(No Model.) 3 Sheets—Sheet 1.

E. THOMSON.

ELECTROSTATIC INFLUENCE MACHINE.

No. 583,957. Patented June 8, 1897.

FIG. 1.

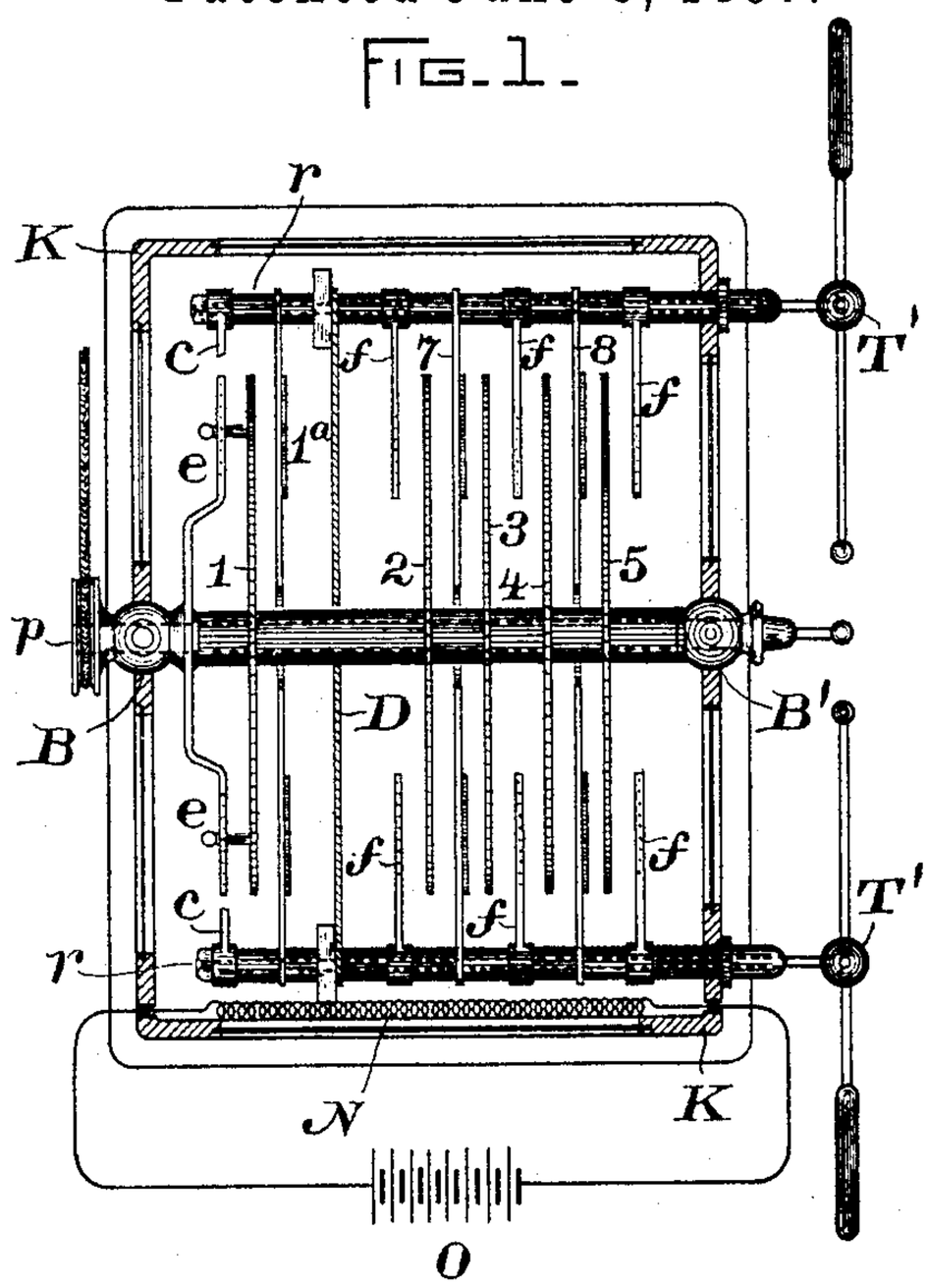
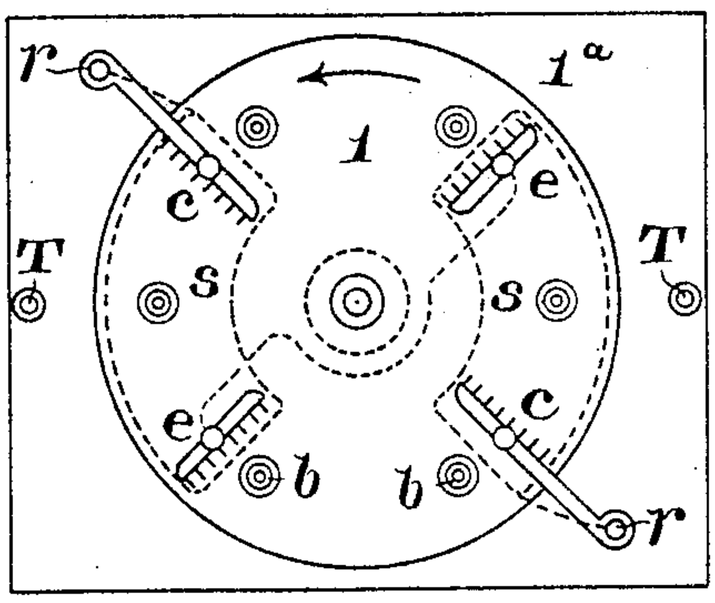


FIG. 2.



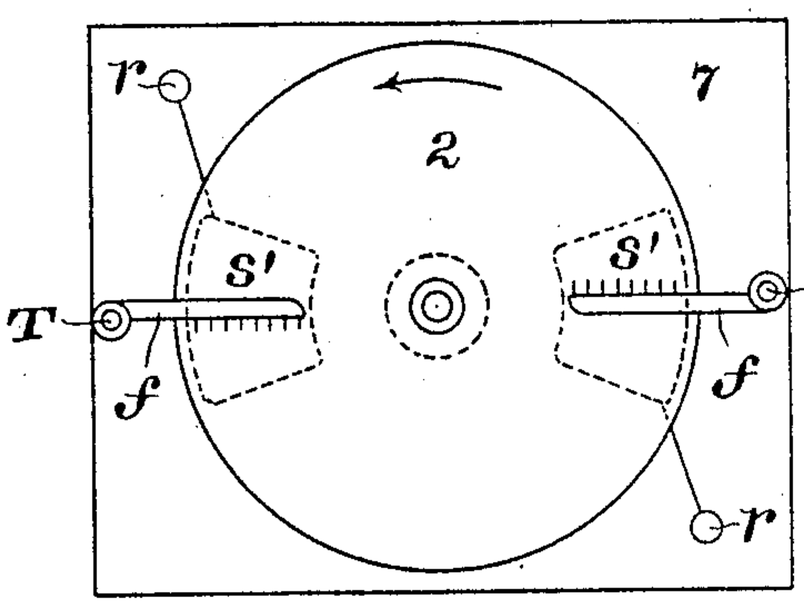
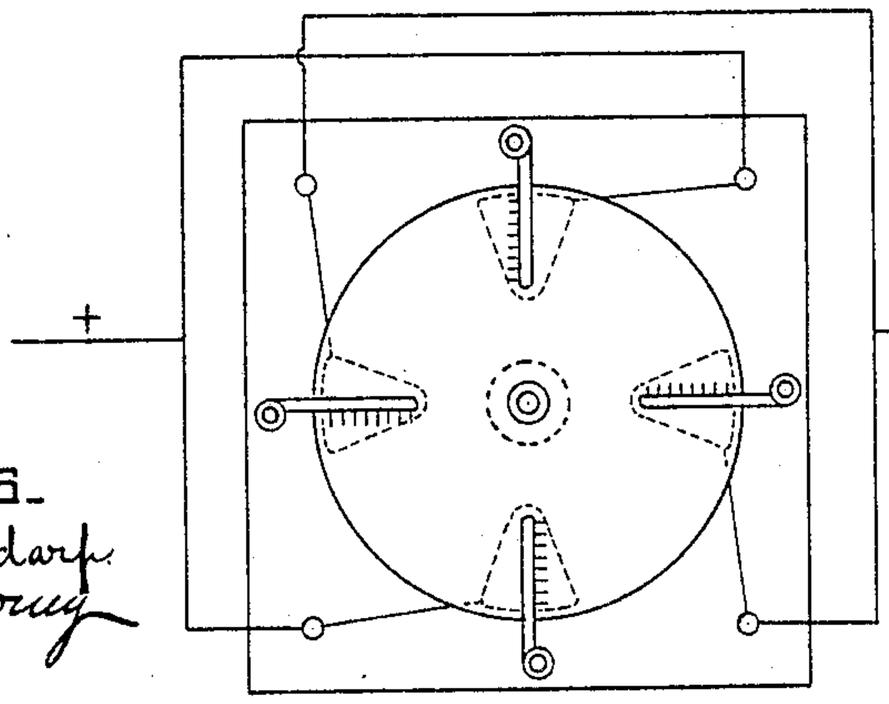


FIG. 3.

FIG. 4.



WITNESSES.
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(No Model.) 3 Sheets—Sheet 2.

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FIG. 5.

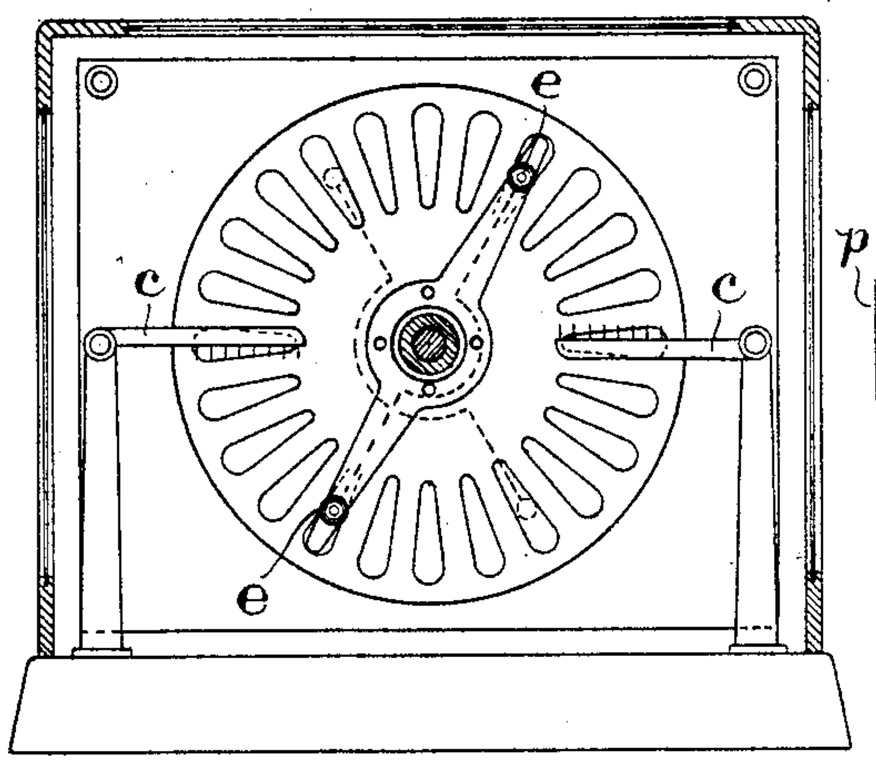


FIG. 6.

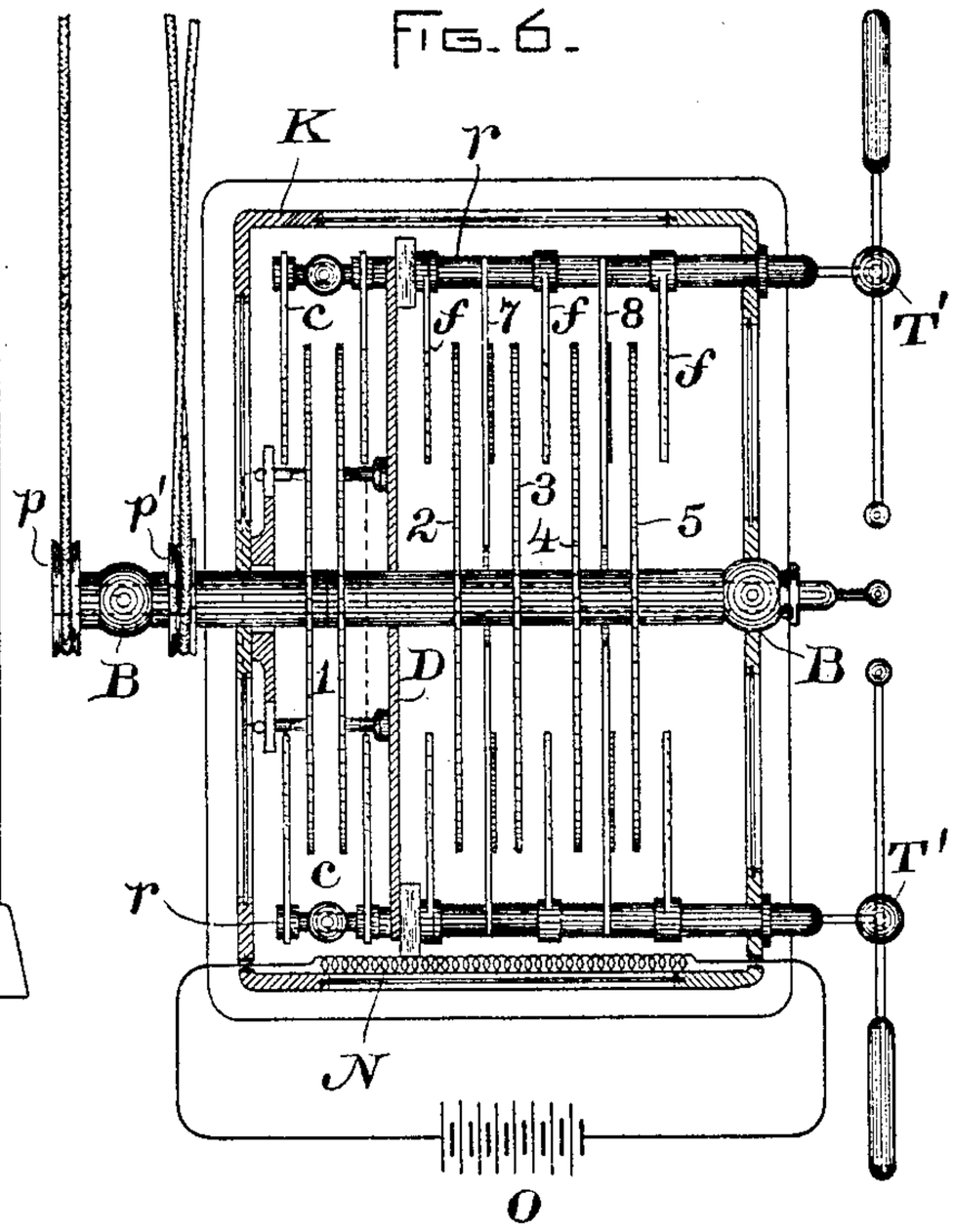


FIG. 7.

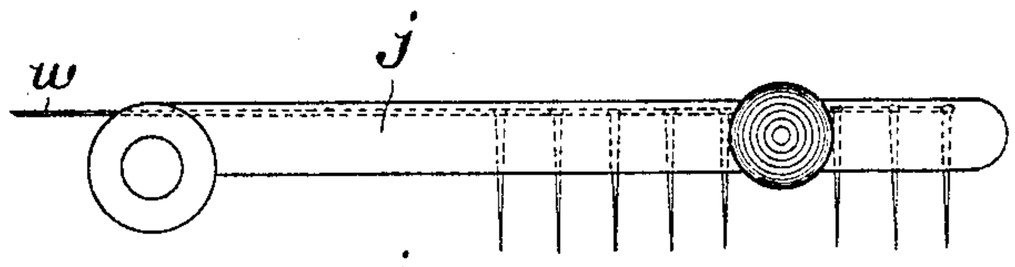


FIG. 8.

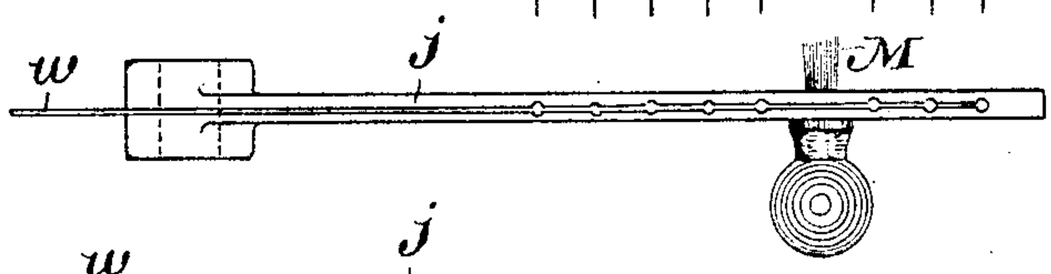


FIG. 9.

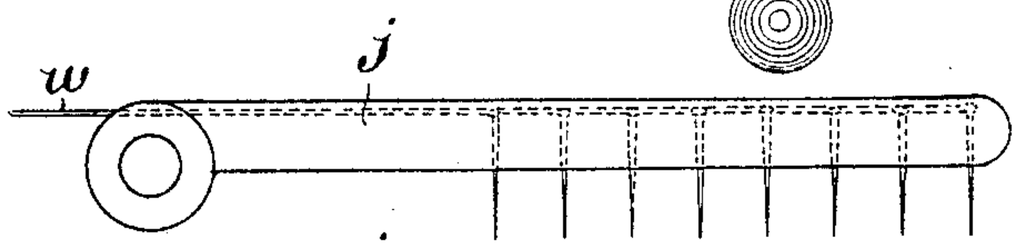
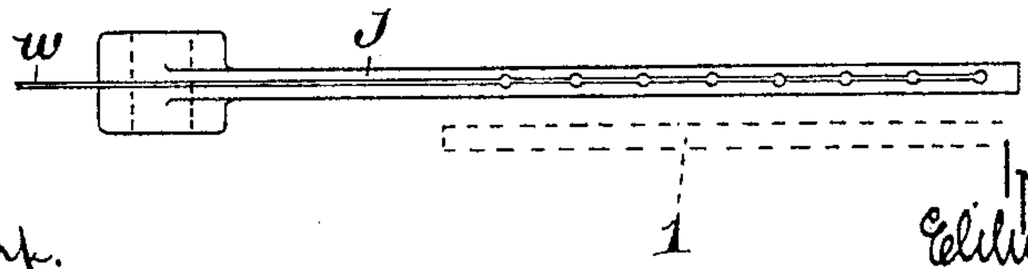


FIG. 10.



WITNESSES.
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ELECTROSTATIC INFLUENCE MACHINE.

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FIG. 11.

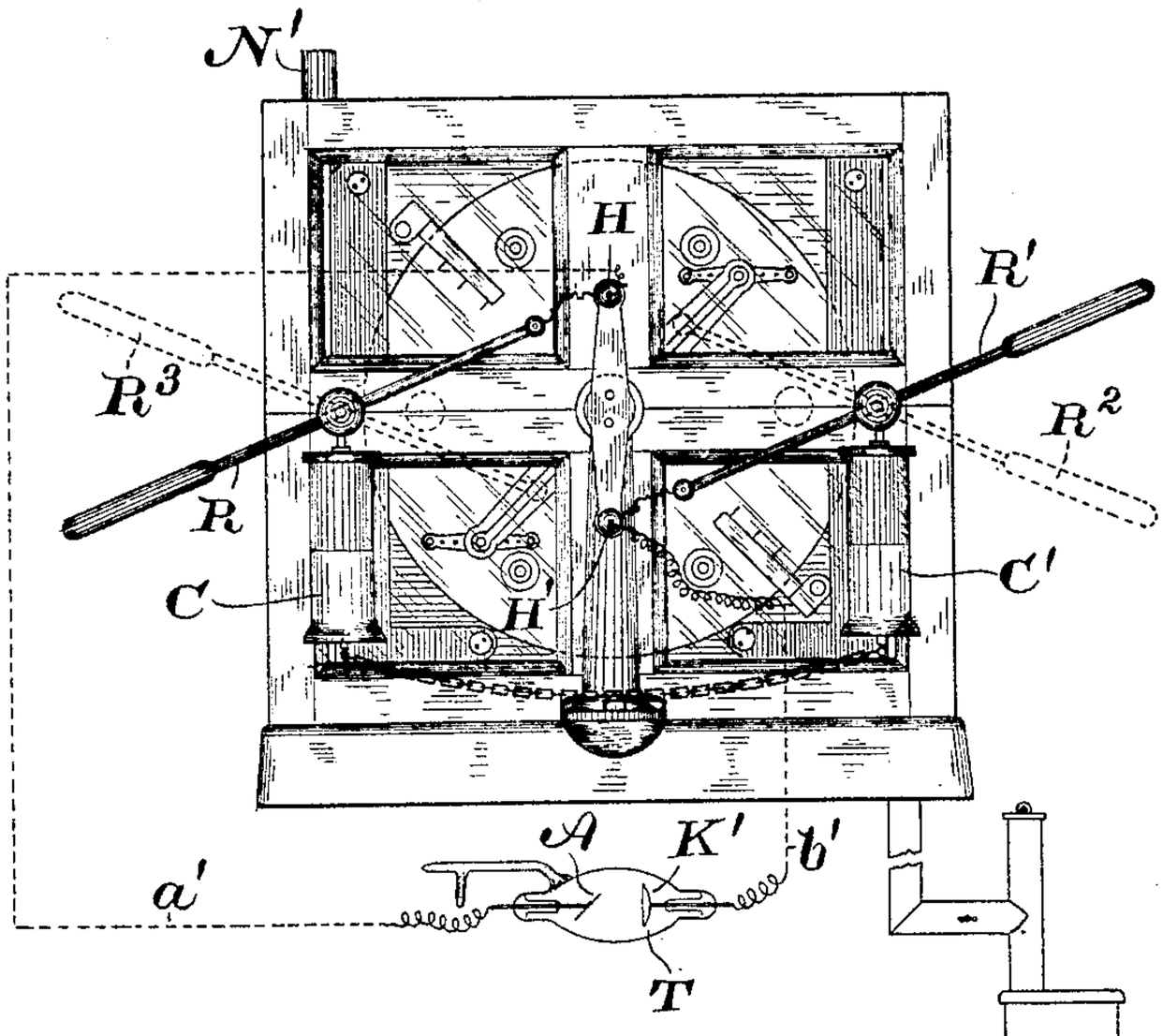
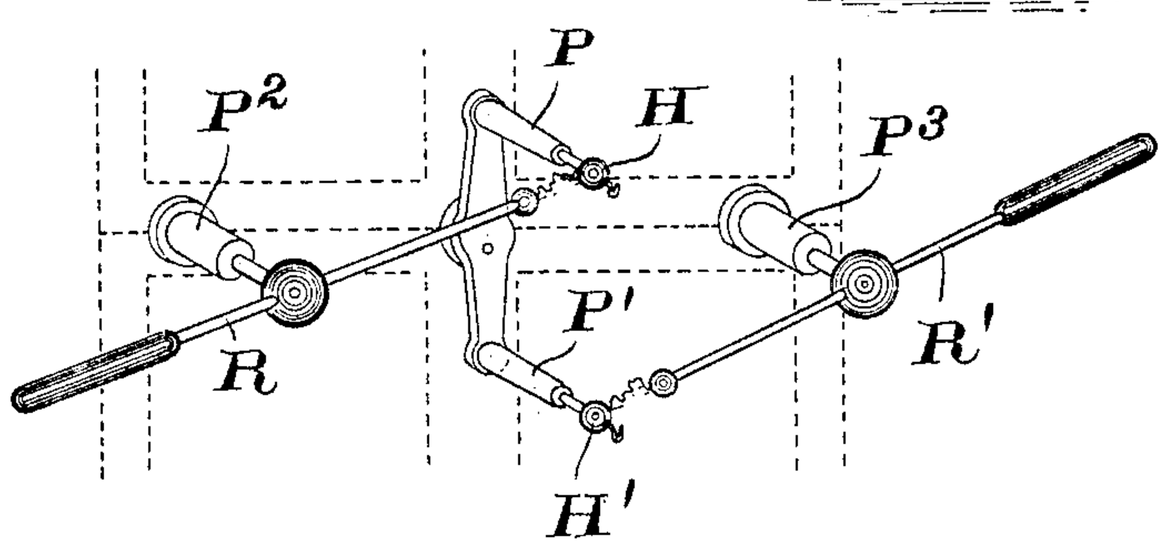


FIG. 12.



WITNESSES.

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UNITED STATES PATENT OFFICE.

ELIHU THOMSON, OF SWAMPSCOTT, MASSACHUSETTS, ASSIGNOR TO THE GENERAL ELECTRIC COMPANY, OF NEW YORK.

ELECTROSTATIC INFLUENCE-MACHINE.

SPECIFICATION forming part of Letters Patent No. 583,957, dated June 8, 1897.

Application filed January 5, 1897. Serial No. 618,030. (No model.)

To all whom it may concern:

Be it known that I, ELIHU THOMSON, a citizen of the United States, residing at Swampscott, in the county of Essex, State of Massachusetts, have invented certain new and useful Improvements in Electrostatic Influence-Machines, (Case No. 503,) of which the following is a specification.

My present invention relates to improvements in static generating-machines, which are capable of producing high-potential electric discharges or currents by electrostatic induction. Some of such machines are the well-known Holtz or Toepler-Holtz or Wimshurst machines. In my invention I employ the principles upon which such devices are founded to construct a novel machine especially adapted to give a considerable output of high-potential current or discharges.

Briefly my invention consists in associating in the same apparatus two machines, one of which is purely an exciter for the other, which latter is purely the producer of useful discharges.

By my invention there is less liability to back discharges producing reversal of polarities, and the machine therefore keeps its polarity more constantly.

My invention also has for one of its objects to provide a convenient means for reversing the direction of current in machines of the general class described. Such machines are liable to sudden reversals under some conditions of use, while for some classes of work, such as exciting Crookes tubes, the discharges are preferably in the same direction. For the purposes pointed out I so arrange the reversing-switch that it may be used not only for its ordinary functions, but also for adjusting the spark-gap distance where Leyden jars or condensers are employed in conjunction with the machines.

My invention consists also in feeding into the casing of the machine a suitable neutral gas, preferably deoxidized air, at a temperature sufficiently high to prevent precipitation of moisture. I by this means prevent the formation of ozone and maintain the insulation of the apparatus.

It is within my invention to maintain the temperature and simultaneously to deozonize the fluid included in the casing by means, such as an incandescent wire of platinum, within the casing itself.

In the drawings annexed, Figure 1 is a section of a machine embodying my invention. Fig. 2 is a side elevation of one of the plates of its exciting portion. Fig. 3 shows one form of working generating-plate. Fig. 4 is another form. Figs. 5 and 6 are respectively a vertical section and a horizontal section, partly in elevation, of a modified form of machine. Figs. 7 to 10 are details of the collectors. Fig. 11 illustrates the commutating arrangement for reversing the connections to the work circuit in case the machine is giving currents in the wrong direction or of wrong polarity in its discharge, for the purpose of saving disconnection of the terminals, since the reversal may be made while the machine is in action. Fig. 12 shows the reversing arrangement separate and also shows how it is used as a variable spark-gap device.

Fig. 1 is a plan view, partly in section, of a machine provided with an outer surrounding case K K, which may be made of thin wood or which may be made of a frame with panels of glass or rubber. This case, however, may be dispensed with if atmospheric conditions permit, as when the surrounding air is very dry. Running through the center of the casing is a shaft carried in suitable bearings or uprights B B′ and carrying a pulley *p* on one end. The shaft serves to revolve and sustain a number of plates 1 to 5, of glass, hard rubber, or other insulating material. Opposite one side of the plate, the face of which is seen in Fig. 2, is mounted an equalizer *e e*, sustained in a fixed position from the journal B, or in a position which is capable of adjustment angularly around the axis. The equalizer may be of metal or wood or other material, but in the latter case a metal strip or wire runs along to make it conducting, and at each extremity opposite the plate a number of metallic points are carried, which serve the purpose of the ordinary connectors in static machines, thereby equalizing the charges on opposite ends of the diameter of the revolving plate 1. The particular disposition of the points may be as is usual in such ma-

chines—that is, directed toward the revolving plate; but I prefer the constructions which are pointed out in Figs. 7 to 10. These will be further described and their advantages stated.

In Fig. 2 the equalizer combs or collectors *e e* are connected together electrically and mounted opposite the surface of the revolving plate at diametrically opposite positions and at an angle with other combs or collectors *c c*, also diametrically spaced, which may be termed the "sector-charging" collectors. These are preferably mounted on a stationary plate, so as to keep the sector-chargers *c c* entirely insulated from the surrounding portions of the machine. These sector-chargers are connected electrically with the sectors or static inductors of the machine, which sectors or static inductors are mounted on stationary plates of insulating material placed opposite the revolving-plates. The sector-carrying plate for the revolving plate 1 is shown in the plane or position 1ª adjacent to plate 1 in Figs. 1 and 2. The sector-carrying plates clear the shaft of the machine and may be made in sections, though I prefer to have them entire, as shown. They may be made of glass or hard rubber, as usual, and on the side of the plate 1ª away from plate 1 is mounted a pair of sectors *s s*, (seen in dotted lines in Fig. 2,) embracing the area from one set of collectors or combs to the other. These are made in the usual way by pasting shellacked paper against the side of the plate 1ª, allowing a space around them for insuring insulation. They may also be made partly or entirely of tin-foil, a wire or metallic connection being made to the sector-charging combs *c*. The latter may in fact be mounted upon rods *r r*, insulated by being carried in the sector-carrying plates themselves and connected to the sectors of the machine from the rods *r r*. In like manner a similar plate 7 is inserted between revolving plates 2 and 3, another, 8, between the plates 4 and 5, while the sets of collectors with their rows of points are placed opposite the sectors on the other sides of the revolving plate. These are the true collectors of the machine and are in two sets, as shown at *f f f*. They are carried on rods T T, Fig. 2, running through the sector carrying and insulating plates 1ª, 7, and 8 and ending in the insulated terminals T′ T′ of the machine, one of which at any time will be positive and the other negative. One of the set of revolving plates is the exciter-plate of the machine, and carries upon its surface either tin-foil patches or buttons *b b* of metal. These correspond to the usual carriers of the plates of the Toepler-Holtz machine. The other plates are as in Fig. 3, having collectors *f f* opposite one face and the sectors *s′ s′*, carried on an insulating-plate 7, on the other side, the sectors being connected to the rods *r r* and sector-charging collectors *c c*. Both the sets of combs or collectors *e e* and sector-chargers *c c* are provided with light metallic brushes, which are made of tin-foil or wire and touch the carriers or buttons *b b* as they pass during the revolution of the plate 1. The direction of revolution is as shown in Fig. 2 by the arrow. It is well known that in such a structure as Fig. 2, which is in reality a single-plate Toepler-Holtz machine with the prime conductors or collectors left off, the slightest difference of potential existing between any two buttons or carriers *b b* or portions of the revolving plate will, on the revolution of such plate, cause a charge to be produced in the sectors or upon the sector-surfaces *s s* by inductive actions of an accumulative nature, and that this effect is enhanced by the presence of the equalizer *e e*, the result being that the parts shown in Fig. 2 would give rise to a high electric charge of opposite name in the two sectors *s s*. It is unnecessary to go into the theory of the actions, except to say that a button or carrier *b*, arriving at a contact position with the sector-charger *c*, would, by the light metallic brushes carried on the latter, communicate its slight charge to the corresponding sector *s*, which, diffusing from the sector *s*, would act inductively on the revolving plate opposite the equalizer and force off through the equalizer or button which was near or in contact a like charge, thus leaving the plate slightly charged with opposite polarity, as well as the button *b* leaving the equalizer. This button arriving at the opposite sector charged with opposite polarity and making contact therewith causes a like distribution of opposite polarity in the opposite sector, which again acting inductively through the equalizer teeth or comb corresponding to it forces off electricity of like name, which neutralizes that given to the other end of the equalizer and leaves the plate or the carriers thereon more strongly electrified on again arriving at the first-named sector-charger. This enhances the difference of charge and again multiplies itself with each revolution of the plate until the whole plate and the points of the collectors take part in the process by virtue of a sufficiently high potential having been accumulated in the sectors. I leave out any collectors between the sector-chargers and the equalizers, since it is not desired to make the plate 1 contribute any part of the output of the machine, but merely to cause it to work in the most effective way as a sector-charging disk or exciter for the rest of the machine. By connecting the other sectors of the machine exciting a battery of plates (which may be a considerable number and may be represented by plates 2, 3, 4, and 5) to the sector-charger *c c* in the same way that the sectors on the plate 1ª are connected a static inductional field is provided for each revolving plate and sustained by the exciting-plate 1, but opposite the sectors which are thus charged and which act on the revolving plates 2, 3, 4, and 5 are found the main collectors *f f f*, positive and negative, respectively, on opposite sides of the machine, and which when the plates revolve take up

from such plates under the inductive influence of the charged sectors on the stationary insulating-plates charges which are communicated to the terminals T T of the apparatus. Since the polarities of the sectors are maintained positive and negative, respectively, the collectors take up positive and negative charges and charge the terminals, so that the output of the machine depends upon the number and capacity of the revolving plates provided with collectors, while the electromotive force or potential of the machine depends upon the perfection of the insulation of the sectors throughout and to the effectiveness of the exciter-plate 1 in setting up a high difference of potential between the sectors of opposite polarity. Since the sectors *s' s'*, Fig. 3, which act upon the working plates 2, 3, 4, and 5 of the machine have only to act upon the collectors, they may be made to cover but a small angle around the axis, as shown in dotted lines, Fig. 3, and in consequence of this fact it is easily possible to multiply the number of sectors around the axis and the collectors which correspond to them, so as to increase the output of the machine in proportion to the number of sectors around the axis. Thus in Fig. 4 the sectors are doubled in number, and those of like polarity are at opposite ends of a diameter, while the sectors at right angles to them are of opposite polarity. In such case the collectors are grouped in the same way—that is, the two opposite collectors horizontal in the figure are of the same polarity and attached to a terminal of the machine, while the vertical ones are of the opposite polarity and are connected together and to the other terminal. The inductive charges during the revolution of the plates are thus multiplied by two and the output of the apparatus doubled.

The advantage of the improvement described is manifest. It permits the charge in the sectors which act upon the working collectors to be maintained without reference to the condition of closed or open circuit between the terminals of the machine, while the exciting end or portion of the machine, not having any working collectors, the excitation thereby given cannot respond to conditions of the working circuit. The apparatus is therefore not so liable to reversal as other forms of machines in which the working collectors are used throughout. At the same time, since the sector-charging operation is performed for the whole machine by the electrical activity of only a part thereof which is reserved for excitation, the work obtainable from the revolving plates is increased and the insulation of the parts improved. In the case of glass it is of course preferred to varnish it.

For dividing and separating the exciter portion of the machine more effectually from the working portion, especially from the working conductors, a septum or diaphragm D of insulating material is employed, mounted, preferably, between that portion which is the exciting portion and the working portion of the machine, Fig. 1. If the distance between these portions be increased, the diaphragm D might be left out; and, in fact, there is no limitation in my invention to the placing of the exciting portion on the same shaft with the generating or working portion, as they could be run separately and electrically connected and the same result obtained as in the construction shown. It is to be understood also that wherever insulating material is needed to thoroughly separate the portions of the machine which are to be maintained at high differences of potential it is provided in the usual way by rubber pillars, bushings, or the like.

In the modified form of my invention shown in Figs. 5 and 6 I employ for the exciting portion of the machine a complete Wimshurst machine, one of the plates of which is mounted on the main shaft, carried between the bearings B B, as before, and the other plate, revolved by a pulley *p'* in the opposite direction to the other plate of the machine, is carried on a rotating sleeve surrounding the said shaft. The usual crossed equalizers are opposite the plate, and there are tin-foil surfaces on the plates, with metallic brushes on the equalizer, making contact, as more clearly seen in Fig. 5. In this case the main collectors *c c* of the machine are retained, but are not connected with the working circuit or terminals of the machine. These collectors are connected only to the sectors of the plates 7 and 8 and take the place of the sector-chargers *c c* of Figs. 1 and 2. It is not necessary to describe in detail the Wimshurst machine, as this is well known in the art. My invention utilizes this construction as a sector-exciter, exciting the main machine solely by connecting to its terminals *c c* sectors to be charged and kept charged, which provide the static inductive field for the rest of the machine, which may include as many revolving plates and sectors as desired. It is well known that the Wimshurst type of static machine works best and reaches its highest excitation when it is arranged with its terminals disconnected, or on open circuit. Hence it is well adapted to sustain the charges on the sectors, they being insulated and contributing only a static field effect. The construction may have two or a larger number of sectors, like those shown in Figs. 3 and 4, on the working part of the machine, its construction being identical with that shown in the prior figures.

It has been usual hitherto to construct the collectors of static machines with rows of points projecting toward the revolving plates. These points being sharp are very apt in case of slight displacement of the plates to rub on them, blunting the points, at the same time scratching the surfaces of the revolving plates and in some cases lessening the safety of the machine. I depart from this construction radically by making the collectors so that the points are turned in the direc-

tion of revolution of the plates and located nearly in the same plane. This detracts in no way from their effectiveness as collectors, but prevents the possibility of contact and consequent damage. Thus in Figs. 7 and 8 the construction of the collector sector-chargers *c c*, Fig. 2, and the equalizer-combs *e e* is shown. A bar of metal or wood (seen in side elevation in Fig. 7 and in plan in Fig. 8) is provided with a set of pins or metal points projecting therefrom in the direction of revolution of the plate adjacent to which the collector is supported. If the support be, made of wood it suffices to insert ordinary pins through it and connect the pins at any point, as under the heads, by a fine wire, which is led along a groove in the top of the piece *j* and brought into connection with a metallic rod upon which the perforated end is placed. The connecting-wire is marked *w*. Many variations from this construction are of course possible, the chief object of which is cheapness and freedom from the disadvantages of scratching and injury just pointed out.

Where the collectors are to act as contact-makers for the buttons or carriers *b b*, Fig. 2, they are provided in addition with a light metallic brush M, which is directed toward the revolving plate and touches the metallic surfaces carried as they pass. The brush M is also connected electrically with the rest of the collector.

For the main working collectors of my machine the simple construction of Figs. 9 and 10 is sufficient. Here the row of points is as before, but without a brush, since they simply act as static collectors and not contact-makers, and, as before, the points are turned in the direction of revolution and at a slight distance from the revolving plate, the position of which is shown in dotted lines in the lower part of Fig. 10. By arranging the collector-points, as I have shown, in planes parallel to those of the revolving plates another advantage is secured in that a single collector inserted between two revolving plates serves equally for both, and at the same time on account of its flatness the two revolving plates so served may be brought very close together, and far closer than could be the case in other constructions.

I find it an advantage to provide means for quickly reversing the connections of a static machine when it is used on work (such as exciting a Crookes tube) where the polarity must be maintained in a single direction or where, after connection has been made, it is desirable to reverse the connections without disturbing anything other than the properly-provided movable portions of the apparatus. I also find it desirable to be able to make this change of connections and at the same time adjust the sparking-distance or "spark-gap," as it is sometimes called, between the terminals of the work-circuit external to the machine. This is particularly the case when Leyden jars are used as condensers on the terminals. I also find it desirable to be able in the operation of the machine to provide the case inclosing it with an artificial atmosphere without oxygen, so as to obviate the formation of ozone within the case, excluding moisture and preventing loss of insulation and attack by ozone of the various portions of the machine which are corrodible by oxygen. To accomplish these ends, arrangements similar to those shown in Fig. 11 are adopted. At C C′ are condenser-jars mounted on the terminals of the machine in the ordinary way, whereby a condenser-spark is obtained. Connections are made to a Crookes tube T by a wire to one terminal, which should be kept the anode, as *a′*, and by another wire *b′* to the terminal K′, to be kept the cathode. These wires terminate in stationary insulated balls or pillars projecting outwardly from the center of the framework and seen at H H′, Fig. 12, one above the other, and spaced apart a sufficient distance to exceed the total striking distance of the machine. Sliding rods R R′, with insulated handles constituting the terminals, may slide toward and from each other in the usual way and are also arranged to swing up and down through an arc of a circle around the pillars P^2 P^3, which constitute the stationary terminals. Assuming that the rods are in the position shown in Fig. 12 in full lines and that the rod R is positive, with the rod R′ negative, the positive discharge will be communicated to the insulated ball or piece H and the negative to H′ through a spark-gap, which may be made as small as desired down to actual contact or as large as possible within the capacity of the machine. This of course is accomplished by sliding the rods in and out toward the stationary balls H H′, carried on the insulated pillars P P′, suitably supported in turn upon the frame of the machine. If the direction thus given be incorrect for the purposes in view, or if the machine itself reverses its polarity, or if it be desired purposely to reverse the direction of the current through the working circuit including the tube T, and at the same time to adjust the spark-gap to any desired length, all that is necessary to do is to reverse the positions of the rods R R′ and bring them to the positions shown in Fig. 11 in dotted lines R^2 R^3, when that terminal which was positive and presented to H now is presented to H′ and the other or negative at the same time to H, reversing or commutating the connections. This of course can be done without actual contact, and the distance through which the discharge must leap may be adjusted as desired.

I find that a useful addition to the machine is a small stove or furnace, (indicated at F,) connected with a rather long pipe to the interior of the casing of the static machine, Fig. 11, and in which casing openings exist for the escape of displaced or expelled gases, as by a pipe or chimney N′ in the figure. The furnace F is preferably fed with pure carbon

fuel from which moisture and hydrocarbons have been driven. Strongly-carbonized charcoal from hard wood, especially if it has been kept dry, and better yet if it has been washed in hydrochloric acid and the acid thoroughly removed, may be used as fuel. The gases leaving such fuel F to pass up in the casing of the machine are chiefly carbonic acid and nitrogen, with scarcely any moisture present. The machine therefore works in this atmosphere with no free oxygen to become ozonized, and is therefore protected from ozone retained within its inclosing case, while the slight warmth of the gases rising brings the temperature of the machine within the case to a number of degrees higher than that of the atmosphere, in this way raising the dew-point of the contained gases and keeping the machine entirely dry within the casing.

At N in Figs. 1 and 6 I have shown a fine wire of platinum or other suitable material maintained at incandescence by any suitable means, such as a battery or other source of electromotive force O, the wire acting not only to raise the temperature within the casing, but also to reduce to oxygen any ozone that may be formed therein.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. In an electrostatic generator, a charging exciter-plate provided with an equalizer and a pair of sector-charging collectors connected to the sectors of the charging-plate and the sectors of the working plates of the machine, the exciter having no connection with the working circuit.

2. An electrostatic generator comprising a working portion having a number of plates feeding the working circuit, and a separate exciting part having a comparatively small number of plates and corresponding sector-charging collectors arranged to furnish and maintain a charge for the working part of the machine, the exciting part of the machine having no connection with the working circuit.

3. In an electrostatic generating-machine, collectors having their points turned in the direction of revolution of the plates of the machine opposite which they are placed.

4. In an electrostatic generator, a single row of collector-points mounted between two adjacent revolving plates and turned in the direction of revolution of the plates.

5. In an electrostatic generator, fixed terminals for the working circuit, and a pair of movable terminals so mounted that either movable terminal may approach or recede from either one of the work-circuit terminals, and thus act either to reverse the current, or adjust the spark-gap distance, or both.

6. In an electrostatic generator, a pair of movable terminals mounted for both rotary and reciprocating movement, and a pair of fixed terminals for the working circuit, arranged in a line transverse to that joining the axes of rotation of the movable terminals.

7. An electrostatic generator inclosed in a casing, in combination with means for feeding inert gases to the casing, and thereby preventing the formation of ozone.

8. An electrostatic generator inclosed in a casing, in combination with means for feeding inert gases to the casing at a temperature above that of the surrounding air, and thereby preventing the formation of ozone and condensation of moisture within the casing.

9. The combination with an electrostatic generator inclosed in a casing, of a body within the casing maintained at incandescence and acting to reduce to simple oxygen any ozone that may be formed.

10. The combination with an electrostatic generator inclosed in a casing, of a platinum wire within the casing maintained at incandescence by a suitable source of electromotive force, as described and for the purpose set forth.

In witness whereof I have hereunto set my hand this 31st day of December, 1896.

ELIHU THOMSON.

Witnesses:
JOHN W. GIBBONEY,
HENRY O. WESTENDARP.