No. 775,123. PATENTED NOV. 15, 1904.

K. BIRKELAND.

APPARATUS FOR ELECTRICALLY TREATING GASES.

APPLICATION FILED JUNE 15, 1903.

NO MODEL. 5 SHEETS—SHEET 1.

Fig. 1.

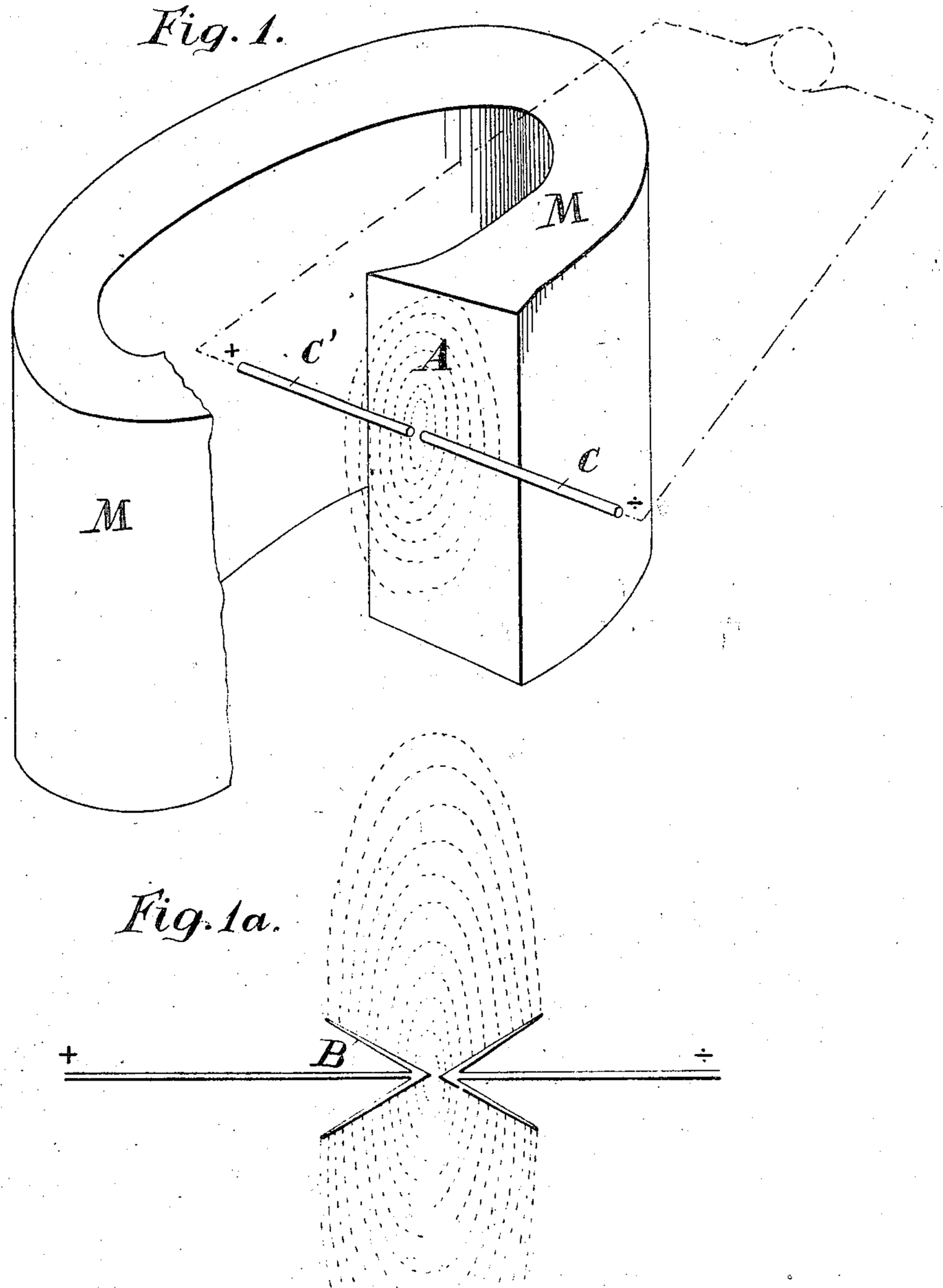

Fig. 1a.

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APPLICATION FILED JUNE 16, 1903.

NO MODEL 5 SHEETS—SHEET 2.

Fig. 2.

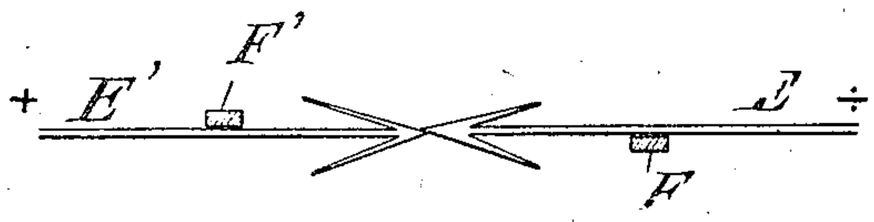


Fig. 3.

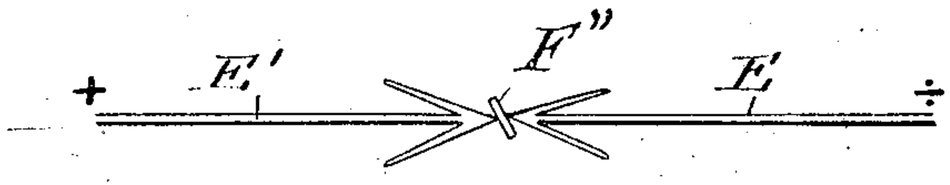


Fig. 4.

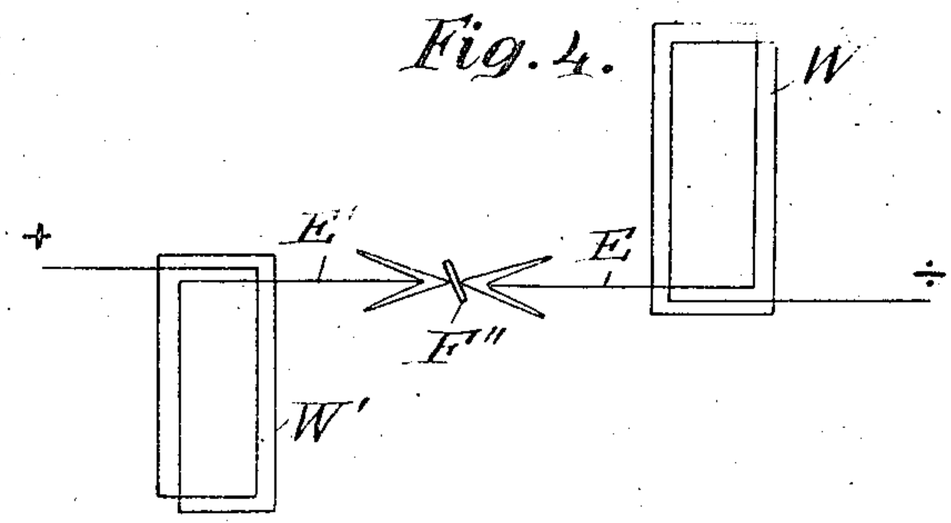
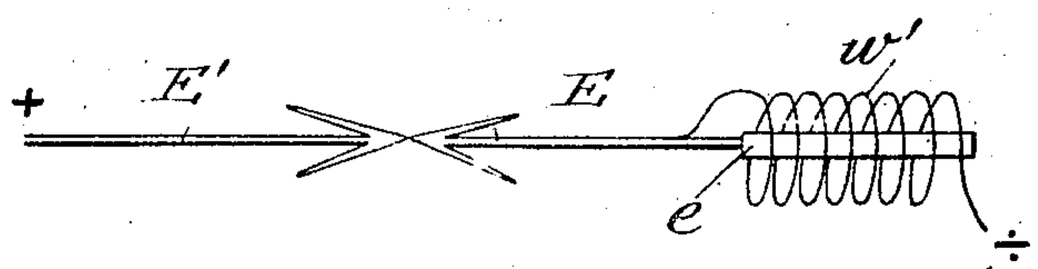


Fig. 5.



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No. 775,123. PATENTED NOV. 15, 1904.

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NO MODEL. 5 SHEETS—SHEET 3.

Fig. 6.

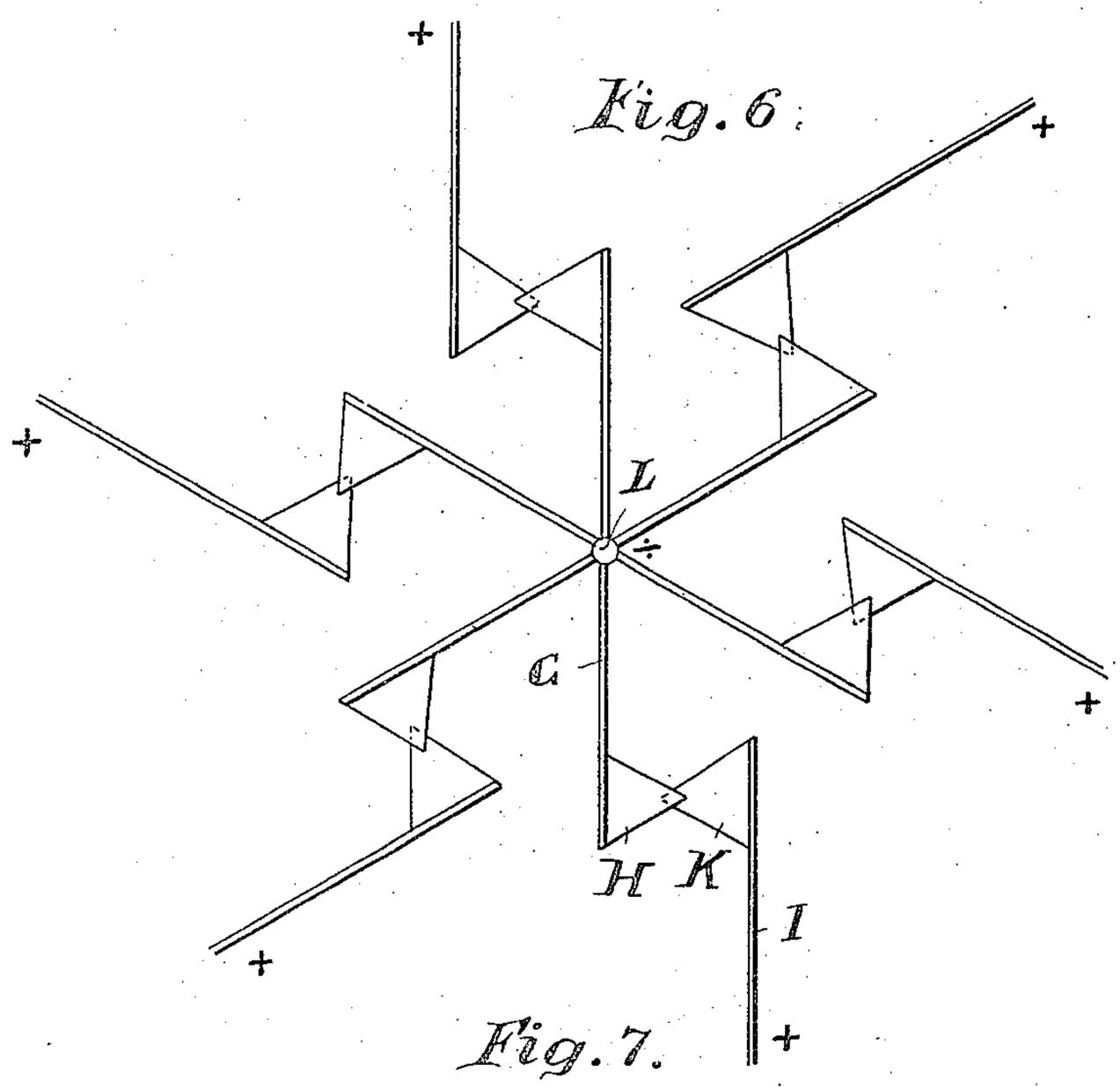
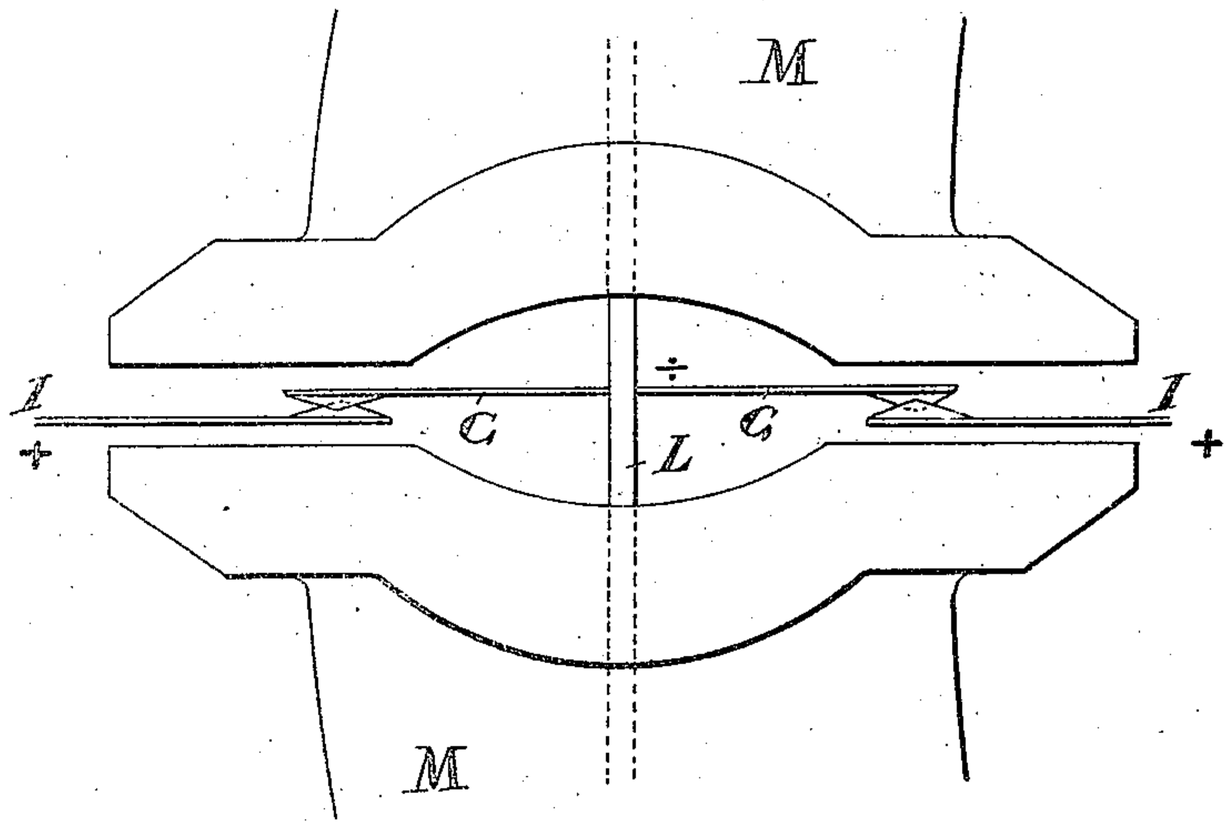


Fig. 7.



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No. 775,123. PATENTED NOV. 15, 1904.

K. BIRKELAND.

APPARATUS FOR ELECTRICALLY TREATING GASES.

APPLICATION FILED JUNE 15, 1903.

NO MODEL. 5 SHEETS—SHEET 4.

Fig. 8a.

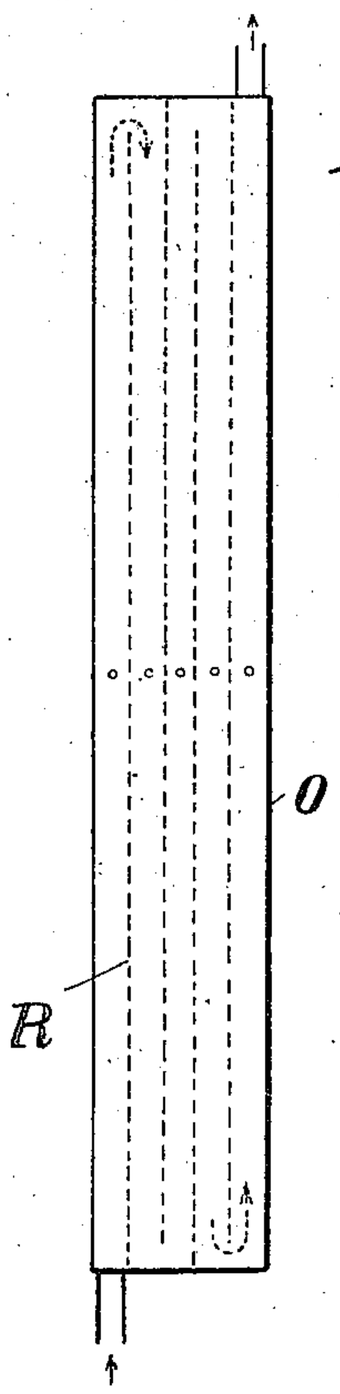


Fig. 8.

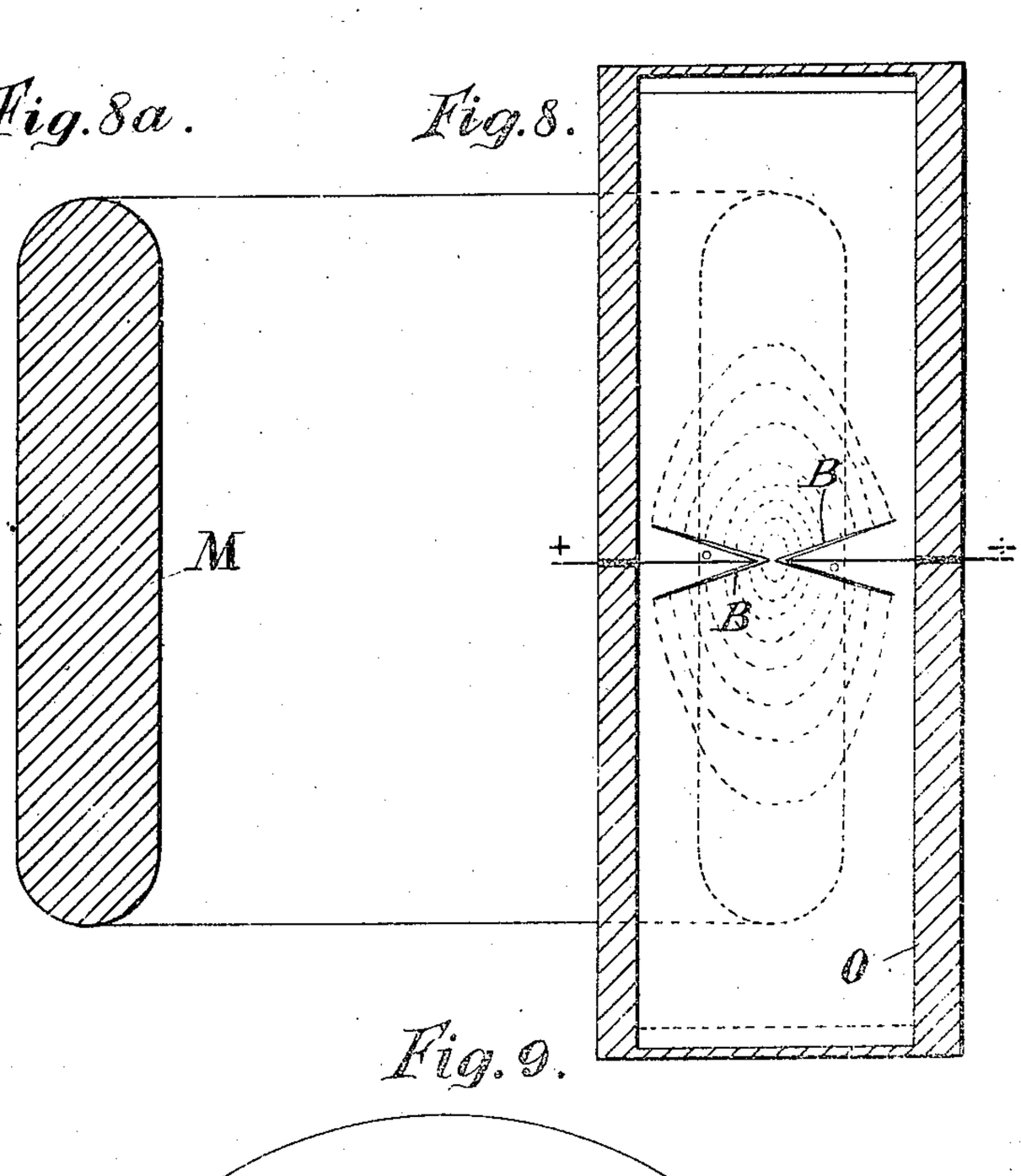
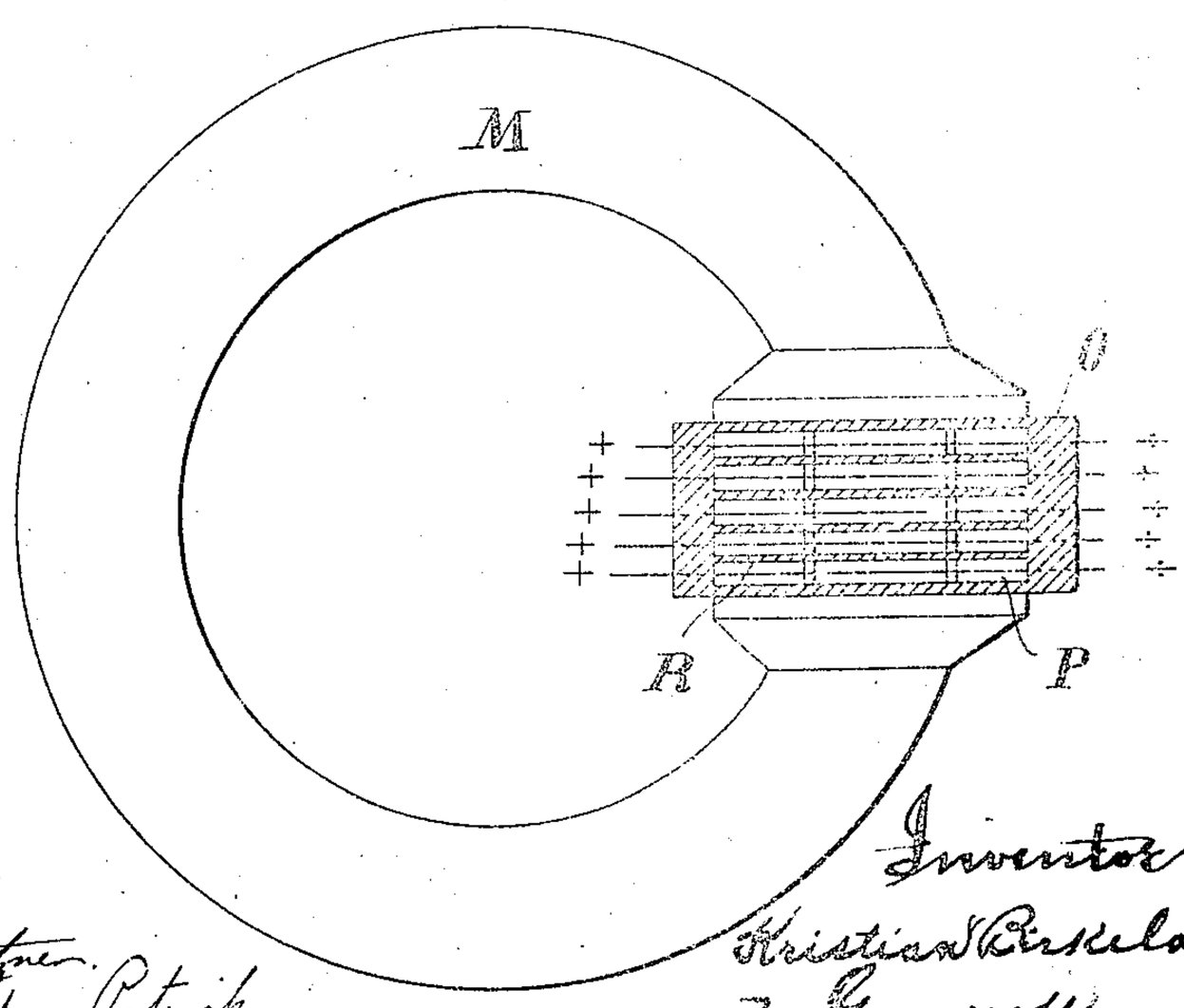


Fig. 9.



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No. 775,123. PATENTED NOV. 15, 1904.

K. BIRKELAND.

APPARATUS FOR ELECTRICALLY TREATING GASES.

APPLICATION FILED JUNE 15, 1903.

NO MODEL. 5 SHEETS—SHEET 5.

Fig. 10.

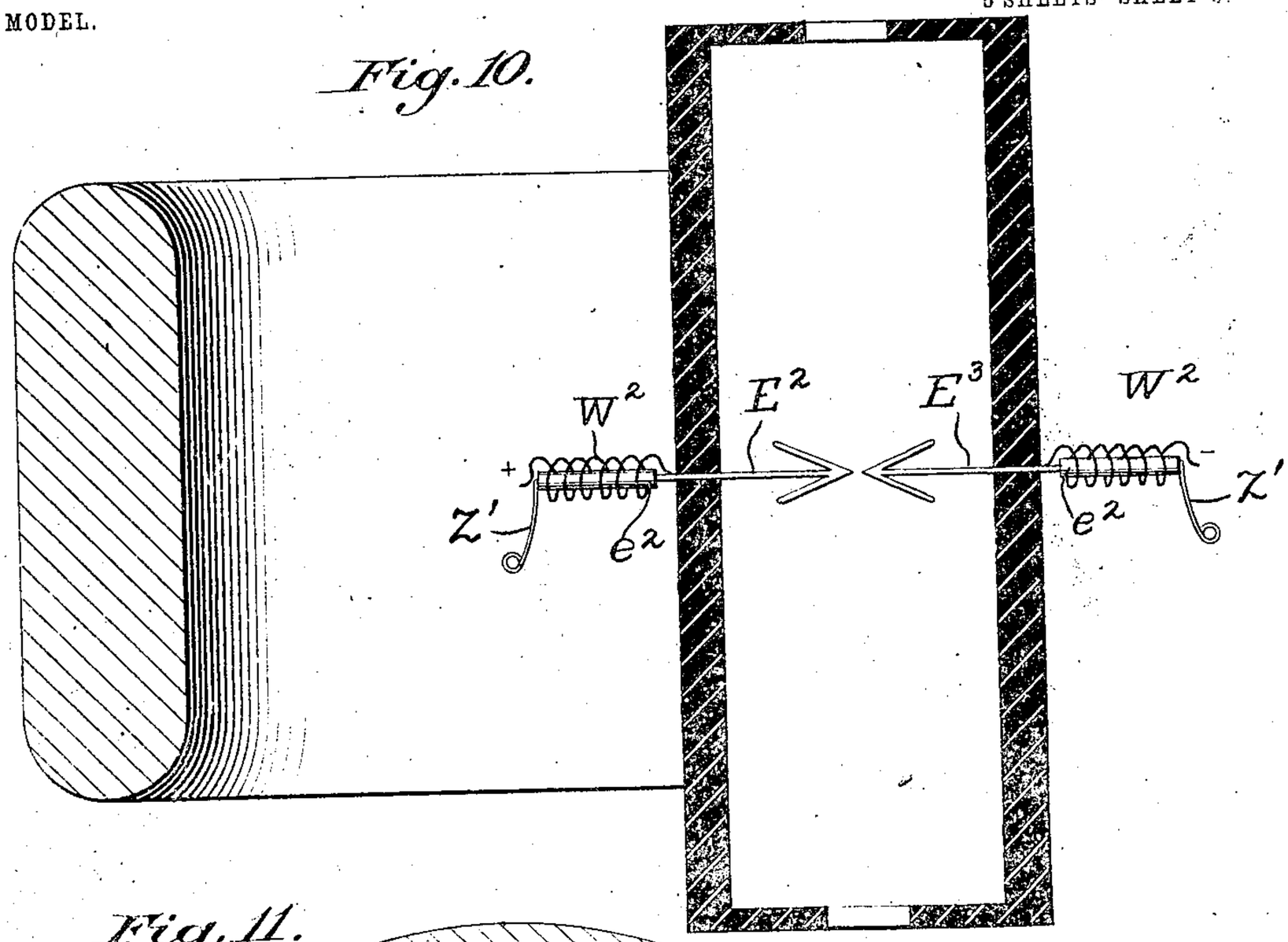
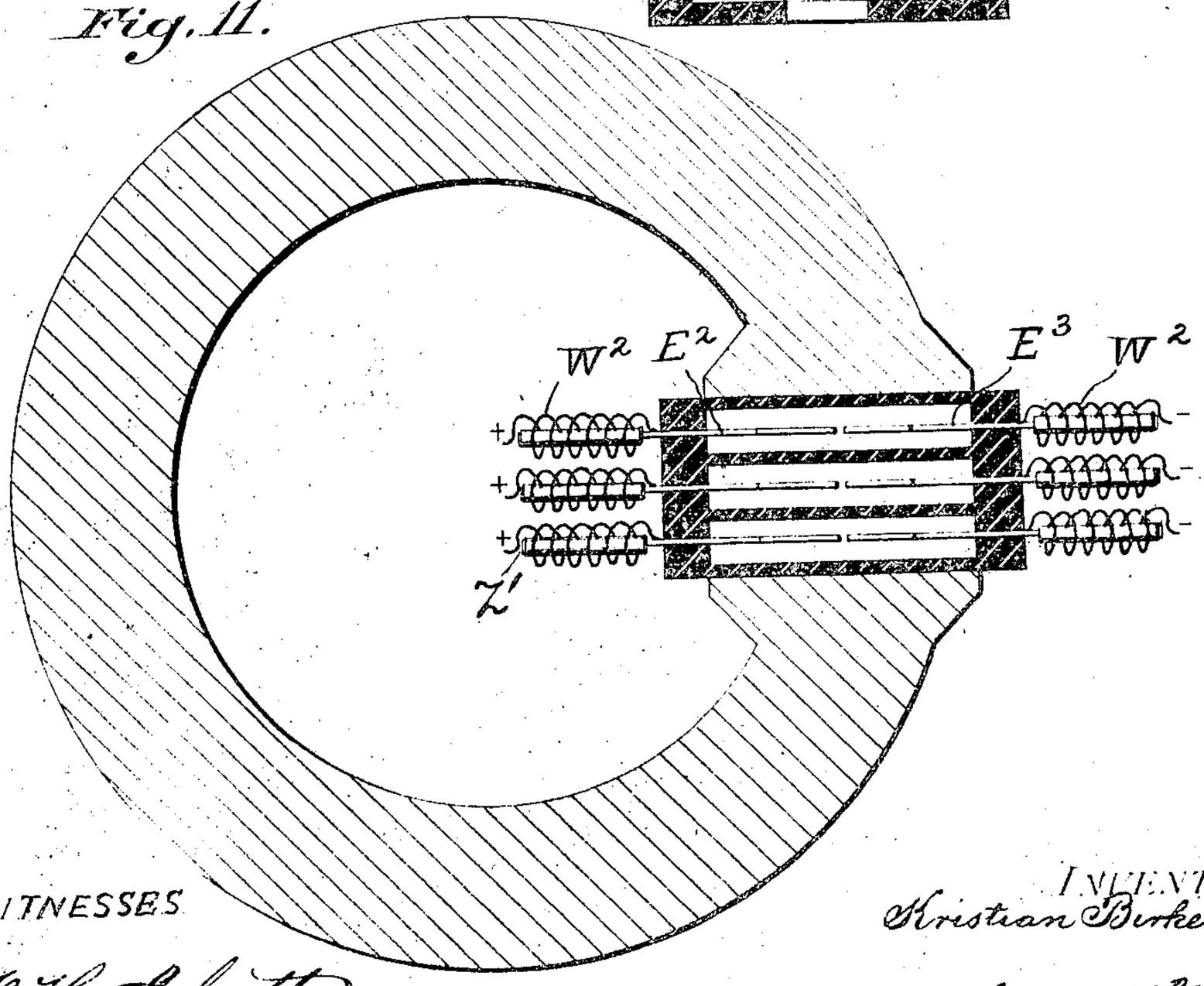


Fig. 11.



WITNESSES

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T. O. Kniest.

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By Georgii & Massie

his Attorneys.

No. 775,123. Patented November 15, 1904.

UNITED STATES PATENT OFFICE.

KRISTIAN BIRKELAND, OF CHRISTIANIA, NORWAY.

APPARATUS FOR ELECTRICALLY TREATING GASES.

SPECIFICATION forming part of Letters Patent No. 775,123, dated November 15, 1904.

Application filed June 15, 1903. Serial No. 161,616. (No model.)

To all whom it may concern:

Be it known that I, KRISTIAN BIRKELAND, a subject of the King of Sweden and Norway, residing at Christiania, Norway, have invented certain new and useful Improvements in Apparatus for Electrically Treating Gases; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to letters of reference marked thereon, which form a part of this specification.

My invention relates to a means for producing electrical arcs of the largest possible surface and to the utilization of such arcs for the purpose of chemical reactions in gases or gas mixtures. I have found in my investigations in this field that chemical reactions on gases, such as vapors, may be produced in an industrially-profitable way if the area of contact between the gases and the arc is made sufficiently great per time unit. For this reason my invention involves as one of its features the means for the production of such arcs of sufficient area.

My invention also comprises the means for causing such arc to act upon such fluids and such other features, means, and combinations of parts, as will be hereinafter set forth, and pointed out in the claims.

In the drawings accompanying this specification, Figure 1 is a diagram, drawn in the form of a perspective view, illustrating the method. Fig. 1ª is a view of a special form of electrodes used to form the arcs. Figs. 2, 3, 4, and 5 illustrate a number of forms of the electrodes and arrangements used in connection therewith. Fig. 6 is an elevation, and Fig. 7 a plan view, of a special arrangement of the electrodes. Fig. 8 is a vertical cross-section, and Fig. 9 a horizontal section, of an apparatus for oxidizing gases. Fig. 8ª is a front elevation of the tubular housing in which the gases are treated. Fig. 10 is a vertical section, and Fig. 11 a horizontal section, of another form of apparatus embodying my invention.

An apparatus embodying my invention, broadly considered, comprises means for causing the arc to be formed within a powerful magnetic field, as illustrated in the diagram Fig. 1. In this figure, M represents an electromagnet, (one pole of which is broken away,) and C C′ electrodes which are situated in the field between the two poles of the magnet M and transversely to the flux or lines of force of said magnet M. Under certain conditions by such an arrangement when a current is sent through the electrodes C C′ an arc will be formed of the shape indicated by the dotted lines A, the arc being in the shape of a disk at right angles to the lines of force of the magnetic field. To obtain this result, I have found it advantageous in case of currents of high voltage—for instance, ten thousand volts—to let the poles of electrodes C C′ have a distance from each other of a few millimeters. If direct currents are used, there will, without any mechanical interruption of the current, ordinarily be formed in succession a very great number of such arcs, (up to several hundreds per second.) If alternating currents are used, there will be two systems of such arcs, one-half of the arcs being formed on the under side of the conductors and one-half on the top side. It is found preferable to provide the electrodes at the ends of the conductors with strips of platinum B, fixed to the point of each electrode and forming an angle with the electrode, as indicated in Fig. 1ª, where these strips are shown to be arranged in the manner of arrow-heads. If a current of less voltage is made use of—say, for instance, a direct or alternating current of six hundred volts or less—I have found it desirable to arrange the electrodes C C′ in such way that their poles are in rapid succession caused to intermittently approach and then to recede from each other a short or greater distance—say, for instance, a part of a millimeter or more. I prefer to cause them to approach sufficiently to come into contact with each other. By such arrangement arcs similar to those described with reference to Fig. 1 will be formed and will be thrown violently upward or downward.

The arrangement of the electrodes for the purpose of giving the required vibratory movement to one or both for the purpose of the above-described intermittent rapid approach and recession of the points of the electrodes may be in different ways, and I have, for the sake of illustration, shown in the drawings a number of arrangements which may be made use of.

In Fig. 2 the vibratory electrodes consist of two springs E E′, which when in the position shown touch each other at the points. A stop F below the spring E serves to limit its downward movement, and a stop F′ above the spring E′ serves to limit its upward movement. The same result may be obtained by an arrangement as shown in Fig. 3, where, instead of the two stops F and F′, a single stop F″ is placed between the points of the electrodes E E′. This stop is made of conducting material and is placed at an angle to the electrodes, as indicated. When an alternating current of suitable strength is passed through the vibratory spring-electrodes at one time, the spring-electrode E will be thrown upward and at another time the spring-electrode E′ will be thrown downward. This is due to the fact that when the positive wave of the current is passing through both electrodes the magnetic field interacts with said positive wave and tends to move both electrodes in one direction; but as only one electrode is free to move in a given direction only this electrode moves, the other remaining stationary against its stop. When the negative wave passes through the electrodes, the tendency of the interaction between the current and field is to give both electrodes a movement in the direction opposite to the prior one, and since only the other electrode is free to move in this direction it will be moved by the interaction of current and field, while the first-mentioned electrode will be stationary. A circuit-breaker system of such simplicity can only be used when the intensities are comparatively great for instance, over twenty amperes per current breaker and it is desirable in this case, for the sake of safety, to impart to the electrodes a periodical limited longitudinal movement in order to prevent the possibility of welding together or union of the contact-pieces, in which case current interruptions could, of course, not take place. If low intensities are used, this way of interruption is only available when the current is caused to pass through a few windings—for instance, as indicated in Fig. 4, where W W′ indicate the windings, each in series with its respective electrode E E′, whose movements are limited by the stop F″. By suitably arranging the windings transverse vibrations might, of course, also be imparted to the electrodes as well as an oscillatory movement with respect to the longitudinal axis of the electrodes, if this is desired. The contact-points between the electrodes should be located in this case on an arm projecting out from the axis.

Instead of automatically operating the circuit-breaker above referred to, other means may be used to produce short contact interruptions in rapid succession. One means may consist in large tuning-forks, each operated in the usual way by means of a small electromagnet combined with a circuit-breaker. By connecting one branch of the fork with one of the electrodes the latter will, when the fork is caused to vibrate, be moved in rapid alternation to and from the other electrode, so as to make and break contact with the same alternately. The rapid motions of the electrodes to and from each other may also and very conveniently be produced by means of a small motor with eccentric gear. A suitable vibrating movement in the longitudinal direction may also be produced by providing the electrodes with extensions (iron rods) reaching out of the magnetic field and adapted to be drawn into a spiral coil through which the main current passes, as shown, for example, in Fig. 5, in which E E′ are the electrodes, the former being attached to a core *e*, of electromagnetic material, which is movable within a coil *w′* in series with said electrode. A spring Z′ may serve to bring the electrodes in contact with each other, as shown, for example, in Fig. 10. On a current impulse said iron rod will be attracted and drawn into the spiral so as to break or weaken the current, whereupon the electrode is returned to contact with the other electrode by the action of the spring. This means of interruption may be used both for direct current and for alternating current. Another means would be to cause the disk-shaped arcs to be formed within a cylinder, the contact between the electrodes being produced by rotation. One system of electrodes might, for instance, be fixed on the inside of the cylinder and a corresponding system of electrodes adapted to revolve about the axis of the cylinder, so as to make contacts in rapid succession. It would be suitable in this case to dispose the magnetic field in an annular form around the cylinder-axis by means of current-coils. In this instance the disk-shaped arcs will form planes parallel to the axis of the cylinder. A further arrangement would be to cause an annular system of electrodes to rotate between the poles of an electromagnet perpendicularly upon the line through the centers of both pole planes, as illustrated in Figs. 6 and 7. In these figures L represents a shaft which by suitable means may be put in rotation—as, for example, by a pulley driven by a belt from any suitable prime mover or source of power. (Not shown.) It carries radial arms G, which are electrical conductors or electrodes and terminate in contact-springs H. I represents sta-

tionary electrodes terminating in similar contact-springs K. When the shaft F rotates, the two sets of contact-springs will alternately close and break the circuit. This system of circuit-breakers is disposed between the pole-pieces of the electromagnet M, as indicated in Fig. 7. For currents of rather high voltage it is not necessary that the contact-pieces of the electrode should during the revolution bodily touch each other. It is only necessary that the distances be so short as not to cause an interruption of the currents. When a current of very high voltage is used, the electrode system G need not even revolve, but may be stationary at some distance from the electrodes I.

In Figs. 8 and 9 I have shown, in vertical and in horizontal section, respectively, one form of apparatus for carrying out my invention for the purpose of oxidizing the nitrogen contained in air, said apparatus comprising, besides the means for dilating or spreading the electric arc, means for bringing the fluid to be acted on into contact with such arc in the form of a current of such fluid which is carried into contact and past said arc. In these figures, M represents an annular electromagnet. Instead of an electromagnet a battery of steel magnets may be used. Between the poles of the electromagnet is arranged the means for supplying the fluid to be acted on in the form of a tubular housing O, which is divided into a series of vertical channels P by partitions R, which alternately extend to the top and the bottom plate and alternately leave a space open between their ends and said plates, so that a zigzag channel is formed, through which air is passed. (See Fig. 8ª.) The housing and the partitions within the same should wholly or partly be made of insulating and fireproof material. Within each of said channels P are placed one or more pairs of electrodes or circuit-breakers of the kind above referred to—for instance, such as described with reference to Fig. 1ª or Fig. 2. If using electrodes of the latter kind or other electrodes with an intermittent motion and when an alternating current of suitable strength is passed in parallel through all the circuit-breakers, (in front of which suitable inductive resistances are inserted in the circuit,) it will cause at one time a downward movement of one of the electrodes and another time an upward movement of the other electrode, so that frequent though very short contact interruptions will be produced. Now the peculiar phenomenon above referred to will be noted that even though the contacts are only a fraction of a millimeter apart the arcs will at once be thrown violently downward or upward and the space filled up with disk-shaped arcs. The base-points of the outermost arcs will extend along the platinum wires B, Fig. 8, toward their ends, and it depends upon the oscillatory velocity of the circuit-breaker, upon the power of the magnetic field, and upon the current intensity how far the arcs will extend before a new contact is made and the previous arcs are extinguished. When a current of very high voltage is used, the current may be sent partly or wholly in series through the whole set of circuit-breakers. If a direct current is used, only one electrode remains at rest, and it is preferable in this case not to place the latter in the middle of the magnetic field. The air may be passed either directly in parallel through all the flat channels or in series through the same, as shown in Fig. 8ª of the drawings, the air passing in this case upwardly past the first arc, downwardly past the second, upwardly past the third, and so on. In this way the same quantity of air will make contact with a great number of arcs. If it is desired to bring the gases into contact with a still greater number of arcs, a plurality of such arc systems having each their separate electromagnet may be arranged at suitable intervals from each other and in vertical or horizontal rows.

In Figs. 10 and 11 is shown a modified form of apparatus for oxidizing gases in which the electrodes are vibratory in a horizontal direction, being pressed yieldingly toward each other by any suitable means, such as the springs Z', and drawn outward against the springs by the interaction between the current in the coils W^2 and the respective cores e^2, which are secured to the ends of the electrodes E^2 E^3.

The remaining elements of construction are like those shown and described in connection with Fig. 9.

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

1. The combination, with means for producing a magnetic field, of means for producing an electric arc in said field, and means for passing a current of gas into contact with and past said electric arc.

2. The combination, with means for producing a magnetic field, of electrodes located in said field, means for supplying electricity to said electrodes, and means for passing a current of gas past said electrodes.

3. The combination, with means for producing a magnetic field, of a pair of vibratory electrodes mounted in said field and arranged to produce an arc between their terminals, means for supplying a current to said electrodes, and means for supplying to said electrodes a gas to be acted upon by said arc.

4. The combination, with means for producing a magnetic field, of a pair of electrodes mounted in said field, means for supplying a current to said electrodes, and means for imparting a motion to one or both of said electrodes so as to cause a rapid and intermittent approach and recession of the points of said electrodes.

5. The combination, with means for produc-

ing a magnetic field, of a pair of electrodes mounted in said field, means for supplying a current to said electrodes, and means for imparting a rapid vibratory motion to one or both of said electrodes so as to cause the points of said electrodes to come into contact with each other.

6. The combination, with means for producing a magnetic field, of a pair of electrodes mounted in said field, one at least being vibratory, and means for supplying a gas to said electrodes.

7. The combination, with means for producing a magnetic field, of a plurality of pairs of electrodes mounted in said field, each pair being arranged to produce an arc, means for supplying current to said electrodes and means for passing a current of gas past said arcs in series.

8. The combination, with means for producing a magnetic field, of a pair of electrodes mounted in said field, means for vibrating said electrodes and means for supplying a current to said electrodes.

9. The combination, with means for producing a powerful magnetic field, of a pair of electrodes mounted in said field, means for vibrating said electrodes, means for supplying a high-voltage current to said electrodes and means for supplying to said electrodes a gas to be acted upon.

10. The combination, with means for producing a magnetic field, of means for producing an arc transversely to the flux of said magnetic field, and means for supplying a gas to said arc.

11. The combination, with means for producing a magnetic field, of a pair of electrodes arranged transversely to the flux of said magnetic field, means for supplying current to said electrodes, and means for supplying a gas to be acted upon by said electrodes.

12. The combination, with means for producing a magnetic field, of vibratory electrodes located in said field, means for supplying alternating current to said electrodes, and means for supplying a gas to be acted upon by said electrodes.

In witness whereof I have hereunto set my hand in presence of two witnesses.

KRISTIAN BIRKELAND.

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JOH. VAALER.