A. W. HULL.

ELECTRON DISCHARGE DEVICE.

APPLICATION FILED NOV. 13, 1916.

1,387,985. Patented Aug. 16, 1921.

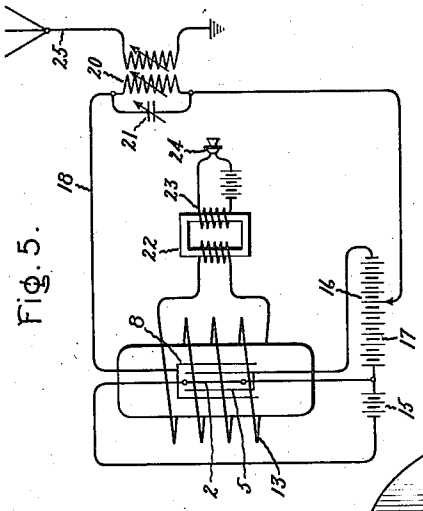


Fig. 5.

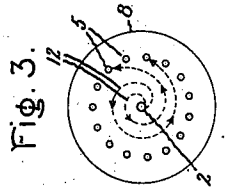


Fig. 3.

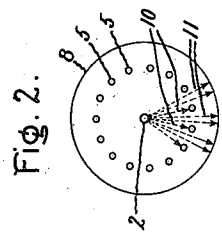


Fig. 2.

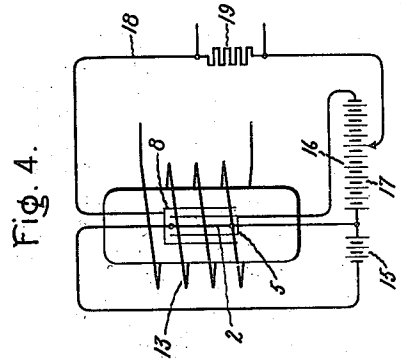


Fig. 4.

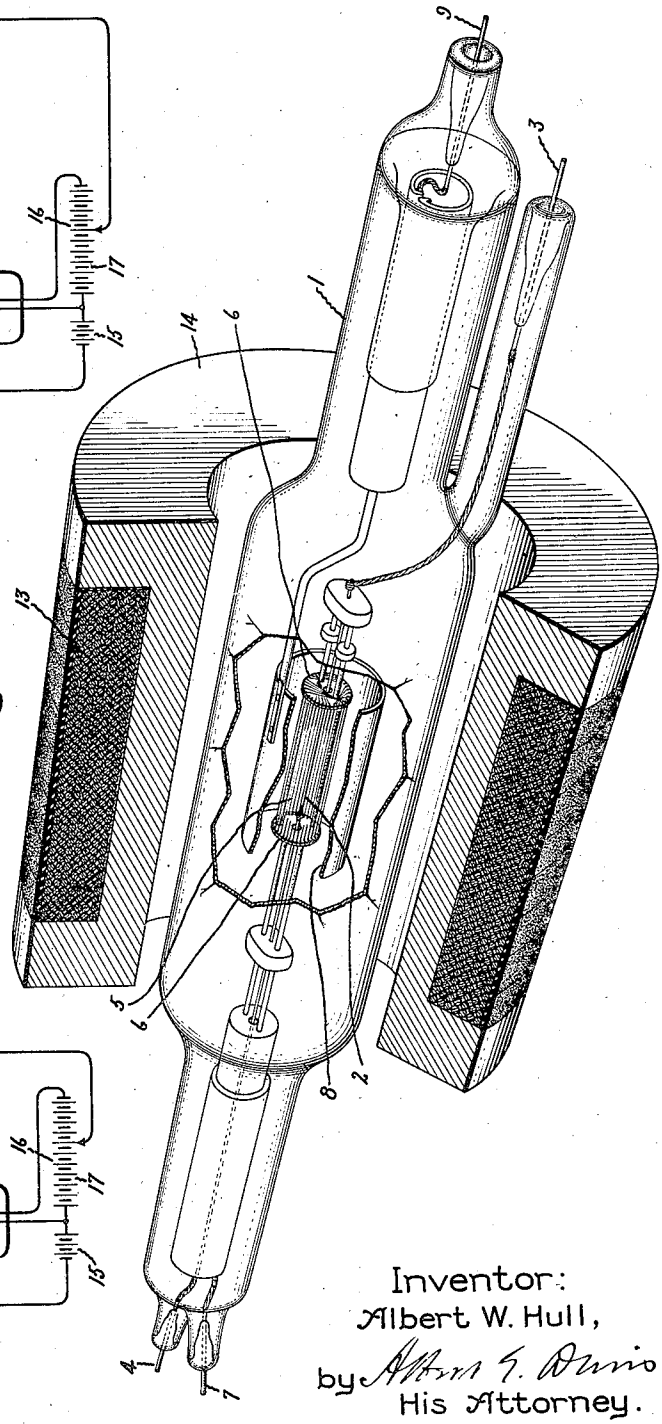


Fig. 1.

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by Albert G. Davis
His Attorney.

UNITED STATES PATENT OFFICE.

ALBERT W. HULL, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ELECTRON-DISCHARGE DEVICE.

1,387,985. Specification of Letters Patent. Patented Aug. 16, 1921.

Application filed November 13, 1916. Serial No. 130,990.

To all whom it may concern:

Be it known that I, ALBERT W. HULL, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Electron-Discharge Devices, of which the following is a specification.

My present invention relates to the construction and operation of electron discharge devices and particularly devices which are suitable for use as relays for amplifying variable currents or for controlling the amplitude of the current flow in an electric circuit in accordance with variations in the amplitude of the current flowing in a controlling circuit.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its construction and mode of operation together with the objects and advantages thereof will best be understood by reference to the following description taken in connection with the accompanying drawing in which Figure 1 shows an elevation of a device embodying my invention; Figs. 2 and 3 are diagrammatic representations of the movement of the electrons in such a device under different conditions of operation and Figs. 4 and 5 show circuit connections in which my device may be utilized to advantage.

The device shown in Fig. 1 consists of a highly evacuated envelop 1 provided with a linear filamentary cathode 2 connected to leading-in conductors 3 and 4 for supplying current for heating it to incandescence. This cathode is preferably surrounded with a grid-like structure which is coaxial therewith and in the present illustration consists of fine wires 5 wound back and forth between the circular supports 6. This structure serves as anode for the device and is connected to a leading-in conductor 7. Surrounding the cathode and anode and coaxial therewith is a third electrode consisting of a metal cylinder 8 connected to the leading-in wire 9. It will be observed that in the form of my invention illustrated the electrodes are arranged in circular symmetry to one another, that is, they are so arranged that the active surfaces of the electrodes are substantially surfaces of revolution about a common axis which, as in the construction illustrated, is preferably the major axis of the envelop. The envelop 1 should preferably be exhausted to such a degree of vacuum that when potentials of the magnitude desired for operation are supplied to the electrodes there will be no visible manifestation of ionization such as blue glow.

If the cathode is heated to incandescence and a potential is impressed on the anode whereby it is made positive with respect to the cathode, there will be a flow of electrons from cathode to anode. If the third electrode is at the same potential as the cathode these electrons will all flow to the anode, their paths being indicated diagrammatically by the dotted lines 10 in Fig. 2. If, however, the third electrode is made slightly positive with respect to the cathode a portion of the electrons will pass between the wires 5 of the anode and strike the third electrode, the paths of such electrons being indicated by dotted lines 11 in Fig. 2. The velocity with which these electrons will strike the third electrode will depend upon the potential difference between it and the cathode. If this potential is increased the velocity will increase until the electrons striking the third electrode are able by their impact to liberate secondary electrons. These secondary electrons leaving the third electrode will be attracted to the more positive anode. As the potential of the third electrode is increased a point will finally be reached at which the rate of increase in the emission of secondary electrons exceeds the rate of increase in primary electrons received and the current in the external circuit between cathode and third electrode will begin to decrease. As the potential is further increased a point may be reached at which the number of secondary electrons leaving the third electrode is just equal to the number of primary electrons which strike it, that is, each electron that strikes liberates on an average one secondary electron. No current will then flow in the external circuit between the cathode and third electrode. If the potential of the third electrode is further increased the number of secondary electrons given off becomes greater than the number of primary electrons received, and as a result the third electrode loses electrons, the current in the circuit between cathode and third electrode re-

versing in direction. In brief, as the potential in the circuit between cathode and third electrode increases the current increases for a time and then decreases; that is, there is a certain range over which the circuit has a negative resistance characteristic. For a more complete description of the characteristics of such a device reference may be had to my co-pending application, Serial No. 47,938, filed August 30, 1915. In that application I have shown that such a device may be employed for various useful purposes by controlling the current between cathode and third electrode by varying the potential applied to the third electrode. One of the objects of my present invention is to provide a modified form of control for the current through such a device. It will be noted that in the diagrammatic representation of Fig. 2 the electrons tend to move in radial lines from the cathode. If, however, the electrons are subjected to the action of a magnetic field in a direction parallel to the cathode, or at right angles to the electrostatic field between the electrodes and to the paths of the electrons instead of moving in radial lines they will tend to move in spiral lines tangentially to the anode as indicated by the dotted lines 12, in Fig. 3. As the strength of the magnetic field is increased these lines contract toward the cathode and if the field is made strong enough it will be apparent that all of the electrons will be intercepted by the wires 5 and none of them will reach the third electrode 8. If, however, the magnetic field acting upon the electrons is varied between zero and the value at which none of the electrons will reach the third electrode, a variable number of electrons will be able to pass between the grid wires 5 and reach the third electrode 8. The magnetic field for controlling the flow of electrons in this way may be furnished by a winding 13 upon a spool 14 surrounding the tube.

In the arrangement shown in Fig. 4 I have shown diagrammatically an organization whereby the device described may be utilized for amplifying variable currents. As here indicated the cathode 2 is supplied with current by the battery 15 and the battery 16 supplies a definite positive potential to the anode 5. A smaller positive potential is applied to the third electrode 8 by the portion 17 of battery 16. The variable currents which are to be amplified are caused to flow through the winding 13. With the connection shown the current flowing in the conductor 18 connecting the cathode and third electrode will vary in accordance with the variations in the current flowing in the controlling winding 13. This variable current in conductor 18 may be utilized for the operation of any desired indicating apparatus or a resistance 19 may be inserted in the circuit and the variations in potential across this resistance may be employed for the operation of the desired apparatus.

In another copending application, Serial No. 60,402, filed November 8, 1915, I have explained how a device having the negative resistance characteristic described may be utilized for producing high frequency oscillations by including an inductance shunted by capacity in the circuit between cathode and third electrode. If the present device is organized in such a way as to produce oscillations the amplitude of the oscillations produced can conveniently be controlled by varying the amplitude of the current flowing in the controlling winding. Such an arrangement is indicated in Fig. 5 in which a variable inductance 20 shunted by a variable capacity 21 is included in the circuit between cathode and third electrode. The current in winding 13 for controlling the amplitude of the oscillations produced may be derived from the secondary of the transformer 22 through the primary 23 of which current is caused to flow from the local circuit of a telephone transmitter 24. By coupling inductance 20 with the antenna 25 continuous oscillations will be impressed upon the antenna which vary in amplitude in accordance with the variations in the current through the telephone transmitter 24.

While I have shown and described a single form of my device, my invention is not limited to the particular form illustrated as it will be apparent that many modifications in the shape and arrangement of the various parts may be made without departing from the scope of the appended claims. It will also be apparent that it may be utilized for other purposes than those shown and described.

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

1. The method of operating an electron discharge device comprising an electron emitting cathode, an anode and a third electrode which consists in causing a stream of electrons to flow from the cathode to the third electrode and thereby producing an emission of secondary electrons from the third electrode sufficient to give the device a negative resistance characteristic, and subjecting the stream of electrons to the action of a variable magnetic field thereby varying the number of primary electrons which can reach the third electrode.

2. The method of operating an electron discharge device comprising an electron emitting cathode, an anode and a third electrode which consists in applying a constant positive potential to the anode, applying a positive potential to the third electrode of such a value as to produce an emission of secondary electrons therefrom sufficient to

give the device a negative resistance characteristic, and subjecting the electrons to the action of a magnetic field and thereby varying the number of electrons flowing between cathode and third electrode.

3. The method of operating an electron discharge device comprising an electron emitting cathode, an anode and a third electrode, which consists in applying a constant positive potential to the anode, applying a smaller positive potential to the third electrode to produce an emission of secondary electrons therefrom and subjecting the electrons to the action of a variable magnetic field.

4. The method of operating an electron discharge device comprising an electron emitting cathode, an anode and a third electrode, which consists in applying a constant positive potential to the anode, applying a positive potential to the third electrode of such a value as to give the device a negative resistance characteristic, and varying the current flow between cathode and third electrode by means of a variable magnetic field.

5. The method of operating an electron discharge device comprising an electron emitting cathode, an anode and a third electrode, which consists in applying a constant positive potential to the anode, applying a positive potential to the third electrode of such a value as to give the device a negative resistance characteristic, and producing a magnetic field in a direction parallel to said cathode.

6. The method of operating an electron discharge device comprising an electron emitting cathode, a grid anode and a third electrode, which consists in producing an emission of electrons from said cathode to said anode and third electrode, subjecting said electrons to the action of a magnetic field in such a way that they will move in spiral lines around said cathode and tangentially to said anode and thereby causing a greater number of electrons to be intercepted by the anode than when the magnetic field is absent.

7. The method of amplifying a variable current which consists in producing an emission of electrons from a cathode to a grid anode and third electrode surrounding said cathode, producing a magnetic field by means of the current to be amplified and subjecting the electrons to the action of said magnetic field in such a way that they will tend to move in variable spiral lines and a variable number will be intercepted by the grid anode.

8. The method of amplifying a variable current which consists in producing an emission of electrons from a cathode to a grid anode and third electrode surrounding said cathode, producing a magnetic field in a direction parallel to said cathode by means of the current to be amplified, and thereby causing the electrons to move in variable spiral lines whereby a variable number will be intercepted by the grid anode.

9. The method of amplifying a variable current which consists in producing an emission of electrons from a cathode to a grid anode and a third electrode surrounding said cathode and subjecting the electrons to the action of a magnetic field produced by the current to be amplified in a direction parallel to said cathode.

10. In combination, an electron discharge device comprising an evacuated envelop containing a cathode, an anode surrounding said cathode and a third electrode surrounding said anode, means for impressing a definite positive potential upon the anode, means for impressing a smaller positive potential upon the third electrode, and means for producing a magnetic field in a direction parallel to said cathode.

11. In combination, an electron discharge device comprising a plurality of electrodes inclosed in a highly evacuated receptacle and having sources of potential applied to said electrodes in such a way that the device has a working range over which the current flow therethrough increases and decreases inversely as the potential applied thereto, and means for producing a magnetic field for controlling the flow of current between said electrodes.

12. In combination, an electron discharge device comprising an electron emitting cathode and electrodes coöperating therewith, sources of potential applied to said electrodes in such a way that the device has a working range over which the current flow therethrough varies inversely as the potential applied thereto, and means for producing a magnetic field for controlling the flow of current through said device.

13. In combination, an electron discharge device comprising an electron emitting cathode, an anode, and a third electrode inclosed in a highly evacuated receptacle, sources of potential applied to said electrodes in such a way that the device has a working range over which the current flow from the cathode to the third electrode varies inversely as the potential applied thereto, and means for producing a magnetic field for controlling the current flow from the cathode to the third electrode.

14. In combination an electron discharge device comprising an electron emitting cathode, an anode surrounding said cathode, and a third electrode surrounding said anode sources of potential applied to said electrodes in such a way that the device has a working range over which the current flow from the cathode to the third electrode varies inversely as the potential applied thereto, and means for producing a magnetic field

for controlling the flow of current from cathode to third electrode.

15. In combination, an electron discharge device comprising an electron emitting cathode, an anode and a third electrode inclosed in a highly evacuated envelop, means for producing a flow of primary electrons from said cathode to said third electrode and a flow of secondary electrons from said third electrode to said cathode, and means for producing a magnetic field for varying the number of primary electrons reaching said third electrode.

16. Means for amplifying a variable current comprising a negative resistance device having an electron emitting cathode and cooperating electrodes inclosed in an evacuated receptacle, and being operable as a negative resistance by electron currents independently of any appreciable gas ionization, and means for producing by the current to be amplified a magnetic field for controlling the current through said negative resistance.

17. Means for amplifying a variable current comprising a negative resistance device, a magnetizing coil surrounding said device, and means for supplying the current to be amplified to said magnetizing coil, said negative resistance device comprising an electron emitting cathode, and coöperating electrodes in an evacuated receptacle, and being operable as a negative resistance by electron current independently of any appreciable gas ionization.

18. Means for amplifying a variable current comprising a negative resistance device having an electron emitting cathode and cooperating electrodes in an evacuated receptacle and operable as a negative resistance by electron current independently of any appreciable gas ionization and having a working range over which the current flow therethrough increases and decreases inversely as the potential applied thereto, a magnetizing coil surrounding said receptacle for producing a magnetic field therein, and means for energizing said magnetic coil by the current to be amplified.

19. Means for amplifying a variable current comprising a negative resistance device having a electron emitting cathode, an anode and a third electrode inclosed in a highly evacuated envelop and having a working range over which the current flow from the cathode to the third electrode varies inversely as to the potential applied thereto, and means for subjecting the electrons flowing from said cathode to the action of a magnetic field produced by the current which is to be amplified.

20. Means for amplifying a variable current comprising a negative resistance device having an electron emitting cathode, an anode and a third electrode inclosed in a highly evacuated envelop and having a working range over which the current flow from the cathode to the third electrode varies inversely as the potential applied thereto, a magnetizing coil surrounding said device and means for exciting the coil by the current to be amplified.

21. Means for amplifying a variable current comprising a negative resistance device having an electron emitting cathode, an anode and a third electrode near the anode and so positioned with respect to the cathode and anode that it will receive electrons from the cathode when it is more positive than the cathode, and that secondary electrons given off from the third electrode can readily reach the anode, and means for producing by the current to be amplified a magnetic field in a direction parallel to said cathode.

22. Means for amplifying a variable current comprising an electron discharge device having an electron emitting cathode, an anode and a third electrode, means for producing a flow of primary electrons to said third electrode and thereby producing an emission of secondary electrons from said third electrode, and means for producing by the current to be amplified a magnetic field for varying the number of primary electrons which can reach the third electrode.

23. The method of amplifying a variable current which consists in producing an emission of electrons from a heated cathode to an electrode surrounding said cathode, producing a magnetic field by means of the current to be amplified and subjecting the electrons to the action of said magnetic field in such a way that the number of electrons reaching said electrode which surrounds the cathode will vary in accordance with variations in the current to be amplified.

24. The method of amplifying a variable current which consists in producing an emission of electrons from a heated cathode to an electrode surrounding the cathode, producing a magnetic field in a direction parallel to said cathode by means of the current to be amplified, and thereby causing the electrons to move in variable spiral lines in such a way that a variable number will reach the electrode surrounding the cathode.

25. The method of amplifying a variable current which consists in producing an emission of electrons from a linear heated cathode to an electrode surrounding said cathode and coaxial therewith, and subjecting the electrons to the action of a magnetic field produced by the current to be amplified in a direction parallel to said cathode.

26. In combination, an electron discharge device comprising a linear filamentary cathode adapted to be heated to incandescence to emit electrons, and an electrode surrounding said cathode and coaxial therewith inclosed in an evacuated envelop, means for producing a flow of electrons from said cathode to

said electrode surrounding said cathode, and means for producing a variable magnetic field in a direction parallel to said cathode and thereby varying the number of electrons which will reach said electrode from said cathode.

27. Means for amplifying a variable electric current comprising an electron discharge device having a linear filamentary cathode adapted to be heated to incandescence to emit electrons, an electrode surrounding said cathode and coaxial therewith, means for producing a magnetic field by the current to be amplified and means for subjecting the electrons emitted by said cathode to the action of said magnetic field in such a way that the number of electrons reaching the electrode which surrounds said cathode will vary in accordance with variations in the current to be amplified.

28. Means for amplifying a variable current comprising an electron discharge device having a filamentary cathode adapted to be heated to incandescence to emit electrons, an electrode surrounding said cathode and coaxial therewith and means for producing by the current to be amplified a magnetic field in a direction parallel to said cathode and thereby causing the electrons emitted by said cathode to move in variable spiral lines in such a way that a variable number will reach the electrode surrounding the cathode.

29. Means for amplifying a variable electric current comprising an electron discharge device having a linear cathode adapted to be heated to incandescence to emit electrons, an electrode surrounding said cathode and coaxial therewith and means for producing by the current to be amplified a magnetic field in a direction parallel to said cathode.

30. The method of operating an electron discharge device comprising an electron emitting cathode, a grid electrode surrounding said cathode and a third electrode surrounding said cathode and grid electrode which consists in producing a variable magnetic field in a direction parallel to said cathode and thereby varying the current flow from said cathode to said third electrode.

31. The method of operating an electron discharge device comprising an electron emitting cathode, a grid electrode and a third electrode surrounding said cathode and grid electrode, which consists in producing oscillations by means of said device and varying the amplitude of the oscillations produced by producing a variable magnetic field in a direction parallel to said cathode.

32. The method of amplifying a variable current which consists in producing an emission of electrons from a cathode in such a way that part of said electrons will pass through a grid electrode to a third electrode surrounding the cathode and grid electrode, and subjecting the electrons to the action of a magnetic field produced by the current to be amplified in a direction parallel to said cathode.

33. In combination, an electron discharge device comprising a filamentary cathode adapted to be heated to incandescence to emit electrons, a grid electrode adjacent said cathode and a third electrode surrounding said cathode and grid electrode, and means for producing a variable magnetic field in a direction parallel to said cathode and thereby varying the number of electrons which will reach said third electrode from said cathode.

34. Means for amplifying a variable electric current comprising an electron discharge device having a filamentary cathode adapted to be heated to incandescence to emit electrons, a grid electrode adjacent said cathode and a third electrode surrounding said cathode, means for producing a magnetic field by the current to be amplified, and means for subjecting the electrons emitted by said cathode to the action of said magnetic field in such a way that the number of electrons reaching the third electrode will vary in accordance with variations in the current to be amplified.

35. Means for amplifying a variable electric current comprising an electron discharge device having a linear cathode adapted to be heated to incandescence to emit electrons, a grid electrode adjacent said cathode and a third electrode surrounding said cathode and grid electrode, and means for producing by the current to be amplified a magnetic field in a direction parallel to said cathode.

36. In combination, an electron discharge device comprising a filamentary cathode adapted to be heated to incandescence to emit electrons, a grid electrode adjacent said cathode and a third electrode surrounding said cathode and grid electrode, means for causing said device to produce oscillations, and means for producing a varying magnetic field in a direction parallel to said cathode and thereby varying the amplitude of the oscillations produced.

37. In combination, an electron discharge device comprising a plurality of electrodes inclosed in a highly evacuated receptacle and having sources of potential applied to said electrodes in such a way that the device has a working range over which the current flow increases and decreases inversely as the potential applied thereto, and means for producing a magnetic field in a direction substantially at a right angle to the electrostatic field between the electrodes.

38. In combination, an electron discharge device comprising two electrodes one of which is adapted to emit electrons independently of gas ionization and one of which surrounds the other, a conducting grid inter-

posed between said electrodes, sources of potential applied to said electrodes for producing a flow of current from said cathode through the evacuated space between the electrodes, and means for producing a magnetic field in a direction substantially at a right angle to the electrostatic field between the electrodes.

39. In combination, an electron discharge device comprising a plurality of electrodes inclosed in an evacuated receptacle, at least one of said electrodes being adapted to emit electrons independently of gas ionization, sources of potential of such a value and applied to said electrodes in such a way that the device has a working range over which the current flow therethrough increases and decreases inversely as the potential applied thereto, and means for producing a magnetic field for controlling the current between said electrodes.

40. In combination, an electron discharge device comprising a cathode and a coöperating electrode inclosed in an evacuated receptacle and arranged in circular symmetry to each other about an axis, said cathode being adapted to emit electrons independently of gas ionization, means for producing a flow of current between said electrodes, and means for producing a variable magnetic field in a direction parallel to the axis of symmetry of said electrodes and thereby varying the current between said electrodes.

41. In combination, an electron discharge device comprising a cathode adapted to emit electrons independently of gas ionization and a coöperating electrode inclosed in an evacuated receptacle, means for producing a flow of electrons between said electrodes, said electrodes being so arranged with respect to each other that the electrons will tend to move in substantially radial paths between the electrodes, and means for producing a variable magnetic field in the space between said electrodes in a direction substantially at a right angle to the paths of the electrons.

42. Means for amplifying a variable electric current comprising an electron discharge device having a plurality of electrodes inclosed in an evacuated receptacle and arranged in circular symmetry to each other about an axis, at least one of said electrodes being adapted to emit electrons independently of gas ionization, means for producing a flow of current between said electrodes, and means for producing a magnetic field by the current to be amplified, and for subjecting the electrons emitted by said cathode to the action of said magnetic field in such a way that the current between said electrodes will vary in accordance with variations in the current to be amplified.

43. Means for amplifying a variable electric current comprising an electron discharge device having a cathode adapted to emit electrons independently of gas ionization and a coöperating electrode inclosed in an evacuated receptacle, means for producing a flow of electrons between said electrodes, said electrodes being so arranged with respect to each other that the electrons will tend to move in substantially radial paths between the electrodes, and means for producing by the current to be amplified a variable magnetic field in the space between said electrodes in a direction substantially at a right angle to the paths of the electrons and thereby varying the current carried by the electrons between the electrodes in accordance with variations in the current to be amplified.

44. In combination, an electron discharge device comprising a cathode adapted to emit electrons independently of gas ionization and a coöperating electrode surrounding said cathode and arranged in circular symmetry with respect to said cathode about an axis, means for producing a flow of current between said electrodes, and means for producing a variable magnetic field in a direction parallel to the axis of symmetry of said electrodes and thereby varying the flow of current between the electrodes.

45. Means for producing and controlling high frequency oscillations comprising an electron discharge device having a cathode and a coöperating electrode inclosed in an evacuated receptacle, means for producing a flow of electrons between said electrodes, said electrodes being so arranged with respect to each other that the electrons will tend to move in substantially radial paths between the electrodes, an oscillating circuit associated with said electrodes and means for producing a variable magnetic field in the space between said electrodes in a direction substantially at a right angle to the paths of the electrons.

46. Means for producing and controlling high frequency oscillations comprising an electron discharge device having a cathode and a coöperating electrode inclosed in an evacuated receptacle and arranged in circular symmetry to each other about an axis, an oscillating circuit associated with said electrodes, means for producing a flow of electrons between said electrodes and means for producing and varying a magnetic field in a direction parallel to the axis of symmetry of said electrodes and thereby producing a corresponding variation in the flow of electrons between said electrodes.

47. Means for producing and controlling high frequency currents comprising an electron discharge device having an electron emitting cathode and a coöperating electrode surrounding said cathode, and ar-

ranged in circular symmetry to said cathode about an axis, an oscillating circuit associated with said electrodes, means for producing a flow of electrons between said electrodes and means for producing and varying a magnetic field in a direction parallel to the axis of symmetry of said electrodes and thereby producing a corresponding variation in the flow of electrons between said electrodes.

48. The method of operating an electron discharge device having a cathode adapted to emit electrons independently of gas ionization and a coöperating electrode inclosed in an evacuated receptacle, which consists in producing a flow of electrons in substantially radial paths between said electrodes and producing a variable magnetic field in the space between said electrodes in a direction substantially at a right angle to the paths of the electrons, and thereby varying the current between said electrodes.

49. The method of operating an electron discharge device having a cathode adapted to emit electrons independently of gas ionization and a coöperating electrode inclosed in an evacuated receptacle for amplifying a variable electrical current, which consists in producing a flow of electrons in substantially radial paths between said electrodes and producing a magnetic field in the space between the electrodes by the current to be amplified, thereby causing the current between said electrodes to vary in accordance with variations in the current to be amplified.

50. The method of operating an electron discharge device comprising a cathode adapted to emit electrons independently of gas ionization and a coöperating electrode inclosed in an evacuated receptacle for amplifying a variable current, which consists in producing a flow of electrons in substantially radial paths between said electrodes, producing by means of the current to be amplified a magnetic field in a direction substantially at a right angle to the paths of the electrons, and subjecting the electrons to the action of said magnetic field thereby varying their paths in such a way that the current between the electrodes will vary in accordance with variations in the magnetic field.

51. The method of operating an electron discharge device having an electron emitting cathode and a coöperating electrode inclosed in an evacuated receptacle, and having an oscillatory circuit associated with said electrodes, which consists in producing a flow of electrons between said electrodes, producing high frequency oscillations in said oscillatory circuit, producing a magnetic field in a direction substantially at a right angle to the paths of said electrons, and varying the strength of said magnetic field and thereby varying the amplitude of the high frequency oscillations produced in said oscillating circuit.

52. The combination in a high frequency signaling system of an electron discharge device having an electron emitting cathode and a coöperating electrode inclosed in an evacuated receptacle, an oscillatory circuit associated with said electrodes in such a way that high frequency oscillations will be produced in said oscillatory circuit, means for producing a magnetic field in the space between said electrodes, and means for varying the strength of said magnetic field in accordance with variations in a signaling current and thereby varying the amplitude of the high frequency oscillations produced in said oscillatory circuit.

53. The combination in a signaling system of an electron discharge device having a cathode and a coöperating electrode inclosed in an evacuated receptacle, an oscillatory circuit associated with said electrodes in such a way that high frequency oscillations will be produced in said oscillatory circuit, means for producing a magnetic field in the space between said electrodes, and means for varying the strength of said magnetic field in accordance with variations in sound waves, thereby producing a corresponding variation in the amplitude of the high frequency oscillations produced in said oscillatory circuit.

In witness whereof, I have hereunto set my hand this 11th day of November, 1916.

ALBERT W. HULL.