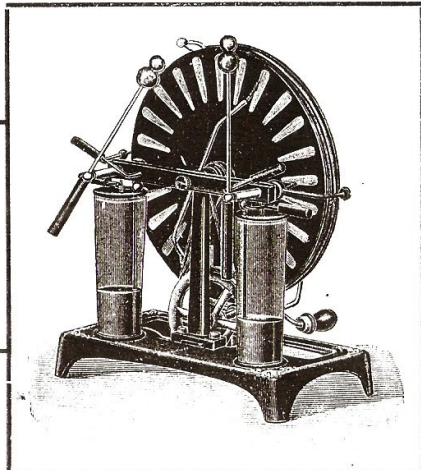
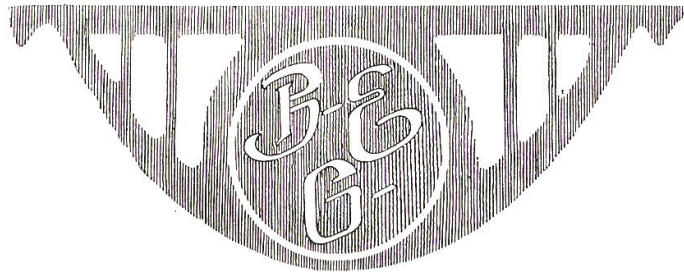


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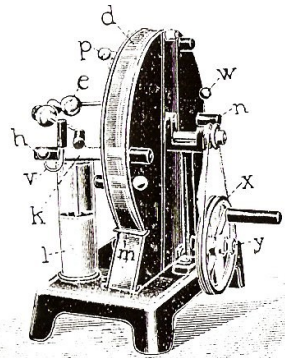


Fig. 2. Back view of a condenser machine with fixed casing. Nos. 300 to 302.

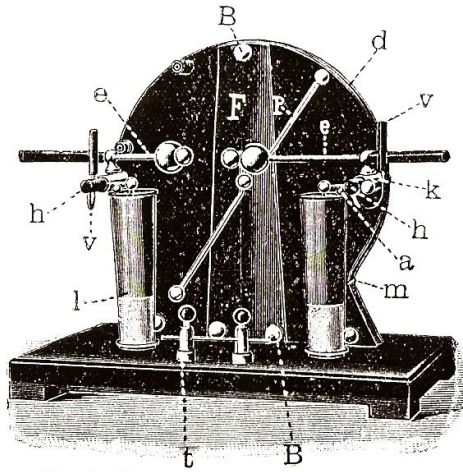


Fig. 3. Front view of a condenser machine with fixed casing. Nos. 303 to 304.

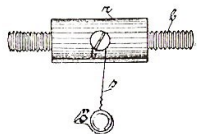


Fig. 4. Attachment of the brushes (for condenser machines with fixed casing only).

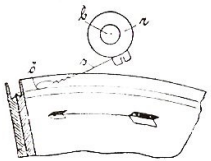


Fig. 5. Correct position of the brushes (for condenser machines with fixed casing only).

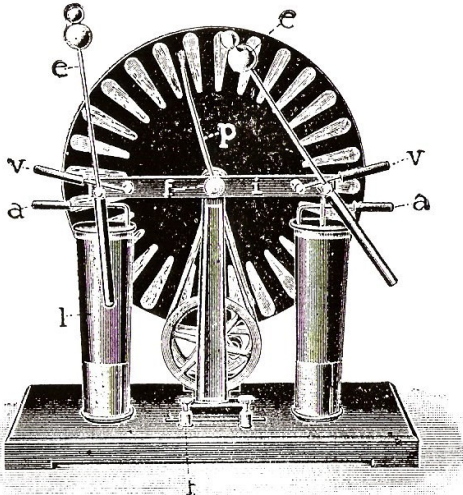


Fig. 6. Influence machine with double rotation.

e Electrodes.
l Leyden jar.
a Cut-out for the same.

v Interrupter.
p Polarizer (transverse conductor)
t Terminals for high frequency currents.

d Protection strips.
k Conductors.
n Nuts.

Manual of Static Electricity.

Introduction.

The credit must be given to English investigators of first recognizing the importance of electro-static machines and discovering various uses to which they could be put.

Although the influence machine was known 10 years ago in England and used for many purposes, being, for example, an almost indispensable agent for electro-medical treatment, it was hardly known even by name in other civilized countries. But in the year 1912 electrostatics entered upon a new stage in their development, in consequence of the invention of the condenser machine by Dr. Wommelsdorf. Owing to the influence of the discs on all sides, 4 to 10 times the current efficiency can be produced with a condenser machine as with influence machines of a like size, system Wimshurst.

No other study will perhaps excite the same interest as electrostatics, and the number of effective and instructive experiments is almost inexhaustible.

The young, who must in modern times, absorb such an amount of dry science, will learn by experiment, without exertion, facts which they are quite indifferent to in the ordinary scholastic course. It is the purpose of the present manual to illustrate the nature of electric high tension, the most modern and most important branch of electro-technics, with the aid of absolutely harmless machines and carefully constructed apparatus.

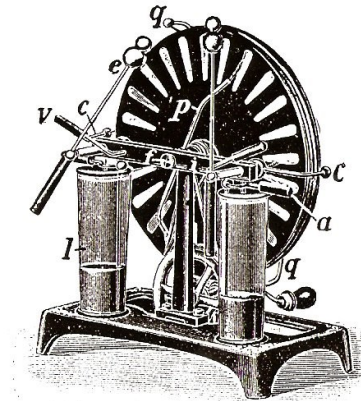


Fig. 7. Condenser machine with double rotation.

It must here be expressly stated that every machine is carefully tested before despatch, so that there is no possible risk of failure. The machines can however, only be expected to act properly, if the instructions are strictly adhered to. The instructions should therefore be first carefully studied.

A. Experimenting with electrostatic machines.

I. Rules for all classes of machines.

1. **Unpacking.** On receipt of a machine which has been properly packed, observe the remarks in § 21 to § 23 (page 6), before commencing to fit it together.

2. **Direction of rotation.** All machines must be turned exclusively to the right, as the brushes or sectors would otherwise be damaged.

3. All vulcanite handles should be held at the extreme end, in order to protect oneself from sparks.

4. **The maximum length of spark.** Whether a condenser or influence machine is used, the negative electrode *c* must always be nearly vertical, or somewhat to the rear, to attain the greatest length of spark (with condenser machines with fixed casing it should be vertical to the latter) whilst the positive electrode *e* must be at an inclination to it, as demonstrated in figure 6. A commencement should always be made with small sparks and the larger ones allowed to develop gradually. The greatest length of spark can only be attained by strictly adhering to this rule, which will be found quite simple after a little practice.

5. The negative electrode will be recognized by a sharp humming noise when reversed, as shown in fig. 4. The position of the electrode must then be changed, by giving the other a vertical position.

6. The electrode balls must be rubbed perfectly clean to attain the maximum length of spark, and dust should be carefully removed from all other parts with a dry cloth.

7. **Connection of apparatus, interrupters.** The line wires or hains must, under no circumstances, be hung directly on the electrodes *e*; they must be hung on the interrupters *v* (figs. 2, 3, 6 and 7). These are adjustable, so that any desired spark-gap can be obtained. The most favourable position of the interrupting lever *v* will vary for almost every experiment, and this must therefore be ascertained and regulated on each occasion.

8. **Leyden jar cut-out.** On the type de luxe the jars *l* have a cut-out *a*, by which they can be put out of action. The sparking will then be of quite a different character. When switching in, the switch (eventually the ball of the switch) must have good contact with the metal rod projecting from the middle of the jar.

9. **Supply of high frequency currents.** On the machines of the type de luxe which are mounted on wooden boards, 2 terminals are fitted on the sole-plate. In taking current from these, the electrode rods must be brought so closely together that the sparking-over will be small. If the rods on the terminals are now drawn apart, sparking-over will also occur here, namely, pure oscillations or high frequency currents. Under ordinary conditions, the terminals *t* must be connected.

10. **Safe-keeping.** All machines with vulcanite discs must be kept in a dark and dry room. Under no circumstances must the machines be placed in the sun or in a warm stove, as the discs would become distorted and cause jamming.

11. Should a machine fail to work, in course of time, in spite of strict attention to these instructions, or the length of the spark decrease, the disc must be thoroughly cleaned. This applies to all types of machines. See remarks in § 24 to § 27.

II. Special rules for influence an condenser machines with double rotation.

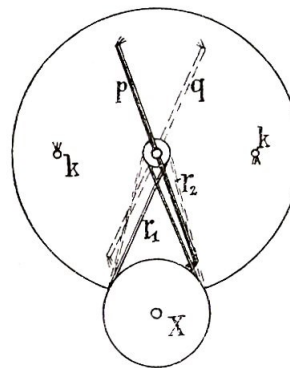


fig. 9. Position of the polarizers *p* and *q* on influence machines. Important.

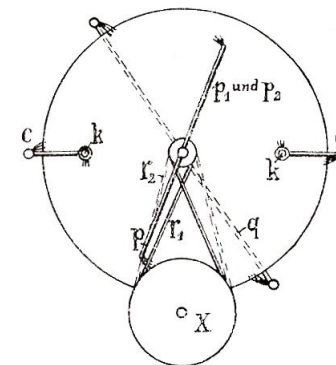


fig. 10. Position of the polarizers *p* and *q* on condenser machines with double rotation.

12. **Position of the polarizers** (very important). On influence machines, the lower half of the polarizers *p* and *q* (figures 9 and 6) must invariably stand close to the right hand of the belt, the front polarizer *p* to the right when seen from the front (jar side), and the rear polarizer *q* to the right when seen from the back, so that they will form an angle to each other.

On condenser machines, the two small polarizers *p*₁ and *p*₂ must be in exactly the same direction, but the large polarizer *q* at an angle to this (see figures 10 and 7), the lower part of the small front polarizer *p*₁ being as close as possible to the left of the belt, when seen from the front.

13. With the object of getting long sparks, the polarizers *p* and *q* (rotating arms) must have a more vertical position, so that the lower arms almost touch the leather cord, as demonstrated in figure 6. Strict attention must also be given to § 4 to § 6. On the other hand, should the main requirements be more reliable self-excitation and a rapid succession of small sparks, the polariser *q* must not be given such a vertical position. The most favourable position can readily be ascertained by shifting when in operation.

14. **The hair pencil or brushes** of the conductors *k* should not touch the discs, though they should be quite close; on the other hand, the brushes of the polarizers *p* and *q* must slide gently over the discs (or, in the groove of the discs). Under no circumstances must single bristles be allowed to protrude from the brushes or spread from the groove towards the neighbouring disc. The bristles of all brushes must be well twisted together, and must not stand apart after the manner of a hair pencil. Important!

Exchange of damaged brushes. This is very simply done by drawing them out of the thread with a pair of pliers, and then screwing in a new brush, and cutting to the proper size. Only proper brushes, procured from the suppliers of the machine, should be used, as others would be liable to damage the sectors, or would not fit in the thread.

15. **Leather cords.** The front leather cord *r*₁ (figs 9 and 10) that is, the one on the front side of the machine (jar side), must invariably run crossways; on the other hand, the other one (rear cord) *r*₂, and both the other cords on condenser machines, must run straight, as the machine will otherwise fail to act. (See figs. 6, 7, 9 and 10.)

16. **Currents with periodically changing direction**, (highly interesting) can only be obtained with condenser machines of double rotation, which is done by disconnecting one or both hair pencils of the large polarizer q , by turning the balls to a greater or lesser distance from the groove, or eventually turning one or both brushes completely back, whereby the most favourable position can be ascertained and varied by trials. The alternating current resulting can be excellently demonstrated with the pendulum (experiment 44) electrometer (60) paper tassel, (45) or with a Geissler tube (53).

17. **Conversion of an influence machine** of double rotation into a condenser machine. The Wommella machines of double rotation are so arranged that they can be converted without trouble, by any inexperienced person, into a condenser machine with double rotation. Any one possessing an influence machine on this system can therefore increase the capacity (number of sparks) four to six-fold by merely procuring supplementary parts.

III. Special rules for condenser machines with fixed casing.

In addition to the rules 1 to 11, under I, attention must also be paid to the following remarks:

18. **An essential point is the proper position of the brushes** (see fig. 5). The machine can only be self-excited when the wire ring o (fig. 5) for each steel wire s slides horizontally (not sloping) on the ridge of the groove. If this is not the case, the wire (on tube r) must be turned outwards, after loosening the nuts on the side of the machine, the ring δ bent horizontally and then turned inwards into the groove, until it touches the ridge.

19. When turning, the hand or clothing must not come too close to the discs, as this would reduce the length of the sparking.

20. **Self-excitation**. If no self-excitation takes place on a machine, although the electrodes c have been pushed together, a brief pressure must be exercised on the friction cushion button fitted at the back on the fixed casing, whilst turning. The friction of the cushion will cause the machine to start quickly, without losing its excitation so quickly.

IV. Unpacking and fitting the machines.

21. For purposes of better packing, all machines must be partially taken to pieces. Before and during the process of putting them together, the following points must be observed.

22. **In the case of influence and condenser machines** with double rotation (see figs. 6 and 7) the Leyden jars 1 must first be placed in the depressions in the sole plate provided for this purpose; then the vulcanite rod i , on which the rotary electrode rods e are fitted, must be screwed up by means of the milled headed screw f . On machines with 18 and 21 cm discs, a polarisator p must be inserted before this, between vulcanite rod i and bearing pedestal, and this is also held by the milled headed screw. The metal rods of the Leyden jars 1 must protrude into the holes intended for them on the under side of the vulcanite rod i . The operation must be done exactly as demonstrated in figs. 6 and 7, and special attention must be paid to the proper position of the leather cords (see § 15) as well as to the correct positions of the polarisators p and q (§ 12), because it will otherwise be impossible for the machine to work properly. The correct arrangement of the switchable Leyden jars is also an important point (§ 8).

23. **On condenser machines with fixed casing**, the jars 1 must also be fixed by inserting the bent wire projecting from the centre of the jar (the balls must first be unscrewed), into the hole in the front vulcanite nut h (left and right), and screwing up as far as possible the ball on the thread which protrudes.

V. Cleaning the machines.

24. **Failure of a machine**. If a machine acts irregularly, or not at all, all parts must undergo a thorough cleaning, but the discs in particular. After being cleaned, every machine, of whatever system it may be, will recover its full capacity, because no wear or exhaustion of the material occurs, as is the case, for example, on cells.

25. Polished metal parts must be absolutely clean and smooth, and must never be touched with sharp tools, pliers or similar instruments, without putting some soft material between them, because even slight damage to the surface may reduce the sparking length to the extent of one half (easily recognizable in the dark, on account of the radiation.) Foil sectors which are entirely or partially worn off, must be pasted on again with liquid glue.

26. Vulcanite discs without Bakelit coating (on influence machines) will be preferably well rubbed with a mixture of spirits and French chalk on both sides, on the other hand, celluloid or vulcanite discs with Bakelit coating must be thoroughly rubbed with benzine,

27. Any superficial cleaning, without employing heavy pressure, is absolutely useless, and it is equally useless to use an oily or dirty cloth. The discs should be laid on a table and vigorously rubbed on both sides, until they show a high polish and are perfectly dry and smooth.

VI. Dismounting the machines.

28. **On influence and condenser machines with double rotation**, the vulcanite rod i with the jars 1 etc. must first be removed, as described under § 22. In order to dismount the discs, the following points must be observed: On machines on which the bearing is open at the top, the rear milled-headed-screw must be simply loosened, so that the shaft with the discs can be readily taken out, after slipping off the driving belt. If the bearing is not open at the top, the back supporting pedestal must be slightly eased on the sole-plate by loosening the two screws, so that it can be forced back a little, and thus make it possible to draw the discs with the axle upwards through the axle hole.

On condenser machines, the 3 discs on an axle must be loosened successively, by unscrewing the brass washers between the discs. When putting together again, attention must be paid to § 22.

29. **Dismounting condenser machines with fixed casing**. As the inner surfaces of the rotating disc must be more frequently cleaned than the fixed ones, the fixed frame is arranged so that it can be drawn out. After unscrewing the two bolts B at the top and bottom of the centre strip F , both halves must be drawn apart, and the rotating disc will then be accessible. Its axle nut must then be removed from the shaft and the two single discs taken apart. (for cleaning with benzine, refer to § 26 and 27). The inside of the two halves of the frame must also be frequently cleaned. In order to prevent getting the screws mixed, it will be advisable to take one half to pieces at one time, and carefully note the position for the separate screws, nuts and balls, because they must not be confused. Care must also be taken that the paper layers are not laid towards the rotating disc.

VII. Sources of faults.

a) On influence and condenser machines with double rotation.

30. One or all polarizers p and q (that is the rotating arms with brushes) are on the wrong side or not crossways. (See § 12 and figures 9 and 10.)

31. The four brushes of the same do not touch the discs, which is absolutely essential! On the other hand, the two brushes on the conductors should not touch the disc, but must be at a distance of about 1 mm away.

32. Single bristles of the brushes spread and radiate in the dark, with the result that the sparking length will be reduced. The bristles of the hair-pencil must be twisted together, and not spread out as on brushes.

33. The leather cords may have been put on wrongly: the front one (that is the one nearest to the electrodes) must be crossed, whilst the other shorter cords must run straight. See figs. 6, 7, 9 and 10!

b) On condenser machines with fixed casing.

34. A brush may be missing or is fixed wrongly, its ring does not slide horizontally on the ridge, or it stands contrary to the direction of rotation. fig. 5 and § 18 should be carefully studied.

35. When fitting together again, after dismounting, the balls and vulcanite nuts may have got mixed. Adhere strictly to the illustrations 2 and 3 and § 29.

c) For all types of machines.

36. Oil may have been supplied too plentifully, so that it has penetrated between the discs. Oil must only be thinly applied.

37. Irregular action or failure to work is a sign that the surfaces of the discs must be cleaned, if everything is otherwise in order. Proceed exactly as instructed in § 24 to § 29.

B. Electro-statical experiments.

I. General Rules for making electro-statical experiments.

38. In order to carry out the experiments here described, a number of rules must be observed which will apply for all experiments, and are therefore given as introductory remarks, before dealing with special instructions for the individual experiments.

39. All apparatus, in particular, all insulating parts such as glass, vulcanite, silk thread, must, like the machine, be absolutely free from dust and quite dry.

40. The wires from the machine to the apparatus must neither touch each other nor the table, because this would allow the electricity to escape, without reaching the apparatus. They must therefore be kept as far as possible from each other, as well as from the table or other objects (about 2 inches), the wires being supported, if necessary by a glass-tumbler, which must, however, be absolutely dry.

41. Sharp edges and points should be avoided as far as possible in the wires, as the high tension electricity escapes through these.

42. Almost all experiments will turn out better if the wires are not connected directly with the electrodes, but with the interrupters, which are then removed slightly from the electrodes, so that the electricity must jump over to the interrupters through the air. The most favourable distance will be different for every experiment and must be ascertained or regulated on each separate occasion.

43. If a machine pole must be diverted or earthed, after starting an experiment this must be done by laying a line (chain or something similar) on one of the two electrodes and connecting this with the table. It will, however, be preferable to make the connection with a gas or water main, if available in the vicinity.

II. Special instructions for elementary experiments.

Natural law: bodies charged alike repel each other.

44. **Double pendulum** (Nos. 811 & 911). We place the metal hook on the universal stand and hang on it the two elder-pith balls which are fastened on threads. If we now pass current to these through a stick of sealing wax or celluloid plate which has been rubbed, the balls will separate. They will have electricity of the same sign and consequently repel each other.

45. **Paper tassel** (Nos. 808 & 908). The paper tassel is put on the stand and the latter connected with the machine by means of a line wire whilst the other pole of the machine is earthed. On turning the machine, the single strips of paper will be charged alike and consequently repel each other.

Natural law: bodies charged with electricity of opposite sign, attract, and repel with electricity of the same sign.

46. **Ring and bells** (Nos. 802 and 902). The apparatus must be placed on the stand, so that a ball is located exactly between two bells. A conducting wire is then hung on the hook of the stand, whilst the other line of the machine is hung on the ring on the upper part. If the machine is now put in action, the balls, which are insulated, will be alternately attracted and repelled by the bells. If this experiment does not succeed at the first attempt, the balls can be given a slight push; more energetic rotation of the machine will not help in any way.

47. **Dancing balls** (Nos. 817 & 917). The glass of this apparatus must be perfectly dry and, if necessary, rubbed with a soft cloth before using. The small wooden form is first placed on the stand, and the elder balls put on it, covering the whole with the glass globe. One wire will be hung on the ring, and the other on the stand, whereupon the lines are connected with the interrupters of the machine. As soon as the metal disc in the glass globe becomes electrically charged, it will attract the balls and again repel them, because the electrical charge is of the same sign. This will produce a hopping or dancing movement.

48. **Smoke condensation** (Nos. 817 & 917). The following experiment is made with the ball dancing apparatus referred to under 47. A small wooden holder is first fixed on the stand and a fumigating candle placed on it. The machine will have already been connected with the apparatus, by attaching one conducting wire to the stand and the other in the ring at the top of the glass globe. The fumigating candle must now be lighted and the glass globe promptly put over it. The candle will then be deprived of air, or oxygen, and will consequently go out, the globe becoming full of smoke. This smoke can then be precipitated with the aid of electricity by putting the machine in motion.

49. **Magical ball** (Nos. 816 & 916). The apparatus must be placed on the stand and the latter connected with the machine by means of a trolley wire, whilst the other connecting line of the same is hung on the small hook of the apparatus. The small glass ball (dry) will at once commence to spin round at an enormous rate.

50. **Lightning tube or board** (Nos. 819, 919, 803, 903 and 622). For this, as well as the following experiments, the room must be darkened as far as possible, in order to make the light phenomena as effective as possible. After attaching the lightning tube or board to the hook which has been fixed on the stand, the bottom end must be connected with one of the machine interrupters, and the upper end with the other interrupter. If the machine is now put into function, small sparks will be produced between the strips of foil forming in their entirety a most charming effect.

51. **Radiating points** (Nos. 807 and 907). If the point is fixed on the stand, and electricity conducted to it from a pole interrupter of the machine, electricity will be given off in the form of a luminous appearance, which must, of course, be observed in the dark. If the hand is held over the radiating point, the escape of the electricity can be plainly felt, like a draught of air. For this reason it is also customary to speak of the „electric wind“.

52. **Flying wheel** (Nos. 806 and 906.) The principle of the flying wheel rests on utilising the electric wind. The wheel is fixed on the point and this again on the stand. The latter is then connected with one pole of the machine, whilst the other is earthed. The wind proceeding from the points is so strong that the apparatus will be put into rapid rotation.

53. **Geissler tubes** (Nos. 804 and 904). In the dark, it is possible to carry out brilliantly coloured experiments. The tubes must be hung, like the lightning board, on the stand, by means of the hook-shaped holder, and connected similarly with the machine.

54. **Handles for electrifying** (Nos. 809 and 909). One or several persons can be electrified with the handles. If it is intended to electrify several persons, they must hold each others hands firmly. The two outer persons will each take a handle, the wires of which are fastened to the interrupter, in the hand which is left free. The two interrupters must first be placed fairly close to the electrodes, and the machine started. The persons undergoing the process will only feel slight shocks, and if it is desired to increase them, the interrupters must be gradually removed further from the electrodes. If only one person is to be electrified, he must naturally take a handle in each hand. The handles should be held with wet hands, if small machines are used, or a special Leyden jar can be switched in.

55. **Electric mortar** (Nos. 818 and 918). The mortar is fixed on the stand, an elder-pith ball inserted, and then the hook of the mortar connected with the interrupters of the machine by two lines. If the machine is now put into action, sparking-over will occur in the interior of the mortar which will heat and expand the air to such an extent, that it will toss up the elder ball. This experiment will prove even more successful, if a Leyden of as large a size as possible is switched in (see experiment 57).

56. **Leyden jar** (Nos. 701 and 703). Just like all other apparatus, the Leyden jar must also be kept perfectly clean and dry. Its duty is to collect electricity. In order to charge the jar, it must be placed near the machine, so that the electrode ball touches the jar ball, and the other machine pole must be laid on the outer covering of the jar by means of a conducting wire the machine can then be started

To discharge the Leyden jar, the discharger must first be placed on the outer covering of the jar and turned, so that its ball also touches the jar ball. It will then be observed that heavy sparking-over will result.

57. **The switchable Leyden jar** (Nos. 814 and 914). In comparison with that just described, this jar has great advantages, as it is possible to effect the discharge by means of a switch at any time. At a word of command the mortar can therefore be fired off, or the Geissler tube illuminated.

In order to charge this jar, the electrodes are connected with the open switch, either directly or through a wire. In order to discharge it, it is only necessary to lay a chain or wire from the jar ball to the outer metal covering, and then close the switch (this chain can be laid before charging). No special discharger is therefore necessary with the switchable Leyden jar.

If it is intended to utilize the jar to drive apparatus, one pole of the machine must first be passed to its outer cover and then on to the apparatus, the other pole of the machine being simply passed to the inner covering or to the open switch of the jar, whilst the other hook of the apparatus is connected with the middle ball rod of the Leyden jar. Whenever the switch is closed, the apparatus connected will come into function.

58. **The electrophorus** (No. 851). This consists of a vulcanite plate and a conductor with vulcanite handle. The plate is laid on a table, thoroughly rubbed with a cloth, and then the conductor placed on it. Before taking it off again, we touch it momentarily with a finger. Whenever we then bring our finger joints near it, it emits a spark. This can be frequently repeated without having to rub up the vulcanite plate again.

In order to charge a Leyden jar, the sparks must be allowed to jump from the conductor into the ball or, in the case of switchable jars, directly into the open switch. The more sparks which are allowed to pass into the jar, the greater will be the charge. With the object of effecting the discharge, we must proceed as described in the experiments 56 and 57.

59. The apparatus will be preferably driven through the medium of the Leyden jar, exactly in the manner described. Of course, the wires cannot be conducted to the two poles of the machine, but to the outer metal coating and the ball of the Leyden jar which has been previously charged.

III. Further experiments for more advanced students.

The following apparatus which can be had separately, or in cases containing a good selection, may be looked upon as a supplement for the enlargement of the experiments already described. All the apparatus are designed, so that they will fit on the same universal stand.

a) Electric repulsion.

60. **Quadrant electrometer** (No. 601). One pole of the machine is connected with the hook of the stand, whilst the other is earthed. The greater the tension, the more marked will be the deflection of the indicator.

61. **Sand apparatus** (No. 603). The sand used must be absolutely clean and dry. The connection with the machine will be effected by a wire which is hooked on the stand, the other machine pole being earthed. In an unloaded state the grains of sand will flow in a smooth stream through the small opening in the metal vessel. But as soon as the machine is put into action they will repel each other, and be emitted from the opening in a large circle.

62. **The repelling ring** (No. 604). The apparatus is connected by a wire with the machine, both poles being earthed. If tension is now given off by the machine, both rings will have an electric charge of the same sign, and will consequently repel each other. Care must be taken that the inner ring rotates easily and, if necessary, this must be regulated by the screw provided for this purpose.

63. **The hopping spiral** (No. 605). The spiral is hung on the hook provided, and this is placed on the stand, the whole being brought as near as possible to the machine, one pole of which has been earthed. If the machine is now put into work, and the pole which has not been earthed, connected with the holder by turning, the spiral will adopt a hopping motion, providing the connection is effected and interrupted at regular intervals.

b) Electrical attraction and repulsion.

64. **Motor for influence-electricity** (No. 611). The two hooks of the apparatus are connected with the interrupters by means of two wires. If the rotating body will not start by itself, it must be given a slight push. After oscillating a time or two, it will soon commence to rotate with rapidity.

65. **The rotating disc** (No. 612). The apparatus is placed on the stand and connected by two conducting wires with the interrupters of the machine. If the latter is then started, the disc will commence to rotate rapidly.

66. **The running ball** (No. 613). The apparatus is connected with the interrupters of the machine by two wires, which are attached to its end poles. If the machine is now started, the ball will be attracted on the vulcanite beam from one pole to the other, running constantly backwards and forwards.

67. **The oscillating ball** (No. 616). This is treated exactly like the last apparatus alluded to (No. 613). The ball, which hangs from a silk thread, makes most conical movements, under the simultaneous action of the positive and negative electricity.

68. **The rotating ball or ring** (No. 615 and 614). The ball or ring is placed on the point of the apparatus, and this is fixed on the stand, the apparatus being connected with the machine by means of the conducting wires. Care must be taken that the two poles of the apparatus are as near as possible to the ring or ball. Rapid rotation will result from the electricity given off.

c) Formation of sparking.

69. **Musical sparks**, (No. 628). This apparatus which was invented by Dr. Wommelsdorf, is the most effective in electro-statics, in spite of its reasonable cost. After connecting the two rings with the interrupters of the machine, or with an inductor by means of two conducting wires (the most favourable distance must be ascertained by trials), the spark tones will be produced, the height of which can be varied at will by raising or lowering the slide. Care must be taken that the path of the slide is air-tight.

70. **The ignition apparatus**. (No. 621). The small apparatus is placed on the stand, and then a small ignition cap on the vulcanite plate. After this, the two poles of the machine (ball and hook of the stand) are connected with the interrupters of the machine, a Leyden jar being switched in, if feasible.

71. **Apparatus for penetrating glass** (No. 624). The thin sheet of glass which must be penetrated, must be as large as practicable and absolutely dry. It must be laid on the vulcanite rod, which must first be moistened with a little oil for insulation purposes; a drop of oil should also be provided on the top of the glass sheet, where the point presses against it. As we shall see below, under breath-figures, the apparatus is connected with the machine and the latter turned slowly. If the sheet of glass is too small, the sparks will jump round the edges, without penetrating it.

72. **Production of electric breath-figures** (No. 624). With the same apparatus which is used for penetrating glass, another extremely interesting experiment can be made, namely the production of electric breath-figures. The apparatus is placed on the stand. A coin is then put on the small vulcanite column, over it the dry glass plate and then another coin on the same spot, the whole being held in position by the spring of the movable rod. The apparatus must then be connected with the interrupters of the machine, by hanging one wire on the ring of the apparatus and the other on the stand. When the machine has been allowed to run 3-5 minutes, the glass must be examined more closely, and if nothing is to be seen, breath upon it and the exact reproduction of the coin will be visible. This reproduction will remain for months, if not removed by some sharp agent, such as spirit and French chalk.

d) Seat and conduction of electricity.

Natural law: Electricity only collects on the surface of any body.

73. **The surface apparatus** (No. 631). The apparatus is placed on the stand, and connected with one pole of the machine through a wire (hook of the stand) whilst the other pole is earthed. On starting the machine, the two upper elder-balls will repel each other, because they have an electric charge of the same sign; on the other hand, the two inner balls will remain at rest. This experiment proves that electricity only collects on the surface of a body.

74. **The radiating ring** (No. 632). This is a very interesting experiment, which can only be made in a darkened room. The apparatus is placed on the stand and one conducting wire is hung on it, whilst the other is attached to the small ring of the apparatus. If the machine is now started, a very beautiful corona of rays will result between the plate and the outer wire ring, in consequence of the electricity emitted. The proper position of the interrupters must be ascertained by trials.

75. **The light apparatus** (No. 633). The apparatus is connected with the machine by two wires which are hung on the two interrupters. A candle must then be fixed on the small metal point, lighted and set, so that the flame will be at about the same height as the balls. On starting the machine, the flame will be blown from the positive to the negative electric ball.

Another very taking experiment can be made with this apparatus. The two balls must be removed from the apparatus and the extra ball with point, which is provided, placed on the vulcanite column.

If the flame is now properly set, the light will be blown out by the electricity emitted from the point.

76. **The lightning conductor**, (No. 634). This experiment is peculiarly instructive on account of the practical importance of the lightning conductor. The point must first be unscrewed and removed and a wire laid from the hook of the stand to the other coating of a Leyden jar. A little cotton-wool, soaked in benzine or sulphuric ether, must then be placed on the small plate of the apparatus, and a spark from the ball of the Leyden jar allowed to strike into the metal button of the apparatus. We shall then see, that the cotton-wool will be ignited by the electric spark. After this, the small point, which here represents the lightning conductor, must be again screwed on and connected with earth, that is with the table, by a wire.

If the jar, which represents a thunder cloud, is now brought gradually nearer to the point, the electricity will escape through the lightning conductor to earth, without igniting the ether.

e) Physiological effects (Electro-therapeutics).

77. **The insulating cushion** (No. 641). With this apparatus, the foot of which must be quite dry, most amusing experiments can be made. A person places himself on the cushion and connects himself by a wire, or with the handle described on page 10, with one pole of the machine, whilst the other pole is conducted to the table (or still better to a gas or water main). Anybody touching the person standing on the cushion, will receive a slight shock. The hair of the person standing on it will stand on end, when a hand is placed over his head. The astonishment of the spectators will also be very great when the person on the cushion takes one end of a Geissler tube in his hand, and this becomes luminous, although this will, of course, only be visible in a darkened room.

g) Electrical measuring appliances.

78. **The gold-foil electroscope** (No. 673). This serves to demonstrate the presence of extremely small quantities of electricity and is very delicate. It will most reliably indicate even the smallest charges. For accurate measurements, it should therefore be used in preference to the double pendulum described under experiment 44.

h) Wireless Telegraphy, Tesla experiments with electric waves etc.

79. These experiments can be made with spark inductors, just as well as with condenser machines. It would be going too far to endeavour to describe the manifold experiments which are possible, within the limits of this small booklet, and we will therefore confine ourselves to general hints. The trolley wires have only to be

carried from the apparatus to the interrupter levers of the machine, instead of to the two pole terminals of the spark inductor, and, if necessary, the Leyden jars disconnected. In this category we must include.

80. **The Self-induction coil** (No. 681). With this instructive apparatus the astonishing effect of a wire spiral on jar discharges can be demonstrated. Whilst other electric currents (for example, from cells or from the machine without jars) naturally invariably select a path through the thick, and highly conductive spirals, and not through the air, the current from Leyden jars prefers the cross-over between the balls, providing the air-path is not too great and only amounts to about 1 mm. The upper ring and the hook of the stand are connected with the interrupters of the machine, or still better by switching in a larger Leyden jar.

81. **Resonance apparatus, syntonised on the Dr. Wommelsdorf system** (No. 684). The jar, which is not syntonised, is connected with the interrupters of the machine, that is, on the one side the jar switch and, on the other, the ring laid round the outer coating. The wire spiral of the second apparatus must then be placed opposite that of the first apparatus, at a very short distance initially. If the syntonony is correct, sparks must then be formed on the switch of this jar which is placed very close. The syntonony is produced by passing the metal ring along the wire spiral, until the point is ascertained where the production of sparks is the greatest.

82. **Tesla transformer, syntonised** (No. 685). Here again the jar switch is connected on the one side, and the ring laid round the outer covering on the other side, with the interrupters of the machine. After starting the machine, the most favourable sparking gap must be ascertained by shifting the jar switch, at which the sparking spray is most brilliant. The syntonony is here produced by passing the metal ring along the thick metal spiral, until the most favourable position is ascertained, where the spray emitted from the secondary coil is the strongest. Of course, the secondary coil must be placed as nearly in the centre as possible of the strong coil, for this experiment.

i) Experiments with Röntgen rays.

83. The tube-shaped part of the Röntgen tube must be carefully clipped in the stand provided for this purpose, and connected with the machine, by passing a wire to the two interrupters of the machine from the two extreme electrodes.

As soon as the Röntgen ball glows, it will be possible to distinguish at once between the cathode half and the anode half. The former gives a green clear light, whilst the latter will remain almost colourless and dark. The direction of the current must then be selected, so that the two ball-halves are formed on illumination, and, if this is not the case, the current direction of the machine must be changed, that is, the wires on the tube exchanged. If it is impossible to readily distinguish, which is the brighter half of the tube, resort must be taken to the fluorescent screen.

The two interrupters of the influence or condenser machine must, above all, be regulated until the tube shows as clear a light as possible (see under B, I).

Radioscopy.

84. After the tube has been connected with the machine, as already described, it must be placed at an inclination, in such a way that the rays, or the brighter half of the tube, inclines upwards. If the screen of barium platinocyanide is now held before this side, and some object placed just in front of the screen, such as a purse, hand etc., so that the rays will first strike against the object and then against the screen, the desired Röntgen photograph of the object will be seen through the peep-hole on the other side.

Photographing.

85. The tube must be fixed so that the Röntgen rays, or the bright half of the tube is turned downwards, that is, towards the table. It must, however, stand absolutely horizontal, and the platinum mirror, in the centre point of the tube, must be exactly over the point, which must show the centre of the picture.

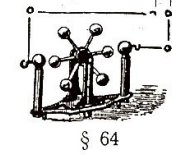
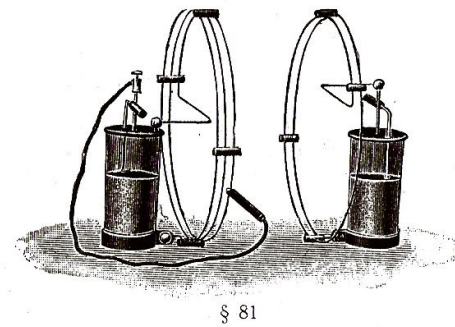
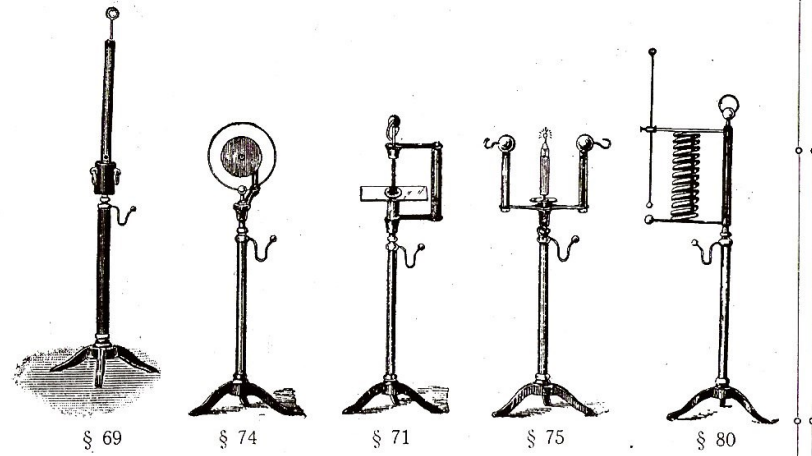
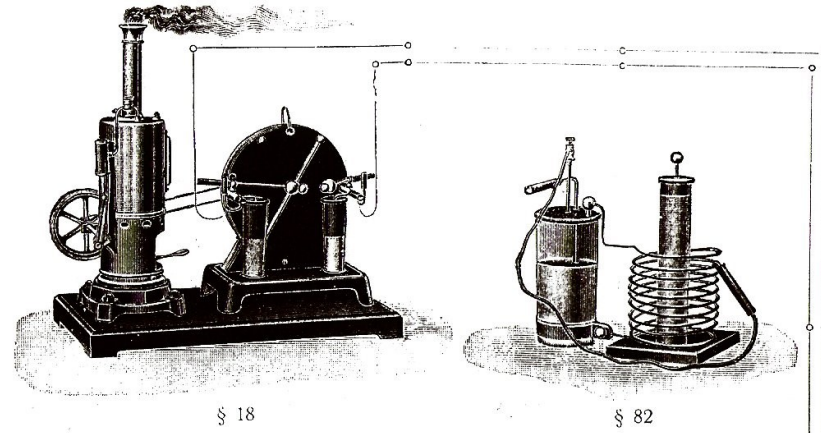
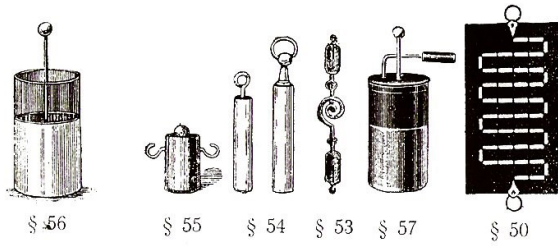
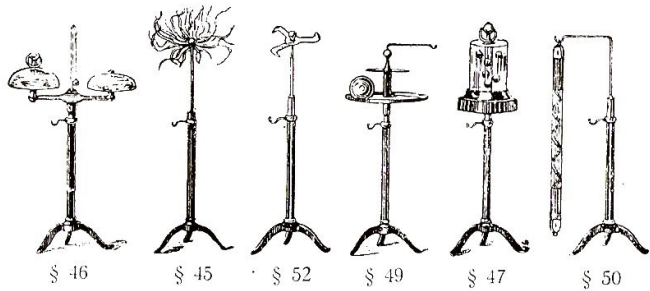
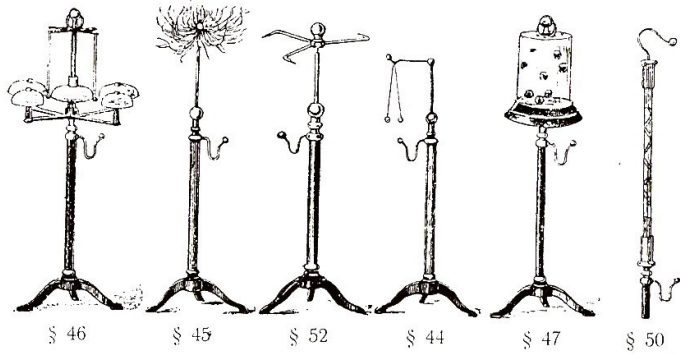
When taking a photograph, the sensitive plate, which must be doubly wrapped in black paper, must be laid on the table, with the layer upwards, and the object to be photographed directly upon it. In order to photograph some part of the human body, this must also rest upon it, quite close and flat and, of course, perfectly motionless, because the picture would otherwise not be clear. The machine must now be started and the rays allowed to penetrate for a time into the object to be photographed. The length of this period, the so-called exposure, will have to be ascertained by trials, because this depends on various circumstances for example, on the size of the machine, tubes etc., so that it is impossible to lay down definite rules.

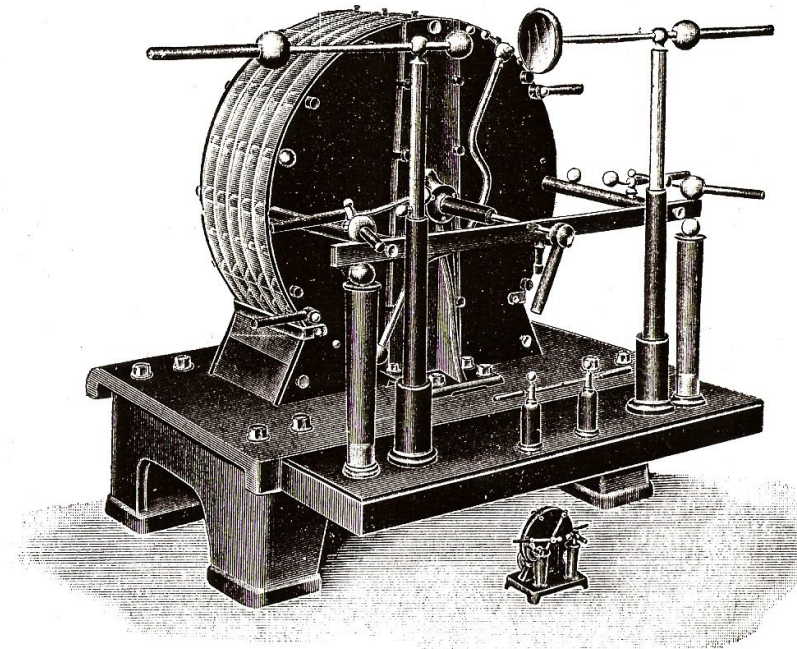
Generally speaking, an exposure of about 10 minutes will be required to photograph a hand, with a good Röntgen tube and a Wimshurst machine with 2 rotating discs of 26 cm diameter, or with a Wommelsdorf condenser machine with rotating discs of 18 cm diameter.

86. With small machines it will be better to commence with easy subjects, perhaps with a closed case of drawing instruments or a pair of spectacles in a case. The distance of the Röntgen tubes from the plate should not be too great at first, perhaps 8 to 10 cm and then later this can be increased to about 15 cm, which will give a clearer picture, though it requires three times as long an exposure. Distance and time should be at once noted, as a guide for the next occasion.

The further treatment of the photographic plates, so-called dry plates, the development, fixing etc. will be preferably learnt from the instructions provided with the apparatus.

In conclusion, it must be remembered that pictures can be taken with the condenser machine, with 18 cm disc, which cannot be excelled, providing the experiments are properly carried out.





View of the condenser machine, system Dr. Wommelsdorf 459—479.
The strongest influence machine of the world.