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METHOD AND APPARATUS FOR THE GENERATION OF ELECTRIC OSCILLATIONS

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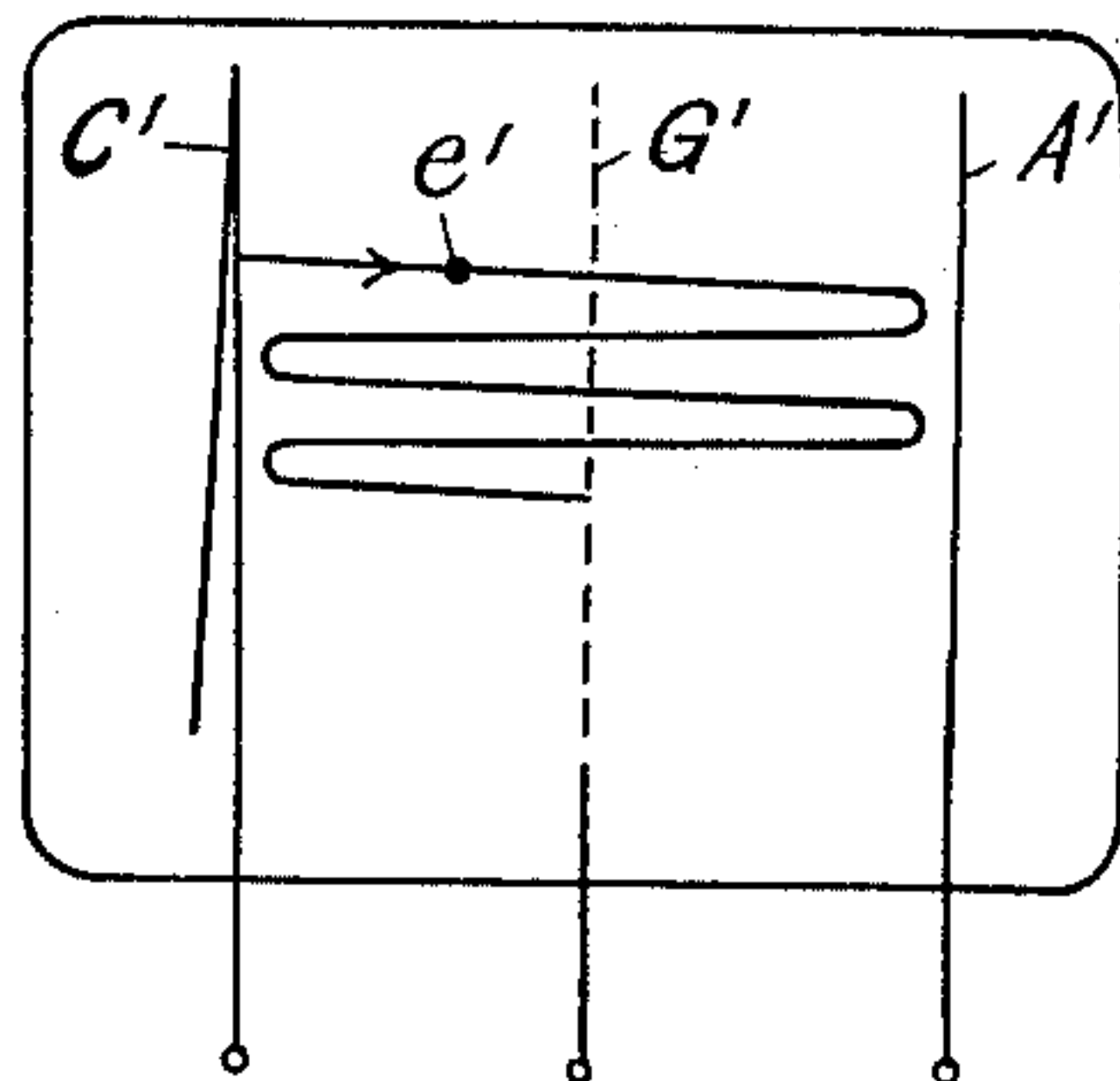
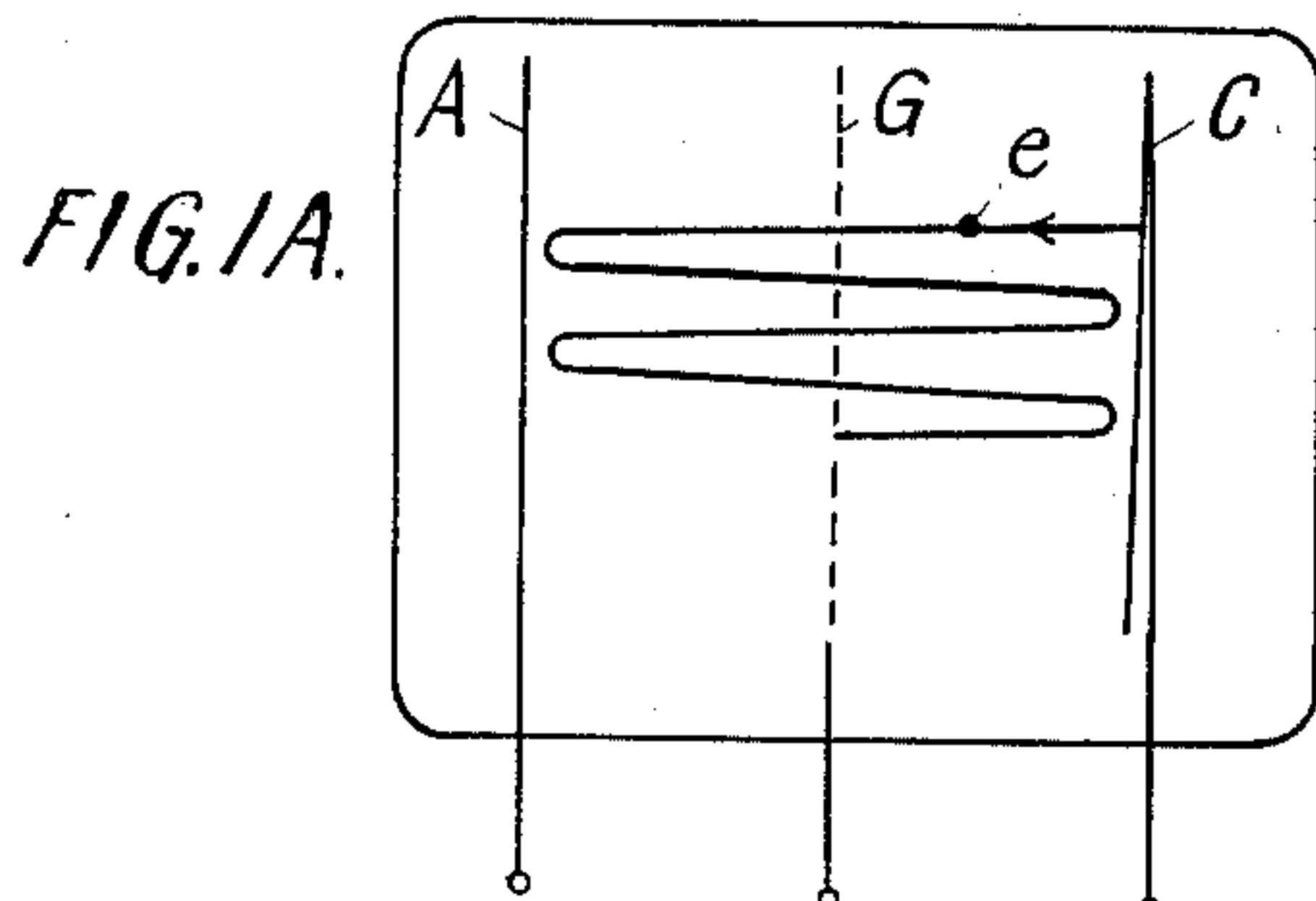


FIG. 2.

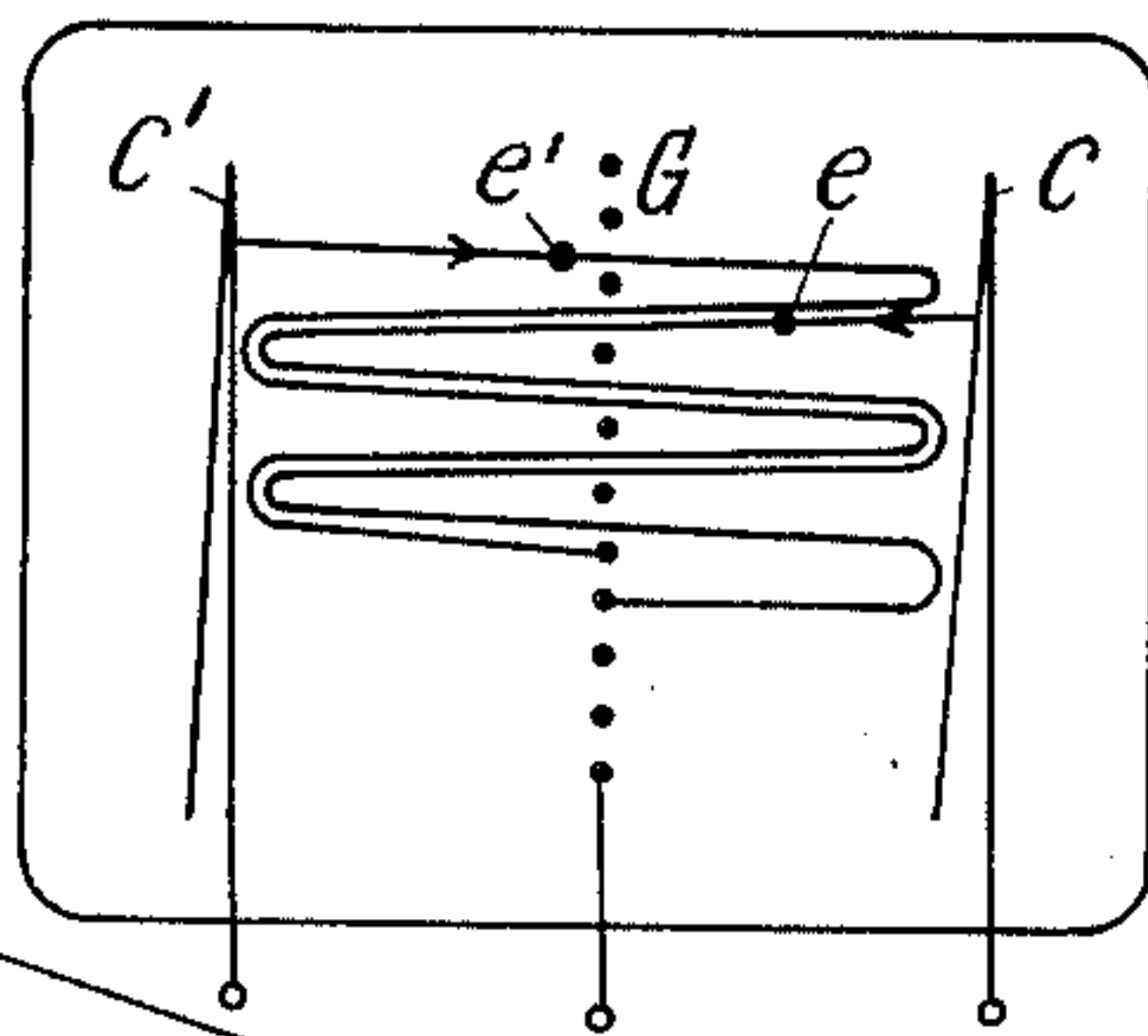


FIG. 3.

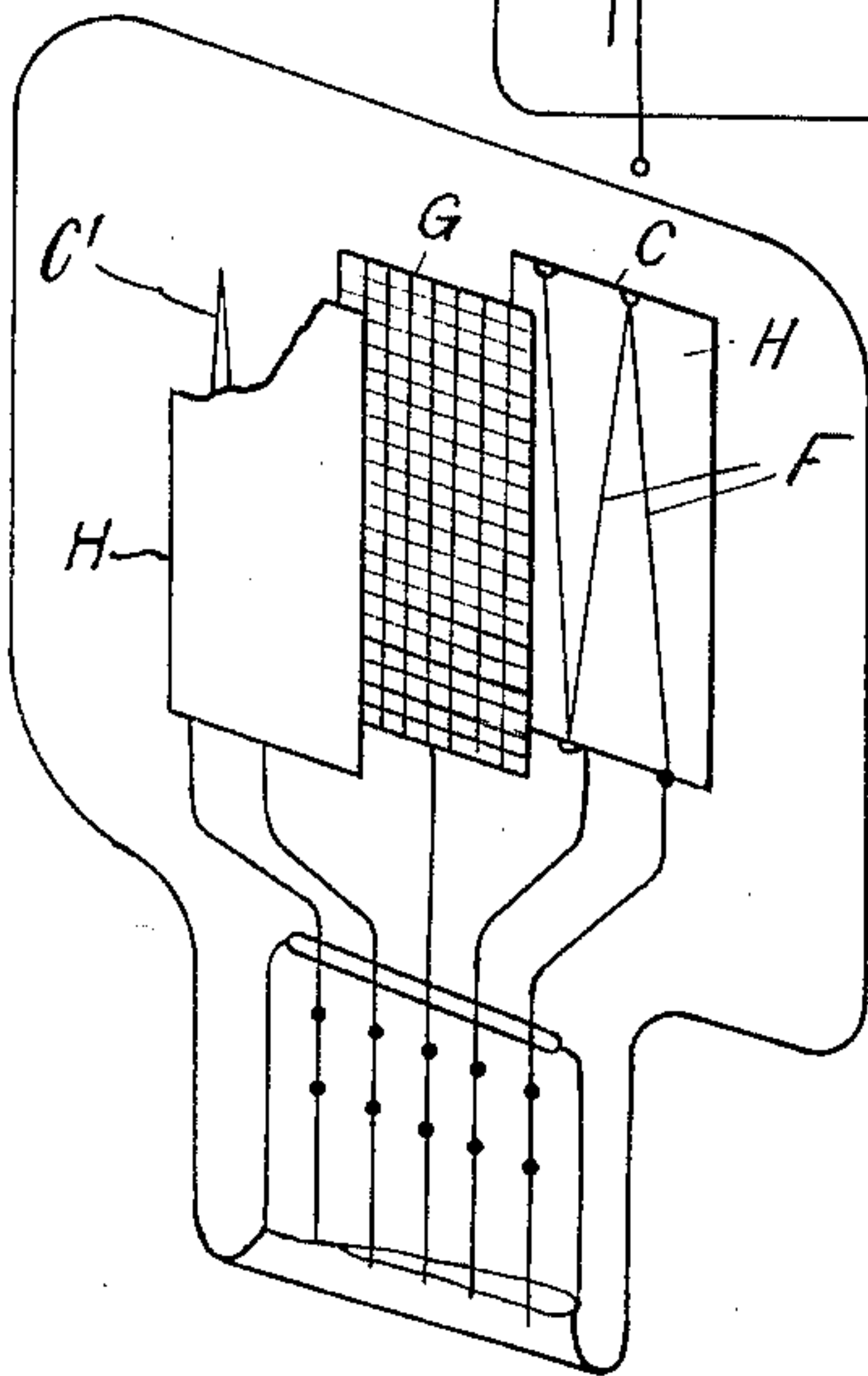


Fig. 4.

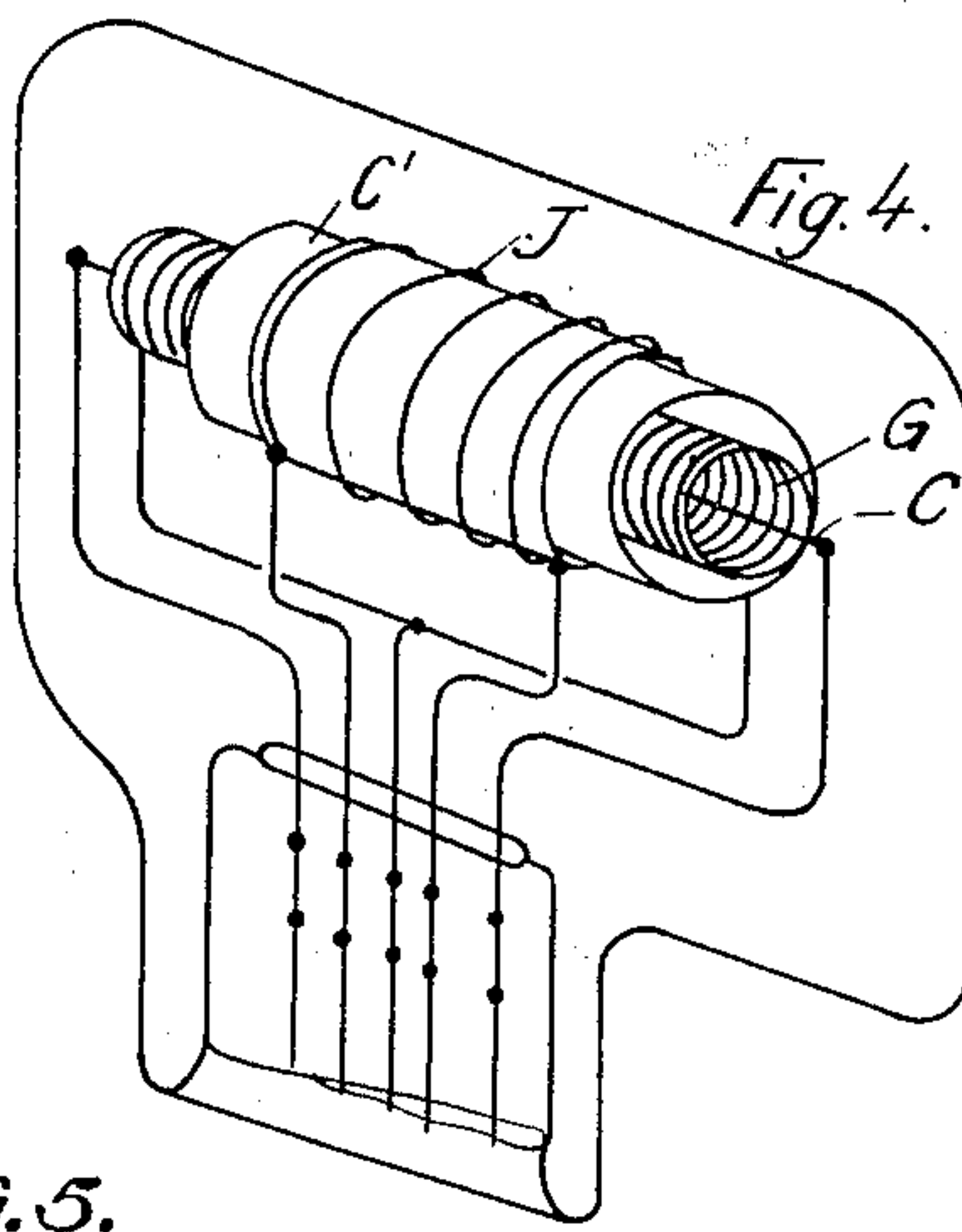
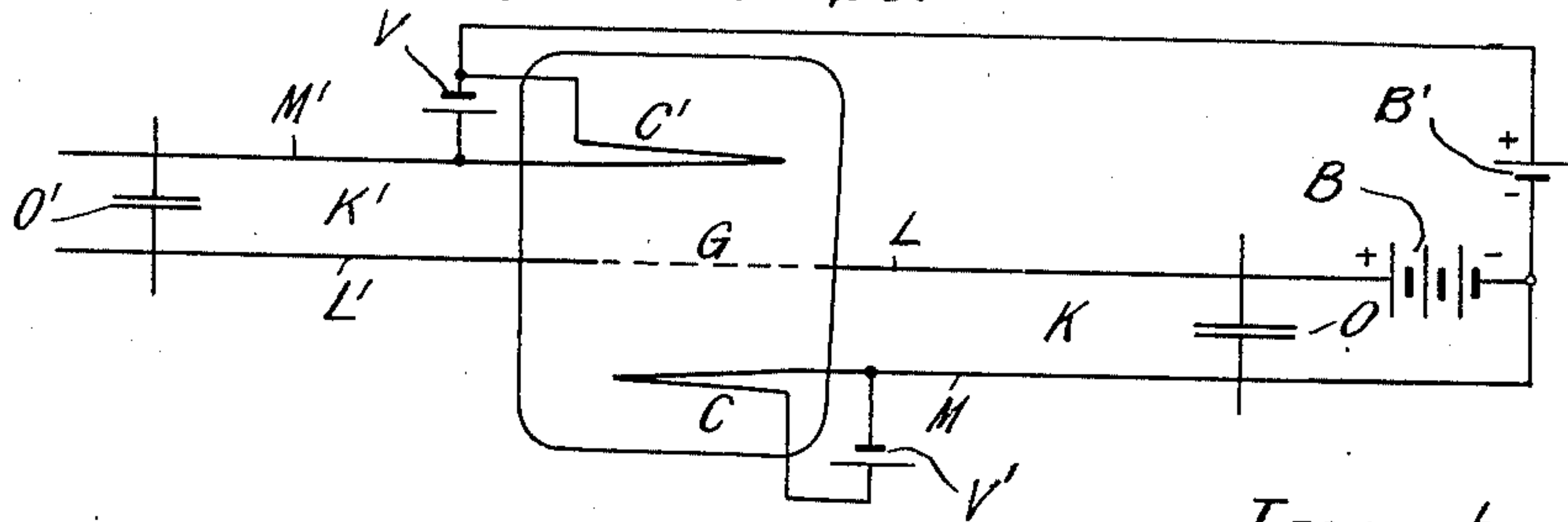


FIG. 5.



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UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR THE GENERATION OF ELECTRIC OSCILLATIONS

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19 Claims. (Cl. 250—36)

My invention refers to the production of electric waves and more especially of ultra-short electric waves by means of electron tubes.

As a rule electric oscillations are produced by means of electron tubes in regenerative connection, whereby the alternating potential of the anode of a three electrode valve is fed back upon the grid in such a manner that all losses of energy are compensated for. Therefore, in a regenerative arrangement of this kind the smallest oscillations, after having once received a starting impulse, will build steadily up to a limit, determined by the power carrying capacity of the tube and the dissipation, phase and frequency characteristics of the associated circuit. In such a system the frequency of the oscillations is determined by an oscillatory circuit included in the system at any desired point. The frequency remains constant throughout the building up process of the oscillation to their resonance value.

This method, however, is not adapted for the production of very short waves because the time of transit of the electrons within the tube is not negligible as compared with the duration of the oscillation periods. In consequence thereof feedback conditions, as far as they concern the time phase relation of the alternating potentials at the grid and the anode, cannot be satisfied.

Very short waves are commonly produced by a process suggested by Barkhausen and Kurz. According to this process the time during which the electrons remain in the space between the electrodes determines the frequency, in that a movement of the electrons is brought about owing to the particular field distribution produced by the operating potentials which differ substantially from those employed in the usual operation of a vacuum tube. To this end the grid is given a high positive, the anode a low negative potential. Since the heated filament is emitting a set of electrons, in order to obtain a pendulum movement effective in the outer circuit, it may be presumed that the electrons swing synchronously and with equal phase. Such movement of the electrons may be explained by way of example in the following manner by regarding the influence of the negative space charge on the emission current. The electrons returning from the grid anode space through the grid increase the negative space charge in the grid cathode space and in consequence thereof the emission current is decreased. During the next quarter period the electrons leave the grid cathode space, so that the space charge is decreased to its initial value and the emission current is increased to the saturation value.

Then a new set of electrons is hurled through the grid meshes into the grid anode space and the control action by the space charge repeated when the electrons return. In this manner the emission intensity is periodically increased and decreased and the frequency of the current oscillations is equal to the frequency of the pendulum movement of the electrons, which in turn increases with the field intensity. Therefore the frequency increases when the grid voltage increases and the distances between the grid and the electrodes decrease.

Short wave length oscillations generated by the Barkhausen-Kurz method have a lower limit which cannot be exceeded by increasing the voltages or by decreasing the distance between the electrodes. This may be easily explained by the controlling action of the negative space charge, because at high voltages or low distances between the electrodes the field intensity increases rapidly and as the field intensity increases above a certain amount, the space charge is decreased to such an extent that a controlling action no longer occurs. Particularly the space charge beyond the grid decreases rapidly when the grid potential increases. In consequence thereof, when the grid voltage is increased above a certain value, the periodic electron stream in the brake field arrangement becomes a continuous one and the generation of oscillations ceases.

I have discovered that oscillations of appreciably shorter wave lengths may be generated by replacing the anode of a three electrode valve in the Barkhausen-Kurz method by a second cathode. In this valve two sets of electrons are emitted by the cathodes, so that the electrons passing through the grid cause periodical changes of the space charge in the opposite grid-cathode spaces thereby controlling the electrons emitted by the opposite cathodes. In consequence thereof the electrons emitted by the two cathodes control each other in counter phase relation.

In apparatus involving this invention the space charges controlling the emission currents are not only built up by the electrons emitted by the opposite cathode and passing through the grid, but also by the electrons emitted by the adjacent cathode. In consequence thereof at a given grid voltage the space charge is larger than in a Barkhausen-Kurz circuit and the field intensity may be increased beyond the limit of the Barkhausen-Kurz method without stopping the generation of oscillations.

In this manner the frequency range obtainable in accordance with this invention is increased and oscillations of appreciably higher frequencies may be generated than by the ordinary

5 Barkhausen-Kurz method.

I wish it to be understood that the foregoing theoretical explanation is merely given by way of example and that I do not wish to be limited by this explanation.

10 In the drawing affixed to this specification and forming part thereof various explanatory diagrams and various embodiments of my invention are illustrated by way of example.

In the drawing

15 Figs. 1A and 1B are diagrams illustrating the movement of an electron in a Barkhausen-Kurz valve,

Fig. 2 is a diagram showing the movement of the electrons in a valve embodying this invention,

20 Figs. 3 and 4 are perspective views of two embodiments of my invention.

Fig. 5 is a wiring diagram including a valve according to this invention.

25 Referring first to Fig. 1A, C is the cathode, G the grid and A the anode of the valve in the brake-field connection well-known in the art, whereby the grid G carries a relatively high positive potential and the plate A is at a zero or a small negative potential. An electron e emitted by the cathode C passes through the grid G and is braked or slowed down by the field in the grid-anode space. In practice the cathode C emits not merely one electron but a set of electrons which build up a periodically and synchronous varying negative space charge controlling the movement of the electrons.

Fig. 1B shows diagrammatically a Barkhausen-Kurz valve symmetric to that shown in Fig. 1A. C' is the cathode, G' the grid and A' the plate of the valve. The electrodes are arranged symmetrically with respect to Fig. 1A.

By superimposing the diagrams of Figs. 1A and 1B the diagram shown in Fig. 2 is obtained. C and C' are two cathodes and G is the grid arranged between the cathodes. The grid G is struck by two sets of electrons coming from two opposite directions as shown by the electrons e and e' . The electrons emitted by the cathode C pass through the grid G, enter into the space between the other cathode C' and the grid G, and are braked. In consequence thereof the space charge in the first mentioned grid cathode space is periodically varied and the electrons emitted by the cathode C' are controlled by the electrons emitted by the cathode C. Inversely the electrons emitted by the cathode C' enter through the grid G into the space between the grid and the cathode C. Here these electrons are braked. In this manner, the electrons emitted by the two cathodes control each other in counter phase relation.

The frequency of the oscillations induced by the electrons emitted from the cathode C sometimes differs from the frequency of the oscillations induced by the electrons emitted by the cathode C' due for instance to a non-symmetry of the grid with regard to both cathodes, as may be well understood. In order to equalize the frequencies a biasing voltage may be imparted to one of the cathodes.

Referring now to Fig. 3, C and C' are the cathodes, and G is the grid arranged between the cathodes. The electrodes are formed as plane electrodes, the cathodes consisting of heated

filaments F, the filaments being shielded in the outer direction by means of equipotential metal sheets H.

Referring to Fig. 4, the cathode C is here formed as a filament surrounded by the grid G, having the form of a cylindrical spiral. The other cathode C' is formed as a hollow metal cylinder the interior of which is covered with an electron emitting compound. The cathode C' is heated by means of the spirally wound heating filament J.

In Fig. 5 oscillating circuits are shown to be connected to the electrodes of the valve. In a three electrode valve well known in the art with braking-field connection the oscillations of the electrons may be influenced by means of an oscillating circuit connected to the grid and the plate of the valve, as is described for instance in more detail in a paper published by me in the transactions of the "Institute of Radio Engineers", vol. 17, page 229 et seq. I have discovered that in a valve according to my invention the mutual control of the electrons may be improved by means of oscillating circuits connected to the electrodes.

In Fig. 5, K is the oscillating circuit comprising two wires L and M connected to the grid G and the cathode C of the valve, respectively, and O is a condenser bridging said wires K' is an oscillating circuit comprising two wires L' and M' connected to the grid G and the other cathode C' of the valve, respectively, and O' is a condenser bridging the wires L' and M'. The cathodes C and C' are shown heated by separate heating batteries V and V' respectively. The cathode C' is given a bias with regard to the cathode C by means of a biasing battery B' and the grid electrode is given a highly positive bias with respect to both cathodes by means of battery B.

I wish it to be understood that I do not desire to be limited to the exact details of construction shown and described, for obvious modifications will occur to a person skilled in the art.

I claim:

1. A short-wave circuit comprising an electron tube having two cathodes, means for imparting a biasing voltage to one of said cathodes with respect to the other of said cathodes, a single grid intermediate said cathodes and means for applying to said grid a relatively high positive potential with respect to said cathodes.

2. A short wave length oscillation generating device comprising a three-electrode valve, two cathodes within said valve, a single grid between said cathodes in said valve, a source of high positive potential for biasing said grid electrode with respect to said cathodes, an oscillating circuit connected to said grid and to one of said cathodes and a second standing wave oscillating circuit connected to said grid and to said other cathode.

3. The method of producing ultra high frequency electrical oscillations which consists in producing two different streams of electrons directed toward each other, accelerating and decelerating each of said streams so as to mutually control the space charge to which the other stream is subjected and utilizing the resultant variations in the streams caused by the varying space charges as high frequency electrical oscillations.

4. The method of producing ultra high frequency oscillations by direct electron swinging movements within a vacuous space which consists in simultaneously emitting in opposite di-

reactions at least two sets of electrons accelerating said sets of electrons in a direction towards each other whereby one set of electrons controls the space charge of the other set of electrons.

5 5. The method of producing ultra high frequency electric oscillations by direct electronic swinging movements about a positively charged foraminous electrode which consists in emitting and accelerating electrons from at least two opposite directions towards said foraminous electrode.

15 6. The method of producing ultra high frequency electric oscillations by direct electronic swinging movements about a positively charged foraminous electrode which consists in emitting and accelerating at least two sets of electrons in opposite directions towards said foraminous electrode whereby one set of electrons controls the space charge of the other set of electrons.

20 7. In an ultra short wave system comprising an electron discharge device, at least two electron emitting electrodes for said device arranged opposite each other, a third foraminous electrode intermediate said first electrodes, a source of high positive potential applied to said foraminous electrode in respect to said emitting electrodes, and a parallel-wire standing wave tuning system connected to a pair of said electrodes.

30 8. In an ultra short wave system comprising an electron discharge device, at least two electron emitting electrodes for said device arranged opposite each other, a third foraminous electrode intermediate said emitting electrodes, a source of high positive potential applied to said third electrode in respect to said emitting electrodes, and two standing wave parallel-wire tuning systems connected each to said foraminous electrode and one of said emitting electrodes, respectively.

40 9. In an ultra short wave system comprising an electron discharge device, including at least two electron emitting electrodes arranged opposite each other, a third foraminous electrode intermediate said emitting electrodes, a source of high positive potential applied to said third electrode in respect to said emitting electrodes, means for providing biasing potential difference between said emitting electrodes, and a standing wave parallel-wire tuning system connected between two of said electrodes.

50 10. In an ultra short wave system comprising an electron discharge device, at least two electron emitting electrodes for said device arranged opposite each other, a third foraminous electrode intermediate said emitting electrodes, means for applying a high positive potential to said foraminous electrode in respect to said emitting electrodes, further means for providing a biasing potential difference between said emitting electrodes, and two standing wave parallel-wire tuning systems connected each to said foraminous electrode and one of said emitting electrodes, respectively.

65 11. In combination with an ultra high frequency system, a vacuum tube having means for producing a plurality of electron streams directed towards each other, an actuating and controlling electrode arranged in the region of interaction of said electron streams, and means for applying actuating and biasing potential to said electrode with respect to said means for producing electron

streams for producing ultra high frequency in-phase swinging movements of said electron streams by mutual control of their space charge effects.

12. In combination with an ultra high frequency system as described in claim 11 including circuit means directly connected to said actuating electrode to utilize electrical oscillatory energy set up by the electron swinging movements.

13. The combination with an ultra high frequency system as described in claim 11 in which the means for producing a plurality of electron streams comprises a pair of electron emitting cathodes and the actuating and controlling electrode is apertured and is arranged in the space between said cathodes.

14. The combination described in claim 11, characterized in this, that the means for producing a plurality of electron streams comprises a pair of cathodes, the actuating and controlling electrode comprising a foraminous electrode intermediate said cathodes and that equi-potential shielding electrodes for said cathodes are disposed at the sides of said cathodes opposite from said foraminous electrode.

15. The combination described in claim 11, characterized in this, that the means for producing electron streams are two cylindrical cathode electrodes arranged substantially coaxially with respect to each other and the actuating and controlling electrode is a cylindrical foraminous structure arranged in the space between and coaxial with said cathodes.

16. In combination with an ultra high frequency system, a discharge device comprising at least two sources of electrons so arranged that the electrons issuing from said sources interact in the space discharge path, an actuating foraminous electrode arranged in the zone of interaction of said electrons and a standing wave oscillatory system connected to both ends of said actuating electrode.

17. A high frequency oscillation source comprising an electron tube having two cathodes each lying in a plane a single plane grid between said cathodes, means for impressing high positive potential upon said grid with respect to each of said cathodes, and an individual Lecher oscillation circuit connected in a path between each cathode and said grid.

18. A high frequency oscillation source comprising an electron discharge device including a grid and two cathodes in concentric relationship, the grid being interposed between said cathodes, means for impressing high positive potential upon said grid with respect to each of said cathodes, and an individual Lecher circuit connected in a path between each cathode and said grid.

19. The method of generating electrical oscillations of high frequency comprising the steps of emitting electron streams in two relatively opposite directions, causing the electrons in each of said streams to follow an oscillatory path, the movements of the electrons in said streams having at least a portion in common, and causing said oscillating electrons to generate oscillatory electrical energy having the characteristic frequency of the electron oscillations.

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