Sept. 2, 1924. 1,507,016

L. DE FOREST

RADIOSIGNALING SYSTEM

Filed Sept. 23, 1915 2 Sheets-Sheet 1

Fig. 1

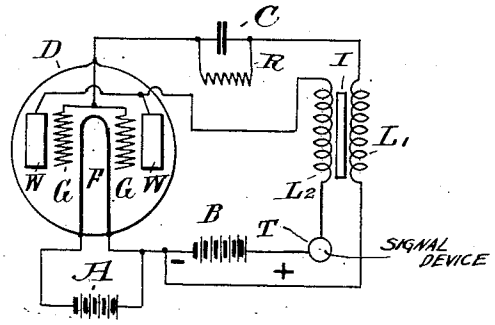
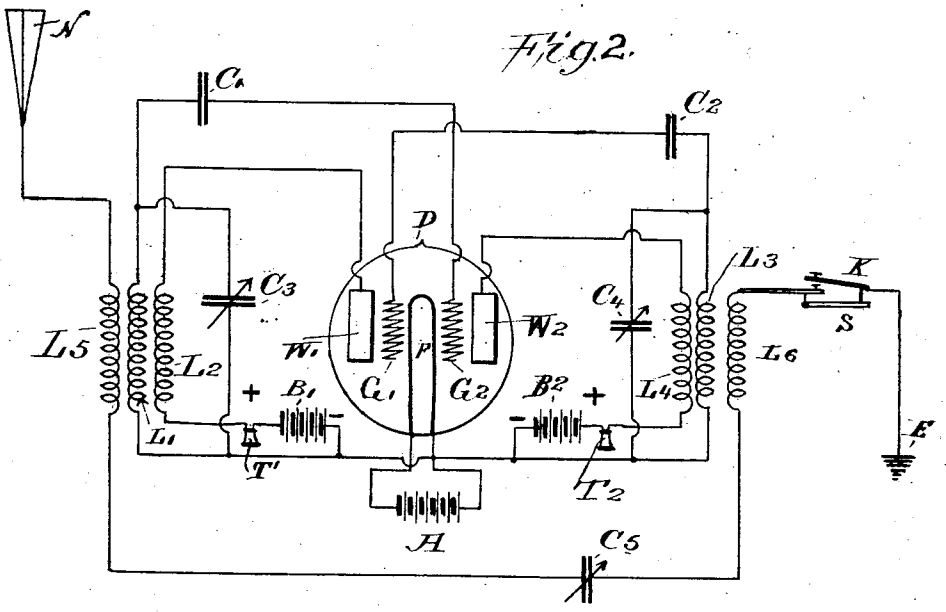


Fig. 2.



Inventor
Lee de Forest
By his Attorney
Samuel E. Darby

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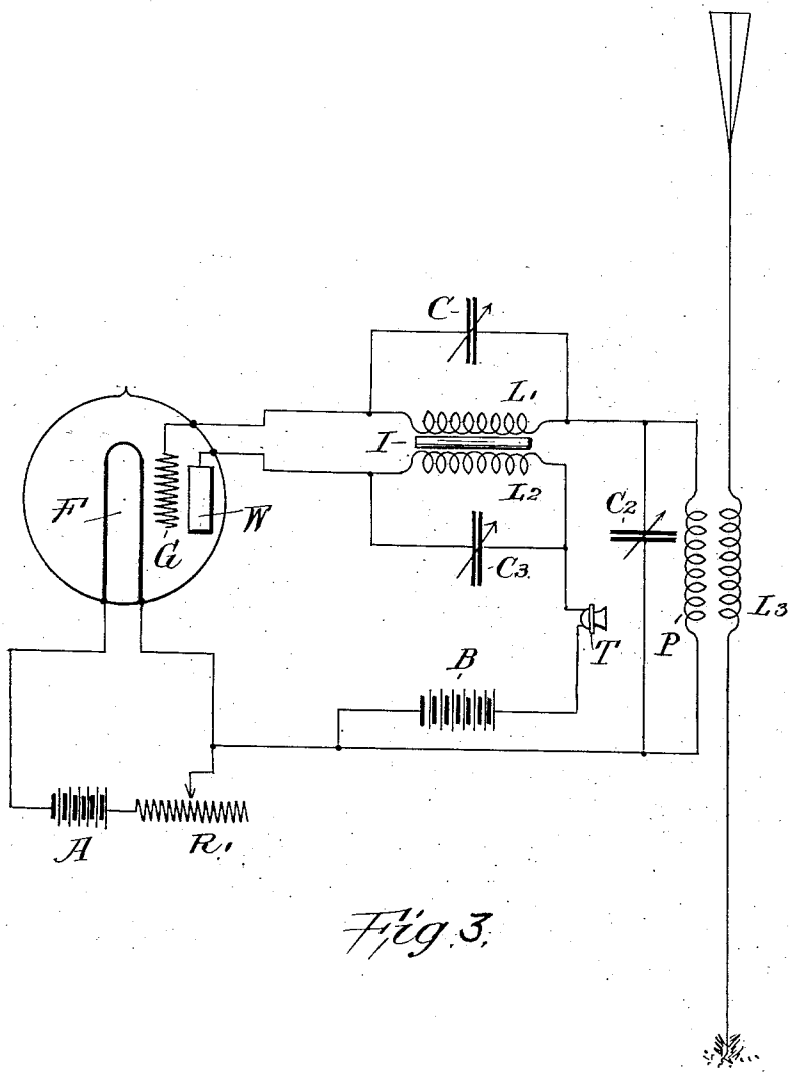

Fig. 3.

Inventor
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By his Attorney
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Patented Sept. 2, 1924. 1,507,016

UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW YORK, N. Y., ASSIGNOR TO DE FOREST RADIO TELEPHONE AND TELEGRAPH COMPANY, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE.

RADIOSIGNALING SYSTEM.

Application filed September 23, 1915. Serial No. 52,176.

To all whom it may concern:

Be it known that I, LEE DE FOREST, a citizen of the United States, residing in the city of New York, county of Bronx and State of New York, have made a certain new and useful Invention in Radiosignaling Systems, of which the following is a specification.

This invention relates to radio signaling systems.

The object of the invention is to provide a radio signaling system which is simple and efficient in operation.

Further objects of the invention will appear more fully hereinafter.

The invention consists substantially in the construction, combination, location and relative circuit arrangements all as will be more fully hereinafter set forth, as shown in the accompanying drawing and finally pointed out in the appended claims.

Referring to the drawing, Figs. 1, 2, 3, all show various circuit arrangements embodying my invention.

In accordance with my present invention, I propose to employ an evacuated vessel with hot and cold electrodes therein, known as the audion, together with suitable circuit connections to cause the audion to operate as a generator of undamped oscillations, and to so arrange the circuit connections to cause the audion to operate as a generator of undamped oscillations, and to so arrange the circuit connections referred to so as to allow such a generator to also be employed as a detector. The underlying principle of my present invention as will be more fully described, is the association, preferably by inductive coupling means, of the circuits of the cold electrodes of the audion.

In Fig. 1 I have shown a simple circuit arrangement for accomplishing the objects of my invention wherein D is the exhausted vessel, F the hot or filament electrode, and A is the battery for heating the same in the usual and well known manner and controlled by the resistance R_1 as shown in Fig. 4, if desired. G designates the grid or "input" electrodes and W the wing or "output" electrodes. Preferably, and as shown, though I do not desire to be limited in this respect, the wing and grid electrodes are arranged in pairs, both grids and both wings being connected in parallel. The input electrodes G are connected to one side of the filament F by a circuit including therein one coil of a transformer L_1. The output electrodes W are likewise connected to the filament F by a circuit including the coil L_2 of the transformer, and the usual source of voltage such as battery B or other direct current source with its positive terminal connected to the cold electrodes W through the telephone or signal indicating device T, as shown.

In series with the grid or input electrodes G and in the circuit thereof I propose to place a stopping condenser C, and to shunt around this condenser a high and preferably non-inductive resistance R, of from 25,000 to 100,000 ohms.

The transformer whose coils are L_1 L_2 may be a "telephone transformer" as shown, with the coils having several thousands turns each surrounding an iron core I, in which case the system will oscillate at "audio" or low frequencies, or the windings may contain only a few hundreds of turns each, of several milli-henries inductance, and the coils more or less spatially separated or "loosely coupled" in which case the system will oscillate at high or "radio" frequencies.

In the first case, that is, when the system is oscillating in "audio" frequencies the system becomes a "siren" and will generate powerful telephonic currents having a clear musical note heard in the telephone receiver T. The pitch of this note can be varied by altering the inductance of either of the coils L_1 L_2 in any well known manner, or by altering their coupling as by withdrawing from the transformer the iron core I, or by varying the distributed capacity of the winding or the spatial relation of the windings, or the capacity of the condenser C, the value of the resistance R, or the potential of the battery B, or the brightness of the filament F in any manner well known in the art.

When such an oscillating system as shown in Fig. 1, is employed for generating radio frequencies, the capacity of the ordinary telephone wires leading to the telephone receiver or signaling device T is usually sufficient to form a by-path around the high-impedance and high resistance of this device. The impedance of source B to the

radio frequency oscillations, I have found to be insufficient to materially dampen the same. My invention as defined in the claims is not to be limited in this respect however, for other expedients will readily suggest themselves to those skilled in the art.

If the system described is to be employed as a generator of high frequency oscillations for transmission purposes the signal device T may be a transmitter if desired. An alternative arrangement is shown in Fig. 2 wherein a key indicated at K is inserted in the antenna-earth system. As it is obvious that my invention applies to either transmitting or receiving systems, I wish it to be understood that by the term "signal device," as used throughout the specification, I mean broadly either a transmitter or a receiver of signals.

When an audion with its cold electrodes associated or inter-linked as shown, is used as a receiving system its ordinary sensitiveness as a detector is many times increased by virtue of the "kick-back" or progressively amplifying effect of the received signal impulses.

In Fig. 2 I have illustrated a "compound audion" containing two insulated grid members G_1 and G_2, and two insulated wing members W_1 and W_2, each of the four electrodes being connected to the filament F by a circuit containing inductances L_3, L_1, L_2, and L_4, respectively. The coils L_1, L_2, may be inductively associated as shown, and likewise inductances L_3, L_4, may be inductively associated, so as to allow reaction of the one upon the other in each pair.

As shown, I prefer to associate the grid nearest one wing with the current of the wing lying furthest away, usually on the opposite side of the filament, as thereby I find that the reaction of the circuits upon each other is the most violent. Each wing W_1 W_2, has, preferably, its own source of electro-motive force as indicated at B_1, B_2, respectively, although I am not to be limited in this respect as it is obvious that a common source may be employed. In the circuit of the sources B_1 and B_2, I employ telephone receivers T_1, T_2, preferably, one receiver for each ear of the operator. I employ the usual stopping condensers C_1 and C_2 in the circuits of the grids G_2 and G_1, respectively, and the variable capacities C_3 and C_4, shunted around the coils L_1, L_3, to render the grid circuits oscillatory. The coils L_1, L_2, and L_3, L_4 of the two oscillating circuits are associated inductively or otherwise to the same antenna-earth system comprising the usual elements N, L_5, C_5, L_6, and E, as shown, whether the arrangement be used for receiving or transmitting signals.

When using the arrangement shown in Fig. 2, as a generator of alternating currents the sources of the wing currents, B_1 and B_2, respectively, should be of high voltage, as for example, direct current generators of from 600 to 1200 volts.

In the antenna-earth system, I show a transmitting key K connected directly therein. I also employ a hand operated switch S shunted around the same to cut the key K out when the system is used as a receiving system. The periodicities of the oscillating circuits L_1, C_3 and L_3, C_4, should be made the same, or nearly the same by properly adjusting their respective capacities or inductances. If the natural rates of oscillation of these two circuits are not quite the same, beats or interferences are set up in the antenna, resulting in a harmonic variation of amplitudes of the radiated wave train which may be of practical value when signaling to receiving stations where the receiver can give audible responses only to interrupted or intermittent trains of waves.

It will be noted that in accordance with my invention, the connection of the terminals of the wing and grid coils is important. I have found that the oscillations set up are much more intense when one end of one of these coils is connected to the grid or plate as the case may be, than when the opposite end of that coil is thus connected. In other words, by reversing coil L_2 relative to coil L_1, the oscillations set up may be found to be much more intense than before such reversal of connections. The principle here involved is that the phase of the two pulsating currents in the coils L_1 and L_2, shall be so displaced relative to each other that a positive charge or surge upon the wing electrodes shall be next followed by a negative charge or surge upon the grid, the effect of this being that thereby an increase of current through the coil L_2 to the wing results in a succeeding increase in the resistance of the gas path between the wing and the filament electrodes, and conversely, a diminution in the current from the wing to the filament electrodes results in a succeeding decrease in the resistance of the path. It is by these means that one circuit is enabled to react upon the other so that successively increasing pulsations are set up in the two associated circuits until the losses by resistance, leakage and load, are equal to the increment of energy supplied from the battery or source B B_1, B_2 whereupon a stable condition of oscillation or pulsation is attained.

In Fig. 3 I have shown a modified arrangement wherein the wing and grid circuits are inductively associated as in Fig. 1, through coils L_1 and L_2 around which are shunted capacities C and C_3, respectively. In this arrangement I prefer to associate the grid circuit with the antenna earth circuit through inductance L_3 of the antenna

system. In this instance I shunt a capacity C_2 around the inductance P as shown. The core I is also used in coupling between the oscillating circuits of the cold electrodes, and the reaction effect is secured between these circuits as hereinbefore described.

It will be understood that many other circuit arrangements will readily occur to those skilled in the art without departing from the broad scope of my invention as defined in the claims. Therefore, having set forth the objects and nature of my invention, and having shown and described various embodiments thereof, what I claim as new and useful and of my own invention and desire to secure by Letters Patent, is,—

1. In a radio signaling system, an evacuated vessel including hot and cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, separate circuits connecting each of the cold electrodes to the hot electrode, said circuits being inductively associated.

2. In a radio signaling system, an evacuated vessel containing hot and cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, separate oscillating circuits connecting each of said cold electrodes to said hot electrode, said circuits being inductively associated.

3. In a radio signaling system, an evacuated vessel including hot and cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, separate circuits connecting each of the cold electrodes to the hot electrode, said circuits being inductively associated, and an antenna system associated with said circuits.

4. In a radio signaling system, an audion including hot and cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, separate circuits connecting each of said cold electrodes to said hot electrode, and means to set up successively increasing pulsations in said circuits, and an antenna system inductively associated with said circuits.

5. In a radio signaling system, an audion including hot and cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, separate oscillating circuits connecting each of the cold electrodes to said hot electrode, said circuits being inductively coupled and an antenna system inductively associated with said coupling.

6. In a radio signaling system, an evacuated vessel containing hot and cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, separate circuits connecting each of said cold electrodes with said hot electrode, said circuits being inductively associated, a source of electromotive force and a signaling device being included in one of said circuits.

7. In a radio signaling system, an evacuated vessel containing hot and cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, circuits connecting each of said cold electrodes with said hot electrode, said circuits being inductively coupled, a source of electromotive force and a signaling device being included in one of said circuits and an antenna system inductively associated with said coupling.

8. In a radio signaling system, an evacuated vessel containing hot and cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, circuits connecting each of said cold electrodes with said hot electrode, said circuits being associated, a source of electromotive force and a signal indicating device being included in one only of said circuits and an antenna system associated with said circuits, and means for operating said radio signaling system as a transmitting station.

9. In a radio signaling system, an evacuated vessel containing hot and cold electrodes therein, circuits connecting each of said cold electrodes with said hot electrode, said circuits being inductively associated, a source of electromotive force and a signal indicating device being included in one of said circuits and an antenna system associated with said circuits, and means for operating said signaling system as a receiving station.

10. In a radio signaling system, an audion including hot and cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, separate circuits connecting each of said cold electrodes to said hot electrode, said circuits being inductively associated with each other.

11. In a radio signaling system, an evacuated vessel containing a hot electrode and a plurality of grid electrodes and a plurality of wing electrodes, circuits connecting each of said grid electrodes and said wing electrodes with said hot electrode, the circuits of the grid electrodes being inductively associated with the circuits of the wing electrodes.

12. In a radio signaling system, an evacuated vessel containing a hot electrode and a plurality of grid electrodes and a plurality of wing electrodes, circuits connecting each of said grid electrodes and said wing electrodes with said hot electrode, the circuits of the grid electrodes being associated with the circuits of the wing electrodes respec-

tively, and a signal indicating device included in each of the circuits of said wing electrodes.

13. In a radio signaling system, an evacuated vessel containing a plurality of wing electrodes and a plurality of grid electrodes, a filament electrode interposed between said grid electrodes and between said wing electrodes, circuits connecting each of said wing and grid electrodes with said filament electrode, the circuits of said grid electrodes being inductively associated with the circuits of said wing electrodes respectively.

14. In a radio signaling system, an evacuated vessel, containing a plurality of wing electrodes and a plurality of grid electrodes, a filament electrode interposed between said grid electrodes and between said wing electrodes, circuits connecting each of said wing and grid electrodes with said filament electrode, the circuit of each of said grid electrodes being inductively associated with the circuit of said wing electrode on the opposite side of said filament electrode.

15. In a radio signaling system, an evacuated vessel containing a plurality of wing electrodes, and a plurality of grid electrodes, a filament electrode interposed between said grid electrodes and between said wing electrodes, circuits connecting each of said wing and grid electrodes with said filament electrode, the circuits of said grid electrodes being inductively coupled with the circuits of said wing electrodes respectively.

16. In a radio signaling system, an evacuated vessel containing a plurality of wing electrodes and a plurality of grid electrodes, a filament electrode interposed between said grid electrodes and between said wing electrodes, circuits connecting each of said wing and grid electrodes with said filament electrode, the circuits of said grid electrodes being inductively coupled with the circuits of said wing electrodes respectively, and an antenna system inductively associated with said coupling.

17. In a radio signaling system, an evacuated vessel containing a plurality of wing electrodes, and a plurality of grid electrodes, a filament electrode interposed between said grid electrodes and between said wing electrodes, circuits connecting each of said wing and grid electrodes with said filament electrode, the circuits of said grid electrodes being inductively coupled with the circuits of said wing electrodes respectively, the circuit of each of said grid electrodes being inductively coupled with the circuit of said wing electrode on the opposite side of said filament.

18. In a radio signaling system, an evacuated vessel containing a plurality of wing electrodes, and a plurality of grid electrodes, a filament electrode interposed between said grid electrodes and between said wing electrodes, circuits connecting each of said wing and grid electrodes with said filament electrode, the circuits of said grid electrodes being inductively coupled with the circuits of said wing electrodes respectively, the circuit of each of said grid electrodes being inductively coupled with the circuit of said wing electrode on the opposite side of said filament, and an antenna system inductively associated with each said coupling.

19. In a system for generating oscillations, a work circuit, and means for generating and transmitting the generated oscillations comprising an oscillatory circuit having two electrodes in an exhausted receptacle, and a second circuit inductively coupled thereto having a conducting body interposed between said electrodes.

20. In a system for generating oscillations, a work circuit, and means for generating and transmitting the generated oscillations comprising an oscillatory circuit having two electrodes, a second circuit inductively coupled thereto and having a conducting body interposed between said electrodes.

21. In a system for generating oscillations, a work circuit, and means for generating and transmitting the generated oscillations comprising an oscillatory circuit having two electrodes, a second circuit inductively coupled thereto and having a conducting body interposed between said electrodes and means for varying the frequency of the produced oscillations.

22. In a system for generating oscillations, a work circuit, and means for generating and transmitting the generated oscillations comprising an oscillatory circuit having two electrodes means for producing a flow of current between said electrodes and a second circuit inductively coupled with the first circuit and having a conducting body interposed between said electrodes.

23. In a system for generating oscillations, a work circuit, and means for generating and transmitting the generated oscillations comprising an oscillatory circuit having two electrodes means for producing a flow of current between said electrodes and a second oscillatory circuit inductively coupled with the first oscillatory circuit and having a conducting body interposed between said electrodes.

24. The method of generating alternating currents which consists in causing current to flow in one of two inductively coupled circuits, and varying the flow of current in the first circuit by impressing the potential induced in the second circuit upon a conducting body interposed between two electrodes in the first circuit.

25. Means for producing sustained electrical oscillations comprising an oscillatory circuit having two electrodes in an exhaust-

ed receptacle and a second circuit coupled thereto having a conducting body interposed between said electrodes.

26. Means for producing sustained electrical oscillations comprising an oscillatory circuit having two electrodes, a second circuit coupled thereto having a conducting body interposed between said electrodes, and means for varying the frequency of the produced oscillations.

27. Means for producing sustained electrical oscillations comprising an oscillatory circuit having two electrodes, means for producing a flow of current between said electrodes, and a second circuit coupled with the first having a conducting body interposed between said electrodes.

28. The method of producing electrical alternating currents which consists in causing current to flow in one of two coupled circuits and varying the flow of current in the first circuit by impressing the potential induced in the second circuit upon a conducting body interposed between two electrodes in the first circuit.

29. In a system for generating electrical oscillations, a work circuit, and means for generating and transmitting the generated oscillations to said work circuit comprising an evacuated vessel having a hot electrode, a cold plate electrode and a cold grid electrode, said cold electrodes being electrically associated with each other, and a source of current for the hot electrode.

30. The method of producing high frequency alternating currents, which consists in causing current to flow in one of two associated circuits and varying the flow of current in the first circuit by impressing a charge induced in the second circuit upon an element in the space between the electrodes respectively included in said second circuit.

31. Means for generating high frequency oscillations, including an evacuated vessel having separated wing, grid and filament electrodes therein, circuits for said electrodes, and a source of current supply having its terminals respectively connected to two of said electrodes and operating to generate oscillations in one of said electrode circuits.

32. The combination with a work circuit and means for generating and transmitting the generated alternating currents to said work circuit, comprising an evacuated vessel having a hot and a plurality of cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, means to supply current to said electrodes, and circuit connections between said electrodes.

33. The combination with a work circuit and means for generating and transmitting the generated alternating current to said work circuit, comprising an evacuated vessel having a hot and a plurality of cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, a circuit connection between the cold electrodes, and means for impressing an electromotive force in the space between the cold and hot electrodes, and means to supply current to the hot electrode.

34. The combination with a work circuit and means for generating and transmitting the generated alternating currents to said work circuit, comprising an evacuated vessel having a hot and a plurality of cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, a circuit connection between the cold electrodes, a circuit connection between one of the cold electrodes and one side of the hot electrode, a source of current included in said last-mentioned circuit connection, and means for supplying current to the hot electrode.

35. A work circuit and means for generating and transmitting the generated oscillations to said work circuit, comprising an audion and its associated circuits.

36. The combination with a work circuit and means for generating and transmitting the generated oscillations to said work circuit, comprising an evacuated vessel having filament, grid and plate electrodes therein, means to supply current to said electrodes, and circuit connections between said electrodes.

37. In a system for generating electrical oscillations, an evacuated vessel having a hot electrode, a cold plate electrode and a controlling electrode, circuits connected to said cold plate electrode and said controlling electrode, respectively, and coupled with each other, and a source of current for the hot electrode.

38. The combination with a translating device, of means for generating and transmitting to said device the generated oscillations, comprising an evacuated vessel having filament, grid and plate electrodes, means to supply current to said electrodes, and circuit connections between said electrodes.

39. Means for producing sustained electrical oscillations, comprising an oscillatory circuit having two electrodes, one of said electrodes comprising an incandescent filament, a second circuit coupled to said oscillatory circuit and having a controlling grid electrode for regulating the discharge between said two electrodes.

40. Means for producing electrical oscillations comprising an oscillatory circuit having two electrodes, one of said electrodes comprising an incandescent filament, a second circuit coupled thereto having a con-

trolling grid electrode associated with said electrodes, and means for varying the frequency of the produced oscillations.

41. The method of producing electrical oscillations with an incandescent filament thermionic discharge device having two coupled circuits each connected to the incandescent filament thereof, which consists in causing current to flow in one of the said two coupled circuits and varying the flow of current in said first circuit by impressing the potential induced in the second circuit upon a controlling grid electrode regulating the current flow in the first circuit.

In testimony whereof I have hereunto set my hand in the presence of a subscribing witness, on this 18th day of September, A. D., 1915.

LEE DE FOREST.

Witness:
S. E. DARBY.