

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. A galvanometer, for instance, which, without the shunt, indicates up to 25 milliampères one by one, will, if the shunt is used, show up to 250 milliampères 10 by 10. The resistance of the shunt can also be so arranged that the numbers on the dial have to be multiplied by 100.

Voltmeter.—If the resistance of a milliampère meter 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 9, page 8.)

A galvanometer, the sensitiveness of which has been reduced by screwing home the shunt, is of course insensible to weak currents ; on the other hand, however, one single cell is already sufficient to deflect the needle of a galvanometer to a right angle, as long as there is not the resistance of a patient in a circuit.

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 suddenly 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 and healthiness of the muscle. They are therefore very important for diagnosis. To interrupt and to reverse the current can be managed with one single instrument, of which we add a diagram.

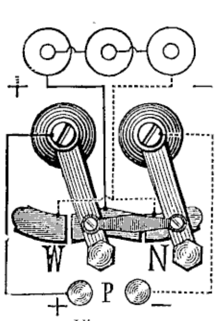


Fig. 7.

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. From each crank a wire is leading to a terminal screw. Current reversers are manufactured in many shapes, but in principle their construction is always the same.

Current Alternator and Combiner.—In order to be able to change the continuous or the faradic current suddenly, without having to connect the electrodes with other terminals, and in order to be able to apply at the same time continuous and faradic currents combined, Dr. de Watteville has suggested a convenient apparatus, which outwardly resembles a current reverser, and of which we add a diagram too (Fig. 8). 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.

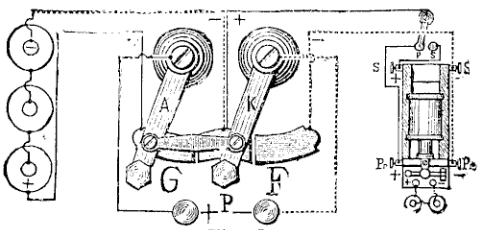


Fig. 8.

Cords.—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 some twelve 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. These short wires should not be soldered on to the cords, as soldered parts stand no bending, and would soon break; a ball joint, however, is convenient and durable. Some prefer the cords to be insulated with india-rubber tubes, some others with silk or cotton. In the former case the cords are well protected against moisture, but the india-rubber contains sulphur, which makes the copper brittle. India-rubber covered cords do not last longer than a year, whereas silk or cotton-covered cords last for a long time, provided they are not soaked in water together with the electrodes.

Handles.—The handles are provided with a terminal for the reception of a connecting cord, and with a thread fitting the electrodes. They are always provided with an insulating handle, so that the physician holding them is not exposed to the action of the current. Many handles are provided with a trigger, for making or breaking the current ; this can conveniently be managed on the handles with one finger only, whereas a hand is required to work an interrupter on the battery. There are also handles which contain a current reverser or a rheostat, but they are complicated, and are of real advantage in very few cases only.

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 or chamois leather, which may be screwed on to the handles, or have a terminal to receive the cords direct. Through frequent use—the moisture and the oxide—the covers get soiled, and should be renewed from time to time, and the oxide has to be removed from the metal plates with emery paper. 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. Small metal knobs on long

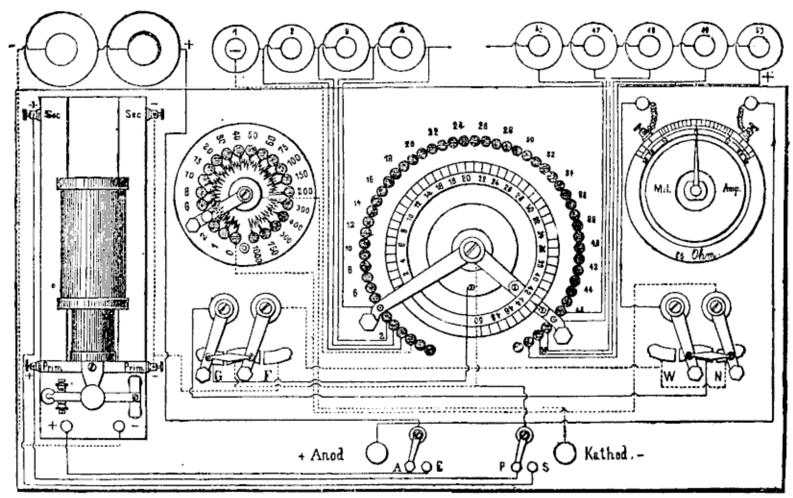


Fig. 9.

Diagram of the Connections of Battery No. 139.

insulated wires are in use for conducting the current to the larynx, nose, rectum, vagina, uterus, etc., and for treatment of strictures. Needles are employed for destroying hairs, nævi, tumours, etc. All these electrodes get 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 used for electrolysis should be of carbon, gold or platinum.

Density of the Current.—The size of the electrodes is of considerable importance. The larger the electrodes, the smaller is the resistance of the human body. With electrodes of ten square inches twice the current can be sent through the body than with electrodes of five square inches surface under otherwise equal conditions. This leads us to the density of the current, or, in other words, the proportion of the strength of current to the sectional area of the conductor. If, for instance, with electrodes of three square inches surface 20 milliampères are passing through the body, the current is three times as dense as if electrodes of nine square inches and the same strength of current were used ; in other words, in the first case each square inch of the places of application receives 6·6 milliampères, whereas in the second case only 2·2 milliampères are received by the same area. The physiological and chemical effects would in the first case be three times as strong on and near the place where we apply the electrodes as in the second case. Statements that such and such results have been obtained with so and so many milliampères are therefore incomplete, unless the diameter of the electrodes used, and the time of application are mentioned as well. On entering the body the current divides itself into numerous loops and branches, and follows the best conducting parts till it reaches the other electrode. The density is greatest where the two electrodes touch the body ; it is a little less near the straight line connecting the two electrodes, and smallest in those parts of the body which are most distant from the electrodes ; but experiment shows that even those parts are reached by some small part of the current.

The effect of the current is frequently desired in one definite spot only, but as we necessarily require two electrodes to complete the circuit, they are chosen of very different diameter : a small one (active electrode), to concentrate the current on the nerve or muscle, etc., which is to be influenced by the current, and a large one (called the indifferent electrode), which may be applied to the hands or any easily accessible part of the body. If the latter electrode is chosen sufficiently large, undesired effects, such as pain or blisters, etc., will be avoided.

Electrolysis.—This is of special importance if the chemical properties of the current are to be used for destroying any tissues, etc. (electrolysis). If, for instance, a needle connected with the negative pole is inserted close to a follicle, and an electrode of two inches diameter, connected with the positive pole, is held with the patient's hand, the current is of course equally strong in both electrodes ; but in the one the whole effect of the current is concentrated on a needle's point, and the chemical action of 1 milliampère suffices already to destroy the follicle, so that the hair can be extracted after a few seconds. The chemical action on the other electrode, however, is divided over so large a surface that the current mentioned will leave no visible effect.

Faults.—It is not an easy undertaking to describe in a few words the faults which may occur in a battery, and how they can be found out and rectified. The preceding sections, explaining the batteries and accessories, will enable anyone who takes an interest in his instruments to find out the reason of any disturbance; whereas for him who does not trouble to learn to understand the anatomy of his battery, any number of pages about this theme will be insufficient, for he will ever remain dependent on the help of an electrician. If a battery does not work, the only reasonable thing to do is to ascertain where the fault is, whether it is in the cells, or in the connection between the cells and the terminals, or in the cords, handles, etc. Most frequently the fault will be found in the connecting cords. They are liable to break, and this shows itself by their too great flexibility, they are cut off then up to the unspoiled part. In all batteries with a great number of elements, a spark appears if the two ends of the connecting cords are brought in contact and separated again. If no spark is seen, fasten one end of a cord to a terminal, and touch with the other end the other terminal. If still no spark is visible, touch peg 1 with one end of a cord, and with the other end touch the last peg of the collector, and if there is still no spark, try with groups of, say, five elements each, either on the pegs of the current collector or directly on the terminals of the cells. If the elements are not very old, a spark will be obtained from several of these groups, and the faulty cells may be singled out. A whole battery may fail because one of the many screws on the cells may have got loose, on account of differences of temperature or shaking in the transit, for a loose screw no longer makes any contact with the wire which connects the cell with the next one. This can easily be rectified by tightening the screw. Another reason may be, that in consequence of short circuit (caused by a wrong position of the current collector, or by a fault in the cell) a zinc is eaten through, or that the fluid has escaped through a crack in the element vessel. In both cases the connection is interrupted, and the defective cell or cells have to be removed and refilled, or replaced by new ones; if this is impossible at the time, the last cells of the battery may be taken off and put in place of the defective ones, until new ones can be obtained. (Batteries which are so constructed that each single cell can be taken out, are for this reason much better than those in which the cells are soldered together, or otherwise inaccessible, for if one single cell in them goes wrong, the whole battery has to be sent back to the maker.) A galvanometer makes it much easier to find such a fault; the cords are connected with the galvanometer, and the other ends are placed first on pegs 1 and 2, then on pegs 2 and 3, etc.; in this way each cell can be tested, and a fault found out at once. In batteries provided with a double collector it is simpler still. The tongue is a sensitive galvanoscope, too. If we touch with it two wires connected with a cell, we feel a peculiar taste if the cell is working. We strongly recommend, however, to try this experiment with groups of not more than ten cells only, for we heard of a case where a doctor, believing that his patient got no current from a 40-cell battery, put the cords on his tongue, and remained unconscious for three-quarters of an hour in consequence of the shock.

It is rare that a fault occurs in the connections between the cells and 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 get oxidised, especially in acid batteries, and have to be cleaned occasionally with fine emery paper; dust between the pegs should be removed with a fine hair brush. The screws which keep the crank of the current collector and reverser on their axes may get 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, etc., 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 utilizing the currents supplied for lighting houses, for galvanisation and electrolysis, are explained on pages 46—51.

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

A very 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 a few minutes 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 even the strongest current used for electrolysis rarely exceeds 200 milliampères. For cautery, however, 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. Even a 100-cell Leclanché battery with cells of 0·6 ohm internal resistance, would give only

$$\frac{150 \text{ volts}}{60 + 0{\cdot}06 \text{ ohm}} = 2{\cdot}49 \text{ ampères.}$$

This explains why a battery made for galvanisation cannot be used for cautery, and why a cautery battery cannot be used for galvanisation, notwithstanding its big cells—two questions which are very frequently put to us.

Connection of Cells.—Up to now *one* method of arranging the cells has been mentioned only, 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. Two cells connected in this way are equal to one single cell of double size, and this is a great advantage for galvanic cautery, for by lessening the internal resistance we enable it to yield, with small external resistance, a stronger current. Principally, however, 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. We can, for instance, connect 6 cells, of 1·5 volt, 0·15 ohm internal resistance, and 20 ampère hours capacity each, in series, and obtain then 9 volts, 0·9 ohm internal resistance, and 20 ampère hours; or else we can connect every two cells parallel, and the three double cells in series. We then obtain 4·5 volts, 0·225 ohm, and 40 ampère hours; or 3 cells parallel and the two

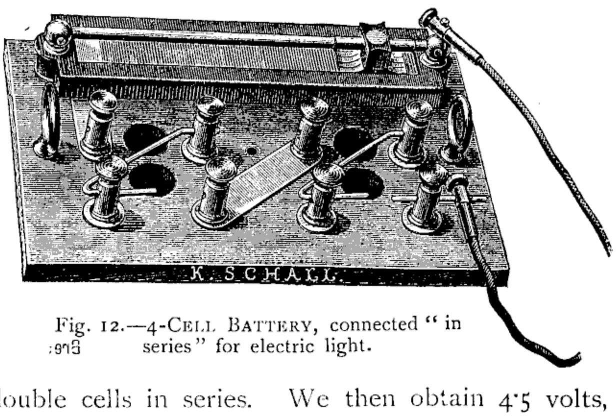


Fig. 12.—4-Cell Battery, connected "in series" for electric light.

groups in series, which would give 3 volts, 0·10 ohm, and 60 ampère hours; and lastly we can connect them all parallel, and would then obtain 1·5 volt, 0·025 ohm, and 120 ampère hours. The mixed connection is the most convenient one for cautery batteries, and is most frequently used. The two diagrams show the two different ways of connecting the 4 cells of a frequently used 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 the production of a strong light as well. We shall refer to this later on under the section for electric light.

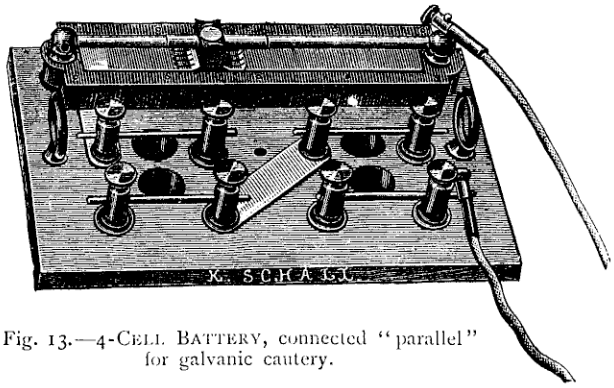


Fig. 13.—4-Cell Battery, connected "parallel" for galvanic cautery.

Which are the most suitable Elements?—There is no great variety of cells with a sufficiently small internal resistance. Cells with two different acids, such as Bunsen and Grove cells, are certainly very powerful and constant, but as they have to be emptied and cleaned each time after having been used, they have long since been put aside as too troublesome for surgical purposes.

Bichromate Cells.—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 5½ by 6½ inches, will keep a burner requiring 16 ampères incandescent for, approximately, twenty minutes. They are powerful, their E.M.F. being 2 volts, and they are easily put in action. And especially they can very 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

* The peculiar type of bichromate cells known as "bottle elements" have made bichromate batteries famous for inconstancy. In these bottle elements, carbons and zincs are put together as closely as possible, so that they can pass through the narrow neck of the bottle. The consequence of this arrangement is that internal resistance is very low and the current very powerful for the first moment, but the small quantity of acid between carbon and zinc gets used up rapidly, and the strength of currents drops therefore 50 to 75 per cent. within the first minutes. If, however, the space between carbon and zinc admits *a sufficient quantity of acid*, bichromate cells may heat a cautery burner even for hours constantly.

electrician's help. They are portable, as far as this is possible, for a battery of 23 lbs. weight filled with acid. Plates of india-rubber, floating on the surface of the acid, as well as properly constructed vessels, prevent spilling and evaporation. 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. The zinc plates last from two to five years, according to their use, and can be replaced easily without tools. It is necessary to clean and refill the bichromate batteries once in three to six months, according to their size and use, but it is very important to remove at least once in every six months the crystals adhering to carbons, zincs, and especially to the acid vessel. The quality of the acid is also of great importance for these batteries, as the strength of current depends very much on it. We recommend the following solution: *Dissolve* 1 lb. of bichromate of potassium in 8 lbs. of hot water, add *slowly* 2½ lbs. of strong sulphuric acid, while stirring constantly, and dissolve in this mixture, while it is hot, 3 ozs. of bisulphate of mercury.

Dry Leclanche Cells.—One kind of Leclanché cell has so small an internal resistance that it can be used for *small* cautery operations. Six elements of 4 by 4 by 7 inches, three of which are connected parallel, and the two groups in series, are able to keep a burner requiring up to 12 ampères incandescent for about two hours altogether—not continually, as the battery requires some rest for recovering; but constantly for about five minutes at a time. These batteries are not to be recommended for regular use in the consulting room of a busy throat specialist, but they are convenient for eye and ear specialists, who require small burners only. They are suitable for portable batteries on account of the absence of any liquid.

The disadvantage of these batteries is that, after nine to twelve months' time, the current gets too weak for cautery, *whether the battery has been used or not*, on account of the gradual increase of the internal resistance. The cells will then still do for surgical lamps, bells, &c.; they cannot, however, be refilled, but have to be replaced by new cells which can easily be put in the battery boxes.

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; this would necessitate frequent attention to the battery. A rheostat, however, enables you to immerse the battery completely from the beginning, and to reduce the current to the proper dimensions by inserting an artificial resistance. As the cells have a larger surface by the deeper immersion, 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.

Rheostats for cautery cannot be made with thin wire, as such wire would get incandescent too; hence for a current of 10 to 18 ampères we employ German silver wire of 2 to 3 mm. diameter, and about 2 ohms total resistance. This wire is wound in a spiral, and a longer or shorter piece of it can be inserted, by means of a sliding spring. 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 the proper temperature for operations. A bright red or yellow heat is best ; white heat, or dark red heat, causes bleeding.

Galvanometers.—Galvanometers are not necessary for cautery, as it is not important to know how many ampères are required for obtaining the proper temperature of the platinum. They are convenient only for controlling the battery and for experiments.

Cords.—Connecting cords for cautery ought to be thick, because, if thin, they would either get too warm, or else weaken the current considerably. Their resistance should not be more than 0·02 ohm.

Handles.—There exist many different shapes of handles for holding the burners. All of them are fitted with a trigger, mostly like the trigger of a pistol, in order to enable the operator to introduce the platinum wires cold, and to heat them at the desired moment only, by closing the circuit through a pressure on the contact. Many handles have an arrangement for drawing a wire loop together, for the removal of polypi, tumours, etc., with the incandescent platinum or steel loop.

Burners.—The platinum burners which are made pointed, knife, cup, or ball shaped, are soldered on to copper wires of different lengths and curves, according to whether they are meant to be used in the nose, larynx, mouth, ear, etc. The copper wires are partly 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 get 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 recognised 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 with silver by the electrician. 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 good 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 on the broken place. A rheostat may get burned through under unfavourable circumstances—both faults have to be remedied by the electrician. 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 52—60.

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 (0·01 ohm to 0·1 ohm) than in all other cells, and for this reason they produce a remarkably powerful current, which, being completely depolarized, 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, as strong currents are frequently required for a considerable time to work them. They are, moreover, convenient for running motors, heating cautery burners and small surgical 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 of 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 get converted entirely into peroxide of lead, and the negative plates into spongy metallic lead. 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 charging get, 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 got back 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 unutilized. In discharging too heavy a current, the cell will become polarized in consequence of the same difficulty. There is no fixed rule how many ampères may be used for charging or discharging accumulators, this depends in the first instance on the capacity of the accumulators, and, secondly, 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 (as dampness, dirt, etc.), and also on account of impurities of the acid. (If these are considerable, especially if the acid contains a trace of arsenic, the accumulator cannot be charged at all.) 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 are useless, and have to be replaced by new ones.

The following rules can be derived from the above statement:—

(1) The capacity of the cells must be in direct proportion to the discharging current. If, for instance, the accumulators are intended for working 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 charging 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 in a 100-volt circuit. If four lamps of this same candle power are connected parallel, the charging will be finished in five hours.

It is possible to charge accumulators from primary batteries. The so-called gravity cells (copper-zinc without a porous pot) are best suited for the purpose. These cells have nearly 0·9 volt each, and as towards the end of the charging the E.M.F. of the accumulators rises to nearly 2·5 volts, four of these cells should always be connected in series for each single accumulator cell. If only four cells are used to charge a 20-ampère hour accumulator, the charging will take about 170 hours. If, however, you take twelve cells, and connect each three parallel, and the four groups in series, the charging will be done in about 55 hours. Cells like these can remain permanently connected with the accumulators, but some vitriol of copper should be added to each cell once or twice a week. There should also be a galvanometer in the circuit to measure the strength of the charging current and control its direction.

Thermopiles may also be used for charging accumulators; it will, however, be more advantageous to use large bichromate cells instead of the accumulators in most of the cases where a current from a dynamo is not available for charging.

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.

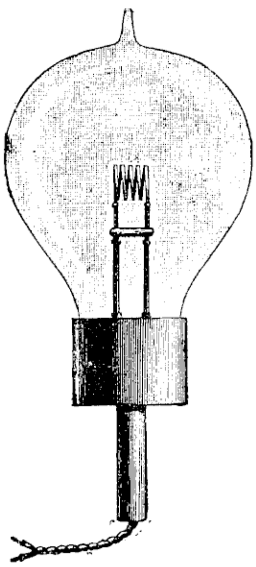
A Voltmeter is very convenient for controlling accumulators. While in good condition, each cell gives fully 2 volts. If the E.M.F. falls to 1·8 volt per cell the charge is nearly exhausted, *and the accumulator should be re-charged at once.*

During discharging, accumulators may be connected parallel, but while charging this should be avoided. Six 20-ampère hour accumulators connected in series give 12 volts, and, say, 5 ampères for 4 hours. The same battery connected so that two cells are parallel and the three groups in series, will give 6 volts and, say, 10 amperès for 4 hours.

Many attempts have been made to produce dry accumulators, but up to now they have been a failure.

BATTERIES AND INSTRUMENTS FOR ELECTRIC LIGHT.

Advantages of the Electric Light.—The electric light is whiter and more intense than any other kind of light. It develops less 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 much closer to the object which has to be examined. Moreover, the doctor is independent of the focal length of a reflecting mirror, and can bring his eyes closer to the object or can keep further away as he chooses. All 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 else to discover bleeding arteries during operations, or to make part of the body transparent (antrum) for diagnostic purposes. It is, moreover, a most convenient night light for medical men, who are often called out at night; for a turn of the switch, which may be fixed on the bedstead, is sufficient to light up the whole room. Finally, it is useful as a reading lamp in carriages, for invalids, etc., although in these latter instances, the fact that the electric light produced by batteries costs still about 3d. to 5d. an hour for a 2½-candle lamp is a disadvantage. In houses where the electric light is laid on, lamps of 32 to 100 candle-power may be used with the concave mirror for examining throat, nose, eye, etc. Special lamps are made, the carbon filament of which is not horse-shoe shaped, but fitted in the centre of the lamp, so that the lamp can very well be used with a lens. These lamps give a good light of 25 to 100 candle-power, according to the lamp chosen. If properly arranged, the lamps do not show light and dark spots, and as to convenience and cleanliness, they are superior to any other lamp.



Resistance of the Lamps, and Strength of Current required.— The resistance of the incandescent lamps used for medical purposes varies from 7 to 25 ohms. The strength of current required for rendering the carbon filaments of the usual lamps incandescent is 0·25 to 1·0 ampère; 0·5 ampère is about the average. In order to obtain this strength of current with the resistances mentioned before, 6 to 12 volts are required, and either batteries of four to eight cells, connected in series, are necessary, according to the E.M.F. and the internal resistance of the cells, or the current from the main has to be reduced by suitable transformers or rheostats. The diameter of the lamps used for surgical purposes must be small, in most cases less than 1 inch; the long carbon filament required for lamps to be used with 100 to 250 volt supplies has no room in these small bulbs, and it is therefore impossible to use the surgical lamps directly with the current from the main.

The carbon filaments have a much higher resistance than the platinum burners used for cautery, but require considerably less current to become incandescent; but all cautery batteries with four and more cells can very well be used for surgical lamps too. Most of the lamps require, however, more milliampères than the small portable cells, constructed for galvanisation and electrolysis, are able to keep up for any length of time. These batteries of many small cells certainly make the lamps incandescent, but they polarise too quickly with a current of 500 milliampères, and consequently the light is not constant, but diminishes after a very short time; only the large Leclanché cells used for faradic batteries depolarise quickly enough to give a steady light for some minutes at least with these lamps. The cells for batteries for the electric light ought to be larger than the cells for galvanisation, but they need not be as large as the cells for cautery; the larger they are, the longer they will be able to keep a lamp incandescent, and the more cells there are, the longer may the carbon filament be. The *number* of cells does *not* influence the *time* a battery can keep a lamp incandescent; a 6-cell battery keeps a lamp burning for the same time as a 10-cell battery, provided that both are fitted with the same kind of cells.

What are the most suitable Cells?—The variety of cells for producing light is not very great, because no cells with high internal resistance can be used, and because nearly all the batteries have to be portable.

Bichromate Cells.—Bichromate batteries (about their treatment, mixing the solution, etc., see page 26), *provided that the cells are not made too small*, are constant enough, and quite apart from their high E.M.F. and great strength of current, they have the great advantage that the owner is independent of the electrician for some years at least, as he can easily keep them in order himself. They have, however, to be refilled every three or four months, and as far as convenience and cleanliness go, they have certainly been surpassed by other batteries, suitable for doctors living within reach of the manufacturer.

Accumulators are very suitable for surgical lamps, and are described on pages 28—31.

Leclanché Dry Cells have an E.M.F. of 1·5 volt, and an internal resistance of 0·3 ohm. They are small enough to be very portable, and as they contain no liquid they can be sent charged as ordinary luggage all over the world. They are, owing to their peculiar construction, more constant than fluid elements of the same size. If the cells used are not too small these batteries are the only ones which are really reliable for fifteen to eighteen months, *without requiring re-charging or any other attention during this time*, and are, therefore, more convenient than bichromate batteries or accumulators; but the cells have to be replaced by new ones—*even if the battery has not been used*—after about one-and-a-half years. The new cells can easily be put in place of the old ones, so that the battery itself need not be returned to the maker.

If the battery need not be portable, fluid Leclanché cells are very suitable for incandescent lamps; but *large* cells must be used, at

D

least for lamps requiring one ampère. As to the refilling of liquid Leclanché cells, see page 11.

For **Transformers and Rheostats** for utilizing the 100 to 250 volt currents from dynamos for small surgical lamps, see pages 52—56.

Rheostats are not absolutely necessary for surgical lamps, but they 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. Rheostats for surgical lamps ought to have a total resistance of about 30 ohms, which can be inserted gradually. They are best made of German silver wire, which ought to be thick enough to allow a current of 2 ampères to pass without getting hot.

Galvanometers are not necessary, as a bright light only is required, and there is no need for knowing how many ampères are wanted for each lamp. The cords need not be as thick and heavy as those used for cautery, and as the difference between the positive and negative poles is of no consequence in this case, they are generally so twisted, that there seems to be only one cord· leading from the battery to the instrument.

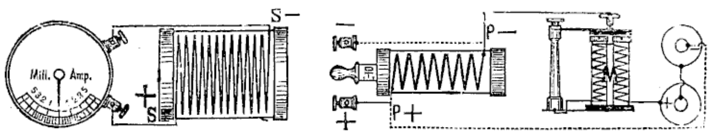
Normal rate of Burning.—The amount of light which a lamp can yield may not be increased to any extent by increasing the strength of current, without damaging the lamp. The carbon filament should be a little more than yellow. If this degree of incandescence is exceeded, the lamp can certainly give twice as much light than under normal circumstances, but its life gets considerably shortened, as the carbon filament evaporates by being over-heated. If the current used is very much in excess of what the lamp requires for becoming white hot, the lamp will stand it but for a few minutes, or give only one momentary flash. 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. The life of small surgical lamps varies between twenty and one hundred lighting hours with ordinary use, and the candle-power as a rule varies between one and five candles.

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 get 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. With plunge batteries, the fault may be easily set right, but accumulators have to go back to the electrician. For Leclanché dry batteries new cells have to be bought, but they can easily be put in place of the old ones and reconnected, so that there is no need of sending the batteries back.

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, and all the marvellous acquisitions of the last forty 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*. 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 40) 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 wood, paper, 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 the better 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 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.* We shall come back to a further difference between primary and secondary currents later on.

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, or better, if it is wound round a cylinder into which an iron core can be pushed. It is, however, preferable, that 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 exactly at the same time, the making and breaking of the inducing current, and the sudden appearance and disappearance of a strong magnet.

E.M.F. of the Induced Current.—The E.M.F. of the induced current depends 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 ; the closer they are together, the higher is the E.M.F., and *vice versa.*

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

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

Measuring the strength of Induced Currents.—The strength of the induced currents cannot be measured with an ordinary galvanometer, partly because the secondary current is alternating, and would, therefore, make the needle deflect one moment to the right, and the next moment, to the left. There are certainly some galvanometers without permanent magnets, which might be used, but the chief obstacle is that the currents are intermittent, *i.e.*, as the shocks last but a very short time, the galvanometer remains for a time without any current, until a second impulse occurs. If there are 30 interruptions per second, such a galvanometer would indicate more current than if there are only 5 interruptions per second, although in both cases the strength of current would be exactly the same. The only possibility for measuring the currents of faradic coils in absolute units consists in measuring their E.M.F., and later on we shall describe an apparatus for this purpose.

Chemical Action and Mechanical Effect of the Induced Current.—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 in the secondary current neutralises partly the effect of the preceding impulse. The mechanical effect of these suddenly appearing and disappearing currents on the human body, however, is very intense. If we place electrodes on the body, 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 very strong muscular contractions; if we increase the diameter of the wire, the contractions get more powerful; if the secondary coils are wound with thick wire (No. 18 to 22 B.W.G.) they produce exactly 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 the primary current, or a secondary coil with thick wire only can be used.

Construction of Medical Coils.—The shape and external appearance of the coils used for medical purposes vary very much, but still (if we except the magneto-electric machines, which, on account of several deficiencies, are rarely used now) they are all constructed on the same principle. The primary coils have between 100 and 300 turns of wire. The resistance of the primary coils is made small, 5 to 15 ohms, so that one or two cells can produce a strong current in them already, and the diameter of the wire ought, therefore, not to be too small. Insulated copper wire, No. 22 B.W.G., is mostly used for the primary coils. The E.M.F. of the primary current varies under these circumstances between 5 and 30 volts, according to the number of turns, and according to whether the iron core is drawn out or pushed home.

How to Regulate the Primary Currents.—The E.M.F. of the primary current can be regulated in different ways; for instance, by inserting a larger or smaller number of turns of wire by means of a crank, etc. The simplest and almost only method practically used, however, 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 gets stronger the more it is pushed in. Instead of drawing the iron core out, a damper in the shape of a brass or copper 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 2,000 to 6,000 turns, for in most cases it is desired to obtain a high E.M.F. The wire used for it is generally thin copper wire, about No. 36 B.W.G. The resistance of the secondary coil varies under these circumstances between 100 and 900 ohms, and the E.M.F. between 10 and about 200 volts. The strength of the secondary current can be regulated in

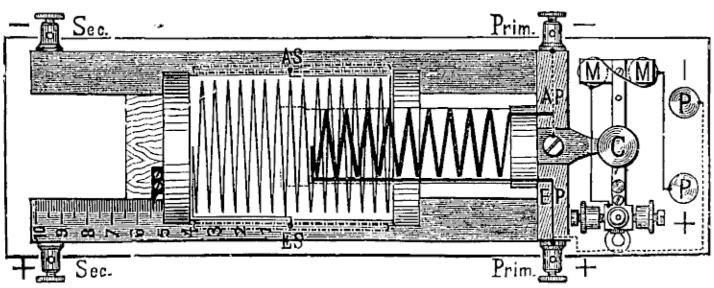


Fig. 19.

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, however, 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, which were first suggested by Dubois Reymond, are decidedly preferable to any other coils for diagnostic, and for physiological purposes. The strength of current in this apparatus can be further regulated by pushing the iron core in and out. The secondary current might also be regulated by means of a crank which inserts more or less turns of wire, but this does not allow as fine graduations as the moving of the iron core or the coils; —or it might be regulated with rheostats; but this is not very practical and is seldom used as high resistances would be required.

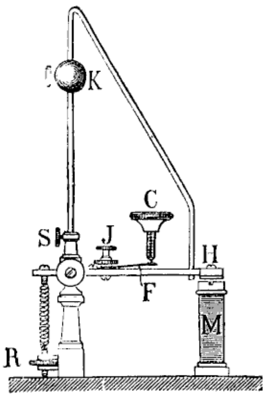


Fig. 20.

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 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. The power of the spring, as well as the strength of the inducing current, have, however, something to do with the rapidity of the interruptions. 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; they can be reduced to twenty or even less per minute. A few apparatus are fitted with clockwork, which can be made to run at any speed, and the interruptions produced per minute are accurately registered by the clockwork. 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.

What are the most suitable Elements? Bichromate Cells.—Various kinds of elements may be used for working medical coils; we will begin with the bichromate cell. We have already mentioned its advantages, *i.e.*, its high E.M.F., small internal resistance, and, more especially, the fact that it can be easily kept in order without technical help, and these qualities, added to its small size and cheapness, render it very suitable for the majority of medical coils. One cell is sufficient for supplying a strong inducing current. The vessels for the elements are best made of strong glass, as all ebonite vessels leak after a time. The cells are closed with india-rubber stoppers to prevent spilling in carrying the apparatus. The acid consists of 1 oz. bichromate of potassium, dissolved in 10 ozs. of water to which are added 2½ ozs. strong sulphuric acid, and ½ oz. bisulphate of mercury. As the acid does not decompose, it is best to mix about a pint at a time. If the acid turns green, the cells should be emptied, rinsed out and re-filled with fresh solution. With most of the portable apparatus one charge of the cell suffices to keep the hammer going for about two hours. The fact that acid cells are troublesome on account of the frequent re-charging and the inconstancy of the cells, has been the cause that other cells have come into use for working the coils as well.

Leclanché Cells.—Large Leclanché cells are also very well suited for working coils, and are used for them in all office batteries.

Dry Cells.—Leclanché dry cells are so very well suited for portable induction coils, that they supersede all other cells for this purpose. They are much more constant than the acid cells, but the chief advantage is that they contain no acid to spill and corrode the coil, clothes, etc. It is no exaggeration to say, that under 100 cases in which coils went out of order and required repairs, it was 99 times due to the spilling and evaporation of acid. We have sold several thousand coils with dry cells during the last fifteen years, and *none of them* has come back for any other purpose except the renewal of the cells. An Obach R. cell, measuring 1¾ × 1¾ × 4½ inches, will work for instance a Spamer coil for 30 to 60 hours (according to whether the iron core is withdrawn or pushed home), and when exhausted it costs 2s. 6d. to replace this cell by a new one. The acid and zinc required for working the same coil for a similar length of time would cost more,—not reckoning the damage done by the acid to the coil, the temper, clothes, etc. After long experience with these cells in our coils, we would cease to make coils with acid cells altogether if the latter had not still some advantage for the Colonies and out-of-the-way places, where the dry cells cannot so easily be replaced. New dry cells can easily be put in the place of the old ones without returning the coil to the maker.

Thermopiles.—If an apparatus need not be portable, or if experiments have to be made where absolute constancy of the inducing current, even for years, is of importance, thermopiles are most suitable, as their E.M.F. changes less than the E.M.F. of any other source of electricity. They are started by lighting a small gas, oil, or spirit flame. They are convenient and reliable for all induction coils which have not to be portable, and they are not likely to require repair, unless they get damaged by a fall or some such misadventure.

Faults.—If an induction coil fails, you should see first whether the element is exhausted. Acid cells require refilling about once in a fortnight, if the apparatus is in daily use. 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; for very often apparatus which were in quite 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 $\frac{1}{16}$th part of an inch, and the platinum point of the contact screw should just touch it. Those apparatus in which the hammer is fastened to a rigid bar, as in Nos. 6, 6A, 7, 8, 16, and all sledge coils, are less liable to get out of order and to require readjustment than those coils the hammer of which is attached to a watch spring, as in coils 1 to 5, and 14. The interruptions of these latter apparatus are also frequently less regular. If an interrupter has not the proper distance from the electro-magnet, it has to be carefully bent, till it keeps the proper 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. The coil and the connections are very well protected, and can be damaged only by spilling a good deal of acid; the connections get oxidised in such a case, or the wires may even be eaten through. An apparatus damaged in this way has to be sent back to the manufacturer.

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; they are only useful for currents from 50 milliampères upwards. The second, and more important reason, is that galvanometers cannot be used unless all the interrupters of the coils, the current of which is to be measured, vibrate at a uniform and 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.

Professors Ziemssen and Edelmann have shown that currents of very short duration and a certain E.M.F. give the same physiological effects whether they are produced by an induction coil, a galvanic battery, or a condenser discharge. A coil was, therefore, constructed in which the scale was graduated in volts; the readings of the scale are correct as long as the primary current has exactly 0·3 ampère. Moreover, condensers were constructed of 1 microfarad capacity, which can be charged from a battery and discharged through the patient in rapid succession by a key working like the interrupter of a coil. If the number of volts used for charging the condenser is known, the current used can be measured, and the results can be compared, just as the number of milliampères used with a continuous current.

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 (or the current from the main), 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 easily be varied and adjusted 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 means of the rheostat controlling the speed of the motor, and can be read off a speed counter. The E.M.F. used can be regulated by increasing or diminishing the number of cells in the circuit. More particulars will be found in "Medical Electrology and Radiology," October, 1904.

These phenomena are being 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. The diagram *a* (taken with per-

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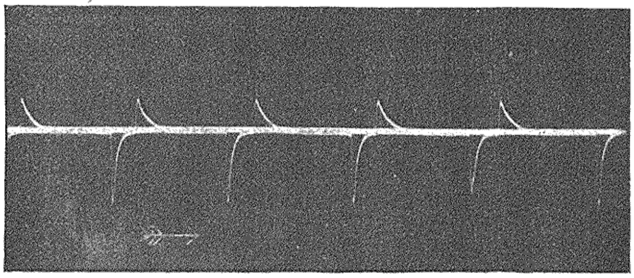
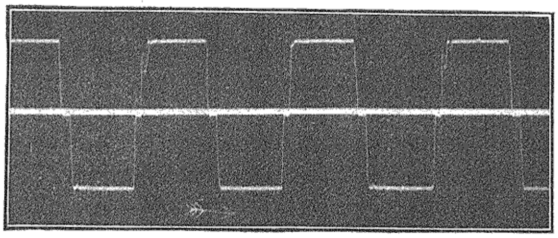


b



mission of the author from "Medical Electricity," by Dr. Lewis Jones) shows the tracings of the secondary current obtained from a coil No. 19; the diagram *b* shows the tracing of the current obtained with one of our motor reversers No. 245. In this diagram the period during which the current is "on" is about as long as the period during which it is "off."

FRANKLINISATION.

Static electricity is now used very frequently for nervous and hysterical diseases, sleeplessness, etc., in America, Austria, Germany, and especially in France, but in Great Britain it is yet seldom used. The reason for this is, no doubt, the climate, which is unfavourable for static machines here, but as there are now machines which can be started even in the dampest weather, a few words about them will not be amiss. As far as the origin of static electricity is concerned, and about the construction of the machines, we must refer to larger works on electricity. Static machines are considered by many physicists the most ingenious of all physicial instruments, and as the process is rather complicated, it seems to us useless to attempt to describe it in a few words only. The electricity yielded by static machines is of a very high E.M.F. The number of volts can be estimated according to the length of the sparks.

For sparks of	0·18	0·7	5	15·6	18·8	mm. length,
have approximately	1000	2000	5000	12000	15000	volts.

Sparks of 100 millimètres' length being nothing uncommon with such machines, we may suppose that the E.M.F. amounts frequently to 100,000 volts and more. The strength of current, however, is exceedingly small, and the chemical effects are 0 for all practical purposes.

The manner of application is about as follows: For general franklinisation the patient is placed on an insulating chair, and connected with one pole of the machine for some twenty minutes. For local applications he is also mostly placed on the chair, and an electrode connected with the other pole is brought near the spot which is to be franklinised. If this electrode is fitted with a point, the so-called electrical wind appears, which, according to Charcot and Boudet, is specially valuable for neuralgic pains, etc. If the electrode is fitted with a ball, sparks appear, which are used to excite paralysed and unsensitive organs. With Morton's electrode the spot of application can be localised exactly, and with such an arrangement the sparks can also be applied internally.

According to different authors it seems to be of special importance with this kind of electricity, which pole is applied to the patient. According to them (for instance, Dr. Stein), the negative pole has a depressing influence on many patients, whereas the positive pole has an invigorating influence; and this seems to be in accordance with the fact, that, under normal conditions, the air is always charged with positive electricity (of 100 days the air electricity is positive on about 95 days, and negative only on about 5), and only under abnormal conditions, during thunderstorms, or hail and heavy storms, etc., it changes to negative electricity. We must leave it to our readers to find out how far these statements are correct, but we will give a few hints which will make it possible to tell the negative pole from the positive one. In a dark room the poles can be easily distinguished. The pole on whose comb brushes of light appear, is charged with negative electricity, and the pole on whose comb points of light appear, is charged with positive electricity. If a burning candle is placed between the poles of a machine in action, the flame points towards the positive pole.

Static machines are turned either with the hand, or else, and this is much more convenient, with small motors. In towns where the electric light is laid on, these will mostly be electro-motors, but in other places they may be small water motors, gas motors, etc., or else electro-motors which are driven by batteries. About the treatment of these machines, we must refer to the directions for use sent with the machines.

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 1,000 of such switchboards for medical purposes in daily use, some of them since fifteen 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. A battery of large accumulators is nearly always used in connection with the dynamos; during the evening the current is supplied directly by the dynamos, but during part of the day-time it is supplied by the accumulators. 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 100,000 watts only 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, and for a few types of arc lamps, but for charging accumulators it has to be made unidirectional. It cannot be used for galvanisation, electrolysis, or for magnets required for attracting pieces of steel or iron.

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 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, according to Ohm's law, 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, the reason of which has not yet been fully explained. With 200 volts it is much worse than with 100 volts. 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 arranged now on this principle.

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

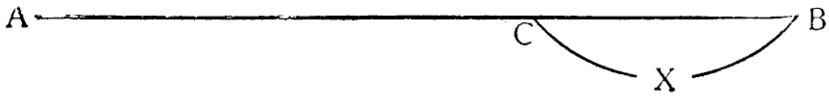


Fig. 21.

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 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 C X B 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 cautery burner, 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, electrolysis, faradisation, and surgical lamps are so weak that this waste is not worth mentioning, it will scarcely amount to one shilling during a whole year; for cautery or exciting 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 cautery.

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

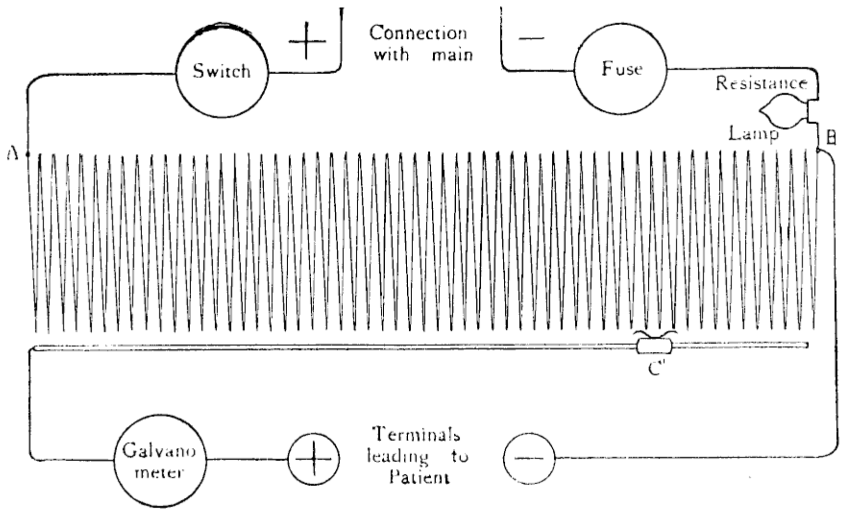


Fig. 22.

wound; the single turns are quite close together, but insulated from one another. The total resistance is over 500 ohms. The sliding spring shown in the diagram Fig. 22 corresponds with the point C in Fig. 21. An incandescent lamp of 15 to 32 candle-power 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 platinoid wire cannot be overheated. Moreover, 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 the operator to turn the current off when the application is over.

If the sliding spring is quite 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. The shunt rheostat can also be used in connection with batteries, but the resistance chosen must then be fairly high, about 1,000 ohms, to prevent waste of the battery.

The diagram (Fig. 22) 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 15—20.

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 the system of underground cables used in Great Britain 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 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. With 100 volts a 32 candle-power lamp, and a 50 candle-power lamp is required for 200 to 250 volt installations. A shunt resistance must be arranged parallel to the interrupter to prevent sparking, which would destroy the platinum contacts.

* 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.

Apparatus for Cautery.—For galvanisation and electrolysis the maximum current required does not exceed 0·3 ampère; the most frequently used cautery 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 3 ampères with 100 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.*, if the windings are chosen correctly for cautery, 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. Moreover, the transformers must not be short circuited, *i.e.*, if a transformer is made for burners requiring about 18 ampères only, it will soon be damaged if an attempt is made to connect it with a burner requiring over 30 ampères. If such unusually large burners are to be used, a transformer of suitable size has to be employed. If these few points are attended to, the motor transformers will remain absolutely reliable, even with strong use, 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.

These motor transformers have the great advantage that, besides for cautery and surgical lamps, they can be used equally well for many other purposes—for instance, 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. A ventilating fan can be attached to them. 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.

The fact that they are useful for so many purposes makes them very convenient for hospitals, for all specialists for ear, throat, and nose diseases, and for many other surgeons.

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 have the advantage that they can be made at a lower price 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 easily be added, but the transformers cannot be used for drills or massage like the motor transformers, or for spark coils or lupus lamps like the rheostats.

The interrupter transformers can be made in various shapes, either in portable boxes or on switchboards to be fixed on the wall. The interrupter must vibrate rapidly and evenly. If a current of 100 volts

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

and 2 ampères is being broken, a lively spark appears at the breaking point. To avoid this sparking, which would burn up the platinum contacts rapidly, a condenser is connected with the two platinum terminals of the interrupter. Even then the sparking is not avoided absolutely, and the platinum contacts have to be renewed ultimately; but if these are fairly stout they will last for a few years with average use. The interrupters are bound to make a slight humming noise.

Rheostats for Cautery cannot be inserted "in series" because there would be such a strong spark in the cautery handle on breaking the current that the handle would be destroyed at once. They have to be constructed on the shunt principle, which has been explained already on page 48. The diagram (Fig. 23) shows the connection of a cautery rheostat. It is sufficient to connect the point C permanently, so that about 10 volts are available in the shunt, and by inserting a small

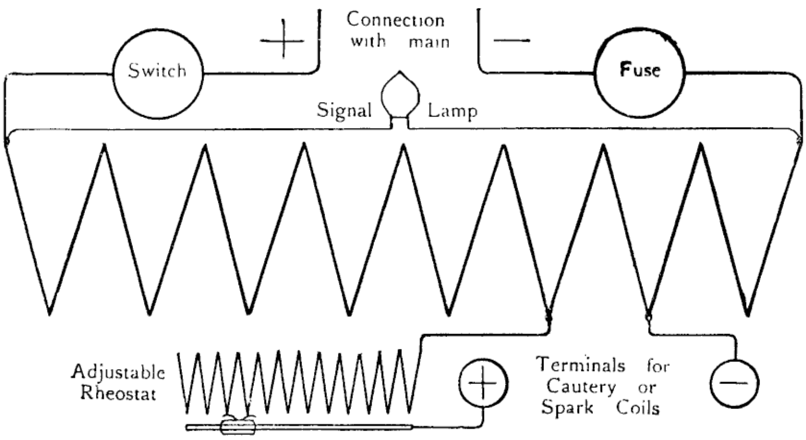


Fig. 23.

adjustable rheostat the current in the shunt can be controlled for larger or smaller burners. The wires used for these rheostats, and the cables and fuses leading to them, must be of such a diameter that they can carry currents of 20 ampères without becoming unduly hot. In many cases a special cable suitable for such a current has to be carried to the rheostat; they cannot be connected with any wall plug, like the transformers. The rheostats are rather wasteful, because only about 10 per cent. (on a 100-volt supply) of the current which has to be paid for is being utilized; about 20 ampères and 100 volts pass through the rheostat, and only about 18 ampères and 10 volts are required for the burners. If the unit costs 6d., this means that the current required for an operation lasting five minutes costs 1d. With a 200-volt current the price would be double. This compares still favourably with the cost of the current produced in batteries, which, under the most favourable circumstances, will cost fifteen times as much as the current produced in dynamos; and, moreover, the shunt rheostat is not more wasteful than if the 100-volt current were stored in a few accumulator cells. Nevertheless, the transformers described on pages 52 and 53 are certainly more satisfactory for cautery, especially if the E.M.F of the supply is greater than 100 volts. For 200-volt currents I do not recommend rheostats for cautery, except in those cases where the current has also to be used either for spark coils or for arc lamps for treating lupus.

The rheostats have the advantage that, with a slight alteration, if the point C is made movable so that any desired voltage can be obtained from the terminals, they can equally well be used for spark coils or for arc lamps. In such a case the rheostats are not nearly as wasteful as for cautery, because for arc lamps 50 to 60 volts, and for spark coils from 30 to 80 volts, are required.

There is no wear and tear in these rheostats, and, as to the safety, the same conditions exist which were mentioned under galvanisation on page 50. I have never heard that patients received a shock, but patient and operator must be on a *dry* floor, and must avoid touching gas or water pipes while the rheostat is being used. Moreover, illuminating instruments which come in intimate contact with the patient, such as a urethroscope, should not be used simultaneously with a cautery burner.

Accumulators can be charged and used for heating the cautery burners. In this case also no special cables are required. 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 greater than that of the rheostat, 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, that the evaporated acid is replaced, and that they are not left too long without being recharged. For fuller information about the charging and treatment of accumulators, see pages 28—31.

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 to 250 volts must necessarily be long in order to have a sufficient resistance; there would be no room for them in these small bulbs. The lamps require usually from 4 to 12 volts, and from 0·3 to 1 ampère; their light varies from 0·5 to about 3 candle-power.

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. A surgical lamp might be connected "in series" with a larger resistance lamp. This arrangement would be very cheap, but would not enable you to vary the amount of light in the small lamp. An objectionably strong spark would also appear on a cystoscope or urethroscope on breaking the current. 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 of surgical lamp, from the smallest which is to be introduced through the male urethra, up to the 3 candle-power lamps, can be used equally well with such a rheostat.

It is necessary that the resistance lamp should have a thicker carbon filament than the surgical lamp, otherwise the latter will not burn brightly. On a 100-volt supply one 50 c.p. lamp, with 200 volts one 75 c.p. lamp, or better two 50 c.p. lamps connected parallel, will be sufficient in most cases. Rheostats on this principle can be made in various forms (see Nos. 2060—2066), 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. If the E.M.F. is 100 volts, the current may be used directly; if it is 200 or more volts, it has to be reduced by means of a shunt rheostat similar to those described under cautery rheostats. Particulars will be found under X-rays on pages 90 and 91.

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 (the rheostat for cautery described on page 54, or those made specially for the arc lamps can be used), but if the lamp is wanted for many hours every day, or if currents of more than 25 ampères are necessary, as in the original large Finsen lamp, a motor transformer has to be employed instead of a rheostat. In the rheostat 75 per cent. of the current would be wasted on a 200-volt supply, whereas the loss does not exceed 30 per cent. in large, and 40 per cent. in small motor transformers. If the Electric Light Co. charges 3d. per unit (1d. to 3d. is usually charged for a "power circuit"), a Finsen-Reyn lamp consuming 20 ampères will cost 6d. per hour on a 100-volt supply, and 1s. per hour on a 200-volt supply with a rheostat. The original Finsen lamp, consuming 60 ampères, would, under such conditions, cost nearly 2s. on a 100 and 4s. on a 200-volt supply with a rheostat, and about 1s. 4d. per hour with either 100 or 200 volts if a motor transformer is being used.

Larger lamps are always self-adjusting, *i.e.*, they are provided with a mechanism which separates the carbon poles as soon as the current is switched on and the arc strikes, till the proper distance for a steady arc has been reached. The length of the carbon rods diminishes gradually, but they are brought nearer together by the same mechanism as soon as the distance between them has become too great. A few small lamps, such as the Strebel hand lamp, or the Lortet-Genoud lamp, have no such mechanism. They are "hand fed," *i.e.*, the carbons must be brought together first so that the points touch. They are separated then by hand with a screwing movement till the proper distance for a steadily burning arc is reached, and after about ten minutes, when some of the carbon has burned away, they are brought a little nearer together to maintain this distance.*

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

* The "hand fed" lamps can also be used on the alternating current. There are also plenty of automatic lamps which will burn well with an alternating current, and will give just as great a candle-power as the continuous current lamps, but, nevertheless, the latter are universally used for treating lupus and for projecting lamps. This is due to the fact that in the continuous current lamp a crater is formed in the positive carbon. This crater is the hottest and most luminous spot of the arc. It is small and quite steady, and can conveniently be placed in the focus of a parabolic mirror or a lens, and a great candle-power can thus be concentrated on the part to be treated. In the alternating current lamp no such crater is being formed, and the arc is less steady; the optical results through a lens are, therefore, not nearly as good.

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.

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.

Many attempts are being made to increase the quantity of ultra-violet light rays—for instance, by using iron electrodes instead of carbon ones. The light obtained from burning iron produces inflammation of the skin more quickly than the light from carbon does, but it has been found that, owing to the very small candle-power, the effect is limited to the skin only, and does not penetrate at all to the deeper tissues, and for this and other reasons the iron arc lamps have been given up again. Iron and some other chemical substances can, however, be used in combination with the carbons, by mixing them with the latter; in this manner the amount of chemical rays can be doubled without reducing the candle-power of the arc. If such special carbons are being used, the duration of the application and the cost of the current required are diminished considerably.

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).

For **Electric Light Baths** (see Nos. 2150—2194) 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. The 100-volt magnet would soon be damaged if it were connected with a 250-volt supply; and, on the other hand, a magnet wound for 250 volts will not reach its full power if it were connected with a 100-volt supply. A special kind of soft iron is used for all these electro-magnets. Rheostats are used with the larger magnets. By inserting a greater or smaller amount of resistance the power of the magnets can be brought under perfect control.

ALTERNATING CURRENT.

The alternating current is superior to the continuous current only for cautery, and for the transformers for high frequency currents; 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.

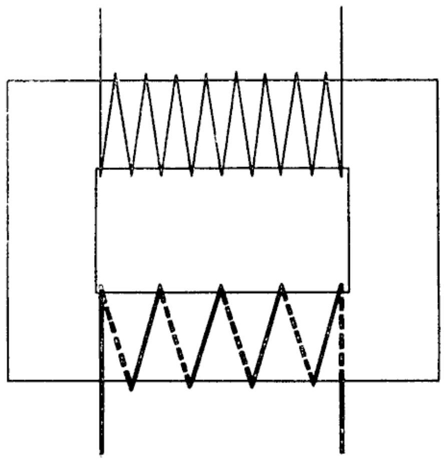


Fig. 25.

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 of this type are used in all houses where an alternating current is laid on, to transform the high tension current from the main, 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 of the "closed iron circuit" type have the highest efficiency; the loss in the transformation does not exceed 3 per cent. in larger transformers, *i.e.*, for every 100 watts sent into the primary coil we obtain 97 watts from the secondary coil.

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 all the many different types of surgical lamps. The efficiency and simplicity of these instruments surpasses very much that of the best continuous current transformers, and that of any other source of electricity which may be used for cautery.

Transformers for High Frequency Currents or X-rays are being constructed since some time to use the alternating current directly, and to dispense with the interrupters which are necessary for spark coils. In these transformers a current of 100 volts and 6 to 18 ampères has to be converted into more than 50,000 volts and a few milliampères. The construction does not differ in principle from that explained above, but, of course, the insulation must be infinitely superior to that of the transformers intended for currents of 100 volts only. For high frequency currents such transformers are very efficient and convenient, because the interrupters required with a continuous current are not wanted any more. The transformed currents are, however, also alternating currents, and cannot be used as such for X-ray tubes until they have been made unidirectional. The reasons for this and the manner in which it can be done are explained in the chapter on X-rays.

The alternating current can also be used with some special interrupters (see Nos. 2546—2549) for ordinary spark coils. Further particulars about this will also be found under X-rays.

Magneto-Therapy.—During the last few years magneto-therapy has occasionally been mentioned and recommended by a few authorities. It has been proved long since beyond doubt that a constant magnetic field has no physiological effects; but the magnets used for this kind of treatment are constructed for the alternating current in such a manner that they can accept and lose magnetism of opposite polarity in rapid succession.

There is no doubt that electric currents are induced in a patient's body and some physiological effects produced by alternating magnets. For instance, if we approach the field of a sufficiently powerful magnet of this kind a rapid succession of flashes are most distinctly perceived in the eyes. It is claimed that this magnetic treatment has a sedative effect, diminishes pain, and increases sleep, etc. The method is too new yet to decide whether all the claims are justified or not. Powerful alternating currents of about 40 ampères are required, and the magnets must be specially constructed for the purpose (see No. 1970).

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.

Synchronous Rectifiers have been constructed independently by Dr. Batten and Mr. Koch. In both instruments a polarized 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 alternating current is correct and the E.M.F. sufficiently high, and to break this circuit while the alternating current flows in the wrong direction. It can also be used to reverse one phase of the alternating current, and is then more economical, but in either case a pulsating unidirectional current is obtained. A condenser has to be used to reduce the sparking on the interrupter; its capacity has to be adjusted to the number of periods of the supply. 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 of lead or carbon, 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 polarizes rapidly, and offers so high a resistance that a current of less than 20 volts cannot pass. If four such cells are connected in series and inserted in an alternating circuit of 100 volts, it is changed into an intermittent unidirectional current, and only one phase can pass. If two groups of such cells are connected suitably, it is possible to rectify the current in such a manner that both phases are being utilized for charging the accumulators. 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.

The efficiency of both the mechanical and the electrolytical rectifiers is about 80 per cent.

Ultimately 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, and motor transformers can be used for many other purposes as well, for which a pulsating current cannot be used—for instance, spark coils, etc.

Sinusoidal Currents can be applied with the alternating current from the main. Particulars will be found under sinusoidal currents on page 70.

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 63—70), and the motor transformers will be found under Nos. 1780—1794.

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 recharging, 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

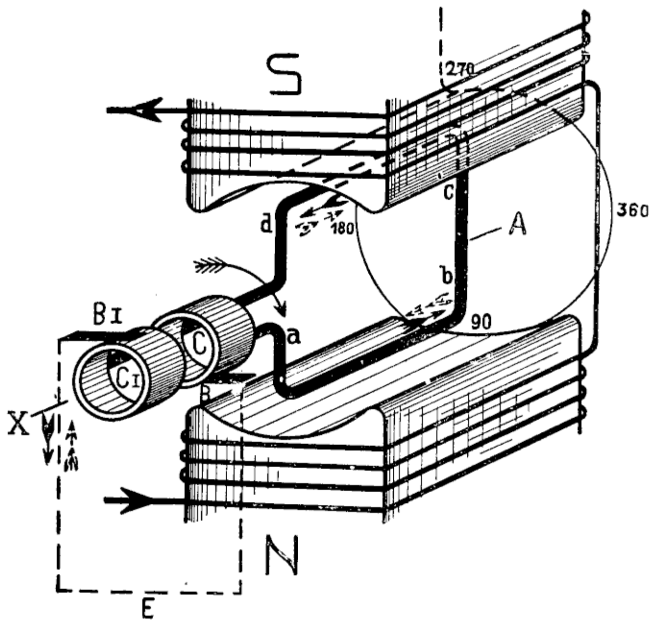


Fig. 27.

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.

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 35 about 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.

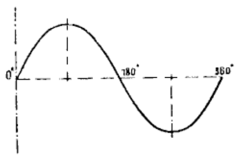


Fig. 28.

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.

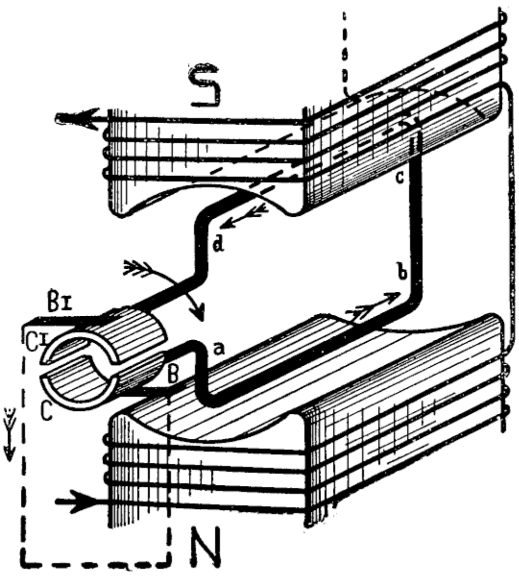


Fig. 29.

The annexed diagram (Fig. 29) 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.

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 which will be described later on.

Practically there is never one coil of wire only, as shown in the two preceding 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, as shown in the following diagram (see page 66). The E.M.F. induced in the upper half has the opposite polarity of that induced in the lower half, as indicated by the arrows. 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 in the direction indicated by the arrows. The diagram shows a ring armature of a continuous current dynamo. The collector consists of twelve separate segments of copper, which are insulated from one another, but connected with the winding of the ring.

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

* 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

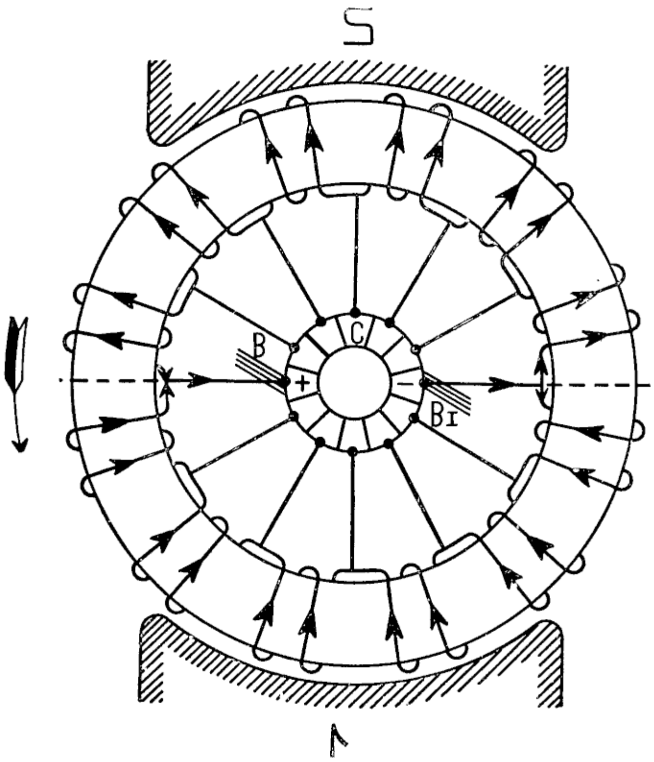
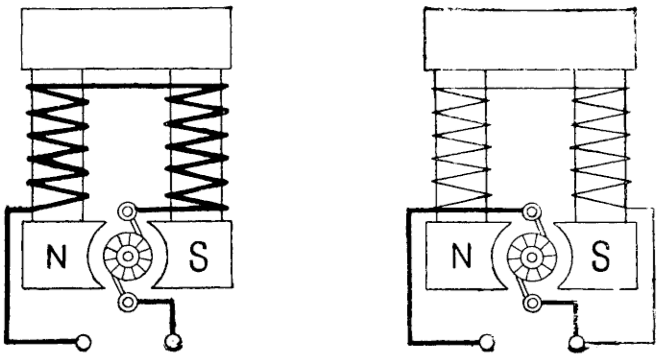


Fig. 31.

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 other brush, as shown in Fig. 32 (*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 current flowing through the external circuit only, as shown in Fig. 32 (*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.



a. Fig. 32. *b.*

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 overlooked or 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. These variable resistances are frequently arranged in the cast iron bases of the motors, and no special connections are then required. The amount of resistance in the circuit can be increased or diminished by altering the position of a crank.

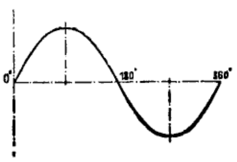
The brushes pressing against the collectors are made of carbon in all motors or dynamos which are intended for currents of 50 or more volts. They do not grind away the copper of the collector, but care must be taken that no oil is put on the collector, partly because oil is a good insulator, and partly because the collectors would be used up by the carbon if oil were added. Copper brushes are to be used instead of carbon ones only if the motors are intended for a low voltage. In such cases the higher contact resistance which exists between a carbon brush and the collector would cause an appreciable reduction in the efficiency, whereas with 100-volt currents this contact resistance is too small to be of importance.

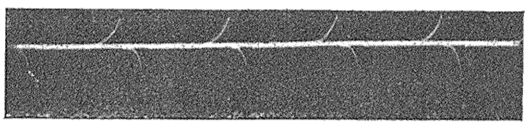
The bearings of a motor or dynamo must not be allowed to run dry, they have to be oiled from time to time.

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, either to obtain sinusoidal currents for treating patients, or for transformers for high frequency currents, or to work spark lamps. 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—1794.

Motor Transformers for Sinusoidal Currents.—Before concluding this chapter I have yet to mention one particular motor transformer (or dynamo) which is being used more and more 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 illus-





trations show 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 produced by 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 shown in the illustration, and the other ends of the three groups

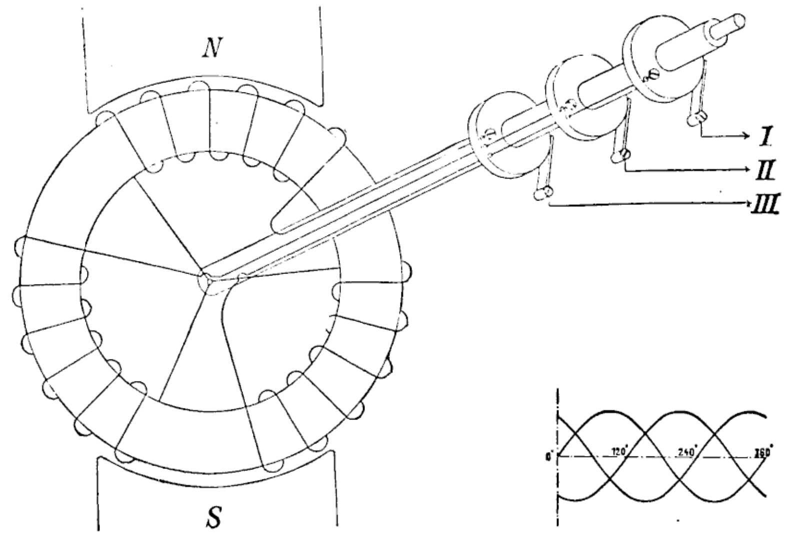


Fig. 33.

are connected together. While the first group is near the north pole of the dynamo, the second is 120 degrees further ahead, past the neutral point and on the way to the south pole; the third group is 240 degrees ahead, past the south pole already and approaching the second neutral point. Three separate waves are thus generated, and are interwoven, as shown in the illustration. In Fig. 34 the three zigzag lines on the left represent the three groups of wire on the armature, and the dotted curves on the right the three waves of current in the external circuit passing through the primaries of the three sledge transformers.

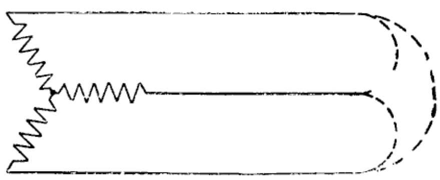


Fig. 34.

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 three-phase sinusoidal current is the most pleasant current to bear, and strong doses of current can therefore be administered in the shape of a three-phase sinusoidal current.

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 ; if a 12-volt current is being used, the sinusoidal current will have 7 volts. In the first case it would be too much, in the second case too little, for a patient, but it can be reduced or increased, so that the strength is suitable by a simple transformer resembling a sledge coil (there must be no interrupter on it, and the iron core must be larger than those employed usually in sledge coils). Such a transformer allows a very fine 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 primaries and the secondaries of the sledge transformers must be adapted to the voltage. If it is 150 volts, the primary must be wound with a wire of the same diameter and more turns than are used for the secondary bobbin ; but if a 12-volt current from an accumulator is being used for the motor, the primary of the sledge transformer has to be wound with few turns of a stout wire, and the secondary with many hundred turns of a fine wire in order to raise the number of volts. If suitable proportions are chosen, the currents applied to the patient can be increased gradually from a few volts up to about 80 volts. The secondary bobbins for a three-phase current are frequently connected together, so that they move simultaneously ; the voltage is thus increased or diminished evenly in all the three phases. The strength of the sinusoidal currents can be measured in milliampères by the so-called hot wire galvanometers.

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. A single-phase sinusoidal current from the main can be converted into a three-phase current only with the help of a motor transformer.

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.

Few inventions before this have made such a stir. A great number of scientific men all over the civilised world began to experiment with the X-rays, as Prof. Roentgen called them, and it was soon evident that this discovery would be of the greatest advantage to surgery. Later on it was found to be also of importance for diagnosis, because the size and movement of various organs, such as the heart, became visible, and since it has been proved that skin diseases like rodent ulcer, lupus, etc., can be cured, the interest taken by the medical world in this new science has been still further increased.

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.

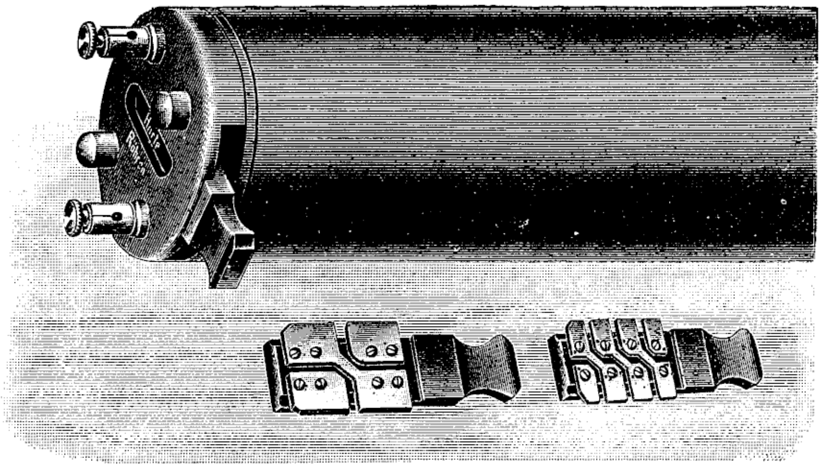
SPARK COILS.

Spark coils are used almost exclusively, which shows that they are the most convenient and efficient apparatus at our disposal. Their construction became possible through the discoveries of Faraday. The principle of the laws of induction has been explained already on pages 35 to 38. The coils which are described there under "Faradisation" are constructed to give a current of 30 to 150 volts suitable to be applied to the human body. In order to overcome the enormous resistance of the focus tubes, one thousand times as many volts are required ; the coils must therefore be much larger, and the insulation must be suitable for so high a pressure.

Since Roentgen's discovery the demand for spark coils has increased a hundred fold, and caused great competition amongst the manufacturers ; the scientific investigation of physicists, and the experience gained in the manufacture of transformers for alternating current, have combined to produce improvements in spark coils which would have been considered impossible in 1896.

The essential parts of a spark coil are :—

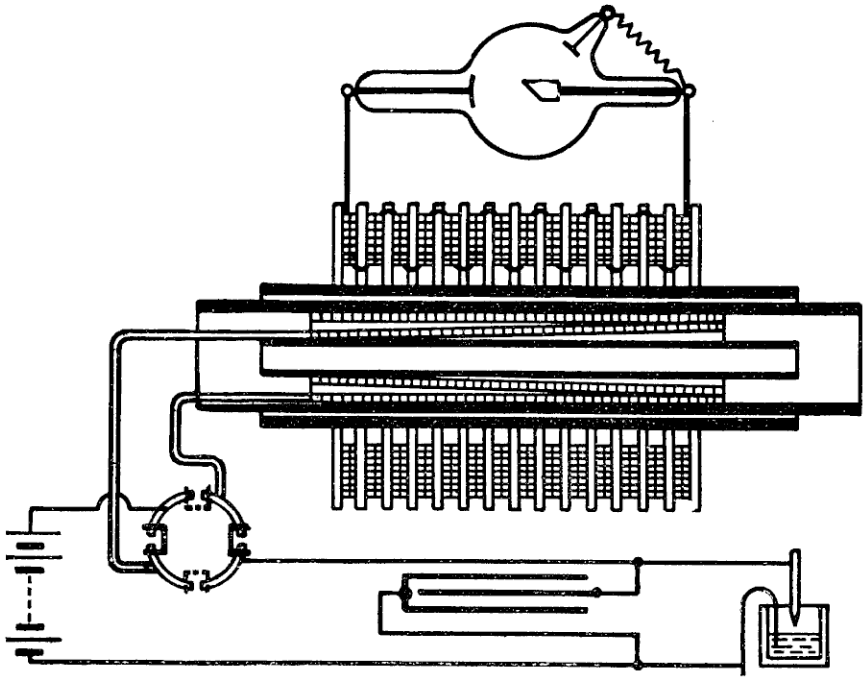
(1) The primary coil. (2) The iron core. (3) The secondary coil. (4) In most cases a condenser ; and finally (5) The interrupter. In addition they are provided with a commutator and discharging rods.



The Primary Coil consists of two to six layers (the number depends on the size of the coil) of insulated copper wire 2 to 4 millimetres thick (the diameter depends on the voltage with which the coil is to be used). In modern coils of larger size these layers are so arranged that they can either be connected in series, or in groups, or parallel, by changing a plug. In the first case the current travels as frequently round the iron core as there are turns of wire, and causes a high self-induction. In the last case, if all the layers are connected parallel, the self-induction is low, and if the layers are arranged in groups, it is half way between the two first-mentioned cases. The resistance, and especially the self-induction of the primary coil, can thus be altered, the advantage of which will be explained later on.

The Iron Core.—This cannot be made of solid iron, because it would accept and lose magnetism too slowly, and currents would be induced in a core of solid iron, which would convert a considerable part of the primary current into heat instead of magnetism (this phenomenon is called hysteresis). Straight wires, or better still, a number of thin sheets are therefore used for the iron core ; the separate sheets are insulated from one another in order to prevent these currents. A very soft iron found in Sweden takes and loses magnetism much quicker than ordinary iron, and this magnetic iron is therefore used in all good coils. The accurate diameter and length which the iron core must be for the various sizes of spark coils have been found out by calculation, which has since been corroborated by experience.

The primary wire is wound round the iron core which has been covered with strong linen tape, and the whole is soaked in melted paraffin wax.



The Secondary Coil consists of many thousand turns of copper wire, 0·18 to 0·2 mm. thick (No. 36), which is doubly covered with silk. In the smallest spark coils it is possible to wind the wires in horizontal layers one above the other, and to insulate one layer from the next by inserting a stout sheet of paper soaked in paraffin wax between them. But if the spark length reaches only 1 in. the E.M.F. between the ends of these layers becomes so great that the insulation is frequently pierced. It was found that the secondary wire may be wound in vertical sections, and the construction of large spark coils has become possible only since then. At first a few sections only were used, but gradually the number has been increased and the single sections were made thinner (less than $\frac{1}{16}$th of an inch). About 100 separate sections are now used for a good 10 in. spark coil, and a correspondingly greater number for larger coils. Some makers go further still and use only one layer for a section. These vertical sections can be insulated from one another more efficiently than the horizontal layers ; there is less difference of potential between the adjoining sections, as those with the greatest difference of potential are farthest apart, and finally, if ever the ebonite tube separating the primary from the secondary coil should be pierced, the damage can be repaired by taking off and building up the vertical sections on another ebonite tube, whereas with horizontal layers the fine wire would have to be unwound altogether, and it becomes frequently damaged or lost in such a case.

Insulation.—Primary coil and iron core are put into an ebonite tube over ½ in. thick, to insulate them from the secondary coil. In larger coils two such tubes (see illustration) and in the largest three tubes are being used. The secondary wire is always drawn through a mixture of melted paraffin wax and resin before it is wound on the coil. The single sections are wound on a special machine. The inner diameter of these sections is left ½ in. to 1 in. wider than the outer diameter of the ebonite tube, and this space is filled up with paraffin wax. In building up the secondary coil with these sections a thin sheet of ebonite or several sheets of good paper soaked in paraffin wax are placed between the adjoining sections.

The thickness of the insulating material means a loss in efficiency. The best results would be obtained if the secondary wire were quite close to the primary coil, but the better the insulation the greater is the guarantee that the coil will stand heavy and long wear without risk of being pierced. A compromise has, therefore, to be made between high efficiency and great durability. It is difficult to draw the line correctly, and some makers prefer to sacrifice a little more of the former, others a little more of the latter. This is the reason why different coils of the same nominal spark length vary so much in size. If the insulation is good a coil can be pierced only with unfair use. It does happen that coils which have been built for a normal current of 50 volts and 5 ampères = 250 watts, and have been tested up to 100 volts and 25 ampères = 2,500 watts, are connected by mistake or carelessness directly with a 250-volt current, and if the mercury interrupter is moving slowly at the same time, the primary current may reach 8,000 watts or more before the fuses act, and for such an excess the best normal insulation is insufficient. An accident may also happen, in spite of all care on the part of the maker, if there is an air bubble in the ebonite tube; this cannot be seen. As a rule such defective tubes break down during testing, but in exceptional cases they stand the strain of being tested, and go later on.

Resistance of the Secondary Wire.—The number of turns on the secondary wire required to produce a given spark length is also of great importance. As the resistance and especially the self-induction increase with greater length, the intensity of the sparks will diminish if the number of turns is unnecessarily large. On the other hand, when the length of the secondary wire is reduced below a certain limit, the number of watts required in the primary rises rapidly. This is inconvenient, because batteries are exhausted more quickly, and interrupters become heated, require cleaning, and are used up more rapidly with a strong current than with a weak one. As long as the internal resistance of the secondary wire is small enough to enable us to obtain the necessary number of milliampères through the high resistance of the tubes, nothing will be gained by reducing the number of turns below the point at which the strength of the primary current has to be raised above the possible minimum.

For instance, if in a coil A with 26,000 ohms resistance in the secondary coil a primary current of 140 watts is sufficient to produce a spark 16 in. long, and in a coil B with only 18,000 ohms resistance 250 watts are necessary to obtain the same spark length, coil A is preferable, in my opinion, on account of the weaker primary current, in spite of its somewhat higher resistance. 26,000 ohms are still almost a negligible quantity compared with a resistance of over 20 million ohms in a soft, and over 150 million ohms in a hard tube. But if we succeed in constructing coil B (without reducing the efficiency of the insulation!) so that it will give 16 in. sparks, also with 140 watts, it would be preferable to A on account of its lower resistance and self-induction. The latter is more important, as it forms a greater obstruction to the current than the mere number of ohms.

As far as the resistance and the primary current are concerned, considerable advance has been made. Eight years ago, over 150 watts were required in most coils to produce a 10 in. spark, and the resistance of the secondaries was very much higher. 150 watts will now produce sparks over 16 in. long, and furry bands can be obtained for *the full nominal spark length*, whereas formerly we had to be satisfied with blue sparks; the band-like sparks were obtained only when the distance between the dischargers was reduced to nearly one-half the nominal spark length.

E.M.F. of the Spark Coils.—Unfortunately we have not yet a wattmeter or a milliampèremeter to measure the strength of these currents, and the spark coils are therefore still classified according to their spark length only. This is a very primitive and unsatisfactory method, as it says only that the coils can produce a certain E.M.F.

A spark of	8	12	16	20	24	30 inches
requires about	108,000	148,000	186,000	216,000	242,000	278,000 volts,

but unless we can see the coil working we are left in the dark about the intensity of the sparks. The high voltages are required to overcome the resistance of the tube, but the effect produced on a fluorescent screen or on a photographic plate *depends only on the number of milliampères which are discharged through a focus tube.* A coil giving 300,000 volts will obviously force more milliampères through the resistance of a given tube than a coil with only 150,000 volts will do; but in comparing coils nominally of the same spark length, it will be found that a coil yielding thick, furry sparks will give much better results than one which gives thin blue sparks only. As long as we have not yet any means for measuring the intensity of the sparks discharged by a coil, it would, in my opinion, be an advantage if the following items were stated for every coil:—

(1) The number of watts which are necessary to just produce a spark of the full nominal length.

(2) The resistance of the secondary coil.

These two figures would show approximately whether the proportions of iron core, primary and secondary coil, are correctly chosen.

(3) A guarantee should be given that the coil has been tested with at least twelve times as many watts as are required to produce the nominal spark length, and that this current can safely be used, without fear of breaking down the insulation.

Closing Current.—In the secondary coil, currents are induced on making and on breaking the primary current, but the latter are much stronger, and if we say that a coil gives sparks of a certain length, we mean invariably those produced on breaking the current. The sparks discharged on closing the primary current have the opposite direction; they are, as we shall see later on, the chief or only cause why the X-ray tubes become gradually harder and ultimately useless. The closing current, and the means to prevent or reduce it, has been investigated carefully, especially by Professor Walter. He found that the E.M.F. of the currents induced by closing the primary current rises in direct proportion with the E.M.F. of the current used in the primary circuit, and in inverse proportion with the self-induction of the primary coil.

The currents induced on closing the primary circuit may reach fully 25 per cent. of the E.M.F. of the currents induced on breaking the primary current. Walter obtained, for instance, from a coil which gives 23 in. sparks on breaking the primary current,

sparks	$\frac{3}{4}$	$2\frac{1}{2}$	$5\frac{1}{2}$ in. long
with	37	110	220 volts,

on closing the primary circuit. The same number of ampères was used in all cases.

Moreover, the E.M.F. of the closing current depends on the amount of self-induction in the primary coil. This self-induction acts as a resistance; if it is low, the primary current and the magnetism of the iron core reach their maximum more rapidly than with a high self-induction. In the experiment mentioned above, a spark $5\frac{1}{2}$ in. long was obtained on closing the primary current in a coil with low self-induction; but in using a coil with high self-induction a spark of not more than $3\frac{1}{2}$ in. could be obtained with the same number of volts and ampères. To keep the closing current low the E.M.F. used in the primary should be low, and the self-induction high. We shall mention later on other means which help to reduce or suppress the closing current.

Size of the Spark Coils.—When Prof. Roentgen made his discovery, it was thought that at least a 10 in. spark was necessary to produce any X-rays at all; but improvements in the focus tubes showed that even 2 in. sparks are sufficient to obtain negatives showing the bones of the hand, but it requires a long exposure to obtain a photograph even of the hand with such a small coil, and the heart, etc., cannot be made visible at all, and the demand for coils giving less than 10 in. sparks ceased gradually. For some time the full power of large coils giving sparks of 18 in. or more could not be utilized, because there were no tubes which could stand such a current, but this difficulty has been overcome, as we shall see later on.

There is no doubt that larger coils will give better results than small ones; more details can be detected, the exposure can be shorter, there is better control over the tubes, and the tubes can be used longer, more milliampères can be obtained with high frequency apparatus, etc. The question, "Which size shall we use?" has to be decided chiefly by the buyer's purse. The price only is against the large coils, everything else is in their favour. 10 in. coils are most frequently used in this country, and for many cases they will be found sufficient, but for large hospitals, or for surgeons who desire to obtain the best results, 16 to 20 in. coils are necessary.

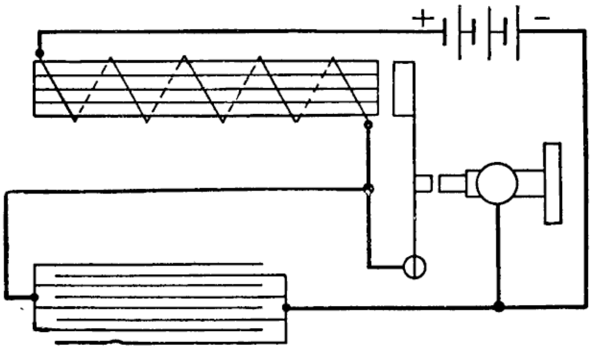
INTERRUPTERS.

The interrupter is an important part of the spark coil, and much care and ingenuity have been bestowed on its construction.

If a current is sent through a spiral wound round an iron core, or if the primary current is closed, an E.M.F. is started in the primary coil, in consequence of self-induction and the presence of the iron core. The polarity of this E.M.F. is opposed to that of the primary current; it acts therefore as a resistance and retards the primary current. It also takes a little time till the iron reaches its full magnetism. When the primary current is broken an E.M.F. is started again, but this time it has the same polarity or direction as the primary current, and intensifies it very much. To judge by the spark appearing at the point where the current is being broken, the E.M.F. started by breaking the primary is about hundred times as great as that of the inducing current.

A good interrupter must keep the primary current closed long enough to enable the current and the magnetism to reach their maximum. The time required for this depends on the iron core and on the voltage used in the primary circuit. With 12 volts about three times as much time is taken as with 100 volts.

The break should be as instantaneous as possible, because the more sudden it is, the more powerful will be the induced current and the spark. Whenever we break a current a spark appears at the breaking point, and this makes it impossible to break it instantaneously; the current diminishes rapidly as the distance between the breaking points increases, but the break is not instantaneous. Various means are being employed to extinguish this spark as quickly as possible ; the most important of these is a condenser.



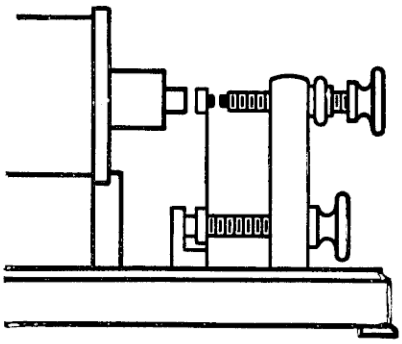
The Condenser used for spark coils consists of many sheets of tinfoil ; the adjoining sheets are insulated from one another by layers of paper soaked in paraffin wax. The first, third, fifth, etc., sheets of tinfoil project at one end, and are connected together, but are insulated from the second, fourth, sixth, etc., sheets, which are connected at the other end. One end of the condenser is connected with one side of the interrupter, the other end with the other side. As soon as the contacts of the interrupter separate the current rushes into the condenser and charges it. It can discharge through the primary coil and the battery or dynamo ; in doing this it passes through the primary coil in the opposite direction, and this helps to de-magnetise the iron core rapidly. The condenser therefore acts in two ways : it reduces the sparks between the contacts of the interrupter, and makes the magnetism of the iron core disappear more quickly. Its great importance is best shown by the fact that a coil which gives a 10 in. spark with a condenser will only give a 5 in. spark without one.

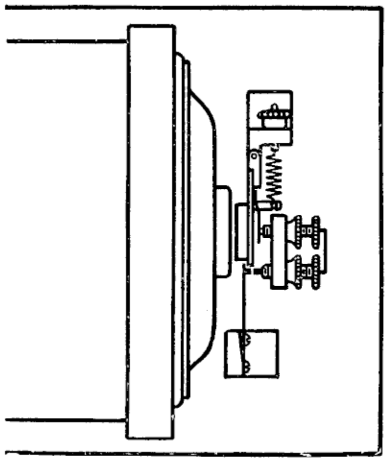
The capacity of the condenser is important. It must be in proportion to the number of watts which are used, and to the self-induction of the primary coil ; the greater these are the larger must be the condenser, and *vice versa.* If it should be too great the sparks become thicker, and their length is somewhat reduced ; if it is too small, there is a greater strain on the insulation of the coil. In coils which are provided with variable self-induction the capacity of the condenser can therefore be also varied.

The sparks between the contacts of the interrupter can further be reduced if the break takes place under an insulating liquid, such as paraffin oil or alcohol, and this is made use of in all mercury interrupters.

The Frequency of an Interrupter, *i.e.*, the number of times it breaks the current in a second, is also of great importance. An interrupter which enables us to obtain fifty sparks in every second has obviously an advantage over one which allows only twenty-five sparks in the same time, provided the sparks have the same length and intensity. There is, however, a limit to the frequency of all interrupters; if it is too great, the duration of contact becomes insufficient, and the sparks diminish in length and intensity.

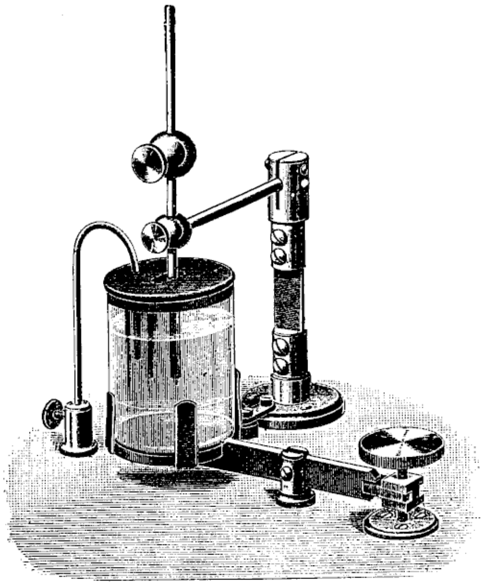
In order to obtain a steady light on the screen, it is necessary to have not less than about 40 interruptions per second. There is no difficulty nowadays in reaching much higher frequencies, but it must always be remembered that 40 *intense* sparks will give better results than 100 *short or thin* ones. It depends on the interrupter, the primary current, and the focus tube, whether anything will be gained by exceeding, say, 50 breaks per second; in many cases it will only be a useless strain on the tubes.





The Platinum and Mercury Hammer Breaks were for a long time the only interrupters used. The platinum interrupter is like a Wagner's hammer; the current passes through the primary coil and a platinum contact into a spring, which bears the hammer, and which by means of its elasticity presses the platinum contacts together, and then back into the battery. The iron core is thereby made magnetic, attracts the hammer, the spring is bent and the platinum contacts become separated in consequence, the current is broken, the iron loses its magnetism and the spring jumps back, thus closing the current again. Frequently the break happens before the primary current and magnetism have had time to reach their maximum, and various attempts have been made to overcome this defect. Most frequently the tension of the spring can be increased by means of a screw, as shown in the illustration; the duration of contact can thereby certainly be raised, but the firmer the spring presses the platinum contacts together the slower will be the separation. The length of the sparks does not at all advance in proportion to the increase which takes place in the primary current, and the interrupter has a tendency to stick. Another construction, which is shown in the second illustration, is decidedly better in this respect. The hammer and the platinum contact are mounted on two *separate* springs; the contacts are separated only some time after the current has been closed, and at the moment when the hammer has reached its greatest momentum. These interrupters give about 20 *full length* sparks per second. The Deprez platinum interrupter can give double the number of sparks, but with greatly reduced length and intensity. More than 20 volts cannot well be used in the primary circuit with the platinum interrupters, otherwise the contacts would burn away too rapidly.

In the **Mercury Interrupters** the hammer bears a copper wire, which is plunged into, and lifted out of the mercury by the rocking movement of the hammer. The cup containing the mercury can be raised or lowered, with a screw to adjust the level and the duration of contact with the mercury. Above the mercury is a layer of paraffin oil, and the breaks are fairly sudden. The sparks are considerably longer and thicker than those obtained with the platinum interrupters, but it is difficult to reach more than 15 interruptions per second.



The results obtained with these interrupters cannot be compared with the effects produced with the new interrupters, and consequently they have been almost entirely superseded by the latter. The platinum interrupters are, however, still used on account of their great simplicity, and they are especially convenient for coils in which portability is important.

A great advance was made when interrupters were constructed in which the make and break was not produced by the rocking movement of a hammer dependent on the magnetism of the iron core. This was first achieved with the

Motor Interrupters.—The current is closed and broken by a copper rod, which is moved up and down by the revolution of a motor. (See No. 2535.) The duration of the contact and the rapidity of the motor can be adjusted, and some 25 full length sparks can be obtained per second. If the speed is increased there is much vibration, noise, and splashing, and in consequence the sparks become very irregular.

The Mackenzie Davidson Interrupter (see No. 2536) is also a dipping interrupter, but runs more quietly on account of the absence of any reciprocating movement. A considerably greater number of sparks can be obtained with this than with the interrupter before mentioned.

In 1899 the **Mercury Jet Interrupters** were invented. In these interrupters a centrifugal pump, driven by an electric motor, ejects a stream of mercury, and this jet strikes alternately a copper segment, or an insulating space filled with oil or alcohol. The breaks are as quick as can ever be obtained with a mechanical interrupter, and as several copper segments can be arranged in a circle, we can reach as many interruptions as we like. The necessary duration of contact is the only limitation. The great rapidity and the sudden break make it possible to employ 100 or even 250 volts with such an interrupter, which is a great advantage, partly because the current from the main can be used, and partly because the primary current and magnetism reach their maximum quicker with a high voltage. The interrupters are so arranged that with a 12-volt current one break, with 20 to 60-volt two, and above 60 three or even four breaks are obtained per revolution. The duration of contact can be adjusted by a crank and by copper segments of various length, and by the speed of the motors. They make up to 2,000 revolutions per minute. We can obtain, therefore, from 40 up to 100 sparks per second, according to the voltage which is available in the primary circuit. The number of sparks can easily be reduced by inserting some resistance in the circuit of the motor, and can be brought down to 10 or even less per second.

The mercury jet interrupters can be used equally well with batteries or the current from the main. They allow the best control over the rapidity, it is easy to vary the number of sparks from about 10 up to over 100 per second, they give us the *thickest sparks which can be obtained at all*, and are certainly the most efficient mechanical interrupters existing at present.

The mercury has to be cleaned after some time in *all* the motor interrupters, and this is not a very pleasant business. The smaller the quantity of mercury contained in an interrupter, and the stronger the primary current used, the more frequently has the mercury to be cleaned. To avoid this cleaning, **Motor Interrupters without Mercury** have been constructed, in which the current is being made and broken by a brush pressing against a revolving wheel. The circumference of this wheel has alternately copper contacts and insulating pieces of slate. The contact resistance between brush and segments is comparatively great, and for this reason an amalgam of mercury is frequently used either in the brush or on the wheel to reduce this resistance. Moreover, the spark tends to destroy the contacts; to reduce it, wheel and brush are frequently placed under oil or alcohol (see No. 2544). In my experience these interrupters work very well if the E.M.F. in the primary is not less than 50 volts, and the number of ampères not more than about 6. They are, therefore, not suitable for use either with batteries or with very large coils. The brushes and the contacts on the wheels wear out and have to be renewed from time to time. The duration of contact and the frequency of the interruptions can be adjusted as in the jet interrupters.

Electrolytical Interrupter.—In 1899 Dr. Wehnelt, of Berlin, discovered an interrupter which is based on an entirely new principle. A small platinum wire and a large lead plate are immersed in diluted sulphuric acid; if the platinum is connected with the + pole, and the lead plate with the – pole of an electric supply, oxygen appears in consequence of the electrolytic action at the anode. The density of the current is very great near the platinum on account of its small size, and, if the current is sufficiently powerful, it will make it even incandescent. The heat produces steam, which forms an insulating mantle round the platinum, and in consequence of this the strength of the current drops suddenly. The steam adheres to the incandescent platinum if there is no coil with a sufficient self-induction in the circuit, but the high E.M.F. of the extra current, started in the primary coil on account of this sudden change in the current's strength, overcomes the insulating resistance, ignites the oxygen and hydrogen, a lively spark appears, the gases are thrown off with an explosion, and the acid regains access to the platinum, thus closing the current. The makes and breaks follow one another with extraordinary regularity and rapidity. The explosions do not begin with less than about 20 volts (it depends on the amount of self-induction available), and the frequency of the interruptions rises with the E.M.F. used.

The results obtained were not quite satisfactory at first; the interrupters were not under control, and, if connected with the current from the main, the discharges were so powerful that the tubes which were available when it was discovered were used up in a very short time. The interrupters became hot and ceased to work, leaked, corroded, etc., and on account of these faults they were given up again. When they were better understood, the defects were gradually corrected, but the prejudice against them continues to exist. There is no doubt that the electrolytical interrupter surpasses all others in efficiency, and, if suitable arrangements are made to control them, *they are the best interrupters all round provided that the continuous current from the main is available.* They are unsuitable with batteries because they require too much current; they work best with about 60 volts and 20 ampères (this is equivalent to nearly 2 h.p.). For high frequency currents, less than 10 ampères are sufficient.

To control the discharge produced with these interrupters, it is necessary to vary:—

(1) The surface of the platinum wire.
(2) The number of volts used in the primary circuit.
(3) The degree of self-induction in the primary coil.

The platinum wire passes through a narrow hole in a porcelain tube (glass is unsuitable because it breaks too easily, especially if a high self-induction is being used), and by means of a screw arrangement a longer or a shorter piece of platinum can be exposed. If we increase the surface of the platinum the ampères increase and the sparks become longer and thicker, but the rapidity of the interruptions diminishes. If we reduce the surface of the exposed platinum the number of sparks increases, but their length and thickness diminishes. A good screw arrangement is therefore necessary to adjust the length of the projecting platinum. Formerly, metal screws were used, but they corroded too easily in the neighbourhood of the acid, and they have therefore been replaced by screws made of ebonite.

The frequency of the interruptions is influenced by the number of volts used in the primary circuit. The higher the E.M.F. the greater is the frequency, and *vice versa.* It is, therefore, necessary to employ a shunt rheostat (see No. 2670) to reduce the 100 to 250 volt currents from the main. According to the condition of the tube as little as 30 or as many as 100 volts may have to be used.

We have mentioned already that the self-induction plays an important part in these interrupters. The old coils, which had few turns of stout wire suitable for 12 volt currents from batteries, do not frequently work well with electrolytical interrupters, because their self-induction is too low; their nominal spark length becomes considerably reduced, or the interruptions may cease altogether and the platinum may become incandescent. To raise this self-induction, separate spirals were inserted in the circuit, or exchangeable primary coils were used, but Prof. Walter simplified this by introducing the variable self-induction. The primary coils are now so arranged that by means of a simple commutator (see illustration on page 72) the layers can be connected in series, or parallel, or in groups. In the first instance, the self-induction is highest, the sparks obtained from the coils are short and suitable for soft tubes; in the second instance, the self-induction is lowest, the sparks are long and suitable for hard tubes; in the third instance, the sparks are of medium length and suitable for medium tubes. Three different degrees of self-induction are sufficient for most cases, but more can be arranged if desired.

These three things give us an excellent control over the electrolytical interrupters; we can vary the number of sparks from about 5 up to 1,700 per second by means of varying the voltage and the length of the platinum. To obtain long and intense sparks we use a low self-induction with a long platinum pin, and if we use high self-induction and a short platinum pin we can reduce the output of the largest coils so that it is suitable for very soft tubes.

The temperature of the acid rises during use, and when it has reached about 90 degrees Centigrade the interruptions cease. It is therefore important that the interrupters should be large. Originally, the glass vessels used contained less than 2 pints of the diluted acid, and after about half an hour's use the interruptions stopped. The glasses used now hold over 8 pints, and it takes several hours of uninterrupted use till the acid reaches boiling point. If it should ever be necessary to use them for many hours at a stretch, the glasses can be placed in a larger basin with water to keep them cool. The diluted acid must have a gravity of about 20 to 25 degrees Baumé (1 oz. of sulphuric acid diluted in about 10 ozs. of water).

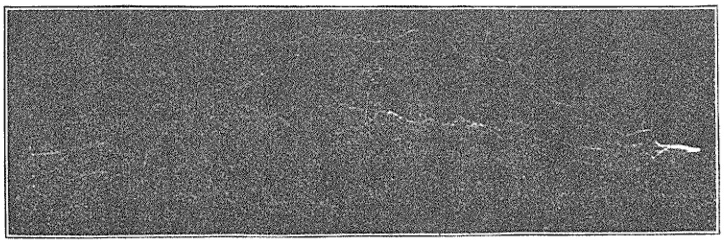
The interruptions in the Wehnelt are so perfect that a condenser is not necessary; on the contrary, they work better without one. If omitted, it means a saving of about 10 per cent. in the cost of the coil, but such a coil cannot then be used with any other interrupter. Many coils are provided with an arrangement that the condenser can be switched on or off, so that they can be used with an electrolytical or any other type of interrupter.

It is important that the interrupter is connected correctly, the platinum with the + pole; if the current passes in an opposite direction, the coil will not work well, the platinum will be dissolved gradually, or if it is rather thin, will be fused instantly. If the direction of the current is correct, the sparks in the interrupter have a red colour; if the direction is wrong, they have a blue colour. The polarity can also be found with pole-finding paper; the negative pole leaves a red stain on the moist paper.

The electrolytical interrupters make some noise, but as they require no attention, they can easily be placed in a lead-lined box or in another room. After they have been properly adjusted and connected, nearly all the regulation can be done with a suitable rheostat. If the coil is provided with variable self-induction, the surface of the platinum has to be altered when another degree of self-induction is being used. Instead of doing this each time, interrupters with three separate platinum pins may be used. With a switchboard it is possible to change simultaneously the degree of self-induction, and the platinum pin through which the current is passing, even if the interrupter is in another room. If the pins have once been properly adjusted for soft, medium or hard tubes, no time is lost in making the change. The electrolytical interrupters require no cleaning, which is a great convenience.

Simon or Caldwell Interrupter.—A modification of the electrolytical interrupter was brought out simultaneously by two independent inventors. Instead of using platinum, two lead electrodes are separated by a diaphragm of porcelain, with a very narrow hole. The density of the current is greatest at this hole, and the interruptions and sparks take place there. The interrupter is simpler still than the Wehnelt, but the resistance of it is rather high, and currents of not less than 130 volts are required to make it work properly; it is not under control as much as the Wehnelt interrupter, and these are, no doubt, the reasons why this modification is only seldom used.

Before concluding this chapter, I will add a few photographs of sparks obtained with mercury and electrolytical interrupters. Photographs of electric discharges may be rather misleading if the conditions under which they were taken vary. Nevertheless, I have thought it worth while to print the following illustrations, because I am sure that the conditions were the same in all cases. The exposure in illustrations I. to V. was about one-tenth of a second, the full nominal spark length of a 16 in. coil was used, and 60 volts were employed in the primary circuit.



No. I.

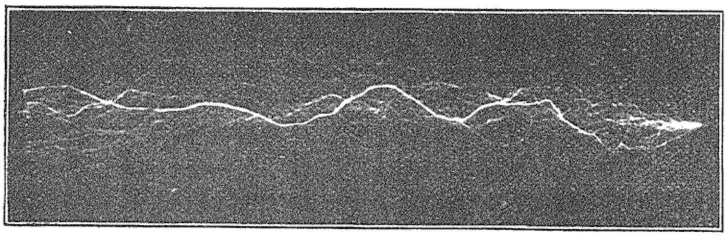
No. I.—Mercury Jet Interrupter, 2·4 ampères (144 watts), blue sparks.

No. II.—Same interrupter, 6 ampères (360 watts), yellow sparks.

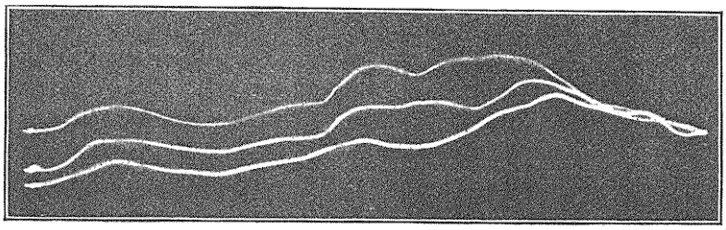
No. III.—Same interrupter, 28 ampères (1,680 watts), thick sparks.

No. IV.—Wehnelt Interrupter, 22 ampères (1,320 watts), length of platinum 4 millimetres.

No. V.—Wehnelt Interrupter, about 35 ampères (over 2,000 watts), length of platinum 25 millimetres. This illustration was added to show



No. II.



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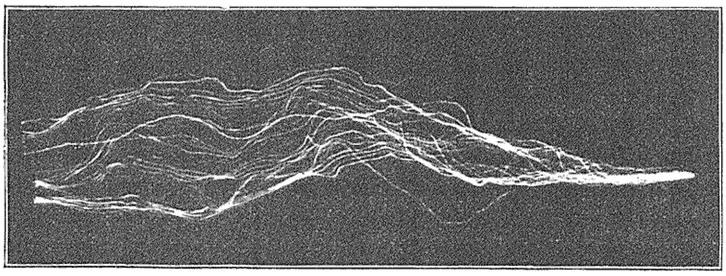
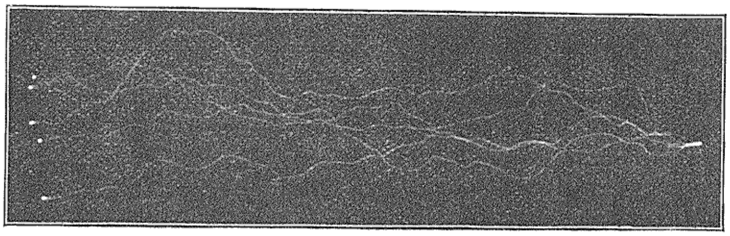
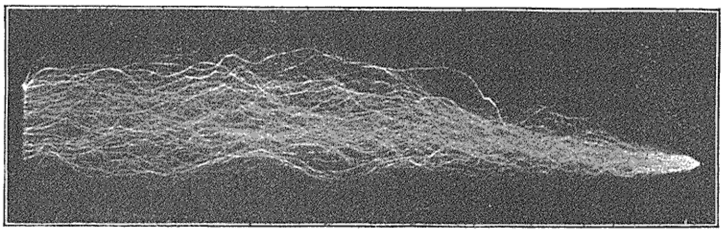


No IV



No. V.



No. VI.

that it is quite easy to obtain slow interruptions with an electrolytical interrupter. When the volts were reduced to 30, the number of sparks was still further diminished to 3 or 4 per second. The illustration does not quite fairly represent the great difference between the blue and the thick sparks: the former have comparatively a greater actinic power than the thick sparks, the flame-like fringe of which has a reddish colour, which makes a faint impression only on isochromatic plates, at any rate with a lens with an aperture of F.7.

No. VI.—Wehnelt Interrupter, exposure 1½ to 2 seconds. This illustration has been added only to show what a totally different picture can be obtained merely by giving a longer exposure. The sparks appeared to the eye exactly like those shown in No. IV. The number of ampères and the length of the platinum were the same as those used for No. IV.

The two following illustrations* may also be of interest. The current produced in a coil can be examined with the help of a Braun's tube—a narrow stream of cathode rays strikes on a fluorescent screen, and is deflected by the current which is to be examined, and which passes through a solenoid placed perpendicularly outside the tube. If the luminous spot is observed on a revolving mirror or photographed on a plate which is being drawn across, the curves obtained are those shown in the lower part of the illustrations. The wave lines in the upper part are produced by a tuning fork making 100 vibrations per second.

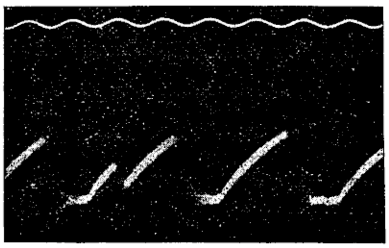


Fig. 1.

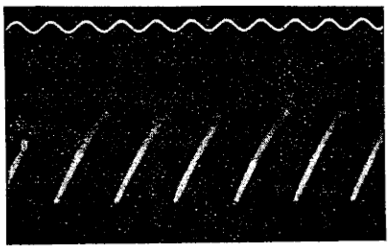


Fig. 2.

Fig. 1 shows the current produced with a Deprez platinum interrupter. The curves show irregularities due to imperfect contact.

Fig. 2 shows the current produced with a Wehnelt electrolytical interrupter. The impulses are absolutely regular, and no time is lost between the end of one impulse and the beginning of the next.

* These illustrations have been taken, with the permission of the author, from Wiedemann's *Annalen*, vol. 69, page 866.

INTERRUPTERS FOR ALTERNATING CURRENTS.

There are several interrupters available now which make it possible to use the alternating current directly for a coil.

Mercury Jet Interrupters can be used if they are provided with an alternating motor, which makes the interrupter run synchronously with the dynamo (see No. 2546). The current has to be broken at the correct moment when the phase has reached its highest E.M.F. The motor has to be started first and brought to the correct speed by means of a flywheel driven by hand ; the duration of contact and the frequency of the interruptions cannot be varied, but otherwise the interrupter resembles the jet interrupter for continuous current.

The Electrolytical Interrupter can be used to a certain extent, but the discharge cannot be compared with that obtained with a continuous current. An arrangement has to be inserted to make the current uni-directional. This can either be done by using a few aluminium cells in the primary circuit, which allow the current to pass in one direction only, and a spark-gap may be inserted for the same purpose in the secondary circuit between tube and coil. Here, again, the frequency of the interruptions cannot be varied, and, moreover, about 1·4 gramme of platinum is dissolved for every hour the interrupter is used with a current of 20 ampères. Other metals have been tried instead of platinum, but without success. To keep the exposed surface constant in spite of this steady diminution, the platinum falls down by its own weight against a piece of porcelain, which can be raised or lowered by a screw to adjust the length of the exposed part.

Koch's Rectifying Interrupter.—In this instrument (see No. 2549) there is an electro-magnet and a permanent steel magnet ; the latter is attracted or repelled by the electro-magnet as it alters its polarity. The steel magnet vibrates therefore synchronously with the periods of the alternating current, and is used to make and break the primary current at the correct moment. Several of these interrupters have been in use now for years, and have stood the test well. They have not required attention or repairs except the unavoidable renewal of the platinum contacts. These interrupters can be used for any size spark coil. The condensator of the interrupter must be adjusted to the number of periods of the supply.

The alternating current can be converted into a continuous current by means of a motor transformer, in which case the ordinary continuous current interrupters can be used ; or accumulators can be charged from the alternating current, if it is rectified by means of an apparatus Nos. 2685 or 2687.

TRANSFORMERS WITHOUT INTERRUPTER.

The alternating current can be transformed so that sparks of any length (according to the size of the transformer) can be obtained from the secondary terminals. The transformers resemble spark coils (see No. 2564A), but the iron core, instead of being an open one as in a spark coil, should be continued outside the secondary bobbin and closed in a complete ring.* The prices of the transformers are higher than those of spark coils giving a similar length of spark. The number of sparks obtained depends on the number of periods of the dynamo; they are usually between 50 to 100 per second. The length of the sparks can be regulated by a suitable rheostat in the primary circuit.

As no interrupter is required at all, these transformers are certainly very convenient where the alternating current is laid on, and they are sure to replace, in course of time, many spark coils. The first apparatus of this kind were constructed by Mr. Koch.

The discharges from such a transformer are alternating. They can be used directly for high frequency apparatus, and grand brush discharges can be obtained with them. They have, however, to be made uni-directional for X-ray purposes. This can be done, for instance, by placing an electrolytic rectifier (aluminium cells) into the primary, and a spark-gap or valve tubes in the secondary circuit. With this method of rectification some closing current will still reach the tubes if the current in the wrong direction has the same E.M.F. as the current in the right direction.

An apparatus has been constructed which makes the current uni-directional by a mechanical rectifier, which completely excludes all current in the wrong direction. It consists of a small synchronous alternating motor; attached to its axis is a vertical ebonite rod which carries at its upper end a horizontal metal wire. When the motor is running, this spins round in an ebonite drum shown at the top of illustration (see Fig. 2564C). The wire from the transformer leads to one of the two terminals of this drum, and another wire leads from the second terminal to the X-ray tube. When the ends of the revolving metal wire approach the terminals, the current begins to leap over, and remains closed until the distance has increased again to a few inches; the current is then broken, but after half a turn of the motor it is closed again. The ebonite drum bearing the terminals can be turned about

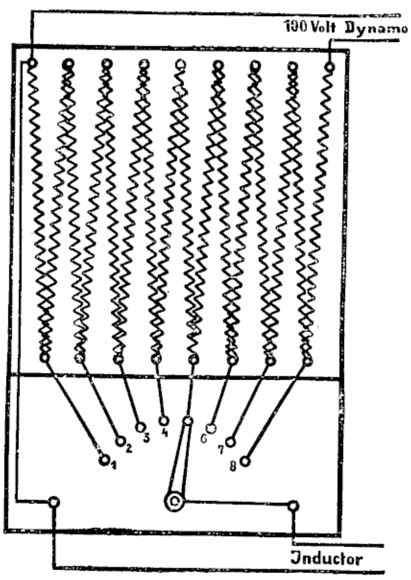
* Our spark coils with open iron cores can be connected without interrupter with an alternating current, but the sparks will then have only half the nominal length; this is sufficient for producing high frequency currents, or for soft X-ray tubes, but to obtain the full spark length for hard tubes without interrupter, coils with closed iron cores are indispensable.

one-third of a turn, so that the current is closed when the highest E.M.F. of the period is reached. The motor will run for hours or even days without getting hot, there is no current in the wrong direction, and the light in the tube is absolutely steady. The apparatus is silent, there is no cleaning of an interrupter nor repairs in consequence of wear and tear, and it is simple to work. These advantages will be most appreciated by those medical men who require the current for many hours every day.

SOURCES OF ELECTRIC ENERGY.

We have yet to mention the sources of electrical energy which are suitable to work the spark coils.

Wherever the **Continuous Current from the main** is laid on, this should be used directly. Some people are under the impression that the current from accumulators will produce better results than the current from the main. This may be so if a coil constructed for a primary current of 12 volts is connected with a 100-volt supply. If the wire on the primary was chosen to suit 10 ampères and 12 volts, it is not surprising that the best results cannot be obtained with 1·2 ampère and 100 volts (this is the same number of watts as with 12 volts and 10 ampères), because the number of ampères is not enough to magnetise the iron core sufficiently. If 10 ampères and 100 volts are used, the condenser is likely to be too small. If the winding of the primary current is chosen correctly for 100 volts and 2 ampères, there is no reason why the current from a dynamo should give other results than that from accumulators. I can connect coils both with accumulators and with the current from the main in my X-ray room ; if the same number of volts and ampères is taken in either case, I cannot find any difference either in the appearance of the sparks or in the readings of the ampèremeter.



It is obviously much more convenient in every way to receive the current ready made by turning a switch, than to have to generate it in primary batteries or store it in accumulators. It will, however, be necessary in most cases to have some rheostat in the circuit to control the current, and this can best be done with a shunt rheostat. The volts can be varied by turning a crank. This allows a much greater range of variation than a rheostat connected "in series" can give, but a small rheostat "in series" is usually added to the shunt rheostat (see No. 2670). This combination is very convenient, because—

(1) The current can be adapted easily to soft, medium, or hard tubes; the former may not be able to bear more than 30 volts in the primary without becoming unduly hot, the latter may require as many as 80 or 100 volts at first to force any current through them at all.

(2) It is an advantage if the E.M.F. used in the primary circuit is not higher than is just necessary to make interrupter and tube work properly; as already mentioned, the E.M.F. of the closing current rises in direct proportion to the E.M.F. used in the primary coil, and this closing current is detrimental to the long life of the tubes, as will be explained later on.

(3) If an electrolytical interrupter is being used, the frequency of the interruptions depends partly on the E.M.F. used, and to control the rate of interruptions it is necessary to be able to vary the E.M.F.

Obviously the advantages of the shunt rheostat will be greater the higher the voltage of the supply.

If an **Alternating Current** is being supplied from the main, the conditions are somewhat different. We have seen before that there are interrupters which enable us to use the alternating current directly with a spark coil, but the rate of interruptions depends on the number of periods of the dynamo and cannot be varied. If the current is required for therapeutic purposes, or for the fluorescent screen, or negatives of average quality, or for producing high frequency currents, I do not think that any material difference will be found between the efficiency of the alternating and the continuous current; but if negatives of the highest possible quality are desired, the continuous current has some advantages, and in such cases a motor transformer (see No. 2678) should be used to convert the alternating into a continuous current. The first cost of these transformers is somewhat great, but they are reliable and require very little attention.

The alternating current can also be used for charging accumulators by means of mechanical or electrolytic rectifiers (see Nos. 2685 or 2687).

If the current from the main is not available, **Accumulators** are the most convenient substitute, provided that a dynamo is within convenient reach from which they can be charged. Full particulars about the charging will be found on pages 28—31.

Large Bichromate Batteries can be used, and there are now large liquid or even dry **Leclanché Cells,** capable of giving a current of 6 to 8 ampères even for an hour at a stretch. With moderate use, the latter batteries have to be recharged about once in a year, and the acid cells after 2 to 8 hours' actual use.

Gas or Oil Engines.—Batteries may be employed, if the apparatus is required moderately, a few times every week for taking photographs or examining a patient with the screen, etc., and if the coil consumes a small number of watts; but if it is wanted strongly for therapeutic purposes, or for high frequency currents, batteries are troublesome and expensive owing to the frequent recharging and cleaning. Moreover, in out-of-the-way places, in the Colonies, or if portability is important, as in field hospitals, batteries are out of the question. In such cases oil or spirit engines with a dynamo can be used very well. These engines have been improved so much that there is no difficulty in erecting them; they are easily started, and cause very little trouble in working. The expenses for fuel do not exceed 2d. to 3d. an hour (see No. 2691).

STATIC MACHINES.

The only apparatus which can be used successfully besides a spark coil or transformer for producing X-rays, is the static machine. Wimshurst machines, or modifications of them, are practically the only types used.

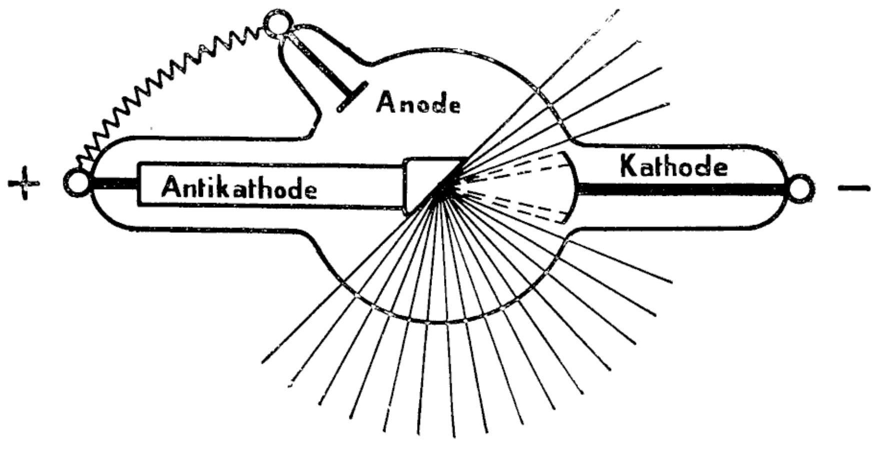
The E.M.F. obtained from these machines depends on the diameter of the plates and the speed of the revolutions; the number of milli-ampères depends on the diameter and the number of plates used. Small machines with four plates of 24 in. diameter will produce a weak green fluorescence in the tubes, but the strength of the current is quite insufficient to give useful X-rays; it is necessary to have machines with at least eight plates of about 30 in. diameter, or a larger number of plates if the diameter is smaller. Even these machines do not produce the heavy currents which we obtain from spark coils, there is no danger of the anticathodes becoming incandescent, and there is no doubt that the exposures required are considerably longer than when a good coil is being used. Pusey and Caldwell reckon that the exposures required have to be 5 to 10 times as long, and in their work on X-rays they give photographs of the hand taken with a coil and static machine under otherwise similar conditions. There is, however, no doubt that some remarkably fine photographs have been obtained already with large static machines by a few experts. The effect on the screen is good, because hard tubes requiring little current can well be used, and because the light is remarkably steady. The tubes used with static machines last a long time, because there is no current in the wrong direction.

The machines occupy a large space, they are dependent on atmospherical conditions, and in our climate, at any rate, there is occasionally trouble on starting them on hot and damp days, in spite of good glass case protection and liberal use of chemicals like chloride of calcium. The machines attract dust, and require occasional thorough cleaning, which takes rather long.

If a static machine is required for therapeutic purposes, it can also be used well for X-rays ; but if a new instrument has to be obtained for Roentgen rays, the advantage all round is up to now decidedly in favour of coils. The current given by static machines is also much too weak to be of use for high frequency apparatus.

FOCUS TUBES.

The quality of the focus tubes is most important for Roentgen rays. Even with the best coil and interrupter a good picture cannot be obtained if the distance between the cathode and anticathode is not correct, or if the tube is too hard or too soft.



Cathode Rays.—If the secondary terminals of a spark coil are connected with electrodes, which are fixed in a highly exhausted glass bulb (the vacuum must be equal to about the one-millionth part of the atmosphere), the current will discharge itself through such a tube rather than through the air. The rays which start from the cathode are called the cathode rays. They have the property of emanating from the cathode perpendicularly, and, if the latter is shaped like a concave mirror, they can be brought to a focus. They can be deflected from their path by the neighbourhood of a magnet, and have the property of heating objects which are placed in their way.

X-Rays.—The cathode rays, in striking a hard substance, are converted into X-rays. Formerly the walls of the glass tube served as the target, but now a disc of iron or copper, covered with a thin film of platinum, is placed in the path of the cathode rays, and is called the anticathode. X-rays emanate from this disc in straight lines, but neither magnet nor prism, nor lens can divert them from their path. They are invisible to the eye, but the glass of the tubes fluoresces brightly under their influence. The colour of the fluorescence depends on the kind of glass used and is generally green, but with other kinds of glass it is blue. The anticathode acts like a screen which the rays cannot penetrate, and, if the current is in the right direction, the space behind this screen remains dark, whereas the space between cathode and anticathode looks as if it were filled with green air. If the direction is wrong, there is an irregular patchy fluorescence only on the walls of the tube, and if this is the case the current should be reversed immediately.

The anticathode may be connected with the second terminal of the spark coil, and thus serve as anode, but most frequently a separate anode of aluminium is used for reasons which will be mentioned later on.

Focus.—If the anticathode is placed exactly in the focus of the cathode rays, the X-rays emanate only from a very small spot, and the outlines of the shadows cast on a screen or plate are well defined. If the anticathode is not in the focus, viz., if it is too near, or too far away, the rays emanate from a larger surface, and the outlines become "fuzzy." If the tube is placed too near to the coil, the cathode rays may be deflected by the magnetism of the iron core, and the anticathode may, under such conditions, come out of focus even if the distance between cathode and anticathode is correct. Static charges tend to make the focus unsteady.

If a heavy current is forced through a tube, the heat is very great in the focus, so great that it may even melt platinum! This tends to perforate the anticathodes, and if they are made very thick, to form a little drop, which makes their surface uneven—in either case the usefulness of the tube will be impaired. To reduce the possibility of such an occurrence, the anticathodes are placed intentionally a trifle inside or outside the exact focus; this can be done without deteriorating the sharpness of the picture. If the focus is sharp, a bright yellow point will be seen on the anticathode while the tube is being used; but, in many cases, there is no need to connect the tube in order to find out whether the anticathode is in focus or not. During the latter stages of exhaustion a current has to be sent through the tubes. Where the cathode rays strike the highly polished surface of the anticathode, a rough spot which looks frosted is formed. This rough spot is visible on the anticathodes of nearly all new tubes ; if it is not much larger than the head of a pin, the anticathode is well in focus ; but if the diameter of this spot should be larger than the eighth of an inch, very sharp outlines cannot be obtained. If a tube is wanted for therapeutic purposes only, it does not matter if the anticathode is out of focus.

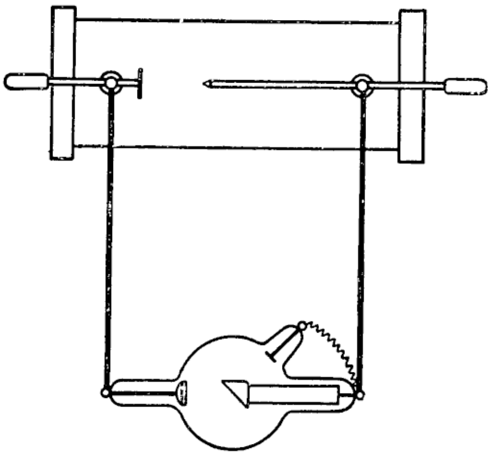
Penetrating Power. – The X-rays have a very short wave length, and have the peculiarity of penetrating substances like wood, ebonite, and flesh, which are opaque to ordinary light. The degree of transparency is in proportion to the specific gravity and thickness of the substance. Aluminium, for instance, is fairly transparent ; heavy metals are opaque. The fact that bones cast a deeper shadow than flesh makes the X-rays useful for surgery.

The quality of the X-rays varies with the degree of exhaustion. —If this is carried as far as possible, viz., if the vacuum is "high," or, as it is more frequently expressed, if the tube is "hard," the X-rays have a much greater penetrating power than if the exhaustion has not been carried quite to the extreme limits, or more shortly expressed, if the tube is "soft." The degree of exhaustion does not determine exclusively the softness or hardness of a tube, it depends to a certain extent also on the spark with which a tube is being used ; one and the same tube may be hard for an 8 in. spark, but medium or soft if used with a 16 to 20 in. spark. This is one of the advantages which larger coils have over smaller ones ; they give us a greater range of control. There is no difficulty in adjusting a 20 in. coil so that it gives sparks of 2 in. only, it can therefore be used for the softest tubes, and tubes which have become a little hard for a 10 in. coil will still be useful if a 16 in. or a larger coil is available.

Soft and Hard Tubes.—In soft tubes the fluorescence is intensely green and uniform ; in hard tubes it is thin and grey green, and there are some irregular flame-like green spots on the walls of the glass. If the tube is very hard, sparks begin to discharge outside, and frequently one of these sparks perforates the glass, air is then admitted, the tube begins to change rapidly, violet light appears, and the tube becomes useless. The hole is in most cases so minute that it cannot be detected, and for this reason it is difficult to repair it.

It is convenient to have some standard about the meaning of "soft," "medium," or "hard" tubes. The bones of the hand and wrist are frequently being used to test the condition of the tube by holding them between screen and tube. If only a black shadow of the hand is visible on the screen, and no bones are discernible, we call the tube very soft. If the bones of the hand are just visible, but the wrist bones still appear as a compact black mass, we call the tube soft. If the wrist bones are clearly visible as black shadows, we call a tube medium, and if the bones also are transparent, and appear as grey shadows, only a slightly darker tint of grey than the flesh, we call a tube hard.

Equivalent Spark-Gap.—The degree of hardness or softness can be measured more accurately in another manner. 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 in. 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 in. apart, we say that the equivalent spark-gap of the tube is 4 in. A tube is very soft if the equivalent spark-gap is 1 in.; soft if it is 2 to 3 in.; medium if it is 4 to 6 in.; and hard if it is 8 in. or more.

The degree of softness or hardness can also be tested by various radiometers, which will be mentioned later on.

Tubes are usually offered as being suitable for a certain size of spark coil; but it would be more correct if they were classified by the equivalent spark-gap and the diameter of the bulb.

One and the same Tube will not do for all purposes.—For hands, teeth, arms, or for the thorax of children, a soft tube with an equivalent spark-gap of about 2½ in. should be used. For the shoulder, the knee, or stones in the kidney of thin patients, a tube with an equivalent spark-gap of about 5 in. will be best, and for the abdomen of stouter patients, or for the screen, a tube with an equivalent spark-gap of 7 to 9 in. will be most suitable. Tubes with an equivalent spark-gap of 12 in. or more are almost useless except in those cases where a heavy foreign body like a bullet or a coin has to be discovered in a stout patient.

Chemical Action. — The X-rays produced by soft tubes are chemically more active; they cause inflammation of the skin, and oxidation of the bromide of silver more intensely than hard tubes. If we expose two plates for one minute each, one under a soft, and the other under a hard tube, the former will reach pitch-black density easily during development, whereas the latter will remain thin and grey. Soft tubes are therefore most useful for photographic or therapeutic purposes, whereas for the screen, medium or hard tubes are preferable on account of their greater penetrating power. The harder the tube, the smaller the contrasts between bone and flesh. The negatives show only different shades of grey; if a soft tube is used, the contrasts are great, and the colour of the negatives varies from black to clear glass.

The Current which passes through tubes can be measured in milliampères by means of galvanometers like Nos. 284—288. Soft tubes allow a current of 2 M.A. or more to pass; hard tubes, 0·05 to 1 M.A.; medium tubes, 1 to 2 M.A. The chemically active rays given off by the tube are in direct proportion to the number of M.A. If a certain result has once been obtained with a tube and a current of about 2 M.A., the same condition can be repeated by adjusting the primary current till the same strength of current is reached in the tube. It is very interesting to watch the galvanometer when a soft tube is being used; the needle may decline, say, to the right and indicate 8 to 10 milliampères, and the fluorescence of the tube will show clearly that much "closing current" is passing. If the latter is excluded, by opening a spark-gap, the needle of the galvanometer jumps *to the opposite side*, and indicates only about 4 M.A.; the fluorescence of the tube changes simultaneously and is sharply divided into two halves, one of which is green and the other dark. This proves experimentally what has been known before theoretically, that the tube offers less than one-tenth as much resistance to the passage of the current in the wrong direction, otherwise it would not be possible that the closing current, the E.M.F. of which cannot well reach more than 20 per cent. of that of the breaking current, could preponderate in strength to such an extent over the breaking current.

If a tube is being heated, it is also interesting to watch how the galvanometer indicates gradually more and more current, without the primary current being varied at all.

Changes taking place in Tubes. Cooling Arrangements.—The degree of softness or hardness changes considerably while a tube is being used. If a heavy current is forced through a tube, the cathode rays will make the anticathode red hot, or even melt it, and if the temperature has reached a certain degree, some remnants of gases are liberated from the hot metal and the walls of the glass; the tube becomes softer, sometimes almost suddenly, and to such an extent that it is useless. Of course, if the strength of the current is reduced, less heat will be generated, but the X-rays will also be less powerful. All tubes are, therefore, provided now with a "heavy," *i.e.*, a thick anticathode, and the best tubes are provided with an arrangement to carry off the heat rapidly. This may be done by either fixing the copper or iron block of the anticathode not on a wire, but on a tube of thin metal which is continued into the neck of the tube (see No. 2598) close to the walls of the glass, so that it can communicate the heat rapidly to the air, owing to its large surface, or else the anticathode can be cooled by water (see No. 2598). In both cases we can use heavier currents, and obtain powerful X-rays without fear of lowering the vacuum rapidly or damaging the tube by overheating it. Such tubes can be used with the full power of coils giving sparks of 20 in. or more, and in consequence it has become possible to make successful "instantaneous" exposures even of the chest. Moreover, the tubes constructed on these principles have made it possible to use the electrolytical interrupter successfully, whereas the ordinary tubes with anticathodes without cooling arrangement are destroyed rapidly by the quantity of current produced with such an interrupter even with a 10 in. coil. The reason why these tubes have not yet superseded all the others is their higher price. They are more difficult to make than the ordinary ones; those with water cooling command very high prices, because it requires the greatest skill of the glass blower to seal a platinum disc efficiently into the glass, as it is done for instance in Mueller's tube (see No. 2598).

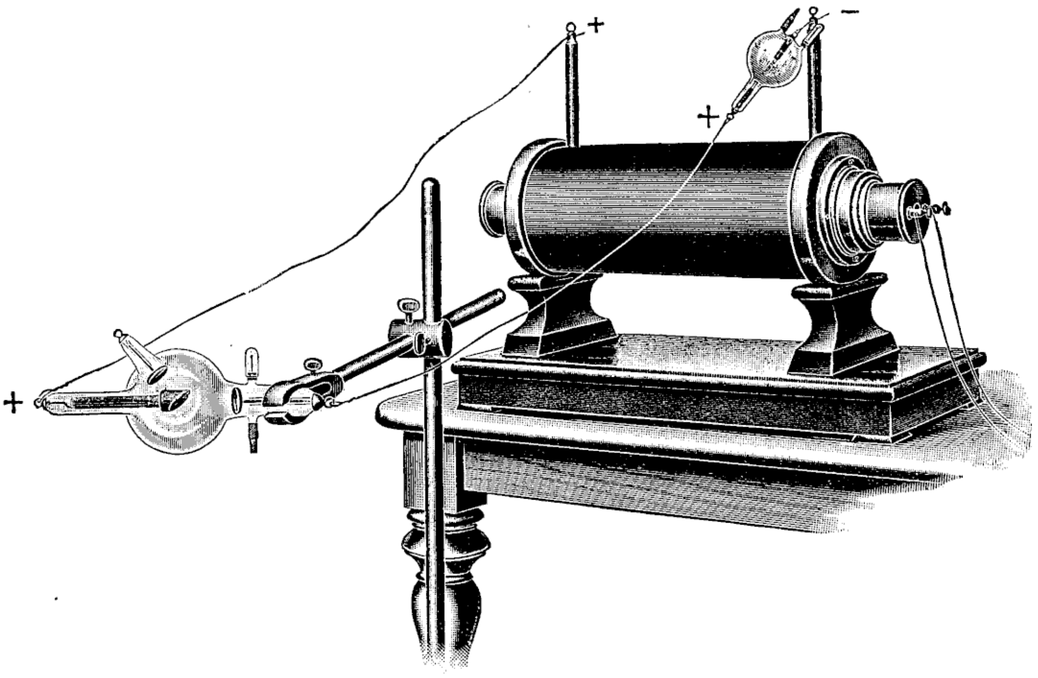
For the examination of hands, arms, etc., the tubes with heavy anticathodes, and no special cooling arrangement, are sufficient if used with ordinary care. For the examination of the chest or abdomen, etc., or for use with an electrolytical or a mercury jet interrupter, and for use with a very large coil, tubes with cooling arrangements have a great advantage.

Influence of the Closing Current. Tubes become harder if a current discharges through them in the wrong direction. Fine particles of the platinum are torn off and absorb some of the few remnants of the gases still left in the tubes, and thus make them harder.* This is the reason why the alternating currents supplied by Tesla transformers or high frequency apparatus, cannot be used for producing X-rays, and why the currents from alternating current trans-

* The smoky grey appearance of tubes which have been in use for a considerable time was attributed to this platinum dust. It is, however, due to the fact that glass containing manganese dioxide becomes gradually darker under the influence of the X-rays.

formers have to be made uni-directional before they are sent through a focus tube. If the E.M.F. of the closing current is sufficiently high to overcome the resistance of the tube, this will also cause a discharge in the wrong direction, and this closing current is the cause why all tubes become gradually harder. The process is retarded a little if a separate anode of aluminium is provided instead of using the platinum-coated anticathode as the anode. It can easily be seen whether the breaking current only or the closing current also are passing through the tube ; in the former case the tube is sharply divided into two halves, one half showing a uniform fluorescence, while the other remains dark. In the latter case there are irregular rings and patchy spots on the glass of the *whole* tube, and some violet light in the part behind the anticathode, which ought to remain dark.

Means to prevent or suppress the Closing Current.—It has been already mentioned that the E.M.F. of the closing current increases with the E.M.F. used in the primary circuit. If the 100 to 250 volt currents from the main are being used, the lifetime of the tubes will be prolonged very considerably if a shunt rheostat is inserted in the primary circuit ;



the voltage can then be reduced till the closing current ceases to pass through the tube ; or a valve tube or a spark-gap ought to be inserted in series with the focus tube to suppress the closing current. Both act on the same principle. The current can discharge between a point and a plate easily, if the point is the + pole, but it does not do so if the

H 2

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. It is, however, important that the valve tube or spark-gap should be inserted correctly, otherwise they would be no help at all. The illustration (page 99) shows the *only* correct manner of connecting coil, tube and valve tube (or spark-gap). It is also necessary to observe that the focus tube is a fair distance away from the valve tube. The spark-gaps (see No. 2619) make a slight noise, but their advantage is that they can be left connected permanently with the coil. They can easily be put out of action by screwing the point home, so that it touches the plate, thus short circuiting them; by opening the screw the resistance can be increased gradually, till the light in the tube indicates that the closing current has ceased. The valve tubes become gradually harder, like the other tubes.

Size of the Tubes.—The changes which are produced in the degree of exhaustion are caused by the liberation or absorption of gases. They depend on the strength of current used, and on the cubic capacity of the tube. The vacuum of a large tube must obviously be more constant than that of a small one; if, for instance, the one-thousandth part of a cubic millimetre of gases is added or taken away from the contents of a bulb $2\frac{3}{4}$ in. in diameter, it will cause nearly ten times as great a change in its vacuum as if the same quantity were added or withdrawn from the contents of a bulb of $5\frac{1}{2}$ in. diameter. In consequence of the greater constancy of larger tubes the diameter of the tubes used is steadily increasing. Originally, tubes with bulbs of $2\frac{1}{2}$ in. diameter were generally used. The size has gone up, and now tubes of $5\frac{1}{2}$ in. are most frequently used, but tubes with bulbs as large as 10 in. are being made.

Regenerating the Tubes.—If a tube is too soft it can be made harder by switching the current on for a little while in the wrong direction, but care must be taken not to overdo it. If it has become too soft in consequence of strong use, it will, in most cases, become harder again by itself; the gases released by the heat are usually re-absorbed when it cools down, but occasionally it takes weeks or months till this process is completed. If we have over-exerted a tube we must put it on the shelf for some time.

If a tube is too hard, it can be made softer by heating. The simplest means to do this is to force a strong current through it by raising the current in the primary; but this current has to be reduced as soon as the effect has been obtained, otherwise it may become so soft that it is temporarily useless. If it is too hard for the particular coil, the glass bulb can be heated with a spirit flame; it has to be moved to and fro, otherwise the thin glass may become soft and be pressed in by the atmosphere. Good results have been obtained by putting tubes which have become too hard in a temperature of 100 or more degrees Centigrade for several hours (in a sterilizing stove or a baking oven); the results thus obtained seem to be more lasting than if the temperature is raised to a higher degree for a short time only.

Many tubes are provided with a special arrangement to reduce the vacuum when it has become too hard. Palladium has the peculiarity of allowing hydrogen to pass while it is hot (a process which is called osmosis). This is used for regeneration in one type of very good tubes (see No. 2589). A small palladium wire is sealed into the glass, and projects outside for a distance of about 1½ in. This part is protected by a small glass tube which can be taken off. When the tube has become too hard, a small spirit flame is applied to the palladium tube for a few seconds, and *after it has become quite cold again* the current is switched on to test whether the change is sufficiently great, or whether heat has to be applied once more.

Chemicals like phosphorus, caustic soda, mica, etc., liberate gases when they are heated. They are enclosed in a small glass tube projecting from the focus tube; the gases liberated from the minerals by the heat of a spirit flame reduce the hardness of the tubes.

An ingenious arrangement which serves for *automatic regulation of the vacuum* is used in the tubes Nos. 2595—2600. It consists of a glass cylinder which communicates with the bulb by means of a small tube. This cylinder contains two electrodes, an aluminium disc above the cathode end of the tube, and a fine spiral of platinum wire above the anode end. Between these two electrodes there is a disc of mica. A wire projecting outside from the aluminium disc can be bent so that a spark-gap of variable length can be arranged with the pole leading to the cathode. The tube is connected with the coil in the usual manner; if it is harder than desired, the wire is bent till sparks jump over and some current enters the tube through the aluminium disc in the cylinder, *via* the mica. The latter is thereby heated and liberates gases; the tube thus becomes softer, and consequently all the current will discharge through the cathode instead of entering partly through the spark-gap. It is thus possible by adjusting the length of the spark-gap to reduce the hardness automatically. On the other hand, if the tube is too soft, the wire connected with the anode is attached temporarily to the platinum spiral, and the current is switched on in the wrong direction for a short time. Minute parts of platinum are torn off and absorb some of the gases.

There is no doubt that regenerating arrangements are a very great help and improvement. Tubes provided with them can be used much longer than those without them, but the store of gases in the chemicals is gradually being used up, and ultimately they share the fate of all tubes in becoming too hard. For the better classes of tubes it is worth while to have them opened and re-exhausted ; but for the cheaper tubes this does not pay.

Before concluding this chapter, I will repeat in a few words the important points :—

When buying a tube, see

(1) That the focus is sharp, and the bulb not too small.

(2) That its degree of softness or hardness is suitable for the purpose for which it is wanted ; one and the same tube cannot give good results for either a hand or a hip joint.

When using a tube, be careful

(3) That the current does not discharge in the wrong direction. If there is evidence of closing current, reduce the voltage or increase the self-induction in the primary, or, if this cannot be done or is still insufficient, insert a spark-gap or a valve tube into the secondary circuit.

(4) That you obtain a steady, intensely green light in the tube. The working of the interrupter and the correct degree of self-induction of the primary are responsible for the steadiness. The intensity of the light depends on the strength of the primary current and the size of the coil.

(5) To reduce the primary current if the anticathode shows any tendency to become red hot. If this causes the X-rays to become too weak, leave it at its strength, but stop the current for a little while at frequent intervals by means of the current reverser, to give the anticathode time to cool down. The frequency of the interrupter may also be reduced.

(6) If you want very short exposures, to use a large sized coil, an electrolytical or a jet interrupter, and a large tube with good cooling arrangement.

(7) To leave the dischargers in position while you are using the apparatus.

DIAPHRAGMS, COMPRESSORS, SCREENS.

In a focus tube the bulk of the X-rays emanate from the anticathode, but some start also from the walls of the glass, or the other metal parts. This is due to the fact that not all cathode rays are brought to a focus: some start from the edge of the cathode, others from the anode in consequence of the closing current, and are converted on the walls of the glass into the so-called *secondary X-rays*. They are more intense in hard than in soft tubes, and are a great inconvenience. They are the cause of the general fogginess of the negatives, and of a serious diminution in the sharpness of the outlines, of the details and of the contrasts which would be so valuable in the more difficult cases.

To reduce the mischief done by the secondary rays, a **diaphragm of lead or zinc** (see No. 2739) is frequently placed between tube and object. The opening in the zinc plate is 1½ to 3 in. wide, and the diaphragm is placed almost immediately below the anticathode of the tube; the secondary rays are certainly reduced by these means, but they are not altogether excluded. The reason will be evident by looking at the

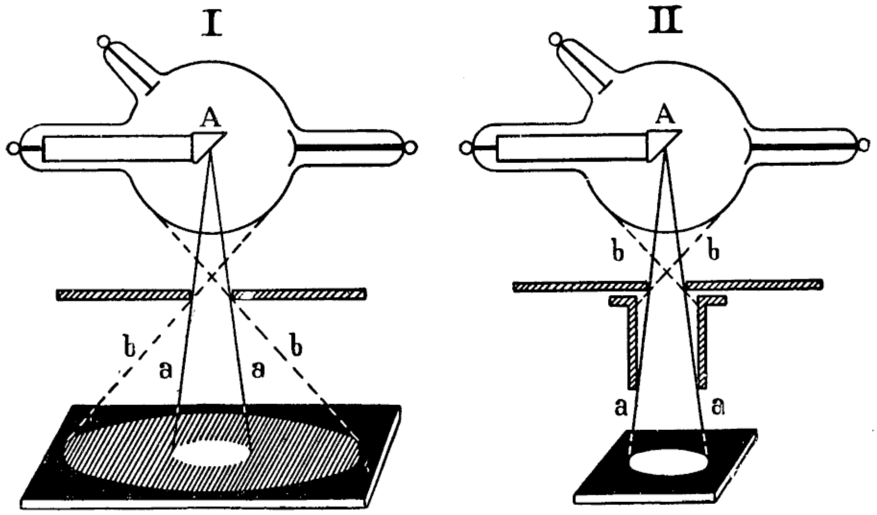


illustration I. If you place a fluorescent screen below the diaphragm, you will see a brightly illuminated central area, which varies in diameter according to the size of the opening in the diaphragm and the distance between anticathode, diaphragm, and screen. Outside this bright circle there is a much wider rim where the screen distinctly gives some fluorescent light, though it is not nearly as bright as the central part. The dotted lines in the illustration indicate how secondary rays can still reach the screen through the opening in such a flat diaphragm. The improvement obtained with them is only a moderate one.

The case is different if, instead of a lead sheet, a heavy metal cylinder with a narrow opening at the upper end is being used, as shown in Fig. II. Only the X-rays emanating from the anticathode can reach the plate, and, if a fluorescent screen is put below, there is a brightly illuminated circle, outside which there is no light.

This **cylinder diaphragm** has been introduced by Dr. Albers-Schoenberg. He combined this diaphragm with a compressor, which is equally important. The X-rays are diffused when they reach the human body ; the greater the thickness they have to penetrate, the greater is the diffusion. By reducing the thickness of the object, the X-rays can penetrate more easily, the exposure is reduced, and clearer negatives are obtained, because there is less diffusion. That part of the body which is most difficult to photograph—the abdomen—can be reduced by several inches by compression for a few minutes without giving the patient pain. Moreover, the movements due to respiration are diminished if the parts are firmly pressed down, and this makes the compressor of use even for such parts of the body which cannot be squeezed together, like the head.

If the cylinder diaphragm and the compressor are combined, the finest details and structures of the bones of all parts of the body, and cracks in the bones, etc., can be shown, which it would be quite impossible to detect without the compressor diaphragm. There is no doubt whatever that the photographs taken with such an apparatus show considerably more detail and more contrast and sharpness of the outlines than those taken without this arrangement.*

The lower end of the cylinder diaphragm is provided with an ebonite rim, and a piece of felt put between it and the skin will reduce discomfiture very much. The cylinder diaphragm can be pressed down by a lever with the hand, or by a lead weight, and be fixed in the desired position.

When a diaphragm is being used, it is of importance to put the focus tube in an accurate position above the cylinder. The area below should be an evenly illuminated circle, and ought not to have an appearance like the moon when it is nearly full. The correct position can be found if a fluorescent screen is placed where the photographic plate has to be put afterwards, before the patient is on the couch. The position of the tube is shifted till an evenly illuminated circle about 7 in. in diameter is obtained.

Diaphragms or Screens are necessary to protect healthy tissue, if the X-rays are used to treat lupus, rodent ulcer, etc. Lead masks, with an opening of suitable size, are placed on the skin. Instead of pure lead,

* Since these lines were published in 1904, I have received several letters from *experts* who gave the cylinder diaphragm with compressor a trial, and they all agree that the gain in the *quality* of the negatives thus obtained is remarkable.

which is always dirty and gives unpleasant electrical discharges on the skin, sheet lead covered on both sides with indiarubber is now being used.

Good protection is also afforded if one half of the bulb of the focus tube is covered with a mask made of thick lead glass (see No. 2612). To this mask, funnels of various diameters can be attached ; the funnels are also of lead glass and can be sterilized. Special tubes of lead glass with a transparent window of other glass at the end of the funnel have been made for the same purpose, but when they have become too hard to be of use for therapeutic purposes, they have to be thrown away. If an ordinary tube with a detachable mask is being employed, the tube can still be used as a medium or hard tube for the screen, and the mask can be transferred to a new soft tube suitable for therapeutic work.

EXPOSURE.

The length of exposure required for various parts of the body is of great importance ; it is an advantage to have it as short as possible to avoid movements due to respiration, but it is difficult to give definite rules as to the accurate number of seconds or minutes required to avoid under-exposure. A few of the most experienced specialists have succeeded, with the help of 20 in. coils, water cooled tubes, etc., in taking almost instantaneous exposures even of the spine and hip joint, where others require an exposure of five to ten minutes. Some of the statements regarding short exposures have to be accepted *cum grano salis ;* there is a great wish to break a record, or to recommend a particular system or apparatus, as surpassing everything else in efficiency, and in the excitement, minutes sometimes appear as if they were a few seconds only.

The length of the exposures depends on :—

(1) The quality of the tube.
(2) The thickness of the object.
(3) The quality and size of the coil and interrupter.
(4) The skill used in the development.

The length of the exposure can be reduced by increasing the frequency of the interruptions, *provided that the intensity of the sparks is not diminished thereby, and that the tube will not become softer on account of the heat.* If either of these changes should take place, the exposure will be prolonged instead of being reduced.

Clothing is no great impediment to the rays, but the shadows of buttons, thick seams, are occasionally misleading, and if for instance stones in the kidneys, or changes in the lungs have to be investigated, there should not be many garments on the patient.

The great importance of a tube with suitable penetration, and the advantage of the larger coils, have been already explained in previous chapters. The distance between tube and object does not play a very important part. There is no reason for placing the tube too far away, but we must not place it too near, otherwise distorted images would result. The distance must be in proportion to the thickness of the object and the size of the plate. For a hand or arm the suitable distance is 12 to 16 in.; for the spine or hip joint, 18 to 24 in., or even 30 in. The object to be photographed must always be as close to the plate as possible.

At present the *average* exposures with a good 10 in. coil and a mercury interrupter vary, as far as I am aware,

From 5 to 60 seconds for a hand or arm.
½ to 4 minutes for an elbow, foot or knee.
1 to 4 minutes for the thorax or head.
1½ to 8 minutes for the pelvis or hip joint.

If an electrolytical interrupter is being employed these figures can be reduced by fully one-half, and if 16 to 20 in. coils are being used they can be reduced further still.

It is well to remember that, as in other branches of photography, the results will be best if we can give approximately the correct exposure; if we over-expose, it is easy to correct the mistake; if we under-expose considerably, the plate is lost.

An under-exposed plate shows patches of clear (or yellow stained) gelatine without any details. An over-exposed plate has no contrasts, and many of the finer details are lost on this account. A correctly exposed plate shows good contrasts even between fine details.

Accelerating Screens.—The time of exposure can be shortened if a fluorescent screen is placed between object and plate, so that the fluorescent side of the screen is *in close contact* with the coated side of the plate. Screens with special cassettes to enclose the plates are being made for this purpose. The rays pass through the fluorescent screen first, their intensity being thereby scarcely reduced, and afterwards reach the plate, which is, moreover, affected by the light of the screen. If isochromatic plates are being used, the barium platino-cyanide screens are the most suitable accelerating screen. If ordinary plates are being used, the screens made of tungstate of calcium are preferable, partly because they have a very fine grain, and partly because the bluish light which they give has great actinic power on the bromide of silver. The accelerating screens destroy some of the finer details of the picture, and their importance was greater in the earlier days, when the exposures required were longer; but in some cases they are a great help even now, as the time of exposure can be reduced by one-half or even two-thirds.

The Plates are put in red and black envelopes in the dark room, so that the sensitive film looks towards that side of the envelope on which the address would be written, and it is placed under the patient so that the rays reach the film without having to pass through the glass. The stock of unexposed plates must be kept either in a lead-lined box or drawer, or else they must be stored fairly far away from the tube, otherwise they might be rendered useless.

All good plates can be used. Edwards Ltd. and Lumière make a special kind of cathodal plates, which contain a slight addition of a fluorescent salt to reduce the length of exposure. As far as shortness of exposure is concerned, the very rapid plates have not the same advantage over medium or slow plates which they have in portrait or landscape photography. This is most likely due to the fact that the thickness of the silver coating is of considerable importance; the medium plates are more thickly coated than the very rapid ones. The intensity of the X-rays is scarcely diminished by passing through the silver film; if six bromide of silver papers are placed one above the other, and exposed simultaneously, the last one will be only a trifle thinner than the first. If the densities of all these layers could be combined, we would obtain greater contrasts and more details; but we cannot increase the thickness of the emulsion on a plate indefinitely, because the developer would not be able to penetrate it any more. There are, however, special plates being made by Schleussner, which are coated on both sides of the glass or film. Some precautions have to be taken with such plates that the lower side does not become scratched in the developing dish.

Development.—It must not be taken for granted that a professional photographer will produce the best results in developing X-ray negatives. He may have developed thousands of plates, but his experience is usually confined to portrait work, where the contrasts between light and shade are great, and a soft picture is aimed at. In X-ray work the contrasts are frequently very slight; in searching for a foreign body, a fracture, or a dislocation, a negative with hard contrasts between bones and the flesh is desired. If the professional photographer has some experience in developing X-ray plates, and takes an intelligent interest in the special requirements, he will, of course, learn it quickly enough, but if this is not the case it is much better to have the plates developed under one's own supervision.

As to the developer, the same rule holds good as in ordinary photography. The name of the developer used is of little importance. The best developer is the one which you have learned to master. Every one of them has some peculiarities and requires considerable study. 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 therefore cannot be modified so much. If Thomas's formula for the composition of the Hydroquinone developer is used, the first traces of the picture appear within 30 to 40 seconds if the plate was correctly exposed, and the negative is fully developed within 4 to 5 minutes. A good plate will stand development in a solution of normal strength for nearly 10 minutes before showing any traces of fog. Medium plates give greater density, and allow greater latitude in development than the very rapid ones. Hydroquinone has, however, the disadvantage of being more sensitive to changes in temperature than other developers; in winter it cannot well be used unless the dark room as well as the dishes and solutions have been warmed.

Of the modern developers, Glycin has the advantage of giving the clearest negatives and most details. Development can be prolonged very much without producing fog. It is also the most suitable developer for the so-called stand development, which offers great advantages for our purposes if it is not important to obtain the results at once.

Place the plate in a clean dish, preferably in an upright position (grooved porcelain troughs which hold 6 or 12 plates are being made specially for the purpose), cover it with Glycin or Rodinal developer, to which 20 times the usual quantity of water has been added, cover the dish 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 more details can be obtained than with the usual way of developing plates; it is the best method of obtaining as much as possible out of a rather under-exposed plate, and as no long experience is required if done in this manner, the development can be left to comparatively unskilled assistants.

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, 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.

HIGH FREQUENCY CURRENTS.

The currents are produced in the following manner:—The secondary terminals of a spark coil (or an alternating current transformer) are connected with the inner coatings of two Leyden jars, and an adjustable spark-gap is inserted between these two jars. When the spark coil is started, the Leyden jars become charged—one with positive, the other with negative, electricity; and when the E.M.F. of the charge is sufficiently high, a spark leaps across the gap. To the eye this discharge appears as one single spark, but it actually consists of a succession of extraordinarily rapid electrical oscillations or waves. As long as the inner coating of a Leyden jar is charged with positive electricity, the outer coating must be charged with a similar quantity of negative; as soon as a spark leaps over, the charge inside disappears, but on account of the change the outer coating becomes positively charged, and this again induces a negative charge on the inside coating; plus and minus have changed places, and the quantity of the charge is a little reduced, but now there is a charge causing a second spark in an opposite direction, and this produces similar results. In this way it continues till the waves have calmed down and cease. If the discharge from a condenser is examined in a rapidly revolving cylindrical mirror, it appears as a conical band of gradually diminishing width and intensity, and from the length of this band and the speed of the mirror it has been calculated that the sparks follow one another in an opposite direction with an interval of about one-millionth part of a second only. On account of their rapidly oscillating character such currents have been called "high frequency" currents.

As already mentioned, every change of potential taking place on the inside coatings induces a similar change of the same intensity, but in opposite direction, on the outer coatings, and the currents thus generated between the outer coatings of the two Leyden jars are applied to patients in a manner to be described later on.

The E.M.F. of these oscillating currents can be raised higher up by induction in various ways. For instance, a spiral with a few turns of stout copper wire can be inserted in the circuit between the two Leyden jars, and if this spiral is placed like a primary coil inside a solenoid of many turns of fine wire, a brush discharge, or sparks similar to those from a large static machine, are obtained from the terminals of the secondary solenoid.

In the year 1891 Nikola Tesla produced some remarkable phenomena of light with such currents; he showed that Geissler tubes, held near a solenoid but without being in contact with it, became fluorescent, and that currents powerful enough to light up a large incandescent lamp would, under such conditions, pass through the human body without causing any pain; in fact, without being felt at all, whereas similar quantities of current with *low* frequency would cause instantaneous death. The currents have also a great repugnance to pass through otherwise excellent conductors if they are so arranged that self-induction is started by their passage, and they would discharge through a short space of air in preference to passing through a few turns of stout copper wire wound to a spiral.

D'Arsonval, and many other scientists after him, made use of these currents for medical purposes. They had solenoids constructed of such a size that a patient could be placed inside (see Fig. 3056), and, by passing high frequency currents through the solenoid, very powerful currents were induced in the patient's body. The patients do not feel the currents, but their presence can be proved in various ways; for instance, by a Geissler tube being brought in contact with the body. It is a sort of general electrification, but the currents employed are far more powerful than those which can be administered in a bath with galvanic or faradic currents, or by a static machine.

It has been proved beyond doubt by many prominent authorities, and by chemical analysis, that the application of these currents stimulates metabolism. The action of the kidneys, the skin, and the respiratory organs is increased, and the elimination of all waste products, such as carbonic acid, urea, etc., is augmented. This kind of treatment is, therefore, specially useful for disorders which are the result of imperfect oxidation, such as rheumatic and gouty diseases, obesity, uric acid troubles, diabetes, etc. They are, moreover, used with success in many skin diseases, and can temporarily relieve pain in neuralgia, herpes, eczema, and similar cases.

There are three methods of applying these currents to the patient:—

If the patient is enclosed in a solenoid such as already mentioned (see No. 3056), it is called "**Autoconduction.**"

The patient is placed on a couch, the lower part of which is fitted with a large metal plate. One Leyden jar is connected with this plate and the other with the patient, so that the metal plate and the patient's body form the two layers of a large condensator, and the couch acts as insulating medium. The electrical equilibrium is disturbed, and the patient becomes charged in rapid succession with strong currents of opposite polarity. This method is called "**Autocondensation.**" Any couch can be adapted for this method with little expense.

Ultimately, the current can be applied locally to the body by means of brush or spark discharges—"**Effluve**"—from suitable electrodes, which are connected with one pole of the resonator or Tesla transformer, the other pole in this case being connected as a rule to earth ; or the current can be passed through the body by means of electrodes held in both hands or applied to any part of the body.

The following apparatus are necessary for the high frequency treatment :—

(1) A spark coil such as is used for producing Roentgen rays ; any coil giving sparks of 10 in. or more will do very well, provided that it is fitted with one of the modern interrupters—a Wehnelt, a Mackenzie Davidson, or a jet (turbine) interrupter.

If the alternating current from the main is available, our spark coils can be used without any interrupter, or a step-up transformer can be used instead of the spark coil. Coil or transformer are the sources of the electric supply required to charge

(2) Two Leyden jars with an adjustable spark-gap and a solenoid (see Fig. 3000). This combination is usually called d'Arsonval's transformer.

(3) In most cases Oudin's resonator (see Fig. 3014) will be found very useful, and for treating skin diseases it is absolutely necessary. It consists of a solenoid of medium sized copper wire wound round a wooden framework of large diameter, and serves to raise the E.M.F. of the current obtained from d'Arsonval's transformer. The lower terminal of the resonator is connected with one Leyden jar, and by means of a sliding contact leading to the other Leyden jar, the number of turns of wire in the circuit is varied, until a lively brush discharge appears at the upper terminal of the resonator, and the cord leading to the patient or to the electrodes is connected with a second movable contact, or with the upper terminal.

Instead of Oudin's resonator a Tesla transformer may be used for raising the E.M.F. These transformers are usually submerged in oil, but can be made also for insulation in air only ; in the latter case they are more bulky. A great quantity of ozone is generated by the Effluve from the Oudin resonator or the Tesla transformer.

(4) Either a solenoid to enclose the patient (see Fig. 3056), or a condenser couch, or some electrodes for local application, and a pair of heavily insulated cables to conduct the current.

The strength of the current is regulated partly by varying the current in the primary of the spark coil or transformer, and partly by adjusting the length of the spark-gap, and by inserting more or less turns of the solenoids in d'Arsonval's transformer or in Oudin's resonator.

I have endeavoured to explain the construction and management of the apparatus, and a few of the physical laws which are of interest. For information about the application of the various instruments for diagnostic and therapeutic purposes, I must refer my readers to books written by medical men, and will add (see page 112) the names of a few which have recently appeared on these subjects.

BOOKS ON ELECTRO-THERAPEUTICS.

The books marked (*) can be supplied by us.

*ALTHAUS, JULIUS, M.D., M.R.C.P., M.R.I. The Value of Electrical Treatment. 3rd edition. 1899. 3/6.

BIEDERMANN, W., M.D. Electro-Physiology. 1898. 20/-.

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. 3rd edition. 1903. 7/6.

*ERB, W., M.D. Handbook of Electro-Therapeutics. Translated by A. de Watteville, M.D. 18/-.

*FENWICK, E. H., F.R.C.S. The Electric Illumination of the Bladder and Urethra. 2nd edition. 1889. 6/6.

*FINSEN, R. Photo-therapy. 4/6.

*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.

*HEDLEY, W. S., M.D. The Hydro-Electric Methods in Medicine. 2nd edition. 1896. 4/6.

*HEDLEY, W. S., M.D. Therapeutic Electricity. 1900. 8/6.

*JONES, LEWIS, M.D. Medical Electricity. A Practical Handbook for Students and Practitioners. 4th edition. 1904. 12/6.

*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.

*TURNER, D., M.D. A Manual of Practical Medical Electricity. 4th edition. 1904. 10/-.

DE WATTEVILLE, A., M.D. A Practical Introduction to Medical Electricity. 2nd edition. 1884. (Out of Print.)

*ALBERS-SCHOENBERG, DR. Die Roentgen Technik. 1903. 260 pages. 9/-.

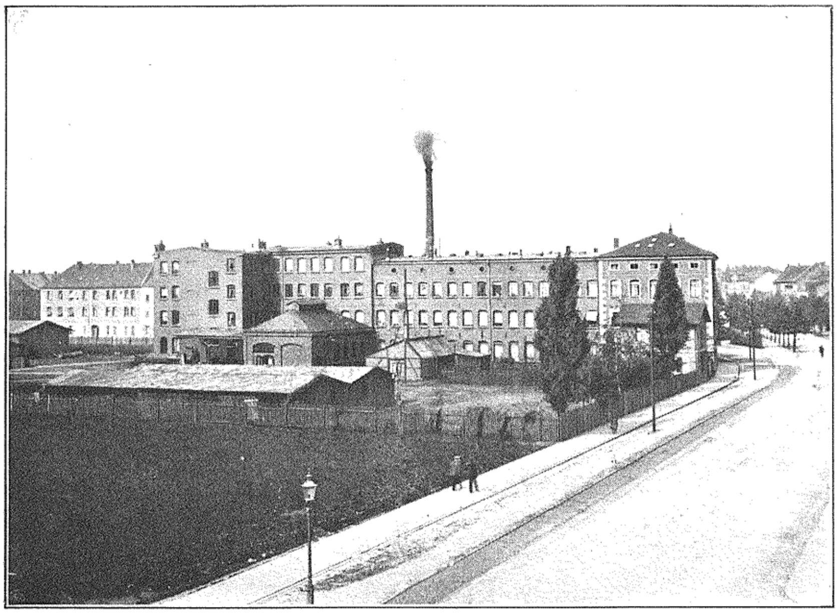
*DONATH, B., DR. Die Einrichtungen zur Erzeugung der Roentgen Strahlen. Zweite Auflage. 1903. 250 pages. 8/-.

*BORDIER, H., DR. Précis d'Electrotherapie. Preface de Mons. le Professeur d'Arsonval. 2nd edition. 1903. 8/-.

*BOUCHARD, C. Professeur à la Faculté de Médecine. Traité de Radiologie Médicale. Paris. 1904. 1,100 pages. £1 6s.

*DENOYES, J., DR. Les Courants de Haute Frequence. 1902. 7/6.

*GUILLEMINOT, H. Electricité Médicale. 1905. 620 pages. 10/-.



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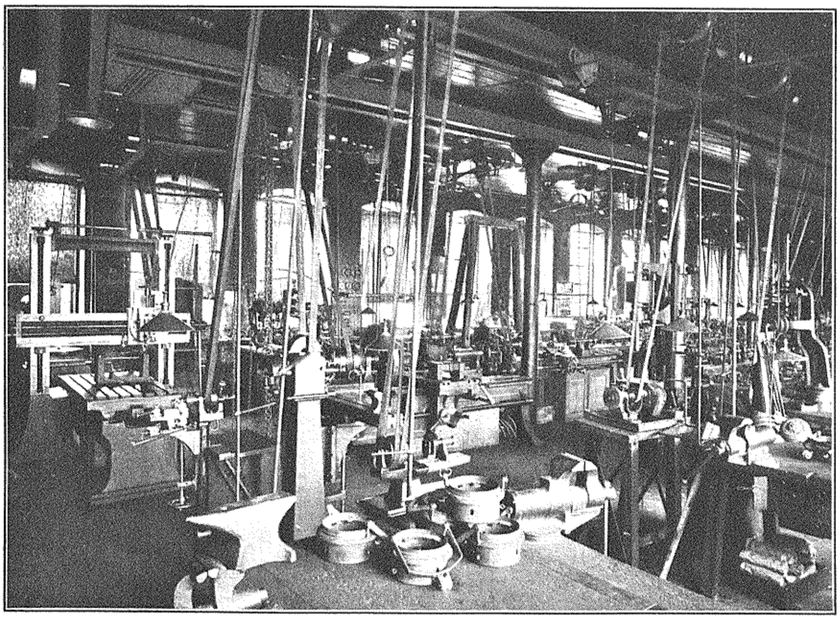

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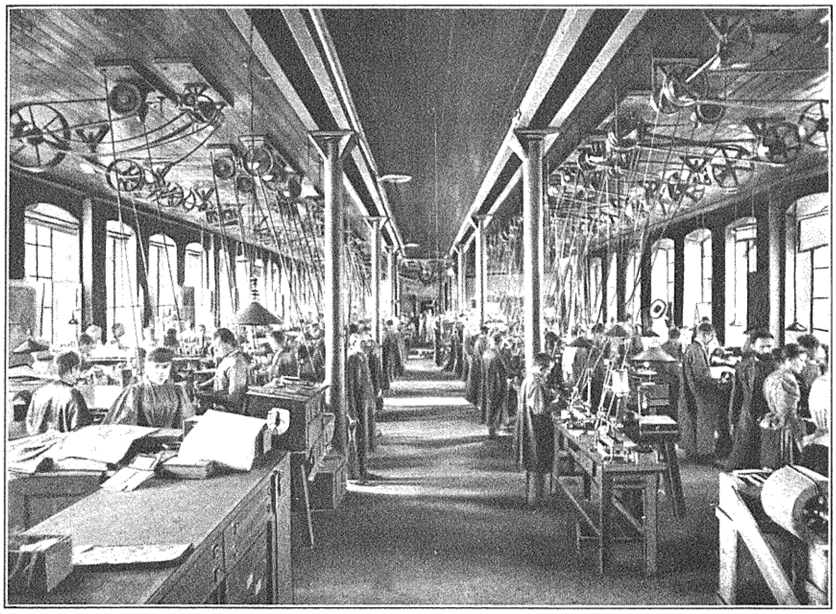
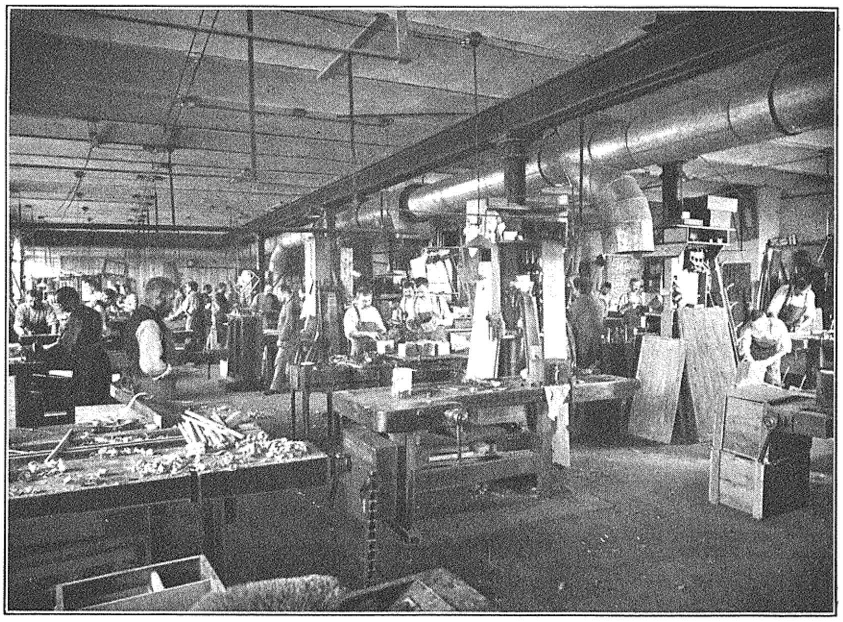
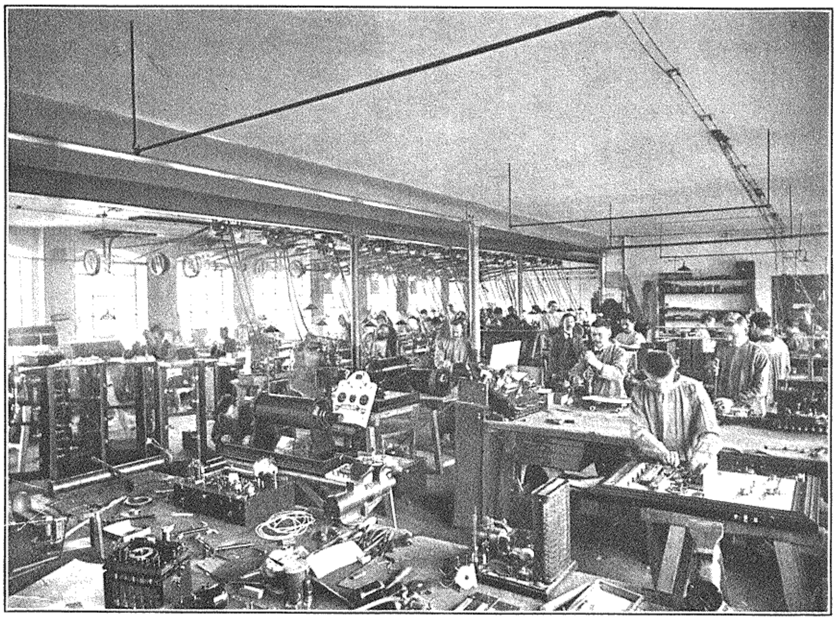


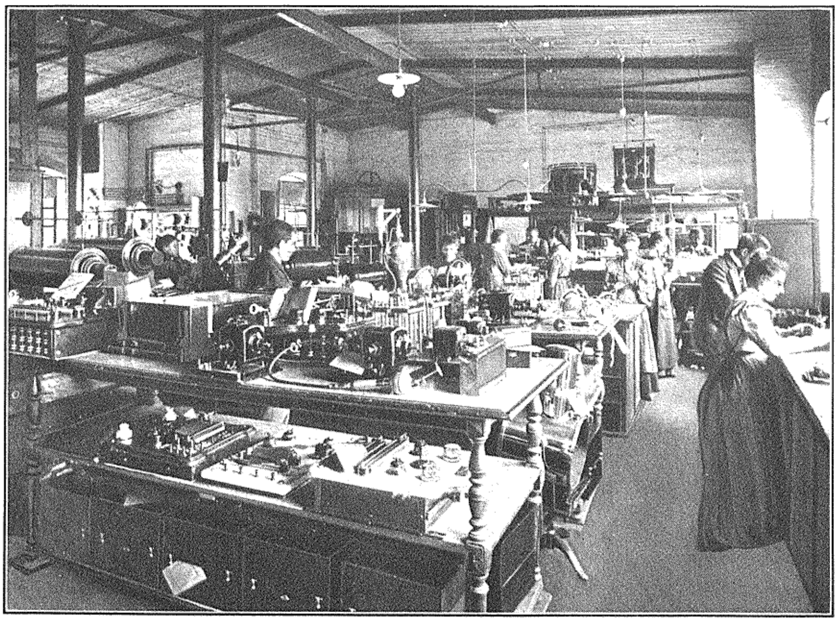
WORKSHOP No. 2.



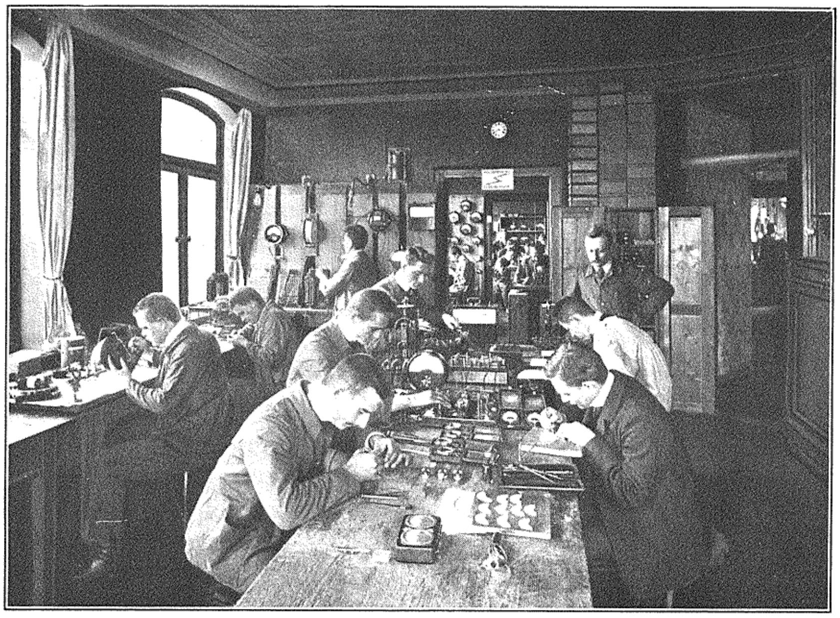
CABINET MAKERS' WORKSHOP.



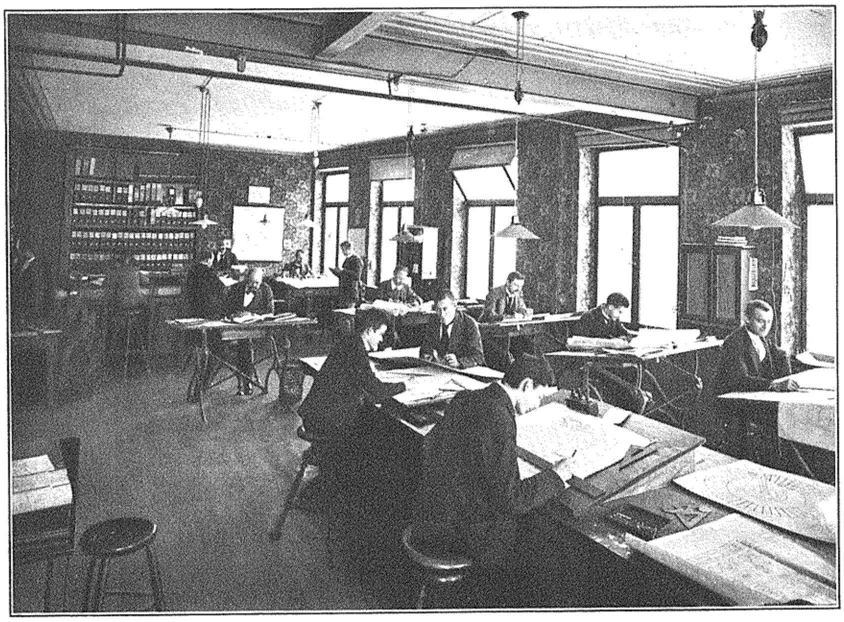
FINISHING ROOM.



TESTING ROOM.

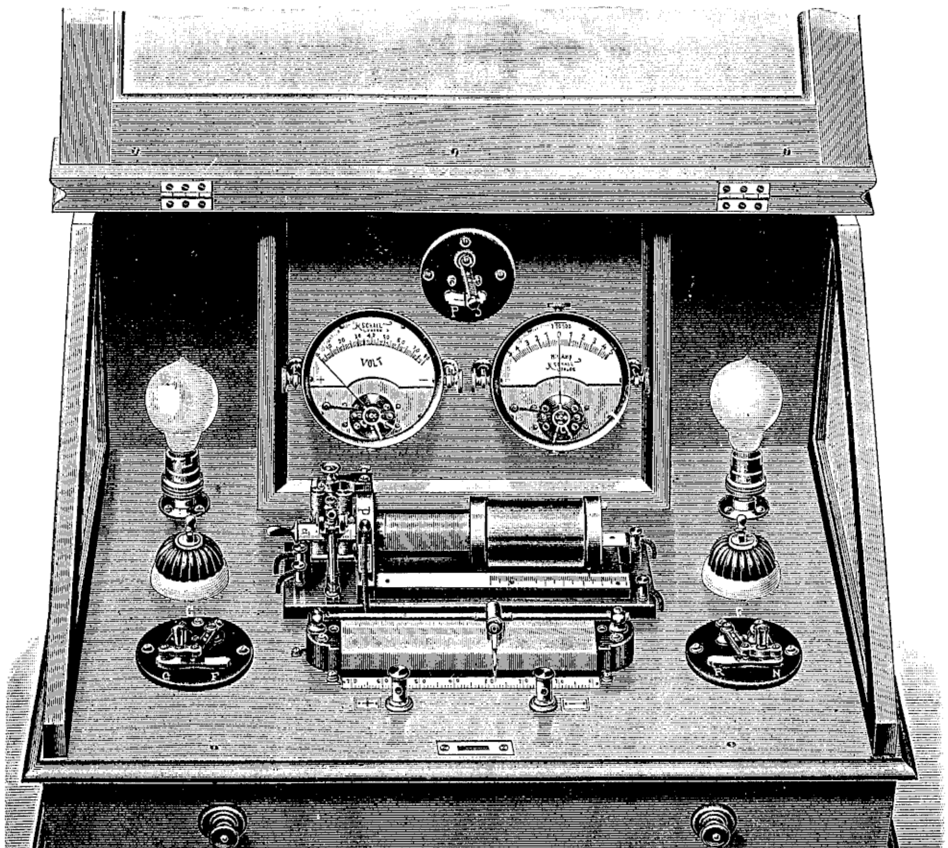


ROOM FOR CALIBRATING GALVANOMETERS.



ENGINEERS' AND DRAUGHTSMEN'S OFFICE.

K. SCHALL'S
Illustrated Price List
OF
ELECTRO-MEDICAL APPARATUS.



75, NEW CAVENDISH STREET,

LONDON, W.

NINTH EDITION. MAY, 1905.

Entered at Stationers' Hall.

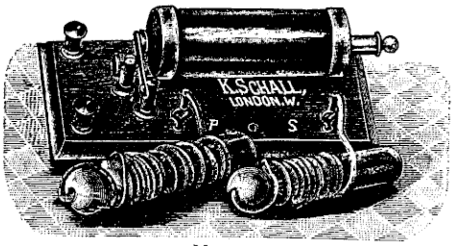
OUR INSTRUMENTS HAVE BEEN ORDERED BY

THE WAR OFFICE, THE ADMIRALTY, THE CROWN AGENTS FOR THE COLONIES, THE INDIAN AND MANY OTHER COLONIAL GOVERNMENTS.

Charing Cross Hospital
Guy's Hospital
King's College Hospital
London Hospital
Middlesex Hospital
New Hospital for Women
Royal Free Hospital
St. Bartholomew's Hospital
St. George's Hospital
St. Mary's Hospital
St. Thomas's Hospital
University College Hospital
Westminster Hospital
St. Peter's Hospital
National Hospital for the Paralysed
Hospital for Epilepsy and Paralysis
Central London Ophthalmic Hospital
Royal Westminster Ophthalmic Hospital
Seamen's Hospital
And over 25 smaller Hospitals in London

Royal Infirmary, Aberdeen
„ „ Belfast
„ „ Bristol
„ „ Derby
„ „ Dover
„ „ Edinburgh
„ „ Glasgow
„ „ Halifax
„ „ Hull
„ „ Lancaster
„ „ Manchester
„ „ Newcastle-on-Tyne
„ „ Salford
„ „ Sheffield
„ „ Southampton
„ „ Stirling
„ „ Windsor
General Infirmary, Birmingham
„ „ Bristol
„ „ Burton-on-Trent
And over 300 other Hospitals in Great Britain

FARADISATION.



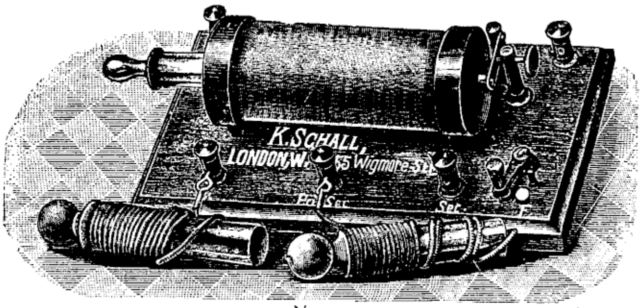
No. 1.

ABOUT INDUCTION COILS.

(*See also pages* 35—44.)

No. 1. Single Coil, with cords and two electrodes, in cardboard box ... £0 7 6

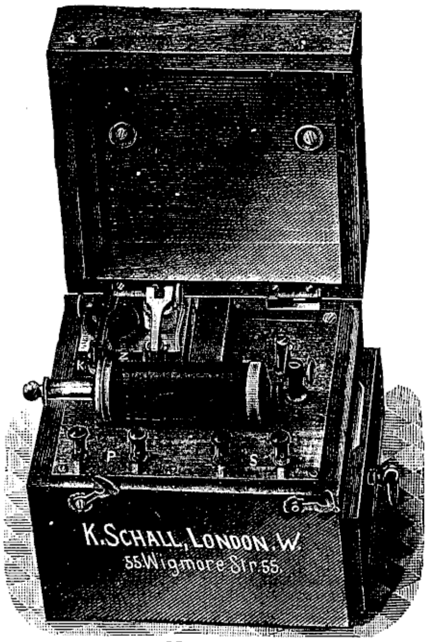
No. 1A. Similar Coil, but with a switch for turning the current on and off £0 9 0



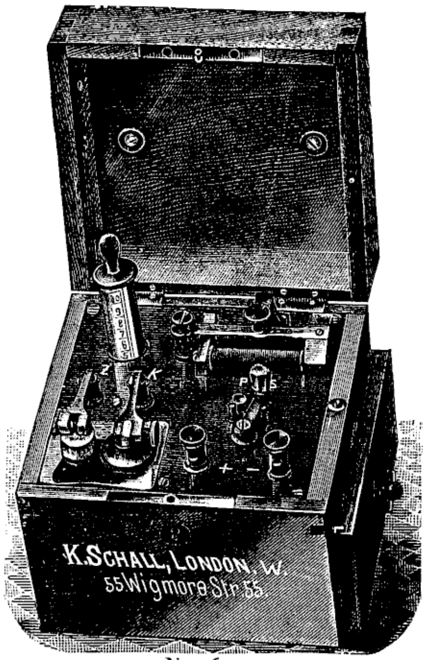
No. 2.

No. 2 Similar Coil, but larger size, and better finish, with crank to switch the current on and off £0 12 6

Separate dry cell $2\frac{1}{2} \times 2\frac{1}{2} \times 6$ inches, for working coils Nos. 1 and 2 ... ... 0 2 6



No. 5.

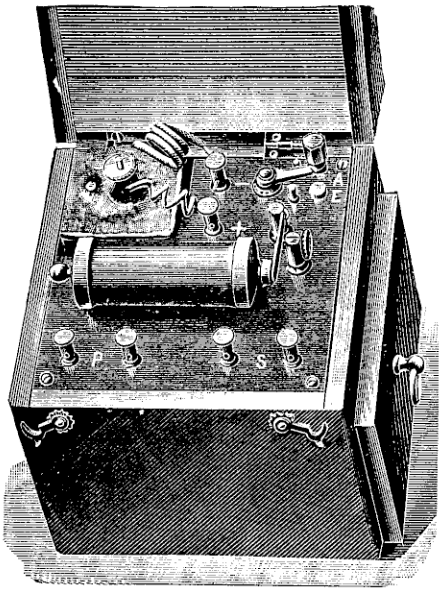


No. 6.

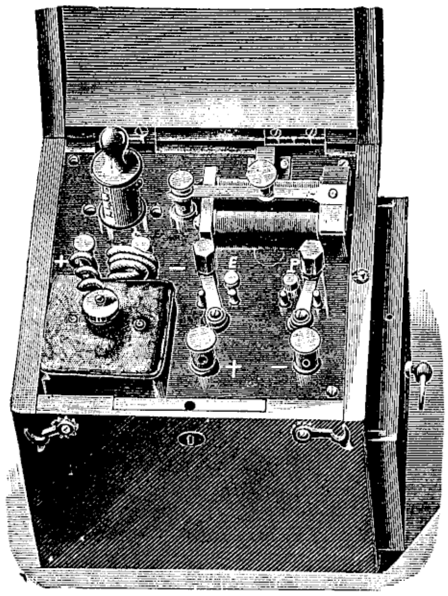
No. 5. Dr. Spamer's Coil, in polished mahogany case, cheap form for patients, with bichromate cell in strong glass vessel, cords, handles, and five electrodes ... £1 0 0

No. 6. Dr. Spamer's Coil, in polished mahogany or walnut case, with bichromate cell, commutator for primary and secondary current, cords, handles and six electrodes 2 0 0

No. 7. The same apparatus with two cells instead of one ... 2 7 0



No. 5A.



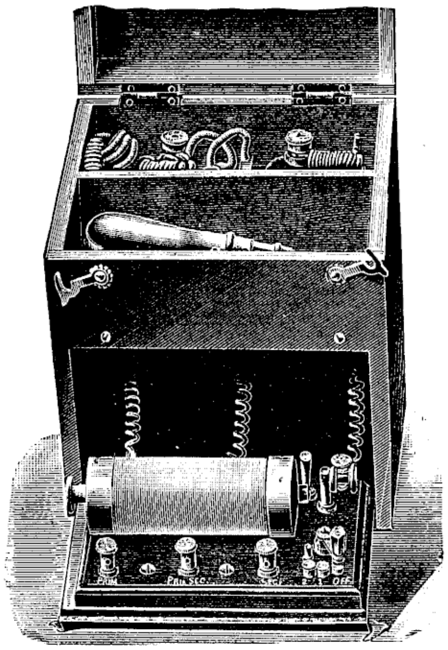
No. 6A.

Coils with Dry Cells.—These coils have the great advantage that there is no acid required to work them. As it is only the spilling of acid which makes a coil get out of order, these coils require practically no repairs and less attention; they are clean, reliable, and convenient. They have been tried now some twelve years, and have superseded most acid coils (see also page 41). The size and quality of the cells chosen is such that one cell will work a coil for forty to sixty hours before it gets exhausted. With an average use of ten minutes a day, the cell has to be renewed once in a year. Price of new Cells, including postage, 2/6.

No. 5A. Same Coil as No. 5, but with dry cell instead of the acid cell, size $5 \times 5 \times 5\frac{1}{2}$ inches, weight $2\frac{3}{4}$ lbs. ... £1 0 0

No. 6A. Same Coil as No. 6, but with dry cell instead of the acid cell, size $5 \times 5 \times 5\frac{1}{2}$ inches, weight 3 lbs. ... 2 0 0

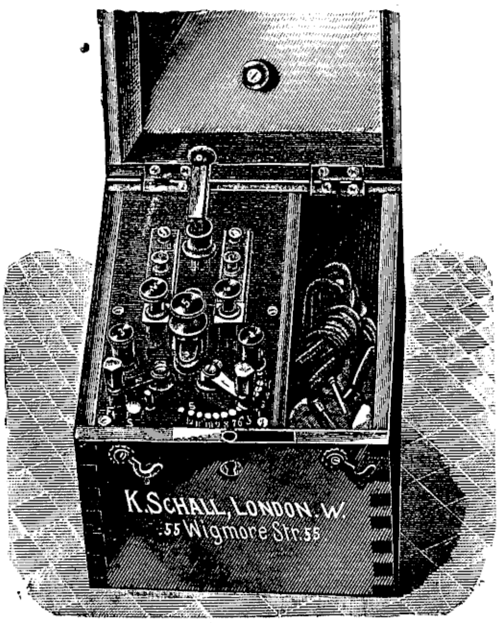
This coil is bought more frequently than any other type. It is compact, powerful, and allows a very gradual regulation of the current's strength. It is provided with a good interrupter and a set of six electrodes.



No. 8.

No. 7A. Dr. Spamer's Coil, with two dry cells...£2 7 6

No. 8. Coil, with two *large* dry cells, working the coil for over 100 hours, size 6×6×7½ inches, weight 5 lbs.£2 2 0



No. 14.

No. 14. Coil, with large bichromate cell, in polished mahogany case, commutator for primary and secondary current, and crank for regulating the strength of current; cords, handles, and six electrodes ...£2 5 0

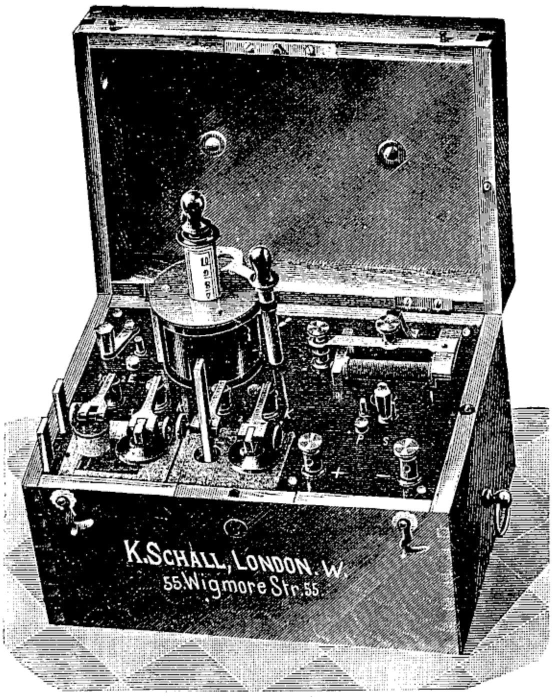
Ready-made acid, in bottles with glass stoppers, containing acid for about nine charges, per bottle, 1/6.

SLEDGE COILS.

If not otherwise ordered, the diameter of the copper wires used in the apparatus Nos. 16—30, is 0·8 millimetre (No. 21 B.W.G.) for the primary coils, and 0·2 millimetre (No. 36 B.W.G.) for the secondary coils, but, if desired, any other size may be used.

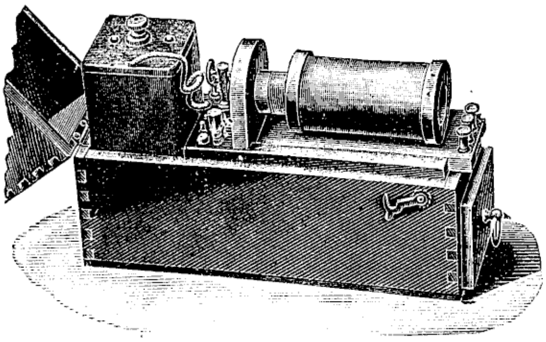
The sledge coils can be arranged so that the secondary coil can be moved by rack and pinion, or by a long screw with crank. In the former case 14/-, and in the latter case 25/-, have to be added to the prices.

No. 16. Dr. Taube's Sledge Coil, with two bichromate cells, size 5 × 7 × 5½ ins., weight 4 lbs. **£3 7 0**



No. 16.

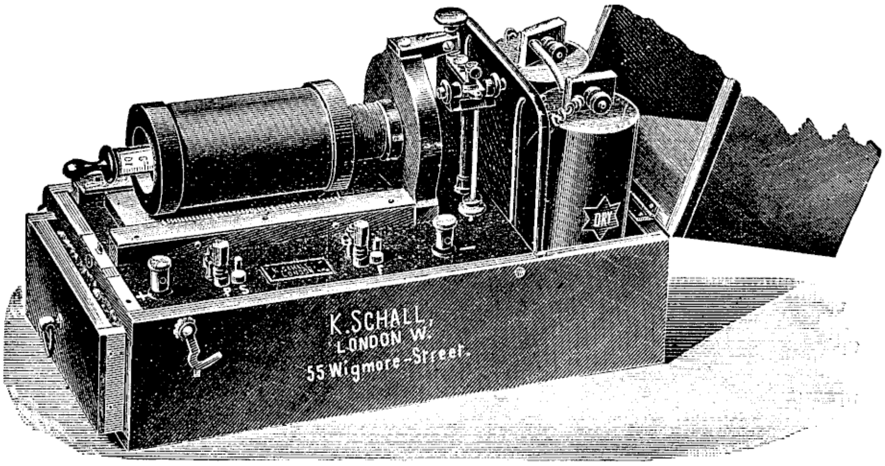
No. 17. Dr. Taube's Sledge Coil, with two dry cells **£3 10 0**


No. 19.

No. 19. Dr. Lewis Jones' Sledge Coil, with one large dry cell, working the coil for about 80 hours altogether ... **£2 0 0**

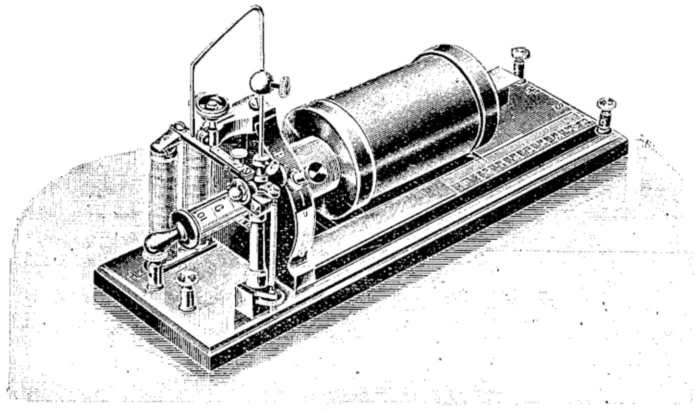
No. 21. Dubois-Reymond's Coil, with two dry cells, in polished mahogany case, commutator for primary and secondary current, cords, handles, and six electrodes, size 5 × 11 × 7 inches, weight 6 lbs. (Fig. 21, page 119) ... **£4 10 0**

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.



No. 21 (see footnote).

Spare Cells for the coils No. 19 and No. 21, 2/6 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 16 0
No. 28.	The same apparatus, with 10,000 turns on the secondary coil	4 0 0

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

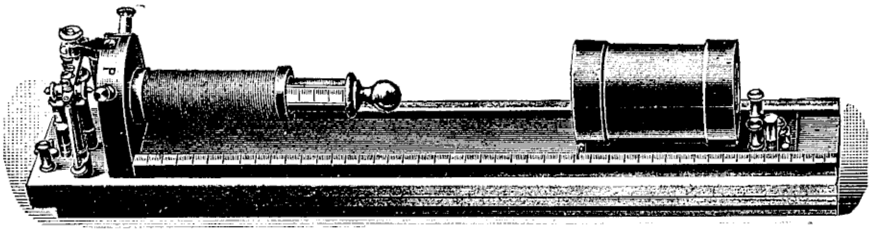
Drs. J. Althaus, Queen Anne Street; Keightley, Queen Anne Street; Sharkey, 22, Harley Street; Head, 61, Wimpole Street; A. Anderson, 37, Wimpole Street; Schorstein, Portland Place; Smith, Nottingham Place; M. Tucker, Harley Street; Knight, Streatham Hill; Routh, Manchester Square; Dickinson, Ealing.

Drs. Winder, Blackpool; Berry, Bournemouth; Scott, Wrotham; Colquhoun, Sandhurst; Warburton, Treherbert; Napier, Glasgow; Major, Bradford; Grant and Durant, Market Harborough; Hall, Leeds; Hamilton, Glasgow; Barlow, Glasgow; Hughes, Brighton; Pendlebury, Ormskirk; Aiken, Fenton; Evans, Cardiff; Peacock, Nuneaton; Playfair, Bromley; Bark, Liverpool; Benthall, Derby; Dawson Turner, Edinburgh.

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.

No. 29. Large sledge coil with 15,000 turns (10,000 feet) of wire on the secondary coil; by means of cranks 2, 4, 6, 8 or 10,000 feet of wire can be inserted, and if desired wire of different diameter may be used for the various sections, which can be used separately or connected in series. The strength of current can be adjusted by varying the distance between primary and secondary coil, by altering the length or the diameter of the wire in circuit, or by inserting wire resistances in the primary, and graphite resistances in the secondary circuit. The interrupter can be adjusted for slow or rapid vibrations **£8 10 0**

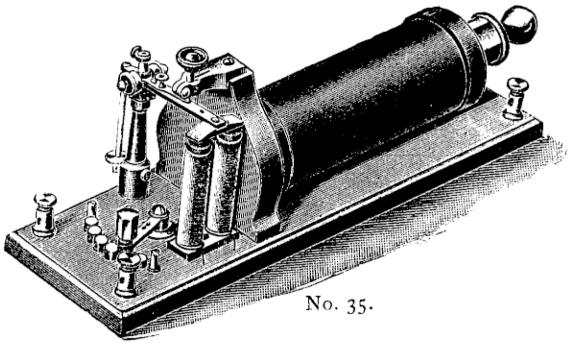
INDUCTION COILS FOR SPECIAL PURPOSES.



No. 30.

No. 30. Dubois-Reymond's Coil, 4 feet long, with scale and Helmholtz's modification for physiological experiments **£4 10 0**

(As supplied to University College, King' College, Guy's, Charing Cross, Westminster, and other Hospitals.)



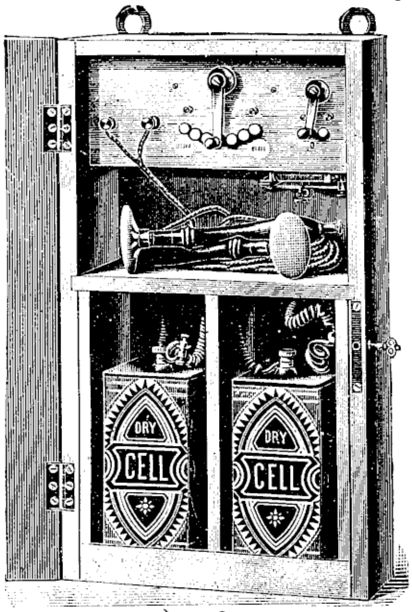
No. 35.

No. 35. Dr. de Watteville's Coil, for primary current only ... **£3 0 0**

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.

No. 40. Schall's Emergency Coil for Operating Theatres, Casualty Wards, etc. £4 4 0

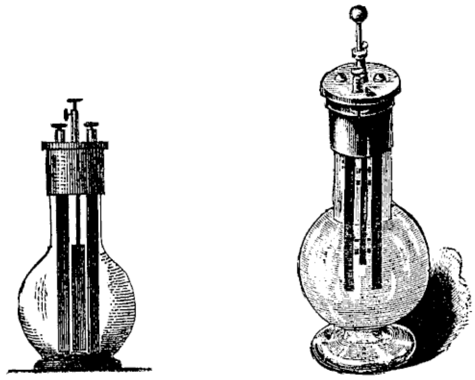
This apparatus (Fig. 40) has been specially constructed for casualty rooms and operating theatres in hospitals, for police stations, life-saving stations, etc., and is so constructed that it requires as little time as possible to set it in action in urgent cases; that persons not accustomed to electric apparatus can work it, and, moreover, it will not easily get out of order nor require repair. It contains either an incandescent lamp—if the electric light is available in the hospital, or else two large dry cells, which, even after standing for years without being used, supply a current strong enough to work the powerful induction apparatus. Two electrodes are permanently connected with the apparatus by means of long and strong cords, so that they have not to be screwed on at the moment of need. The strength of the current can be regulated up to a certain point only by means of a crank, and can be given in seven degrees, the weakest of which even causes pretty strong muscular contractions.



No. 40.

ELEMENTS FOR WORKING COILS.

(See also pages 40 and 41.)



Nos. 70–73.

No. 55.	Dry Leclanché's cell for coils, 5A, 6A, 7A & 17, each	£0	2	6
No. 57.	„ „ „ „ 8, 19, 21, 27, 30 & 35 „	0	3	0
No. 60.	Two large Leclanché's cells (dry or liquid) in oak case with terminals	0	14	0
No. 61.	Four „ „ „ „ „ ...	0	18	6
No. 70.	Bottle bichromate cell, ½ pint ... ... each	0	4	6
No. 71.	„ „ „ 1 „ ... ... „	0	7	6
No. 72.	„ „ „ 2 „ ... ... „	0	10	0
No. 73.	„ „ „ 4 „ (3 carbons and 2 zincs) „	1	0	0
No. 75.	Thermopile, with gas burner for working coils „	2	7	6

GALVANISATION AND ELECTROLYSIS.

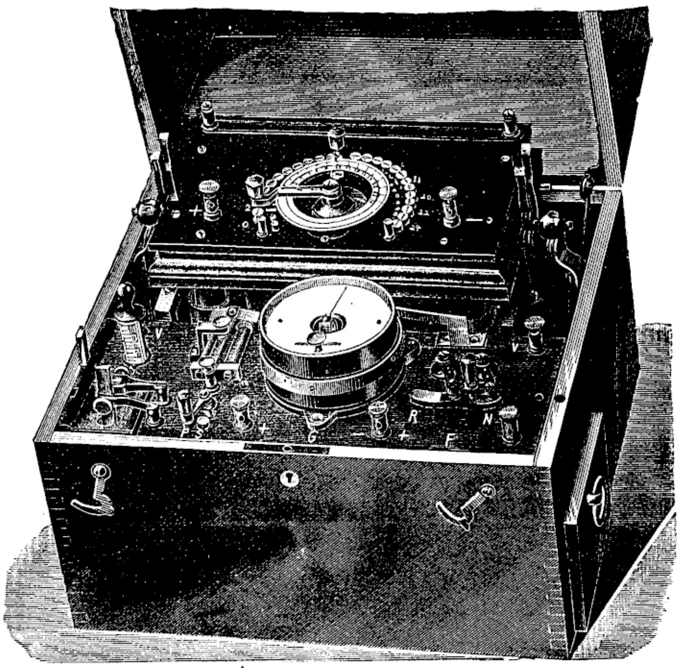
(See also pages 9—23.)

PLUNGE BATTERIES.

The special point in these batteries is that the carbons and zincs are cast together, thus ensuring a good connection, since the breaks of contact, which not infrequently occur in elements that are screwed together, cannot possibly happen. Furthermore, when the zincs have been used up, new elements can easily be fixed even by the most inexperienced. Indiarubber floats prevent the spilling. During the last ten years over 1,500 of these batteries have been sold, the best proof of their practical construction, and experience has shown that, on account of their great simplicity, they require fewer repairs than any other acid batteries.

These batteries are specially suitable for electrolysis.

Plunge Batteries in polished mahogany case, with automatic lifting and lowering arrangement, double collector, current reverser, cords, handles, five electrodes and three spare cells.



No. 90.

No. 86, 24 cells	£7 0 0
No. 87, 32 „	8 10 0
No. 88, 40 „	10 0 0

No. 90, 24 cells with coil (Fig. 90)		£9	0	0
No. 91, 32 „ „		10	10	0
No. 92, 40 „ „		12	0	0
Fitted with galvanometer No. 271	extra	2	15	0
Spare elements for these batteries	„	0	0	9
Spare glasses „ „	„	0	0	3

PORTABLE LECLANCHÉ BATTERIES.

(See also pages 10—12.)

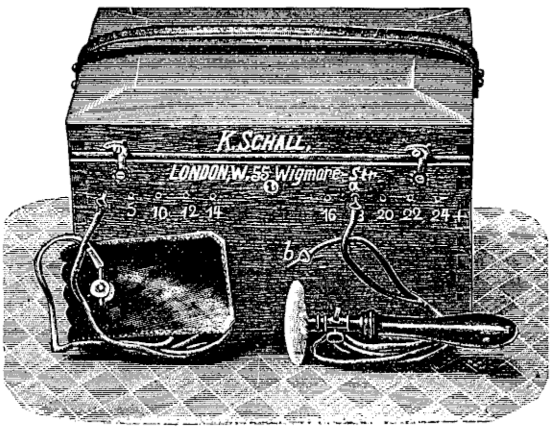
If not otherwise ordered, the batteries Nos. 99—140 will be charged with liquid cells, if remaining in or near London, but with dry cells if they have to be sent away a greater distance. Batteries charged with liquid cells can be sent by rail in the care of the guard only. Batteries charged with dry cells can be sent as ordinary freight all over the world.

The re-charging of the batteries costs 9d. per cell if they are filled with liquid cells, and 1/9 per cell if they are filled with dry cells.

Provided the batteries are not short circuited, batteries Nos. 99—133 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.

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*.

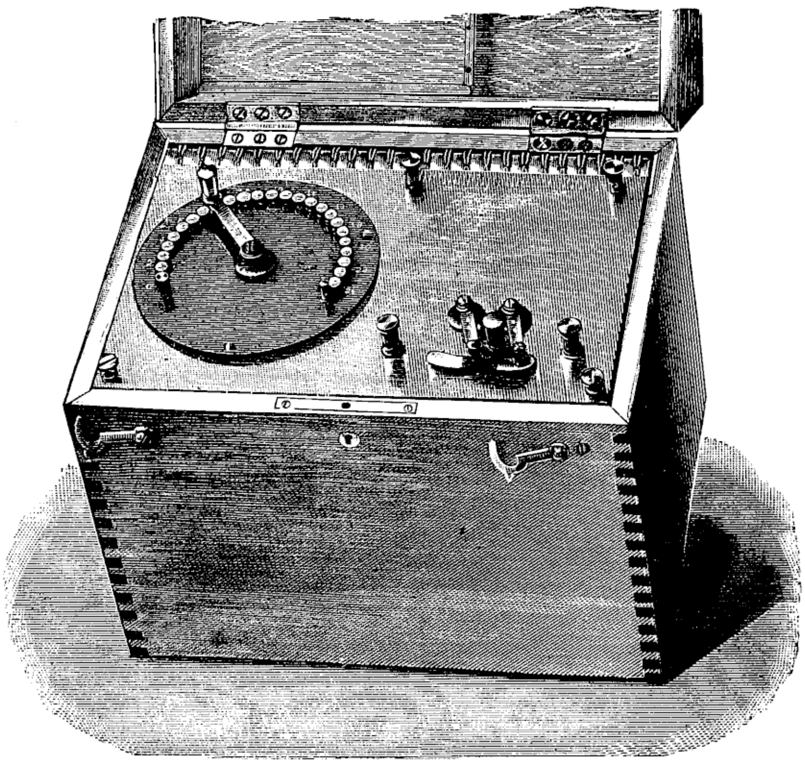


No. 103.

*No. 98.	4 cells	... ...			£0	17	0
*No. 99.	6 „	... ...			1	1	0
†No. 100.	8 „	$3\frac{1}{2} \times 5 \times 6\frac{1}{2}$ inches,	weight 6 lbs.	... ...	1	12	0
†No. 101.	12 „	$5 \times 5 \times 6\frac{1}{2}$ „	„ $9\frac{1}{2}$ lbs.	... ...	2	2	0
No. 102.	18 „	$5 \times 9\frac{1}{2} \times 6\frac{1}{2}$ „	„ $12\frac{1}{2}$ lbs.	... ...	2	15	0
No. 103.	24 „	$7\frac{1}{2} \times 10 \times 6\frac{1}{2}$ „	„ 18 lbs.	(Fig. 103)	3	5	0
No. 104.	32 „	$8 \times 14 \times 6\frac{1}{2}$ „	„ 24 lbs.	... ...	4	2	0
No. 105.	40 „	$8 \times 17 \times 6\frac{1}{2}$ „	„ 30 lbs.	... ...	5	0	0

* Suggested by Mr. Cardew, for treating exophthalmic goître. (Graves's disease.)
† For throat, ear, and eye diseases, for removing hairs by means of electrolysis, etc.

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



No. 117.

No. 116,	18 cells,	4½ ×	9½ ×	11 inches,	weight	16 lbs.	...	**£4**	**10 0**
No. 117,	24 ,,	7 ×	11 ×	11 ,,	,,	21 lbs. (Fig. 117)		**5**	**10 0**
No. 118,	32 ,,	7 ×	13½ ×	11 ,,	,,	29 lbs.	...	**6**	**12 0**
No. 119,	40 ,,	7 ×	7 ×	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."

No. 117A.

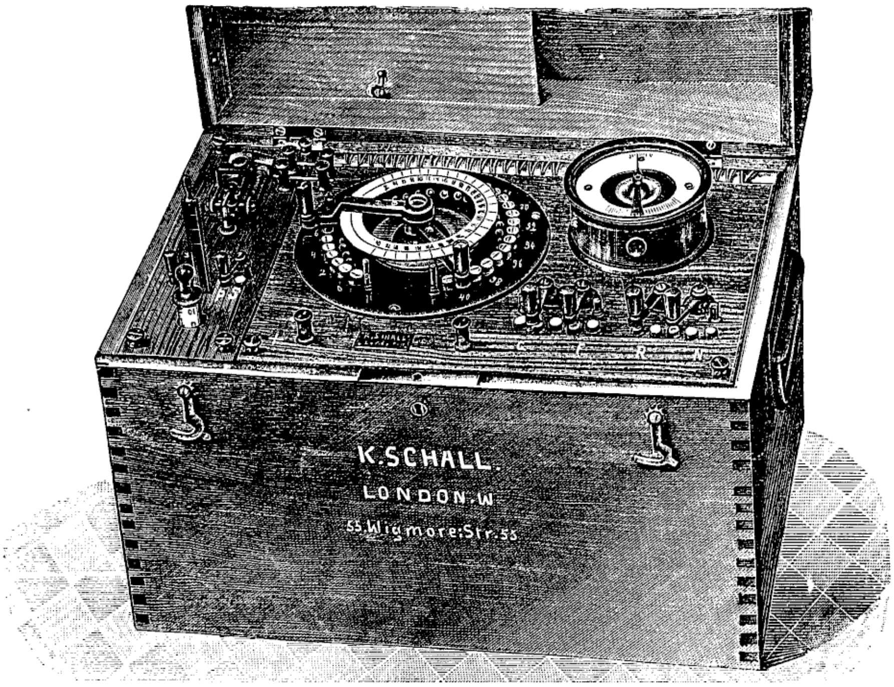
Schall's Combined Batteries.—With current collector, current reverser, coil No. 6A, and large dry cell, cords, handles, and 5 electrodes. The galvanometer shown in illustration is 30/- extra.

No. 116A, 18 cells	£6	10	0
No. 117A, 24 „ (Fig. 117A)	7	10	0
No. 118A, 32 „	8	12	0
No. 119A, 40 „	9	12	0

No. 124.

Schall's Batteries, with double collector, current reverser, galvanometer (No. 270 or 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. (Fig. 124)		12	0	0
No. 125, 50 „ 8½ × 16½ × 11 „ „ 47 lbs. ...	...	13	0	0



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.

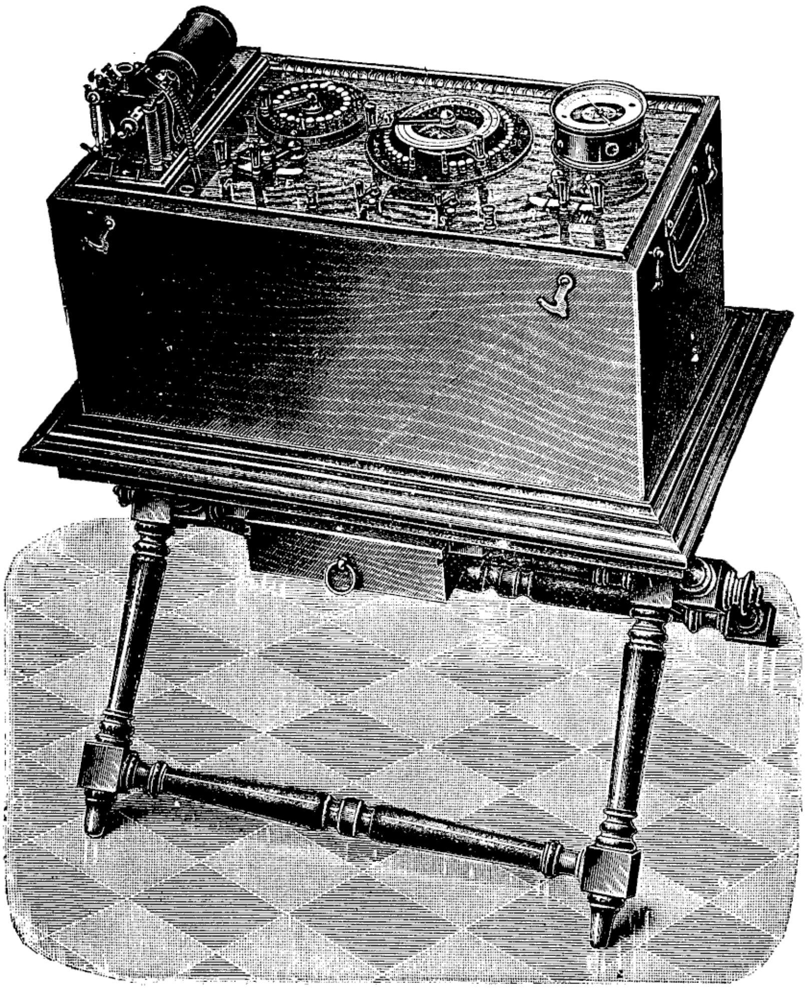
No. 130. 24 cells, 7 × 13 × 11 inches, weight 34 lbs. ...	...	£12	15	0
No. 131. 32 „ 7 × 15½ × 11 „ „ 42 lbs. ...	...	14	10	0
No. 132. 40 „ 9 × 16½ × 11 „ „ 48 lbs. (Fig. 132)		16	5	0
No. 133. 50 „ 10½ × 16½ × 11 „ „ 57 lbs. ...	...	18	0	0

To save space, the Coil No. 27 is arranged vertically in the batteries 130—133, but, if preferred, it can be mounted in the same manner as Fig. 139 shows, without alteration in price.

Schall's Combined Batteries, larger size, with double collector, current reverser, galvanometer No. 270 or No. 271, coil No. 27, Dr. de Watteville's commutator, cords, handles, and nine electrodes.

No. 137. 32 cells	£16	0	0
No. 138. 40 „ 12 × 23 × 14 inches	18	0	0
No. 139. 50 „ (Fig. 139, page 127)	20	0	0
No. 140. 60 „	22	0	0

The addition of a rheostat (No. 310) increases the price of the batteries by £1 each.



No. 139.

These batteries are excellent for consulting rooms, hospitals, etc., for galvanisation, electrolysis, faradisation, and for lighting small lamps. They contain all the necessary accessories for measuring the strength of current, the E.M.F. of the cells, and the resistance of the patient.

No. 142. Stand, with drawer for the reception of the electrodes, and two movable shelves, to put a water basin, etc., on £3 9 0

There are several hundred of our Leclanché batteries 123—140 already in use. They have been supplied, amongst others, to :—

The War Office and the Admiralty.

Drs. Lauder Brunton, Nunn, Stratford Place; Andrew Clark, T. Little, T. James, W. Cheyne, S. Sharkey, Harley Street; Maddick, Pasteur, Chandos Street; Mott, H. Bennett, Sir F. Semon, Hood, Lewis Jones, Wimpole Street; Mason, Pitt, Turney, Schorstein, Bridger, Portland Place; Mont. Murray, Jackson, Routh, Manchester Square; Scanes Spicer, Welbeck Street; Hedley, Mansfield Street; J. Althaus, Queen Anne Street; Juler, Cavendish Square;

Buzzard, Grosvenor Street; Broadbent, Seymour Street; Morrison, Cadogan Place; Harvey, Astwood Road; Skinner, York Place; Cosens, Oxford Terrace; Warner, Brechin Place; Currie, Queen's Road; Manley Sims, Hertford Street; Holmes, Old Burlington Street; Beauchamp, Cromwell Road; Goldsborough, Welbeck Street.

Lord Kelvin, Dr. Macintyre, Glasgow; Drs. Milne Murray, Taylor, Turner, Ronaldson, Bruce, Haultain, Edinburgh; Aldous, Plymouth; Armstrong, Buxton; Brown, Hayward, Wilson, Liverpool; Cremon, Cummins, Pearson, Cork; Griffith, Swansea; Griffith, Hayward's Heath; Green, Sandown; Cross, Clifton; Battersby, Cannes; Barron, Ascot; Beatty, Clacton-on-Sea; Friel, Waterford; Greenbury, Bradford; Mason and Bridgman, Burton-on-Trent; Moberley, Bridlington Quay; Nicol, Llandudno; Passmore, Gainsborough; Reid, Canterbury; Russel, Burslem; Richardson, Croydon; Rayner, Malvern; Renney, Sunderland; Rendall, Mentone; Roderick, Llanelly; Powell, Exmouth; Shelly, Hertford; Surridge, Knutsford; Smith, Ingatestone; Thomas, Bromley; Winder, Blackpool; White, Leeds; Wood, Woolpit.

Guy's Hospital, St. Mary's Hospital, St. Thomas's Hospital, London Hospital, University College Hospital, Westminster Hospital, National Hospital for Diseases of the Heart, Central Ear and Throat Hospital, General Dispensary, Marylebone; London County Lunatic Asylum, Hanwell; St. Andrew's Home, Folkestone; 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, Dundee, Downpatrick, Greenock, Waterford, and Worcester; County Asylum, Whittingham; Haywood Hospital, Burslem; Addinbrooke Hospital, Cambridge; Grimsby District Hospital; Sidmouth Hydropathic Co.; Hazelwood Hydropathic Co.; St. Anne's Hill Hydropathic Co., Cork, etc., etc.

No. 143. Trolley, for hospital use (Illustration on application)... **£4 10 0**

For apparatus for utilizing the current supplied from dynamos for galvanisation, electrolysis and faradisation, see pages 203–210.

STATIONARY BATTERIES.

For physicians who have to apply electricity frequently, and whose batteries need not be portable, as well as for hospitals and other establishments, etc., the stationary batteries have great advantages, because cells of large type can be used for them. They are more constant than the small cells used for portable batteries, and last on an average for three years without requiring re-charging, or any other repairs whatever. (The cells working the induction coil may require re-charging oftener, if strongly used.)

(As to the cells used for these batteries, see also page 11.)

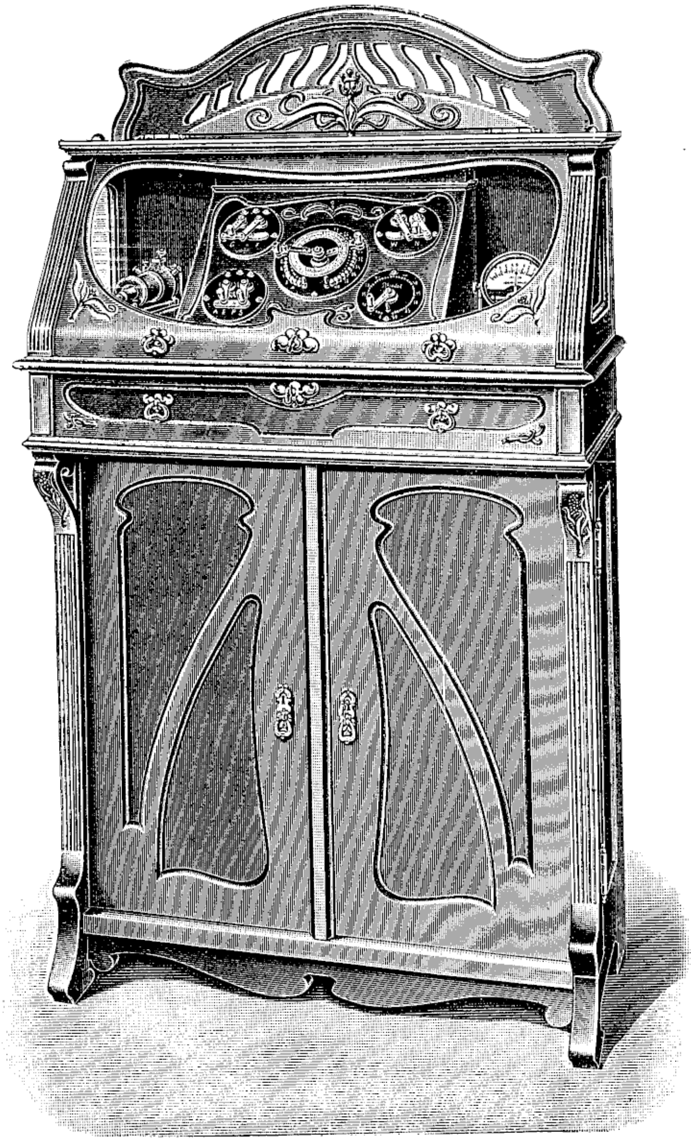
The batteries Nos. 160—175 may be used for surgical lamps requiring not more than 1· ampère.

No. 160. 44 Leclanché cells, in oak cabinet (Fig. 170), double collector, galvanometer No. 288, cords, handles, and six electrodes **£30 0 0**

No. 162. The same battery, but with coil No. 27, commutator for primary and secondary current, and Dr. de Watteville's commutator in addition **£36 0 0**

No. 170 44 Leclanché cells, in oak or walnut cabinet, with double collector, galvanometer No. 288, rheostat No. 321, current interrupter and current reverser, coil No. 27, Dr. de Watteville's commutator, cords, handles, and nine electrodes, Fig. 170... **£42 0 0**

(As supplied to St. Mary's Hospital, Sir Victor Horsley, Sir Russell Reynolds, Dr. Lloyd Roberts, Dr. M. M. Sharpe, Dr. C. H. Haines, Mr. Tucker, Sir Lauder Brunton, Dr. Gamgee, Dr. Macvail, Dr. Macintyre, Dr. Bachelor, Western Infirmary, Glasgow ; and others.)



No. 170.

Batteries Nos. 160, 162, and 170, with 50 cells instead of 40, each extra	**£3**	**0**	**0**
,, ,, ,, ,, ,, 60 ,, ,, ,, ,,	**6**	**0**	**0**

No. 175. 60 Leclanché cells, in carved oak cabinet, with double collector, Brenner's current breaker and current reverser, graphite rheostat, galvanometer No. 290, large coil No. 28, and Dr. de Watteville's commutator, handles, cords, and nine electrodes **48 0 0**

Nos. 160—175 are the most frequently used combinations of apparatus. There are, however, many other combinations possible. The apparatus can be fixed on tables instead of on cupboards, or can hang on the wall in order to take up less room. We are prepared to meet the wishes of medical men as to special combinations, size and shape, and to send estimates and photographs.

K

DR. SCHNEE'S FOUR-CELL BATH.

In this bath only the arms and feet of the patient are immersed in water. This system offers considerable advantages over a whole bath in many cases.

It is more convenient because the patients need not undress altogether. The strength of current passing through the patient can be measured accurately, whereas in the full bath we do not know how much current reaches the patient, and how much passes directly through

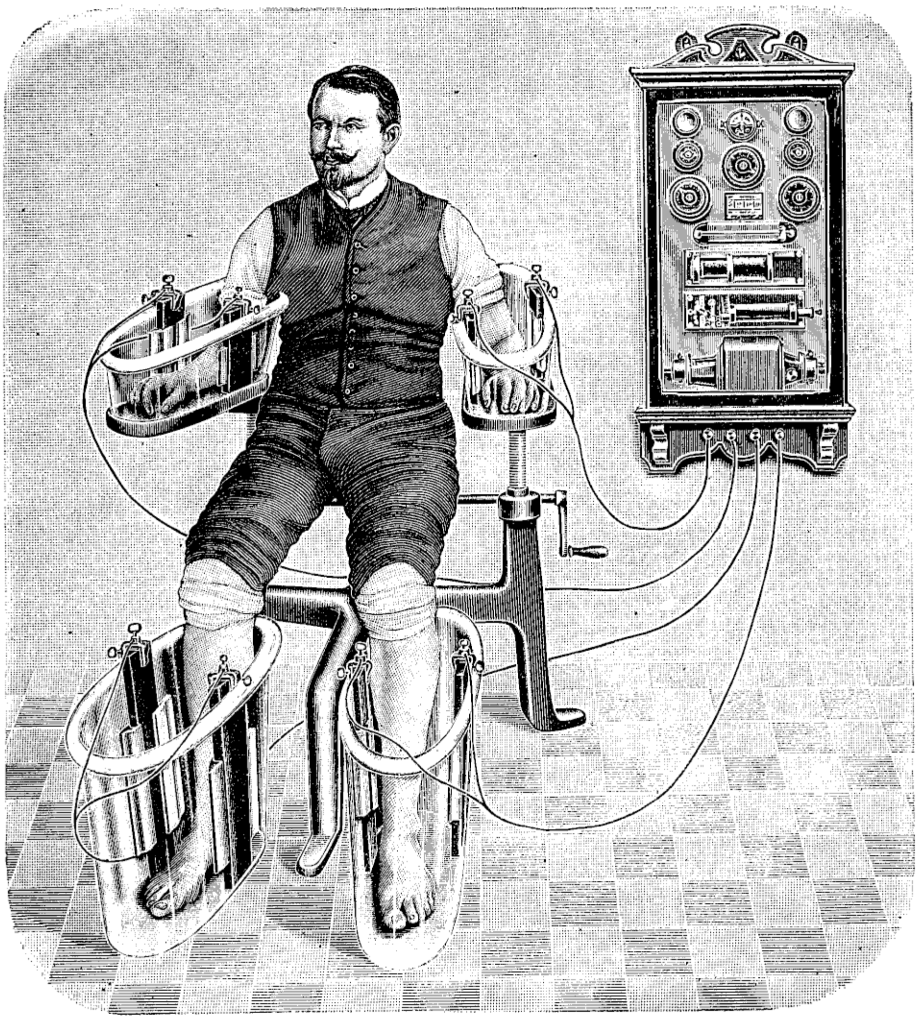
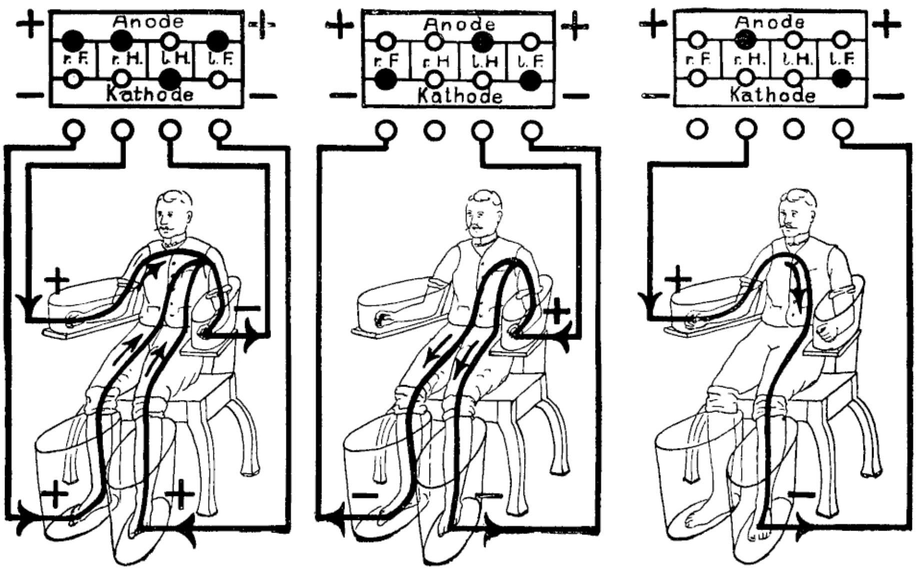


Fig. 180.

the water. The patients can bear much stronger currents than with local applications, on account of the large surface exposed to the current. The direction of the current can be varied by means of a commutator, a great 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 as in a full bath, because these porcelain tubs are not connected with the water pipes, and are well insulated from earth. Drugs may be added to the water, and can be introduced through the skin by the continuous current. The quantity of water required is not great, the apparatus does not therefore depend on the proximity of a water supply.



Dr. Schnee's four-cell bath has been patented in Great Britain (No. 14875, 1897, and No. 26401, 1898). We have been appointed agents for making the apparatus.

No. 180. Complete outfit of Dr. Schnee's four-cell bath, consisting of a switchboard for galvanisation, faradisation and sinusoidal currents, with galvanometer, reverser, etc. ; commutator to control the direction of the current ; chair for the patient, and four porcelain tubs with carbon electrodes. The tubs for the arms can be raised or lowered, Fig. 180 ... ... £65 0 0

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

No. 181. Chair, with commutator to control the direction of the current, and four porcelain tubs with carbon electrodes £26 0 0

No. 183. Separate porcelain tub for the foot, with carbon electrode 1 6 0

No. 184. Separate porcelain tub for the arm, with carbon electrode 1 1 0

No. 185. Commutator to control the direction of the current, with the necessary terminals, etc., mounted on ebonite ... 1 12 0

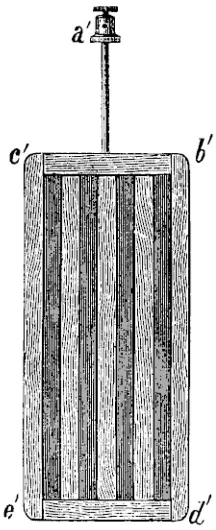
K 2

ELECTRIC BATH.

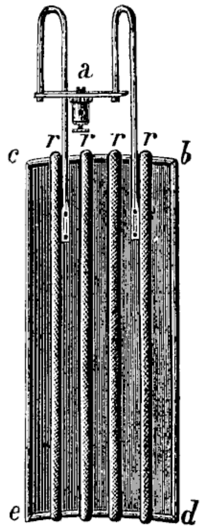
Any wooden or porcelain bath tub is fit for an electric bath. Metal tubs may be insulated to a certain extent by means of bath enamels, so that the electric current can therein be applied to the patient. Tin electrodes, about 10 inches square, are immersed in the water at the upper and lower ends, sometimes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

No. 195. Large bath electrode, Fig. 195 £0 14 0

No. 196. The same, bent for the head or foot end of the tub, Fig. 196 ... 0 16 0



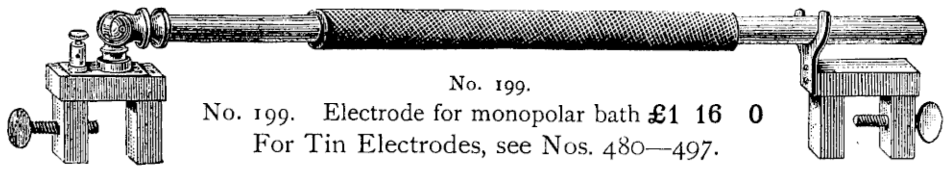
No. 195.



No. 196.


No. 198.

No. 198. Paddle Electrode, Fig. 198 ... ... £0 12 0


No. 199.

No. 199. Electrode for monopolar bath £1 16 0

For Tin Electrodes, see Nos. 480—497.

In this way any bath tub can, without trouble or serious expense, 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—140, or Nos. 160—175 are suitable for applying the galvanic, faradic, or combined currents.

For complete Electric Baths in hydropathic establishments or in hospitals, we recommend a specially constructed bath tub, at the bottom and sides of which six or eight electrodes are fixed, so that the patient does not come in contact with them. A commutator renders it possible to make the galvanic, faradic, or combined current circulate between any pair of electrodes.

The battery and commutator can be placed in the same room as the bath, or in an adjacent room. In either case complete control over the direction and strength of the current in the bath is possible. The commutator has to be connected with the bath tub by as many wires as there are electrodes in the bath.

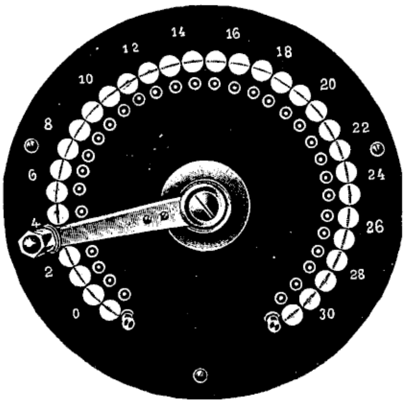
No. 205. Oak Bath Tub, with eight fixed electrodes and commutator £12 10 0

The price of a complete installation of an Electric Bath with extra tub is £17 to £50; without special bath tub from £4 to £40, according to the battery chosen.

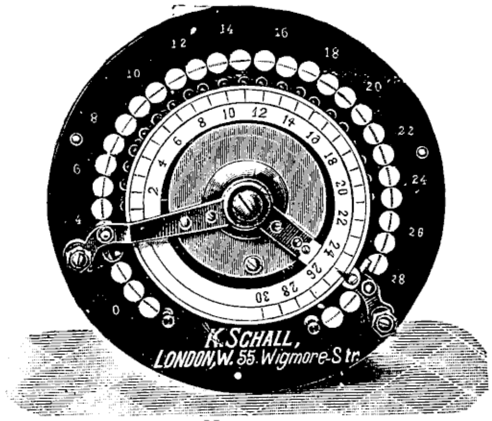
Estimates and Photographs will be sent on application.

CURRENT COLLECTORS, REVERSERS, COMMUTATORS, &c.

(See also pages 14—19.)



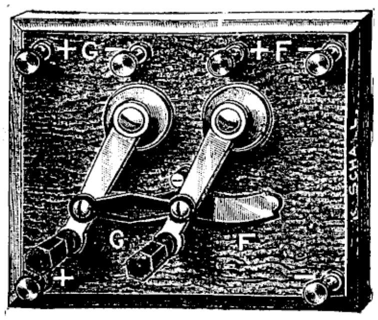
No. 207.



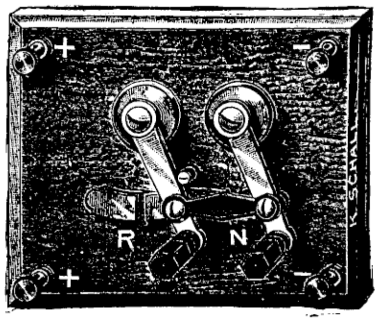
No. 210.

		20	30	40	50	60 Cells
No. 207.	Single Collector, Fig. 207 ...	25/-	27/-	30/-	45/-	48/-

		20	30	40	50	60 Cells.
No. 210.	Double Collector, Fig. 210 ...	45/-	50/-	56/-	68/-	74/-

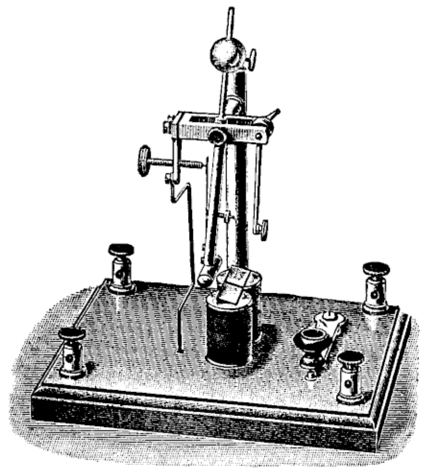


No. 232.

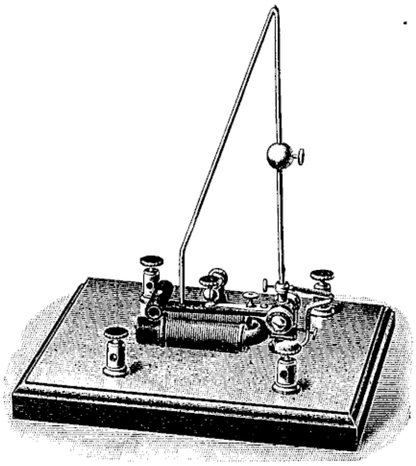


No. 222.

No. 222.	**Current Reverser and Interrupter**, Fig. 222 ...	**£0**	**14**	**0**
No. 232.	Dr. de Watteville's commutator, for the use of galvanic, faradic, or combined currents, Fig. 232	**0**	**15**	**0**
No. 235.	Current Interrupter, in the shape of a telegraph key, mounted on a board, with terminals	**0**	**7**	**0**
No. 237.	Interrupter to be worked with a foot, mounted in cast-iron box	**2**	**9**	**0**

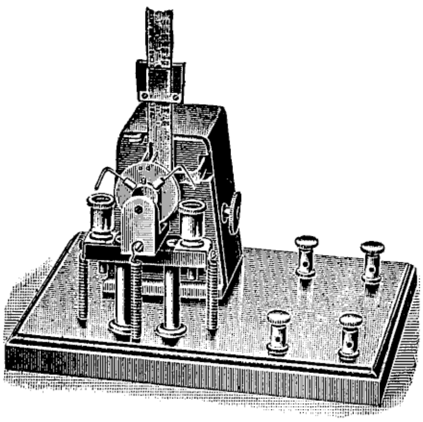


No. 238.

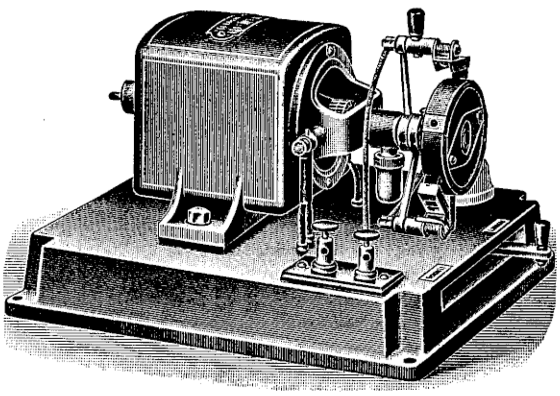


No. 239.

No. 238.	Dr. Tripier's automatic interrupter, Fig. 238. The number of interruptions can be varied from about 40 up to 3,000 per minute	£2 12 0
No. 239.	Dr. Meyer's interrupter, Fig. 239. The number of interruptions can be varied from about 100 up to 3,000 per minute	1 10 0



No. 240.



No. 245.

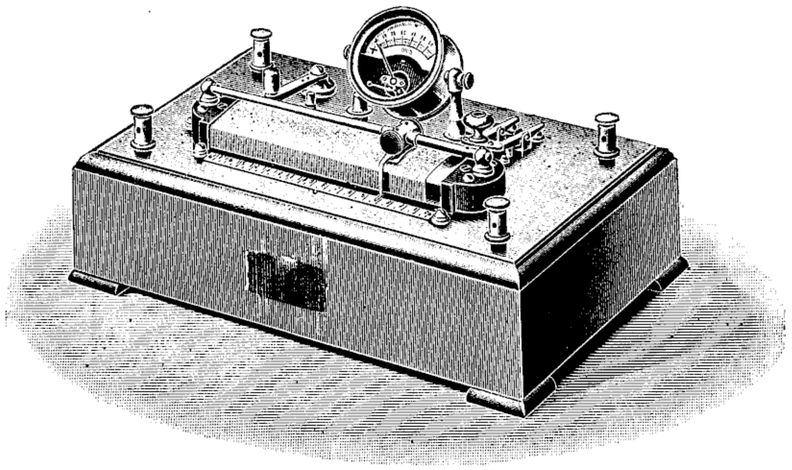
No. 240.	Metronome interrupter, Fig. 240, with two mercury cups. The number of interruptions can be varied from 20 up to 300 per minute	£3 0 0
No. 241.	Similar interrupter, with four mercury cups, so that the current can either be interrupted or reversed	3 12 0
No. 245.	Prof. Leduc's motor interrupter and reverser, Fig. 245, with rheostat to control the number of the interruptions, and adjustable brushes to vary the duration of the time during which the current is open or closed	12 0 0

See also pages 43 and 44. The motors can be so arranged that they can supply also single or three phase sinusoidal currents, or they can be used for massage.

APPARATUS FOR APPLYING CONDENSER DISCHARGES.

Condenser discharges are very suitable for diagnostic purposes, and have the advantage over faradic currents, that the amount administered to the patient can be accurately measured; the contractions produced are practically painless, and without electrolytic irritation.

The apparatus required consists of a condenser of ½ and 1 micro-farad capacity, a current of about 50 volts to charge the condenser, and a volt selector or other arrangement to vary the E.M.F. of the charging current; a voltmeter, discharging key, and automatic reverser.



No. 255.

No. 255. Complete apparatus for condenser discharges, as described above, in portable box, Fig. 255 ... ... £8 10 0

The lid covering the apparatus is not shown in the illustration.

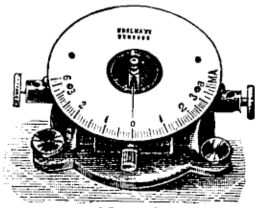
Other combinations of apparatus can be made to order.

GALVANOMETERS.

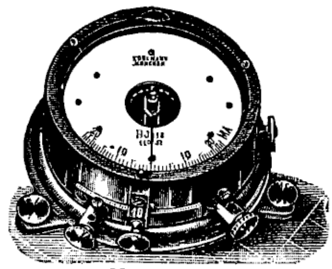
(See also pages 15—18.)

The instruments Nos. 264—274 are called *pocket galvanometers*, because they are provided with a cover, so as to be easily portable. The magnets oscillate inside a solid copper block, to make the instruments dead beat. If the point on which the needle oscillates has become blunt, this point—which consists of an ordinary sewing needle, No. 10—can easily be taken out and replaced by a new needle by anybody. The new needle should project just as far as the old one did when the galvanometer was being graduated, or else the division would become inaccurate. To get the correct projections of the needle, the galvanometers 264—272 are provided with a black T-shaped gauge. It is held against the horse-shoe, and the new needle is fixed in such a position that its point just touches the top of the gauge.

The galvanometers Nos. 264—274 are divided to meet the horizontal intensity of London, and the greatest error is guaranteed not to exceed 2 per cent



No. 264.



No. 271.

No. 264. Edelmann's galvanometer, in cardboard box, showing up to 6 milliampères each $\frac{1}{10}$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. Dr. Edelmann's galvanometer, in polished mahogany box, showing up to 5 milliampères every $\frac{1}{10}$th part of a milliampère; or by using the shunt, each single milliampère up to 50 milliampères 2 14 0

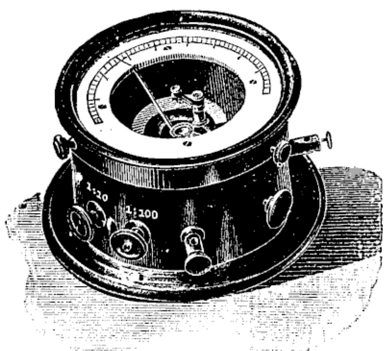
No. 271. The same instrument, showing each single M.A. up to 25, or by using the shunt, every 10 milliampères up to 250 M.A., Fig. 271 ... ... 2 14 0

No. 272. The same instrument, with two shunts, showing up to 5, 50 or 500 milliampères 3 10 0

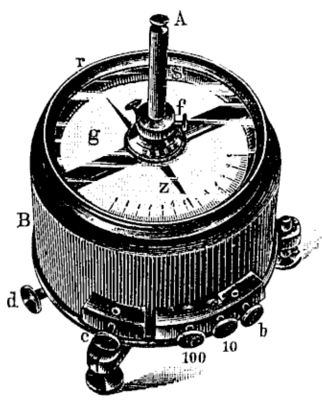
No. 273. Floating galvanometer, showing up to 300 M.A. 2 10 0

No. 274. Dead beat galvanometer, for measuring sinusoidal and alternating (faradic) currents, showing up to 300 milliampères 5 0 0

GALVANOMETERS WITH MAGNET SUSPENDED ON COCOON.



No. 277.



No. 278.

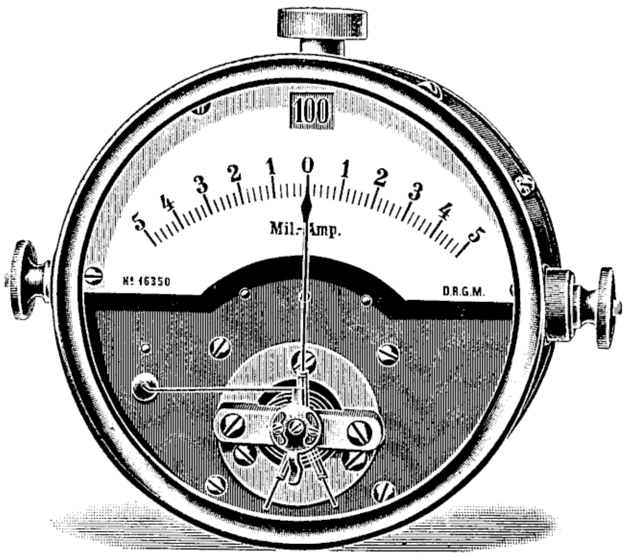
No. 277. Galvanometer, with two shunts, showing up to 5, 50, or 500 milliampères, Fig. 277 ... ... £4 10 0

No. 278. Dr. Edelmann's Universal galvanometer, Fig. 278 ... 7 12 0

Nos. 277 and 278 indicate every $\frac{1}{10}$th part of a milliampère from 0 to 5, each single milliampère from 0 to 50, and 10 by 10 milliampères from 0 to 500 milliampères.

No. 279. The same instrument, but with an additional resistance, allowing the instrument to be used also as a voltmeter £8 16 0

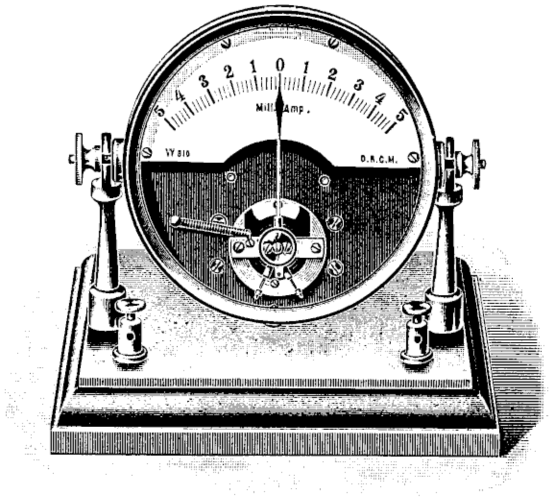
D'Arsonval Galvanometers.—These instruments have the following advantages: They are dead beat; they are independent of the earth's magnetism, and can be used horizontally or vertically or in any other position; they are independent of electrical fields or magnets, and will indicate correctly even in the neighbourhood of a dynamo. Care must be taken not to make "short circuit" while these galvanometers are inserted; if too much current passes through them the hair springs will be damaged.



No. 288.

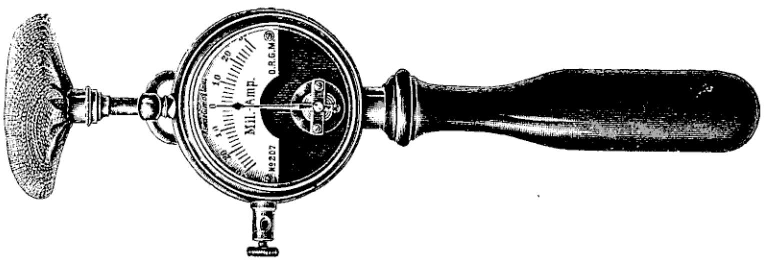
No. 280.	Small d'Arsonval galvanometer, diameter 2½ inches, reading up to 25 or 50 milliampères	£2	0	0
No. 281.	Similar instrument, reading up to 25 milliampères, or with shunt up to 250 milliampères	2	6	0
No. 284.	D'Arsonval galvanometer, diameter 4½ inches, reading up to 3 or 5 milliampères, indicating each tenth part of a milliampère	2	16	0
No. 285.	D'Arsonval galvanometer, diameter 4½ inches, reading up to 5 milliampères, or with shunt up to 50 milliampères (or to 3 and 30 milliampères)	3	5	0
No. 286.	Similar instrument, reading up to 25 or 250 milliampères	3	5	0
No. 288.	Similar instrument, Fig. 288, reading up to 5, 50 and 500 milliampères	3	12	0

The galvanometers Nos. 284, 285, and 288 *can also be used for measuring the currents passing through X-ray tubes.*



No. 290.

No. 290. Polished board, with terminals and forks to suspend galvanometers 284—288, Fig. 290 ... ... £0 10 0



No. 299.

No. 299. If desired, small galvanometers can be connected with the electrode holders, as shown in Fig. 299... ... Price £2 0 0

No. 300. Large galvanometer, similar to **No.** 288, diameter 7 inches, provided with an arrangement so that it can be used as a voltmeter up to 100 volts 7 10 0

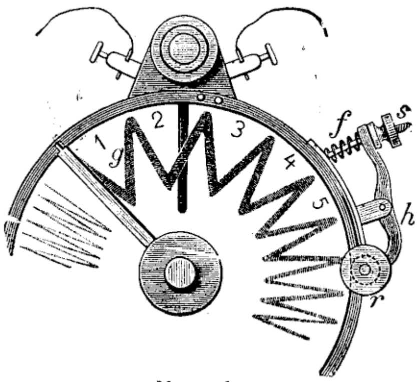
For **Ampèremeters** and **Voltmeters** see Nos. 960—970, pages 159, 160.

RHEOSTATS.

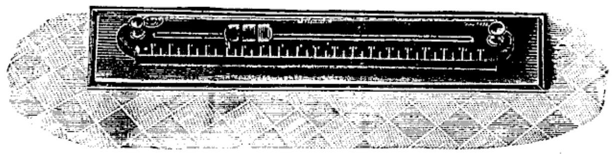
(See also page 15.)

GRAPHITE RHEOSTATS.

No. 306. Rheostat with mercury contact, total resistance about 100,000 ohms, which can be diminished *gradually*, without any jumps, down to about 20 ohms by turning the glass dial, Fig. 306, **£1 17 0**



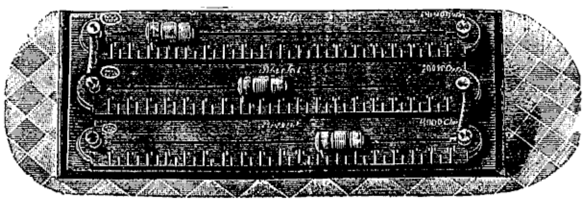
No. 306.



Nos. 308—319.

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

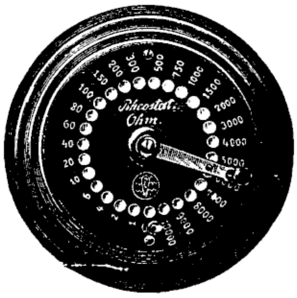
No. 308.	From	3 to	200 ohms	... ...	£0 18 0
No. 309.	,,	5 to	600 ,,	... ...	0 18 0
No. 310.	,,	5 to	1,000 ,,	... ...	0 18 0
No. 311.	,,	10 to	5,000 ,,	... ...	0 18 0
No. 312.	,,	25 to	10,000 ,,	... ...	0 18 0
No. 313.	,,	50 to	25,000 ,,	... ...	0 18 0
No. 314.	,,	50 to	50,000 ,,	... ...	1 0 0
No. 315.	,,	100 to	75,000 ,,	... ...	1 0 0
No. 316.	,,	100 to	100,000 ,,	... ...	1 0 0
No. 319.	,,	500 to	1,000,000 ,,	... ...	1 5 0



No. 320.

No. 320. Several of these rheostats can be mounted on a board, and be connected in series, so as to have, for instance, one rheostat with a low, one with a medium, and one with a high resistance. Price of the board, with 3 rheostats, including terminals and connections **£2 12 0**

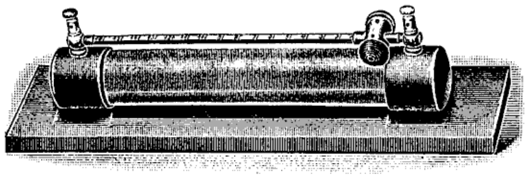
METAL RHEOSTATS.



No. 321.

No. 322.

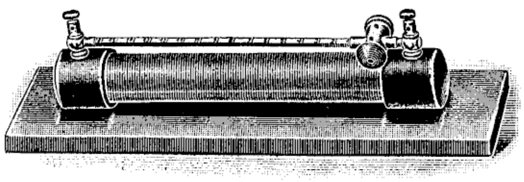
No. 321.	1,000 ohms, in 26 sub-divisions, Fig. 321	£2	16	0
No. 322.	5,000 ohms, in 30 sub-divisions, Fig. 322	3	12	0



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.

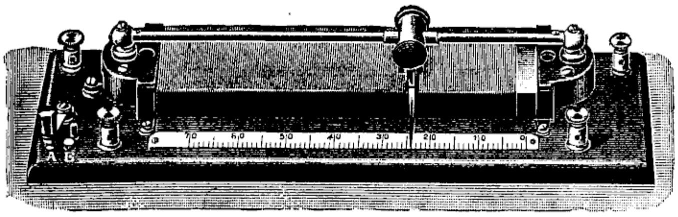
No. 324. Metal rheostat, with about 100 contacts, Fig. 324—

(*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 0·3 ampère.

SHUNT RHEOSTAT (VOLT REGULATOR).

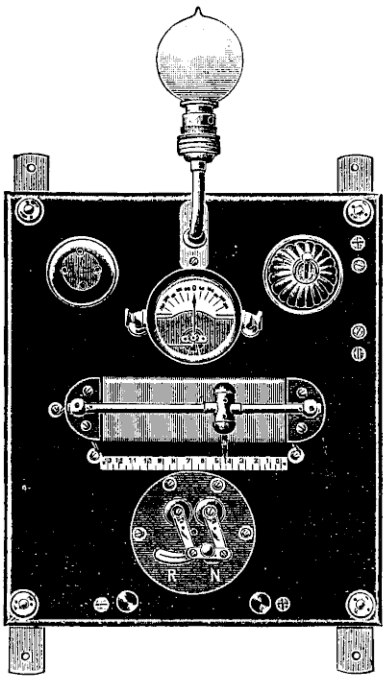
(See also pages 48—50.)



No. 327.

No. 327	Volt regulator, Fig. 327, mounted on board with terminals...	**£1 16 0**
No. 328.	Double volt regulator	**3 5 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, by means of which it will be possible to vary the E.M.F. by about 0·005 volt at a time.



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; they may be used with primary batteries, but in such a case they have to be wound specially, so that the total resistance reaches about 1,000 ohms. The price is increased thereby by 20/-.

The illustration shows a volt selector mounted on slate, with galvanometer and switch, for controlling the current of a battery (accumulators or large Leclanché cells, which may be in a distant room) for galvanisation or electrolysis. Price, including galvanometer, £7.

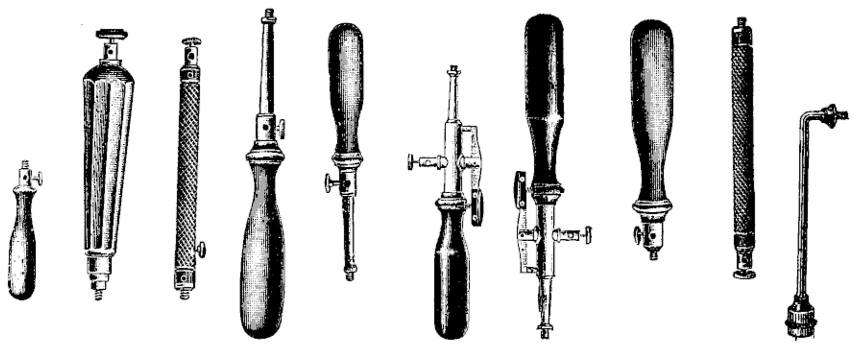
CONNECTING CORDS.

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	**2/6**
No. 332.	Ditto ditto 2 „	**3/0**
No. 336.	Separate terminals to be attached to silk cords ... each	**0/6**

ELECTRODES.

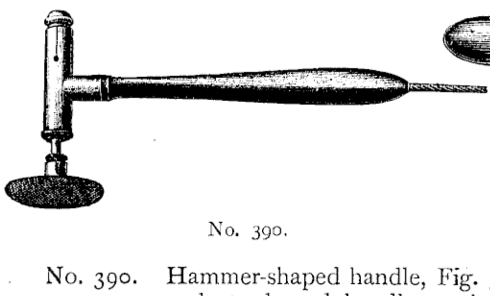
No. 365.	Handle for the reception of large sponges, diameter 4 inches, for general galvanisation and faradisation, without sponge	**7/0**
No. 366.	Ditto ditto ditto with sponge	**10/0**

The sponges can easily be exchanged in Handle No. 365.

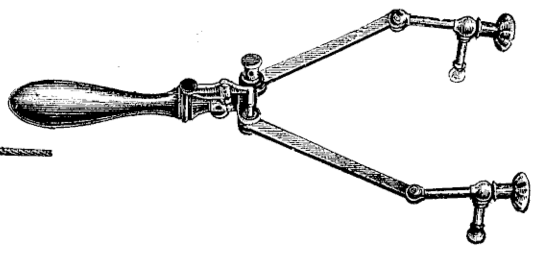


378. 372. 371. 376. 377. 370. 385.

No. 370.	Simple handle, 3 inches long	**1/6**
No. 371.	,, 4 ,, ...	**2/6**
No. 372.	,, 5 ,, ...	**3/0**
No. 376.	Handle for *interrupting* the current, 5 inches long	**5/0**
No. 377.	,, ,, ,, 6 ,, ...	**5/0**
No. 378.	,, ,, ,, for throat electrodes ...	**6/0**
No. 381.	Handle for *making* the current, 5 inches long	**5/0**
No. 382.	,, ,, ,, 6 ,, ...	**5/0**
No. 383.	,, ,, ,, for throat electrodes... ...	**6/0**
No. 385.	Connecting piece for fixing the electrodes at a right angle to the handles, Fig. 385	**2/0**

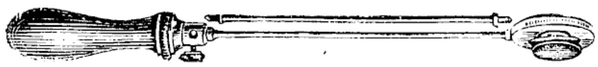


No. 390.



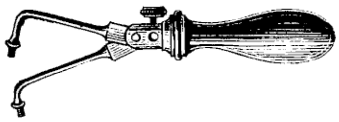
No. 393.

No. 390.	Hammer-shaped handle, Fig. 390. There is a spring between electrode and handle, so that it can be used for percussion and electric treatment combined	**8/0**
No. 393.	Double handle, Fig. 393, with key for interrupting or making the current. The two arms bearing the electrodes are insulated from one another	**26/0**

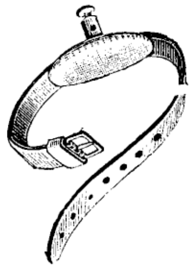


No. 398.

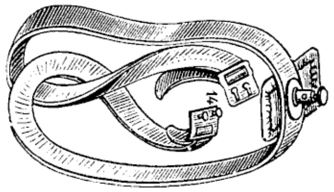
No. 398. Handle, with long insulated shaft, for introducing electrodes under the clothes 12/0



No. 400.



No. 412.



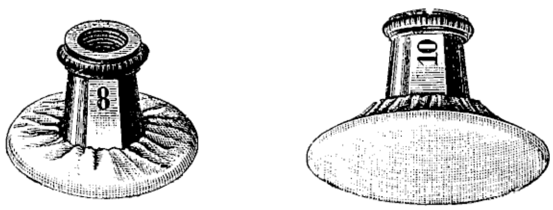
No. 418.

No. 400. Double handle, by Dr. Althaus 10/0

No. 412. Bracelet for fixing electrodes to the arms or wrists 4/6

No. 418. Belt electrode, by Beard and Rockwell 6/0

Nos. 430—432.



Nos. 442—449.

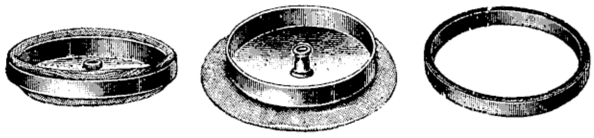
No. 430. Button shape electrodes, small... ... ... 1/3

No. 431. „ „ „ medium 1/6

No. 432. „ „ „ large 1/6

Round Tin Plates, covered with leather.

No. 442.	¾ inch diameter ...	1/4	No. 445.	2 inches diameter ...	2/0
No. 443.	1 „ „ ...	1/6	No. 447.	3 „ „ ...	2/9
No. 444.	1½ „ „ ...	1/9	No. 449.	4 „ „ ...	4/0

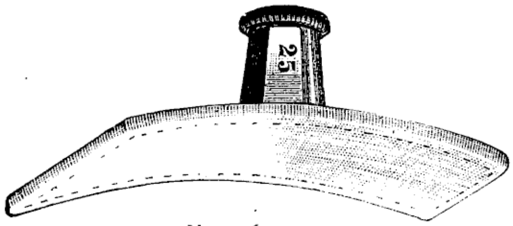


No. 453.

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.
	1/4	**1/6**	**1/9**	**2/6**	**3/-**	**4/-**	**5/6**	**7/-**



Nos. 460—470.

Square flexible electrodes, of tin, with leather covers.

No. 460.	1 square inch ...	**1/6**	No. 466.	6 square inches ...		**3/0**
No. 462.	2 ,, inches ...	**1/9**	No. 468.	8 ,, ,, ...		**3/9**
No. 463.	3 ,, ,, ...	**2/0**	No. 469.	10 ,, ,, ...		**4/0**
No. 464.	4 ,, ,, ...	**2/3**	No. 470.	12 ,, ,, ...		**4/6**

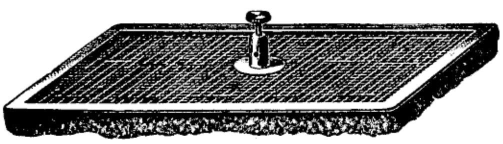
Nos. 442—449 and 460—470, with carbon plates and leather cover, 50 per cent. more.

No. 475. Electrode for neck, covered with wash leather **4/6**

No. 475.

Flexible tin electrodes, with white flannel covers and terminals, back of the electrode covered with wax cloth (see illustration No. 103, page 123).

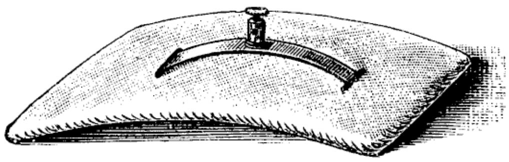
No. 480.	2½ × 4 inches ...	**1/3**	No. 491.	3¾ × 7 inches ...	**2/3**
No. 483.	2¾ × 5 ,, ...	**1/6**	No. 493.	4½ × 8½ ,, ...	**2/6**
No. 486.	3 × 5½ ,, ...	**1/6**	No. 495.	5 × 8½ ,, ...	**3/0**
No. 489.	3½ × 6 ,, ...	**1/9**	No. 497.	6 × 10 ,, ..	**4/0**



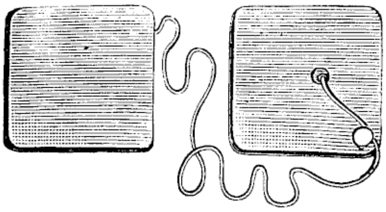
No. 500.

No. 500.
Flexible metal gauze electrodes, with sponge, according to sizes, **5/0** to **12/0**

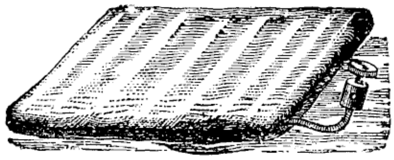
No. 510. Large indifferent electrode **5/0**



No. 510.

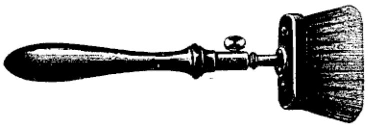


Nos. 520—521.



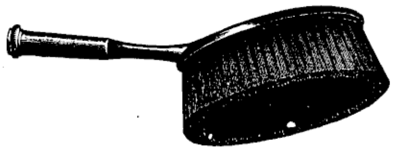
Nos. 525—528.

No. 520.	Foot plate electrode, with flannel cover and terminal,	100 square inches	**7/6**
No. 521.	Ditto ditto	130 ,, ,,	**8/6**
No. 525.	Flexible pillow electrodes	70 ,, ,,	**10/0**
No. 526.	,, ,, ,, ...	100 ,, ,,	**12/0**
No. 528.	,, ,, ,, ...	140 ,, ,,	**14/0**

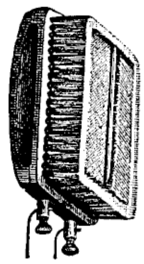


No. 545.

Nos. 540—542.



No. 550.

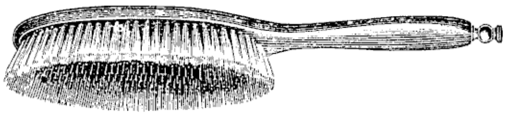


No. 555.

Brush electrodes with metal wire, without handles—

No. 540. Small **1/6**
No. 541. Medium **1/9**
No. 542. Large **2/6**

No. 545. $2\frac{1}{2}$ square inches ... **5/6**
No. 550. 7 ,, ,, Fig. 550 **7/0**
No. 555. Double brush, 9 square inches, Fig. 555 ... **10/0**

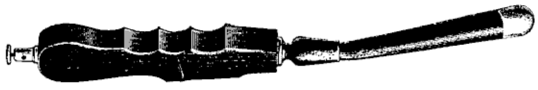


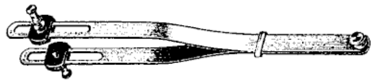
No. 557.

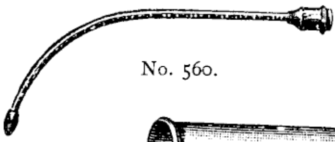
No. 557. Large brush, with handle, Fig. 557... ... **9/6**

No. 559.

No. 559. Comb electrode, Fig. 559 ... ... **3/9**


No. 571.

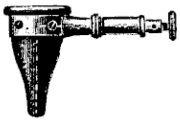

No 587


No. 560.

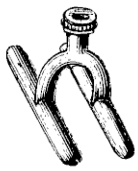

No. 572.


No. 590.

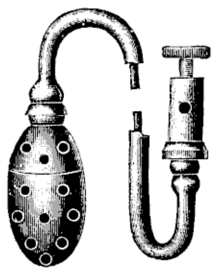

No. 573.


No. 585.


No. 586.


No. 589.

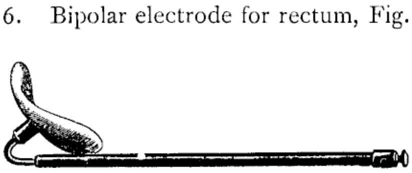
No. 560. Electrode for larynx, with olive shaped button, shaft insulated with gutta-percha, Fig. 560 ... ... 2/6
No. 566. Electrode for stomach, Fig. 566 ... 9/6
No. 568. „ for cervix, 3 sizes ... each 6/6
No. 570. „ for rectum „ ... „ 4/6
No. 571. „ „ Fig. 571 ... ... 14/0
No. 572. Zinc electrode for rectum, Fig 572 ... 3/0
No. 573. Electrode for rectum, with douche, Fig. 573 6/0


No. 566.


No. 574.


No. 576.

No. 574. Electrode for rectum, with irrigation, Fig. 574 ... ... 10/0
No. 575. Electrode for bladder 3/0
No. 576. Bipolar electrode for rectum, Fig. 576 ... ... 6/6


No. 577.


No. 578.

No. 577. Electrode for the perineum, Fig. 577... ... ... 11/0
No. 578. Electrode for the scrotum, Fig. 578 ... ... 9/0
No. 580. Mr. Cardew's bladder electrode, with ebonite tap and soft catheter 8/0

No. 585. Electrode for the ear, Fig. 585 … … … … **6/0**

No. 586. Dr. Weber Liel's electrode for the ear, Fig. 586 … … **6/0**

No. 587. Double electrode for the ear, Fig. 587 … … … **9/6**

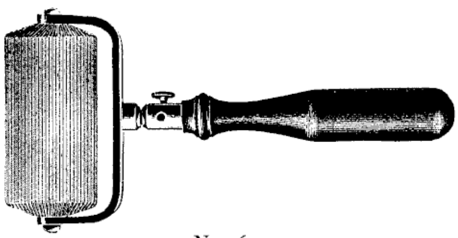
The two electrodes are insulated from one another, and can be used bipolar or monopolar, as desired.

No. 588. Electrode for the eye, Fig. 588 … … **9/6**

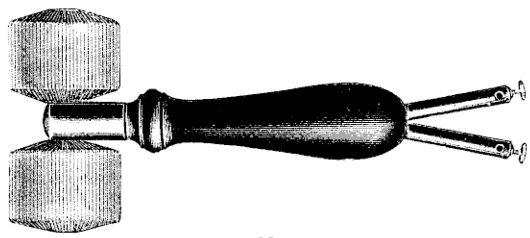
No. 588.

No. 589. Spinal electrode, Fig. 589 **4/0**

No. 590. Electrode for penis, Fig. 590 … … … … … **7/0**



No. 603.



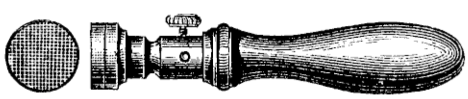
No. 604.

No. 600. Wheel electrode, $1\frac{1}{2}$ inch long, without handle … … **4/6**

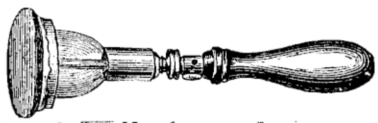
No. 602. „ „ $2\frac{1}{2}$ inches long … … … … **5/6**

No. 603. „ „ $3\frac{1}{2}$ „ Fig. 603 … … … **7/0**

No. 604. Double wheel electrode, with handle, Fig. 604 … … **12/6**



No. 620.



No. 610.

No. 610. Glass vessel for holding various liquids (unpolarisable or diffusion electrode), Fig. 610 … … $1\frac{1}{2}$ inch diameter **6/0**

No. 612. Ditto ditto ditto $2\frac{1}{2}$ inches „ **7/0**

No. 620. Dr. de Watteville's electrode for testing sensibility, with 200 separate wires, Fig. 620… .. … … … **9/0**

ELECTRODES FOR CATAPHORESIS.

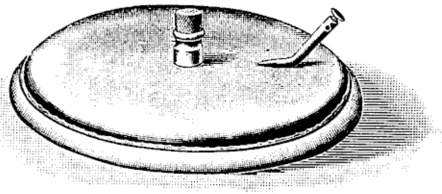
The galvanic current has the property to convey the molecules of solutions from the positive to the negative pole; it does this even through porous diaphragms, such as the skin, through which the chemicals could not penetrate without the help of the current. This is known as cataphoresis, and it is being utilized more and more in medicine, for the local administration of drugs, such as iodide of potassium, quinine, cocaine, guaiacol, arsenic, morphium, lithium, etc., etc.

It is applied in the following manner :—

Two electrodes, which must be made of non-corroding material (carbon, platinum, glass, ebonite, etc.), are brought in contact with pieces of blotting paper, cotton wool, etc., which have been soaked with a solution of the chemicals to be introduced. The electrodes are applied to the part of the body to be treated, and connected with a supply of 20 to 40 volts; the direction of the current has to be reversed at least every three or four minutes. A short time after the application, the presence of the chemicals can be proved in the urine.

No. 630.

No. 632.

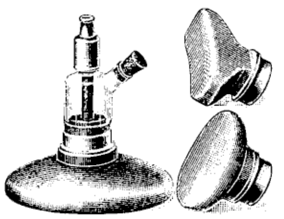


No. 638.

No. 630. Glass vessel, with carbon rod, and porous clay cap, diameter 2½ ins., Fig. 630 ... ... **8/0**

No. 632. Cup of ebonite, with a spiral of platinum wire to make contact, Fig. 632 ... ... **10/0**

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 ... **12/0**

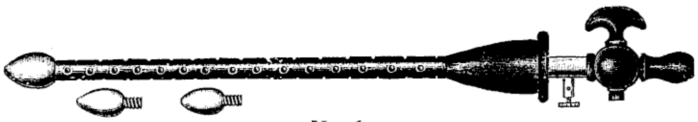


No. 640.

No. 642.

No. 640. Glass electrode, Fig. 640, with carbon rod and three different terminals, for treating ringworm, alopecia areata, etc. **£2 15 0**

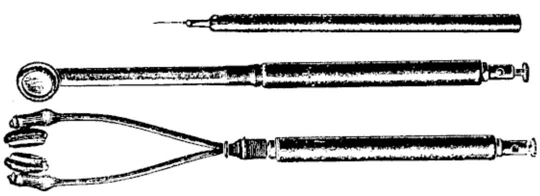
No. 642. Dr. Meissner's double electrode, diameter 2 ins., Fig. 642 **16/0**



No. 645.

No. 645. Cataphoresis electrode for the urethra, Fig. 645 ... ... **18/0**

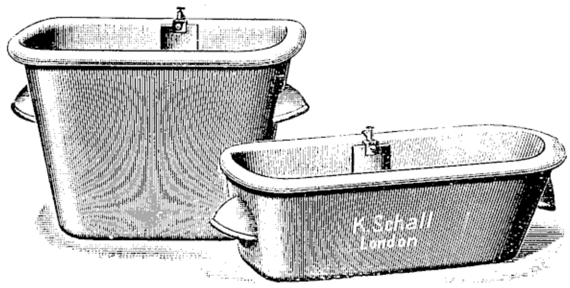
647.
648.
649



No. 647. Ebonite electrode, with platinum point, for dental cataphoresis, Fig. 647 **7/0**

No. 648. Cup electrode, for dental cataphoresis, Fig. 648 ... **9/0**

No. 649. Double cup, for dental cataphoresis, Fig. 649 ... ... **15/0**



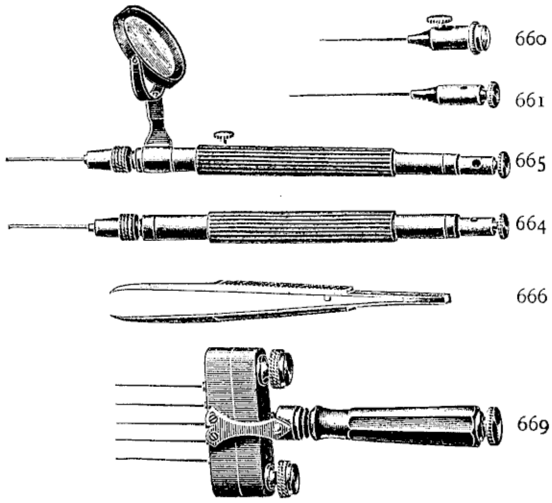
No. 652 No. 651.

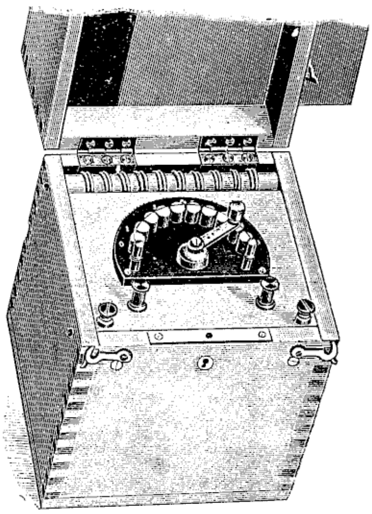
No. 651.	Large porcelain tub, for an arm bath, with carbon electrode, Fig. 651	£1 1 0
No. 652.	Large porcelain tub, for a foot bath, with carbon electrode, Fig. 652	1 6 0

These tubs are convenient for the treatment of gout, etc., by means of cataphoresis. The drugs are added to the water and introduced through the skin by means of cataphoresis.

ELECTRODES FOR ELECTROLYSIS AND FOR THE TREATMENT OF STRICTURES.

Needles for removing hairs, nævi, and small tumours.



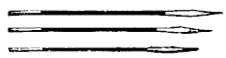


No. 675.

No. 660.	Steel needle with terminal, Fig. 660	1/6
No. 661.	Platinum needle with terminal, Fig. 661	2/6
No. 662.	Gold needle	3/0
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...	6/0
No. 664.	Needle holder for the reception of different needles, Fig. 664	4/0
No. 665.	Needle holder with interrupter ... ... „ 665	4/6
No. 666.	Forceps for epilation ... ... „ 666	2/6
No. 668.	25 steel needles (No. 12)	0/6
No. 669.	Dr. Lewis Jones multiple bipolar needle holder, for treatment of nævi, Fig. 669...	15/0

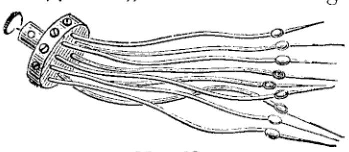
No. 675. Complete set for epilation, consisting of 9-cell battery with collector inserting the cells one by one (see Fig. 675), bracelet electrode No. 412, needle holder No. 664, forceps No. 666, a packet of needles and connecting wires **£3 6 0**
Explicit directions for use are sent with this outfit.

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



Nos. 676—679.

No. 676.	Needle, 1 inch long...	**3/0**	No. 678.	Needle, 3 inches long...	**4/0**
No. 677.	,, 2 inches long	**3/6**	No. 679.	,, 4 ,, ,, ...	**4/6**



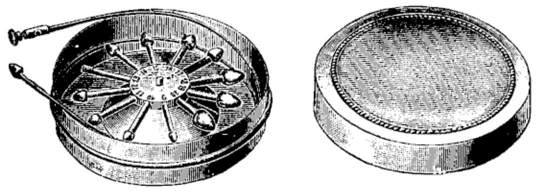
No. 680.

No. 695.

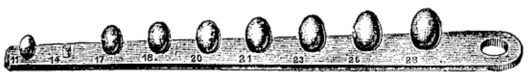
No. 680. Electrode, holding 12 steel needles, Fig. 680 ... ... **8/0**
No. 682. Electrode, holding 12 platinum needles **16/0**
No. 695. Voltolini's double needles, Fig. 695 ... ... **3/3**

No. 710.

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

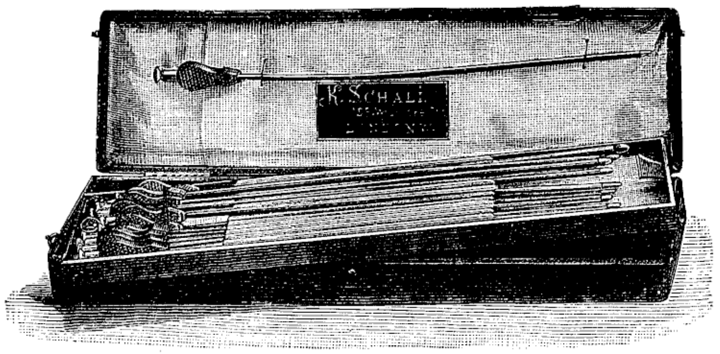


No. 713.



No. 712.

No. 712. The same with 12 slides, of various sizes, Fig. 712 ... ... **15/0**
No. 713. Similar electrode, very flexible, in metal case, Fig. 713 ... **16/0**



No. 715.

No. 715. Complete set of 12 urethral electrodes, in case, Fig. 715 **£3 0 0**

No. 730. Electrode for electrolysis of the Eustachian tube **12/6**

No. 735. Electrode for electrolysis of the lachrymal duct, with blunt platinum top, Fig. 735... **10/6**

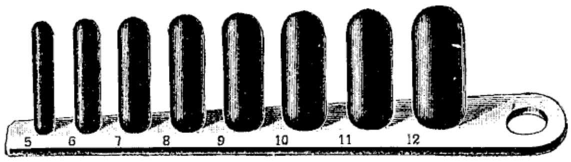
No. 735.

No. 740. Bougie electrode, with 12 heads of various sizes, for the treatment of strictures of the rectum **18/6**

ELECTRODES FOR THE TREATMENT OF UTERINE FIBROIDS, ETC.

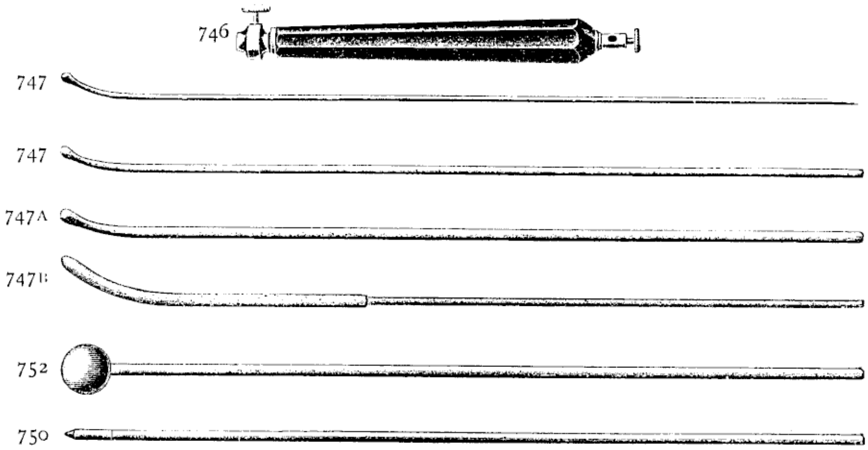
No. 745.

No. 745. Dr. Apostoli's carbon electrodes, Fig. 745 ... ... **8/0**



No. 745A.

No. 745A. Similar electrodes, but with a set of 8 carbon cylinders of various diameters, Fig. 745A **£1 0 0**

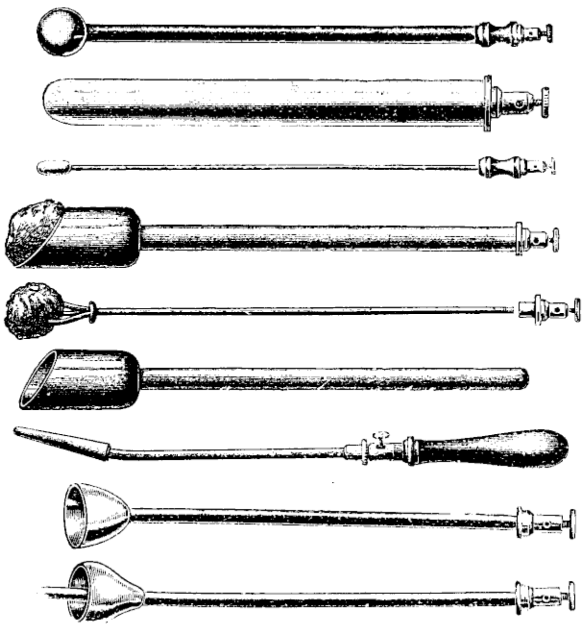


No. 746. Handle for the reception of uterine sounds, Fig. 746 ...**£0 7 0**
No. 747. Prof. Engelmann's aluminium sound, Fig. 747 ... ... **0 2 6**
No. 747A. Dr. Apostoli's sound, of silver, Fig. 747A **0 9 0**
No. 747B. Prof. Engelmann's sound, of aluminium, Fig. 747B ... **0 2 9**
No. 748. Dr. Apostoli's platinum sound, with handle and 3 insulators of different lengths **7 10 0**
No. 749. Dr. Apostoli's sound, consisting of a copper wire 2·7 mm. thick, over this is drawn a tube of pure platinum—the walls of this tube are 0·3 mm. thick—the ends of the tube are also of pure platinum. Price, including handle and insulator **3 15 0**

We guarantee that this sound will wear exactly as well as No. 748.

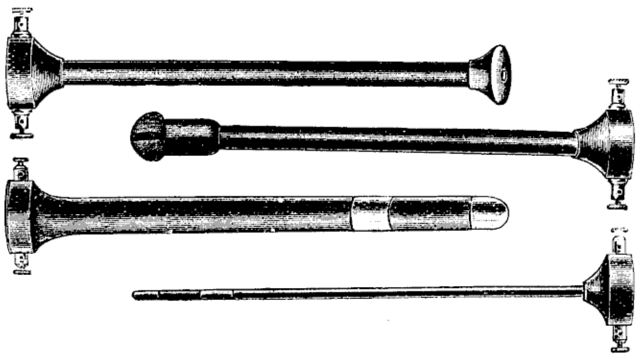
No. 750. Steel trocars, Fig. 750 ... ... each 2/6
No. 752. Prof. Engelmann's ball electrode, Fig. 752 ... ... 4/0

No. 755.
No. 757.
No. 760.
No. 764.
No. 764.
No. 764.
No. 766.
No. 768.
No. 769.



No. 755.	Vaginal electrode, with nickel-plated ball on insulated stem, Fig. 755		£0	5	0
No. 757.	Vaginal electrode, Fig. 757		0	4	6
No. 760.	Uterine electrode, Fig. 760		0	4	6
No. 764.	Dr. Gueron's electrode for uterus, with separate sponge carrier, Fig. 764		0	12	6
No. 766.	Dr. Richter's electrode for uterus, with conical metal electrode 3 ins. long, on insulated stem, Fig. 766 ...		0	10	6
No. 768.	Cup shaped electrode for uterus, Fig. 768		0	10	0
No. 769.	Similar electrode, with central pin projecting, Fig. 769 ...		0	12	0
No. 780.	Dr. Milne Murray's electrode for uterine fibroids		2	15	0

No. 785.
No. 787.
No. 789.
No. 790.



No. 785. Dr. Apostoli's double concentric disc electrode, Fig. 785 ... 12/6
No. 787 Ditto ditto ditto Fig. 787 ... 13/6

No. 789. Dr. Apostoli's double vaginal electrode, Fig. 789 ... ... **15/0**
No. 790. ,, ,, electrode for the urethra and uterus, Fig. 790 ... ... **10/6**

(The electrodes Nos. 785—790 are intended for the localization of galvanic and faradic currents.)

No. 795. Tin Plate, with connecting cord, to be used with potter's clay **6/0**

(See also Electrodes Nos. 510 and 525.)

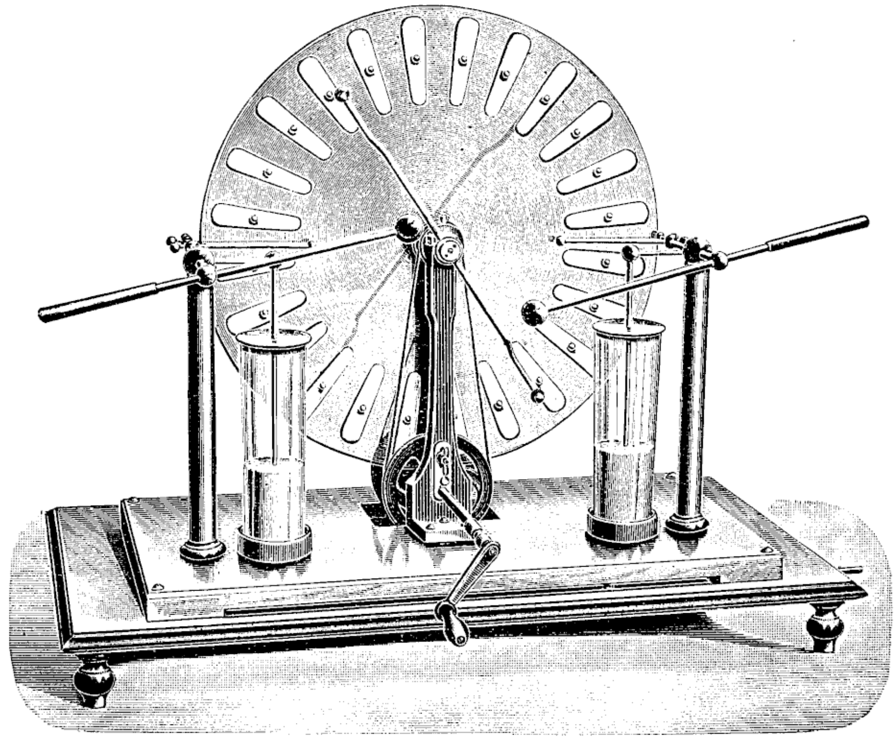
APPARATUS FOR FRANKLINISATION.

(Static Electricity. See also pages 44—45.)

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

WIMSHURST MACHINES.

No. 800.	Two plates, diameter 16 inches	**£7**	**15**	**0**
No. 801.	,, ,, $20\frac{1}{2}$,, ...	**9**	**0**	**0**
No. 802.	,, ,, $24\frac{1}{2}$,, ...	**11**	**0**	**0**

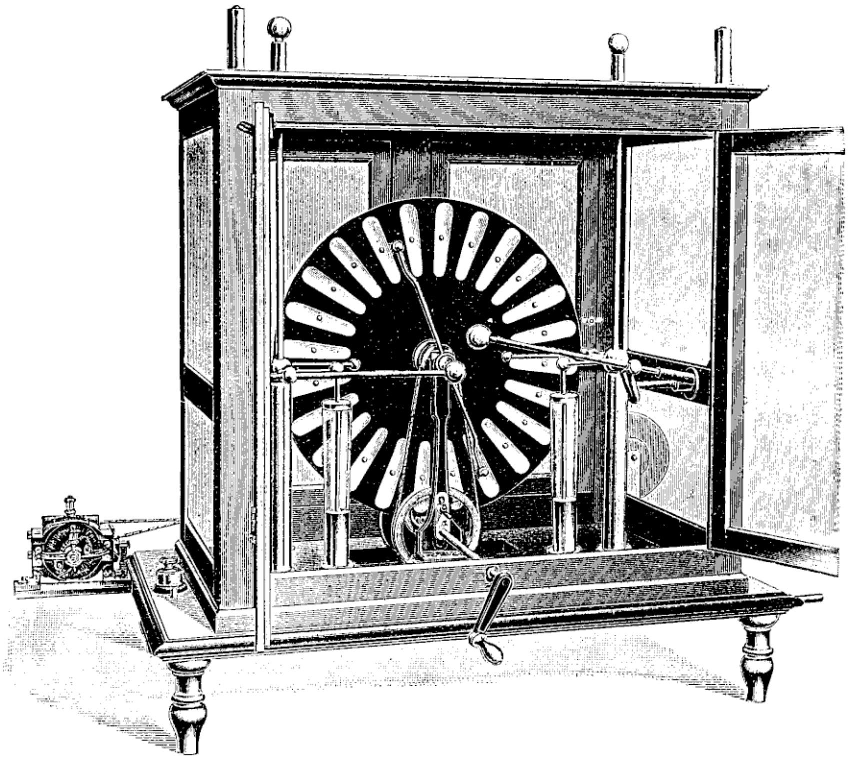


No. 806.

Machines of best quality and finish.

No. 806.	Two plates, diameter $20\frac{1}{2}$ inches, Fig. 806	**£12**	**0**	**0**
No. 807.	Four ,, ,, $20\frac{1}{2}$,, ...	**18**	**10**	**0**

No. 809.	Wimshurst machine with four plates of 20½ inch diameter, best quality, in polished glass case, with space and transmission for electric motor, and arrangement for regulating the spark length, Fig. 809	£27 0 0



No. 809.

No. 820.	Large Wimshurst machine, on polished mahogany, walnut or oak board, with 8 glass plates of 30 in. diameter ...	£47 0 0
No. 821.	Similar machine, with ebonite plates instead of glass plates	54 0 0
No. 824.	Large Wimshurst machine, with 12 glass plates of 30 in. diameter	65 0 0
No. 825.	Similar machine, with ebonite plates instead of glass plates	76 0 0
No. 828.	Large Wimshurst machine, with 8 glass plates of 36 in. diameter	62 0 0
No. 829.	Similar machine, with ebonite plates	68 0 0

No. 832. Large Wimshurst machine, with 12 glass plates of 36 in. diameter £84 0 0

No. 833. Similar machine, with ebonite plates 92 0 0

Best quality glass case, with polished mahogany frame, for machines Nos. 820 and 821 ... ... 10 10 0

Best quality glass case, with polished mahogany frame, for machines Nos. 824—829 ... ... 15 0 0

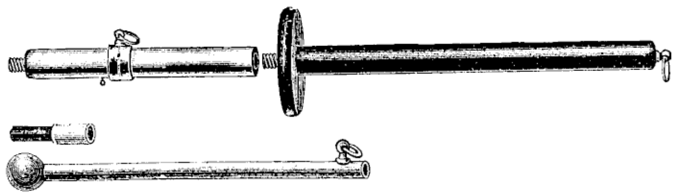
Best quality glass case, with polished mahogany frame, for machines Nos. 832 and 833 ... ... 17 0 0

¼-H.P. continuous current motor, with rheostat and pulleys, for machines Nos. 820—829 ... ... 18 0 0

½-H.P. continuous current motor, with rheostat and pulleys, for machines Nos. 832 and 833 ... ... 25 0 0

No. 870. Electrode, with wooden ball or wooden point 0 8 6

No. 871. ,, with metal ball or metal point 0 8 6



No. 875. Large insulating platform, to put a chair on £2 5 0

No. 879. Multiple point electrode, Fig. 879, page 156 ... ... 0 18 0

No. 880. Bowl for the head 2 10 0

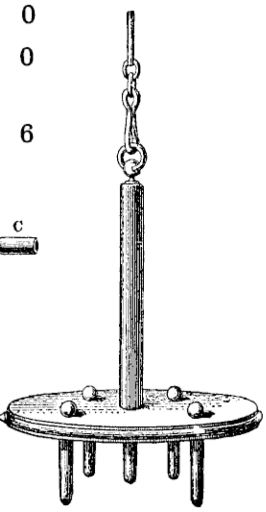
No. 882. Ozone apparatus £1 6 0

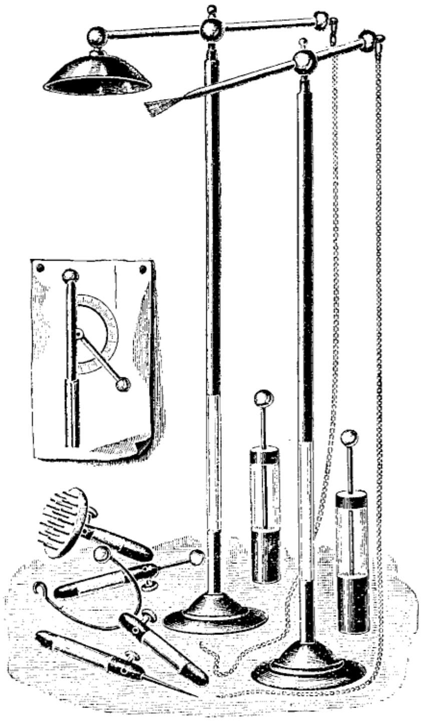
No. 883. Ozone inhaler, Fig. 883, page 156 1 5 0

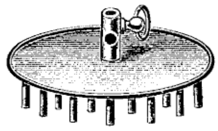
No. 885. Insulated cable, with balls at the ends ... ... per yard 0 6 6

No. 889. Glass tube, with two movable balls for regulating the length of the sparks, Fig. 889 £1 1 0

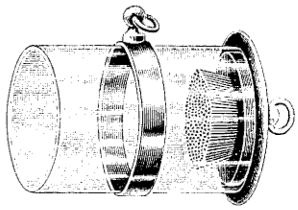
No. 889.







No. 879.



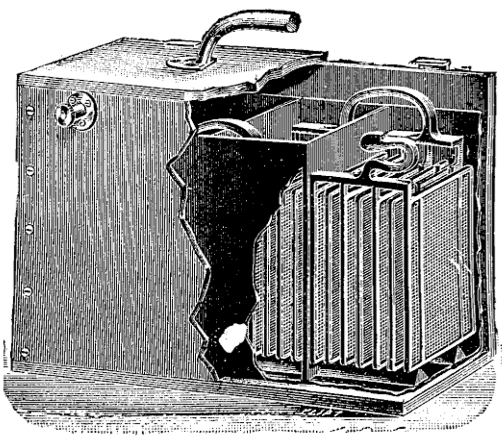
No. 883.

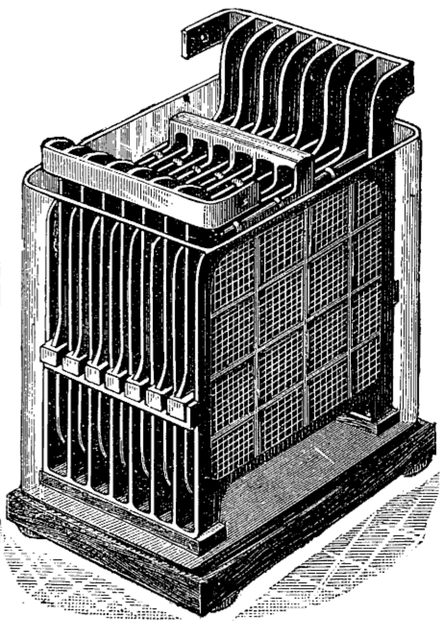
No. 896. Leyden jars according to size ... **6/-** to **£1 1 0**

For Electro Motors for driving static machines, see also No. 1778.

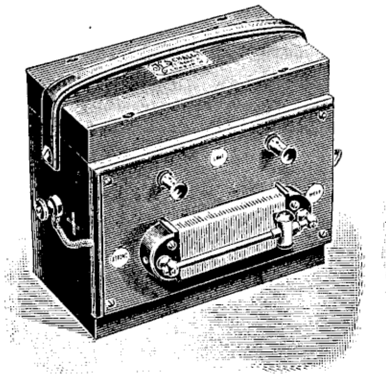
ACCUMULATORS.

(See also pages 28—31.)

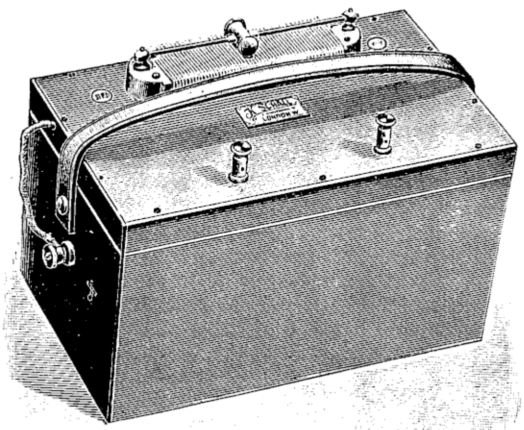




	No.	Capacity in ampère hours.	Charge or discharge.	Weight.	Price charged.
Single cells in lead-lined Teak Cases.	907	14	3 ampères	9 lbs.	£0 12 6
	908	21	5 ,,	11 ,,	0 14 0
	910	35	8 ,,	17 ,,	0 17 0
	911	50	15 ,,	22 ,,	1 0 0
	912	70	20 ,,	30 ,,	1 6 0



No. 916.



No. 922.

No. 916. 8-Volt accumulator, for surgical lamps only, capacity 15 ampère hours, in polished mahogany case, **with rheostat**, Fig. 916 ... ... **£3 0 0**

Size $4\frac{1}{2} \times 8\frac{1}{2} \times 6$ in., weight 15 lbs.

No. 918. 12-Volt accumulator, for surgical motors or surgical or reading lamps, capacity 21 ampère hours, in polished walnut case, **with rheostat** **5 0 0**

Size $4\frac{1}{2} \times 16 \times 6$ in., weight 30 lbs.

No. 921. 4-Volt accumulator, for cautery burners, capacity 45 ampère hours, in polished walnut case, **with rheostat** **3 10 0**

Size $7\frac{1}{2} \times 7 \times 6\frac{1}{2}$ in., weight 24 lbs.

No. 922. 8-Volt accumulator, for cautery or surgical lamps, capacity 45 ampère hours, in polished walnut case, **with rheostat**, Fig. 922 ... ... **5 12 0**

Size $7\frac{1}{2} \times 12 \times 7$ in., weight 45 lbs.

No. 923. 12-Volt accumulator, for surgical motors, spark coils, cautery, or surgical lamps, capacity 45 ampère hours, in polished walnut case, **with rheostat** **7 12 0**

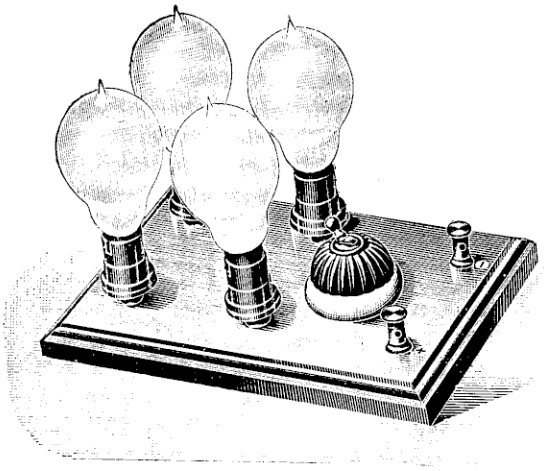
Size $7\frac{1}{2} \times 18\frac{1}{2} \times 6\frac{1}{2}$ in., weight 60 lbs.

No. 925. 12-Volt accumulator, in teak case, capacity 50 ampère hours, **without rheostat** **6 0 0**

Other sizes can be made to order.

RESISTANCES FOR CHARGING ACCUMULATORS FROM THE MAINS.

No. 950.



No. 952.

No. 950. Resistance lamp holder, with terminals for connection with accumulators, Fig. 950 ... ... £0 9 0

This Lamp Holder is inserted into an ordinary Edison lamp holder, and is suitable for lamps up to 60 candle-power (2 ampères) on a 100-volt supply, or 1 ampère on a 200-volt supply. The poles are ascertained by means of pole-finding paper.

No. 952. Board with 4 lamp holders, switch, fuse and terminals to connect with accumulators, Fig. 952 ... ... 1 10 0

This board is suitable for currents up to 8 ampères on a 100-volt supply, or 4 ampères on a 200-volt supply.

No. 954. Similar board, with 8 lamp holders 2 0 0

Suitable up to 16 ampères with 100 volts, or 8 ampères with 200 volts.

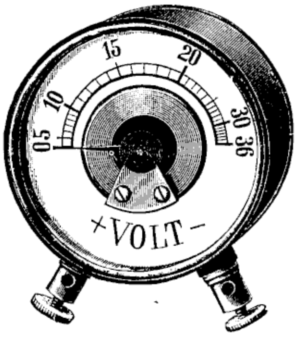
No. 958. Book with pole-finding paper 0 1 6

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

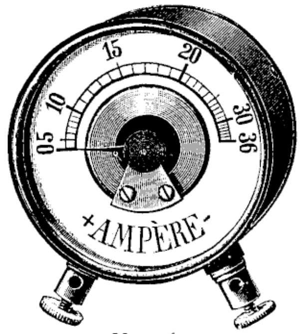
Litmus paper may also be used. The positive pole makes a red mark on litmus paper, and the negative pole a blue mark.

VOLTMETERS, AMPÈREMETERS.

ELECTRO-MAGNETIC VOLTMETERS AND AMPÈREMETERS.



No. 960.



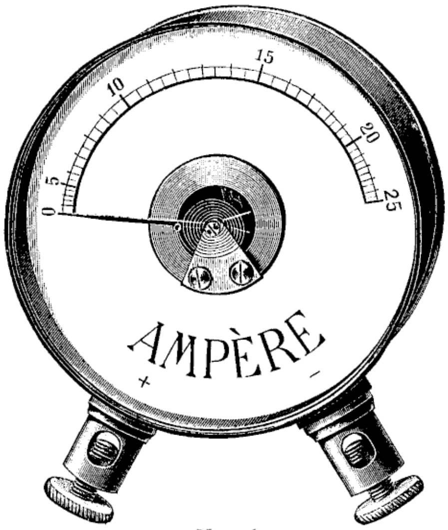
No. 962.

No. 960. Voltmeter, Fig. 960, diameter 2 in.

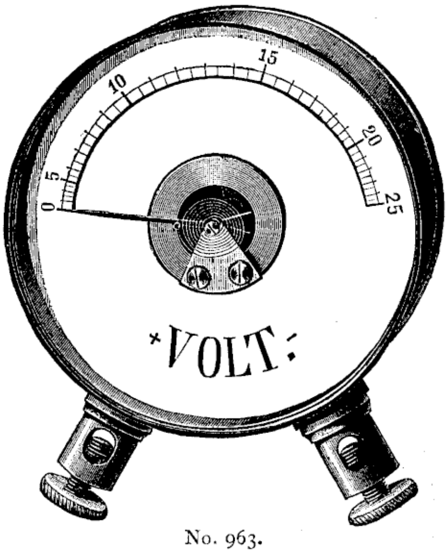
Reading from	0·5 to 3	3 to 10	5 to 30	10 to 50 volts.
	24/-	**24/-**	**24/-**	**26/-**

No. 962. Ampèremeter, Fig. 962, diameter 2 in.

Reading from	0 to 2	0 to 10	0 to 20 ampères.
	25/-	**25/-**	**25/-**



No. 964.



No. 963.

No. 963. Voltmeter, Fig. 963, diameter 4 in.

Reading from	0·5 to 3	3 to 10	5 to 20	10 to 50	20 to 100 volts.
	28/-	**28/-**	**28/-**	**30/-**	**32/-**

No. 964. Ampèremeter, Fig. 964, diameter 4 in.

Reading from	0 to 2	0 to 10	0 to 20	0 to 50 ampères.
	28/-	**28/-**	**28/-**	**30/-**

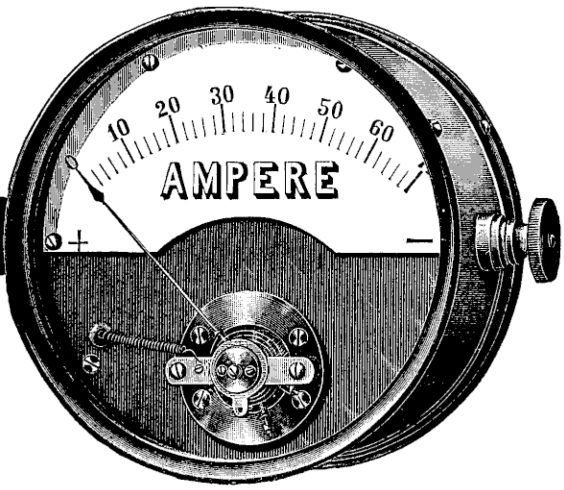
The instruments Nos. 960—964 can be used with continuous or alternating current, but if they are intended for an alternating current please mention when ordering.

Dead beat Volt and Ampère Meters of highest accuracy.

The construction of these instruments was originally invented by Lord Kelvin, and modified afterwards by d'Arsonval. They are not affected by magnetic or electrical fields close by, they are dead beat, and the divisions on the scale are even—for instance, in an instrument divided up to 100 volts the distance between 0 and 10 volts or 90 and 100 volts is just as great as that between 40 and 50 volts in the centre of the scale.

No. 968. Voltmeter, diameter 4¼ in. (similar to Fig. 969).

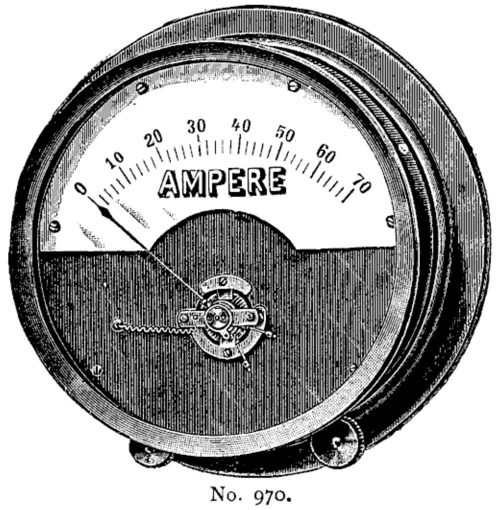
Reading up to	5	12	30	70	100	170 volts.
	£3	**£3**	**£3**	**£3**	**£3/3**	**£3/10**



No. 969.

No. 969. Ampèremeter, Fig. 969, diameter 4¼ in.

Reading up to	1	3	10	15	25	50 ampères.
	£3/10	**£3/10**	**£3/10**	**£3/10**	**£3/10**	**£3/10**



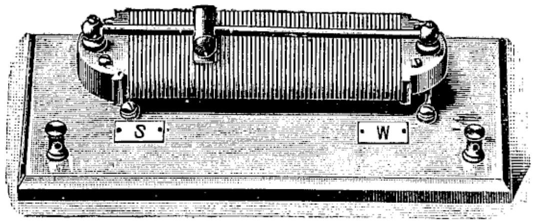
No. 970.

The instruments can also be made as shown in Fig. 970 for larger switchboards. The diameter is 6 inches. The prices of the voltmeters are £3 12s., and the ampèremeters, £4.

The instruments can also be so arranged that 0 is in the centre of the scale, and that the needle deflects either to the right or to the left to indicate the direction of the current. The prices are increased thereby by 10/- for each instrument.

For **Milliampère Meters,** see Nos. 264–299, pages 136–138.

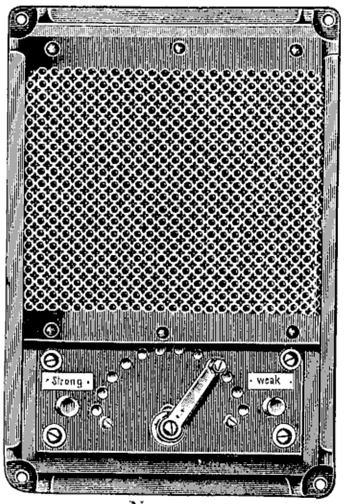
RHEOSTATS FOR ACCUMULATORS, BICHROMATE BATTERIES, ETC.



No. 980.

No. 980.	Rheostat wound on slate core, and mounted on polished mahogany board with two terminals, Fig. 980, resistance 30 ohms, suitable for surgical lamps requiring not more than 2·0 ampères	£1	0	0
No. 981.	Similar Rheostat, resistance 10 ohms, suitable for lamps and motors requiring not more than 8 ampères ...	1	0	0
No. 983.	Similar Rheostat, 9½ inches long, resistance about 0·8 ohm, for cautery burners and spark coils, requiring up to 20 ampères	1	5	0
No. 985.	Similar Rheostat, 14 inches long, total resistance about 1·0 ohm, suitable for cautery burners and spark coils requiring up to 30 ampères	2	10	0

Other sizes, or a combination of several of these rheostats on a board with switch, fuse, terminals, ampèremeter, voltmeter, etc., can be made to order.



No. 995.

No. 995. Rheostat in iron frame, with crank, Fig. 995, for motors, lamps, etc. £2 0 0

For rheostats for galvanisation, etc., see also Nos. 306–328 and 1820–1850.

For rheostats for spark coils, see also Nos. 2670 and 2671.

For rheostats for cautery, etc., see also Nos. 2000–2050.

M

BICHROMATE BATTERIES FOR GALVANIC CAUTERY & FOR WORKING SPARK COILS.

(See also pages 23—28.)

*The batteries marked * may also be used for lighting surgical lamps and driving surgical motors.*

The batteries marked † may also be used for working spark coils.

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 exciting spark coils.

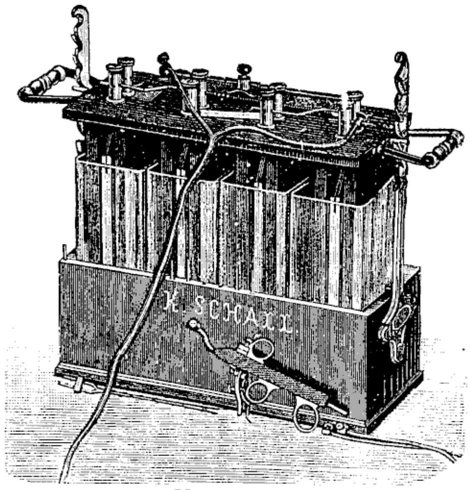
SIMPLE BATTERIES,

IN OAK CASE, FOR HOSPITALS, &c.

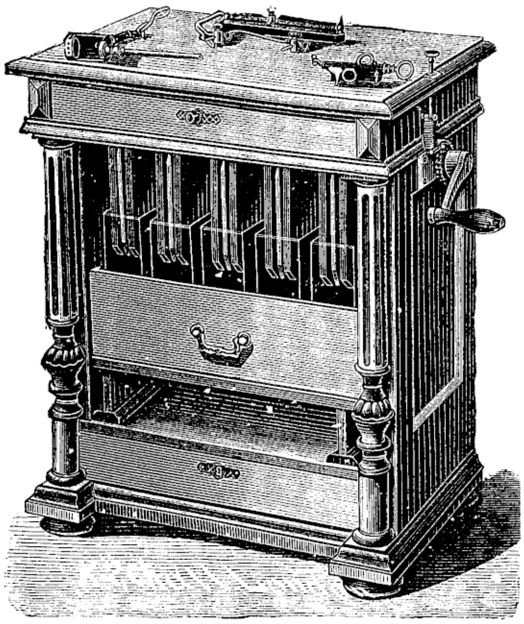
Each cell gives a current of over 30 ampères.

No. 1000.	2 cells	.	£3 0 0
*No. 1001.	4 ,,	.	4 0 0
†*No. 1003.	8 ,,	.	6 10 0
†*No. 1004.	12 ,,	.	8 10 0

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



No. 1001.



No. 1010.

LARGE BATTERIES,

FOR SPECIALISTS OF THROAT, NOSE, ETC., DISEASES, AND HOSPITALS.

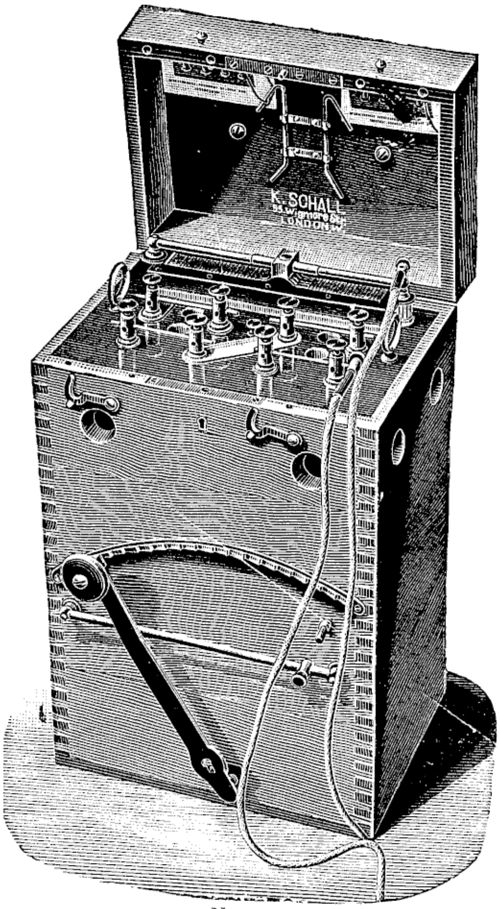
IN OAK CASE, with rheostat and cords.

†*No. 1009.	10 cells	£18 10 0
†*No. 1010.	12 ,,	21 0 0

Spare zincs for batteries Nos. 1000—1010, consisting of 11 parts pure zinc, and 1 part of mercury, weight 2 lbs. 4 oz. . 2/6 each.

One pair of spare carbons, 6/0 each.

Spare glasses 1/9 ,,



No. 1040.

SCHALL'S PORTABLE CAUTERY BATTERY,

IN OAK CASE, with rheostat and cords.

*No. 1040. 4 cells, $7 \times 9\frac{1}{2} \times 15$ inches. Weight, 24 lbs., Fig. 1040 ... ... **£5 10 0**

†*No. 1042. 6 cells... **7 15 0**

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

There are now about 800 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., as long as not more than about 10 milliampères are required, or when both poles (needles) are introduced through the skin.

The acid for the batteries Nos. 1040 and 1042 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. If the battery is used several times every day, refilling is necessary about every four weeks, but if it

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 day's illness"—unlike most electrical plant.

Yours faithfully,
John K. Murray.

Whittlesea, Cape Colony.

is used only now and then, refilling is necessary every three months. There is little danger of any acid being spilled in carrying the batteries, as perforated plates float on the acid and prevent its splashing over. In plunging the battery in, the perforated plate is pressed down to the bottom of the ebonite vessel, and rises again to the surface as soon as the elements are removed from the acid.

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	**2/6**
One pair of carbons	„	**6/0**
Ebonite vessel for 4-cell battery	„	**15/6**
Ditto do 6-cell do	„	**21/0**
Acid, ready mixed, for charging the batteries Nos. 1000—1042	per gall.	**3/0**

Accumulators for cautery and spark coils will be found on page 157. Rheostats and Transformers for utilizing the currents from Dynamos for cautery and spark coils will be found on pages 215-222.

We have supplied Batteries Nos. 1040 and 1042, amongst many others, to the following hospitals and medical men :—

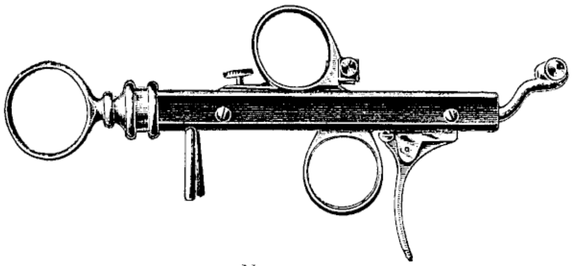
St. Bartholomew's, Charing Cross, Guy's, St. Peter's, St. Thomas's, Great Northern, London, St. Mary's, and Westminster Hospitals ; Lock Hospital, Soho Square ; Hospital for Diseases of the Heart and Paralysis, German Hospital, Victoria Hospital for Children, Central London Ophthalmic and Queen's Jubilee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

A. Anderson, G. W. Anderson, A. W. Addinsell, H. T. Butlin, Buckstone Brown, S. Beauchamp, W. Bull, G. A. Critchett, Bruce Clarke, T. H. Clarke, R. Clarke, C. Cripps, A. W. Clemow, G. Caley, E. Curwen, M. Collier, Stretch Dowse, E. H. Ezard, S. Edwards, H. Fenwick, E. A. Fletcher, J. E. Foster, W. Fearnley, Gage-Brown, W. S. A. Griffith, H. T. Griffiths, W. Groome, S. Grubb, F. de Havilland Hall, Reginald Harrison, H. Hetley, W. S. Hedley, Sir Victor Horsley, T. Hutchinson, W. R. Holmes, L. Hudson, T. S. Harvey, G. Herschell, Lewis Jones, C. James, H. J. Johnson, W. H. Kelson, T. E. Lane, H. Lack, Malcolm Morris, H. W. Mackenzie, T. Macgregor, R. Owen, F. B. O'Connor, H. Oppenheimer, S. Paget, B. Pollard, L. H. Pegler, C. A. Parker, T. H. Prangley, Pepperdene, John J. Pollard, Prof. W. Rose, R. Rushworth, A. Routh, T. B. Ryley, F. A. Richardson, D. Roberts, C. Symmonds, R. J. A. Swan, G. Stoker, A. M. Shield, T. B. Smith, W. R. Stewart, Dr. Shearer, Dr. Stoker, Sir Henry Thompson, M. Tuchmann, G. L. Thomson, H. A. des Voeux, O. Ward, E. B. Waggett, G. L. Wilkin, P. Whitcombe, C. Williams, R. H. Wilbe, H. F. Waterhouse, etc., London, and over 600 doctors in the Provinces and the Colonies.

INSTRUMENTS FOR GALVANIC CAUTERY.

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

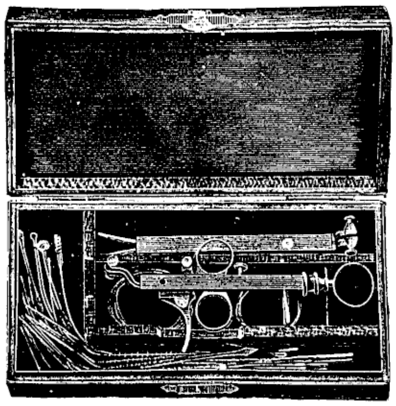


No. 1100.

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

No. 1101.

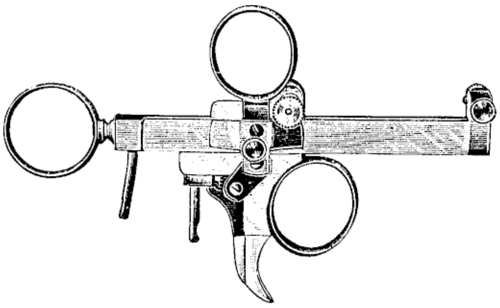
No. 1101. Simple Handle, by Dr. Schech, Fig. 1101 ... ... £0 15 0



No. 1104.

No. 1103. Schech's Handles are mostly used. The price of a case containing Universal Handle, six different burners, two ligature tubes and one porcelain burner, platinum wire for one loop, and steel wire for twelve loops is £3 0 0

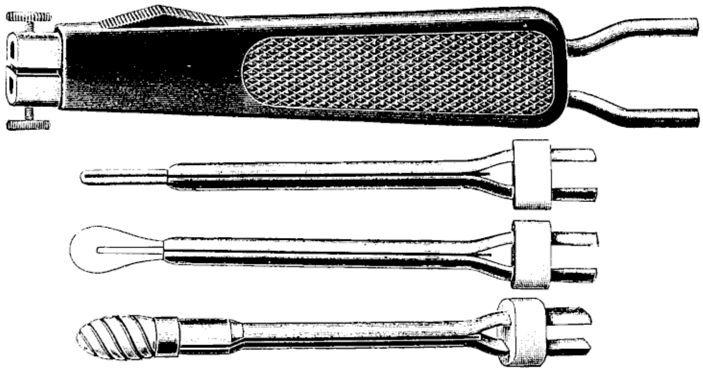
No. 1104. Schech's Universal Handle and Simple Handle, with ten platinum burners, two ligature tubes, two porcelain burners, platinum and steel wire, in case, Fig. 1104 ... £4 4 0



No. 1112.

No. 1112.
Universal Handle,
by Dr. Kuttner.
Fig. 1112 ... £1 14 0

No. 1114.

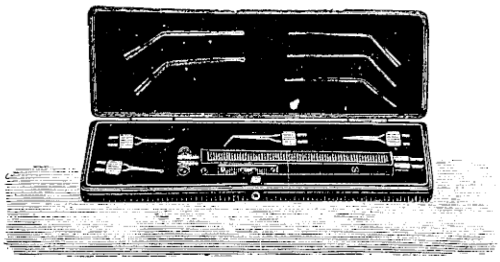


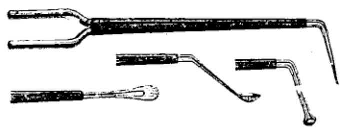
No. 1114. Cautery handle, Fig. 1114, suitable for burners requiring up to 40 ampères (for gynæcological operations)... £1 0 0

Point or knife-shaped platinum burners for this handle (see illustration) ... ... each 0 15 0

Porcelain burner (see illustration) 0 18 0

One pair of extra stout cables for handle No. 1114 ... 0 12 0





No. 1117.

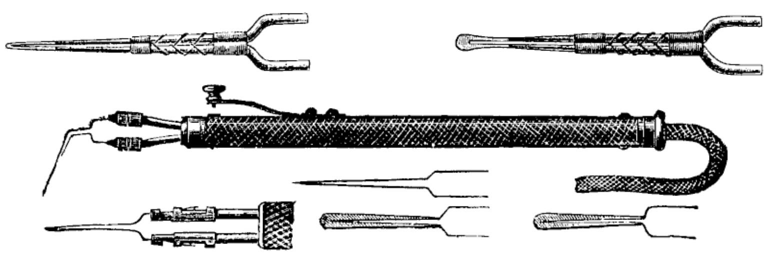
No. 1116.

No. 1116. Handle for eye operations, with five burners, in case, by Prof. Sattler-Nieden, Fig. 1116 ... ... £1 5 0

No. 1117. The same instrument, with five additional burners for the ear, Fig. 1117 ... ... 1 15 0

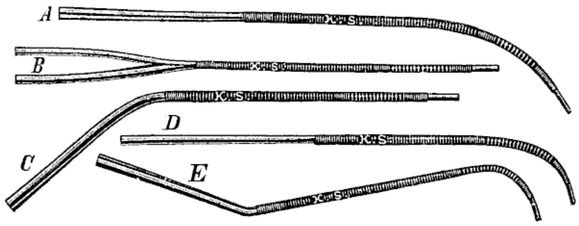
No. 1118.

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



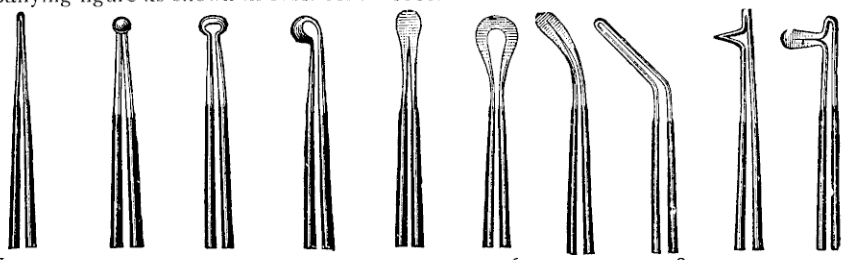
No. 1119.

No. 1119. Handle for dental, etc., purposes, with five burners, in case, Fig. 1119 ... ... £1 10 0

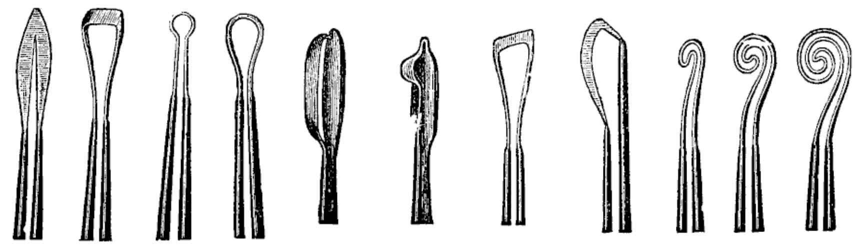


Shape and description of the ordinary curves of burners and ligature tubes. The length is 4, 6, or 8 inches, as desired. Other curves or burners can be made to order.

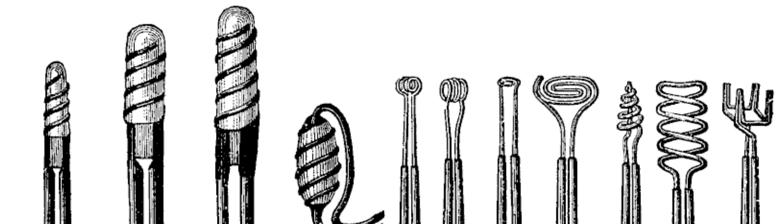
In ordering, please state the desired length in inches, and for the curve quote the capital letter printed by the side, and the form of the platinum, with its accompanying figure as shown in Nos. 1120—1161.



Nos. 1120 1121 1122 1123 1125 1126 1127 1128 1129 1130



Nos. 1131 1132 1133 1133A 1134 1135 1136 1137 1140 1141 1142



Nos. 1150 1151 1152 1153 1155 1156 1157 1158 1159 1160 1161

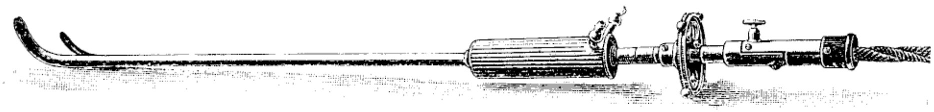
Shape and numbers of the burners: Nos. 1120—1142 platinum, 1150—1153 porcelain, 1155—1161 platinum.

Prices of the burners: Nos. 1120—1137, 3/-; 1140—1152, 4/9; 1155—1161, 5/3; ligature tubes, 3/-.

If desired, an alloy of platinum and iridium can be used for the burners instead of pure platinum. The alloy remains stiff and hard, whereas pure platinum gets soft after it has been incandescent. The burners 1120—1142 require 15 to 18 ampères and 6 to 12 volts. The eye and ear burners require only 8 to 10 ampères.

Nos. 1120, 1122, 1123, 1125, 1133 and 1150, are the most frequently used shapes of burners, and if not otherwise ordered, these shapes only—some straight for nose, etc., and some bent for the larynx—will be used for the sets Nos. 1103 and 1104.

Platinum wire for one large loop	£0	3	6
Steel wire, 0·3 or 0·4 millimetre thick, for six loops	0	1	0
Cases for cautery instruments	0	4	0



No. 1175.

No. 1175. Bottini-Freudenberg's instrument for burning the prostate **£5 10 0**

(As supplied to Mr. Bruce Clarke, Mr. Fenwick, and others.)

This instrument requires a current of 40 to 45 ampères.

No. 1179.

No. 1179. Dr. Mackenrodt's burner, with handle, Fig. 1179 ...**£3 0 0**

A platinum cup covers the porcelain burner. The instrument requires 20 ampères.

BATTERIES FOR ELECTRIC LIGHT.

(See also pages 31—35.)

In order to make the lamps, which are described on the following pages, incandescent, 8 to 12 volt batteries 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 56, and Nos. 2000—2067.

The most suitable batteries are **accumulators** (see pages 28—31 and Nos. 916—925), or **bichromate batteries** (see page 33 and Nos. 1001—1042, and 1192), or **dry Leclanché batteries** * (see page 33 and Nos. 1180—1188).

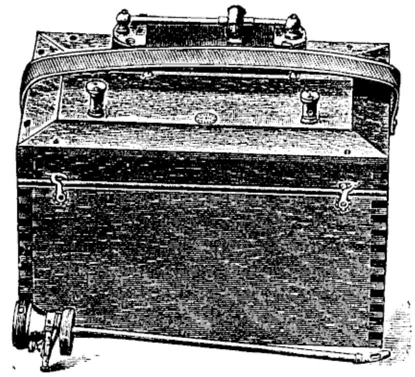
For the batteries we have stated approximately how many ampère hours the elements used in the batteries will yield, and for the instruments we have stated the average number of ampères required by the lamps. These two figures will help to find out how many hours a battery will keep a lamp incandescent before having to be re-charged. For instance, a battery fitted with cells of 10 ampère hours' capacity will keep a lamp requiring 0·5 ampère incandescent for 20 hours ; a lamp requiring 1 ampère for 10 hours ; a lamp requiring 1·5 ampère for 6·5 hours altogether ; in other words, if a lamp requiring 0·5 ampère is kept incandescent for *5 minutes daily*, and the cells of the battery have a capacity of 10 ampère hours, the battery will be exhausted, and want re-charging after about eight months.

* Extremely small dry batteries are now being extensively advertised for surgical lamps and other purposes. While new, these batteries give a good light for a short time, but as the amount of electricity to be obtained from a battery must be in direct proportion to the quantity of chemicals contained in the battery, it is obvious that these small batteries can last for a short time only. They are not suitable for any operation or examination lasting several minutes, and the cells have to be replaced by new ones after a few months already, *even if the batteries have not been used.* For this reason we do not consider them to be satisfactory for medical purposes.

Leclanché Dry Batteries for electric light, with rheostat and cords. (See also page 33.)

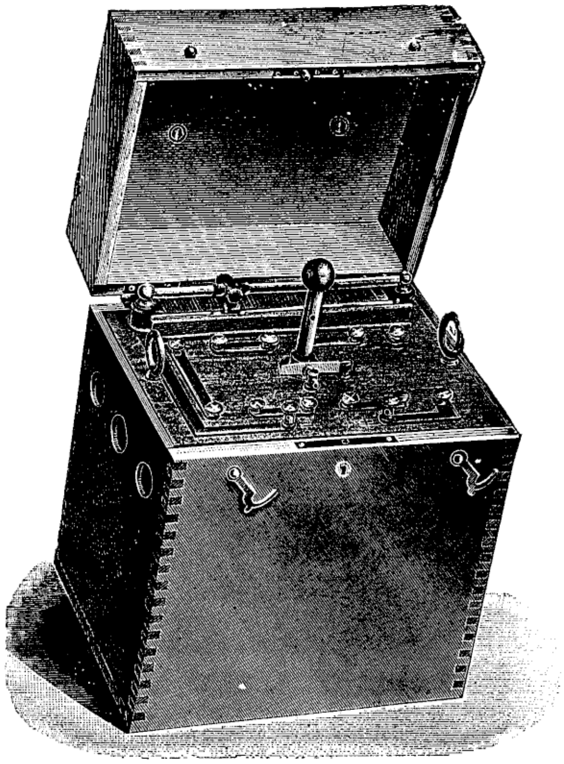
			Volts.	Capacity in amp. hours.	Weight.	
No. 1180.	6 cells,	4 × 5½ × 5½ inches	9	5	4 lbs.	£1 10 0
„ 1186.	8 „	6 × 9½ × 8 „	12	15	15 „	2 7 0
„ 1188.	8 „	6½ × 13 × 9 „	12	30	24 „	2 14 0

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
„ „ „	1186	„	0 2 6
„ „ „	1188	„	0 3 0



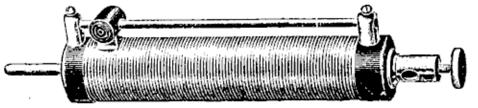
No. 1192.

No. 1192. 6 cell Bichromate Battery, with rheostat, for surgical lamps or surgical motors **£3 15 0**

This battery gives a *perfectly steady* light for 3 to 4 hours, and can be used for all lamps requiring between 4 and 11 volts and 0·4 to 1·5 ampères. Indiarubber floats prevent the spilling of the acid, and the battery can easily be recharged and kept in order for many years without the help of an electrician. It is specially useful for surgeons using incandescent lamps at irregular intervals, and for surgeons living abroad.

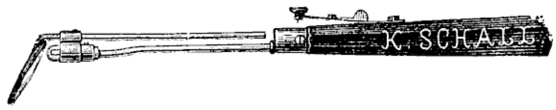
INSTRUMENTS FOR ELECTRIC LIGHT.

Where no special price is mentioned for spare lamps, it is **1/9** for ordinary, or **2/0** for the so-called "cold" lamps; the latter can be supplied for all the illuminating instruments mentioned below.



No. 1195.

No. 1195. Special rheostat for the "cold" 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 8 6**

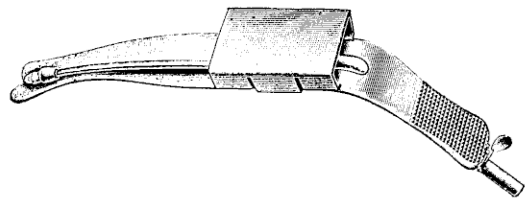


No. 1200.

No. 1200. **Laryngoscope,** by Dr. Semon, with case and one spare lamp, Fig. 1200 ... ... **£1 14 0**

The lamps require 7 to 11 volts and 0·6 ampère.

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.



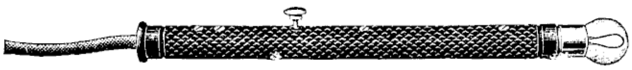
No. 1201.

No. 1201. Apparatus for examining the larynx directly, Fig. 1201. It consists of a tongue depressor and a "cold" lamp, which can be attached to it. Price, with spare lamp and case... ... ... **£2 0 0**

No. 1202.

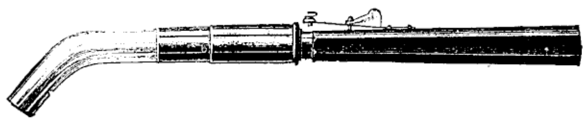
No. 1202. Salpingoscope or antroscope (Prof. Valentine's and Dr. Hirschmann's), Fig. 1202, for examining the posterior part of the nose, pharynx, the antrum of Highmore, etc. The diameter is 3·5 millimetres (No. 11 French gauge). It is provided with "cold" lamps, and can be used also as a cystoscope for small children... ... ... **£4 12 0**

Extra spare lamps, 3/9 each.



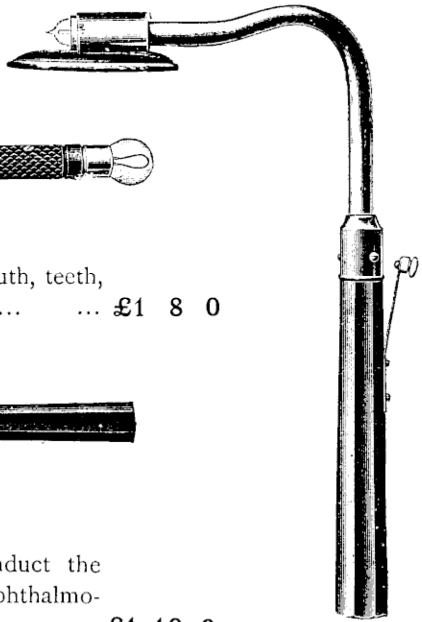
No. 1203.

No. 1203. Lamp for examining the mouth, teeth, etc., as shown in Fig. 1203 ... ... **£1 8 0**



No. 1204.

No. 1204. Lamp with glass rod to conduct the light without any heat, for ophthalmoscopic purposes, Fig. 1204 ... ... **£1 10 0**



No. 1205.

No. 1205. **Tongue depressor,** by Schall, with case and one spare lamp, Fig. 1205 ... ... **£1 15 0**

The lamps require 7 to 8 volts and 0·6 ampère.

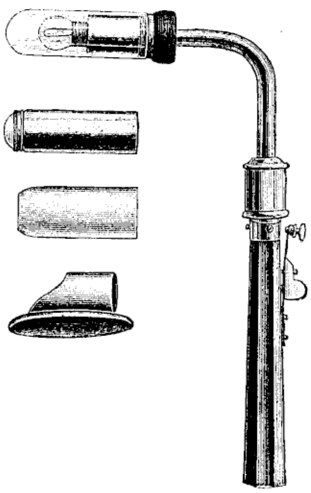
The ebonite spatula can be removed to be cleaned.

No. 1206. Similar instrument, but with larger lamps, for making the antrum transparent; the lamps give a light of about 4 candles **2 0 0**

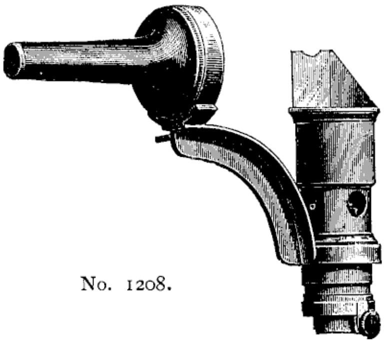
The lamps require 11 volts and 1 ampère.

No. 1207. Hand lamp, Fig. 1207 ... **£2 12 0**

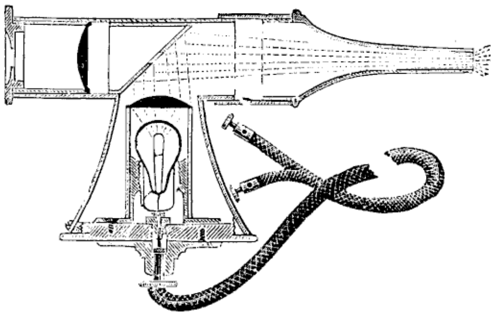
This lamp can be used as a hand lamp, or as a tongue depressor, or with a bull's-eye lens for making the antrum transparent.



No. 1207.



No. 1208.



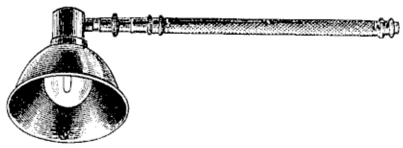
No. 1209.

No. 1208. Schall's **Otoscope,** fitted with incandescent lamp, case, spare lamp, and three ear funnels in case, Fig. 1208 ... **£2 15 0**
(Patent No. 1725, 1896.)

This instrument gives a very brilliant light, and allows perfectly free movement for the operating instruments.

No. 1209. Brunton's **Otoscope,** with electric lamp, spare lamp, and case, Fig. 1209 ... ... **£2 5 0**

No. 1210.



No. 1211.

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

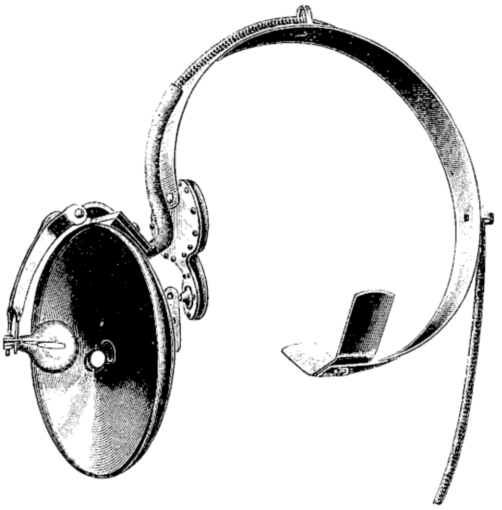
The lamp is carried on a spring, which can be clamped to any speculum. The lamps require 7 volts and 1 ampère.

No. 1211. **Hand lamp with platinized reflector,** for abdominal and other operations, in case, with one spare lamp, Fig. 1211 ... ... **£1 15 0**

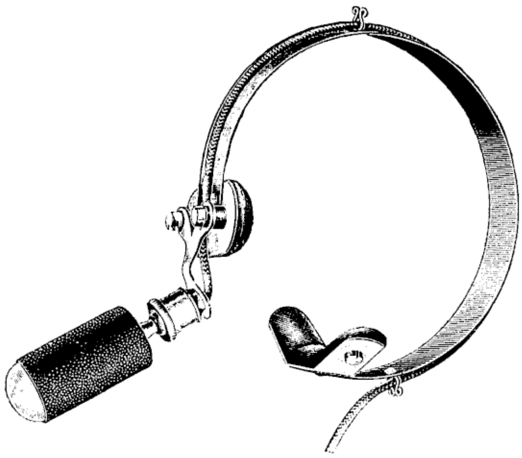
The lamps require 8 to 10 volts and 0·75 ampère.

No. 1212. Forehead lamp, with concave mirror and lamp, as shown in Fig. 1212, with case and spare lamp **£2 6 0**

The lamps require 8 volts and 1 ampère.



No. 1212.



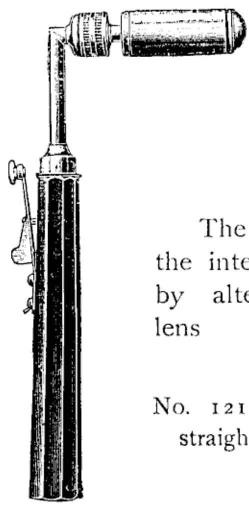
No. 1214. Forehead lamp, with steel band, spare lamp and case, Fig. 1214 **£1 14 0**

The lamps require 8 volts and 0·5 ampère.

Handle, to use No. 1216 as a hand lamp (similar to No. 1215), **9/6.**

No. 1214.

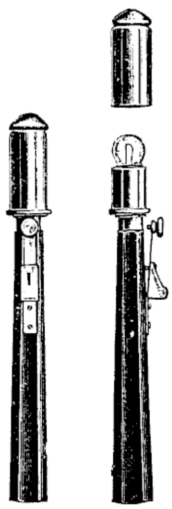
The lamps No. 1214 do not show a picture of the carbon filament; the light is bright and homogeneous. If the lens is pushed back as far as it will go, the illuminated area is large, and the light diffused; if it is drawn out the diameter gets smaller, but the light is more concentrated and intense. A parallel beam of light can be obtained with the lamp if desired.



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

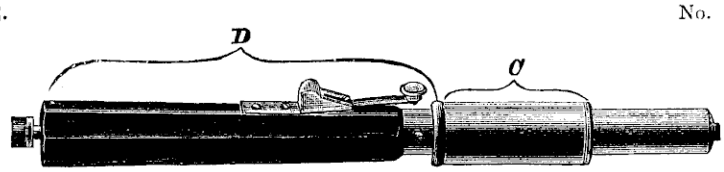
The diameter of the illuminated area and the intensity of the light can be regulated by altering the distance of lamp and lens

No. 1216. The same instrument, straight, Fig. 1216 ... ... **£1 16 0**



No. 1215.

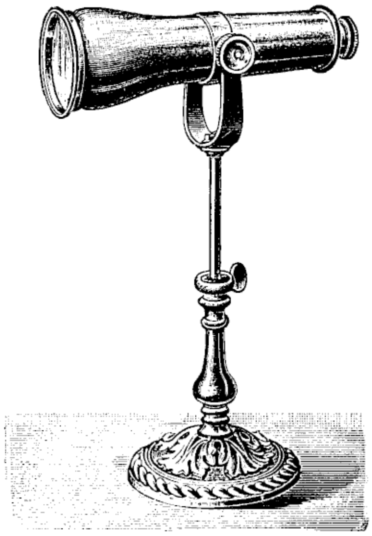
No. 1216.



No. 1217.

No. 1217. Hand lamp, for testing the reaction of the pupils, Fig. 1217, with spare lamp and case **£3 0 0**

No. 1218.

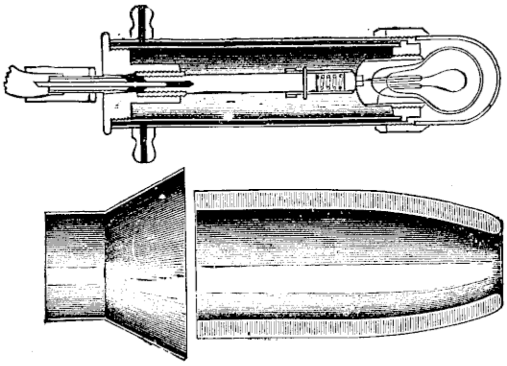


No. 1219.

No. 1218. Lamp with bull's-eye, and stand with universal movement, for surgical and dental operations, microscopic work, etc., Fig. 1218 ... ... **£2 10 0**

No. 1219. Lamp on stand, as shown in Fig. 1219. The optical arrangement consists of three lenses, the position of which can be varied so that either diffused light or a parallel beam of light is obtained. The lamp gives a powerful light and is very convenient for dermatological, microscopic, etc., purposes **£3 0 0**

No. 1220. Lamp for transillumination of larynx, nose, temples, ear, etc., with india-rubber funnel and water cooling arrangement, Fig. 1220 **£1 18 0**



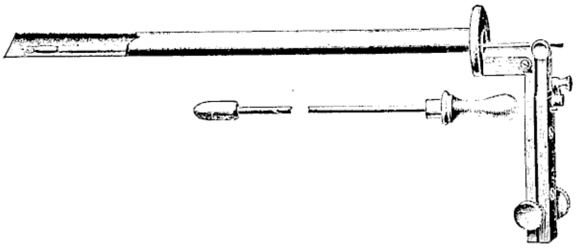
No. 1220.

No. 1222.

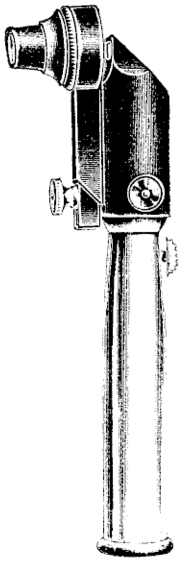
No. 1222. **Lamp for abdominal operations,** made for St. Bartholomew's Hospital, price, including one spare lamp and case, Fig. 1222 ... ... **£1 12 0**

The lamps require 9 volts and 0·75 ampère.

It is introduced through wounds during abdominal operations, to find bleeding arteries, etc. The lamp is protected so as not to dazzle the eye of the operator. The instrument can be easily sterilized.



No. 1253.



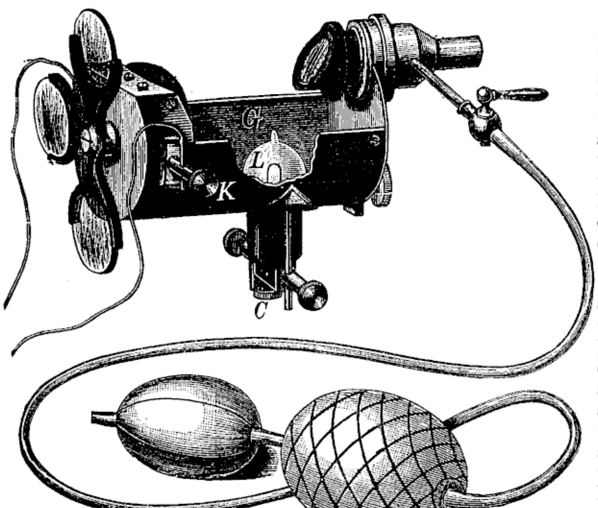
No. 1251.

No. 1251.	Dr. Casper's urethroscope, Fig. 1251, with three tubes, spare lamp and case	£3 3 0
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 5 0
No. 1254.	Small battery, with rheostat, suitable for Dr. Valentine's urethroscope ...	1 18 0

No. 1256. **Fenwick's urethroscope,** with one spare lamp, inflating arrangement and double bellows, Fig. 1256 ... £4 0 0

The lamps require 9 volts and 0·75 ampère.

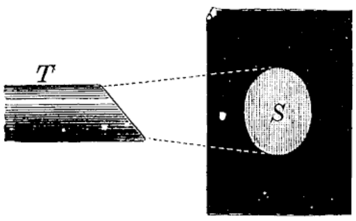
This instrument can be used equally well for the rectum, ear, œsophagus, nose, vagina, etc.



No. 1256.

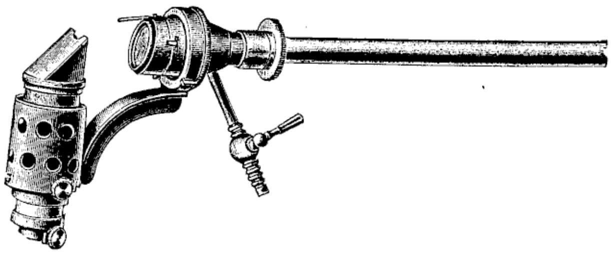
In the mode of reflection, this instrument is a distinct innovation. In other endoscopic instruments the lamp was usually placed in front of a perforated mirror, and the operator looked at the object through a perforation; but in this instrument a mirror is placed behind the lamp, and its concavity permits 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 such narrow and long canals as the male urethra, to observe and to use the operating instruments at the same time. This arrangement also makes it possible with the aid of a cotton holder to apply acids, caustics, etc., exactly on the spot where their effect is most wanted, or with a pair of forceps to seize foreign bodies in the œsophagus, urethra, etc. It is chiefly employed for lighting up the male urethra, the ear, nose, œsophagus, rectum and vagina.

No. 1257. Complete set, consisting of the above instrument, with spare lamp in case, 5 urethral tubes and 2 cotton holders £5 12 0



No. 1258.

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.



No. 1258A.

*No. 1258.	**Schall's Urethroscope** (Patent No. 1725, 1896), with spare lamp and cords	£2 2 0
No. 1258A.	The same instrument, with the inflating arrangement and double bellows in addition, Fig. 1258A	2 16 0
No. 1259.	Complete set, consisting of instrument No. 1258, in case, with 3 urethral tubes and 2 cotton holders ...	3 3 0
No. 1259A.	Complete set, consisting of instrument No. 1258A, in case, with 3 urethral tubes and 2 cotton holders ...	3 18 0

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.

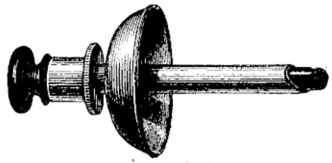
No. 1261.

No. 1261.	Urethral Tube, No. 16 French gauge, $3\frac{1}{2}$ inches long, Fig. 1261	4/-
No. 1262.	Do. No. 18 French gauge, 4 ins. long	4/-
No. 1263.	Do. No. 20 „ „ $4\frac{1}{2}$ „ „	4/-
No. 1264.	Do. No. 22 „ „ 5 „ „	4/-
No. 1265.	Do. No. 24 „ „ 5 „ „	4/-
No. 1266.	Do. No. 26 „ „ 5 „ „	4/-

Other sizes and lengths of tubes are made to order.

Similar tubes, with cups, as shown in Fig. 1269, 5/- each.

* As supplied to St. Bartholomew's Hospital, London Hospital, St. Peter's Hospital, Mr. Hurry Fenwick, and over 140 hospitals and surgeons.



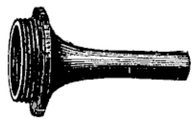
No. 1270. No. 1269.

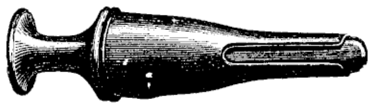
No. 1270. Urethral Tubes, lengthwise, open, Fig. 1270 ... each 8/-
No. 1272. Tubes for the prostate, with conductor ... ... ,, 6/-
No. 1274. Cotton holders for the urethra ... ... ,, 2/-

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/-

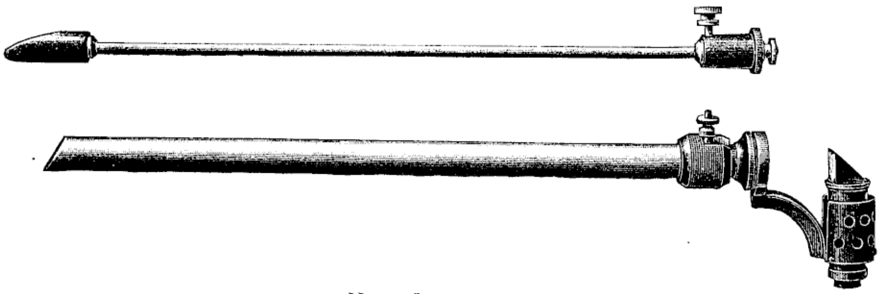
For illuminating the ear and nose, funnels of different diameter can be screwed on to the instrument.





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. 1285.

No. 1285. Tube for examining the œsophagus, diameter 15 mm., length 11 in., Fig. 1285... each 11/-
No. 1286. Tube, diameter 17 mm., length 18 in. ,, 14/-
No. 1288. Metal Ring, to connect the œsophagus tubes with the urethroscope ... ... each 4/-
No. 1289. Forceps, for the œsophagus, by Boecker ,, 35/-

With such a pair of forceps an artificial set of teeth has been removed from the œsophagus, in Prof. v. Billroth's clinique.

No. 1286

N

CYSTOSCOPES.

Cystoscopes were made originally, at the suggestion of Prof. Nitze, by Mr. J. Leiter of Vienna, who spent over a year of his life and a small fortune, more than he could ever hope to recover, in order to make these instruments a success. Incandescent lamps of a sufficiently small size were not yet available when the first instruments were being made, a fine platinum wire had therefore to be used for illumination. Platinum wires give less light and more heat than incandescent lamps, a water cooling arrangement was therefore necessary, and the instruments were complicated and of little practical use until incandescent lamps were employed for the cystoscopes in the year 1886. They were introduced here by us, and Mr. Hurry Fenwick used them first in Great Britain in 1887, and described them in his work: "The Electric Illumination of the Bladder and Urethra."

Since that time the value of these instruments has been recognised, and the demand has steadily increased; several other firms have since begun to make cystoscopes and various improvements have been made which will be mentioned later on. There is no doubt that the workmanship of the metal part of the instruments made by Leiter has not been surpassed, if it has ever been reached, by any of his competitors; in the optical part of the cystoscope, which is even more important, there is no competition at present, because all the different makers obtain the lenses and prisms from the same optician, Mr. A. Bénèche. If the optical parts of various instruments of the same length and diameter are carefully compared, it will be found that there is no difference between them as far as diameter of the visible area, and clearness and sharpness of the image are concerned.

At the suggestion of Mr. Fenwick the lenses were altered so that a larger area became visible; the beak of the instruments was made shorter and bent so that they can be introduced more easily, and the manner of attaching the cords has been altered, so that the instrument can be turned round its axis without twisting the cords. A cap can now be screwed over the telescope, and while thus protected the instruments can be put in boiling water for sterilization. The so-called "cold" lamps are now being used, they consume only 7 volts and 0·3 ampère, and give even less heat than the ordinary lamps do, which require 8 volts and 0·7 ampère; the "cold" lamps can be touched with the fingers even if kept burning in the open air; the ordinary lamps will remain cool only if immersed in some fluid. The ordinary lamps give, however, a little more light, and last longer. The lamps are either mounted in sockets, they are then protected by a window of rock crystal, which is cemented into the beak; or else the lamps may be fixed in the beak itself, and this has the advantage that a little larger lamp may be used, but the beaks have then to be renewed whenever a new lamp is wanted. In either case the lamps can be easily replaced.

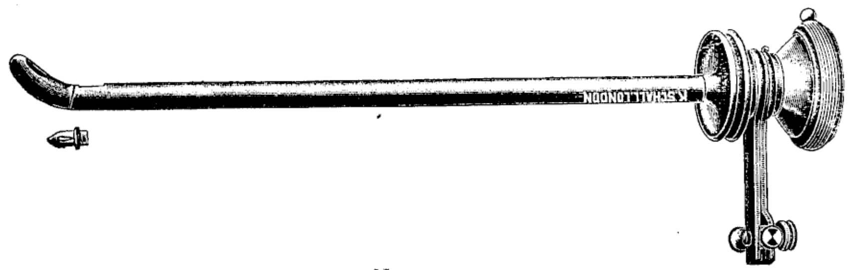
Cystoscopes are being made (No. 1305) in which the bladder can be washed out while the telescope remains in position; a stream of fresh water enters above and flushes the prism. In another construction

(No. 1308) the optical part can be removed, a large opening is thus available, and the bladder can be emptied and washed out rapidly; the fluid passes through a glass ball, so that it can be seen at once when the contents of the bladder have become sufficiently clear to begin the examination with the telescope. Cystoscopes are being made through which one or even two catheters can be introduced to draw a sample of urine from the right or the left kidney. Ultimately, a cystoscope has been constructed (No. 1312) in which the position of the prism can be altered while in the bladder, so that the orifice of the prostate can be examined.

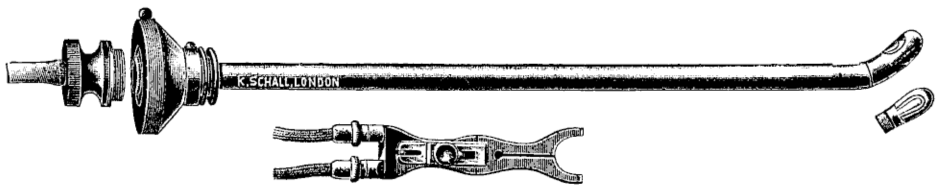
To be examined with a cystoscope the bladder always ought to contain 5 to 8 ozs. clear water. If the water in the bladder is not clear, it ought to be rinsed out previous to the operation.

If not otherwise ordered, "cold" lamps will be sent with the cystoscopes mentioned below.

The price of spare lamps for Nos. 1301A and 1302 is 2/-; the price of spare lamps for the other cystoscopes is 4/-.



No. 1301A.



No. 1301B.

Fig. 1301A shows the pattern used from 1888 till 1904, with a cartridge lamp; Fig. 1301B shows the pattern of 1905 with arrangement for sterilization, and the lamp mounted in the beak of the instrument.

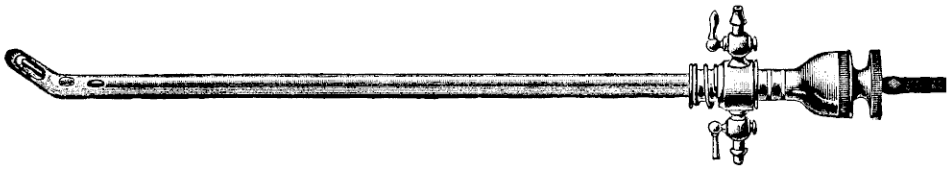
No. 1301.	Hurry Fenwick's cystoscope (made by Leiter) for the anterior wall, diameter 7 millimetres (No. 22 French gauge), with telescope and one spare lamp, Fig. 1301. With this instrument over three-fourths of the whole bladder can be examined	**£4**	**9**	**0**
No. 1302.	Ditto, for the posterior part of the bladder, with one spare lamp	**2**	**2**	**0**

The telescope of No. 1301 can be used with the cystoscope No. 1302.

N 2

This type of cystoscope is more frequently used than all the others taken together. We have supplied over 600 of them ; they are now being used by *all* the leading specialists and hospitals in Great Britain and the Colonies.

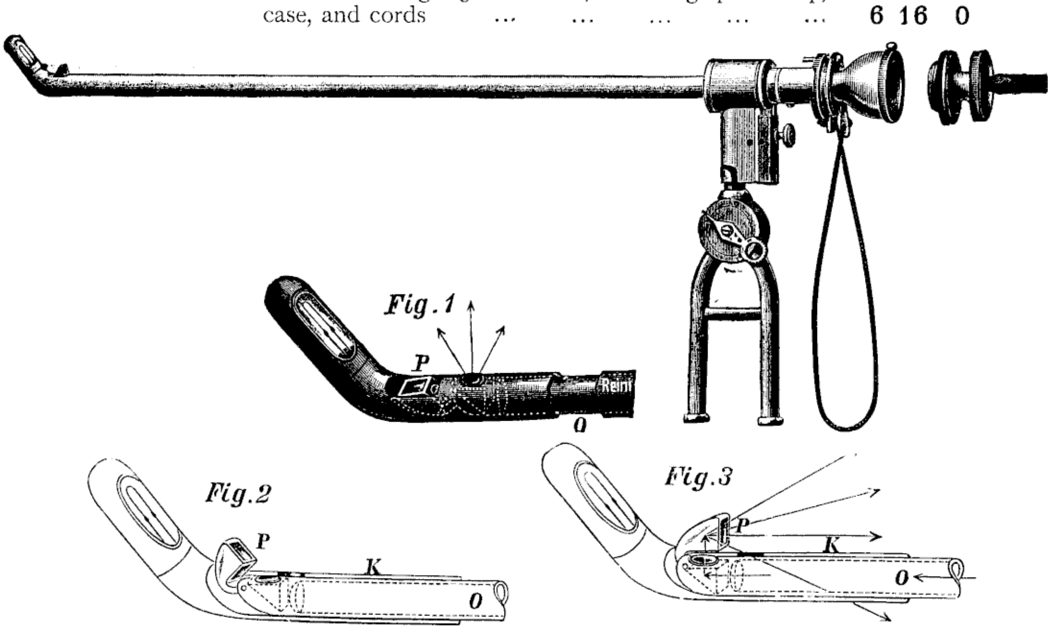
No. 1303. Cystoscope for the female bladder, diameter 12 millimetres, length of the part to be introduced 14 centimetres £5 10 0



No. 1305.

No. 1305. Prof. Nitze's cystoscope, with irrigation, Fig. 1305, with spare lamp, cords, and case, diameter 8 millimetres (No. 24 French gauge) £5 15 0

No. 1308. Dr. Schlagintweit's cystoscope for irrigation or evacuation of the bladder, with special tap to control the evacuation, and glass ball which shows the colour of the fluid in the bladder. The tap for irrigation is shown in Fig. 1312. Price, including spare lamp, case, and cords 6 16 0



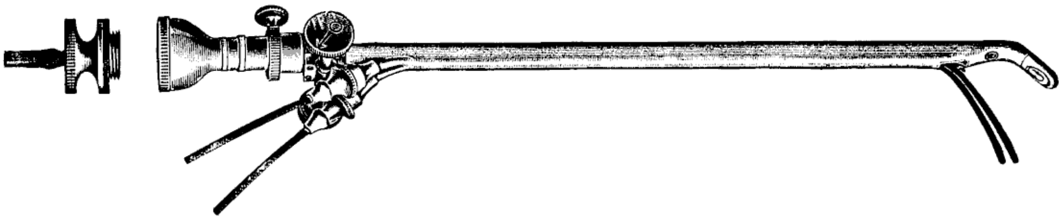
No. 1312.

No. 1312. Dr. Schlagintweit's cystoscope, Fig. 1312, for irrigation or evacuation of the bladder, with tap and glass ball. It can be used either as an ordinary cystoscope, or else the position of the prism can be changed, as shown in the three small illustrations, so that the instrument can be used for examining the orifice of the prostate. Price, including spare lamp, case, and cords £8 10 0

No. 1315.

No. 1315. Cystoscope, with irrigation and arrangement so that a catheter can be introduced into the orifice of the ureter, Fig. 1315. The direction of the catheter can be controlled by means of a screw. Price, including spare lamp, case, and cords **£7 10 0**

Spare catheters for Nos. 1315 and 1317 ... each **0 5 0**



No. 1317.

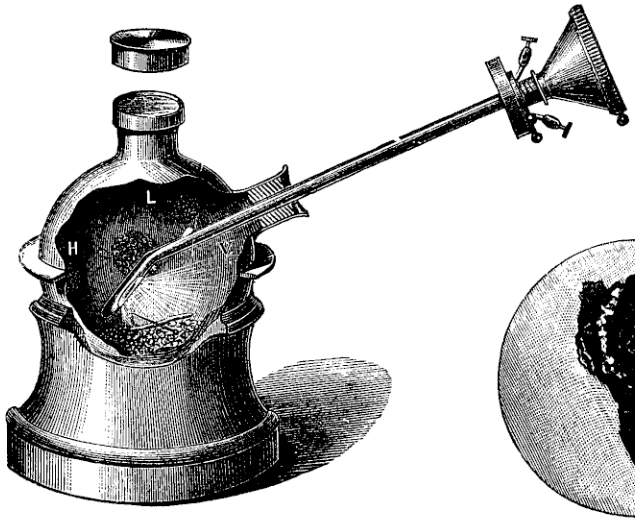
No. 1317. Cystoscope, with irrigation and arrangement for introducing two catheters, Fig. 1317, diameter No. 26 French gauge. Price, including two catheters, one spare lamp, case, and cords **£8 15 0**

No. 1327.

No. 1327. Prof. Nitze's cystoscope for taking photographs of the living bladder, Fig. 1327. Ten exposures may be made on one plate, and the instrument can be used either for direct examination with the eye, or for taking photographs. Price, including spare lamp, case, cords, and one dozen plates **£9 10 0**

One dozen plates for the above cystoscope **0 3 6**

No. 1328. Special stand to hold the cystoscope while a photograph is being taken... ... ... **5 15 0**



No. 1329.

No. 1343.

No. 1329. For practising with Cystoscopes and for demonstrations, a Phantom as shown (Fig. 1329), exhibiting artificial tumours, stones, and foreign bodies, &c., is very convenient **£0 18 0**

Fig. 1343 shows two blood-red villous papillomata, of the exact size seen by a Leiter Cystoscope in a lady aged 50, who had suffered many years from painless hæmaturia. It was modelled according to the plan recommended by Mr. Hurry Fenwick ("Brit. Med. Journ.," Jan., 1889).

No. 1330. **Gastroscope,** with telescope **£9 10 0**

This apparatus is essentially of the same construction as the Cystoscope.

No. 1332.

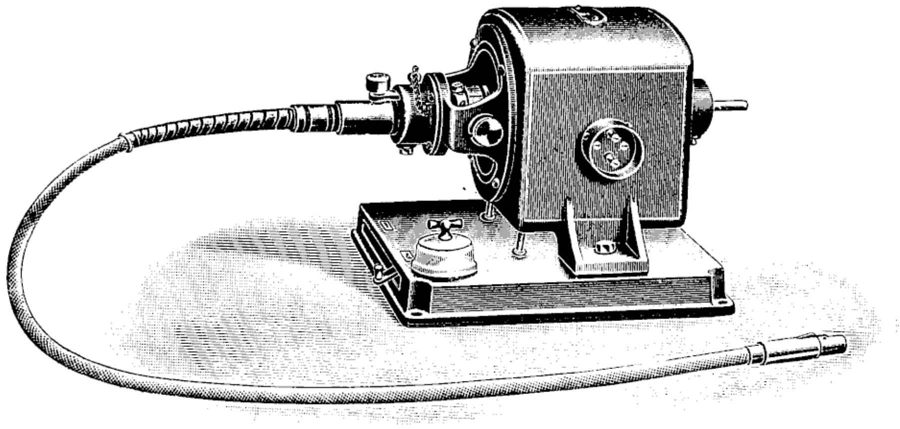
No. 1332. Instrument for making the stomach transparent, with spare lamp, Fig. 1332 ... ... **£3 12 0**

To utilize this apparatus, the stomach is emptied, and filled with water: the instrument, which is as flexible as an indiarubber tube, is then swallowed, and shows in a dark room the exact position, size and shape of the stomach.

Surgical Lamps to be used in connection with the 100 to 250 volt currents supplied from dynamos will be found under Nos. 2080—2145 on pages 224—229.

ELECTRIC MOTORS.

(See also pages 63—70.)



No. 1410.

Electric motors are coming 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 of the ear, for centrifuges, static machines, and ventilating fans, for interrupters for spark coils, etc., etc.

They can be worked from batteries, or from the current supplied for lighting houses. If the latter is available, it is, of course, more convenient than batteries, but the winding of the motors has to be adapted to the special conditions present in the house in which it has to be used, and in ordering a motor which is to be worked from the current from the mains, 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, or if the motor has to be used in different houses, a 6-cell accumulator or a 6-cell bichromate battery with large cells will work a 12-volt motor very well. The bearings of our motors are of gun-metal, and are provided with self-oiling cups. The motors are shunt wound ; in consequence of this the speed of the motors is almost independent of the amount of work they have to perform.

The motors can be mounted in different ways : they can either be placed on a chair or table, or on a telescopic stand as shown in Fig. 1485. The latter is convenient, as the correct height is of importance for the smooth working of the flexible shaft. They can also be suspended from an adjustable bracket from the wall or from the ceiling.

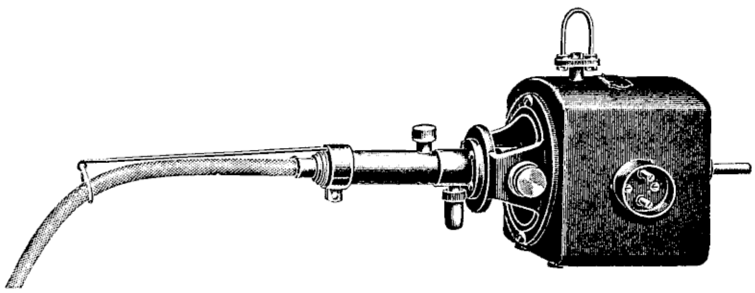
A rheostat should be used with every motor; if 100 to 250 volt currents are used, the motors will be damaged if the full current is switched on suddenly. The current ought to be turned on gradually by diminishing the resistance. The same rheostat also serves to control the speed of the motors. In most of our surgical motors the rheostats are fixed in the cast-iron bases of the motors.

CONTINUOUS CURRENT MOTORS

For surgical operations, for massage, etc., with connecting plug, switch, rheostat in cast-iron base, and arrangement to make the motors stop dead beat, Fig. 1410.

(The motor transformers No. 2000 and the sinusoidal motors Nos. 1900 and 1901 can also be used for surgical operations, and for massage.)

		12	100	200 to 250 volts.
No. 1410.	$\frac{1}{16}$ horse-power, Fig. 1410	£5 10	£6 8	£7 0
No. 1411.	$\frac{1}{8}$ horse power ...	7 0	7 15	8 16



No. 1416.

Similar motors, with connecting plug, switch, and ring to suspend the motors on a bracket or from the ceiling, Fig. 1416. The rheostats for these motors have to be fixed separately on the wall.

		12	100	200 to 250 volts.
No. 1416.	$\frac{1}{16}$ horse-power ...	£4 15	£5 9	£6 6
No. 1417.	$\frac{1}{8}$ horse power ...	5 16	6 10	7 12

No. 1419. Rheostat for the motors Nos. 1416 and 1417, in iron frame, with crank (Fig. 995, page 161) £1 16 0

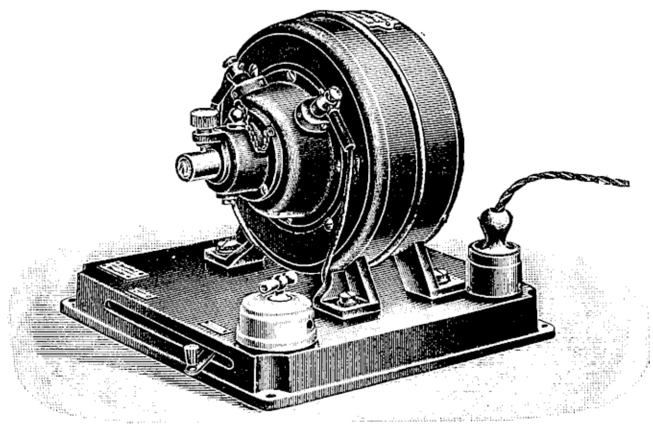
The motors Nos. 1410 and 1416 are powerful enough for all surgical operations in the nose and ear, for most operations on the skull, and for all purposes of massage.

The motors Nos. 1411 and 1417 are preferable if trephines of $\frac{1}{4}$ inch diameter or more are to be used. For the largest conical trephines of 1 to $1\frac{1}{2}$ inches diameter, we make special motors of $\frac{1}{4}$ horse-power. Estimates for these will be sent on application. A specially powerful and heavy flexible shaft is necessary for the motors of $\frac{1}{4}$ horse-power.

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 ... **£9 12 0**

(*b*) For 200 volts ... **£10 12 0**



No. 1420.

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.

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 various hand pieces are slipped on and held in position by a spring catch.

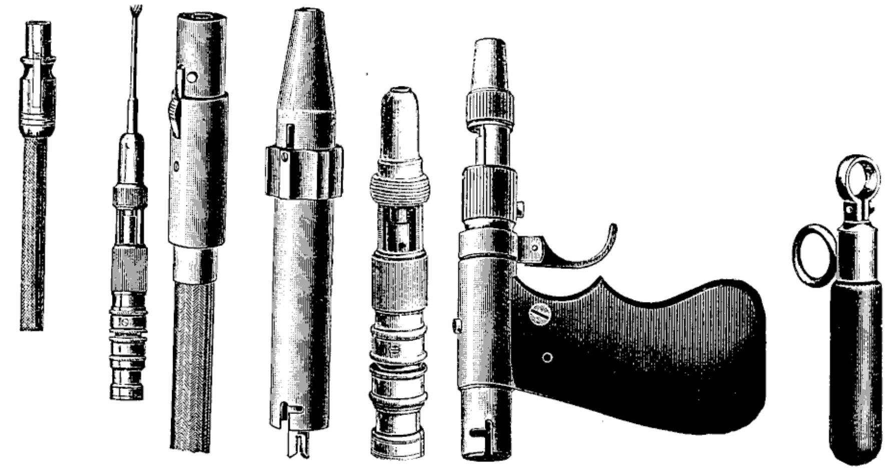
The hand pieces hold the drills, burrs, or the massage appliances. The drills, etc., are released by drawing back a spring. The axle of our hand pieces run in ball bearings, and the covers can be taken off for sterilization. The hand pieces are made in various sizes and shapes, either for small operations in nose or ear, or for the trephines for the skull; some are provided with a ring or drigger (Nos. 1454 and 1456) to stop the drills instantaneously; other hand pieces (Nos. 1462 and 1464) 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 ... **£1 18 0**

No. 1433. Flexible shaft, diameter of the steel cable 7 millimetres, suitable for trephines and for massage, length 40 inches **2 8 0**

No. 1434. Flexible shaft, diameter of the steel cable 9 millimetres, length 40 inches **2 15 0**

Thinner flexible shafts, for dental purposes, will be found under Nos. 1710 and 1711.



No. 1450. No. 1452. No. 1454. No. 1456. No. 1459.

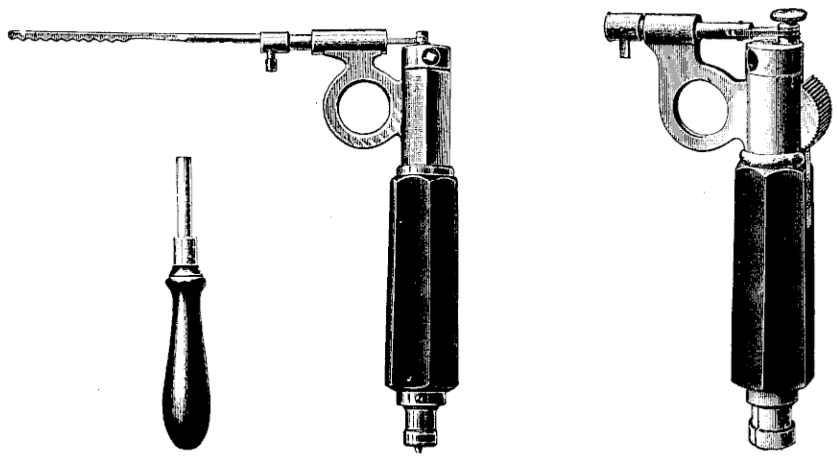
No. 1450. Hand piece, for drills, etc., Fig. 1450 ... ... **£1 5 0**

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

No. 1454. Hand piece, with a sliding ring to stop the tools instantaneously, Fig. 1454 ... ... **2 7 0**

No. 1456. Hand piece, with a drigger to stop the tools instantaneously, Fig. 1456 ... ... **2 16 0**

No. 1459. Handle to hold the hand piece, and to enable the operator to direct and steady the hand piece with both hands, Fig. 1459 ... ... **0 10 0**



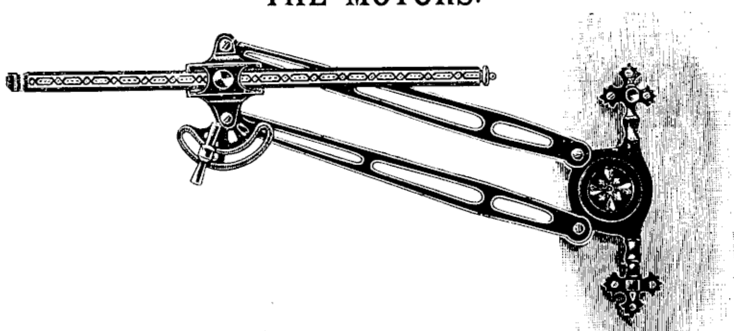
No. 1462. No. 1464.

No. 1462. Handle to convert the circular movement into a longitudinal one, for straight saws, chisels, etc., Fig. 1462 **£2 6 0**

No. 1464. Similar handle, with arrangement to stop the tools instantaneously, Fig. 1464 ... ... **2 17 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. A key is supplied with the handles for this purpose, and is included in the price.

BRACKETS AND TELESCOPIC STANDS FOR THE MOTORS.



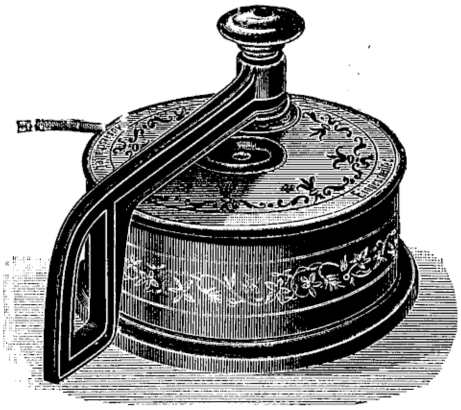
No. 1480.

No. 1480. Strong bracket for suspending the motors, Fig. 1480. The bracket is movable in any direction, and its greatest length is 42 inches **£2 17 0**

No. 1485. Telescopic stand, with castors, Fig. 1485 **£3 0 0**

No. 1486. Plain stand, similar to No. 1485, but without telescopic arrangement **£1 10 0**

No. 1488. Table of American oak, with rubber covered castors, and with a drawer for the reception of flexible shaft, drills, etc. **£3 6 0**



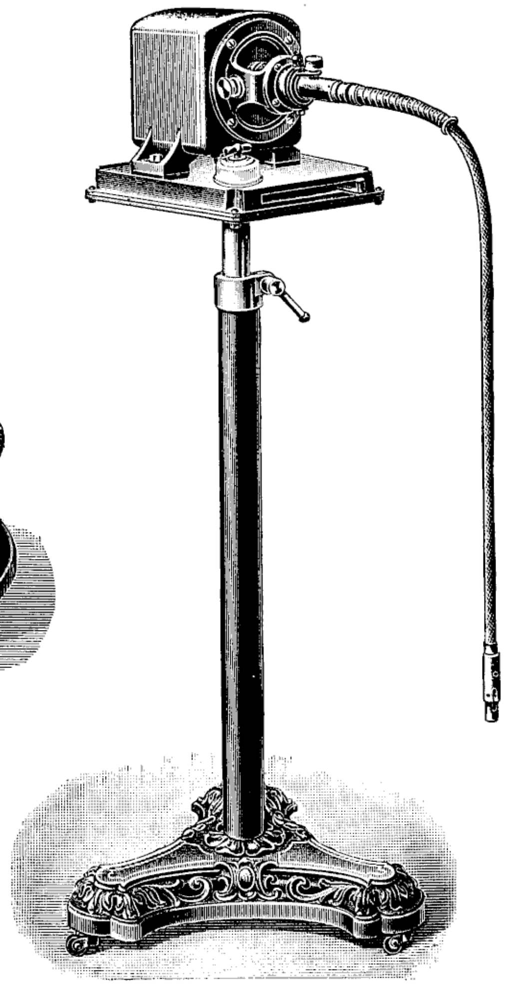
Nos. 1490—1493.

No. 1490. Foot contact with rheostat, to start, stop, and regulate the speed of the motors, for 12 volts, Fig. 1490 ... ... **£5 0 0**

No. 1492. Similar rheostat, for 100 volts **£6 10 0**

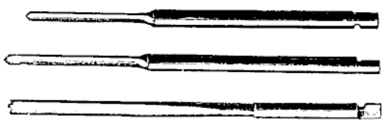
No. 1493. Similar rheostat, for 200 to 250 volts ... **£7 0 0**

Other types of foot contacts will be found under Nos. 1701 and 1702.



No. 1485.

DRILLS, BURRS, TREPHINES, CIRCULAR SAWS, ETC.

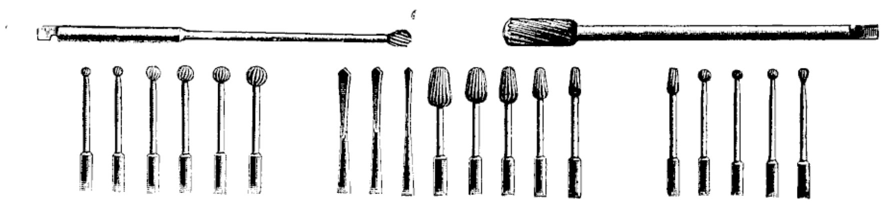


No. 1500.

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. **4/6 5/6 9/- 15/-** each.



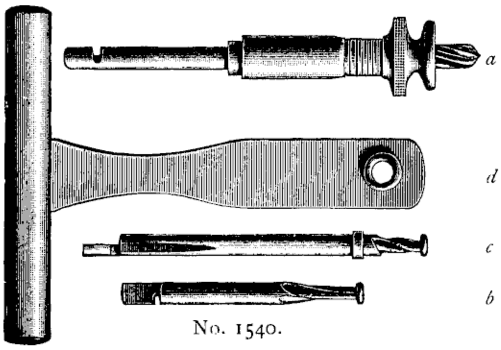
No. 1520.

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. 1535.

No. 1535. Trephine for opening the antrum, Fig. 1535 ... ... **£1 0 0**

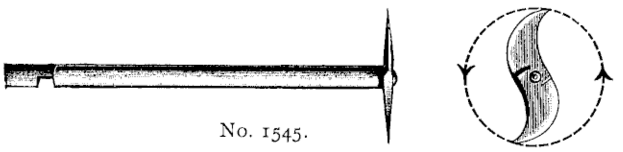


No. 1540.

No. 1540. Drill for the skull, with adjustable guard to control the depth of the hole, Fig. *a* ... **17/0**

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

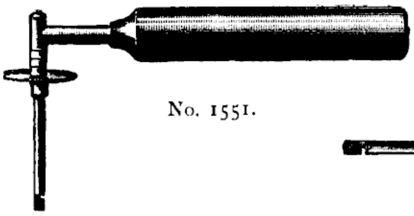
Handle, to guide the reamers, Fig. *d* **2/9**



No. 1545.

No. 1545. Scarificator, Fig. 1545, for treating lupus, eczema, scars, etc. Diameter of the knife 1 centimetre **9/0**

No. 1546. Similar instrument, diameter 2 centimetres **10/6**



No. 1551.

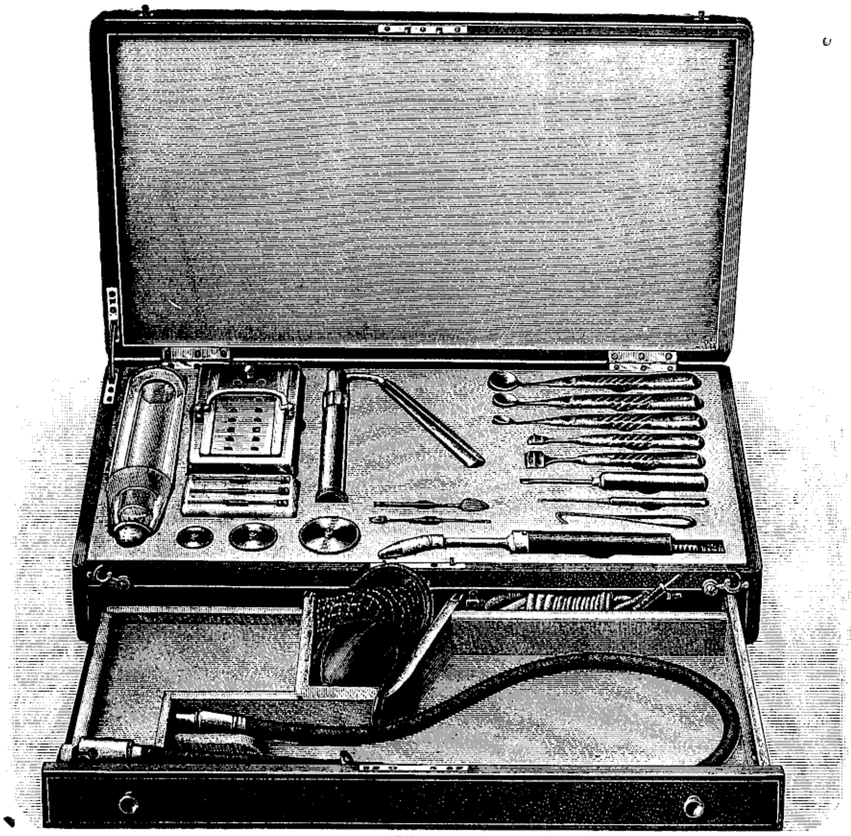
No. 1550.

No. 1550. **Straight handle for circular saws,** Fig. 1550, with 1 circular saw and 2 keys to fix the blades **£0 17 6**

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

No. 1553. **Circular saws,**

$\frac{3}{4}$ in.	1 in.	$1\frac{1}{4}$ in. diameter.
5/-	5/6	6/- each.



No. 1560.

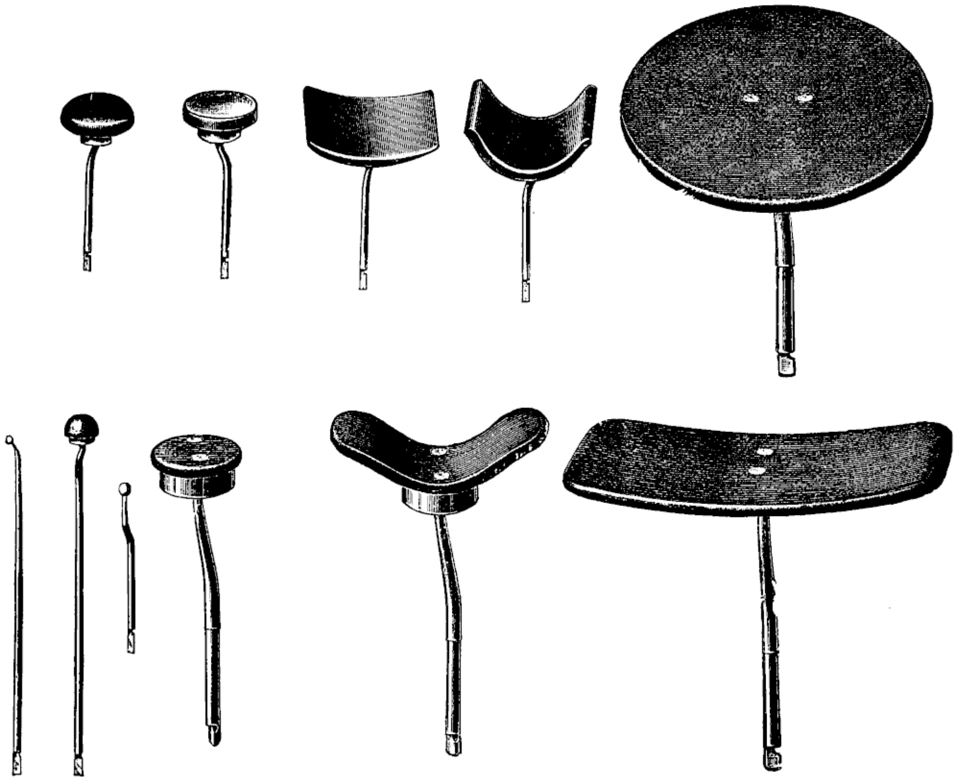
No. 1560. Prof. Mosetig-Moorhof's and Dr. Silbermark's instruments for bone plugging with iodoform. (A full description will be found in the *Lancet*, January 21st, 1905.) The set of instruments consists of a special kind of hand piece, some circular saws, drills, and large burrs, chisels and sharp spoons, a hot air syringe, and suitable glass vessels for iodoform. Price of the complete set shown in Fig. 1560, in case **£19 0 0**

In addition, a surgical motor Nos. 1410—1420 or No. 2000 is required.

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

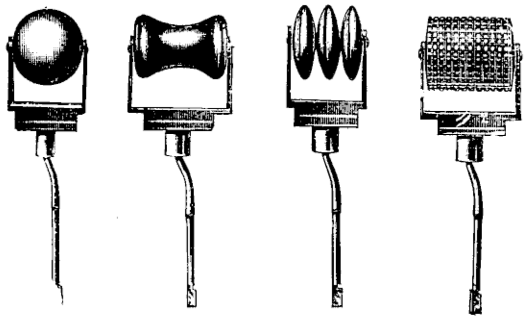
The manual applications of massage and kneading can now be replaced efficiently with the help of motors by mechanical power, to the great relief of the operators. Massage and rapid vibration (the latter replaces the kneading, knocking or percussion treatment) can be applied with these motors with absolute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

The motors Nos. 1410—1420, 2000, or the sinusoidal motors Nos. 1900 or 1901 are required for working the plates, discs, rollers, rotating hammers, and centrifugal vibrators, etc., illustrated below.



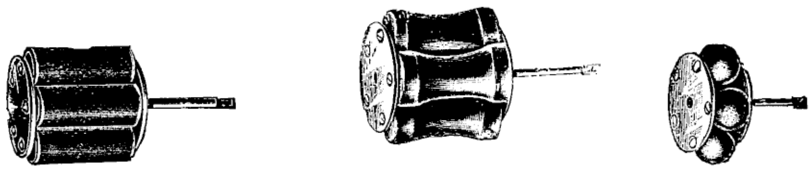
No. 1600.

No. 1600. Round or square concussor plates of various diameters, from 4/- to 8/-



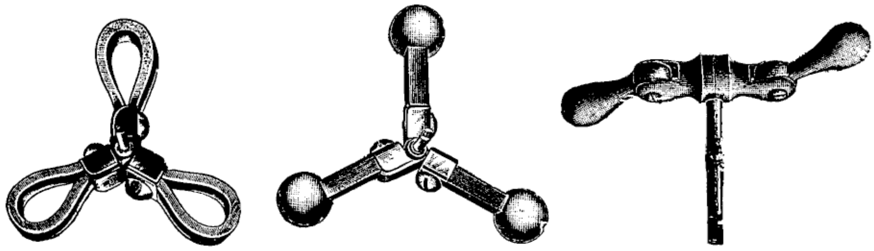
No. 1610.

No. 1610. Concussor rollers, balls, and discs, for the application of massage to spine, abdomen, etc. ... ... from **8/-** to **12/-**



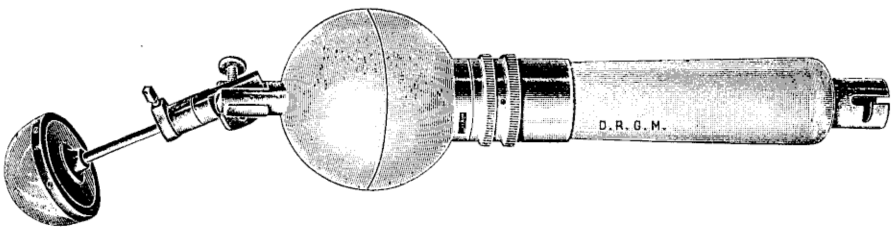
No. 1620.

No. 1620. Rollers, with 5 rotating cylinders or balls of ebonite ... **9/-** to **11/-**



No. 1630.

No. 1630. Rotating hammers, of metal, leather, or indiarubber, for knocking and percussion ... ... **9/-** to **11/-**



No. 1640.

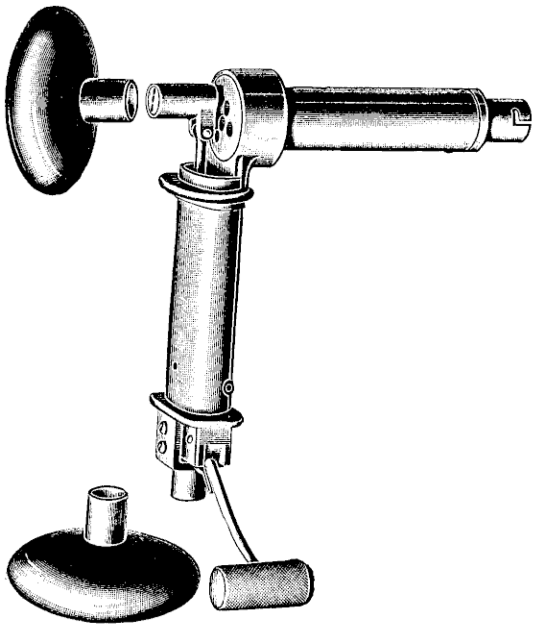
No. 1640. **Centrifugal Vibrator,** Fig. 1640 ... ... **£3 12 0**

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. 1642. Flat or convex metal discs, 3 to 10 centimetres diameter, fitting the centrifugal vibrator No. 1640 3/6 to £0 8 0

No. 1645. Convex indiarubber discs, fitting the centrifugal vibrator No. 1640—

38 millimetres diameter	0	5	6
57 „ „	0	8	0
80 „ „	0	10	0



No. 1650.

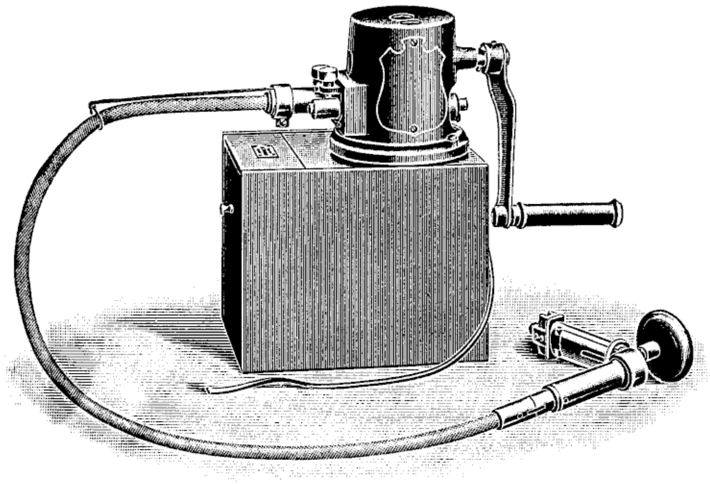
No. 1650. Dr. Johansen's new universal vibrator, Fig. 1650 ... £3 14 0

This instrument is simple in construction, does not get out of order, and is considerably more powerful than No. 1640, but is completely under control, so that hard or soft blows can be administered; it does not shake the hands of the operator as much as No. 1640 does.

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 hammer can be inserted (as shown in the illustration) or removed, and the length of the stroke can be varied in wide limits.

This instrument can only be used with the flexible shaft No. 1434.

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

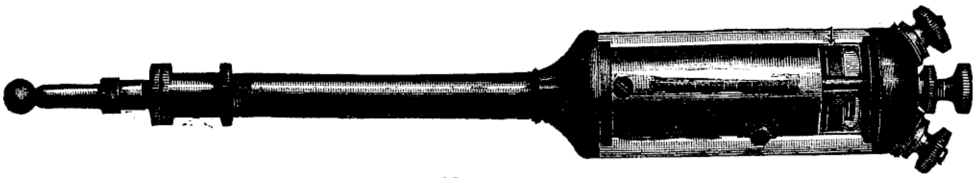


No. 1659.

No. 1659. Hand driven motor, for vibratory massage, or for drilling holes, etc., Fig. 1659 ... ... £3 12 0

(The flexible shaft and vibrator shown in illustration are not included in the price.)

No. 1660. Apparatus for massage of the mucous membranes in nose, ear, etc., complete with battery 2 12 0



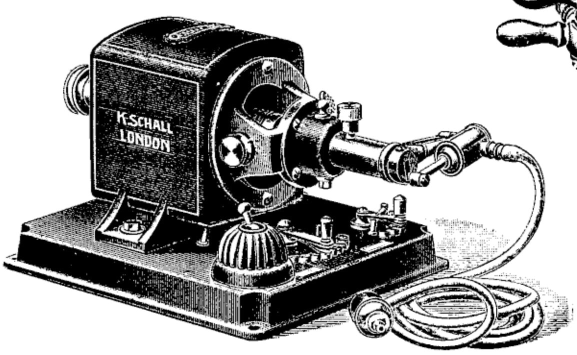
No. 1665.

No. 1665. Dr. Piesbergen's apparatus for massage of the eye, Fig. 1665, with dry Leclanché cell and cords ... £2 10 0

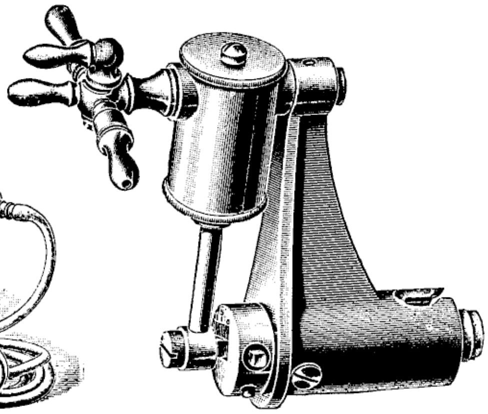
AIR PUMPS FOR PNEUMATIC MASSAGE OF THE EAR, ETC.

The air pumps can be attached either to one of the motors Nos. 1410—1420, 2000, or the sinusoidal motors Nos. 1900 or 1901, or to a hand driven motor with flywheel.

The air pump No. 1672 can also be used for massage of the eye or head, for supplying a current of air for the Eustachian tube, for hot air syringes, 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.



No. 1670.

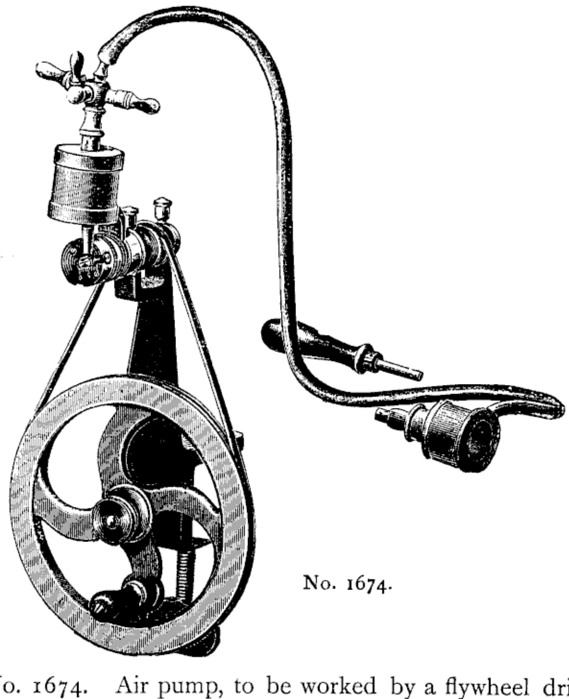


No. 1672.

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 a key to vary the length of the stroke.

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 12 0**

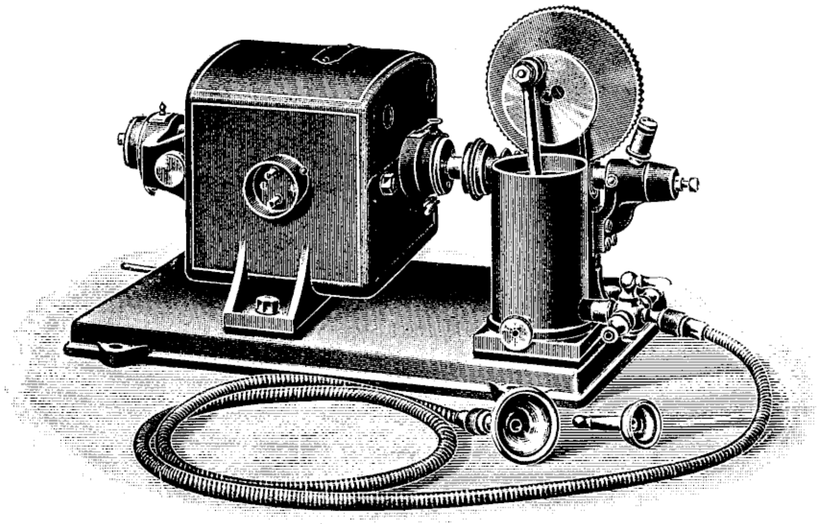


No. 1674.

No. 1676.

No. 1674. Air pump, to be worked by a flywheel driven by hand, Fig. 1674 ... ... complete **£4 4 0**

No. 1676. Prof. Lucae's pneumatic sound, fixed on a membrane, Fig. 1676. This sound is to be fixed on air pump No. 1670 or 1672 ... ... **0 10 6**

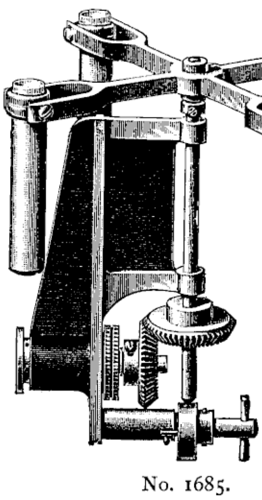


No. 1680.

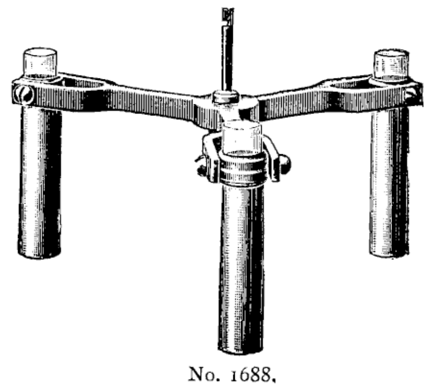
No. 1680.	Motor of ⅛ horse-power, with large air pump, Fig. 1680, for pneumatic massage of the skin, for vibratory massage, and for spraying drugs by means of compressed air, for continuous current, including switch, rheostat, indiarubber tubes, etc.	£20	0	0
No. 1681.	Similar motor, but for alternating current	21	0	0

CENTRIFUGES

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

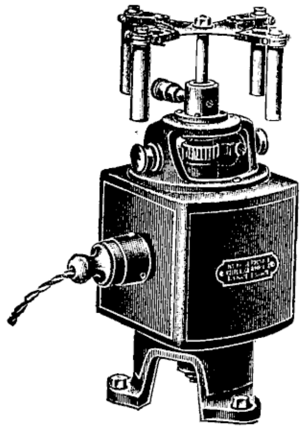


No. 1685.



No. 1688.

No. 1685.	Centrifuge to be attached to the motors Nos. 1410—1420, 1900 or 2000, Fig. 1685	£3	0	0
No. 1688.	Fork of aluminium, to be inserted in a surgical hand piece, Fig. 1688	1	1	0



No. 1690. Continuous current motor of $\frac{1}{16}$ horse-power, Fig. 1690, with centrifuge attached. The motor makes about 2,000 revolutions per minute—

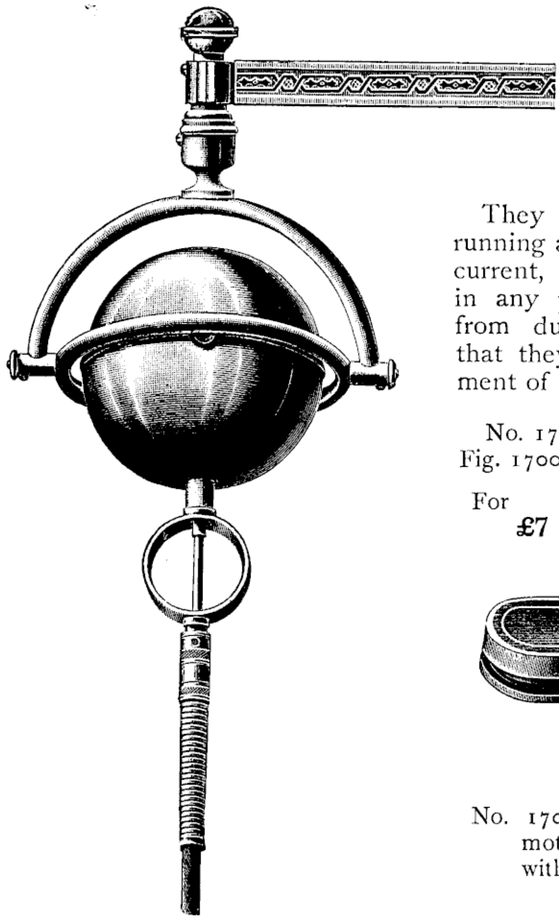
For	12	100	200 to 250 volts.
	£7 0 0	£7 12 0	£9 0 0

No. 1692. Similar motor, but for alternating current ... **£11 11 0**

A rheostat No. 1419 has to be used with these motors.

No. 1690.

DENTAL MOTORS.

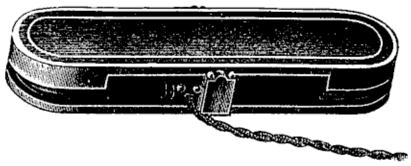


No. 1700.

Of all the numerous constructions of dental motors, the type illustrated has proved to be the best in every way; and these motors are gradually superseding all other kinds. They are powerful even while running at a slow speed, require little current, are absolutely silent, start in any position, are well protected from dust, and are suspended so that they follow easily every movement of the hand.

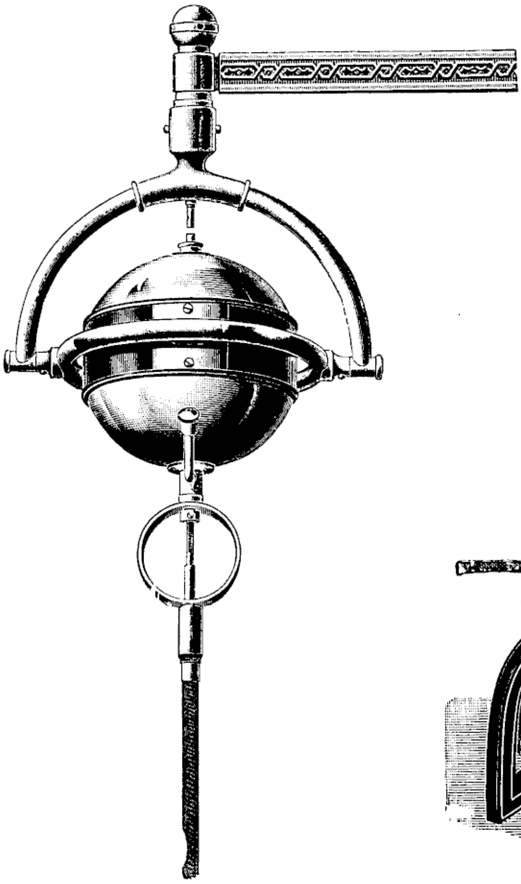
No. 1700. Continuous current motor, Fig. 1700—

For	12	100 volts.
	£7 16 0	£8 15 0

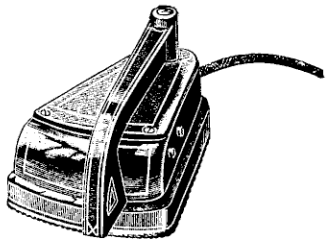


No. 1701.

No. 1701. Foot contact, to start the motor or to stop it dead beat with pressure of the foot, Fig. 1701 **£2 0 0**



No. 1706.



No. 1702.

No. 1703.

No. 1702. Foot contact, to start, stop, or reverse the direction of the motor, Fig. 1702 ... ... £3 9 0

No. 1703. Foot contact combined with a rheostat, Fig. 1703, to start, stop, or reverse the motor, and to control its speed—

For	12	100	220 volts.
	£4 10 0	£5 0 0	£6 10 0

No. 1706. Alternating current motor, Fig. 1706, for 100 volt currents 10 0 0

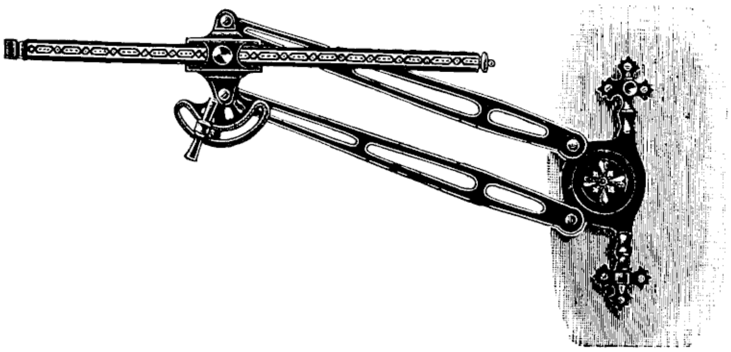
If the E.M.F. of the supply exceeds 120 volts, it has to be reduced by means of a transformer to about 100 volts.

No. 1708. Foot contact (see Fig. 1703), to start the motor No. 1706 or to stop it dead beat, with rheostat and reverser ... £6 15 0

No. 1710. Flexible shaft and hand piece, No. 4, for the dental motors... ... ... 1 18 0

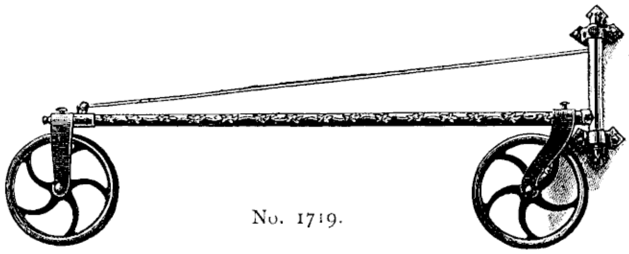
No. 1711. Flexible shaft and hand piece No. 7 ... ... 2 7 0

BRACKETS AND STANDS FOR SUSPENDING THE DENTAL MOTORS.



No. 1715.

No. 1715. Bracket, Fig. 1715, to be fixed on the wall £3 0 0
No. 1718. Telescopic stand for the dental motors 2 18 0



No. 1719.

No. 1719. Pulley with counterweight, Fig. 1719, to suspend motors from the ceiling £3 7 0

Illuminating instruments for dental purposes will be found under Nos. 1200—1214.

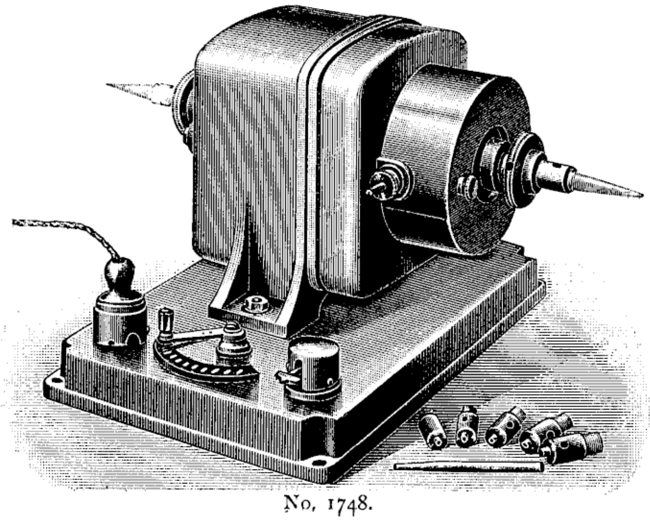
Cautery instruments will be found under Nos. 1100—1120.

Transformers and rheostats for using illuminating or cautery instruments with the current from the main will be found under Nos. 2000—2044.

Batteries or switchboards for cataphoresis will be found under Nos. 116 or 1820—1840.

No. 1748. Large motor, for grinding or polishing, or for driving a small lathe, Fig. 1748. For 100 to 250 volt continuous current, £12 10 0

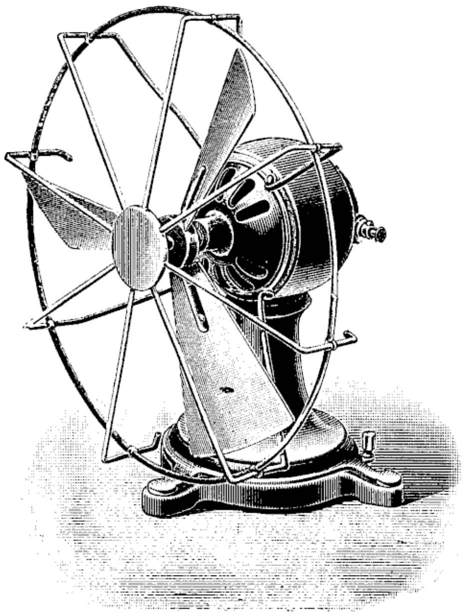
No. 1749. Similar motor, but for alternating current, £17 0 0



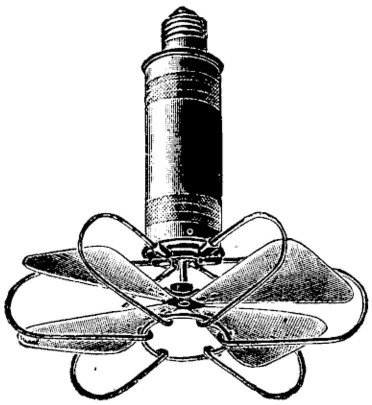
No. 1748.

FAN MOTORS FOR VENTILATION.

No. 1765.	Fan motor, for **continuous current,** with rheostat for varying the speed, diameter of the fan 9 in., for 100 volts, Fig. 1765	£3 0 0
No. 1766.	Similar motor, but wound for 200 to 250 volts... ...	3 10 0

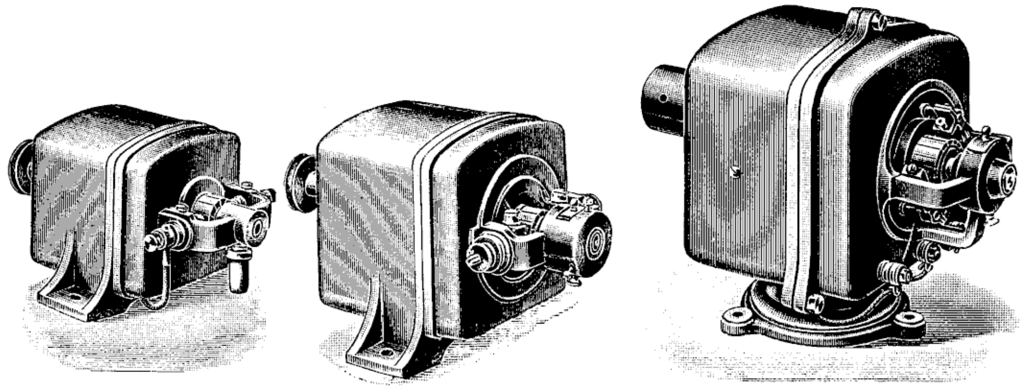


No. 1765.



No. 1773.

No. 1767.	Fan motor, similar to No. 1765, but with a fan of 12 in. diameter	£3 6 0
No. 1768.	Fan motor, similar to No. 1766, but with a fan of 12 in. diameter	3 15 0
No. 1769.	Fan motor, for **alternating current,** with rheostat for regulating the speed, diameter of the fan 12 in., for 100 volts	4 10 0
No. 1769A.	Similar motor, but wound for 200 volts	5 0 0
No. 1773.	Small ventilating motor, Fig. 1773, to be attached to an Edison-Swan lamp holder—	
	(*a*) For 100 volt continuous currents	1 12 0
	(*b*) For 200 to 250 volt continuous currents ...	1 17 0
	(*d*) For 100 volt alternating currents	1 12 0
	(*e*) For 200 volt alternating currents	2 5 0



No. 1776. **Small Electro Motors,** series wound, with pulley—

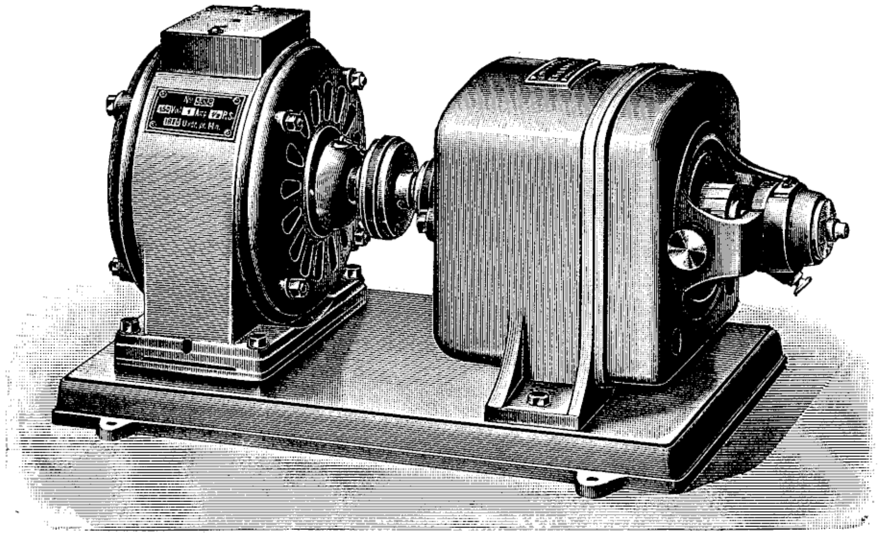
	Horse-power.	Volts.	Price.	Rheostat.
			£ s. d.	£ s. d.
a	$\frac{1}{32}$	12	2 15 0	0 18 0
b	$\frac{1}{32}$	100	3 0 0	0 18 0
c	$\frac{1}{32}$	220	3 6 0	1 0 0
e	$\frac{1}{16}$	12	3 6 0	1 0 0
f	$\frac{1}{16}$	100	3 17 0	1 0 0
g	$\frac{1}{16}$	220	4 8 0	1 2 0
h	$\frac{1}{8}$	12	4 12 0	1 0 0
i	$\frac{1}{8}$	100	5 5 0	1 5 0
k	$\frac{1}{8}$	220	6 6 0	1 5 0

No. 1778. **Small Electro Motors,** shunt wound, with pulley—

	Horse-power.	Volts.	Price.	Rheostat.
			£ s. d.	£ s. d.
a	$\frac{1}{32}$	12	3 0 0	0 18 0
b	$\frac{1}{32}$	100	3 8 0	1 0 0
e	$\frac{1}{16}$	12	3 14 0	1 0 0
f	$\frac{1}{16}$	100	4 6 0	1 4 0
g	$\frac{1}{16}$	220	4 15 0	1 4 0
k	$\frac{1}{8}$	12	5 0 0	1 5 0
l	$\frac{1}{8}$	100	5 12 0	1 10 0
m	$\frac{1}{8}$	220	6 12 0	1 10 0
o	$\frac{1}{4}$	100	11 0 0	1 10 0
p	$\frac{1}{4}$	220	11 15 0	1 10 0
r	$\frac{1}{2}$	100	14 0 0	1 10 0
s	$\frac{1}{2}$	220	14 15 0	1 10 0
w	1	100	17 0 0	2 0 0
x	1	220	18 0 0	2 0 0

MOTOR TRANSFORMERS.

(See also pages 63—68.)



No. 1780.

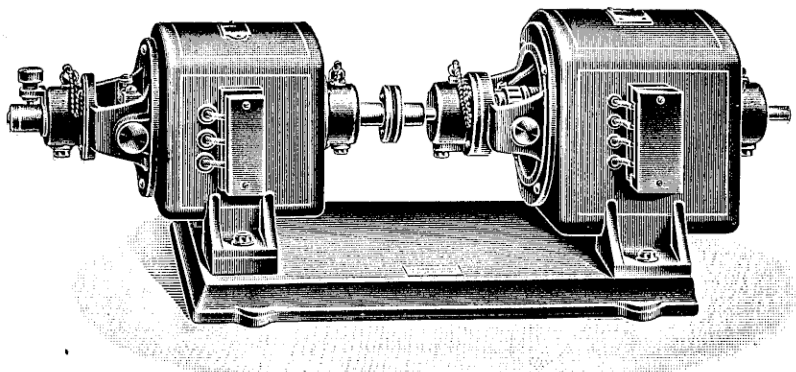
No. 1780. Motor transformer, to convert an alternating current into a continuous current, for galvanisation and electrolysis, Fig. 1780. The continuous current dynamo supplies 70 volts and 0·5 ampère **£19 0 0**

No. 1782. Similar transformer, for charging accumulators. The continuous current dynamo supplies 22 volts and 2 ampères **19 0 0**

These prices include the necessary rheostats.

Larger motor transformers of the same kind, suitable to give 300 to 1,600 watts, for spark coils, arc lamps, etc., will be found under Nos. 2678—2682.

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 45 or above 80, the prices mentioned above will have to be increased. Estimates will be sent on application.

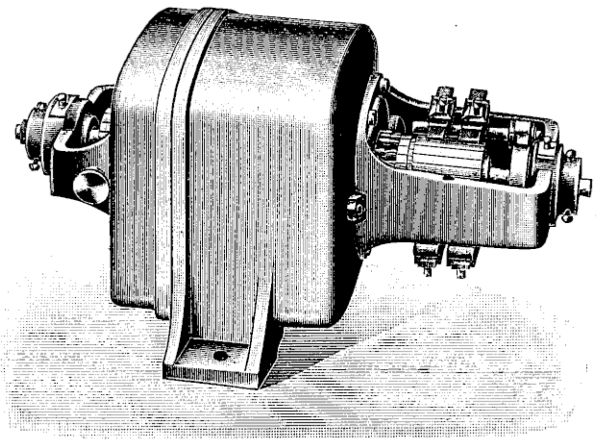


No. 1790.

No. 1790. Continuous current transformer, for galvanisation, electrolysis, or surgical lamps, Fig. 1790. The dynamo supplies a current of 65 watts (65 volts and 1 ampère) **£14 0 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 50). 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**



No. 1794.

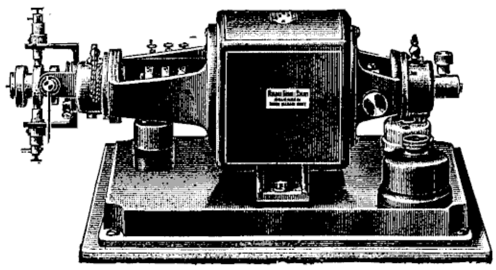
No. 1794. Motor tran-former, Fig. 1794, to convert currents of 100 to 250 volts into currents of 5 to 50 volts, for charging accumulators, for nickel-plating, etc.—

(*a*) Secondary circuit about 150 watts	**£15**	**0**	**0**
(*b*) „ „ 300 „	**19**	**0**	**0**
(*c*) „ „ 550 „	**23**	**0**	**0**

The prices include all the necessary rheostats.

Continuous current transformers, to reduce currents of 200 to 250 volts to 60 volts for a Finsen-Reyn Lamp, or for charging accumulators, are being made. Estimates will be sent on application.

No. 1796. Motor transformer of $\frac{1}{16}$ horse-power, to convert a continuous into a single and three phase alternating current, with rheostat to control the number of periods, Fig. 1796—



No. 1796.

(*a*) For 12 volts	**£10**	**5**	**0**
(*b*) For 100 volts	**11**	**0**	**0**
(*c*) For 200 to 250 volts	**12**	**0**	**0**

See also Nos. 1900, 1901, and 2000.

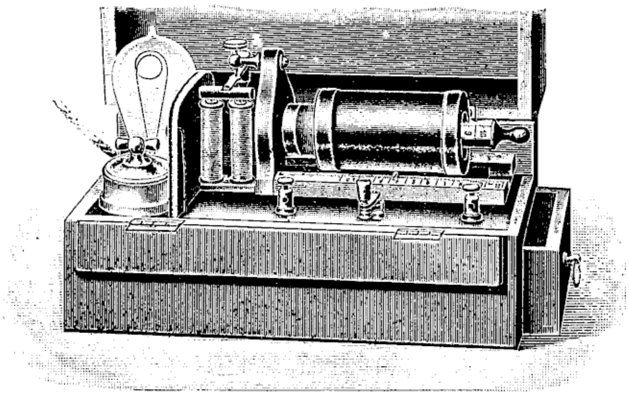
Larger sizes are being made, and estimates will be sent on application.

APPARATUS FOR USING THE CURRENT FROM THE MAIN,

For Galvanisation, Electrolysis, Faradisation and Sinusoidal Currents, for Cautery, Surgical Lamps, Light Therapy, Etc.

(See also pages 46—70.)

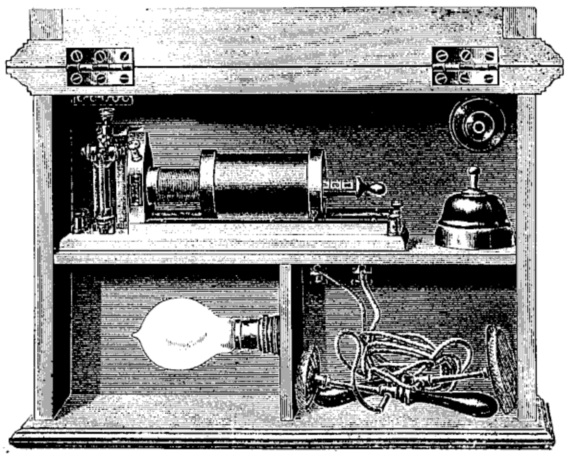
FARADISATION.



No. 1807.

No. 1807. Portable sledge coil, in polished mahogany case, with electrodes, cords, and handles, Fig. 1807 ... ... **£4 10 0**

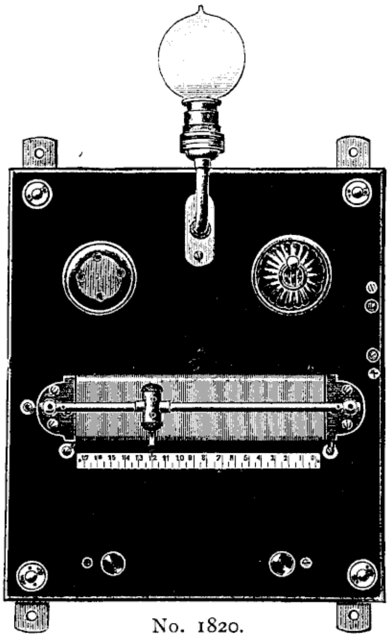
This apparatus is similar to No. 21, but instead of the two dry cells there is a lamp resistance, so that the coil can be used with the current from the main.



No. 1812.

No. 1812. Sledge coil in case, with glass door, for operating theatres, casualty or anæsthetists' rooms, with lamps, handles, and electrodes, Fig. 1812 ... ... **£5 0 0**

GALVANISATION, ELECTROLYSIS, AND FARADISATION.



No. 1820.

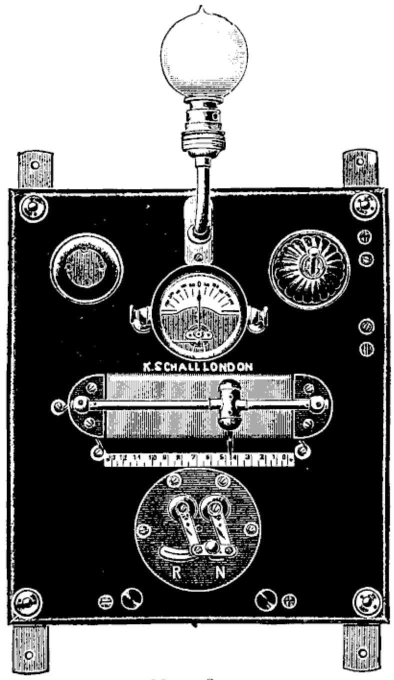
No. 1820. Switchboard, with volt selector, to vary the current from the main from 0·1 volt gradually up to about 70 volts, lamp, switch, and fuse, mounted on enamelled slate, cords, handles, and four electrodes, Fig. 1820 **£4 0 0**

No. 1822. Similar apparatus, with a current reverser, and a galvanometer No. 281 in addition, Fig. 1822 **£7 10 0**

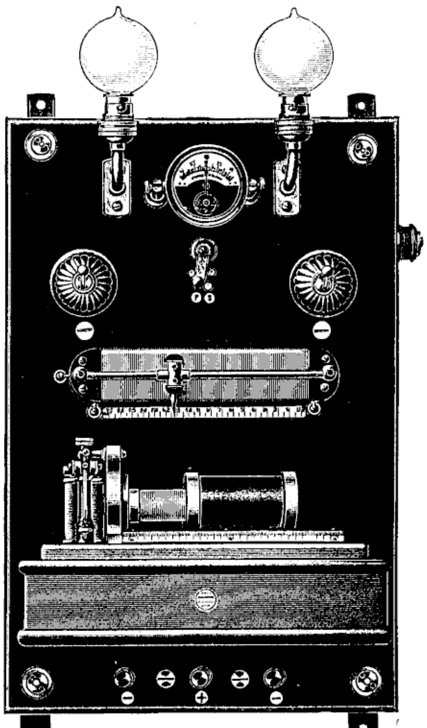
No. 1824. Similar apparatus as No. 1822, arranged in a portable mahogany or walnut case ... **£7 10 0**

The case measures 7 in. by 12 in. by 9 in,

No. 1826. Switchboard, with volt selector for galvanisation, galvanometer No. 281, sledge coil No. 27, for faradisation, two lamps, switches, and cut-outs, mounted on enamelled slate, cords, handles, and five electrodes, Fig. 1826 **£11 6 0**

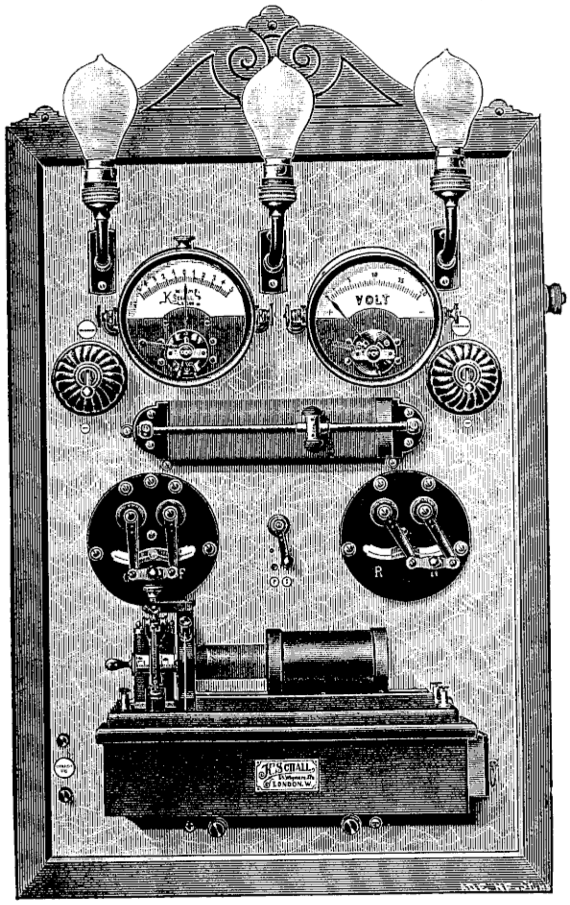


No. 1822.



No. 1826.

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 two shunts; current reverser and Dr. de Watteville's key, three lamps, switches, and fuses, mounted on enamelled slate or marble, cords, handles, and seven electrodes. (The apparatus is similar to Fig. 1831, but is not provided with the voltmeter shown in the illustration) **£16 0 0**



No. 1831.

No. 1831. Similar apparatus, with a voltmeter in addition, Fig. 1831 **£19 10 0**

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

No. 1833.

No. 1833. Switchboard, with accessories as specified under No. 1830, but arranged in a portable polished walnut case, Fig. 1833 ... ... **£15 5 0**

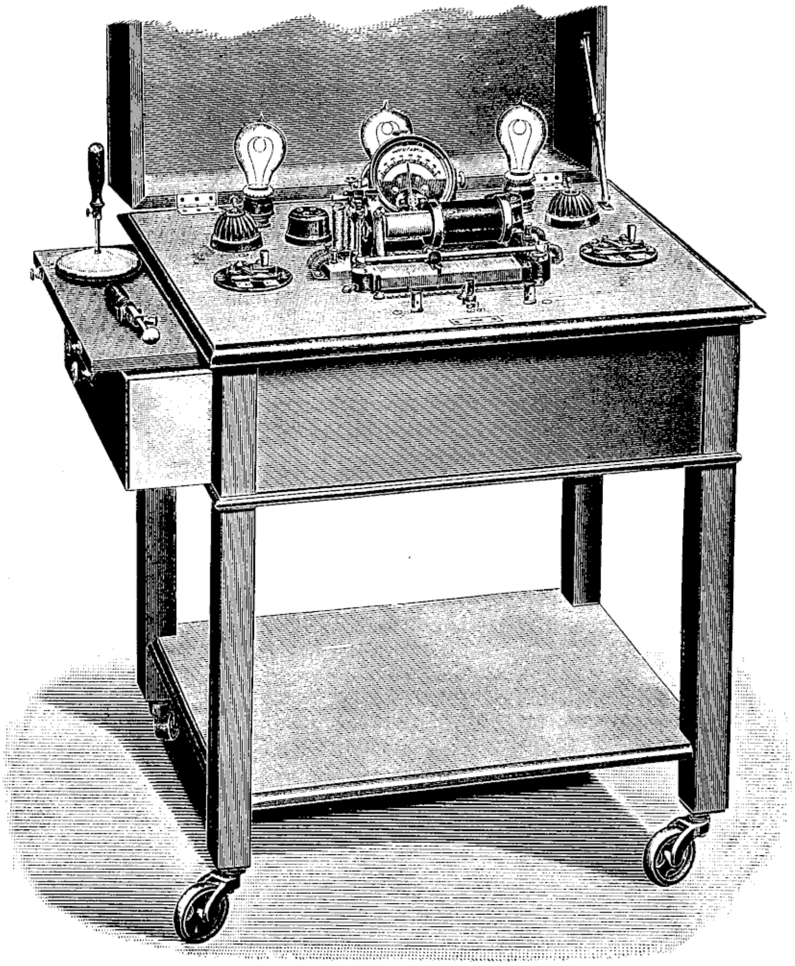
Size 15 in. by 22 in. by 12 in.

Apparatus Nos. 1830—1840 have been supplied to :—

Drs. David Ferrier, Clarence Wright, Gage Brown, W. Travers, Th. G. Stonham, W. Harris, Th. B. O'Connor, Major Drake Brockman, Dr. Collis, J. R. Whait, C. P. White, etc., London.

Drs. Milne Murray, J. Macintyre, Hall Edwards, G. B. Boddie, Alex. Bruce, T. H. Bickerton, John Bark, A. S. Gruenbaum, E. E. Glynn, W. B. Warrington, H. A. G. Brooke, J. Elliott, H. A. Ballance, Th. A. Furlong, J. A. Codd, G. S. Stansfield, Prof. A. Ogston, Dr. A. W. C. Peskett, etc.

London Hospital, King's College, St. Mary's, Westminster, and St. George's Hospital; 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.

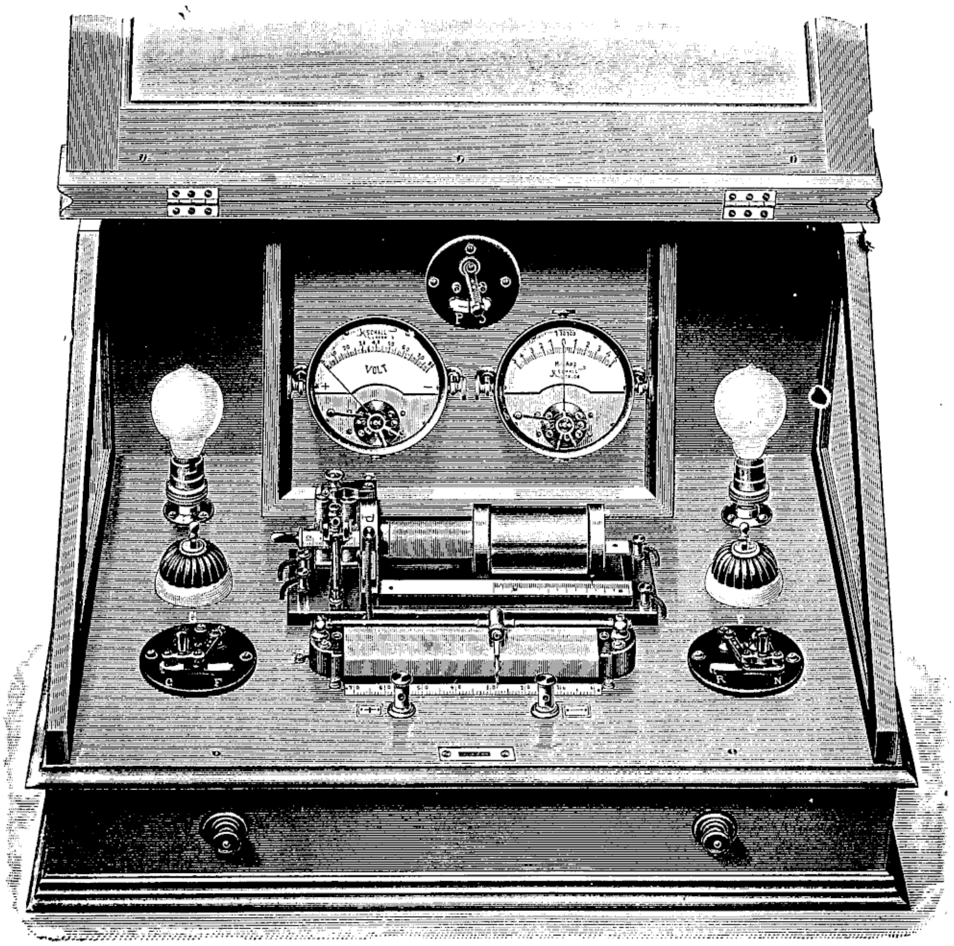


No. 1837.

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 **£20 0 0**

Royal Infirmaries in Edinburgh, Glasgow, Aberdeen, Halifax, and Hull; 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.

Smedley's Hydropathic Establishment; Harrogate Hydropathic Company; Bath Club, Dover Street, London; The Crown-Agents for the Colonies, etc.



No. 1840.

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), Fig. 1840 ... ... **£21 0 0**

GALVANISATION, FARADISATION, CAUTERY, AND SURGICAL LAMPS.

No. 1841. Switchboard on trolley, for galvanisation, electrolysis, faradisation, cautery and surgical lamps, for hospital use. The apparatus contains all the accessories specified under No. 1830, resembles Fig. 1837 in appearance, but an interrupter transformer No. 2020 and a rheostat for surgical lamps are added... ... **£30 0 0**

As supplied to the London Hospital, King's College Hospital, and several other hospitals.

No. 1844. Switchboard on trolley, for galvanisation, electrolysis, faradisation, cautery, surgical lamps, surgical operations with drills, massage, etc. The apparatus contains all the accessories specified under No. 1830, and resembles Fig. 1837 in appearance, but a motor transformer No. 2000 is added—

(*a*) For 100 volts, **£36 0 0**

(*b*) For 200 to 250 volts, **£37 10 0**

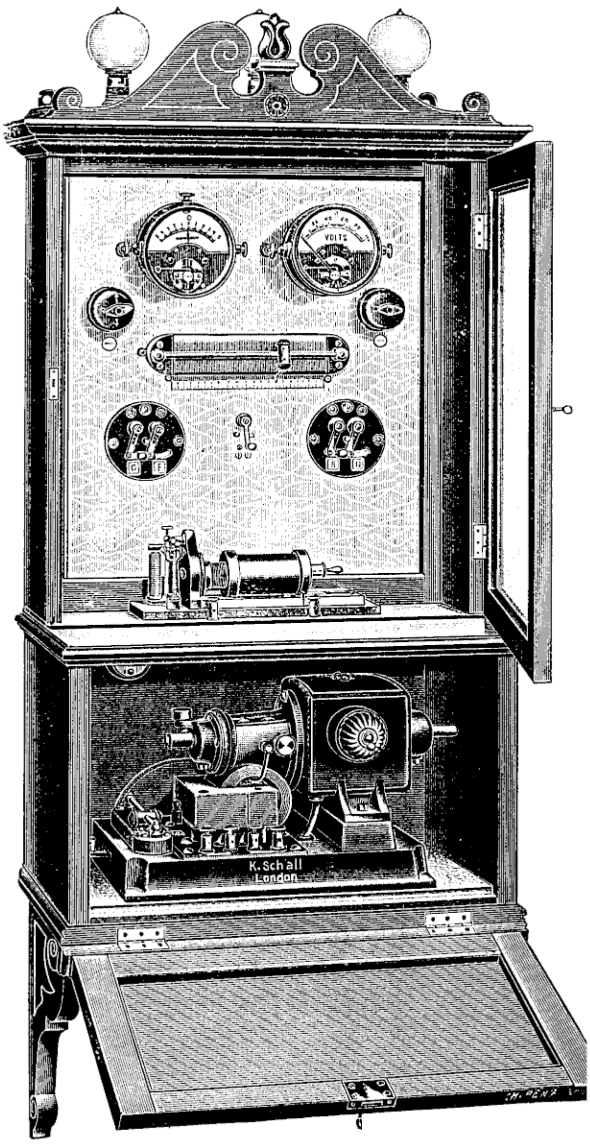
The motor transformer can easily be detached and used separately, if it is wanted for surgical operations.

No. 1847. Switchboard for galvanisation, faradisation, cautery, surgical lamps, surgical operations with drills, massage, etc., Fig. 1847—

(*a*) For 100 volts, **£34 10 0**

(*b*) For 200 to 250 volts, **£36 0 0**

The apparatus contains all the accessories specified under No. 1830; but it is enclosed in a case with a glass door, and a motor transformer No. 2000 is added. This motor transformer can easily be detached to be used separately. The voltmeter shown in the illustration is not included in the price mentioned above. Size, 21 in. wide by 36 in. long by 13 in. deep.



No. 1847.

No. 1850. Switchboard for galvanisation, faradisation, single phase sinusoidal currents, and massage **£32 0 0**

The apparatus contains all the accessories specified under No. 1830, is enclosed in a case with glass door, as shown in Fig. 1847, and is provided with a sinusoidal transformer No. 1900, which may also be used for massage and surgical operations. The motor can easily be detached and used separately.

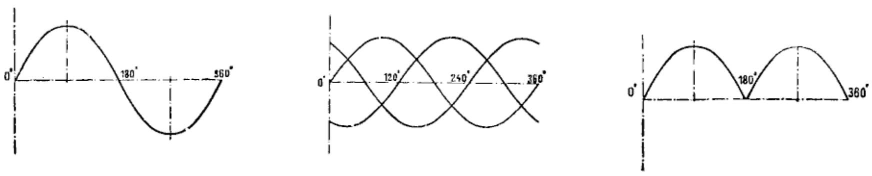
No. 1853. Switchboard for galvanisation, faradisation, single and three phase sinusoidal currents, with three sledge transformers **£37 0 0**

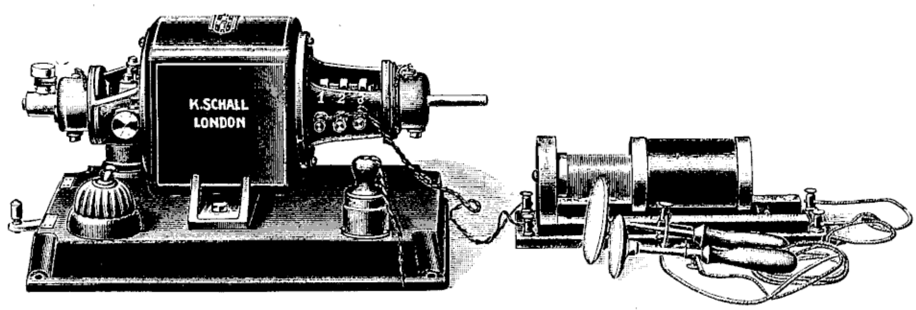
The apparatus contains all the accessories specified under No. 1830, is enclosed in a case with glass door, as shown in Fig. 1847, and is provided with a sinusoidal transformer No. 1901 for single or three phase currents, and with three sledge transformers. The motor can be detached and used separately for massage or surgical operations.

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

APPARATUS FOR TREATMENT WITH SINUSOIDAL CURRENTS.

(See also pages 68—70.)

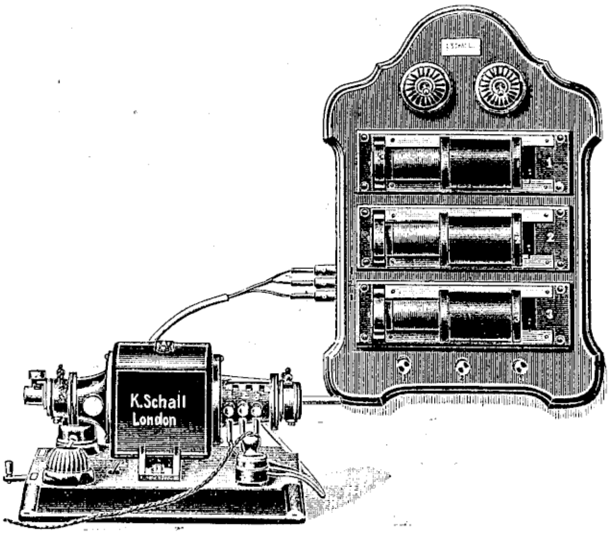




No. 1900.

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*) ,, ,, 100 ,, ,, ... **13 0 0**
(*c*) ,, ,, 200 to 250 volt supply ... **13 15 0**



No. 1901.

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*) ,, ,, 100 ,, ,, ...	18	15	0
(*c*) ,, ,, 200 to 250 volt supply ...	19	10	0

Larger sizes of sinusoidal transformers can be made to order.

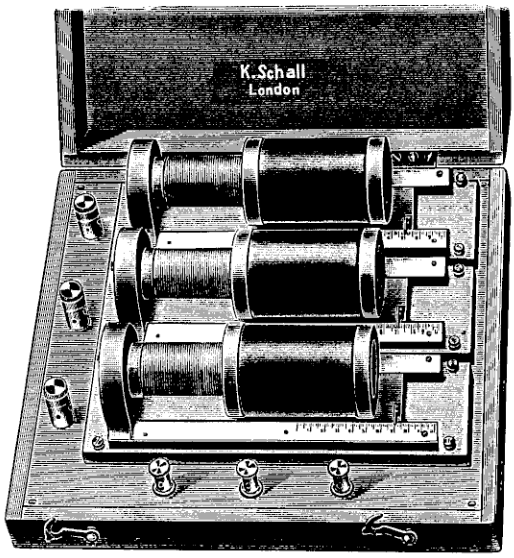
The motor transformers Nos. 1900 and 1901 can also be used for massage and rapid vibration treatment, and for surgical operations with drills, etc., or they can be provided with a Leduc's reverser (see No. 245).

The motor transformer No. 2000 for cautery can also be used for treatment with sinusoidal currents.

If desired, the sledge transformers can be arranged in a portable box instead of on a board to be fixed on the wall (see Fig. 1907).

If the secondary coils of the sledge transformers are to be moved by rack and pinion, or by a screw, the price of the single phase transformers will be increased 10/-, and that of the three phase transformers 30/-.

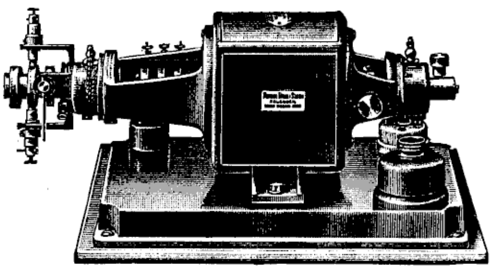
No. 1906. Separate sledge transformer, for use with a motor transformer No. 2000... ... ... £2 0 0

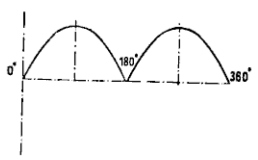


No. 1907.

No. 1907.	Three sledge transformers, mounted on a polished walnut board, or in a portable oak box, as shown in Figs. 1901 or 1907	£7 15 0
No. 1912.	Hot wire milliampèremeter, registering from 0 to 300 milliampères, to measure sinusoidal currents ...	4 4 0

This galvanometer does not register currents of less than about 50 milliampères.

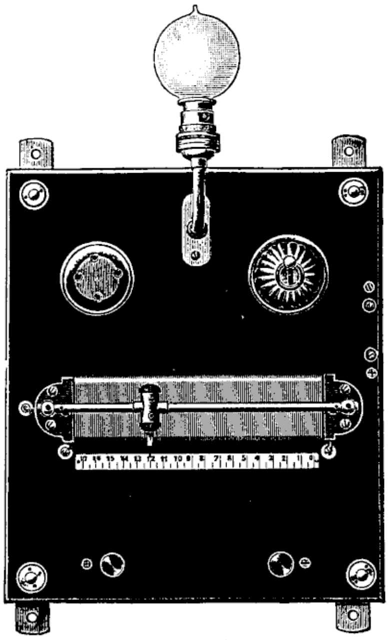




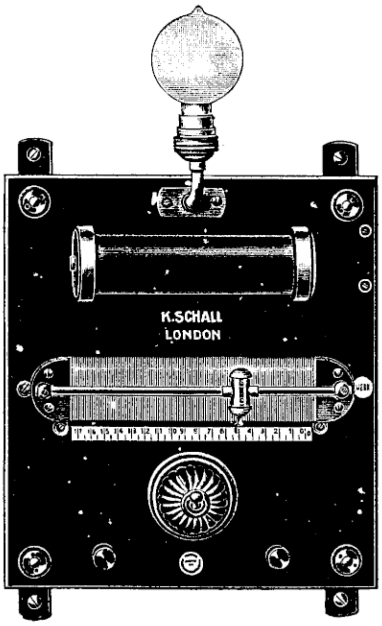
No. 1915.

If desired, a commutator, as shown in illustration Fig. 1915, can be added to the transformer No. 1901 ; with the help of this commutator pulsating unidirectional currents (see diagram) can be obtained, as well as the single or three phase sinusoidal currents, and moreover weak currents of a few milliampères only, which would not register on the galvanometer No. 1912, can then be measured with the help of galvanometers Nos. 285—288.

Estimates for the addition of this commutator, and for switchboards arranged for sinusoidal currents, as well as pulsating unidirectional currents, and provided with galvanometer, will be sent on application.



No. 1926.



No. 1928.

No. 1926. Volt regulator, to use the *alternating current from the main* for *local* applications of single phase sinusoidal currents, Fig. 1926, including cords, handles, and electrodes **£4 0 0**

The E.M.F. of the current can be varied gradually from 0·1 volt up to about 70 volts.

No. 1928. Transformer, with volt regulator, to apply the alternating current from the main as sinusoidal current *in a bath*, Fig. 1928 ... ... **£5 5 0**

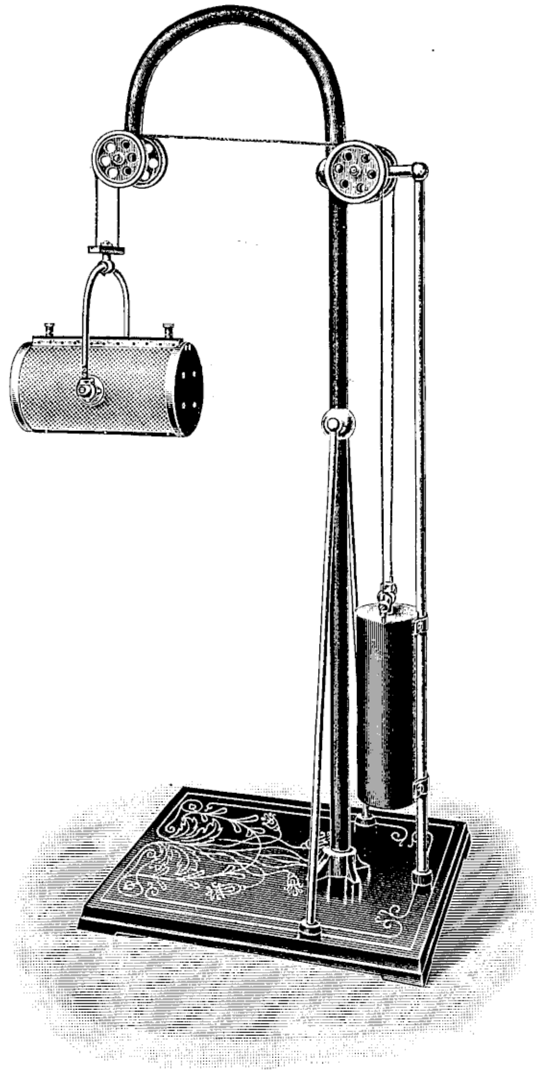
Before the alternating current from the main is applied in a bath, it should be transformed in order to protect the patient from shocks due to leakage (see pages 50 and 51).

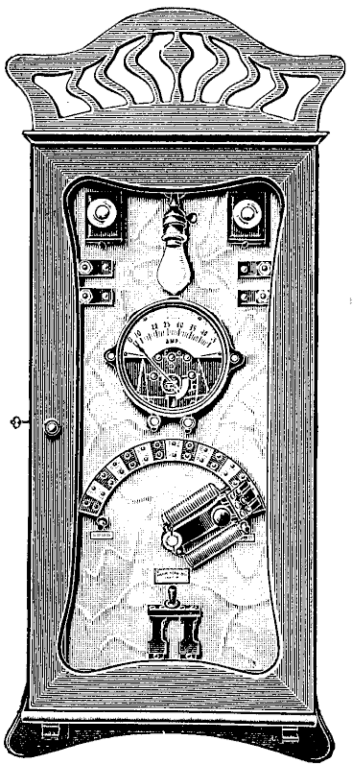
Motor transformers to convert a single phase alternating current from the main into a three phase sinusoidal current can be made. Estimates will be sent on application.

APPARATUS FOR ELECTRO-MAGNETIC THERAPY.

(See also page 60.)

If a patient is brought close to a powerful alternating current magnet, currents are induced in his body by induction ; flashes of light appear in the eyes, a sensation of warmth is produced, the secretion of saliva is stimulated, pains are diminished, and sleep is promoted ; it has a great sedative effect. Fuller information about this new kind of treatment will be found in the articles of Eulenburg, Ladame, Müller, Rodari, v. Sarbo, and others.





No. 1975.

No. 1970.

No. 1970.	Alternating current electro magnet of variable power, suitable for currents up to 40 ampères, suspended in a fork on a strong iron stand, with pulley and counterweight to fix the magnet at the correct height, Fig. 1970	£42	0	0
No. 1971.	Similar magnet, but smaller size, suitable for currents up to 20 ampères	35	0	0
No. 1975.	Switchboard, in case with glass door, containing switch, cut-out, crank to regulate the power of the magnet, Fig. 1975	23	0	0

If the current from the main is continuous, it has to be converted into an alternating current by means of a motor transformer. The price of such a transformer, suitable for 4,000 watts, including rheostats for starting and controlling the motor, is £46.

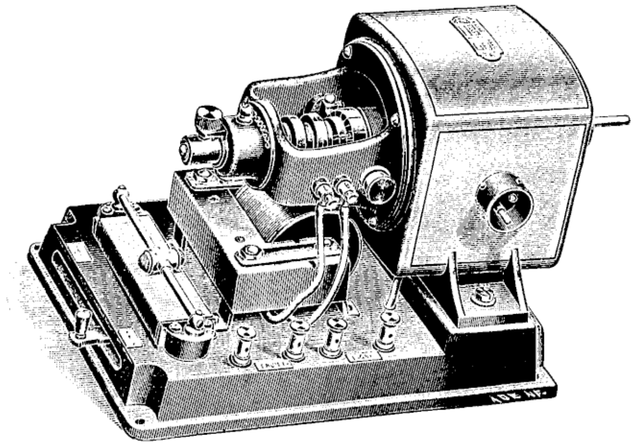
It can be demonstrated by simple experiments that powerful currents are induced by such a magnet. If a copper ring is held before the magnet, it becomes hot in a very short time, and it is repelled by the magnet as currents of similar polarity are induced in the ring. Three fingers are not sufficient to press the ring against the magnet.

If a solenoid is brought near the magnet, currents are induced in it which are sufficient to light an 8 volt lamp connected with this solenoid, even if it is at a distance of a few inches from the magnet.

The cost of a nickel-plated copper ring for the above experiment is 9/- The cost of a solenoid with incandescent lamp is 34/-.

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

(See also pages 52—56.)



No. 2000.

No. 2000. **Motor transformer,** to convert the continuous current from the main into an alternating current of low voltage, suitable for cautery burners requiring from 8 up to 18 ampères, and for all sizes of surgical lamps, Fig. 2000—

(*a*) Motor wound for 100 volts	£16	0 0
(*b*) " " 200 to 250 volts	17	10 0

The current for the cautery burners can be varied by the crank controlling the speed of the motor; the current for surgical lamps can be varied by a sliding rheostat.

No. 2000 (*a*) requires a current of 1·5 ampère; No. 2000 (*b*) requires 0·75 ampère. They can therefore be connected with any wall plug or lamp holder, without special wiring.

No. 2002. Similar motor transformer, but larger size, suitable for burners requiring up to 40 ampères—

(*a*) Motor wound for 100 volts	£23	0	0
(*b*) ,, ,, 200 to 250 volts	25	0	0

These motor transformers can also be used for surgical operations with drills, for applying massage and rapid vibration, for sinusoidal currents, and for working air pumps, ventilating fans, etc.

They are therefore very convenient for hospitals, and for many specialists.

The cautery burners used for eye and ear operations usually require 8 ampères; nearly all burners used for the nose and throat require 16 to 18 ampères. In gynæcology or for incisions in the prostate, larger burners, requiring up to 40 ampères, are being used; if it is attempted to connect one of these latter burners with No. 2000, the motor will be damaged; these *large* burners can only be used with a transformer No. 2002.

INTERRUPTER TRANSFORMERS FOR CAUTERY AND SURGICAL LAMPS.

(See also pages 53 and 54.)

The continuous current from the main is converted into an alternating current of low voltage suitable for cautery by means of an interrupter and a transformer, and for the surgical lamps by means of a shunt rheostat. The current for cautery can be varied gradually between 8 and 25 ampères, and the current for surgical lamps between 4 volts and 20 volts by sliding rheostats.

We have supplied our motor transformer No. 2000, amongst others, to :—

The Admiralty.

P. H. Abercrombie, M. F. Agar, H. S. Barwell, J. W. Bond, G. L. Cheatle, G. L. Cathcart, A. H. Cheatle, B. Dawson, F. S. Eve, W. Edmunds, R. J. Ferguson, A. S. Ferguson, R. H. Fox, J. D. Grant, L. Galsworthy, W. S. Hedley, H. T. Herring, W. J. Horne, G. W. Hill, P. S. Jakins, H. M. Jones, E. Kingscote, R. Lake, E. Law, W. Stuart Low, A. Lawson, W. Lloyd, G. W. Mackenzie, C. W. M. Moullin, B. Pollard, J. Pollard, H. W. F. Powell, C. A. Parker, L. H. Pegler, W. Rose, H. B. Robinson, A. Q. Silcock, J. Startin, B. H. S. Spicer, F. Spicer, J. Shaw, Sir F. Semon, A. H. Tubby, St. C. Thomson, H. Tilley, H. F Tod, W. H. White, H. F. Waterhouse, A. Wylie, D. Wright, T. O. Wood, C. A. Wright, in London.

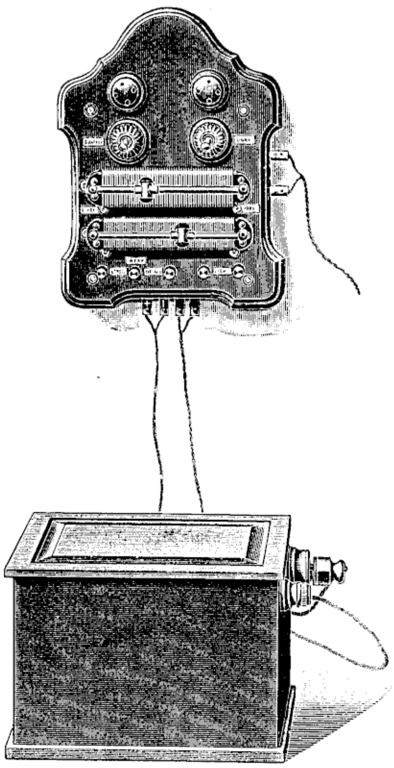
J. Macintyre, P. McBride, A. L. Turner, P. S. Hichens, B. S. Jones, etc., etc.

Charing Cross Hospital, New Hospital for Women; General Hospital, Northampton; East Suffolk and Ipswich Hospital, etc., etc.

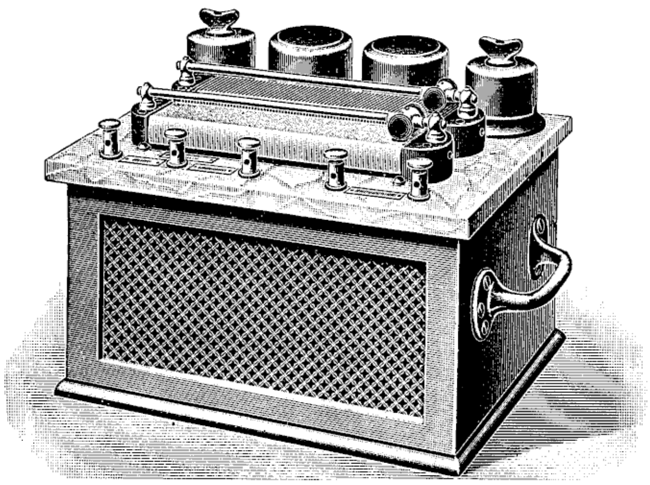
No. 2020. Interrupter transformer for cautery and surgical lamps, arranged on a switchboard to be fixed on the wall, and a separate box containing interrupter and transformer, as shown in Fig. 2020—

(*a*) For 100 volt circuits, **£11 0 0**

(*b*) For 200 to 250 volt circuits, **£12 0 0**



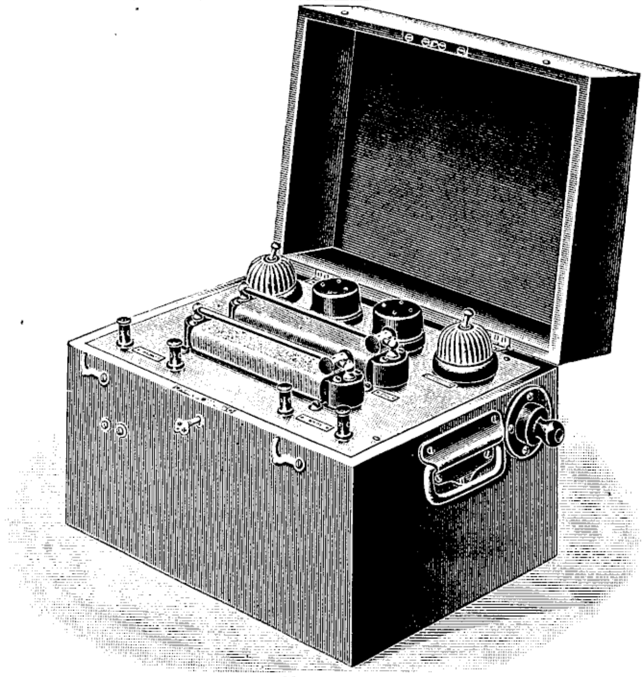
No. 2020.



No. 2023.

No. 2023. Similar apparatus, arranged with a marble top on which the rheostats, switches, etc., are fixed, Fig. 2023—

(*a*) For 100 volt supplies	**£12**	**10**	**0**
(*b*) For 200 to 250 volt supplies	**13**	**8**	**0**

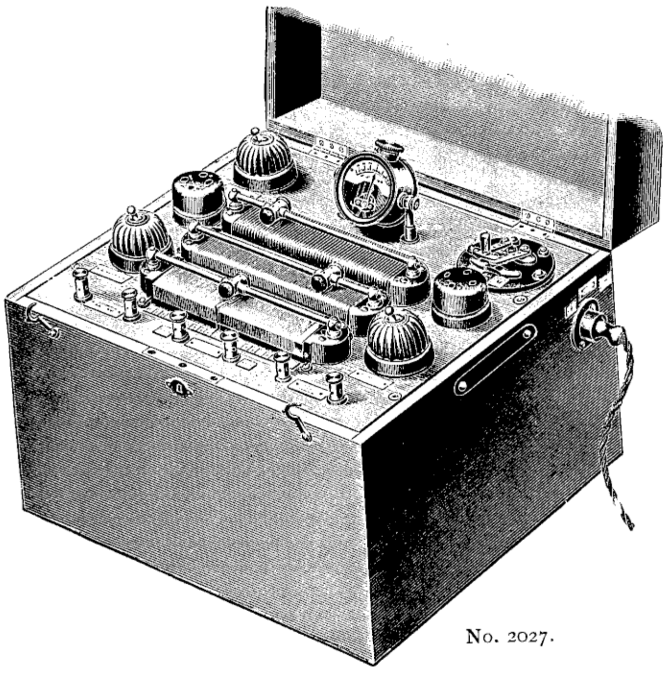


No. 2025.

No. 2025. Interrupter transformer for cautery and surgical lamps, arranged in portable oak box, as shown in Fig. 2025—

(*a*) For 100 volt circuits £14 0 0
(*b*) For 200 to 250 volt circuits 14 16 0

Size, 12 by 16 by 15 inches.



No. 2027.

No. 2027. Similar apparatus as No. 2025, but provided in addition with a volt selector for galvanisation and electrolysis, and with a galvanometer No. 281, Fig. 2027—

(*a*) For 100 volt circuits	£21	0	0
(*b*) For 200 to 250 volt circuits	22	0	0

No. 2029. Similar apparatus as No. 2025, but provided in addition with a volt selector for galvanisation and electrolysis, galvanometer No. 281, and a sledge coil No. 27 for faradisation, current reverser, and Dr. de Watteville's key—

(*a*) For 100 volt circuits	24	10	0
(*b*) For 200 to 250 volt circuits	26	0	0

The transformers Nos. 2020—2029 consume 3 ampères on a 100 volt supply, and 1·5 ampère on a 200 to 250 volt supply, while a cautery burner requiring 18 ampères is switched on. They can therefore be connected with any wall plug or lamp holder, without special wiring.

Cautery burners and lamps are quite independent from one another, and can be used simultaneously.

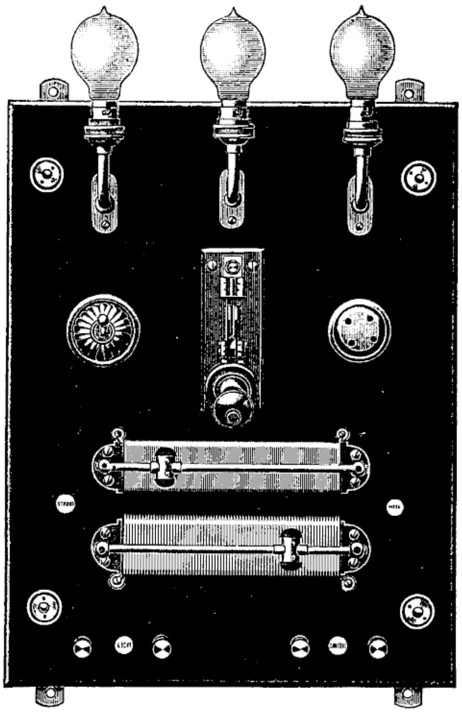
If the transformers are desired for large burners requiring up to 40 ampères, the prices mentioned above will be increased by £3 10s.

We have supplied our interrupter transformers Nos. 2020 and 2025, amongst others, to :—

P. S. Abraham, M. F. Agar, F. M. D. Berry, F. N. Boyd, H. T. Butlin, G. Carpenter, H. W. Carson, A. Carless, J. Calvert, E. Clarke, W. W. Cheyne, Sir A. Cooper, E. T. Collins, M. L. H. Cooper, H. Cripps, Sir A. Critchett, H. R. Crocker, F. S. Edwards, D. Ferrier, R. J. Godlee, C. Gipps, R. M. Gunn, G. H. Graham, F. de H. Hall, R. Harrison, W. J. Hancock, R. J. B. Howard, Sir V. Horsley, J. Hitchinson, F. M. Hovell, R. Johnson, H. Juler, A. C. Keep, H. Lack, J. E. Lane, W. F. Lister, J. B. Lawford, W. Lane, L. H. McGavin, M. McDonald, J. MacGregor, S. Paget, J. Palmer, G. C. S. Perkins, W. A. Propert, J. J. Pringle, H. Power, H. M. Rigby, E. W. Roughton, C. H. Roberts, A. B. Roxburgh, A. J. M. Routh, A. W. M. Robson, M. Scharlieb, J. Shaw, K. Shaw, M. Smale, W. T. H. Spicer, W. R. H. Stewart, W. A. Turner, W. Turner, F. C. Wallis, H. R. Walker, H. J. Waring, W. A. Wills, A. P. L. Wells, G. B. White, C. E. Woakes, D. D'A. Wright; St. George's Hospital; Westminster Hospital, etc., in London; and many surgeons and hospitals in the country.

RHEOSTATS FOR CAUTERY, SURGICAL LAMPS, ARC LAMPS FOR TREATING LUPUS, ETC.

(See also pages 54 and 55.)



No. 2040.

No. 2040. Shunt rheostat, mounted on enamelled slate. The resistance for cautery consists of platinoid wire of $\frac{1}{8}$ in. thick, switch, signal lamp, and adjustable rheostat to vary the current for the cautery burners gradually from 8 up to 20 ampères. The shunt rheostat for the surgical lamps consists of switch, fuse, two resistance lamps, and a sliding rheostat—

(*a*) For 100 volt circuits	**£10**	**10**	**0**
(*b*) For 200 to 250 volt circuits	**12**	**10**	**0**

The rheostats may also be used to control the current for spark coils, for X-ray purposes, and for arc lamps for treating lupus, etc. The latter require 50 to 60 volts, and about 20 ampères; the former require 30 to 80 volts, and 2 to 20 ampères. To suit these requirements, the rheostats have to be provided with a crank, as shown in Fig. 2044, by means of which the voltage can be altered, so that either 30, 40, 50, 60, 70, 80, or 90 volts are available at the terminals.

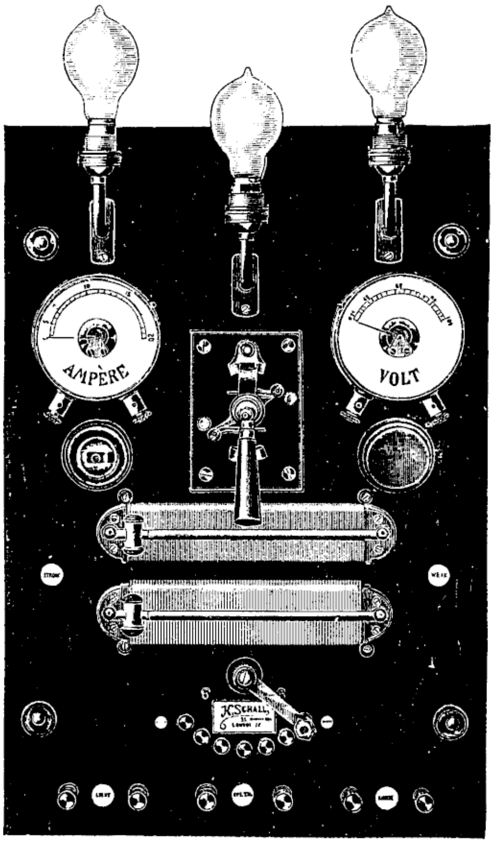
No. 2044. Rheostat for cautery, surgical lamps, arc lamps, and spark coils, with crank to vary the voltage, and sliding rheostat to control the ampères, Fig. 2044—

(*a*) For 100 volt supplies **£12 10 0**

(*b*) For 200 to 250 volt supplies **£15 0 0**

The addition of a volt and ampère meter Nos. 963 and 964 (as shown in illustration Fig. 2044) increases the price by £3 10s.

The addition of dead-beat volt and ammeter Nos. 968 and 969 increases the price by £8.



No. 2044.

The cables and fuses leading to the rheostats Nos. 2040—2044 must be of such a size that they can carry a current of 20 ampères without becoming hot.

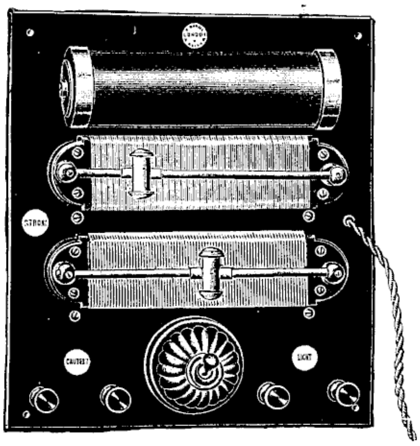
The rheostats Nos. 2040—2044 have been supplied, amongst others, to:—

Drs. Mackenzie, Hans Place; C. L. Sansom, H. Gage Brown, W. Tyrell, F. Naumann, L. Stevens, H. Lovell, E. Cotterell, T. Fallows, G. Stoker, London; Macintyre, Glasgow; Milligan, Manchester; Ballance, Norwich; Grossmann, Bark, Bickerton, Wilson, McDougall, Liverpool; McBride, Edinburgh; McIntosh, St. John's, Newfoundland; Dr. Brown, Preston; G. W. Mackenzie, William Street; H. Symonds, Oxford; Prof. Ogston, Aberdeen; Dr. Furlong, Dublin; Dr. Reid, Canterbury, etc.

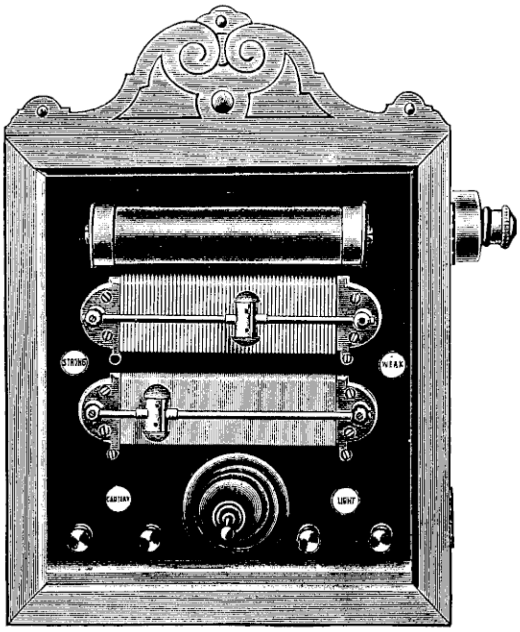
St. Bartholomew's, Charing Cross, King's College, Cancer, and St. Peter's Hospitals, Royal Westminster Ophthalmic Hospital, Poplar Hospital, Italian Hospital, Royal London Ophthalmic Hospital, Victoria Hospital, Chelsea, etc., etc.; Sussex County Hospital, Brighton; Throat Hospital, Hartmann Street, Manchester; Ear Hospital, Manchester; Infirmary, Lancaster; Royal Infirmaries—Aberdeen, Edinburgh, Hull, Glasgow, and Manchester; New General Hospital, Birmingham; Norfolk and Norwich Hospital; Queen's Hospital, Birmingham; West Riding Asylum, Wakefield; Royal Devon and Exeter Hospital, Blackburn Infirmary, Metropolitan Electric Supply Company, Westminster Electric Supply Company, City of London Electric Lighting Company, Chelsea Electricity Supply Company; Electric Light Companies in Newcastle-on-Tyne, Reading, Nottingham, etc.

TRANSFORMERS TO USE THE ALTERNATING CURRENT FROM THE MAINS FOR CAUTERY BURNERS AND SURGICAL LAMPS.

(See also pages 59 and 60.)



No. 2050.



No. 2054.

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, $9\frac{1}{2} \times 9\frac{1}{2} \times 2\frac{1}{4}$ inches.

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

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

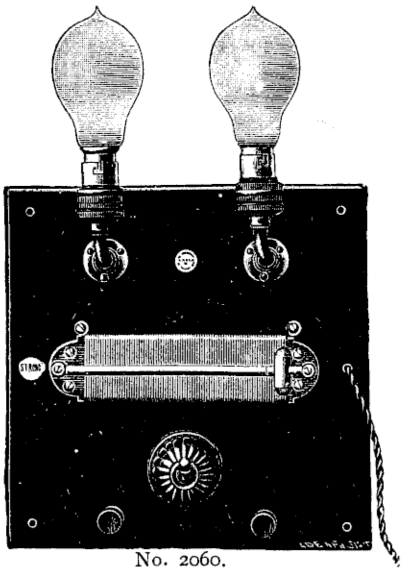
Polished wooden frame with glass door, as shown in Fig. 2054, to protect the transformer from dust, etc. 1 5 0

Our transformer No. 2050 is now used by over 800 medical men and hospitals, which is the best proof of its convenience and reliability.

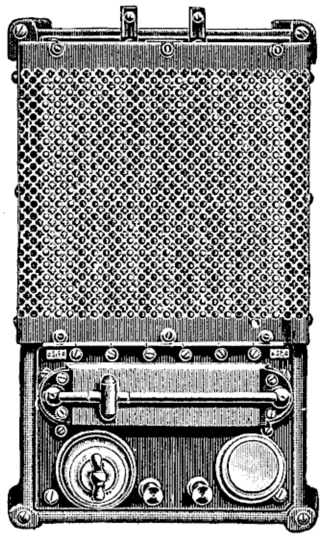
RHEOSTATS FOR SURGICAL LAMPS.

(See also page 56.)

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. 2063.

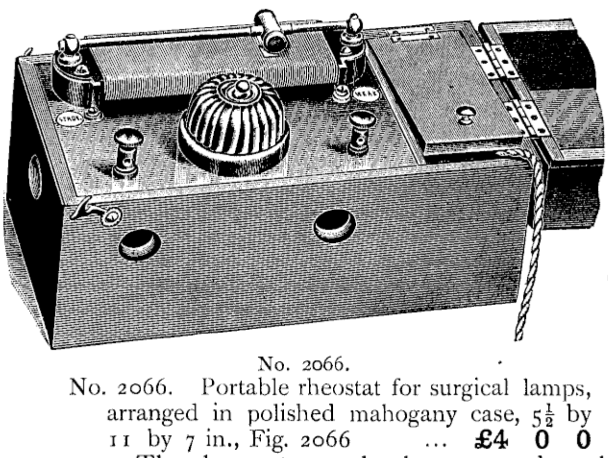
No. 2060. Rheostat consisting of two lamps, sliding rheostat, switch, and terminals, mounted on enamelled slate, suitable for all sizes of surgical lamps, Fig. 2060 ... **£3 0 0**

No. 2063. Rheostat, for the same purpose as No. 2060, but with a wire resistance instead of the two lamps, Fig. 2063—

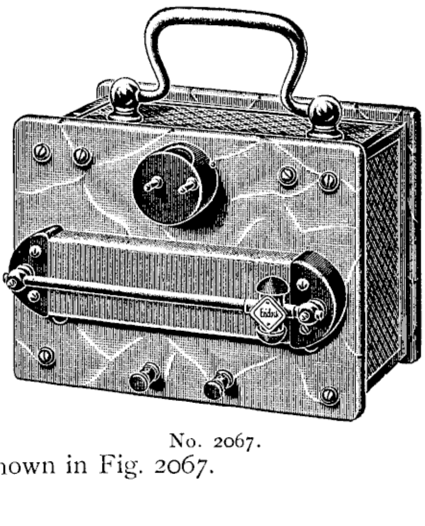
(*a*) For 100 volt supplies **3 10 0**

(*b*) 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.



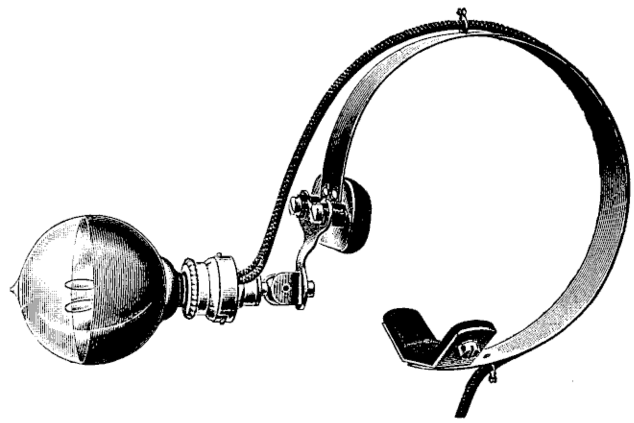
No. 2067.

No. 2066. Portable rheostat for surgical lamps, arranged in polished mahogany case, 5½ by 11 by 7 in., Fig. 2066 ... **£4 0 0**

The rheostat can also be arranged as shown in Fig. 2067.

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.



No. 2080.

No. 2080. Forehead lamp, with incandescent lamp, Fig. 2080 ... **£2 6 0**

This lamp is useful for the operating table to illuminate a large surface; the light cannot be concentrated on small spots, because there is no lens as in No. 1214. For the larynx, nose, ear, etc., the latter is more suitable than No. 2080.

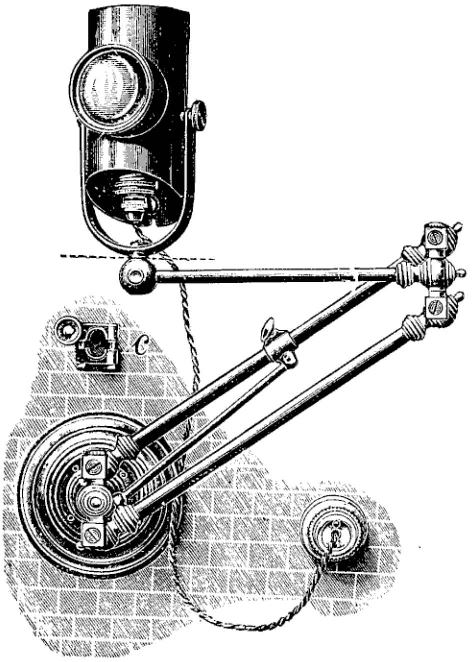
The lamps Nos. 2090—2101 can be provided either with incandescent lamps, which have a carbon filament arranged in a zig-zag in the centre of the glass bulb (so-called focus lamps)—they give a light of 32 to 50 candle-power, and spare lamps cost 3s., including postage—or else they can be provided with Nernst lamps, which give a whiter light of 60 to 100 candle-power; the "Luna" type of these lamps is the most suitable one for use with bull's-eye lenses. As far as homogeneous illumination, *i.e.*, absence of bright or dark parts, is concerned, the light of these "Luna" 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. The price of the complete lamp is 22s.; the price of the spare burners 3/6, including postage.

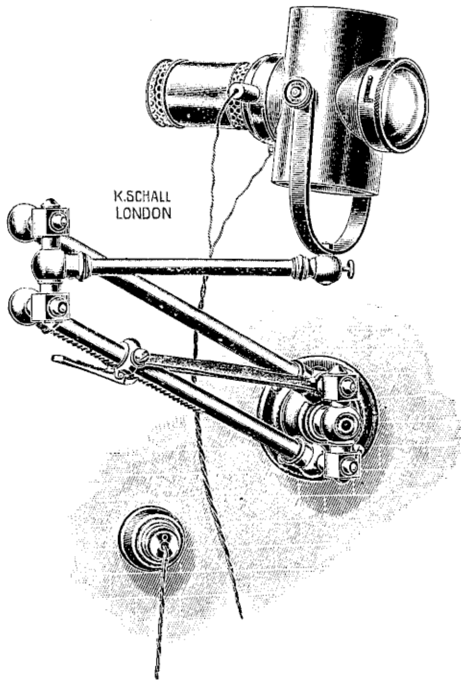
It must be clearly understood that we do not hold ourselves responsible for these burners.

When ordering these 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 "Luna" Nernst lamps, as shown in Fig. 2090A, £1 1s. has to be added to the prices.

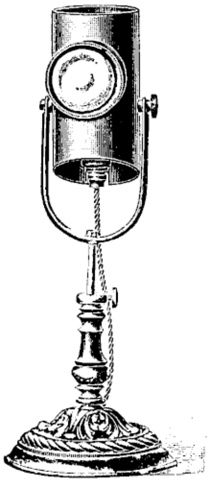


No. 2090.

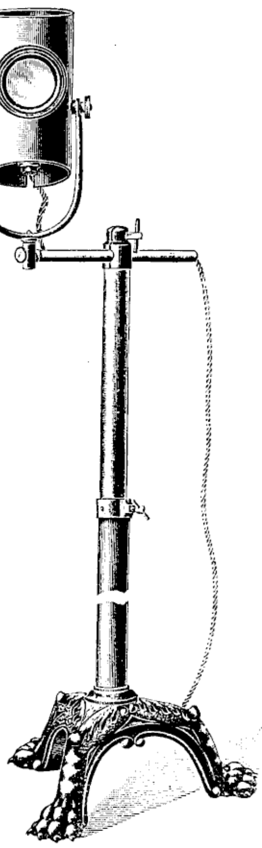


No. 2090A.

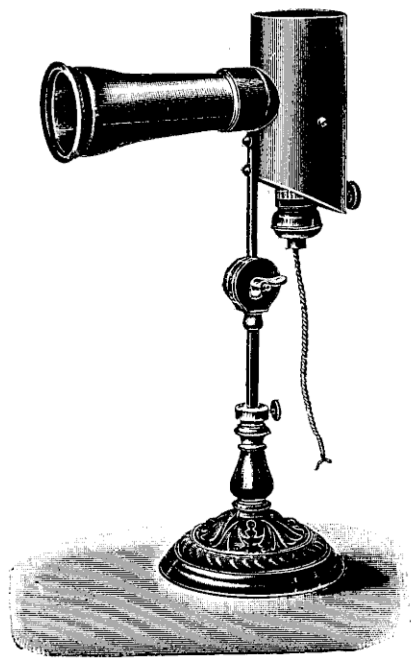
		£	s.	d.
No. 2090.	Dr. MacDonald's lamp, with bull's-eye, for throat, nose, and ear examinations, and for surgical operations. The lamps are movable in any direction, and can be taken off the bracket and used as hand lamps. Price, with parallel bracket, as shown in illustration, and with a 32 candle-power focus lamp, Fig. 2090 ...	£4	4	0
No. 2092.	A concave mirror with ball joint can be fixed on the lamps Nos. 2090—2101 instead of on the forehead of the operator. Price of the mirror	0	15	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	2	0	0



No. 2098



No. 2101.



No. 2106.

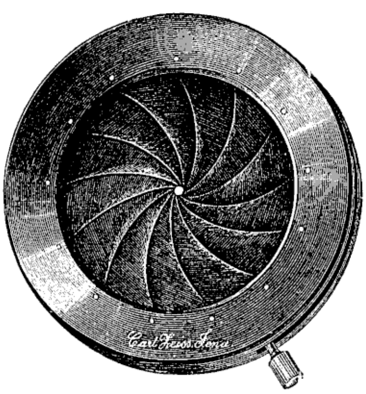
No. 2098.	Dr. MacDonald's lamp on a stand, to be put on a table, Fig. 2098	£2 10 0
No. 2101.	Dr. MacDonald's lamp on a telescopic stand, as shown in Fig. 2101	3 16 0
No. 2106.	The lamps Nos. 2090—2101 can be provided with a Telschow's tube, as shown in Fig. 2106, instead of the single bull's-eye lens; the additional cost of this system of lenses is	1 10 0

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

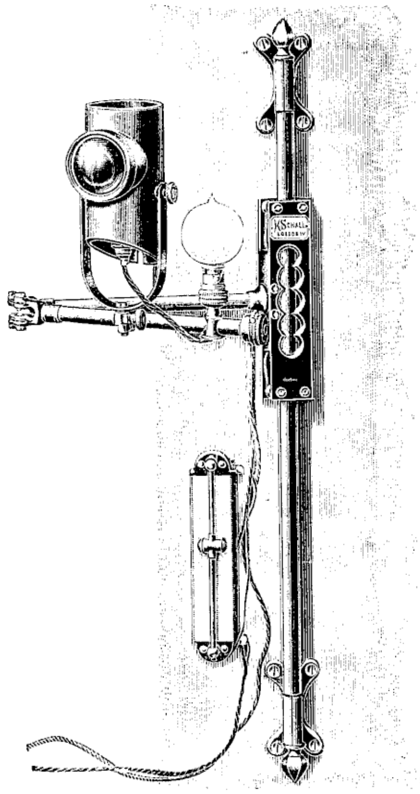
Dr. Greville MacDonald, Sir Francis Laking. Sir Victor Horsley, Sir Felix Semon, Drs. J. Macintyre, F. Spicer, S. Spicer, Rice Oxley, Percy Jakins, E. Law, Prof. Ogston, Prof. Rose, and over 260 other surgeons.

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, etc., etc.

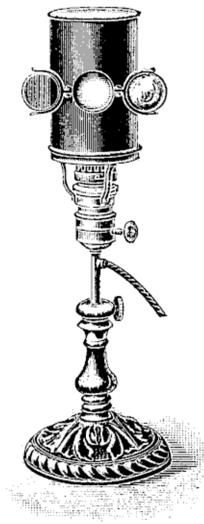
To the Governments of Natal, India, etc., etc.



No. 2108.



No. 2114.



No. 2110.

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

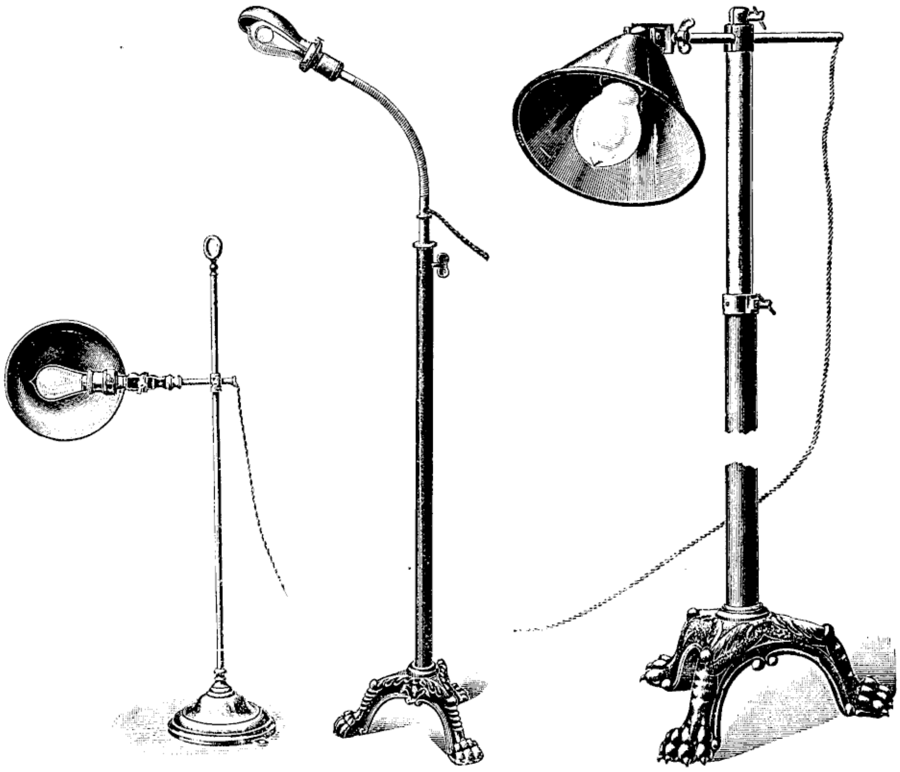
The bull's-eye lens of the lamps Nos. 2090—2101 can be removed and the iris diaphragm can be inserted instead. The intensity of the light can be varied gradually by means of this diaphragm from ½ candle-power up to about 10 candle-power, ***without varying the colour of the light***, which is important for ophthalmoscopic purposes. The frosted glass destroys any trace of the carbon filament.

No. 2110. Ophthalmoscopic lamp, with frosted glass disc, yellow screen and lens, which can be placed separately or simultaneously over the aperture, Fig. 2110 ... **£3 12 0**

No. 2114. Ophthalmoscopic bracket, Fig. 2114, with frosted lamp and switch **3 3 0**

This bracket can also be supplied on a stand, as shown in Fig. 2101.

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



No. 2117. No. 2125. No. 2127.

No. 2117. Table lamp, Fig. 2117, with reflector and ball joint ... £2 6 0

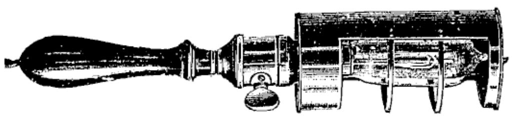
No. 2125. Lamp on telescopic stand, and mounted on a flexible metal spiral movable in any direction, with reflector, Fig. 2125 ... ... 3 0 0

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 the 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.

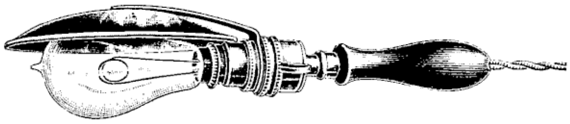
No. 2127. Large lamp on telescopic stand, with reflector, Fig. 2127 £3 0 0

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



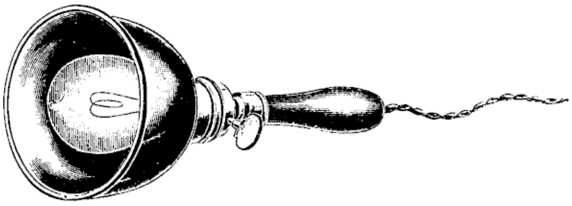
No. 2130.

No. 2130. Hand lamp, with reflector and switch, Fig. 2130 ... £1 15 0



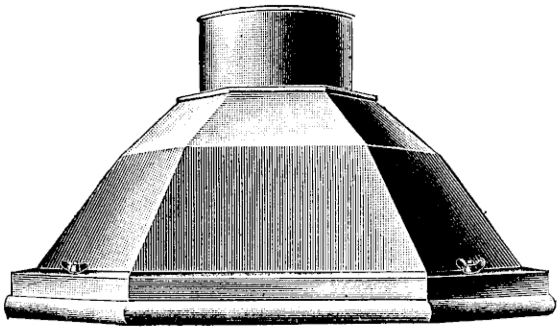
No. 2131.

No. 2131. Hand lamp, with reflector and switch, Fig. 2131 ... £1 4 0

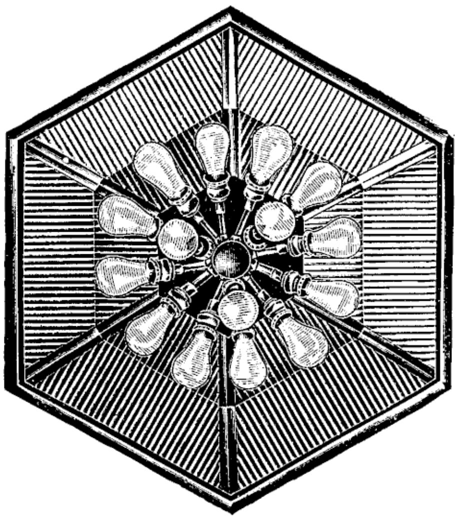


No. 2132.

No. 2132. Hand lamp, with reflector and switch, Fig. 2132 ... £1 0 0



No. 2145A.



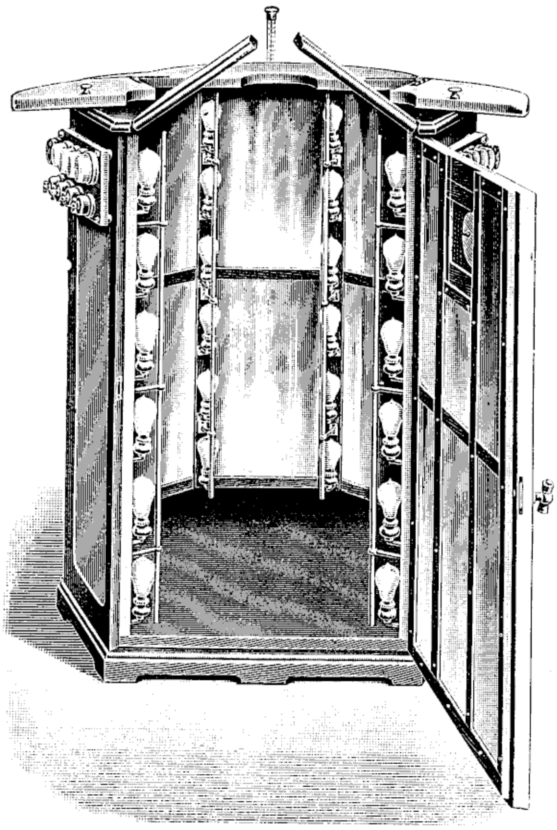
No. 2145B.

No. 2145. Large reflector for operating tables, with sixteen incandescent lamps, fluted mirrors, porcelain screen to give a homogeneous light, and ventilating arrangement, Figs. 2145A and 2145B £12 10 0

No. 2147. Similar reflector, but smaller size, for ten lamps only ... 5 10 0

ELECTRIC LIGHT AND HOT AIR BATHS.

(See also pages 57 and 58.)



No. 2176—OPEN.

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. Kellog, 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 were so favourable that apparatus for this kind of treatment have come into general use.

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, as dry heat is more pleasant than moist heat.

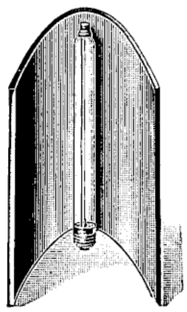
These light baths can be used equally well with a continuous or an alternating current. In ordering, it is necessary to state the number of volts of the supply, and, if arc lamps are desired, it is necessary also to mention whether the current is continuous or alternating.

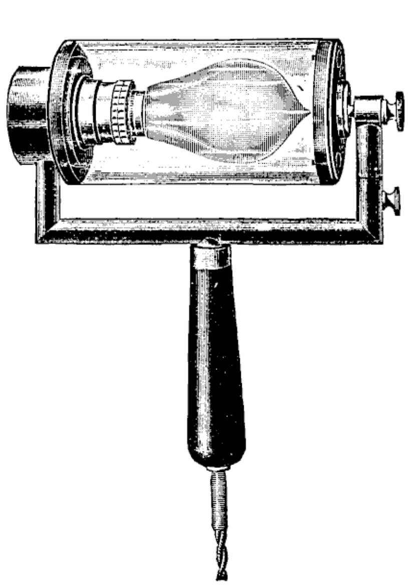
All the light baths are lined with mirrors, or with white porcelain plates ; the latter have a slight advantage because they reflect the light and heat rays better than the mirrors can do.

If desired, the light baths can be made so that there is no wood or metal inside, and that the lamp holders are turned downward and enclosed in porcelain. If thus arranged, the cabinets can be flushed with water and disinfectants for cleaning purposes.

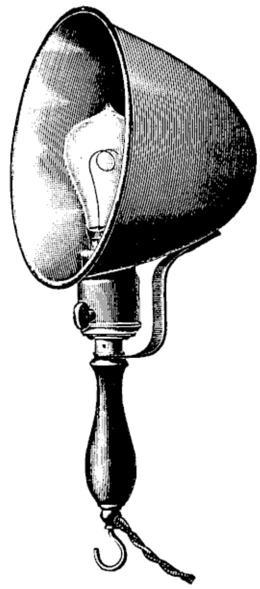
Most of the baths are fitted with white (or coloured) incandescent lamps only, but some are provided with arc lamps as well. These arc lamps give, of course, a higher candle-power and greater stimulation, but it is a mistake to suppose that their light is sufficiently powerful to kill bacteria ; the apparatus required for the latter purpose will be described later under Nos. 2300—2350.

If desired, parabolic reflectors can be placed behind straight lamps (as shown in illustration) ; this has the advantage that the light is used more economically, and that less heat is generated. If ordinary incandescent lamps are being used, only a small portion of the light reaches the patient, the greater part is wasted in illuminating and heating the walls of the cabinet and the air; the shell-shaped reflectors, which are now and then placed behind the lamps, do not alter this state of affairs, but with the parabolic reflectors and straight lamps the amount of light reaching the patient is increased, and the temperature of the surrounding air is kept lower, and less current is consumed.



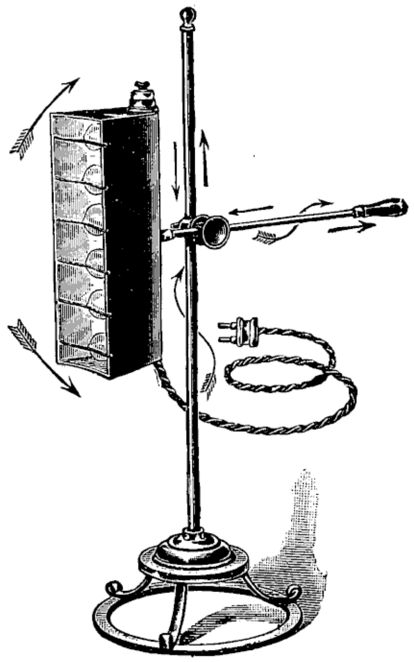


No. 2150.

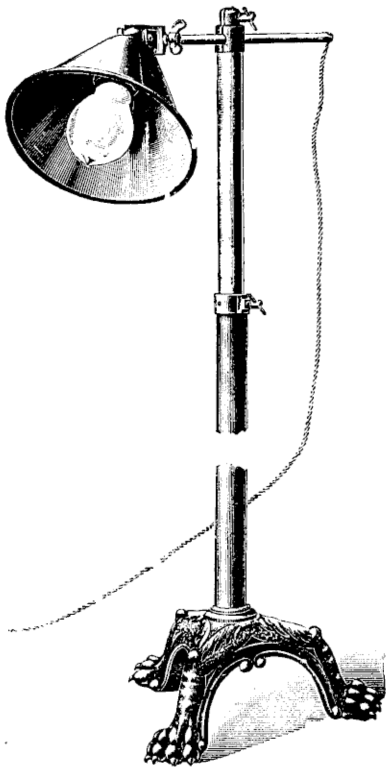


No. 2153.

No. 2150. Massage roller, with incandescent lamp, Fig. 2150	£1	12	0
No. 2153. Hand lamp, with parabolic reflector, Fig. 2153	1	12	0

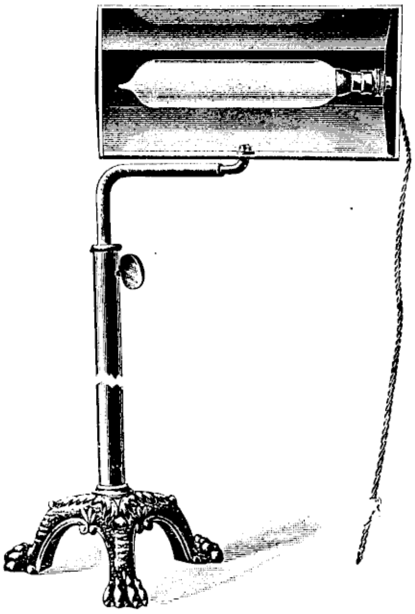


No. 2157.

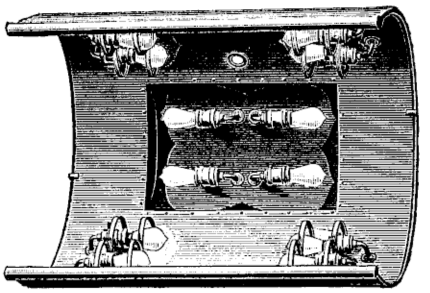


No. 2155.

No. 2155. Telescopic stand, with lamp and parabolic reflector, Fig. 2155	£3	0	0
No. 2157. Reflector, with six lamps, movable in any direction. Switch to turn on either three or six lamps, Fig. 2157	7	0	0



No. 2159.

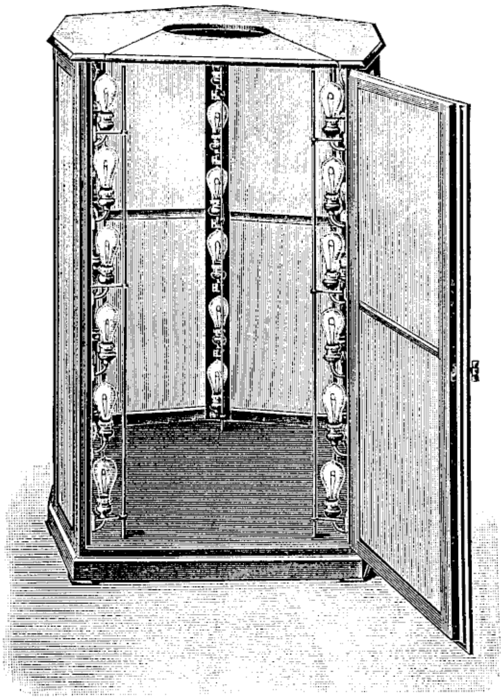


No. 2165.

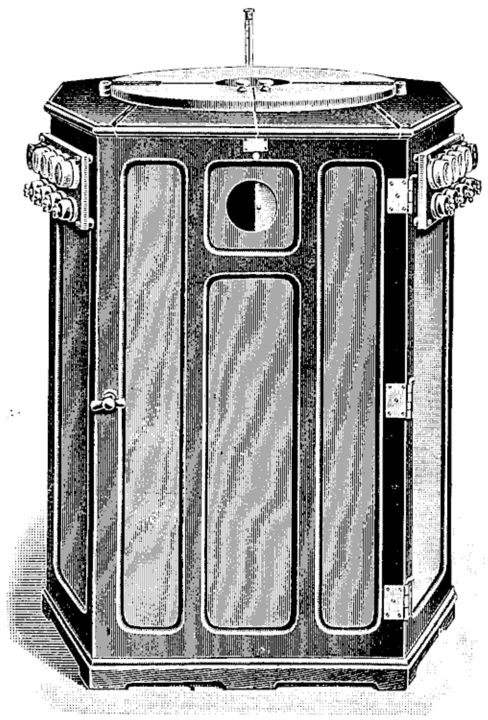
No. 2159.	Reflector, on telescopic stand, with one large cylindrical lamp, Fig. 2159, for local applications while the patient is lying in bed	£3 0 0
No. 2165.	Frame, with twelve lamps, suitable to be placed over a patient lying in bed, Fig. 2165	9 0 0

No. 2170. Plain light bath, with twenty-one lamps of 32 candle-power, lined with mirrors or porcelain plates, two switches, fuses, and thermometer. Size, 4 ft. long by 3 ft. 4 in. wide by 4 ft. 4 in. high, £22 0 0

No. 2172. Similar bath, but fitted with forty-two lamps, Fig. 2172, £25 0 0



No. 2172.



No. 2176—CLOSED.

No. 2176. Prof. Winternitz's light bath, Fig. 2176, with forty-eight incandescent lamps, eight switches, and eight fuses to switch the lamps on or off in groups of six lamps at a time; thermometer and wicker cane chair, which can be raised or lowered. The sides are lined with mirrors or porcelain plates, the floor is covered with linoleum, and at the top is a diaphragm which opens like a pair of scissors to enclose the neck of the patient. The diaphragm can be removed if the patient desires to have his shoulders and arms outside the bath **£38 0 0**

Size: Diameter 4 ft.; height 4 ft. 4 in. The bath can be taken in two pieces so that it will pass through any door.

We have supplied the light bath No. 2176, amongst others, to :—

H.R.H. the Duchess of Fife, H.G. the Duke of Portland, 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, etc., etc.

To the Bath Club in Dover Street, the Turkish Baths at Earl's Court, Wolverhampton, Birmingham, Hydropathic Establishment in Peebles, Rothesay, Tunbridge Wells, Helouan and Sydney, the Keighley Corporation, etc., etc.

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

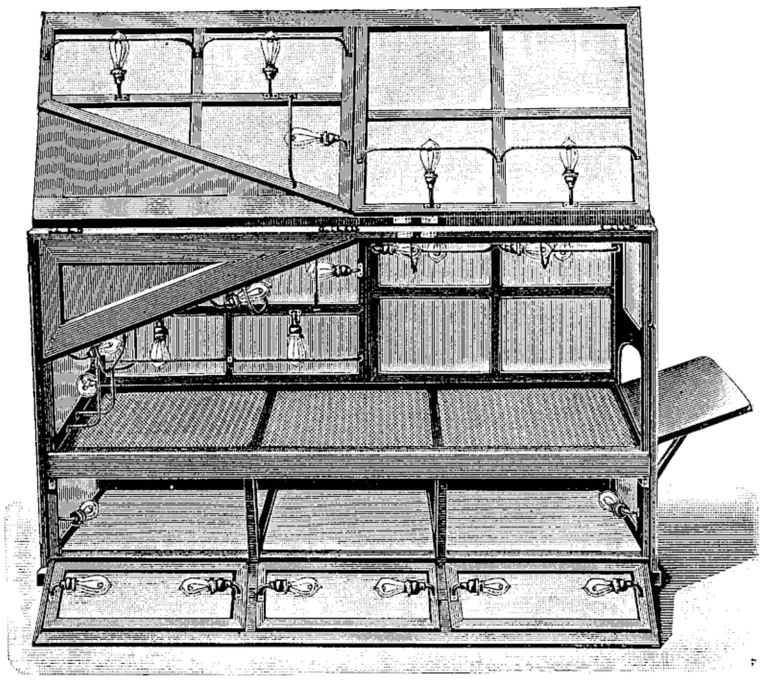
If the lamp holders, etc., are enclosed in porcelain, so that the bath can be flushed with the fire hose, the price will be increased by £6.

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.

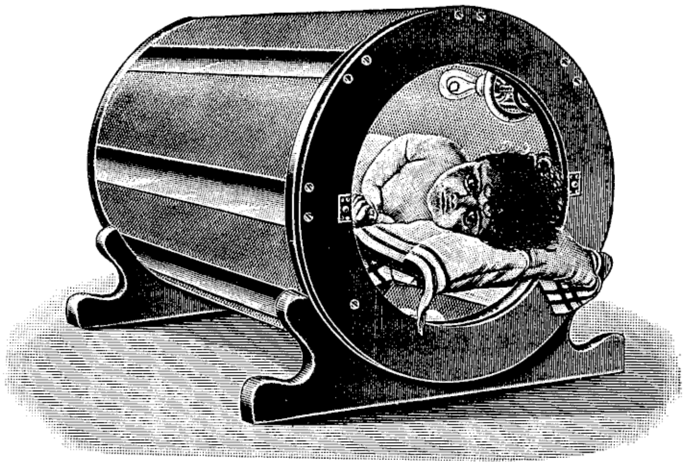
No. 2178. Light bath, with seventeen parabolic reflectors and straight lamps, chair, thermometer, switches, and fuses **£48 0 0**

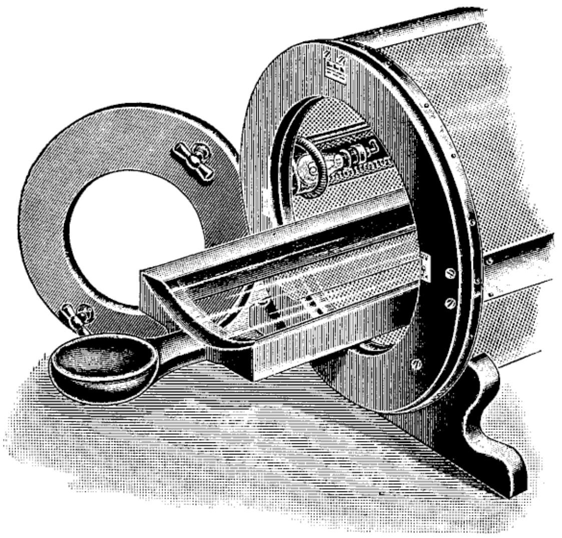
This light bath is similar to the one illustrated in Fig. 2192, but the arc lamps shown there are not supplied with No. 2178.



No. 2180.

No. 2180. Light bath, to receive the patient in a lying position, Fig. 2180. The cabinet is lined with white porcelain plates or mirrors, is fitted with thirty-six incandescent lamps divided into six groups, six switches and fuses, thermometer, etc. **£43 0 0**

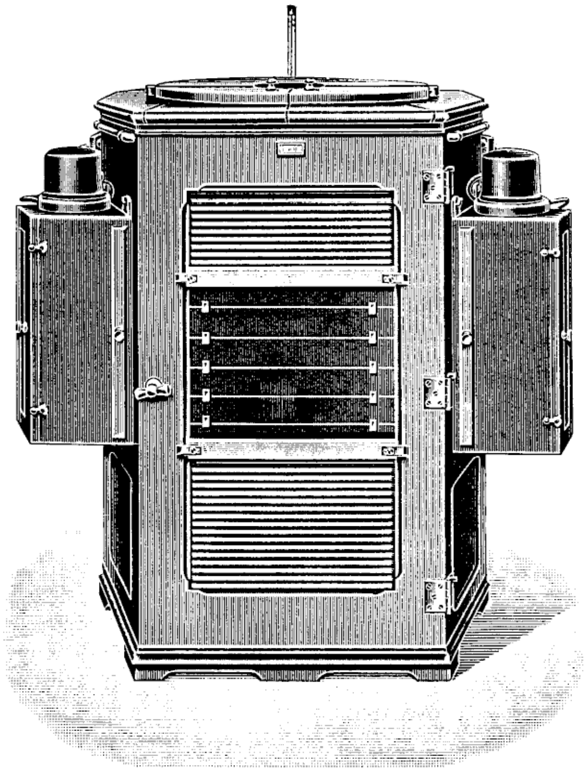




No. 2181.

No. 2181. Light bath for babies and children up to about six years, Fig. 2181. The bath is enclosed by a perforated zinc sheet, so that the air can circulate; it is fitted with eighteen lamps divided into six groups, six switches and cut-outs. The lamps are well protected, so that they cannot be touched or smashed. The child is placed on a slide of glass ... **£24**

LIGHT BATHS WITH ARC LAMPS, AND COMBINED LIGHT BATHS, FITTED WITH INCANDESCENT AND ARC LAMPS.

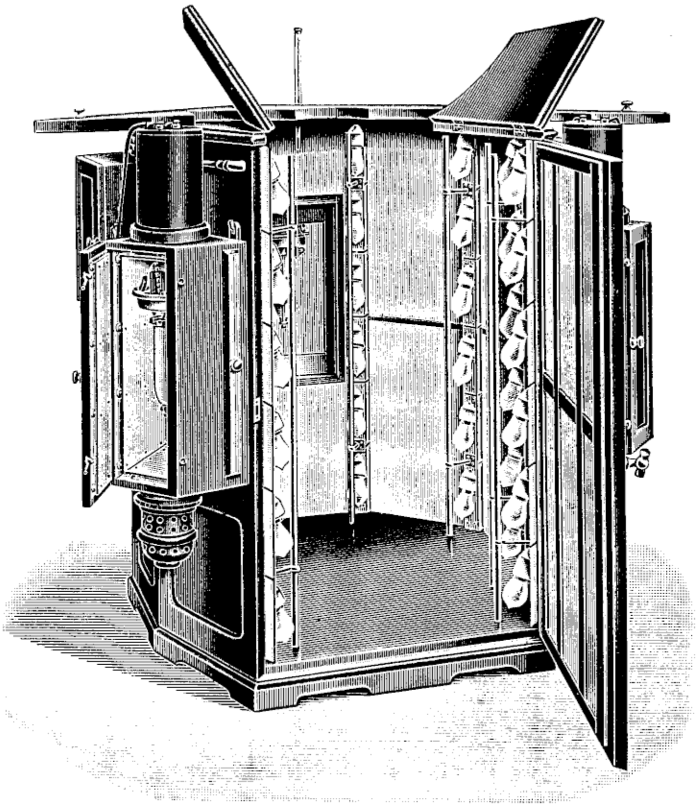


No. 2182.

No. 2182. Light bath with four arc lamps for continuous current, consuming about 10 ampères each, Fig. 2182. The cabinet is lined with white porcelain plates or with mirrors; the floor is covered with linoleum. Price including chair, thermometer, and diaphragm at the top **£37 0 0**

Size: Diameter 4 ft.; height 4 ft. 4 in.

No. 2184. Similar bath, but with arc lamps for alternating current **40 0 0**

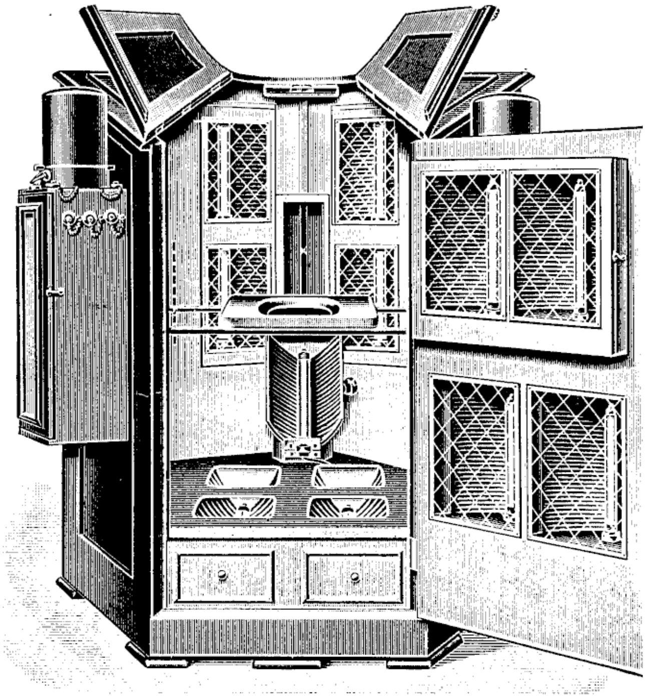


No. 2186.

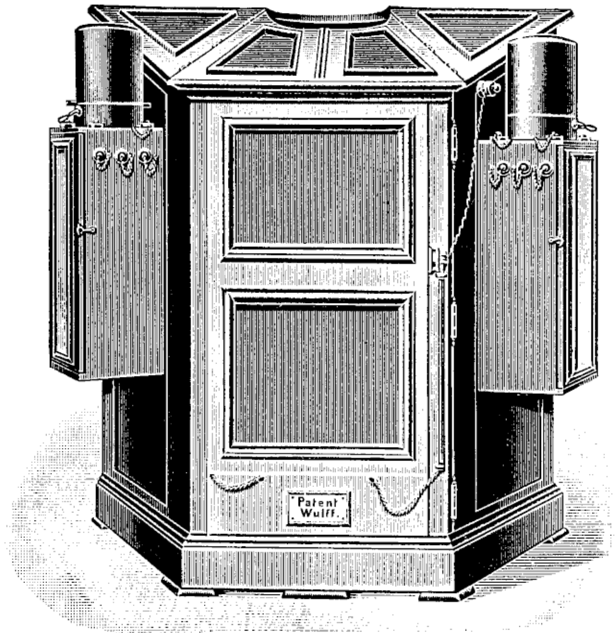
No. 2186. Light bath, as described under No. 2182, with four arc lamps for continuous current, and provided in addition with twenty-four incandescent lamps, and the necessary switches and cut-outs £47 0

No. 2188. Light bath, as described under No. 2184, with four arc lamps for alternating current, and provided in addition with twenty-four incandescent lamps, switches, etc. 50 0

If Nos. 2186 or 2188 are provided with forty-eight incandesce lamps instead of twenty-four, the prices will be increased £6.



No. 2192—OPEN.

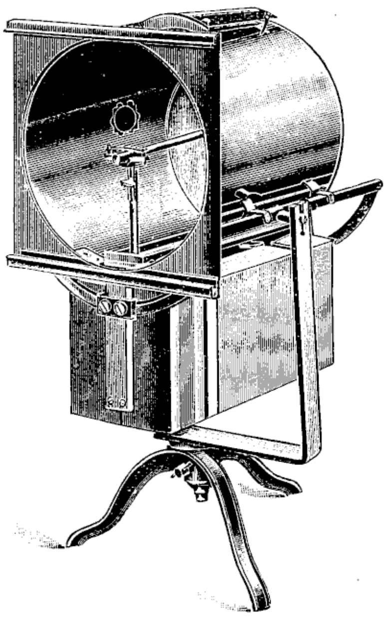


No. 2192—CLOSED.

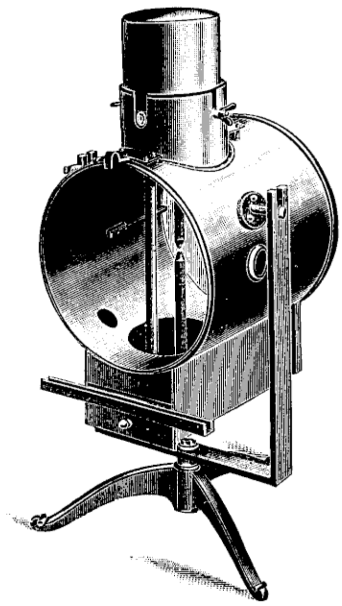
(For Description, see page 240.)

No. 2192. Light bath with seventeen straight incandescent lamps and parabolic reflectors, and three arc lamps for continuous current, Fig. 2192. The cabinet is lined with white porcelain plates or mirrors, is provided with a chair, thermometer, and diaphragm **£66 0 0**

No. 2194. Similar bath, but with arc lamps for alternating current **68 10 0**



No. 2220.



No. 2220A.

No. 2220. Powerful arc lamp, self-regulating, with parabolic reflector of magnalium in strong brass tube, mounted on a stand so that the lamp can be turned in any direction, and provided with a frame to hold glass plates of various colours **£12 15 0**

The lamps can be arranged for 10, 20, 25, or 30 ampères, and require 50 to 60 volts. Fig. 2220 shows the lamp for continuous current; Fig. 2220A shows the lamp for alternating current.

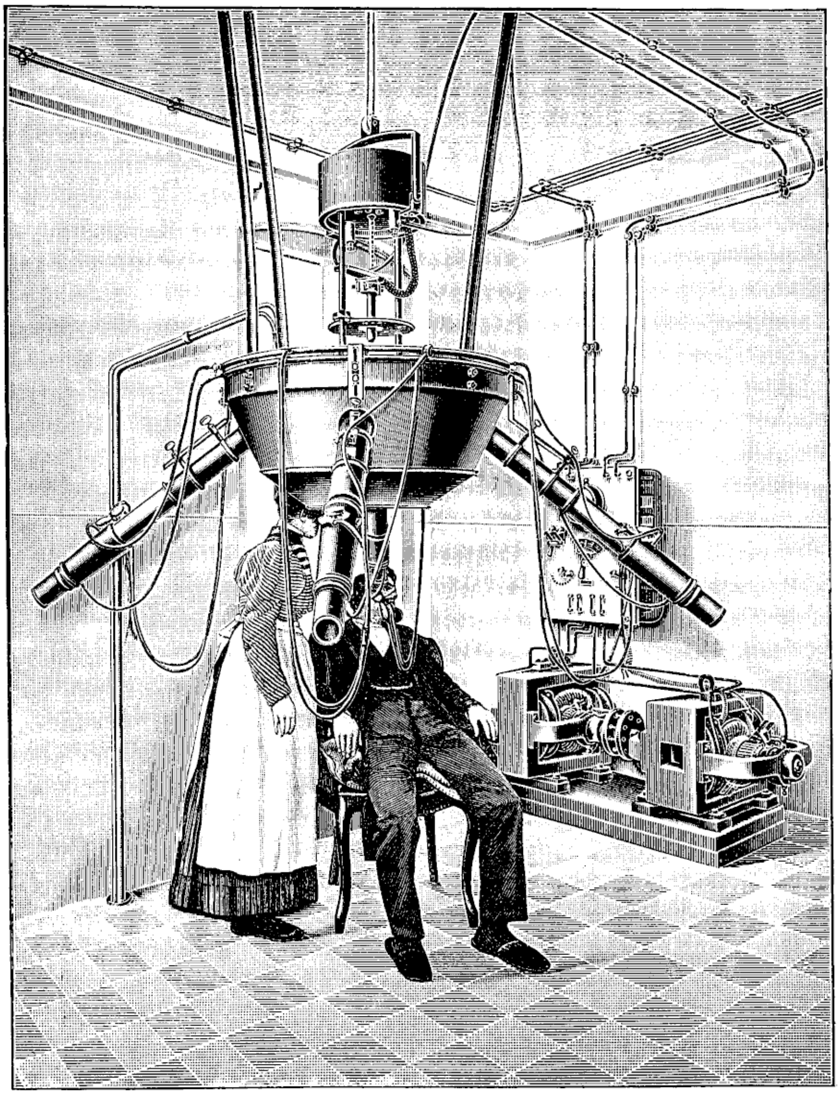
Rheostats, to use these lamps on 100 to 250 volt circuits, vary from £2 10s. to £8 according to the voltage of the supply, and the number of ampères required for the lamp.

No. 2225. Similar lamp, but "hand fed" **£7 10 0**

APPARATUS FOR THE TREATMENT OF LUPUS, ETC.

By Prof. Finsen's Method.

(See also pages 56—58.)



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 uses either sunlight, or more frequently 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 ½ in. 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 Finsen lamp, but the original pattern is a little wasteful, as some light is lost before it reaches the patient, on account of the great distance between the patient and the source of light.

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 lamp, but shorter, is in front of the arc lamp. Only one patient can be treated at a time. Several lamps of this type are in constant use in the London Hospital, and many other hospitals have taken them up.

The Lortet-Genoud lamp is similar, but less powerful (the arc lamp requires about 10 ampères), and is "hand fed," *i.e.*, the carbons must be brought together till they touch, and then be separated by hand till the proper distance is reached. After burning for 5 to 10 minutes the carbons have to be brought a little nearer together again.

Hand lamps consuming 8 to 10 ampères have been constructed by Dr. Strebel and others, and ultimately the light of sparks from large Leyden jars can 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.

The ordinary carbons used for arc lamps are generally used, but some time since carbons specially prepared for these lupus lamps have come on the market. It is claimed that they give twice as much ultra violet light and blue rays as the ordinary carbons do, and, if this is so, it will be a great saving in the consumption of current, and especially in the time of exposure. These carbons are, however, rather expensive.

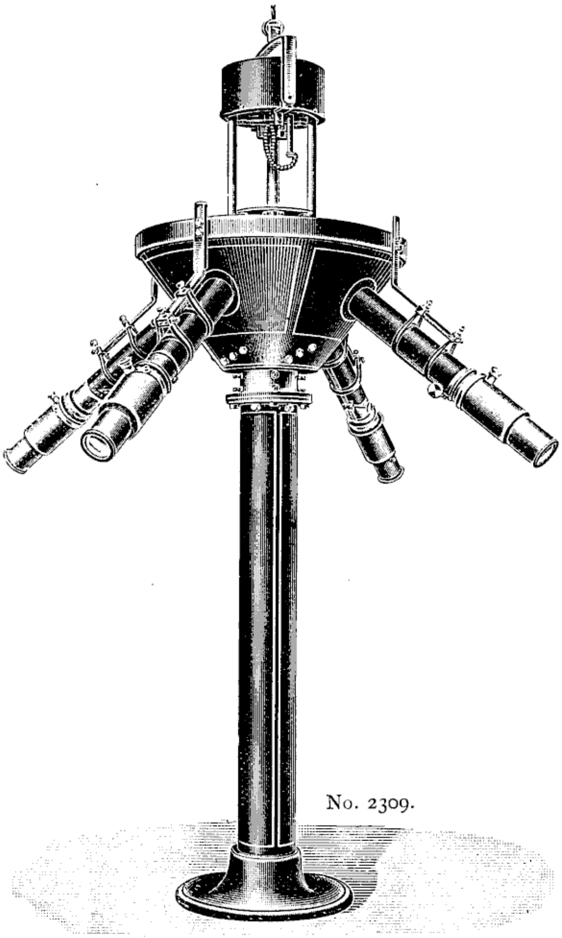
Whatever lamp is being used, the tissues must be made anæmic by pressure, and for this purpose the compressors (lenses of quartz, or pieces of rock salt or ice) are pressed firmly against the skin, either by bandages or with the hand.

No. 2300.	Large arc lamp for 60 volts and 50 ampères, with automatic regulation	£7 0 0
No. 2305.	Professor Finsen's concentrator, consisting of a brass tube with four large lenses made of rock crystal, and a parallel plate of rock crystal	18 10 0

If provided with glass lenses instead of quartz lenses, the price will be £6 less.

No. 2308. Iron frame, to be suspended from the ceiling, for the reception of one to four of these concentrators. It is provided with water pipes and nozzles for connection with the concentrators, and with arms to hold the concentrators **£22 0 0**

The illustration on page 241 shows a complete Finsen lamp, consisting of the arc lamp No. 2300, four concentrators No. 2305, and the iron frame No. 2308.



No. 2309.

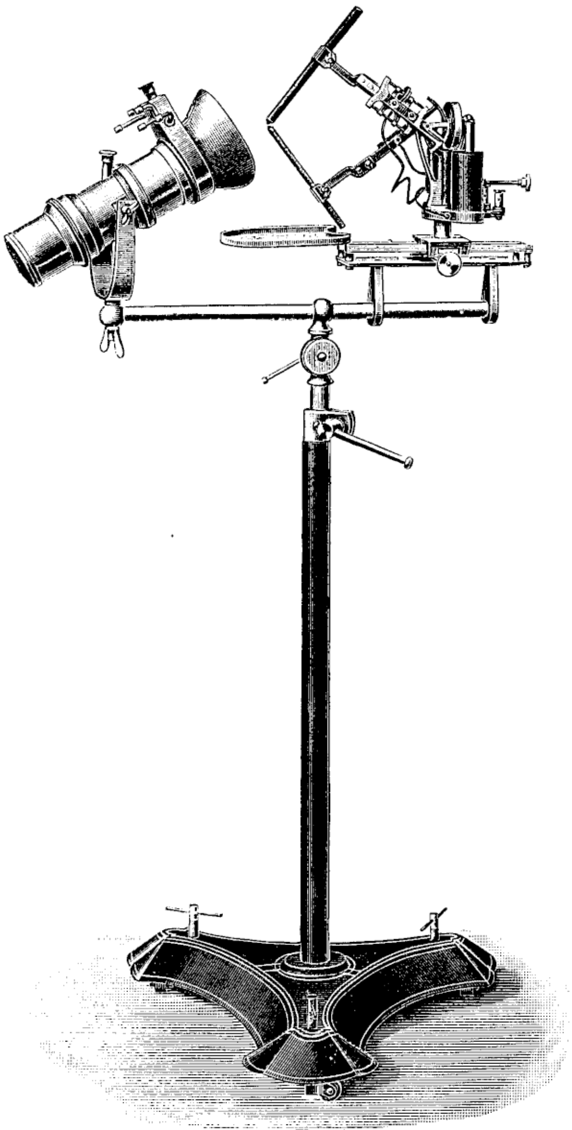
No. 2309. Iron frame, similar to No. 2308, but supported on a strong iron column, as shown in Fig. 2309 ... ... **£25 0 0**

Rheostats to use these arc lamps—

For 100 volt supplies ...	vary from **£5** to	**9**	**0 0**
For 200 to 250 volt currents	„ **£11** to	**26**	**0 0**

Motor transformers to use these arc lamps on 200 to 250 volt continuous current supplies, or on 100 to 200 volt alternating current supplies, vary from £80 to £100, including the necessary rheostats for starting and controlling the motors.

Estimates for the rheostats or motor transformers will be sent on application.



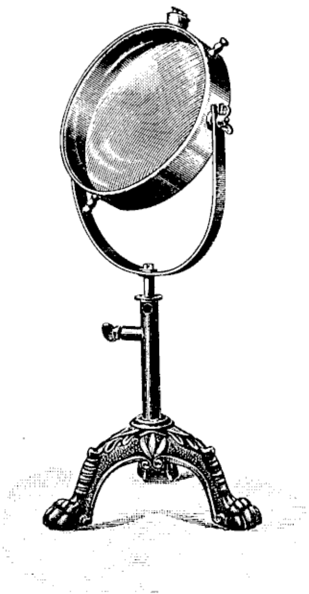
No. 2315.

No. 2315. ***Finsen-Reyn** lamp, consisting of arc lamp with automatic regulation, 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 **£30 0 0**

* We have supplied our Finsen-Reyn lamp, amongst others, to :—Charing Cross Hospital, London ; Royal Victoria Hospital, Belfast ; Infirmary, Cardiff ; Essex and Colchester Hospital, Colchester ; Skin Hospital, Birmingham ; Infirmary, Bradford ; etc., etc.

12 pairs of spare carbons, *best quality*	... ...	£0	2	6
100 " " " "	... ...	0	18	0
Variable rheostat, to use this lamp on a 100 volt supply ...	...	3	0	0
" " " " " 200 to 250 volt supply ...		6	15	0

It is possible to use the lamp No. 2315 on an alternating supply if an electrolytic rectifier No. 2688 is inserted in the circuit. In such a case the arc lamp makes a slight humming noise.



No. 2326.

No. 2327.

No. 2319.

No. 2319. Lens for using sunlight for treating lupus, Fig. 2319 ... £6 15 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 12 0

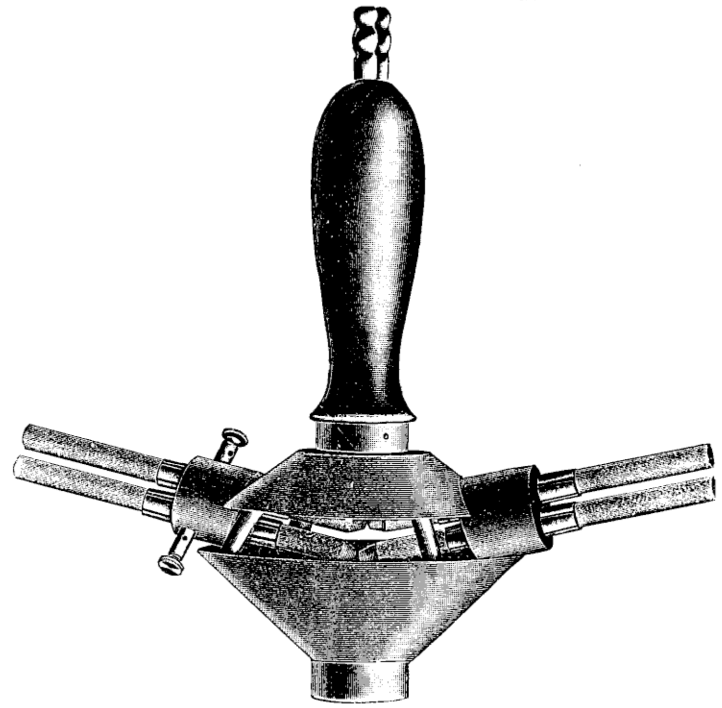
No. 2326. Similar compressor, made specially for treating the eye, Fig. 2326 ... ... 1 4 0

No. 2327. Similar apparatus, made specially for treating the lips and mouth, Fig. 2327 ... ... 1 4 0

Operating tables or couches, to give the patients a comfortable position and adjust them to correct height ... ... from £4 10s. to 17 0 0

No. 2340. Dr. Strebel's hand lamp, with four carbon iron electrodes, for 100 volt continuous or alternating current, Fig. 2340 (see page 246) 10 10 0

The lamps fitted with iron electrodes only (Dr. Bang's Dermo Lamp) produce plenty of ultra violet rays, and are well suited for treating diseases of the skin, but

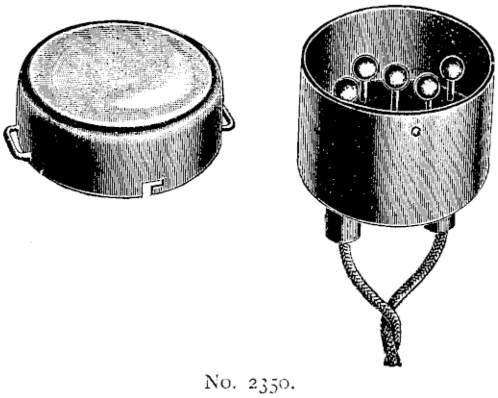


No. 2340.

they have been found insufficient for treating deeper lying tissues, as the candle-power is too small to penetrate below the surface. The Strebel lamp is much better in this respect, as carbons are being used as in ordinary arc lamps to produce a high candle-power; the cores of the carbons are filled with iron so that plenty of chemical rays are also produced. The lamp is provided with a reflector of magnalium, a lens of rock crystal, and a water cooling arrangement. The lamp is "hand fed."

No. 2350. **Spark lamp,** Fig. 2350, with a large lens of rock crystal, diameter 2 in., which serves as a compressor, 2 spare buttons of iron, and cords, **£5 10 0**

No. 2351. Large Leyden jar, on oak board, with 2 double terminals, **£1 5 0**



No. 2350.

These lamps have to be connected with a spark coil such as is used for producing Röntgen rays. A large Leyden jar has to be connected in addition to the secondary terminals of the spark coil. The lens can be taken off to be cleaned, and if desired a piece of ice can be used instead of the rock crystal lens, as suggested by Mr. Walsham.

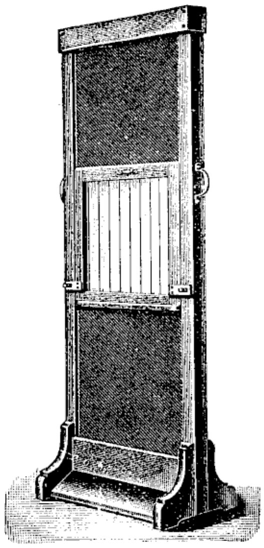
No. 2355. Spark lamp, with condensator and cords, as used in St. Bartholomew's Hospital **£10 0 0**

If this lamp is to be used with an alternating current supply, a step-up transformer, price £6 10s., is required.

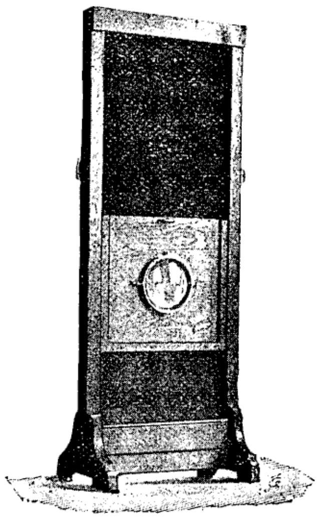
DR. KAISER'S APPARATUS FOR TREATING TUBERCULOUS DISEASES WITH BLUE LIGHT.

Dr. G. Kaiser, of Vienna, found that the blue and violet rays produce slight inflammation, and in consequence of this the circulation of blood and metabolism are stimulated, and the tissues enabled to resist the attack of bacteria. (Full details about his researches and successes will be found in the "Wiener Klinische Wochenschrift," No. 7, 1902, and Nos. 16 and 17, 1903.) He succeeded in killing cultures of tubercle microbes which were fixed on the patient's back, by concentrating the light with the help of lens No. 2361 on the patient's breast.

The apparatus required for this kind of treatment consists of a powerful arc lamp No. 2220, with parabolic reflector of magnalium, and a screen as shown in Fig. 2360. This screen consists of a strong frame of oak, about 5 ft. high, in which can be moved up and down the blue filter. The latter is made either of strips of blue glass, the colour of which has been tested spectroscopically, or else of a hollow lens filled with methylen blue, as shown in Fig. 2361. The latter is to be used if deep lying parts like the lungs are to be treated, the former if tuberculous diseases of the skin are to be treated.



No. 2360.



No. 2361.

No. 2360. Dr. Kaiser's filter, Fig. 2360, for treating lupus and other tuberculous diseases of the skin with blue light **£7 12 0**

No. 2361. Dr. Kaiser's lens, for treating deeper lying tissues with concentrated blue light, Fig. 2361 ... ... **4 10 0**

The lens has to be inserted in the frame No. 2360 instead of the blue glass strips.

No. 2364. Complete outfit for Dr. Kaiser's treatment with blue light, consisting of search lamp with magnalium reflector and rheostat to use it on a 100 volt supply, blue light filter in oak frame, and blue light lens ... **£27 0 0**

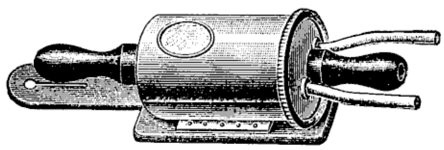
No. 2365. Similar outfit, but for 200 to 250 volt supplies **30 0 0**

APPARATUS FOR APPLYING HOT AIR.

The apparatus Nos. 2400—2408 contain a platinum spiral, which requires a current of 15 ampères and 4 to 6 volts to become incandescent. A cautery battery or accumulator is suitable to supply such a current, or the apparatus can be connected with the transformers or rheostats (Nos. 2000—2044 and No. 2050), which are made to use the current from the main for cautery.

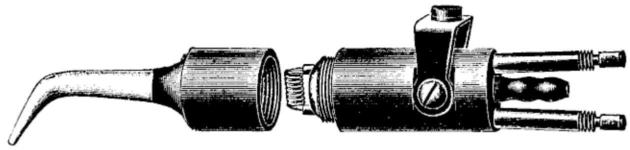
If a current of air is forced past the platinum spiral, either by means of double bellows or a cylinder with compressed air, it becomes heated; its temperature depends on the degree of incandescence of the platinum (the latter can be controlled by a rheostat) and on the quantity of air which is forced past the platinum in a given time.

If it is essential that the stream of air should have a uniform temperature, double bellows of *large* size should be used, because they give a more steady pressure than small double bellows would. The cylinders with compressed air can also be used for supplying a steady stream of air.



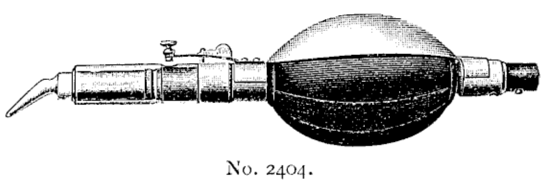
No. 2400.

No. 2400. Hot air apparatus, Fig. 2400. The platinum spiral is inside a brass cylinder, which is provided with a window of mica, and two nozzles. The cylinder is fixed on a piece of leather which can be attached to a button hole **£2 15 0**



No. 2401.

No. 2401. Hot air syringe, Fig. 2401, with tap to control the quantity of air **2 15 0**

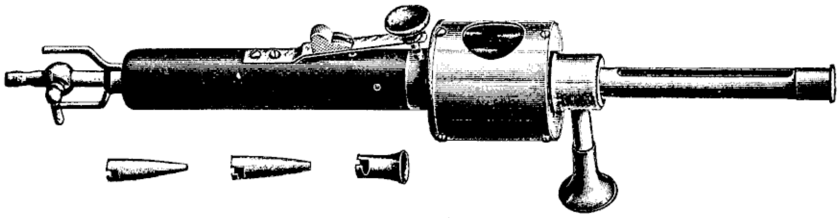


No. 2404.

No. 2404. Hot air syringe (used chiefly for dental purposes), Fig. 2404, with small rubber bellows in a metal cup. The hot air chamber is protected by a glass tube ... **1 14 0**

No. 2407.

No. 2407. Micro hot air burner for dermatological purposes, with two silver nozzles of different sizes, Fig. 2407 ... **1 16 0**



No. 2408.

No. 2408. Hot air douche for treating discolouration of the cornea, Fig. 2408. The apparatus is provided with a sliding contact, a small thermometer, a window of mica, and three different nozzles £5 10 0

No. 2409. Large double bellows for the above apparatus 0 5 0

HOT AIR BATHS.

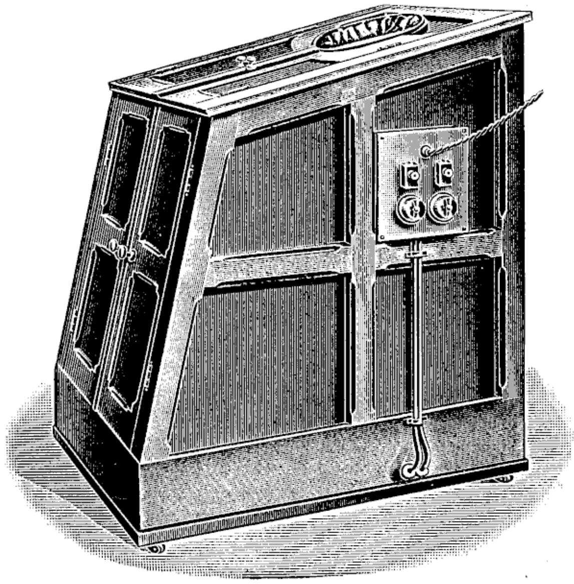
The hot air baths are somewhat similar to the electric light and hot air baths; in the latter the heat is conveyed to the patient by radiation, in the former by contact with heated air. Electricity is the most suitable means to heat the air, because the temperature is easily under control, and can be increased up to about 350 degrees (the exact amount can be read off on a thermometer). The air is quite dry, and not vitiated by any vapours of burning gas or oil, and the patient breathes air of ordinary temperature.

The heat is generated by the electric current passing through suitable resistance wires, which are wound over porcelain frames so that the air has free access. A smaller or greater number of these electric stoves can be switched on to regulate the temperature. The cabinets are lined with cork which is covered with asbestos sheets.

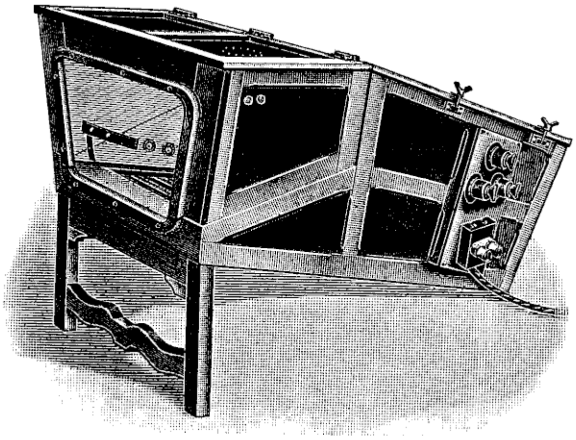
The cabinets are made either for the whole body, or only for parts like the arms, legs, etc.

No. 2420. Electric hot air bath for the whole body, Fig. 2420. The apparatus consists of a cabinet with door, which can easily be opened from outside or inside; an arm chair of variable height, three rheostats, switches, and fuses, **£51 0 0**

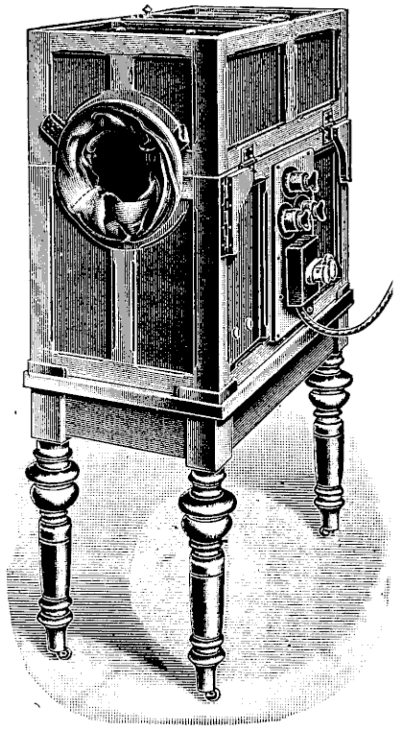
This apparatus consumes about 8 ampères with a 220 volt supply, or 16 ampères with 100 volts.



No. 2420.



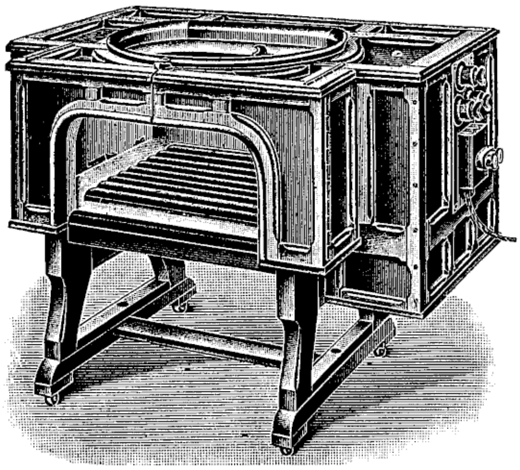
No. 2425.



No. 2427.

No. 2425. Electric hot air bath for one or both legs, Fig. 2425. The patient is seated in a chair in front of the apparatus, which opens so that even stiff or paralysed legs can easily be brought in position. The apparatus is fitted with three rheostats, switches, and fuses, and consumes about 6 ampères on a 220 volt supply £46 0 0

No. 2427. Electric hot air bath, for one arm, Fig. 2427, with three rheostats, switches, fuses, etc. 44 0 0



No. 2429.

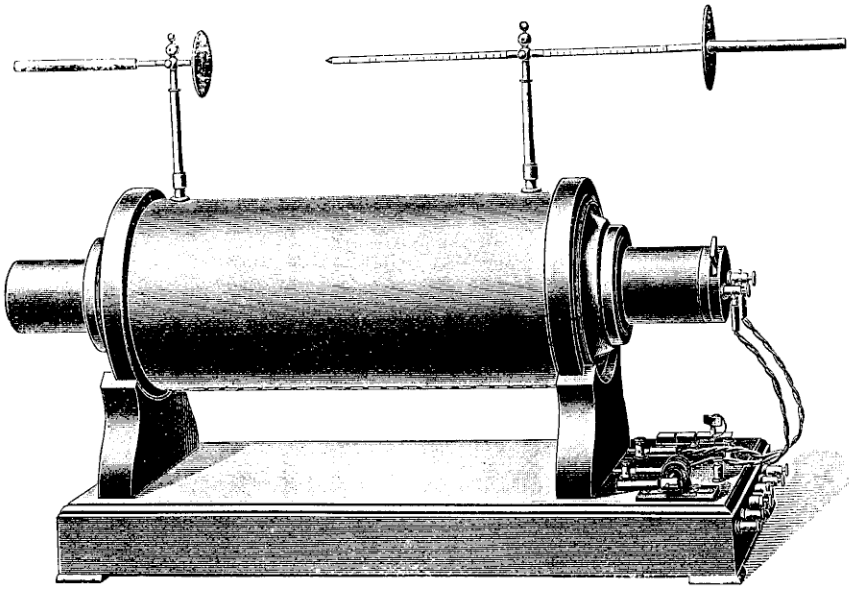
No. 2429. Electric hot air bath for the abdomen, etc., Fig. 2429, with three rheostats, switches, fuses, etc. £46 0 0

APPARATUS FOR PRODUCING RÖNTGEN RAYS.

SPARK COILS

(See also pages 71—77)

With condensator, current reverser and discharger, on polished mahogany base.



No. 2509.

No. 2505.	8 inch spark length	...	**£18**	**0 0**
No. 2506.	10 „ „	...	**22**	**0 0**
No. 2507.	12 „ „	...	**28**	**0 0**
No. 2507A.	12 „ (primary coil in separate tube, removable)	...	**30**	**0 0**
No. 2508.	14 „ „	...	**37**	**0 0**
No. 2509.	16 „ „ (Fig. 2509)		**46**	**0 0**
No. 2510.	18 „ „	...	**55**	**0 0**
No. 2511.	20 „ „	...	**64**	**0 0**
No. 2512.	25 „ „	...	**106**	**0 0**
No. 2513.	30 „ „	...	**130**	**0 0**

The coils are wound in 80 to 300 separate sections, according to spark length; they are guaranteed to give a **thick furry spark for the full nominal spark length,** with interrupters Nos. 2536 or 2540, and not to break down with fair use.

Copy of an unsolicited testimonial :

Dear Sir,—I congratulate you upon the 20 inch coil you have supplied to the Edinburgh Royal Infirmary, I am very much pleased with it. Yours truly,

Dawson Turner.

If the coils are wanted without a condenser for electrolytical interrupters only, the prices will be reduced by 10 per cent.

The illustration on page 251 shows a 16 inch spark coil, with variable self-induction of the primary coil, variable capacity of the condensator, and plug to insert or disconnect condensator, so that either a mercury jet or an electrolytical interrupter can be used.

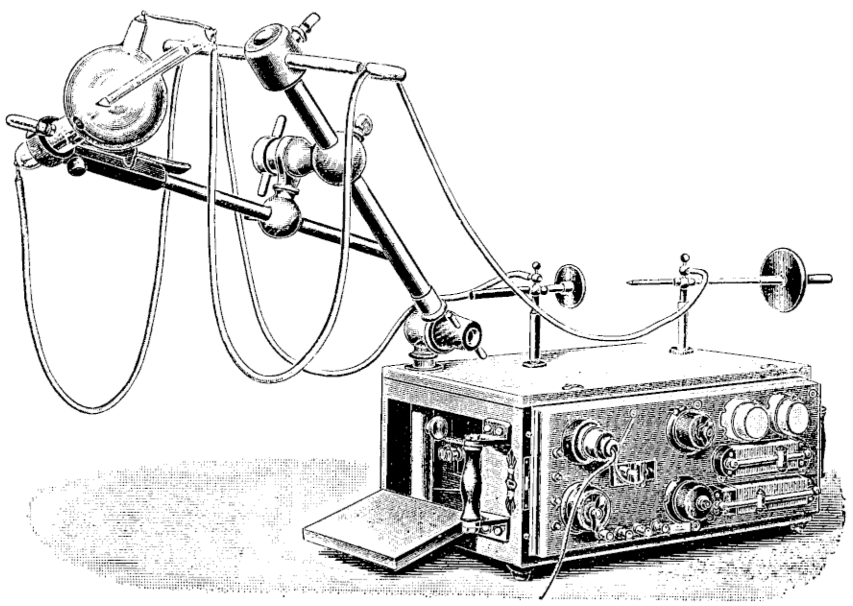
The coils Nos. 2507A—2513 can be supplied with variable self-induction of the primary coil, and variable capacity of the condensator, to adapt the current to soft, medium, or hard tubes. The extra cost for three different degrees of self-induction is £3, and the extra cost for three different degrees of capacity of the condensator is £1 1s.

The one thousandth spark coil was finished in our Works in Nov., 1904. Of this number 420 have had a spark length over 14 inches, and 580 have had a spark length of less than 14 inches.

Our *larger* coils (16 to 20 inch sparks) are being used, amongst others, by:—The Royal Infirmary, Edinburgh; Royal Victoria Hospital, Belfast; Queen's Hospital, Birmingham; St. Mary's Hospital, German Hospital, London; Dispensary in Jeypore.

Professor Ogston, Aberdeen; Dr. Jeffrey, Larbert; Dr. Taylor, Great Grimsby; Dr. J. C. F. Naumann, Dr. J. Shaw, London; Dr. Delany, Bagnalstown; etc., etc.

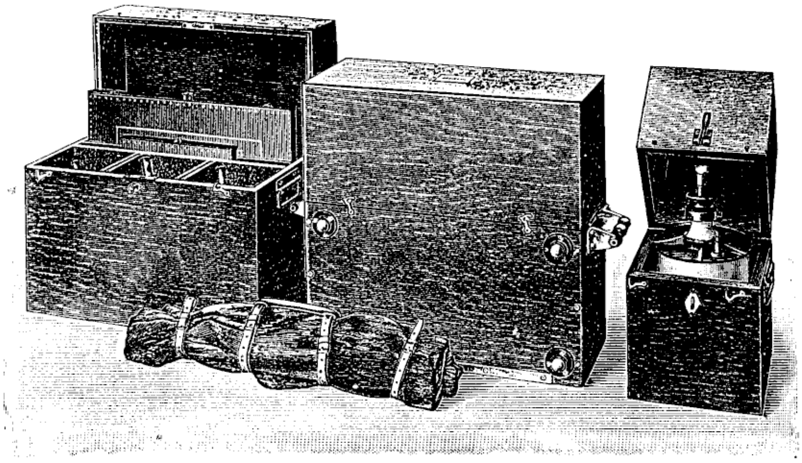
Our 10 inch coils are being used by over 100 hospitals and surgeons.



No. 2520.

No. 2520. 10 inch spark coil in portable box, with platinum interrupter, reverser, condensator, discharger, rheostat, and tube holders, Fig. 2520 ... ... £30 0 0

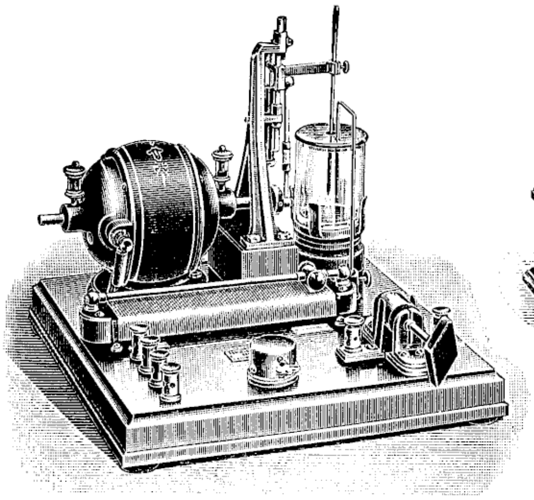
The illustration on page 253 shows the box containing the coil, a box with room for three tubes, fluorescent screens, etc., on the left, and a box containing a Wehnelt interrupter on the right.



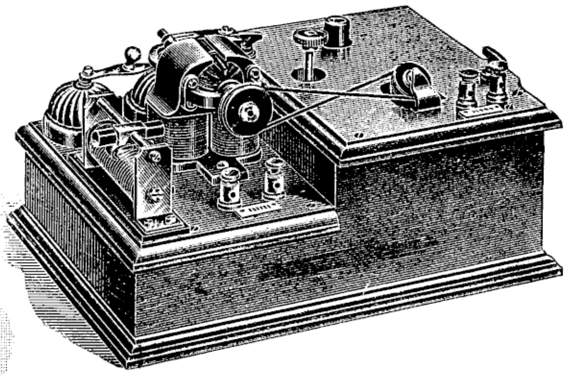
INTERRUPTERS.

(See also pages 77—88.)

No. 2530.	Mercury hammer interrupter, suitable for coils giving sparks up to 20 inches long	£1 10 0
No. 2532.	Platinum hammer interrupter, suitable for coils giving sparks up to 12 inches long	2 0 0

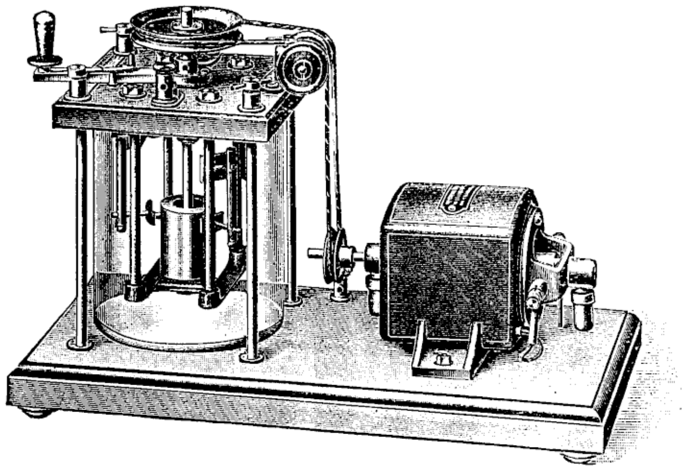


No. 2535.



No. 2536.

No. 2535.	**Mercury Dipping Interrupter,** driven by a separate motor, with rheostat to adjust the speed of the motor, Fig. 2535	£7 0 0
No. 2536.	**Mackenzie Davidson's Interrupter,** motor wound for 12 volts, Fig. 2536	6 16 6



No. 2540.

No. 2540. **Mercury Jet (Turbine) Interrupter,** Fig. 2540.

Motor wound for 12 volts	...	£9 0 0
,, ,, 100 ,,	...	9 9 0
,, ,, 220 ,,	...	9 16 0

Rheostats to control the speed of these motors, **16/-** for 12 volt motors; **20/-** for 100 to 220 volt motors.

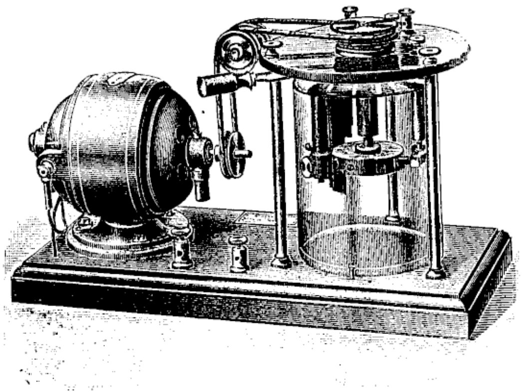
The holes ejecting the mercury are wide. This ensures good contact, prevents the holes from being blocked up by small particles of oxidised mercury, and prevents especially the mercury from being split up into too fine particles, so that cleaning is required only after long hard use. 15 lbs. of mercury are required to fill the interrupter.

The motors used for these interrupters are shunt wound. The speed is variable in the widest limits, and the number of sparks can be varied from about 4 up to 100 per second.

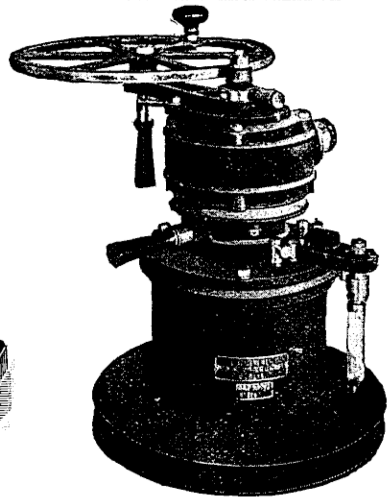
The duration of contact can be altered by turning the lever (seen on left-hand side of illustration), and by this means alone it is possible to vary the strength of current passing through the primary coil from 0·5 ampère gradually up to about 4 ampères. The strength of current can be further controlled by varying the speed of the motor, and, of course, by any shunt rheostat which may be in the circuit of the primary current.

These interrupters are certainly the most efficient mercury interrupters existing at present. They give the greatest control over the strength of current used, the widest range between slow and rapid interruptions, and run longer than any other existing mercury interrupter without requiring cleaning of the mercury.

(As supplied to Prof. Fleming, Dr. Lewis Jones, Dr. J. Macintyre, Dr. C. A. Wright, and many others; Royal Infirmary, Edinburgh; St. Bartholomew's Hospital, London,)



No. 2544.



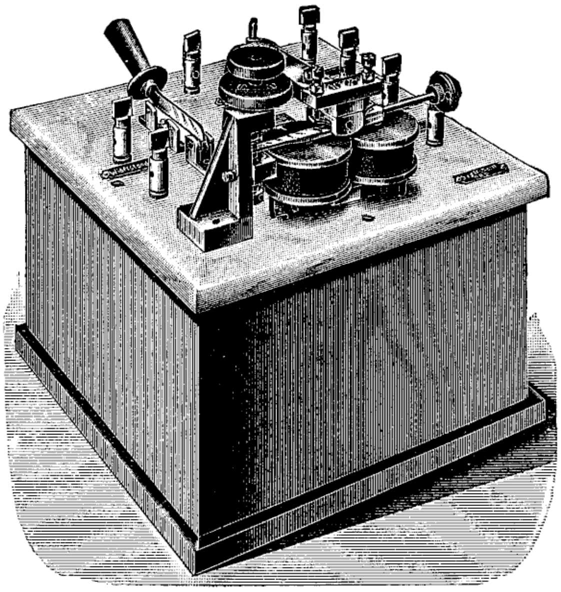
No. 2546.

No. 2544. **Contremoulins-Gaiffe Interrupter,** with rheostat and switch, Fig. 2544... ... ... **£12 0 0**

In this interrupter the current is closed and broken by two contact brushes pressing against revolving copper segments. It has been constructed specially to avoid the cleaning of the mercury.

No. 2546. **Mercury Jet Interrupter, with synchronous alternating current motor,** to use an *alternating* supply for working a spark coil, Fig. 2546 ... ... **£17 10 0**

In ordering this interrupter it is necessary to state the number of volts and the number of periods with which the motor is to be used.

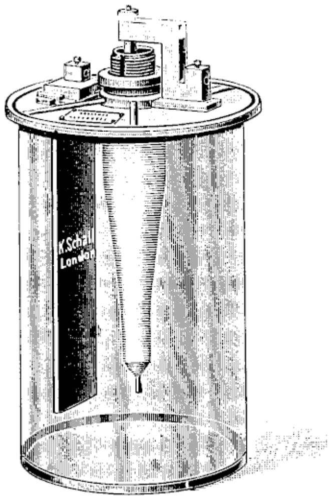


No. 2549

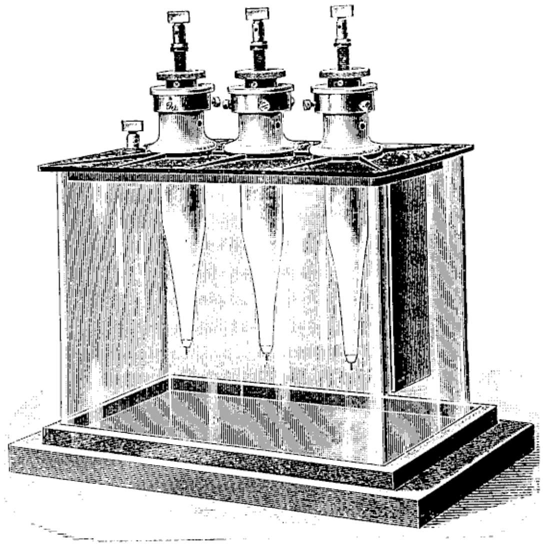
No. 2549. **Alternating Current Interrupter and Rectifier,** Fig. 2549 ... **£17 0 0**

This is a very 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. The interrupter can be seen in working order at our premises.



No. 2550.



No. 2550D.

No. 2550. **Dr. Wehnelt's Electrolytical Interrupter,** Fig. 2550 **£4 4 0**

Diameter of the platinum wire, 2·5 millimetres; length, 35 millimetres.

Diameter of the glass jar, 8 inches; height, 10½ inches. The screws for varying the length of the exposed part of the platinum are of stout ebonite, and cannot stick or corrode.

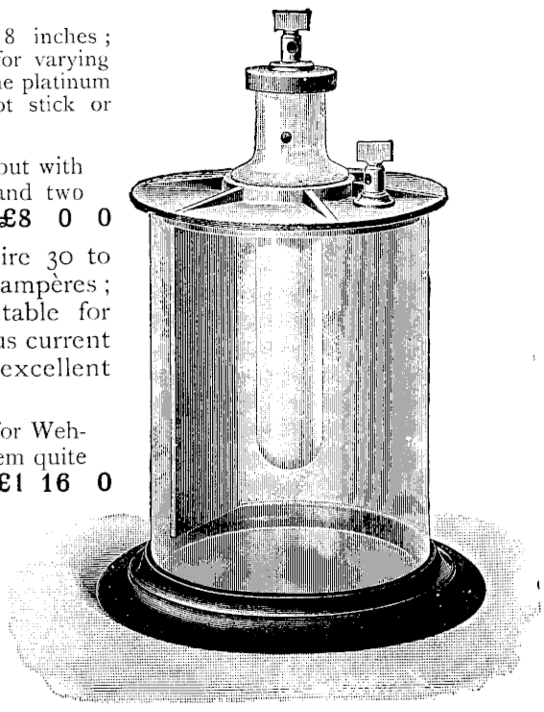
No. 2550D. Similar interrupter, but with three anodes, one is 1 mm. and two are 3 mm. thick, Fig. 2550D **£8 0 0**

These interrupters require 30 to 80 volts, and from 10 to 30 ampères; they are, therefore, not suitable for batteries, but if the continuous current from the main is available, excellent results will be obtained.

No. 2551. Double lined case for Wehnelt interrupters, to render them quite silent **£1 16 0**

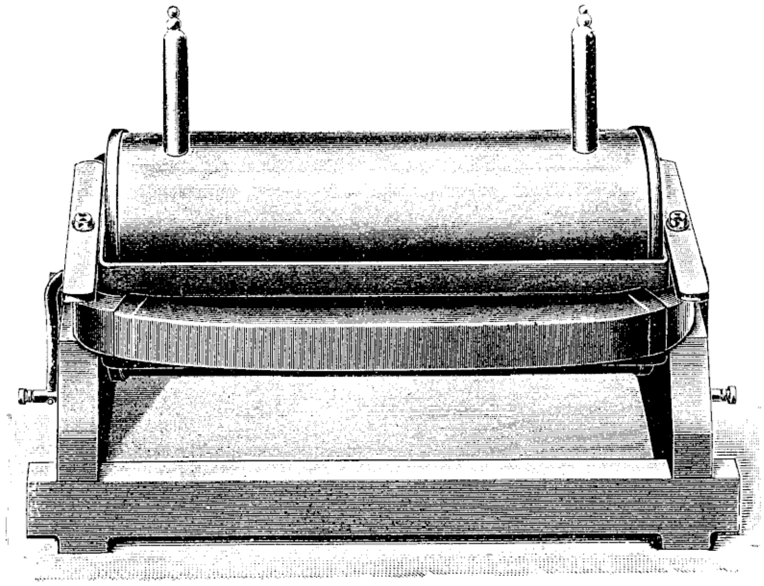
No. 2552. **Simon or Caldwell Interrupter,** Fig. 2552 ... ... **£2 12 0**

These interrupters work well only if 130 or more volts are available.

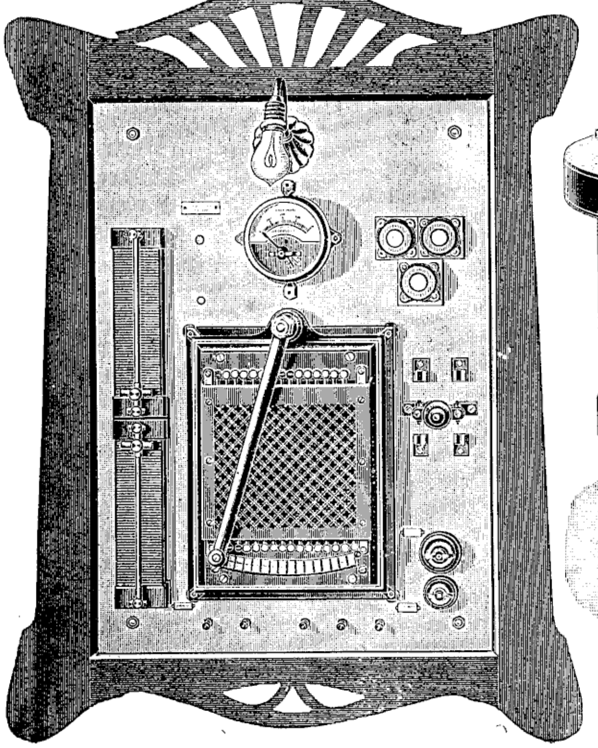


No. 2552.

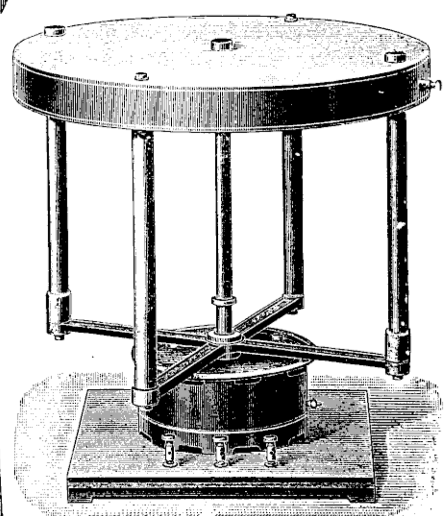
KOCH'S TRANSFORMERS, WITHOUT INTERRUPTER, FOR PRODUCING RÖNTGEN RAYS.



No. 2564A.



No. 2564B.



No. 2564C.

No. 2561. Transformer giving 10 inch sparks, with rectifier and switchboard (containing choking coil, rheostats, ampèremeter, switches, fuses, etc.), to use an alternating current for Röntgen rays *without any interrupter* **£76 0 0**

No. 2564. Similar apparatus, transformer giving sparks 16 inches long, Figs. 2564A, B, and C **97 0 0**

If the apparatus is required for high frequency currents only, the rectifier, Fig. 2564C, is not wanted, and the price will then be reduced by £17 10s.

In order to use these transformers on a continuous current supply, it would be necessary to transform this current first into an alternating current by means of a motor transformer of about 1·5 kilowatt. We cannot see any advantage in doing this, because :—

(1) For X-ray purposes, the efficiency of these transformers is certainly not yet equal to that of a good spark coil with interrupter on continuous currents.

(2) A good electrolytic interrupter and coil do not give any more trouble than a transformer, they do not want cleaning or oiling, and if properly arranged do not make any noise.

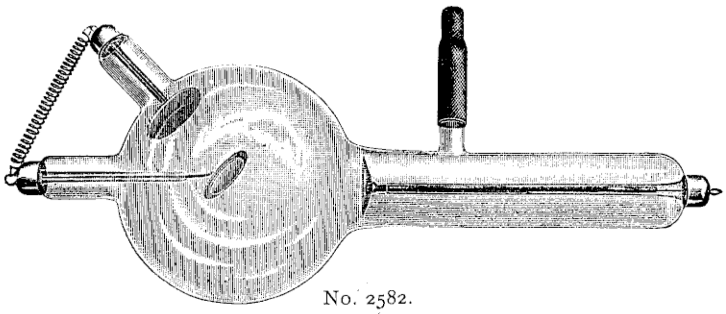
(3) The cost of a high tension transformer, rectifier, and motor transformer is more than twice that of a good electrolytical interrupter, spark coil with variable self-induction, and rheostat.

Prof. Walter's new rectifier, to make the currents of these transformers unidirectional for X-rays, has just come out, but is too late for full description in this edition. It is simpler than the rectifier described above, and consists of two ingeniously arranged alternate spark-gaps with a suitable rheostat.

A full description of this instrument, as well as of a new method of u ing the continuous current for ordinary spark coils, will appear shortly in a special pamphlet.

FOCUS TUBES.

(See also pages 93—102.)



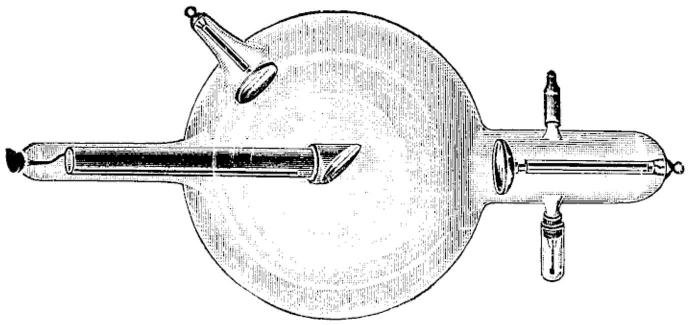
No. 2582.

Plain Tubes with Heavy Anticathodes.

No. 2581.	Diameter of bulb, 3½ inch, for 6—10 inch sparks ...	**£0**	**14**	**0**
No. 2582.	„ „ 4½ „ „ 8—12 „ „ Fig. 2582	**0**	**17**	**0**
No. 2583.	„ „ 5½ „ „ 8—15 „ „ ...	**1**	**2**	**0**
No. 2584.	„ „ 7 „ „ 10—20 „ „ ...	**1**	**16**	**0**

If supplied with palladium wire for regenerating vacuum, the prices of the above tubes will be 7/- more each.

No. 2586. If supplied with automatic regulation, as shown in Fig. 2597, the price of a tube 6½ in. diameter will be **£2 2s.**



No. 2589.

Tubes with Cooled Anticathodes and Regenerating Arrangement, for use with Electrolytical and Mercury Jet Interrupters.

No. 2588.	Diameter of bulb, 4¾ inch	**£1**	**15**	**0**
No. 2589.	„ „ 5½ „ Fig. 2589	**2**	**0**	**0**
No. 2590.	„ „ 6½ „	**2**	**12**	**0**
No. 2591.	„ „ 8 „	**3**	**12**	**0**

The tubes Nos. 2588—2591 are specially constructed to stand heavy discharges. The anticathode consists of a copper block which is fixed on a thin iron tube, as shown in the illustration. The large surface of the tube enables the heat to radiate quickly in the air. If the tubes have become too hard, the projecting palladium wire is heated with a spirit flame for a few seconds. A small quantity of hydrogen can pass through this wire while it is hot.

These tubes are very constant, give excellent results, and last for a long time; the construction is simple, and the cooling and regenerating arrangements are very efficient.

If the wire from the spark coil is connected with the terminal at the end of the anticathode the tubes are considerably harder than if it is connected with the terminal at the end of the anode; each tube offers, therefore, two different degrees of penetration, which is another distinct advantage.

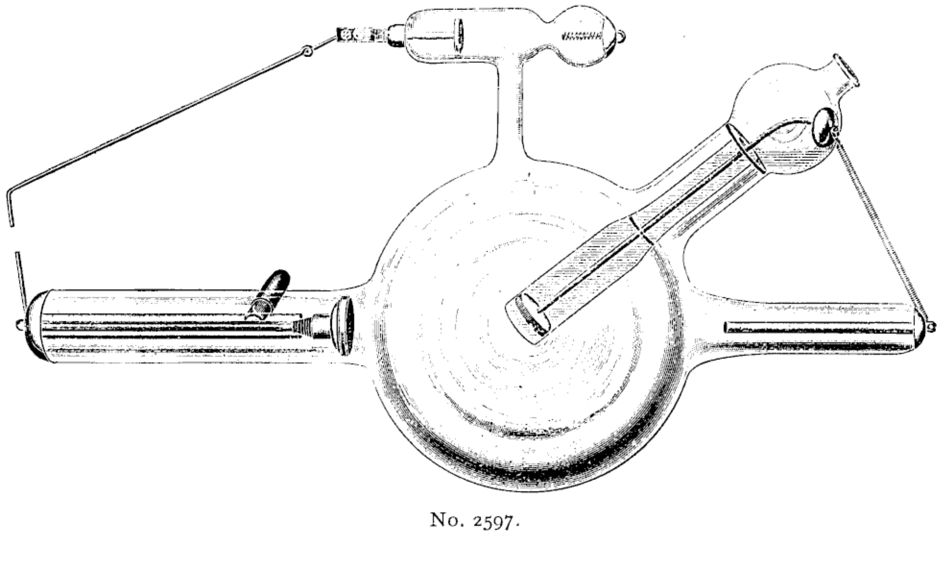
TUBES WITH WATER-COOLED ANTICATHODES, AND WITH REGENERATING ARRANGEMENT.

There are two different types of water-cooled tubes. In the cheaper one, No. 2595, the water is contained in a glass tube which is surrounded by a metal tube carrying the anticathode at the end ; the water, therefore, does *not* come in *direct contact* with the anticathode in this type ; it has, of course, some cooling effect, but with a powerful coil it is quite possible to make the anticathode of such a tube incandescent.

In the tube No. 2597 the anticathode consists of a disc of platinum which is sealed into the end of the glass tube. The water is in *direct contact* with the anticathode, and the cooling is so rapid that it is impossible to make the latter incandescent. These tubes are more difficult to make and more costly, but are more efficient. Some of these tubes have been kept working (for physical experiments) for eleven hours consecutively without an interruption ; the evaporated water had to be replaced repeatedly, but otherwise the tubes have stood the strain well.

In appearance, there is so little difference between the two tubes that one illustration will do for both.

No. 2595. Focus tube, with water cooling and automatic regulation of the vacuum, Fig. 2597 ... ... **£3 0 0**



No. 2597.

No. 2597. Focus tube (Müller's), with water cooling and automatic regulation of the vacuum, Fig. 2597. Diam. of the bulb, 7 in. **£4 10 0**

No. 2598. Similar tube. Diam. of the bulb, 8 in. **5 5 0**

(See also page 101.)

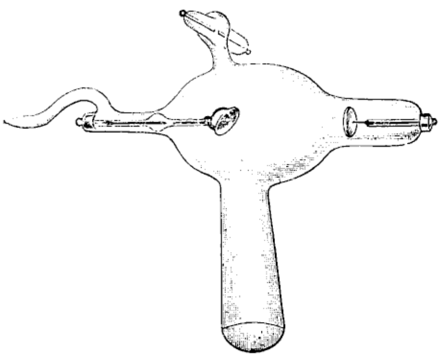
These tubes can bear the strongest currents, and are therefore very suitable for use with the largest coils and an electrolytical interrupter.

The current must not be switched on on any account before the tube has been filled with water.

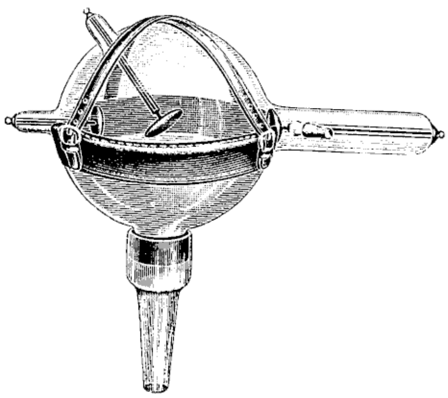
No. 2600. Similar tube (Müller's), with heavy cooled anticathode instead of the water cooling arrangement. Diameter of the bulb, 6½ in. **£2 10 0**

Focus Tubes for Therapeutic Purposes.

The tubes Nos. 2581—2600 can be used equally well for the screen and for photographic and therapeutic purposes; in the latter case it will most frequently be necessary to employ a mask to protect the parts which are not to be affected. The tubes Nos. 2610 and 2611 are made specially for therapeutic purposes; the bulb, etc., is made of lead glass, which is opaque to the X-rays, and only at the end of the projecting neck there is a window made of the special glass which is transparent to these rays. This window can be brought close to the part to be treated, and masks will not be wanted with these tubes.



No. 2610.



No. 2612.

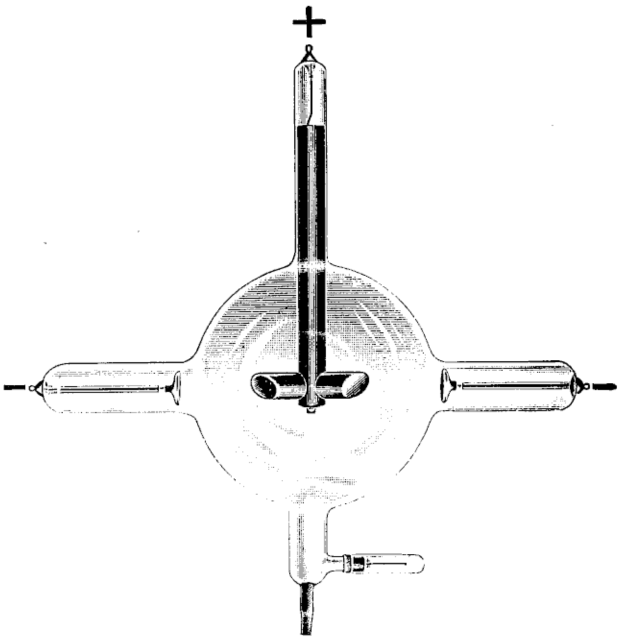
No. 2610. Diameter of window, 1 inch, Fig. 2610 ... ... **£1 0 0**

No. 2611. ,, ,, 2 ,, ... **1 5 0**

The same result can be obtained with a diaphragm shown in Fig. 2612, which can be attached to our tubes Nos. 2583 or 2589. If a tube has become too hard for therapeutic purposes, it can still be used for the screen, etc., and the diaphragm is then transferred to a new soft tube.

No. 2612. Diaphragm of lead glass, with three glass funnels, ¾ inch, 1 inch, and 1½ inches wide, Fig. 2612 ... ... **£1 2 6**

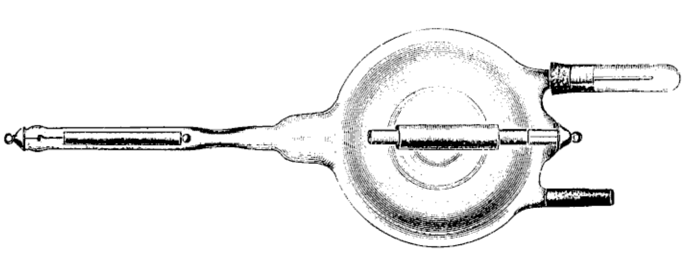
No. 2613. Protecting screen of indiarubber, which has been impregnated so that it is impenetrable to the X-rays **0 18 0**



No. 2616.

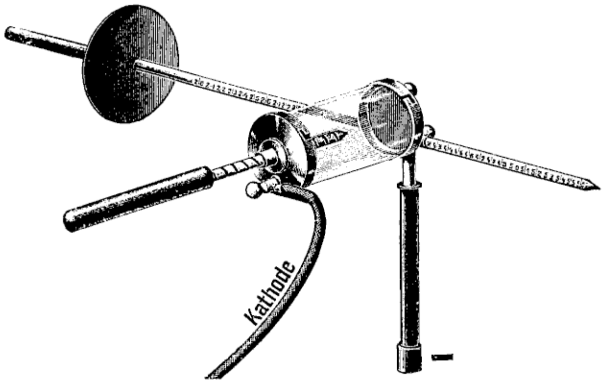
No. 2616. **Focus Tube with two anticathodes** in suitable distance for stereoscopic observation (Mackenzie Davidson's method), Fig. 2616 ... ... **£4 4 0**

Originally Mr. Mackenzie Davidson proposed the use of two separate tubes, which received the current alternately. In order to get good results it is necessary that the tubes should have the same degree of hardness, and this is impossible to attain with separate tubes for any length of time. The difficulty is overcome with the above arrangement, the two halves always having the same degree of penetration. The tubes are provided with a regenerating arrangement.



No. 2618.

No. 2618. **Valve Tubes,** for suppressing the sparks generated on closing the primary current, with palladium wire for regenerating the vacuum, Fig. 2618 ... ... **£1 3 0**



No. 2619.

No. 2619. **Adjustable Spark-Gap,** to suppress the closing current, Fig. 2619 ... ... **£1 2 6**

This spark-gap is very convenient. 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.

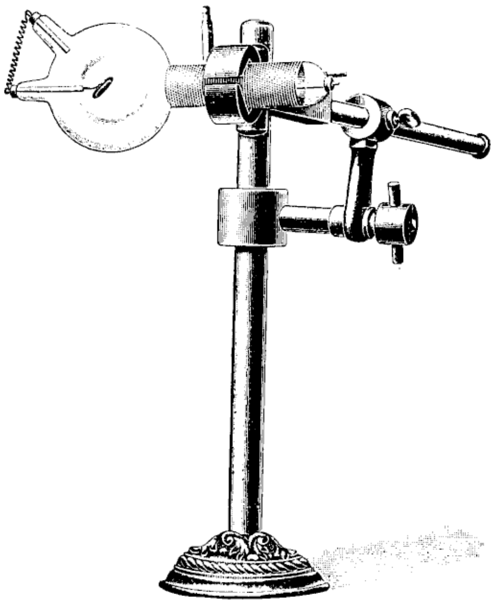
The illustration on page 99 shows how a valve tube, or a spark-gap, is to be connected with spark coil and X-ray tube.

No. 2620.

No. 2620. **Spirit Lamp,** fixed on a long insulating handle o ebonite, Fig. 2620, for warming focus tubes while the current is turned on **£0 12 0**

STANDS TO HOLD X-RAY TUBES.

No. 2622.



No. 2621.

No. 2621. 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), Fig. 2621 ... **£1 15 0**

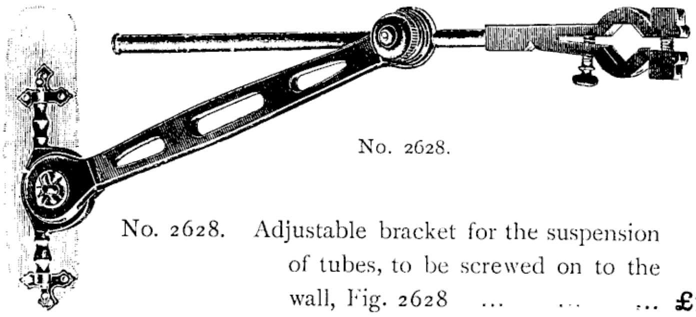
The stand is provided with a heavy cast-iron foot filled with lead.

No. 2622. Large stand, Fig. 2622, 5 feet high from floor, with similar clamp as used in No. 2621 **£2 15 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.)

The stand No. 2622 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 the illustration (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. 2628.

No. 2628. Adjustable bracket for the suspension of tubes, to be screwed on to the wall, Fig. 2628 ... ... £1 18 0

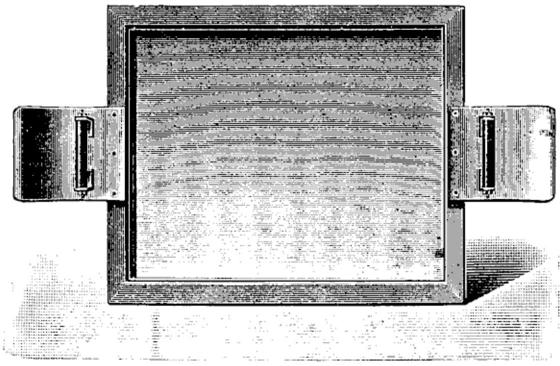
FLUORESCENT SCREENS, for direct observation, coated with two thick layers of large crystals of barium platino-cyanide.

No. 2641.	5 × 7 in.	£1	4	0
No. 2642.	7 × 9½ in.	2	0	0
No. 2643.	9½ × 12 in.	2	18	0
No. 2644.	12 × 15½ in.	4	16	0

Larger screens can be made to order.

No. 2648. **Accelerating Screens** of tungstate of calcium, in cassette for the reception of plates 10 × 12 in. ... 2 14 0

No. 2655.



No. 2659.

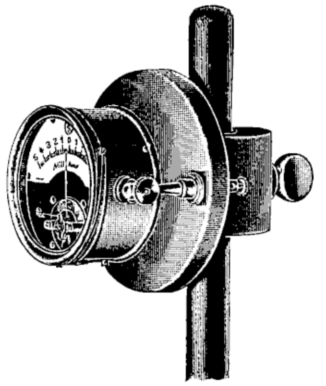
No. 2655. **Cryptoscope,** Fig. 2655, with screen No. 2642 ... £3 0 0

Plates of lead glass, to cover the screens, to protect the operator against the X-rays passing through the screen, and the screens against dust and damage.

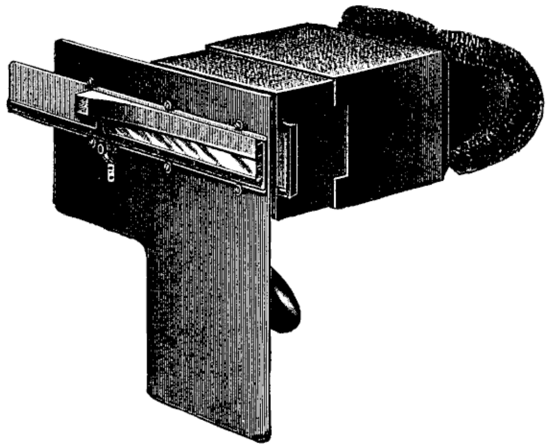
No. 2657.	5 × 7 in.	7 × 9½ in.	9½ × 12 in.	12 × 15½ in.
	2/9	4/-	6/-	10/6

No. 2659. Metal handles, to be screwed on to the fluorescent screens, for the protection of the hands of the operator, Fig. 2659 ... ... per pair £0 18 0

RADIOMETERS.

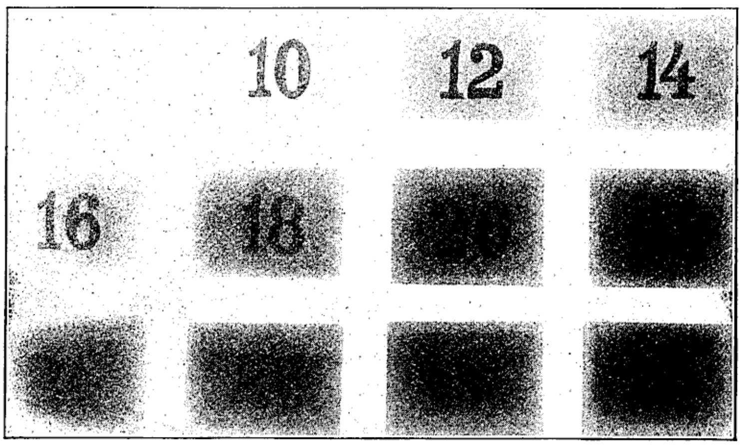


No. 2660.



No. 2664.

No. 2660. Small board, fitting stands Nos. 2621 or 2622, with terminals to carry galvanometers: Nos. 284—288, to measure the current passing through focus tubes, Fig. 2660 (see also page 97) £0 8 0



No. 2661.

No. 2661. Radiometer for testing the penetrating power of X-ray tubes, in polished mahogany case £1 5 0

This instrument contains twelve squares of tinfoil. The first square is made up of eight, the second of ten, etc., the twelfth of thirty sheets of tinfoil. On each square is fastened a figure made of lead. The illustration shows the picture which the instrument gives on a photographic plate or a fluorescent screen. The higher the figure visible, the greater is the penetrating power and *vice versa.*

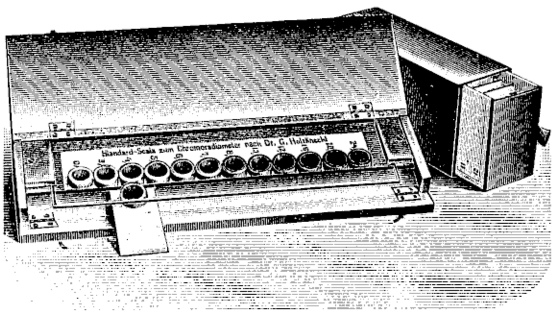
No. 2664. **Dr. Wehnelt's Crypto-Radiometer,** Fig. 2664 ... £4 4 0

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.

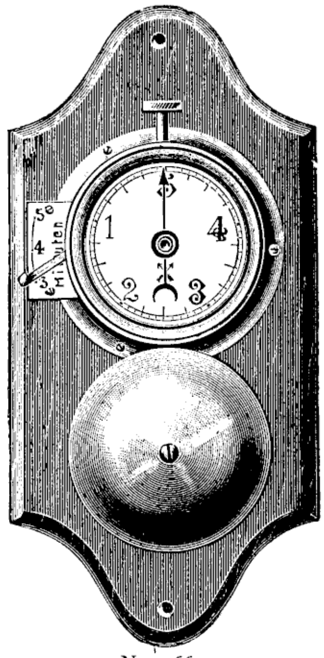
Silver has the peculiarity that it lets the same amount of rays pass whether the tube is soft or hard; the luminosity of the field covered by the silver remains, therefore, uniform, and is used for comparison like the light of a standard candle. The luminosity of the part of the screen covered by the aluminium changes according to the condition of the tube and the thickness of the aluminium.

The metal strips are shifted till the colour and luminosity of both the halves of the fluorescent screen are identical, the position is then read off on the centimetre scale, which moves with the metal strips.

It is thus possible to obtain the most accurate comparison of the degree of penetration of different tubes, or to use the same dose for therapeutic purposes. The tube is examined first, and the amount of current used is increased or diminished as the case may be, till the colour of the halves of the screen agree at the desired position of the scale.



No. 2665.



No. 2669.

No. 2665. Dr. Holzknecht's Chromo-Radiometer, Fig. 2665 **£4 6 0**

No. 2666. One dozen chemical discs for the same **1 7 0**

This instrument serves to measure the active rays emitted by a focus tube in the same manner in which a photometer measures the actinic light for photographic purposes. Dr. Holzknecht found a chemical substance, the colour of which grows gradually darker under the influence of the rays which produce inflammation of the skin, etc.; a disc of these chemicals is exposed simultaneously with the diseased part of the skin, and the colour of the chemical has to be compared from time to time with a standard scale. The amount of inflammation which will follow in about a week's time can thus be accurately dosed beforehand. Detailed printed instructions are sent with the instrument. The chemicals can be bleached and used again a few times.

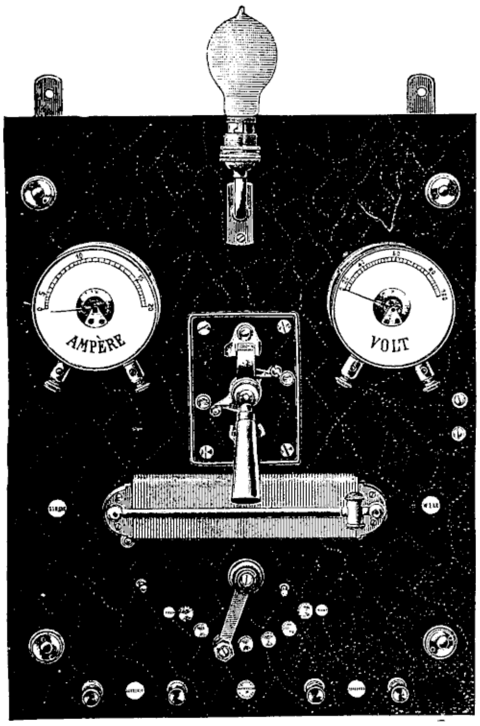
No. 2667. Sabouraud's radiometer **£0 9 0**

No. 2669. Clock, Fig. 2669, with adjustable arrangement to ring after three, four, or five minutes **0 8 0**

These clocks are very convenient for showing the exposure or the development.

A new accurate Chromo-Radiometer has just come out, and will be described in a special pamphlet.

RHEOSTAT WITH SHUNT CIRCUIT, to control the continuous current from the main for spark coils, and for arc lamps used for the treatment of lupus, etc.



No. 2671.

No. 2670. Rheostat with a crank to vary the number of volts of the main, small sliding rheostat to vary the number of ampères, switch, signal lamp, terminals for coil (or arc lamp) and for interrupter, mounted on slate or marble slab, for 100 volt circuits, **£10 10 0**

No. 2671. Similar rheostat, for 220 volt circuits, Fig. 2671, **£11 6 0**

The addition of volt and ampère meters Nos. 963 and 964, as shown in illustration, increases the price by £3 10s.

The addition of volt and ampère meters Nos. 968 and 969, will increase the price by £6 10s.

These rheostats enable you to vary the current from the main by turning a crank, so that either 30, 40, 50, 60, 70, 80 or 90 volts are available at the terminals for the primary circuit.

The current can thus be adapted in the most efficient and simplest manner to the various tubes. A "soft" tube will not stand more than 30 volts if a dangerous degree of incandescence is to be avoided on the anticathode; a "hard" tube may require as much as 80 volts to force any current through it at all. If any change takes place in a tube during exposure, it can easily be corrected by turning the crank a few pegs forward or backward.

Mr. Mackenzie Davidson wrote us the following letter about the shunt rheostat No. 2670:—

Dear Mr. Schall,

I am very pleased with your volt selector. I tried it with the new interrupter with most excellent results.

Yours sincerely,

J. Mackenzie Davidson.

In ordering it is necessary to state the voltage of the supply, the kind of interrupter for which the rheostat is wanted, and whether the primary of the spark coil is wound for low (up to 20 or 30) or high (50 or 100) voltage.

If wound for electrolytical interrupters, the rheostats consume about 20 ampères (2 units per hour on a 100 volt supply); if wound for our mercury jet interrupters and coils, they consume about 8 ampères (0·8 unit on a 100 volt supply).

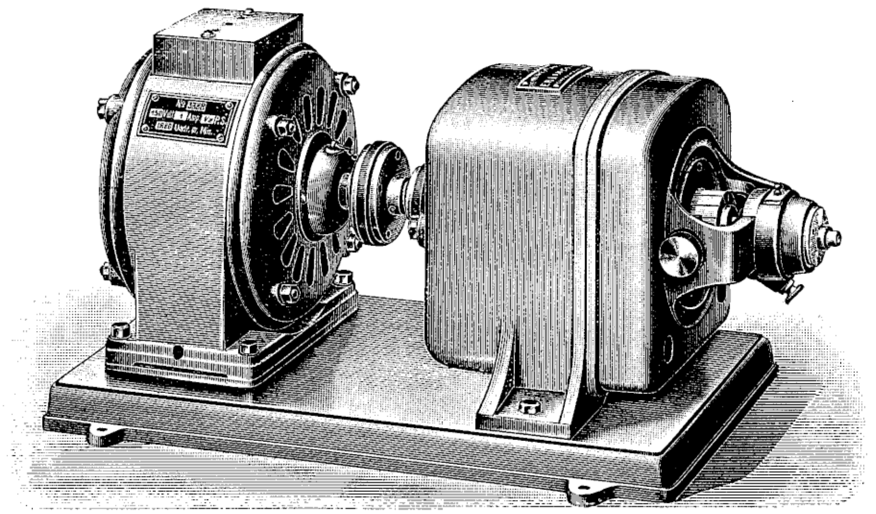
These rheostats have been supplied by us to over 200 hospitals and surgeons. They are used, amongst others, in St. Bartholomew's, Charing Cross, and Guy's Hospital; by Drs. Macintyre, Mackenzie Davidson, Prof. Ogston, etc., etc.

Accumulators suitable for Spark Coils will be found on page 157.

Bichromate Batteries for Spark Coils will be found on page 162.

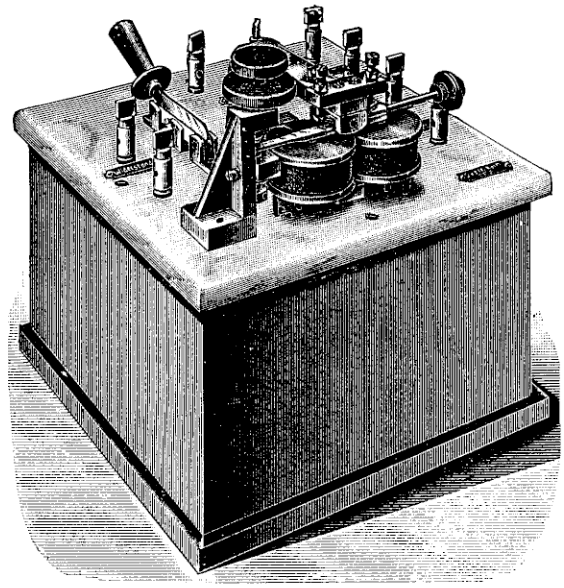
Large Leclanché Cells, suitable for currents up to 10 ampères, **9s.** per cell.

CURRENT RECTIFIERS.



No. 2678.

No. 2678.	**Motor Transformer,** for converting an alternating current into a continuous current of about 330 watts (for instance, 5 ampères and 66 volts), including rheostat for starting and controlling the alternating motor, Fig. 2678	**£38 10 0**
No. 2682.	Similar transformer but larger size, suitable for 1,600 watts (for instance, 25 ampères with 65 volts), including rheostat for starting and controlling the motor	**67 0 0**



No. 2685.

No. 2685. **Current Rectifier,** to convert an alternating current into a pulsating unidirectional current for charging accumulators, Fig. 2685 ... ... £14 0 0

The current is rectified by means of a hammer vibrating synchronously with the alternating current; every second phase of the current is reversed in its direction, and the current in the secondary circuit is kept closed only while the E.M.F. is above a certain minimum.

It is a very efficient, reliable, and convenient apparatus for charging accumulators from an alternating current, and can be seen in constant use at our premises. It is suitable for currents up to 10 ampères. The E.M.F. of the accumulators to be charged must not exceed 80 per cent. of the E.M.F. of the alternating supply; if the latter is 100 volts, not more than 32 accumulators can be charged simultaneously (accumulators reach 2·5 volts each cell towards the end of the charging). The efficiency of the apparatus reaches 80 per cent. In ordering the apparatus please mention the number of volts and periods of the supply; it is important to know the number of periods in order to adjust the capacity of the condensator correctly.

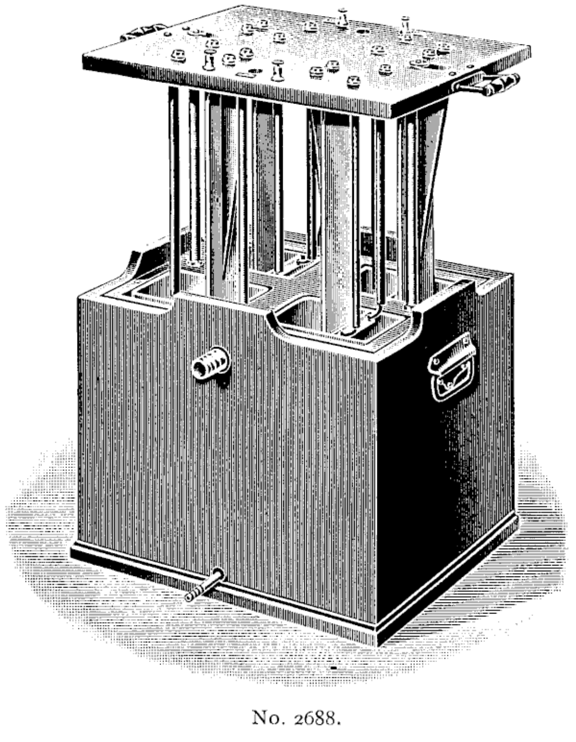
ELECTROLYTIC RECTIFIERS.

These rectifiers are an improved kind of Graetz aluminium cells, consisting of a large passive electrode of lead and a smaller active electrode of an alloy of zinc and aluminium. The aluminium, when it turns cathode, polarizes rapidly, and offers a resistance so high that a current of less than 22 volts cannot pass at all; while the aluminium electrode is anode, no resistance is offered to the passage of the current. If four such cells are connected in series and inserted into the circuit of a 100 volt alternating current, this current is converted into a pulsating unidirectional current of 80 to 85 volts, and with such a current a spark coil with an electrolytic interrupter will work well.

The cells become warm with prolonged use, and after reaching a certain temperature the polarisation ceases ; consequently, if they are to be used for a long time, they have to be placed in a zinc vessel through which a stream of water is passing to keep them cool. If the cells are required for a short time only, the cooling arrangement is not wanted.

In starting the apparatus a small resistance is required till the polarizing film has formed.

No. 2687. **Electrolytic Rectifier,** consisting of 4 cells, suitable for currents up to 15 ampères, with starting rheostat complete **£10 0 0**

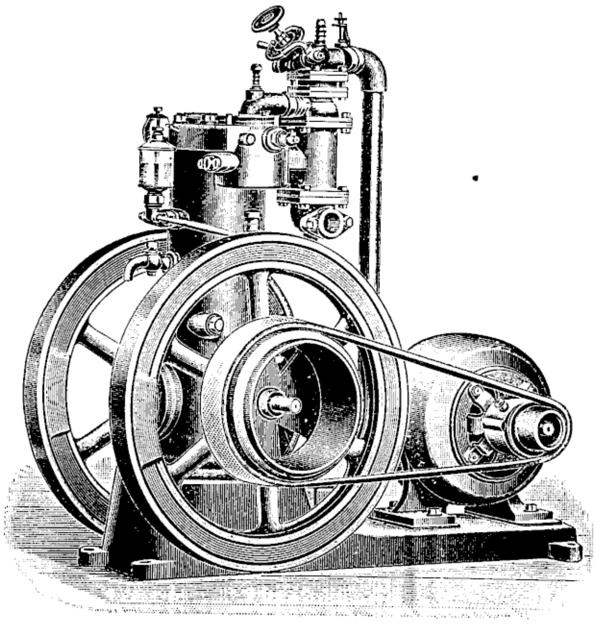


No. 2688.

No. 2688. **Similar Rectifier,** suitable for currents up to 25 ampères, Fig. 2688... ... ... **£12 10 0**

ENGINE WITH DYNAMO

For producing the currents for Röntgen rays, high frequency currents, arc lamps for treating lupus, and for illuminating small hospitals, etc.



No. 2691.

No. 2691. 2 H.P. engine, with two heavy flywheels and dynamo, complete, Fig. 2691 ... ... **£55 0 0**

The dynamo gives a current of about 1,200 watts, which is sufficient for the largest coils. It can also be used for supplying the current for about thirty 16 candle-power lamps.

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.

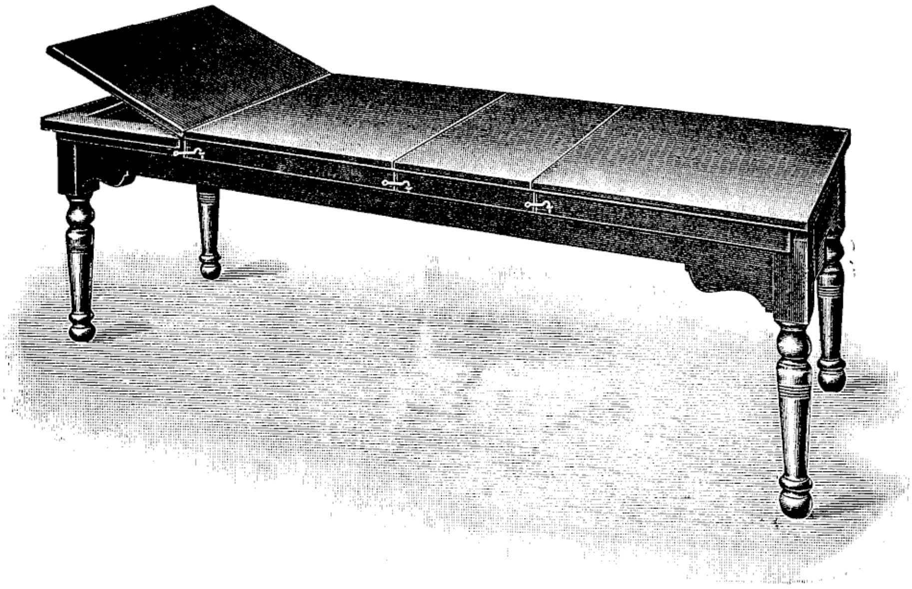
The engines make about 600 revolutions per minute; they are, therefore, not of the high speed type. They are easily started, and require little attention for cleaning, etc.

The engines can be used with methylated spirit, benzine, petroleum, etc., or gas. They require 24 ozs. of spirit, or 16 ozs. of benzine, or 18 ozs. of petroleum 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 cwts.

Estimates for larger engines and dynamos can be had on application.

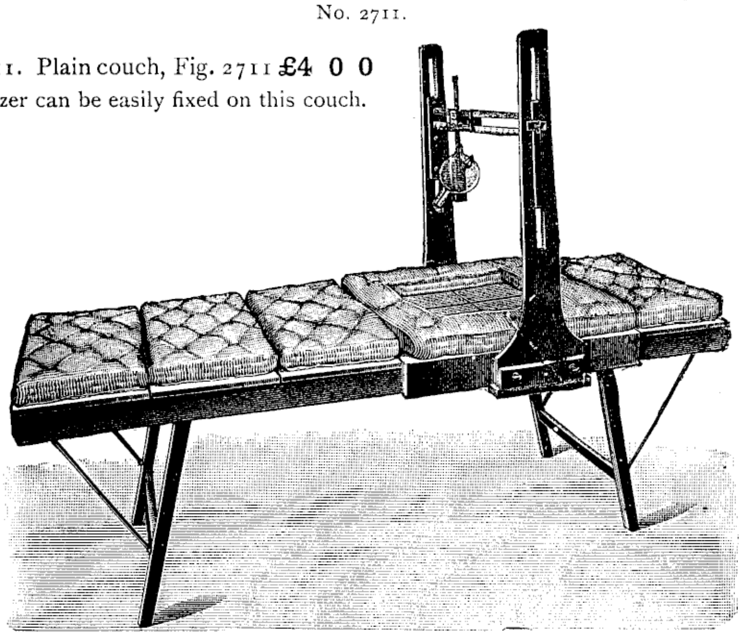
COUCHES, LOCALIZING APPARATUS, ETC.



No. 2711.

No. 2711. Plain couch, Fig. 2711 £4 0 0

A localizer can be easily fixed on this couch.



No. 2717.

No. 2712. Couch, covered with strong canvas, which can be stretched by means of cords, and arrangement for a tube holder underneath the couch... ... ... £4 4 0

No. 2714. Mackenzie Davidson's couch, with localizer 10 10 0

The photographic plates can be replaced without disturbing the patient. It is portable and can be taken to pieces. Illustration can be had on application.

No. 2717. Similar couch, with localizer, Fig. 2717 ... ... £12 10 0

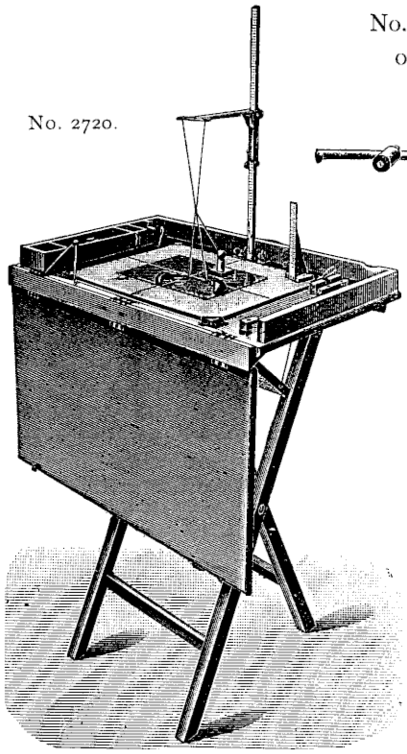
No. 2719. Dr Holzknecht's couch 35 0 0

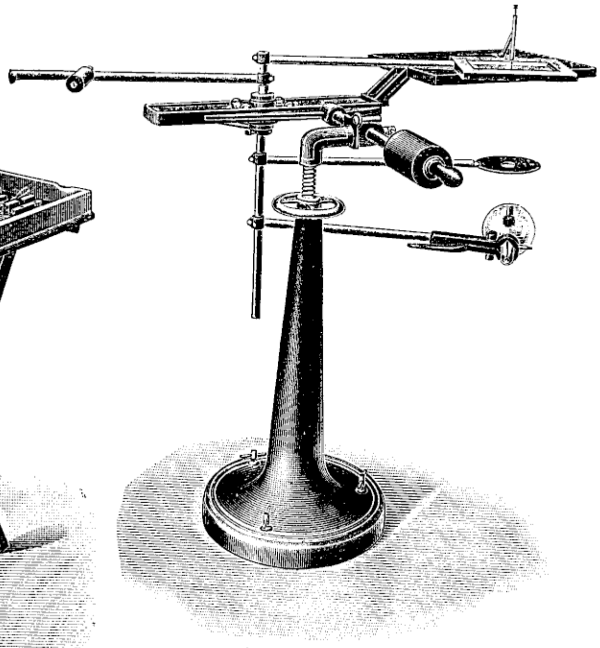
Illustration and details of this most convenient couch will be sent on application.

T

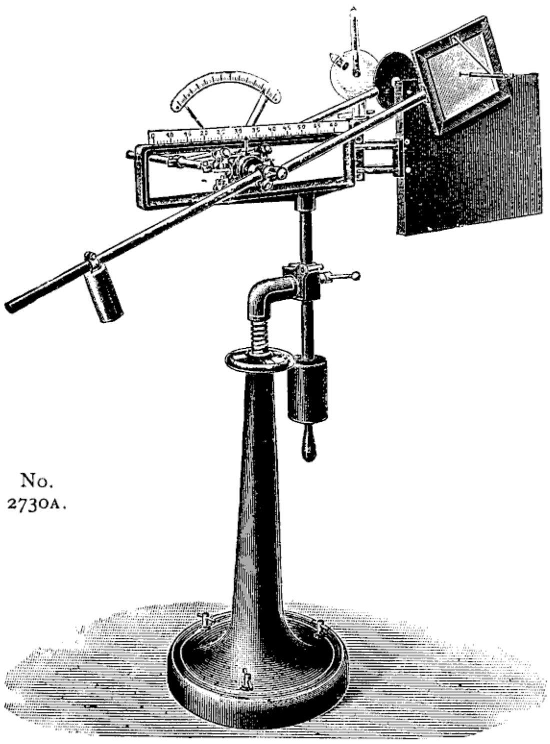
No. 2720. Portable cross-thread localizer, on table, complete, Fig. 2720 **£10 0 0**

No. 2720.





No. 2730.



No. 2730A.

No. 2730. **Orthodiagraph,** for making drawings of the outlines of the heart, etc., in correct, natural size, Fig. 2730 **£24 0 0**

The instrument can be adapted to any position of the patient. Fig. 2730 shows it in the position for a patient lying on the couch; Fig. 2730A shows it for a patient sitting or standing. The drawing can either be made on the skin of the patient, or on a sheet of paper to be fixed on a drawing board. Pencil and tube move simultaneously.

The tubes are carefully balanced. The instrument can also be used for measuring the length and height of objects (bones or foreign bodies), and ultimately it can be used for localizing foreign bodies. Full directions for use will be sent with the instrument.

DIAPHRAGMS AND COMPRESSORS.

(See also pages 103—105.)

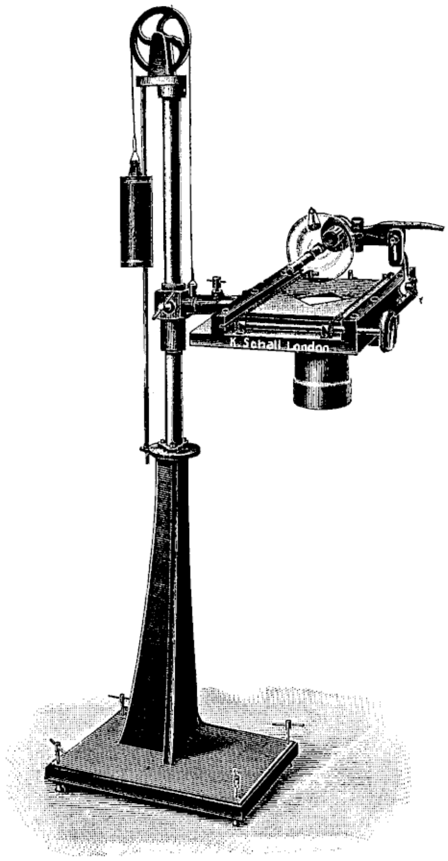
Diaphragms are of great importance for examination with the screen as well as for taking photographs.

You can best convince yourselves of this by making the following experiment: Examine a patient's heart on the fluorescent screen; without a diaphragm the shadow will be weak and the outlines indistinct, but if you place a diaphragm with a hole 3 to 4 inches wide between tube and patient, the shadow will be intense with sharp outlines. (See also pages 103-105.)

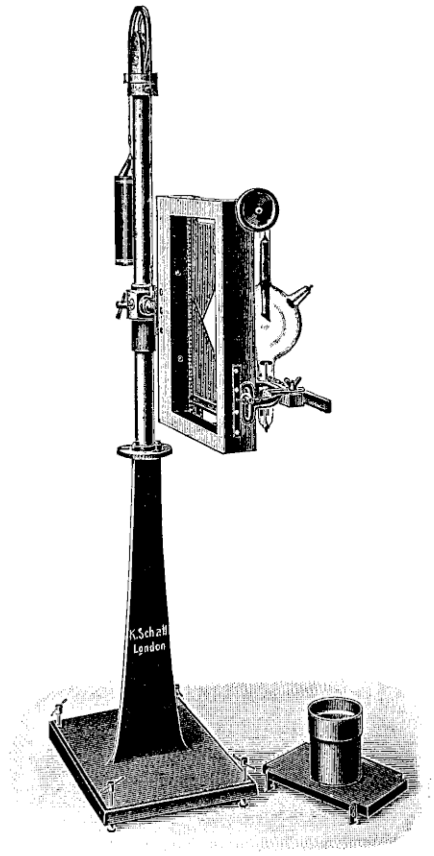
No. 2733.

No. 2732.	Screen for X-rays, on telescopic stand, with two funnels	£3 16 0
No. 2733.	Screen for X-rays, on telescopic stand, Fig. 2733, with cylinder diaphragm and compressor	8 0 0
	If a tube holder No. 2621 is added, as shown in Fig. 2733, the price will be	9 9 0

The cylinder diaphragm can be taken off, and lead glass tubes can be fastened instead as diaphragms for therapeutic purposes.



No. 2735.



No. 2735A.

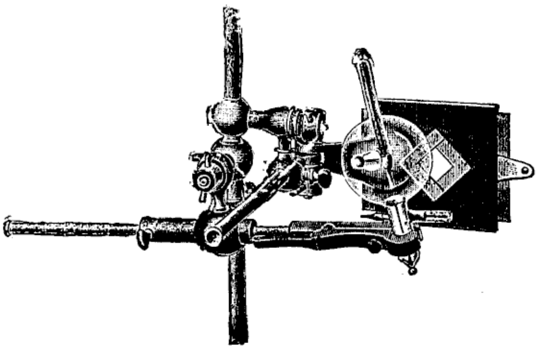
No. 2735. Cylinder diaphragm with compressor, Fig. 2735 or Fig. 2735A £12 12 0

No. 2737. Dr. Guilleminot's stand, with adjustable flat diaphragm, heavy cylinder diaphragm, and compressor... ... 17 0 0

The stand is 6 ft. high and 3 ft. wide. It can be placed over a couch, if it is desired to take a photograph with the cylinder diaphragm and compressor, or it can be placed behind a patient who is sitting or standing, if the screen is to be used. For the latter purpose the stand is provided with a black curtain to exclude the fluorescent light of the tube, and with an adjustable flat diaphragm to protect the skin of the patient, and to limit the illuminated area on the screen.

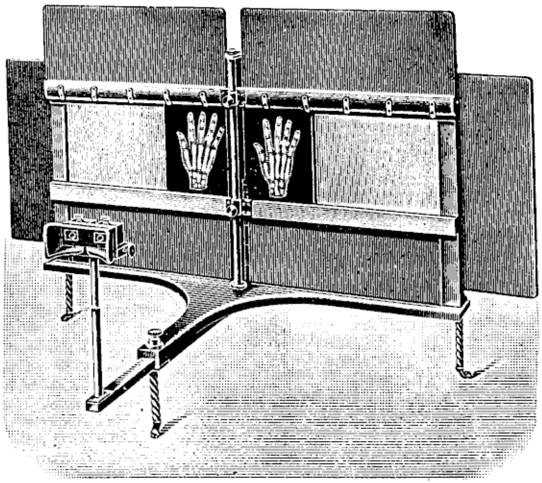
The apparatus can also be provided with frames with cross wires for localising foreign bodies. Illustration will be sent on application.

A full description of this useful stand will be found in *Archives d'Electricité Médicale*, No. 129, September, 1903.



No. 2739

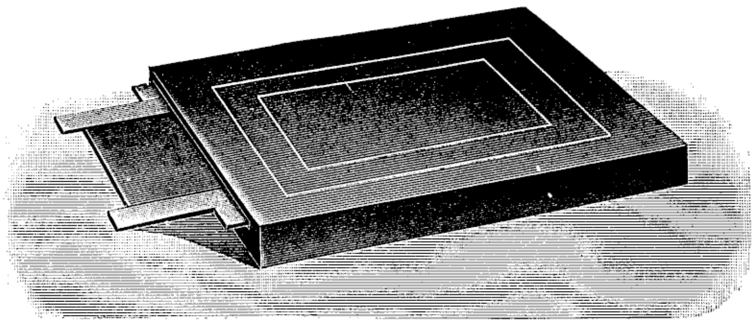
No. 2739. Adjustable flat diaphragm, Fig. 2739, to be attached to our tube stands **£2 6 0**



No. 2741.

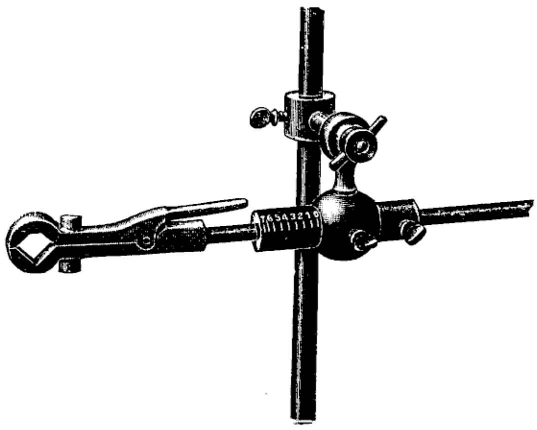
No. 2741. Dr. Walter's stereoscope with frames, to examine plates or prints measuring up to 12 in. by 15 in., as shown in Fig. 2741 ... ... **£10 0 0**

No. 2742. Similar apparatus, but for plates measuring up to 16 in. by 21 in. **11 0 0**



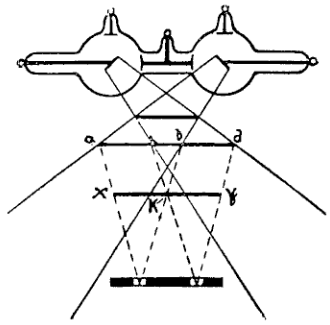
No. 2744.

No. 2744. Cassette for making two separate exposures on one large plate for stereoscopic purposes, Fig. 2744 ... ... **£1 15 0**



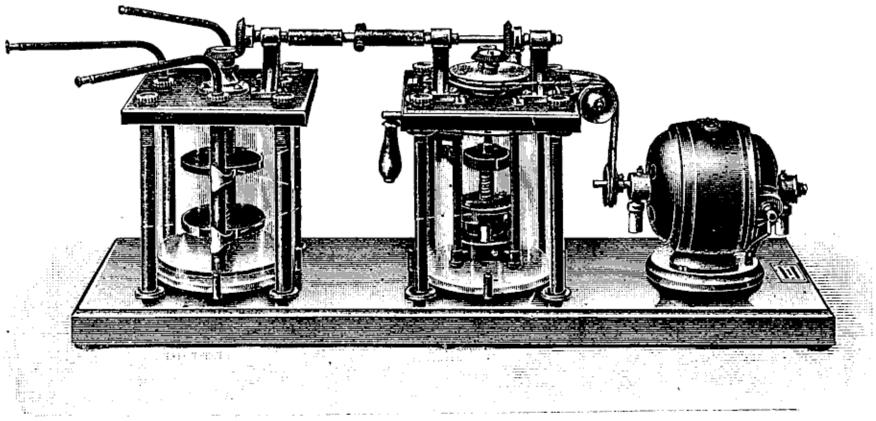
The tube holders Nos. 2621 and 2622 can be provided with a scale as shown in illustration, so that the tube can be shifted for a known number of millimetres, if two exposures are to be made to obtain stereoscopic effect.

COMMUTATOR FOR OBTAINING STEREOSCOPIC RELIEF ON A FLUORESCENT SCREEN.



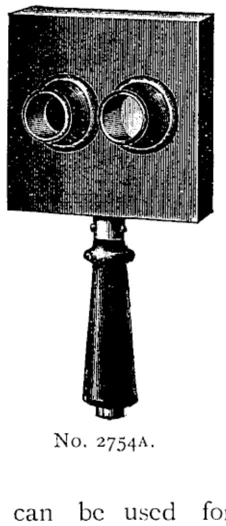
This method was first described by Mr. Mackenzie Davidson. The apparatus consists of a double tube containing two anticathodes (see No. 2616), a commutator, and a double shutter to be held before the eyes. Commutator and shutter are connected by means of a flexible shaft, and work synchronously in such a way that the right eye can see at the moment when the commutator sends the current to the tube on the left, and the left eye can see while the commutator closes the circuit of the tube on the right.

The alternations follow one another so rapidly that the breaks are not noticed by the eye. We see the objects in a steady light, not as a flat image on the screen, but bodily as if they were hanging in the air behind the screen, and we can judge conveniently the distance between the various objects which we see.



No. 2754.

No. 2754. Motor, mercury jet interrupter, and commutator, Fig. 2754, to make and break the current of the primary coil, direct the discharge of the secondary coil to the right or left tube, and to work the shutter of the stroboscope, complete with flexible shaft and stroboscope (the latter is shown in Fig. 2754A) ... **£25 0 0**



No. 2754A.

The same apparatus can be used for suppressing entirely the "closing current" through the tubes.

The jet interrupter can also be used separately as an ordinary jet interrupter, like No. 2546, independent of the commutator and stereoscopic arrangement.

LEAD MASKS, PHOTOGRAPHIC MATERIALS, AND VARIOUS ACCESSORIES.

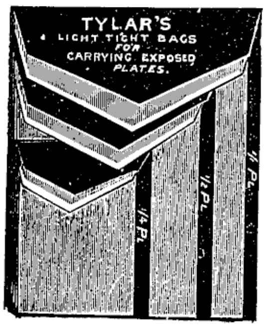
No. 2761.	Masks, with lead 0·25 millimetre thick, covered on both sides with indiarubber ...	per square foot	**£0**	**3**	**0**
		per square yard	**1**	**5**	**0**
No. 2762.	Similar masks, for the complete exclusion of the X-rays, lead 2 millimetres thick	per square foot	**0**	**5**	**0**
		per square yard	**1**	**16**	**0**

These masks consist of lead, which is covered on both sides with adherent layers of pure indiarubber. This makes the handling of the masks clean, enables you to sterilize the masks, prevents the unpleasant electrical discharges between mask and skin, and prevents the crumbling up of the masks. The thinner masks, lead 0·25 mm. thick, are sufficient for protection of the patient during an exposure; the heavy masks, with lead 2 mm. thick, exclude the X-rays completely.

Rubber Gloves, Rubber Aprons, etc., for the protection of the operator, can be supplied. Prices on application.

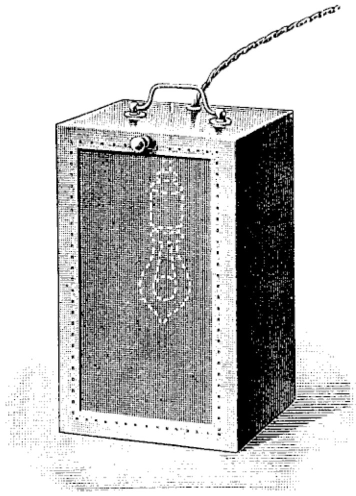
Dry Plates, Films, or Papers of any kind are supplied to order at the list prices charged by the makers.

In ordering plates, please state whether you desire medium, rapid, or instantaneous plates. We beg to draw the attention of our customers to the Röntgen plates coated heavily on both sides; under certain circumstances they give decidedly better results than the plates coated on one side only.



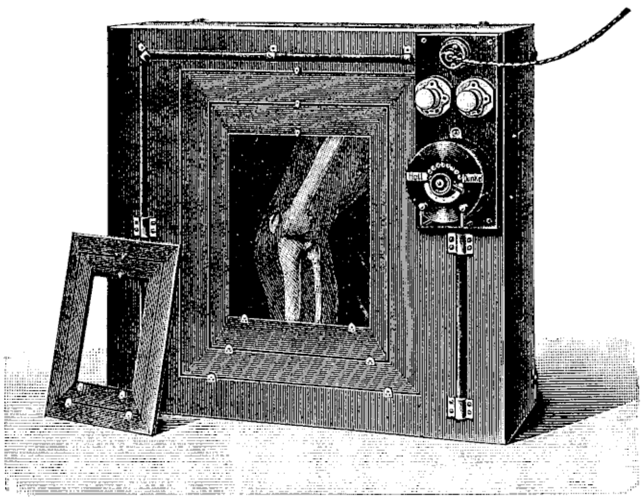
Light-tight yellow and black Envelopes, for protecting plates against daylight during exposure, $6\frac{1}{2} \times 8\frac{1}{2}$ in., **2/-**; 8×10 in., **3/6**; 10×12 in., **6/-**; 15×12 in., **10/-** per dozen.

Developing Trays, Porcelain Dishes, Printing Frames, Boxes for storing negatives, **Ruby Lamps, Glass Measures, Chemicals, Developers,** etc., supplied to order.



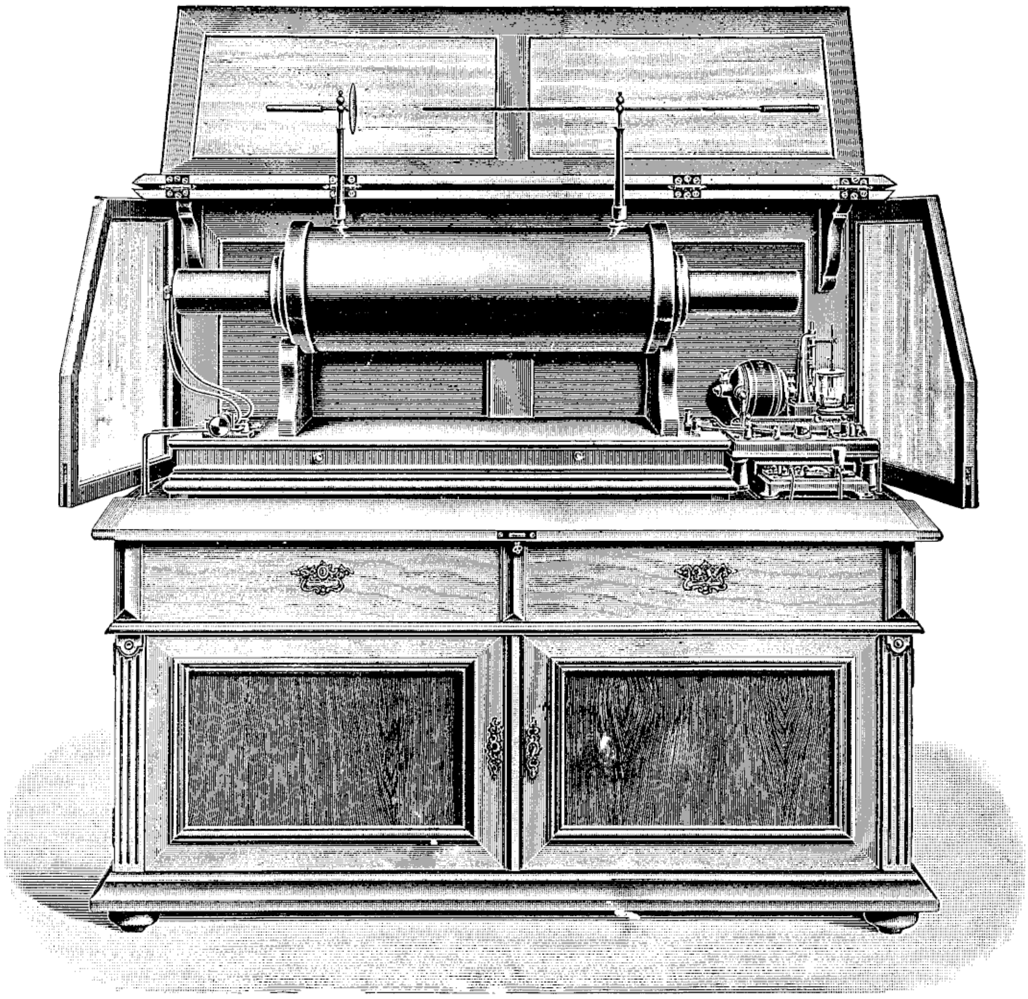
No. 2765.

No. 2765.	Ruby incandescent lamp, in box, Fig. 2765	£1 0 0
No. 2767.	**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 2 0
No. 2768.	Similar set, but for plates up to 12 × 15 in.	1 10 0



No. 2770.

No. 2770.	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. 2770	£5 10 0



CABINETS for the reception of spark coils, interrupter, rheostat, or accumulators can be made to order in various styles. Estimates and photographs can be had on application.

The illustration shows such a cabinet with glass cover for a 20 inch coil.

ESTIMATES OF
COMPLETE OUTFITS OF RÖNTGEN APPARATUS.

Packing, etc., is included in the prices quoted below.

(1) **Estimates for Houses where the CONTINUOUS Current from the main** (100 to 250 volts) **is available.**

No. 2800. 10 inch spark coil No. 2506, electrolytical interrupter No. 2550, rheostat, two tubes No. 2588, stand for tubes No. 2621, fluorescent screen No. 2643, cables and wires for connecting rheostat with coil, and coil with tubes—

(*a*) For 100 volt supplies	**£35**	**12**	**0**
(*b*) For 200 to 250 volt supplies, with rheostat No. 2671	**44**	**0**	**0**

No. 2800. Similar outfit, but with 12 inch coil No. 2507A, *with variable self-induction*—

(*d*) For 100 volt supplies	**46**	**10**	**0**
(*e*) For 200 to 250 volt supplies, with rheostat No. 2671	**55**	**0**	**0**

No. 2800. Similar outfit, but with 16 inch coil No. 2509, *with variable self-induction*—

(*h*) For 100 volt supplies	**63**	**10**	**0**
(*k*) For 200 to 250 volt supplies, with rheostat No. 2671	**71**	**0**	**0**

If the coils are taken without condensator, the price will be £2 8s. less for No. 2800 (*a*), £3 less for No. 2800 (*d*), and £6 less for No. 2800 (*h*).

If volt and ampère meters Nos. 963 and 964 are added, the price will be £3 10s. more.

No. 2802. 10 inch spark coil No. 2506, rheostat, mercury jet interrupter No. 2540, with rheostat to vary the speed of the motor, 16 lbs. mercury, one tube No. 2582 and one tube No. 2589, stand No. 2621 for the tubes, fluorescent screen No. 2643, cables and wires for connections—

(*a*) For 100 volts	**£46**	**0**	**0**
(*b*) For 200 to 250 volt supplies, with rheostat No. 2671	**54**	**10**	**0**

No. 2802. Similar outfit, but with 12 inch coil No. 2507—

(*d*) For 100 volts	**54**	**0**	**0**
(*e*) For 200 to 250 volt supplies, with rheostat No. 2671	**62**	**10**	**0**

No. 2802. Similar outfit, but with 16 inch coil No. 2509, with variable self-induction of primary coil, and variable capacity of condensator—

(*h*) For 100 volts	**75**	**0**	**0**
(*k*) For 200 to 250 volt supplies, with rheostat No. 2671	**81**	**10**	**0**

If interrupter No. 2536 is used instead of the jet interrupter, the price will be £6 less.

If volt and ampère meters Nos. 963 and 964 are added, the price will be £3 10s. more.

If volt and ampère meters Nos. 968 and 969 are added, the price will be £6 10s. more.

(2) Estimates for Houses where the ALTERNATING Current from the main (100 to 200 volts) is available.

No. 2804.	10 inch spark coil No. 2506, interrupter No. 2549 with rheostat, one tube No. 2582 and one tube No. 2589, stand No. 2621, fluorescent screen No. 2643, cables and wires for connections	£48	0	0
No. 2804B.	Similar outfit, but with 12 inch coil No. 2507A ...	52	0	0
No. 2804E.	Similar outfit, but with 16 inch coil No. 2509	72	0	0
No. 2806.	Motor transformer No. 2678, for converting the alternating into a continuous current, 10 inch spark coil No. 2506, jet interrupter No. 2540, including rheostat to control the speed of the motor and 16 lbs. mercury, tube stand No. 2621, one tube No. 2582 and one tube No. 2589, fluorescent screen No. 2643, cables and wires for connections	81	0	0
No. 2806B.	Similar outfit, but with 12 inch coil No. 2507A	89	0	0
No. 2806E.	Similar outfit, but with 16 inch coil, with variable self-induction and with a larger size motor transformer giving 1,600 watts	130	0	0

With interrupter No. 2536 instead of the jet interrupter, the prices of Nos. 2806—2806E will be reduced by £6.

No. 2808.	10 inch transformer No. 2561, with rectifier and switch-board, with rheostats, ampèremeter, etc., to use the alternating current from the main without any interrupter, one tube No. 2582 and one tube No. 2589, stand for tubes No. 2621, fluorescent screen No. 2643, cables and wires for connections ...	£84	0	0
No. 2808E.	Similar outfit, but with a transformer giving sparks 16 inches long	105	0	0

(3) Estimates for Houses in which the Current from the main is not available.

No. 2810.	10 inch spark coil No. 2506, with mercury or platinum hammer break, 12 volt accumulator of 50 ampère hours capacity (or large 8 cell bichromate battery), with rheostat, two focus tubes No. 2582, tube stand No. 2621, fluorescent screen No. 2642, cables and wires for connections	£36	10	0

No. 2810C. 10 inch spark coil No. 2506, 12 volt accumulator of 50 hours capacity (or large bichromate battery of 15 volts) with rheostat, interrupter Nos. 2535 or 2536, including mercury, two focus tubes No. 2582, stand for the tubes No. 2621, fluorescent screen No. 2643, cables and wires for connections £42 10 0

No. 2810D. Similar outfit, but with 12 inch coil No. 2507A ... 50 0 0

No. 2810G. Similar outfit, but with *two* 12 volt accumulators and 16 inch spark coil 72 10 0

No. 2812. Engine No. 2691 (for gas, oil, or spirit), with dynamo complete, 10 inch spark coil, jet interrupter No. 2540, with rheostat to control the speed of the motor and 16 lbs. mercury, tube stand No. 2621, one tube No. 2582 and one tube No. 2589, fluorescent screen No. 2643, cables and wires for connections £98 0 0

No. 2812B. Similar outfit, but with 12 inch coil 104 0 0

No. 2812E. Similar outfit, but with larger engine and 16 inch spark coil, with variable self-induction of primary coil, and variable capacity of the condensator ... 130 0 0

No. 2815. Hospital outfit, consisting of 10 inch spark coil No. 2506, interrupter No. 2536, 6 lbs. of mercury, tube stand, one tube No. 2582 and one tube No. 2589, fluorescent screen No. 2643, cables and wires, 12 volt accumulator of 50 hours capacity with rheostat, all mounted on a strong trolley with rubber covered castors, drawers for reception of the tubes, screen, cables, etc., and cover for the spark coil £52 0 0

No. 2815B. Similar outfit, but with 12 inch spark coil No. 2507A ... 60 0 0

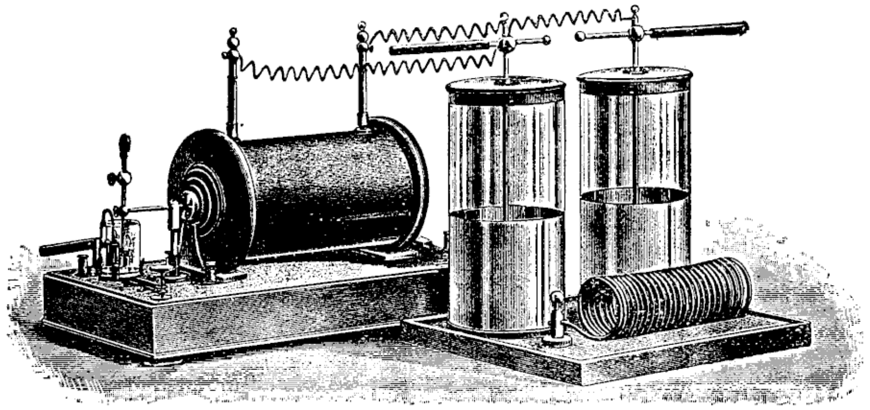
Estimates for other outfits can be had on application.

Lessons in the management of the apparatus are given in our show rooms, and experienced assistants can be sent at moderate charges to any part of Great Britain to fix and connect apparatus and to instruct the owners in their use.

Installations with 10, 12, 16 or 20 inch coils are always kept in stock, and can be delivered within a few days. Larger coils are made to order, and can be delivered within four to six weeks.

APPARATUS FOR HIGH FREQUENCY CURRENTS.

(See also pages 109—111.)

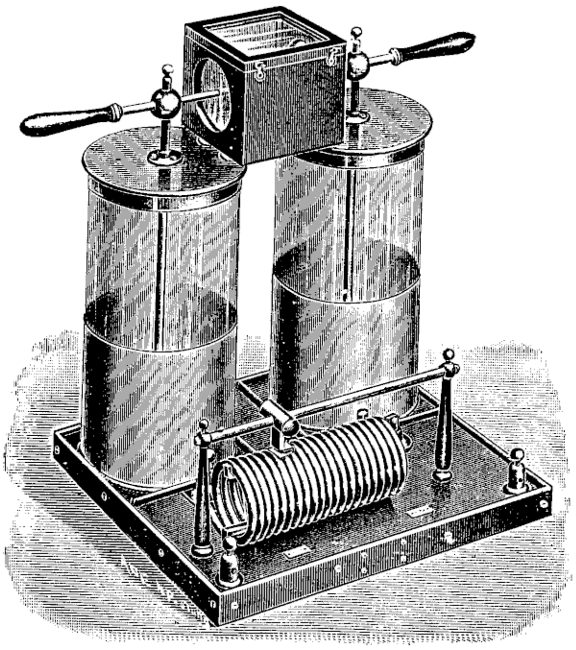


A description of the manner of producing these currents will be found on pages 109—111.

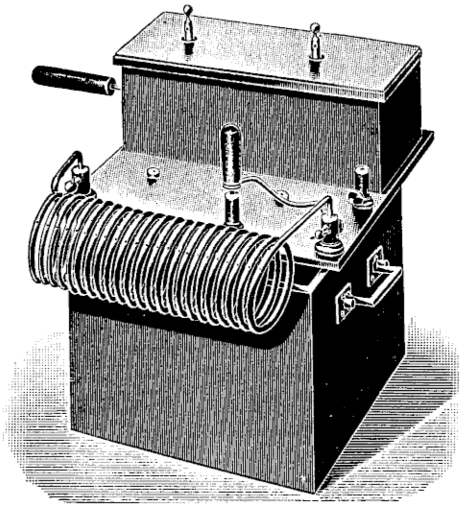
We guarantee that currents of over 500 milliampères can be obtained with the apparatus mentioned below; with careful tuning currents of 900 milliampères have been obtained with apparatus No. 3026 and a 10 inch spark coil. Stronger currents can be obtained with larger coils

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 **£5 16 0**

Size of the Leyden jars: Diameter 6½ in., height 14 in.

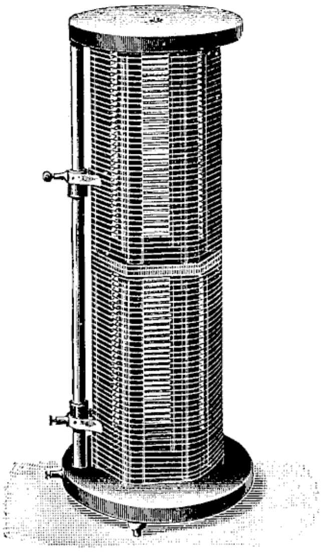


No. 3000.

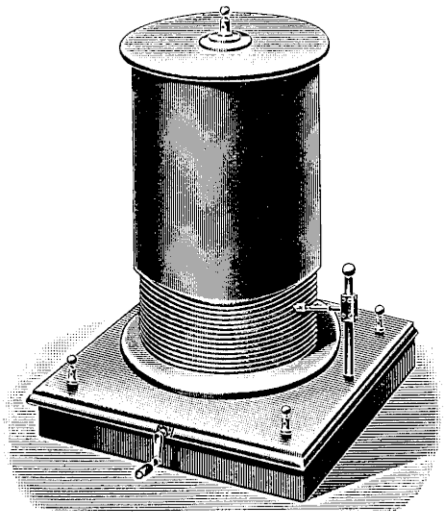


No. 3003.

No. 3003. D'Arsonval's transformer, new type, with condensator, consisting of stout glass and thin copper plates submerged in paraffin oil, spark-gap in case, solenoid, and switch, Fig. 3003 **£7 7 0**



No. 3012.

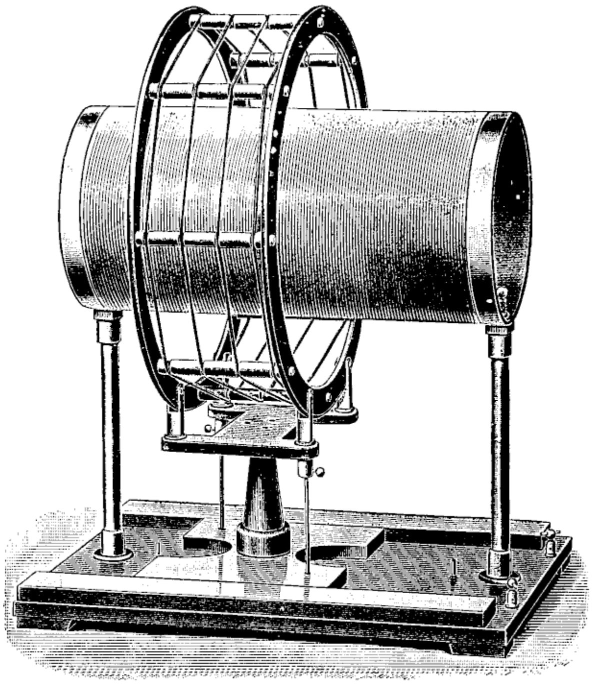


No. 3014.

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. 3014.	**Oudin Resonator,** Fig. 3014, wound on a drum which can be turned for accurate tuning by means of a handle	**7 7 0**

The upper part of the copper spirals of No. 3014 is insulated by a thick layer of paraffin and wax; the terminal on the top bears a projecting ebonite arm (not yet shown in illustration) to prevent the conducting cable from coming too near the spirals.

Diameter of the drum 11 inches, height 20 inches; total height including base and terminal on top 30 inches.



No. 3018.

No. 3017. **Tesla Transformer,** with air insulation. The primary is wound on a frame made of polished mahogany and ebonite, the secondary is wound on a polished ebonite cylinder provided with grooves and supported on strong glass rods. The position of the primary can be varied as in a sledge coil **£7 0 0**

No. 3018. Similar apparatus, larger size, Fig. 3018 ... ... **9 18 0**

Diameter of ebonite tube 12 inches, length 25 inches; size of mahogany base 27 inches long, 21 inches wide; total height of apparatus 32 inches.

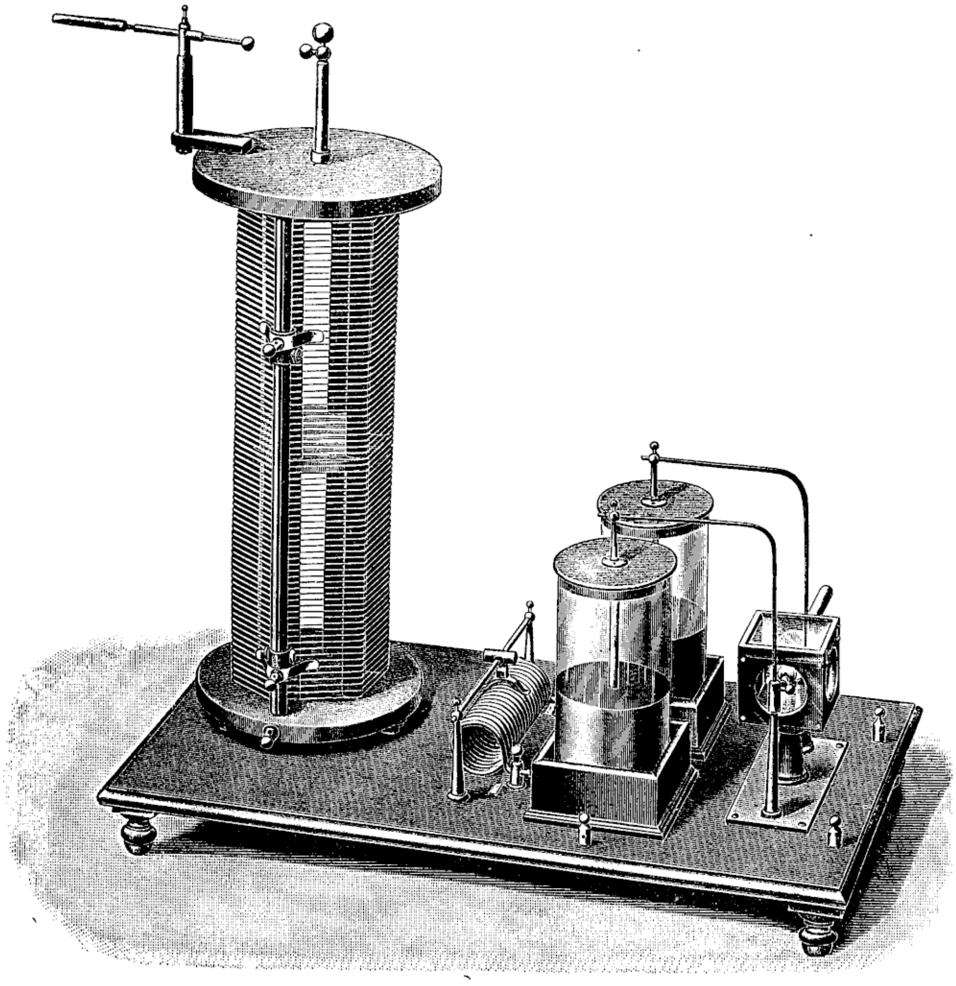
This apparatus gives a greater "effluve" than any of the other resonators.

COMBINED APPARATUS,

Consisting of d'Arsonval Transformer, Spark-Gap, Tuning Spiral, and Oudin Resonator.

No. 3025. Small apparatus, similar to Fig. 3026, consisting of d'Arsonval transformer, spark-gap, separate tuning coil, and Oudin resonator No. 3010, mounted on polished board **£10 0 0**

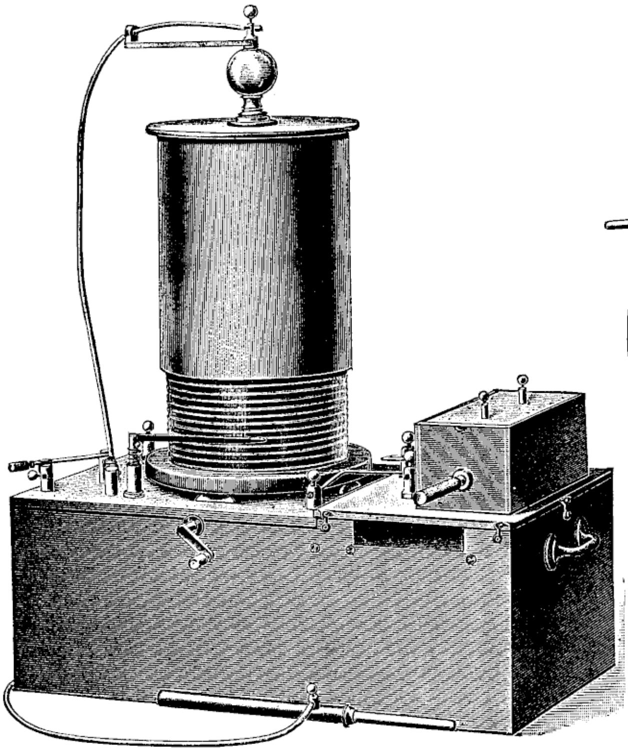
Size of the Leyden jars: diameter $3\frac{1}{2}$ in., height $8\frac{1}{2}$ in.
Length of the board 28 in., width $18\frac{1}{2}$ in. Total height 32 in.



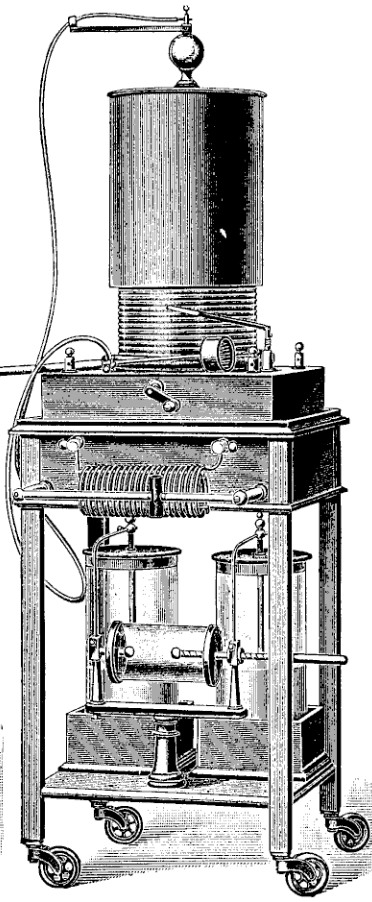
No. 3026.

No. 3026. Similar apparatus, but larger size, Fig. 3026 ... ... **£12 15 0**

Size of the Leyden jars: diameter $6\frac{3}{4}$ in., height 14 in.
Length of the board 45 in., width 25 in. Total height 47 in.



No. 3029.



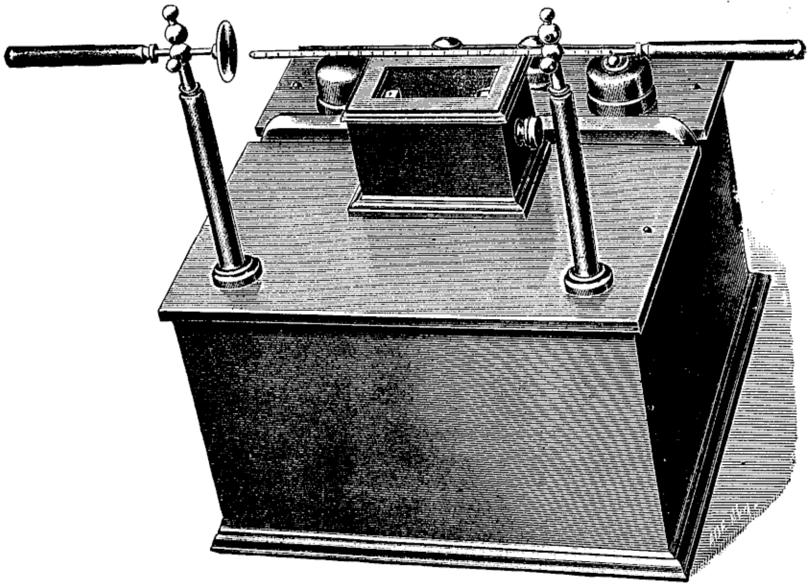
No. 3032.

No. 3029.	Apparatus consisting of d'Arsonval transformer No. 3003, and Oudin resonator No. 3014, mounted on a board, with large drawer for the reception of electrodes, handles, cords, etc., Fig. 3029	£15 0 0
	Size : length 29 in., width 17 in., total height 36 in.	
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	15 0 0
	Size of the Leyden jars : diameter 6¾ in., height 14 in.	
	Size of the apparatus : 21 in. by 21 in., total height 62 in.	

(As supplied to T. J. Bokenham, H Lewis Jones, M.D., E. R. Morton, M.D., W. Tyrrell, W. M. A. Anderson, F. Little, F. W. Morison, E. N. Reichardt ; Royal Infirmary, Edinburgh ; Royal Victoria Hospital, Belfast, etc., etc.)

If a separate small tuning spiral is added, as shown in illustration, the price of the apparatus will be £17.

If small Leyden jars are used, and table of polished deal instead of mahogany, the price of No. 3032 will be reduced to £12 10s.

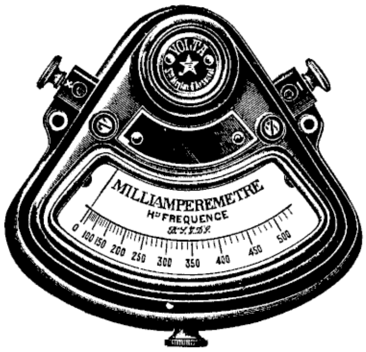


No. 3039.

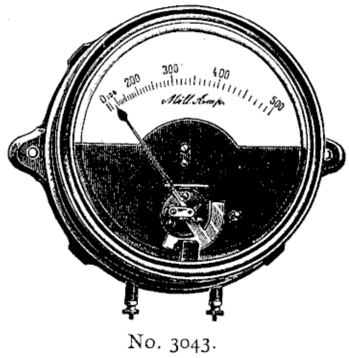
No. 3039. Step-up transformer, to raise an alternating current to about 10,000 volts, condensator and Tesla transformer in polished mahogany case filled with oil, spark-gap with silver terminals safely protected in special box with glass lid. Discharging rods, switch, and fuse, mounted on polished ebonite, Fig. 3039 ... ... **£25 0 0**

This apparatus has to be connected directly to an alternating current supply. A spark coil or interrupter are not required with it.

GALVANOMETERS FOR HIGH FREQUENCY CURRENTS.



No. 3041.



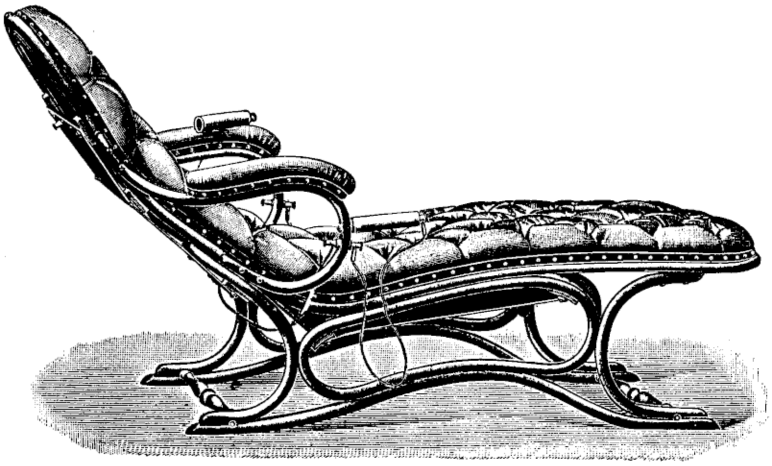
No. 3043.

No. 3041. Milliampèremeter, Fig. 3041, registering up to 500 milliampères **£4 4 0**

No. 3043. Similar instrument, round type, diameter 8 in., Fig. 3043 **4 4 0**

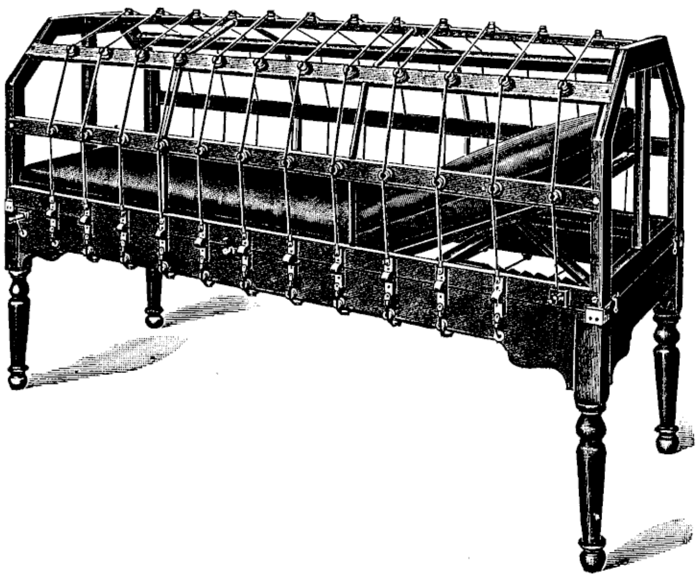
Galvanometers registering up to 1,000 milliampères can be made to order. The prices are the same as those given above.

CONDENSATOR COUCHES AND SOLENOIDS FOR AUTOCONDUCTION.



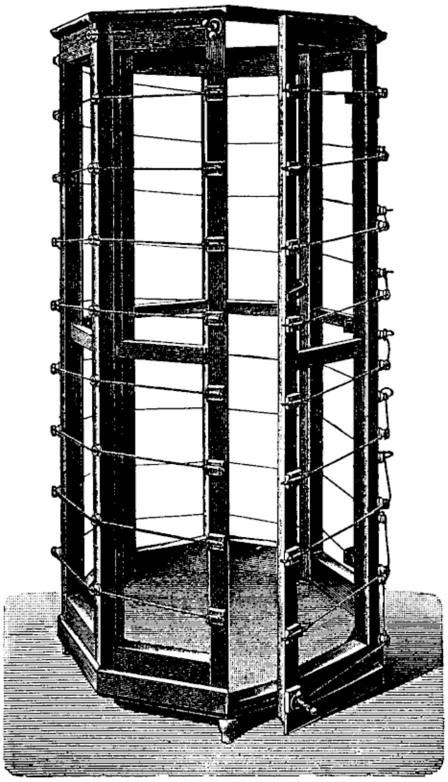
No. 3051.

No. 3051. **Condensating Couch** of Austrian bentwood, thick horse hair mattress covered with dark leather, insulated zinc sheet, and two large electrodes, Fig. 3051 ... ... £9 0 0



No. 3053.

No. 3053. **Combined Condensating Couch and Solenoid for Autoconduction,** Fig. 3053 ... ... £17 0 0

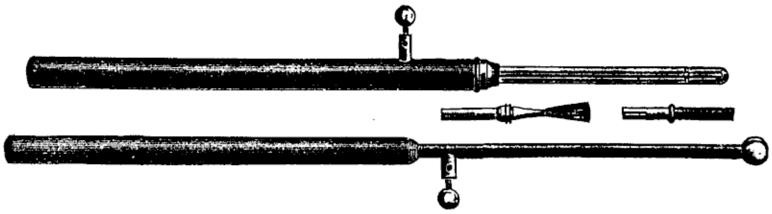


No. 3056.

No. 3056. Upright solenoid, Fig. 3056, for autoconduction **£10 10 0**

No. 3057. Upright solenoid, similar to No. 3056, but the copper spirals can be drawn up like a Venetian blind **£12 12 0**

ELECTRODES FOR HIGH FREQUENCY TREATMENT.

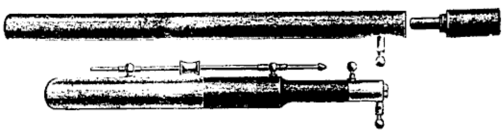


No. 3070.

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**

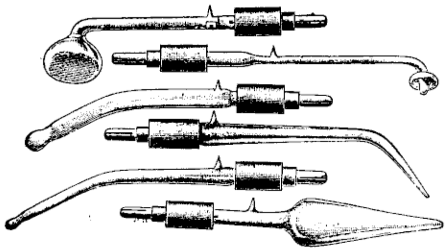


No. 3074.

No. 3076.

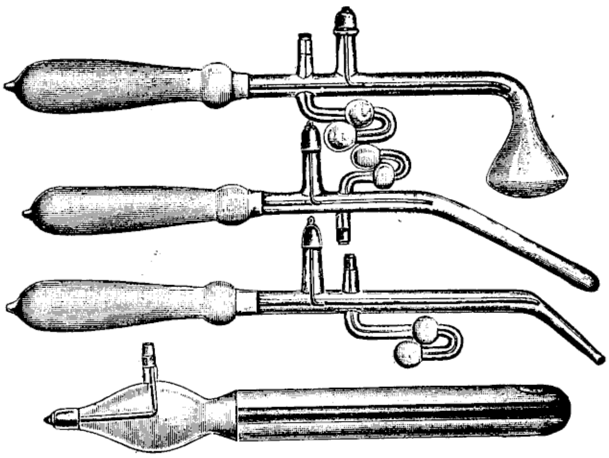
No. 3074. Similar handle, 12½ inches long, for the reception of vacuum electrodes, Fig. 3074 ... ... **£0 12 0**

No. 3076. Handle, 12 inches long, Fig. 3076, with adjustable spark-gap, for the reception of different electrodes ... **1 1 0**



No. 3084.

No. 3090.



No. 3088.

No. 3080. Metal points, brushes, balls, etc , for handle No. 3072, each £0 2 6

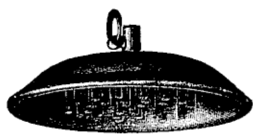
No. 3084. Vacuum electrodes of glass for application to the skin, ear, rectum, uterus, etc. (see illustrations, Fig. 3084) each 0 7 0

No. 3085. Complete set of six vacuum electrodes, including handle No. 3074... ... ... 2 12 0

No. 3088. Glass electrodes, Fig. 3088, filled with saline solution for application to rectum, vagina, ear, etc., and for external applications ... ... each 0 5 9

No. 3089. Vacuum electrodes of glass, similar shapes as shown in Fig. 3088 ... ... each 0 7 0

No. 3090. Conical electrode of thin hollow metal, nickel-plated, for treating hæmorrhoids, including ebonite handle, Fig. 3090 0 12 6



No. 3093.

No. 3092. Multiple point electrode, with twenty-five points in ebonite cup, diameter $2\frac{1}{2}$ inches (the electrode fits handles Nos. 3072—3076) 0 18 0

No. 3093. Large multiple point electrode, Fig. 3093 ... ... 2 0 0

No. 3096. Metal electrodes, for application to ear, rectum, etc., each 0 7 6

No. 3100. Electrode, with ebonite cup, for applying drugs with the discharge of high frequency currents 1 10 0

No. 3140. Heavily insulated conducting cords, 5 feet long, for high frequency currents ... ... per pair 0 14 0

ESTIMATES

Of Complete Installation of Apparatus for Treatment with High Frequency Currents.

In addition to the apparatus mentioned below, it is necessary to have a spark coil with interrupter (or a transformer). Estimates for this will be found on pages 283—285.

If Röntgen rays are not required, the value of two tubes, one tube stand, and one fluorescent screen (£7 12s. to £8 15s.) have to be deducted from the prices quoted on pages 283—285.

In addition to the spark coil, etc., are required :—

One of the combined apparatus described under Nos. 3025 to 3039, specially insulated connecting cords, some electrodes, and a condensator couch (an existing couch can occasionally be adapted for this purpose) or a solenoid, and in many cases a galvanometer.

No. 3201.	Transformer and solenoid No. 3025, cables No. 3140, handle No. 3074, three vacuum and two metal electrodes	£12	0	0
No. 3202.	Similar apparatus, but with No. 3026 instead of No. 3025	14	12	0
No. 3205.	Transformer and solenoid No. 3026, cables No. 3140, two handles, six vacuum and three metal electrodes, galvanometer No. 3043, and condensating couch No. 3051	29	10	0
No. 3207.	Transformer and solenoid No. 3032, insulated cables, two ebonite handles, six vacuum and four metal electrodes, galvanometer No. 3043, and couch No. 3051	31	0	0

Estimates for installation for bipolar treatment, either with transformer No. 3018 or with two separate resonators No. 3014, can be had on application.

The cost of packing, etc., is included in the above prices.

The apparatus can be mounted in cupboards of mahogany, walnut, etc. Illustrations can be had on application.

The total cost of an installation of apparatus for treatment with high frequency currents, including cost of spark coil, etc., varies, therefore, from £60 upwards.

The apparatus can be seen in working order at any time in our show rooms. Diagrams of the connections and full instructions for use will be sent with the apparatus.

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.

VARIOUS INSTRUMENTS.

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

No. 4000.

No. 4004.

No. 4000. Small electro-magnet, with five different points, Fig. 4000 £1 0 0

This magnet is wound for 8 volts, requires a current of 4 ampères, and can carry a weight of about 2 lbs.

No. 4004. Medium sized magnet, Fig. 4004—

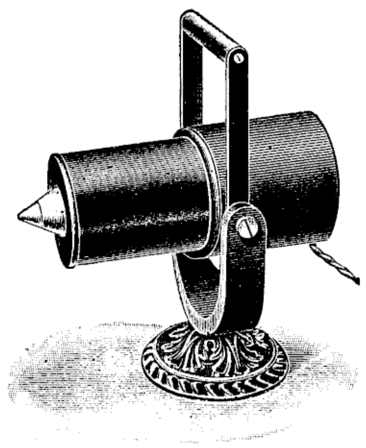
(*a*) Wound for 8 volts and 5 ampères £1 4 0
(*b*) Wound for 100 volts and 0·2 ampère ... 1 12 0
(*c*) Wound for 200 to 250 volts and 0·1 ampère ... 1 16 0

No. 4006.

No. 4006. Large electro-magnet (Prof. Hirschberg's), Fig. 4006, with five points—

(*a*) Wound for 8 volts and 7 ampères £3 0 0
(*b*) Wound for 100 volts and 0·5 ampère ... 3 10 0
(*c*) Wound for 220 volts and 0·25 ampère ... 3 16 0

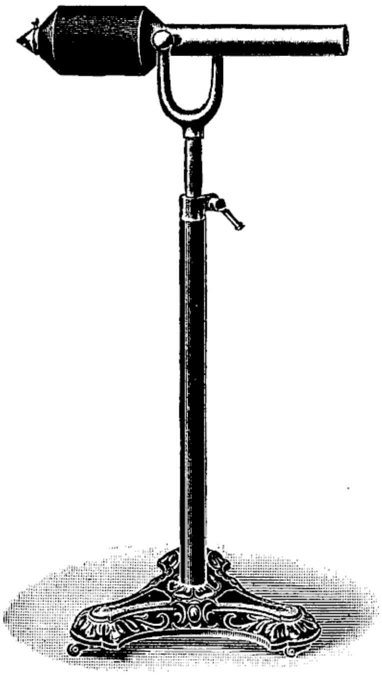
This size magnet can carry a weight of about 16 to 20 lbs.



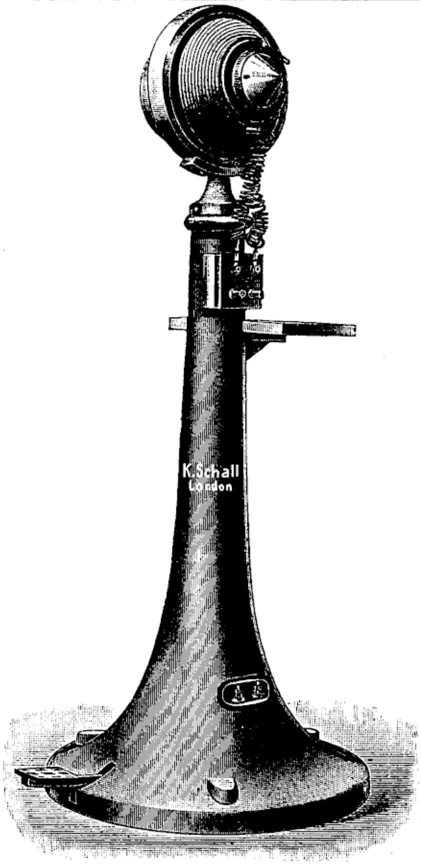
No. 4012.

No. 4012. Prof. Schloesser's electro-magnet. This powerful magnet is suspended in a fork as shown in Fig. 4012; 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
(*b*) Wound for 100 volts and 2 ampères 7 12 0
(*c*) Wound for 220 volts and 1 ampère 8 10 0



No. 4016.



No. 4020.

No. 4016. Large electro-magnet on telescopic stand, with a long iron core suspended in a fork, movable in any direction, Fig. 4016—

(*a*) Wound for 100 volts and 2 ampères ...	...	**£10**	**0**	**0**
(*b*) Wound for 220 volts and 1 ampère ...	...	**11**	**11**	**0**

No. 4017. Rheostat to control the power of this magnet **2 5 0**

No. 4020. Large Haab's magnet, latest type, Fig. 4020—

(*a*) Wound for 100 volts and 15 ampères	...	**32**	**10**	**0**
(*b*) Wound for 220 volts and 8 ampères ...	...	**35**	**0**	**0**

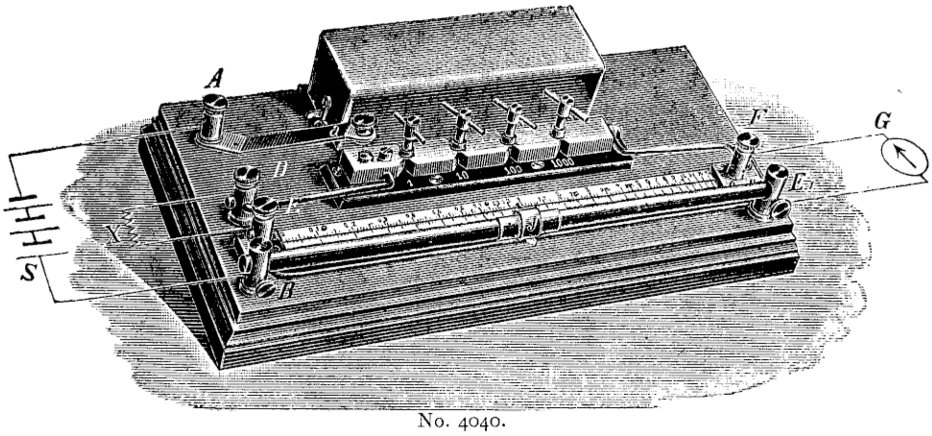
The prices include the switch and rheostat to control the power of the magnet. It can carry a weight of over 300 lbs. The current has to be switched on or off with the foot

No. 4022. Large magnet of similar power as No. 4020, but suspended in a fork, which is movable in any direction, and fitted with counterweight so that it can be adjusted above a patient lying on an operating table—

(*a*) For 100 volts	...	**£56**	**0**	**0**
(*b*) For 200 to 250 volts	...	**60**	**0**	**0**

These prices include a switchboard, with fuse, switch, and rheostat to control the power of the magnet.

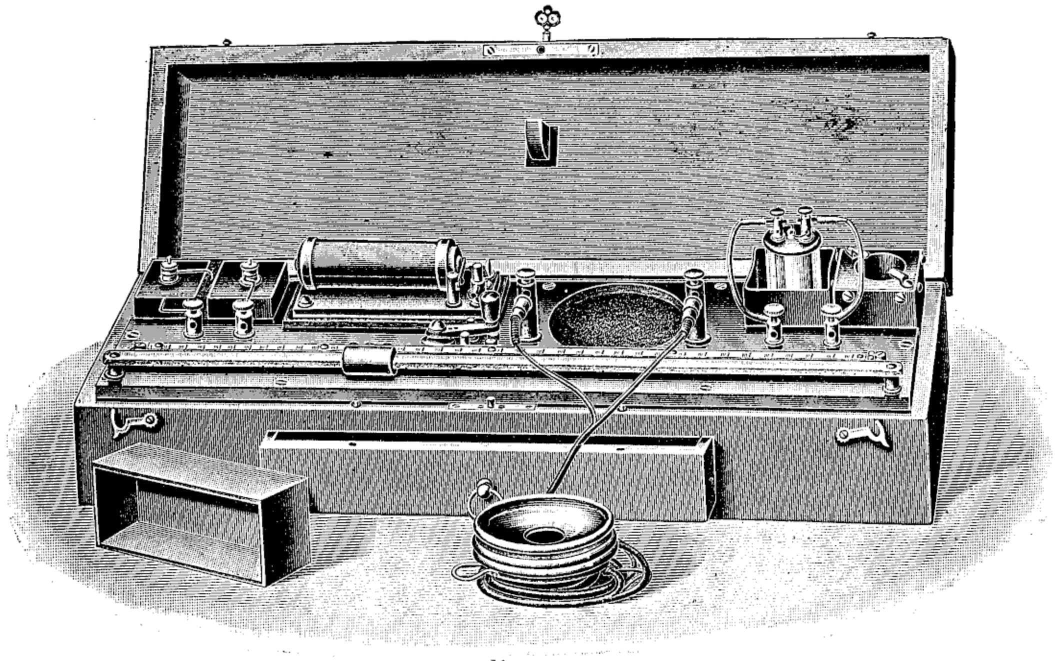
WHEATSTONE BRIDGES FOR MEASURING RESISTANCES.



No. 4040.

No. 4040. Wheatstone's universal measuring bridge, after Prof. Kohlrausch, with resistances of 1, 10, 100 and 1,000 ohms, and bridge wire, Fig. 4040 ... ... £8 0 0

This bridge is especially arranged for quick measurements with direct reading of the resistances of the human body, etc., and is accurate for resistances between about 2 ohms and 10,000 ohms. For measuring the resistance of fluids it is best to use the alternating current and a elephone (price 17/-); for measuring the resistance of solid bodies, the continuous current, with galvanometer Nos. 277 or 278, had better be used.

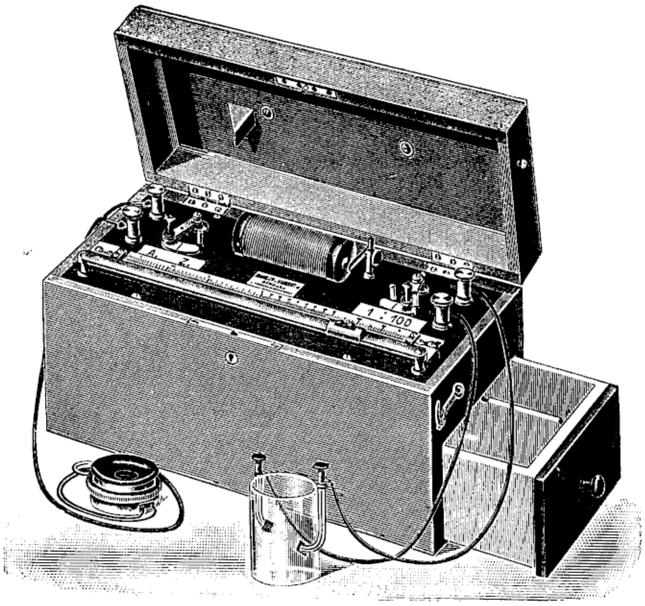


No. 4045.

No. 4045. Apparatus for measuring the conductivity of blood, urine, etc., Fig. 4045 ... ... £12 0 0

This method was suggested originally by Dr. Dawson Turner, and full particulars will be found on page 197 of his book: *Practical Medical Electricity*.

The apparatus consists of a Wheatstone bridge with coil, telephone, and battery arranged in a portable case, and is provided with graduated measure glasses of suitable size for blood or urine. Detailed directions for use are sent with the apparatus.

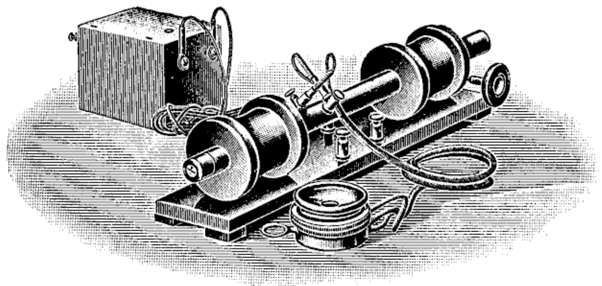


No. 4050.

No. 4050. Apparatus for determining the ions in alkaline solutions and mineral springs, Fig. 4050 ... ... **£5 16 0**

This is another form of Wheatstone bridge with battery, coil, telephone, and measuring glass with two platinum electrodes.

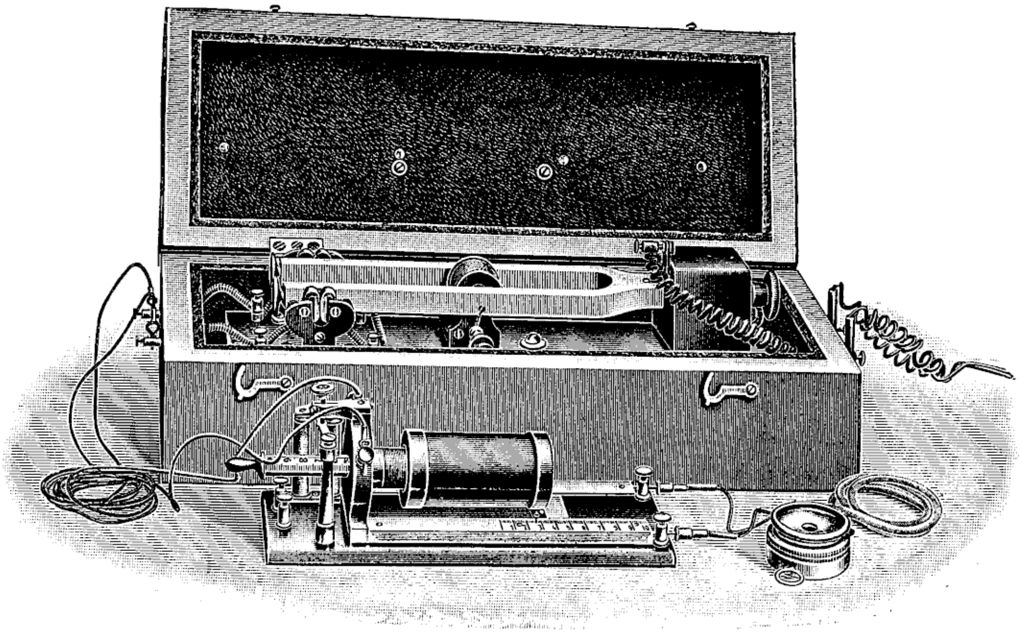
APPARATUS FOR TESTING THE HEARING.



No. 4060.

No. 4060. Apparatus, Fig. 4060, consisting of two primary coils and one secondary coil, which can be moved by rack and pinion. An interrupter, which is placed in a felt-lined box, makes and breaks the current, and a telephone is connected with the secondary bobbin. Price of the complete apparatus, including battery ... **£5 5 0**

The two primaries are connected so that in one position of the secondary coil the telephone will receive no current at all, and will therefore remain quite silent. It would be difficult to obtain this result with one primary coil only.



No. 4065.

No. 4065. Prof. Breitung's apparatus for testing the hearing, Fig. 4065 ... ... £10 0 0

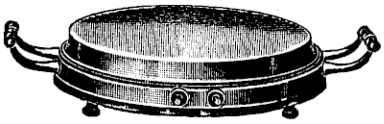
This apparatus consists of a tuning fork worked by an electro-magnet. While the tuning fork vibrates, it induces currents in two small electro-magnets, which are in connection with a sledge transformer (either coil No. 27 or a sledge transformer as used for sinusoidal currents), and attached to the latter is a telephone. The intensity of the sound in the telephone can be varied by altering the position of the secondary coil, which is fitted with a scale. The tuning fork is enclosed in a case lined with felt, so that its sound cannot be heard when the lid of the case is closed.

The apparatus No. 4065 produces a pure musical sound of variable intensity in the telephone ; the apparatus No. 4060 produces a grating noise of variable intensity.

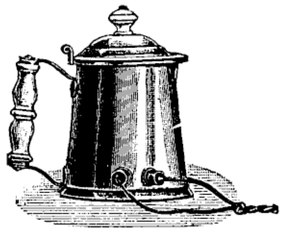
APPARATUS FOR HEATING WATER OR COOKING, ETC. BY ELECTRICITY.

In the apparatus mentioned below the current from the main (continuous or alternating) passes through coils of wire made of an alloy of nickel. These coils become heated and communicate the heat to the water, but care must be taken that the apparatus is not switched on before water has been put in the kettles. The amount of heat can be controlled by connecting the wires to different contacts ; if a very fine graduation of the temperature is desired, a rheostat can be inserted in the circuit.

It is stated how many ampères the apparatus require with 100 volt supplies ; if the E.M.F. is 200 to 250 volts, the figures given have to be reduced to one-half. In ordering please state the voltage of your supply.



No. 4100.



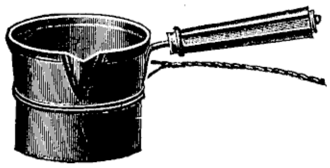
No. 4110.

No. 4112.

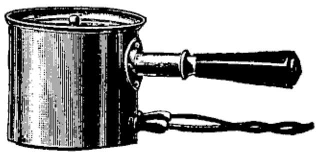
No. 4100.	Hot plate, for keeping warm the objects placed on it, Fig. 4100—			
	(*a*) Diameter $7\frac{1}{2}$ in.; 0·5 ampère	£1	3	0
	(*b*) Diameter 9 in.; 1 ampère	1	16	0
	(*c*) Diameter 12 in.; 2·7 ampères	2	14	0
	(*e*) Rectangular, 14 × 20 in.; 3 ampères ...	5	9	0

Similar plates reaching so high a temperature that the kettles, etc., placed on them can be brought to boiling point, can be supplied. The prices are 15 per cent. higher than those mentioned above.

No. 4110.	Small water jug, containing 1 pint, Fig. 4110, 2 ampères	£1	6	0
No. 4112.	Similar jug, but larger size, containing 3 pints, Fig. 4112, 5·5 ampères	2	2	0



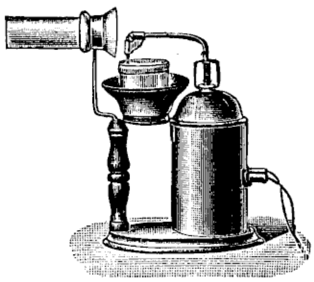
No. 4115.



No. 4116.

No. 4115.	Small open cooking pot, for $1\frac{1}{4}$ pints of water, Fig. 4115, 3·5 ampères	£1	1	0
No. 4116.	Similar pot, but larger size, for 2 pints, and provided with a lid, Fig. 4116, 4 ampères	1	7	0

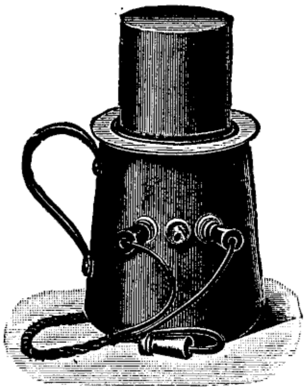
No. 4120.



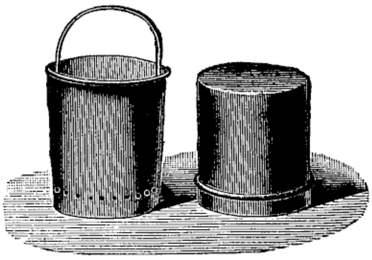
No. 4130.

No. 4120.	Cooking pot with lid, for 3 pints, Fig. 4120, 5·5 ampères	£1	14	0
No. 4121.	Similar pot for 6 pints, 9 ampères	2	6	0
No. 4130.	Electric inhaling apparatus, Fig. 4130	1	12	0

STERILIZING APPARATUS.

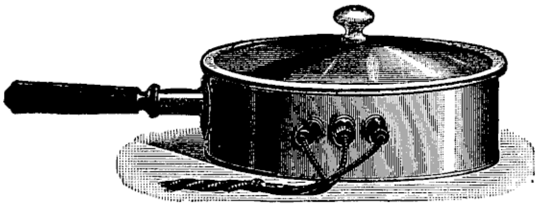


No. 4150.



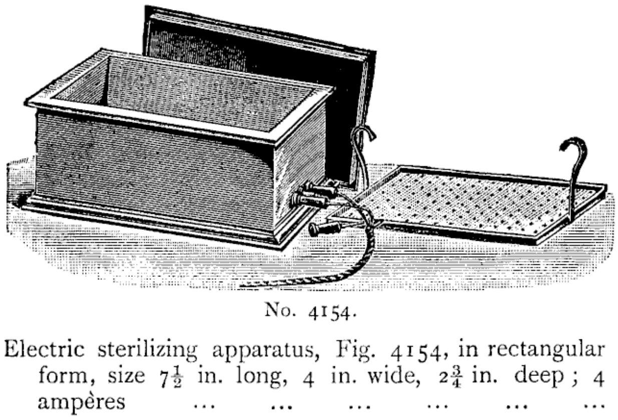
No. 4150A.

No. 4150.	Electric sterilizing apparatus, Fig. 4150, size inside 7 in. high, 3½ in. diameter; 3 ampères	£1 9 0
No. 4151.	Similar apparatus made of solid nickel	1 18 0



No. 4152.

No. 4152.	Electric sterilizing apparatus, made of solid nickel, Fig. 4152; the oval dish measures inside 8 in. long, 5½ in. wide, 2¼ in. deep; 3 ampères	£1 18 0

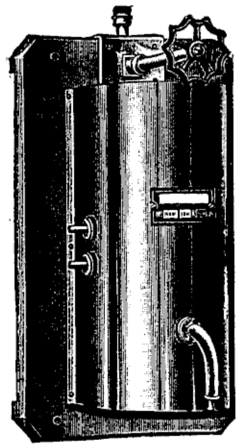


No. 4154.

No. 4154.	Electric sterilizing apparatus, Fig. 4154, in rectangular form, size 7½ in. long, 4 in. wide, 2¾ in. deep; 4 ampères	£2 15 0
No. 4156.	Similar apparatus, 11½ in. long, 8 in. wide, 5 in. deep; 8 ampères	5 18 0
No. 4158.	Similar apparatus, 20 in. long, 8 in. wide, 5 in. deep; 12 ampères	7 0 0

APPARATUS FOR OBTAINING WARM WATER FOR DENTAL, ETC., PURPOSES, OR FOR WASHING HANDS.

No. 4170.



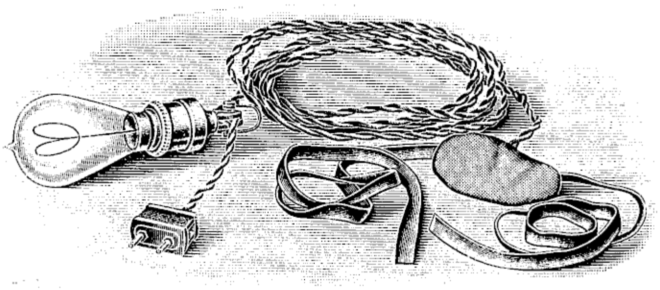
No. 4173.

No. 4170.	Electric warm water kettle with tap, Fig. 4170, size 10 × 8 in.; 10 ampères The apparatus can easily be cleaned inside	£2 17 0
No. 4173.	Electric warm water kettle with tap, Fig. 4173, size 16 × 8 in., greatest projection from wall 7 in.; 12 ampères	6 12 0

No. 4173 has to be connected with the water pipes, and supplies about 50 pints of water of 105° Fahr. per hour.

THERMOPHORES OR COMPRESSORS HEATED BY ELECTRICITY.

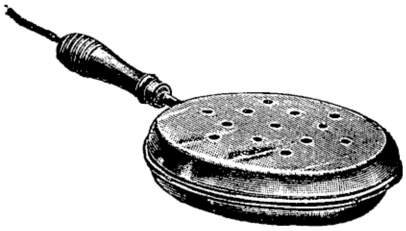
The thermophores are clean, convenient, and temperature is constant and perfectly under control. An incandescent lamp acts as resistance, and in addition a variable rheostat has to be inserted in the circuit.



No. 4180.

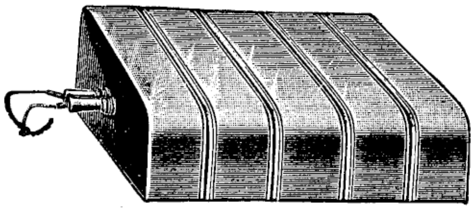
No. 4180.	Electric thermophore, for treating the eye, Fig. 4180 ...	£0 10 6
No. 4181.	Electric thermophore, 8 × 10 in., with 3 yards flexible cable	0 19 0
No. 4182.	Similar apparatus, 12 × 14 in.	1 12 0
No. 4184.	Similar apparatus, 10 × 16 in.	1 12 0
No. 4186.	Similar apparatus, 2½ × 16 in.	0 19 0
No. 4189.	Rheostat for the thermophores	1 18 0

ELECTRIC BED PANS AND FOOT WARMERS.



No. 4195.

No. 4195.	Electric bed pan, nickel-plated, Fig. 4195, diameter $9\frac{1}{2}$ in., with flexible cable 3 yards long	£1	10	0

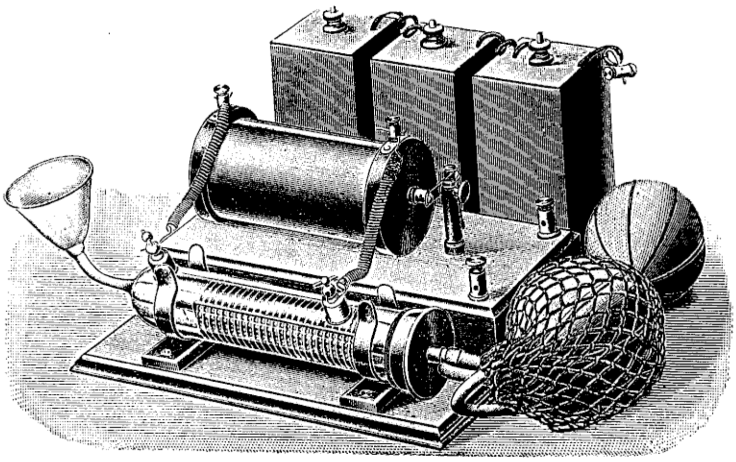


No. 4198.

No. 4198.	Electric foot warmer, Fig. 4198, 14 × 12 × 4 in.; 0·3 ampère	£1	12	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 $\frac{1}{4}$ in.	1	7	0
No. 4208.	Spark coil, giving sparks $\frac{3}{4}$ in. long	2	0	0



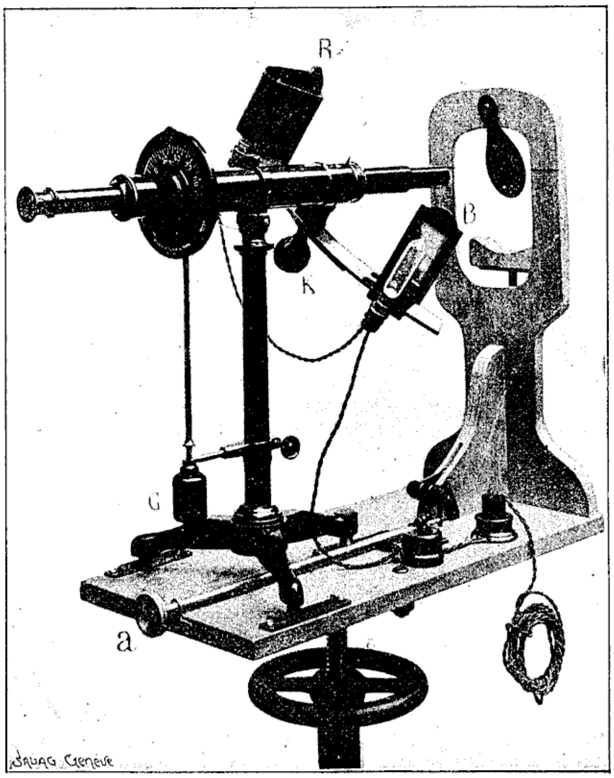
No. 4212.

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	10	0

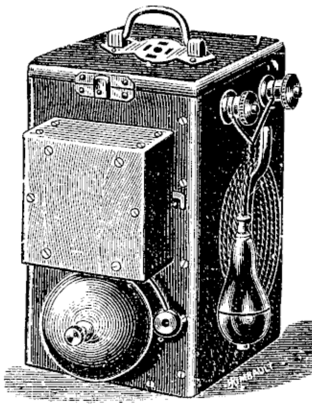
JAVAL SCHIOETZ OPHTHALMOMETER

With new figure plates coloured with complementary colours, and provided with a Wollaston prism. This enables a more accurate adjustment of the images than was possible hitherto, but this improvement can only be used with transparent plates, and not with reflected light. The two lanterns bearing the figure plates are now moved *simultaneously* to or from the centre.

If an electric current is available, two incandescent lamps are the most convenient source of light. Welsbach gaslight or acetylene lamps may also be used for transparent plates, and reflected daylight can be used for the white enamelled opaque plates.



No. 4290.



No. 4300.

No. 4290.	Javal Schioetz ophthalmometer, Fig. 4290, with figure plates for reflected daylight illumination	£12	12	0
No. 4292.	Same instrument, with the new coloured transparent figure plates, and arranged for electric illumination...	16	0	0
No. 4295.	Same instrument as No. 4292, arranged for illumination with incandescent gaslight	17	0	0
No. 4299.	Artificial eye	0	2	6
No. 4300.	Invalid's bell, Fig. 4300, with 12 yards of flexible silk cord, pear push and dry cells	0	18	0

TERMS.

In ordering, please mention the list number of the apparatus to avoid mistakes. *Detailed printed directions for use are sent with each instrument.* The instruments, which are made of the best materials only, are guaranteed for proper working.

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 three months after 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 as electrical apparatus are subject to frequent alterations, 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 batteries 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.

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, you must 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 list 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 35s. 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.

Skilled assistants can be sent to manage batteries during operations. £1 1s. is charged for the first two hours, or less, including the loan of the necessary battery and instruments, and 2s. 0d. for any following hour or part of an hour. If railway has to be used, third class return tickets are charged in addition.

Instruments for taking Roentgen photographs are lent out with all the required accessories. The prices depend on the size and number of plates required, and the length of time for which they are wanted, and vary from £2 2s. to £5 5s.

CONTENTS OF THE PRICE LIST.

Alphabetical List of Contents of the Price List.