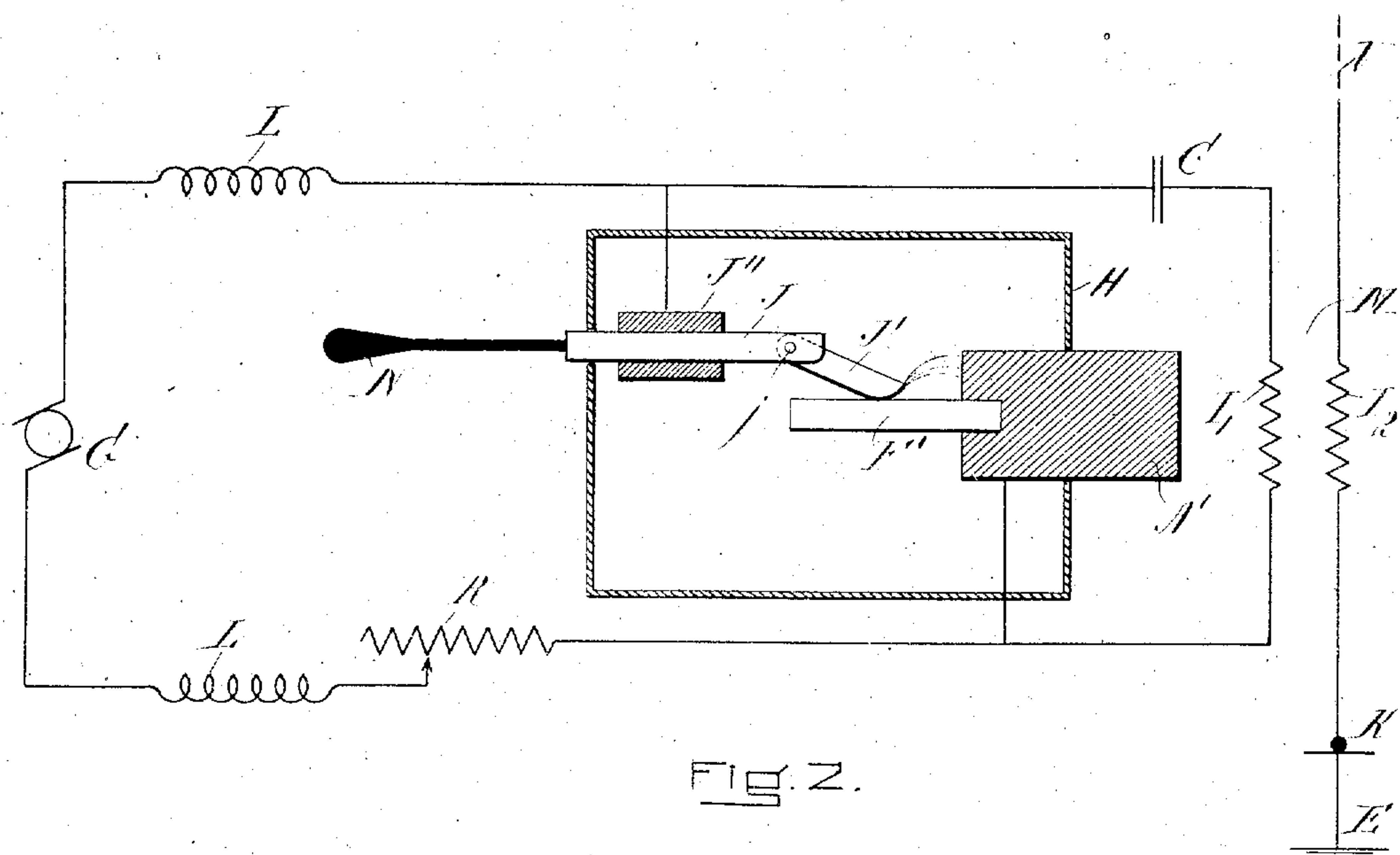
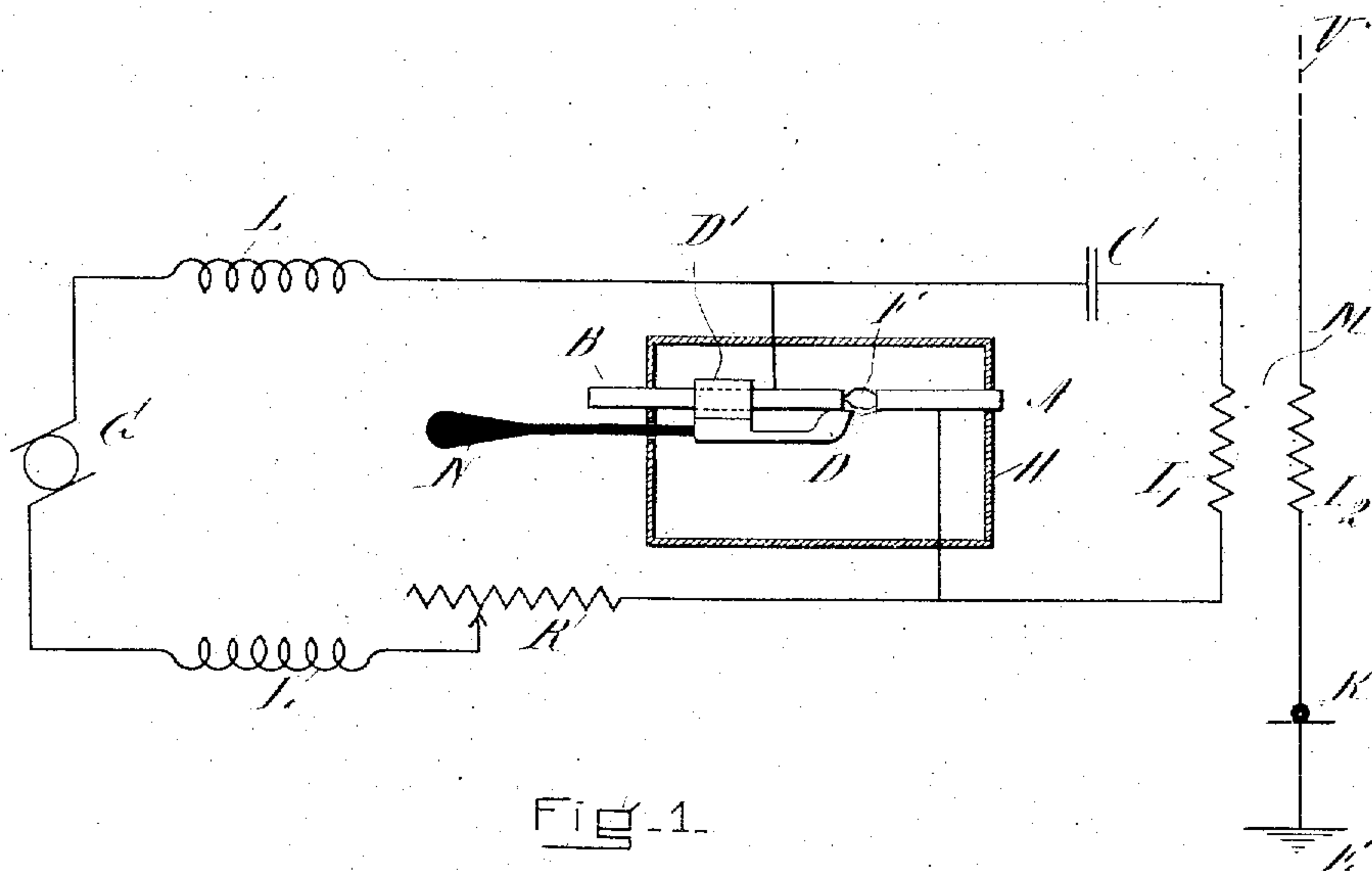


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HIGH FREQUENCY ELECTRICAL OSCILLATION GENERATOR.  
APPLICATION FILED FEB. 8, 1908.

979,277.

Patented Dec. 20, 1910.

2 SHEETS—SHEET 1.



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*Lee de Forest*  
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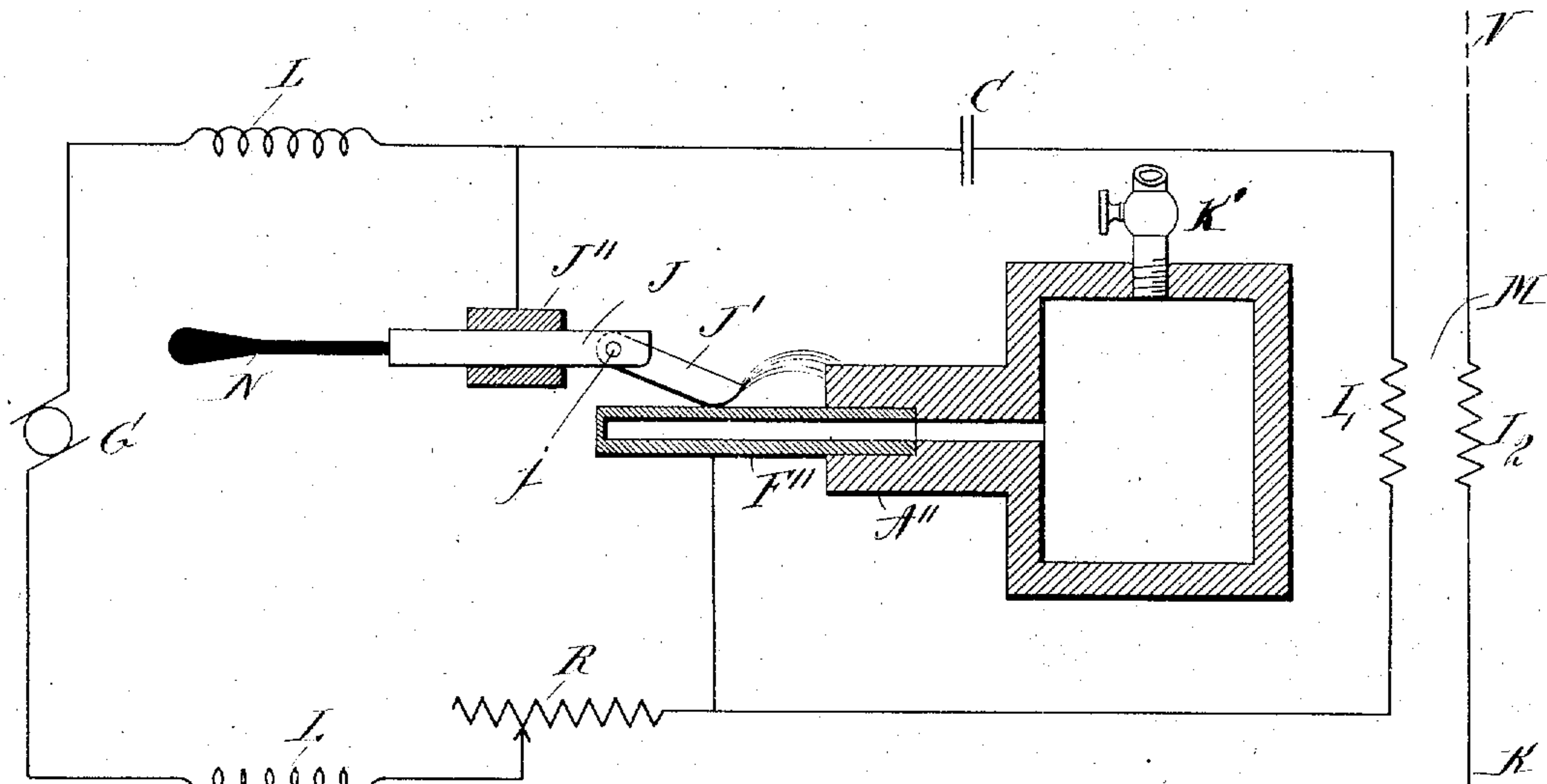


FIG. 3.

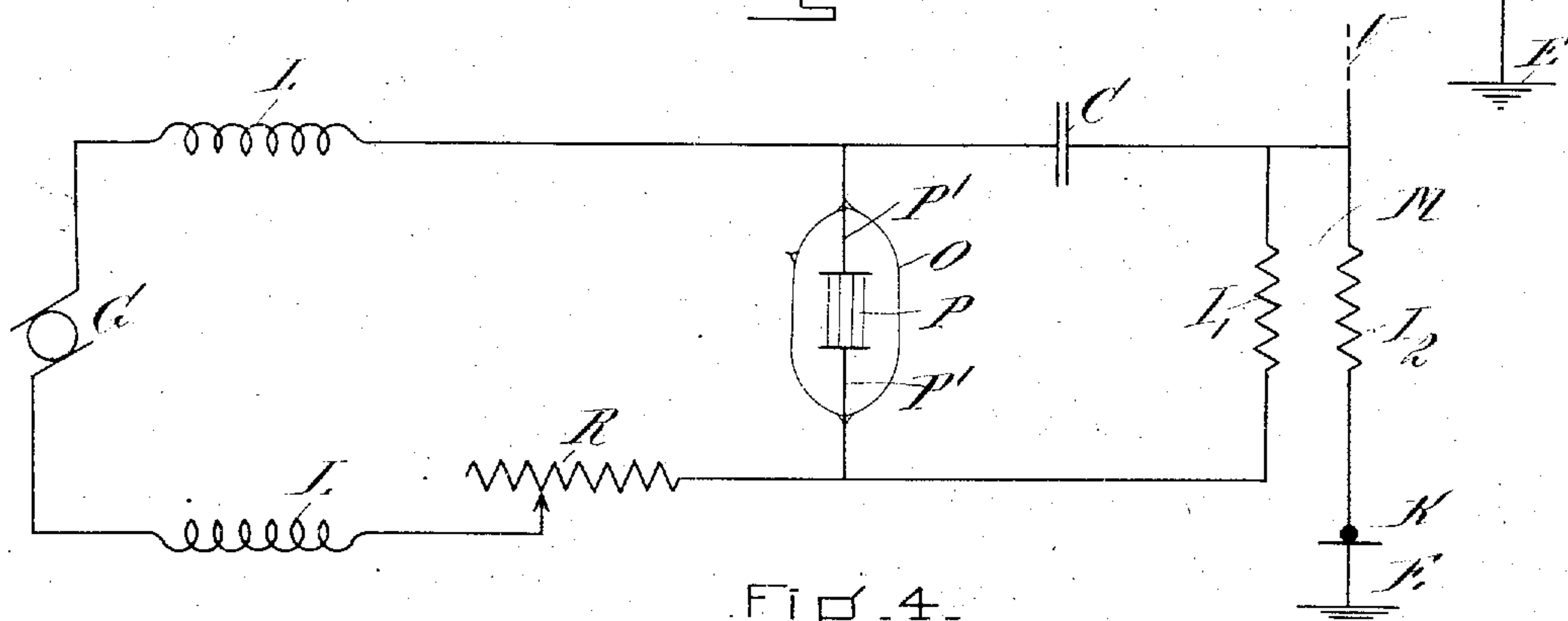


FIG. 4.

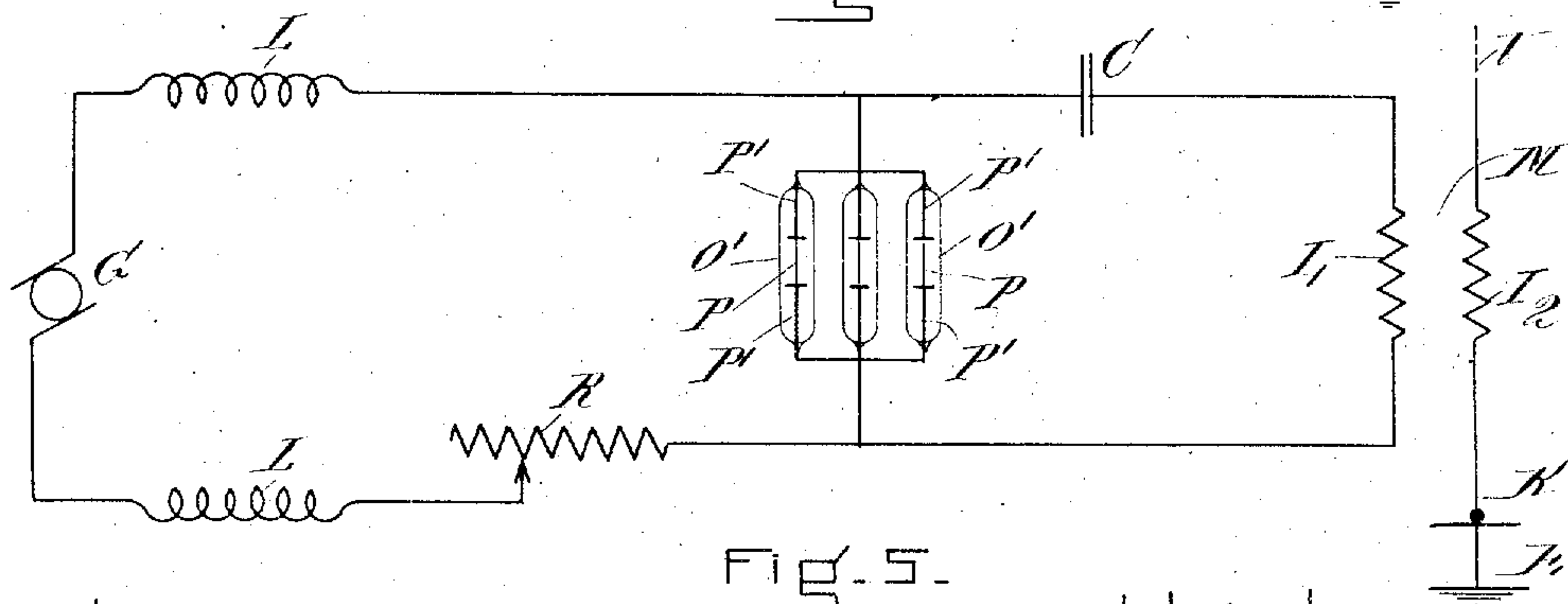


FIG. 5.

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# UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW YORK, N. Y.

## HIGH-FREQUENCY ELECTRICAL-OSCILLATION GENERATOR.

979,277.

Specification of Letters Patent.

Patented Dec. 20, 1910.

Application filed February 8, 1908. Serial No. 414,976.

*To all whom it may concern:*

Be it known that I, LEE DE FOREST, a citizen of the United States, and a resident of New York, in the county of New York and State of New York, have invented a new and useful Improvement in High-Frequency Electrical-Oscillation Generators, of which the following is a specification.

My invention relates to high frequency electrical oscillation generators and more particularly to generators of undamped or practically continuous electrical oscillations of substantially constant amplitude. Heretofore such undamped or practically continuous electrical oscillations have been developed by the well known singing-arc or oscillating-arc circuit which consists of an oscillation circuit having capacity and inductance and a pair of separated arc electrodes, all serially connected and provided with a source of unidirectional electromotive force connected to said electrodes through conductors of high ohmic or inductive resistance. A circuit of this type is subject to certain defects due to the irregularities in the burning of the arc which produce corresponding variations in the oscillations generated therein and which sometimes result in the sudden extinguishment of the arc and in the stoppage of said oscillations.

The object of the present invention is to provide a circuit for developing undamped high-frequency electrical oscillations which shall not require an oscillating arc and which therefore shall be regular and constant in operation. This object may be accomplished by substituting for the arc-electrodes of the prior art a properly conducting heat-resisting medium, such as a conductor of the second class, preferably of short length, of relatively low resistance, and of considerable current carrying capacity. For this purpose a variety of substances may be employed, such as oxids of the zirconium group,—zirconia, glucina, yttria, thoria, etc., commonly called the rare earths, a non-conductor such as pipe-clay or porcelain coated with such oxids, porous substances such as fire-clay impregnated with such oxids, asbestos or mineral wool alone or impregnated with one or more of the rare earths, high resistance graphite, or hard carbon filaments, such as incandescent lamp filaments. These substances when cold are either non-conductors or else are of too

high a resistance to permit of the generation of high frequency oscillations when inserted in an oscillation circuit. For this reason some means must be provided for heating the substance and thereby reducing its resistance. While various heating means may be employed, I prefer to make use of the source of electrical energy, preferably a source of direct current, which energizes the oscillation circuit for heating the conductor of the second class which I substitute for the oscillating arc.

One important feature of my invention consists in the fact that my oscillation circuit is an electrically closed circuit, and in fact, except for the condenser, is physically closed as distinguished from the oscillation circuits of the prior art, which are not closed but are broken by a gap between the arc-electrodes. An oscillation circuit comprising a condenser and an unbroken circuit which may include an inductance connecting the terminals of said condenser possesses many advantages over the oscillation circuits in use today, in that thereby a much greater constancy and continuity of operation is secured.

The drawings which accompany and form a part of the present specification illustrate in diagram the application to a space telephone system of several arrangements of apparatus and circuits whereby my invention has been realized in practice; but it is to be understood that I have shown in said drawings only a few of the numerous embodiments of my invention for the purpose of explaining the principle thereof and that various modifications may be made both in the apparatus and in the circuit arrangements without departing from said principle.

In the drawings Figure 1 represents a space telephone system energized by one form of the oscillation circuit which constitutes the subject matter of the present application. Fig. 2 shows a modification of the oscillation circuit having a non-conductor coated with a conductor of the second class. Fig. 3 shows a further modification in which the oscillation circuit is provided with means for forcing a suitable gas or vapor through a body of porous material coated or impregnated with a conductor of the second class. Figs. 4 and 5 represent other modifications in which short lengths



of hard carbon filaments are employed as a substitute for the oscillating arc.

In the figures, V is an elevated transmitting conductor.

5 M is an oscillation transformer, of which the primary and secondary respectively are shown  $I_1$  and  $I_2$ .

K is a microphone transmitter.

E is an earth connection.

10 C is a condenser.

G is a generator, preferably of direct current.

L, L are inductive resistances.

R is a non-inductive resistance.

15 In Fig. 1 A and B are fixed terminals of copper, carbon or other suitable material, and D is a finger, which may be of copper, secured to the collar D' which may be moved over the terminal B by means of the insulating handle N. F represents a lump of one

20 of the rare earths, preferably thorium oxide or thoria, or asbestos or mineral wool which may be impregnated with one of the rare earths. H represents conventionally a casing inclosing the substance F so that the same may be surrounded with an atmosphere of hydrogen or a gas containing hydrogen.

The operation is as follows: The finger D is brought in contact with the terminal A and slightly withdrawn so as to create an electric arc. When this arc is maintained in a suitable atmosphere, the circuit C D' D A  $I_1$  gives rise to practically continuous or undamped electrical oscillations. The substance F soon becomes heated to incandescence and thereby becomes highly conducting. The result is that the current in the oscillation circuit is shunted from the electrodes D and A and passes through the substance F which is maintained in good contact with the terminals A and B. The arc is now extinguished and the circuit continues to develop high frequency electrical oscillations which are practically continuous or

35 undamped and which are much more regular in frequency and constant in amplitude than those developed by the oscillating arc circuit. These oscillations, being of very high frequency, pass almost entirely over the surface of the substance F on account of the well known phenomenon known as the skin-effect. It is preferable that the substance F shown in Fig. 1 and the various modifications thereof shown in Figs. 2 to 5, inclusive, be so designed as to have a resistance varying between the limits 30 to 50 ohms and to have a current carrying capacity of from two to five amperes.

60 In Fig. 2, F' represents a tube or rod of pipe clay or porcelain or other suitable heat-resisting non-conductor coated with one of the hereinbefore mentioned conductors of the second class. The member F is secured to the fixed terminal A' of the oscillation circuit, which terminal may be copper. The

finger J' is hinged at j to the movable terminal J which is secured to the guide J'' and is adapted to be moved therethrough by the insulating handle N.

The operation is as follows: The finger J' 70 is moved along the member F' until it contacts the terminal A' and is then slightly withdrawn so as to start an electric arc between A' and J'. The circuit C J' A'  $I_1$  gives rise to undamped high frequency electrical oscillations, and as soon as the conductor of the second class becomes heated and its resistance is sufficiently reduced, the arc is extinguished automatically and the oscillations pass along the surface of the 80 member F'.

In Fig. 3 the member F'' is shown as a tube of porous material such as fire clay coated or impregnated with a conductor of the second class and secured to a reservoir 85 A'' provided with an inlet K' through which a suitable gas may be forced under high pressure. This gas will escape through the pores of the member F'' and thus surround the arc which is created between J' 90 and A'' with the atmosphere required for the production of oscillations in the oscillation circuit. After the arc has been extinguished and the oscillations take place over the surface of the member F'' in the 95 manner above outlined in connection with the member F' of Fig. 2, this gas serves to surround the highly heated surface of the member F'' and thereby assists in maintaining the oscillations. By employing the arrangement shown in Fig. 3 the casing H shown in Figs. 1 and 2 may be eliminated. The reservoir A'' may be filled with water, in which case the heating of the member F'' soon vaporizes the water and causes steam 105 to pass through the porous body F'', thereby serving to maintain the oscillations in the oscillation circuit, as more fully explained by me in my Letters Patent No. 850,917, dated Apr. 23, 1907. 110

In Figs. 2 and 3 the members shown at F' and F'' may consist of graphite which when heated by the arc has a sufficient surface conductivity to permit of the creation of high frequency oscillations in the oscillation circuit and which has a sufficiently high internal resistance to prevent the shunting of the current from the generator G through its interior portions.

In Fig. 4 P represents a short length of 120 hard carbon filament such as an ordinary incandescent lamp filament, and as shown, a number of such filaments may be inclosed within the evacuated tube O and connected with the condenser C and inductance  $I_1$  by the leading in wires P'. As shown in Fig. 5, a plurality of evacuated tubes O' each containing one filament P may be employed in place of the multiple filament arrangement shown in Fig. 4. 130



The operation of the arrangements shown in Figs. 4 and 5 is as follows: The filaments P are heated to incandescence by the current from the generator G, whereupon if said filaments are of sufficiently short length and adequate current carrying capacity, the circuit C P I<sub>1</sub> will give rise to practically continuous or undampened high frequency electrical oscillations of uniform frequency and substantially constant amplitude.

The well known rules for constructing singing arc or oscillation arc circuits should be followed in the construction of the oscillation circuit described herein. The generator G is preferably a direct current generator capable of developing 220 volts, the impedances L, L are sufficiently high to resist sudden changes of current and the capacity C and inductance I<sub>1</sub> should be so designed with respect to the resistance of the oscillation circuit that the latter will be highly oscillatory.

The function of the transmitter K connected in the antenna at a point having practically zero potential with respect to earth is to vary the oscillations developed by the oscillation circuit in said antenna in accordance with the vibrations of the air accompanying articulate speech, as more fully explained by me in connection with Fig. 1 of my Letters Patent No. 836,015 dated November 13, 1906.

It will of course be understood that the oscillation circuit hereinafter claimed is not limited in its application to wireless telephony or to wireless telegraphy, but may be employed wherever it is desired to create undamped high frequency electrical oscillations of great uniformity and regularity.

I claim:

1. The combination with a source of electrical energy of a high frequency oscillation circuit comprising a capacity, an inductance and a non-conductor coated with a conductor of the second class, said coated non-conductor being associated with a circuit bridged across the terminals of the energy source and the capacity.

2. The combination with a source of electrical energy of a high frequency oscillation circuit comprising a capacity, an inductance and a non-conductor coated with a conductor of the second class, said coated non-conductor being associated with a circuit bridged across the terminals of the energy source and the capacity and means for heating the latter.

3. The combination with a source of electrical energy of a high frequency oscillation circuit comprising a capacity, an inductance and a non-conductor coated with an oxid of the zirconium group, said coated non-conductor being associated with a circuit bridged across the terminals of the energy source and the capacity.

4. The combination with a source of electrical energy of a high frequency oscillation circuit comprising a capacity, an inductance and a non-conductor coated with an oxid of the zirconium group, said coated non-conductor being associated with a circuit bridged across the terminals of the energy source and the capacity and means for heating the latter.

5. The combination with a source of electrical energy of a high frequency oscillation circuit comprising a capacity, an inductance and a non-conductor coated with an oxid of thorium, said coated non-conductor being associated with a circuit bridged across the terminals of the energy source and the capacity.

6. The combination with a source of electrical energy of a high frequency oscillation circuit comprising a capacity, an inductance and a non-conductor coated with an oxid of thorium, said coated non-conductor being associated with a circuit bridged across the terminals of the energy source and the capacity and means for heating the latter.

7. The combination with a source of electrical energy of a high frequency oscillation circuit comprising a capacity, an inductance and a conductor of the second class, and means for creating an electric arc in juxtaposition to said conductor.

8. The combination with a source of electrical energy of a high frequency oscillation circuit containing a capacity, an inductance, a fixed terminal and a movable terminal forming a bridge across the terminals of the energy source and the capacity, and a conductor of the second class in contact with said terminals.

9. The combination with a source of electrical energy of a high frequency oscillation circuit comprising a capacity, an inductance and two terminals arranged in a circuit bridging the terminals of the energy source and the capacity, a conductor of the second class arranged between said terminals and means whereby an electric arc may be created between said terminals to heat said conductor.

10. The combination with a source of electrical energy of a high frequency oscillation circuit comprising a capacity, an inductance and a hollow porous non-conductor coated with a conductor of the second class, said coated non-conductor being associated with a circuit bridging the terminals of the energy source and the capacity; and means for forcing a gas containing hydrogen through said hollow non-conductor.

11. The combination with a source of electrical energy of a high frequency oscillation circuit comprising a capacity, an inductance and a porous non-conductor coated with a conductor of the second class, said coated non-conductor being associated with a cir-

cuit bridging the terminals of the energy source and the capacity.

12. The combination with a source of electrical energy of a high frequency oscillation  
5 circuit comprising a capacity, an inductance and a porous heat-resisting non-conductor coated with a conductor of the second class, said coated non-conductor being associated  
10 energy source and the capacity, and means

for surrounding said conductor with an atmosphere containing hydrogen.

In testimony whereof, I have hereunto subscribed my name this 27 day of Jan. 1908.

LEE DE FOREST.

Witnesses:

SADIE MULLANE

ISABEL LEVISON.