April 22 , 1924. 1,491,405

A. W. HULL

SIGNAL RECEIVING SYSTEM

Filed March 1, 1921

Fig.1.

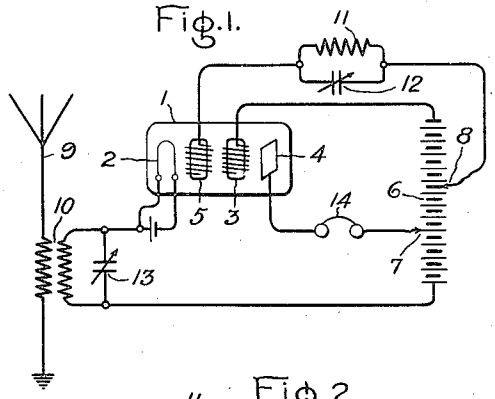


Fig.2.

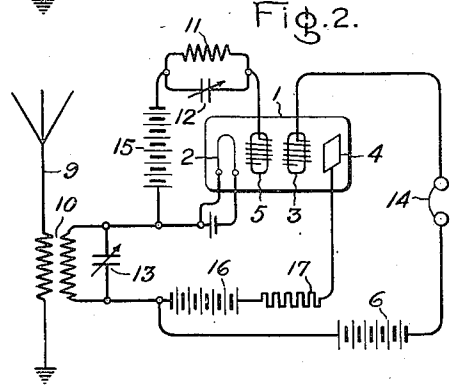
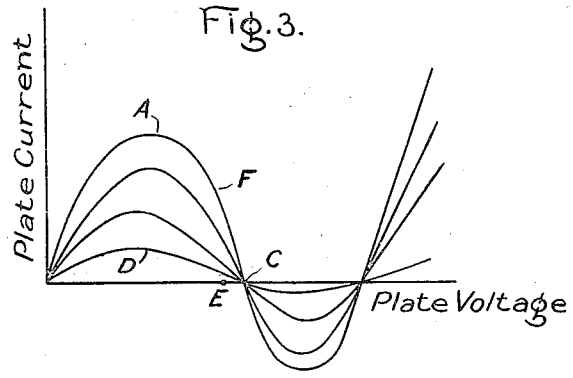


Fig.3.



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Patented Apr. 22, 1924. 1,491,405

UNITED STATES PATENT OFFICE.

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

SIGNAL-RECEIVING SYSTEM.

Application filed March 1, 1921. Serial No. 448,777.

To all whom it may concern:

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

My present invention relates to signal receiving systems and more particularly to systems for receiving continuous wave signals of radio frequency.

One of the objects of my invention is to provide a simple and efficient apparatus and method for receiving continuous wave signals whereby an audible indication of desired signals which are normally incapable of giving such an indication may be obtained.

In carrying my invention into effect I include in the circuit upon which the signaling currents to be detected are impressed, an electron discharge device so that the signaling current flowing in the circuit is carried through this device by means of electrons. By varying the number of electrons which can flow between the electrodes of this device the resistance of the circuit may be varied in any manner desired. In the present case I prefer to vary the number of electrons flowing by means of an electrostatic field produced upon a grid electrode which is properly positioned to vary the flow of electrons. If the potential of this grid electrode is varied periodically between suitable positive and negative values at a frequency somewhat different from that of the signaling currents to be detected, the resistance of the signaling circuit will be varied between maximum and minimum values and the current in the circuit may be caused to vary at an audible frequency.

I also preferably arrange the electron discharge device in such a way as to produce a negative resistance between the cathode and the controlling grid. By tuning the circuit between cathode and controlling grid oscillations will be produced in that circuit and the potential of the grid will automatically be caused to vary periodically at the frequency of the oscillations produced.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation will best be understood by reference to the following description taken in connection with the accompanying drawing in which Figs. 1 and 2 show two different circuit arrangements which may be employed in carrying my invention into effect, and Fig. 3 represents a set of characteristic curves showing the relation between current in the signaling circuit and the potential impressed upon that circuit for different values of potential of the controlling grid.

As indicated in Fig. 1 of the drawing, I utilize an electron discharge device 1, which comprises an electron emitting cathode 2, an anode 3, a third electrode 4 and a discharge controlling grid 5. A battery 6 which is connected in the circuit between the cathode 2 and the anode 3 may also serve to furnish the operating potential for the other electrodes. In the present case, the third electrode 4 is connected to a point 7 in the battery and the grid 5 is connected to a point 8 so that both of these electrodes will be maintained normally at positive potentials lower than that of the anode 3. These potentials are so chosen that the circuit between cathode 2 and grid 5, as well as the circuit between cathode 2 and third electrode 4, will have negative resistance characteristics. Signaling potentials received upon the antenna 9 are impressed upon the secondary of transformer 10 which is included in the external circuit between cathode and anode as well as in the external circuit between cathode and third electrode. By including the input coil in both of these circuits the tendency of the device to produce oscillations in the circuit between cathode 2 and third electrode 4 by reason of the negative resistance characteristic of that circuit is eliminated, the potential of the cathode 2 is also varied with respect to both anode and third electrode. An inductance 11 and variable capacity 12 are included in the circuit between the cathode and grid 5. This circuit having a negative resistance characteristic oscillations will be produced therein, the frequency of which may be varied by adjusting the capacity 12. A variable capacity 13 may also be inserted in shunt to the secondary of transformer 10 for tuning the signaling circuit to the frequency of the incoming signals.

The operation of the device will best be

understood by reference to the curves of Fig. 3 which show the relation between plate potential and plate current for different values of potential of the grid 5. The curve A represents the current for a high potential of the grid 5 and curve D for a low or negative potential of the grid 5. It will be apparent from an inspection of these curves that the effect of varying grid potential is to produce a variation in the apparent resistance of the circuit between cathode and third electrode. In the normal operation of the system the point 7 on the battery 6 is chosen to correspond with the voltage C at which the current flowing between cathode and third electrode is zero. As long as the potential remains at this point the variation in the potential of the grid 5 will produce no changes in the current flowing in the circuit between cathode and third electrode. If, however, a signaling potential is impressed upon the secondary of transformer 10 so that the total potential of electrode 4 corresponds to the voltage E, the variation in the potential of the grid will vary the apparent resistance of the circuit between cathode and third electrode between a substantially infinite value at which the current is zero and a much lower value at which the current is represented by the value F on the characteristic curve A. If the oscillations produced in the circuit of the grid 5 are of the same frequency as the signaling current and properly phased with respect thereto, potentials of one sign may produce currents between cathode and third electrode while signaling potentials of the opposite sign will produce no current in that circuit. The device then would in effect operate as a half wave rectifier and produce a unidirectional current in the circuit between cathode and third electrode. If, on the other hand, currents produced in the grid circuit are of slightly different frequency from the signaling current, the current produced in the circuit between cathode 2 and third electrode 4 will consist of a number of current impulses in one direction followed by a number of current impulses in the opposite direction as the phase relations change so as to produce a current in the telephone receiver 14 having an audible frequency component capable of affecting the telephone receiver. The current in this case would be of the same nature as that described in Goldschmidt Patent No. 1,087,113 and illustrated in Fig. 3c of that patent.

The circuit arrangement shown in Fig. 2 is identical in its operation with that shown in Fig. 1. I have, however, in this case, in order to indicate more clearly the different circuits involved, shown separate batteries 15, 16, for furnishing the operating potentials for the grid 5 and the third electrode 4. In order that greater amplification of the signaling current may be obtained, it may also be desirable to insert a positive resistance 17 in the circuit between cathode and third electrode of approximately the same value as the negative resistance of that circuit. Since a change in the current between cathode and third electrode is accompanied by an equal but opposite change in the current between cathode and anode, the telephone receivers 14 may, if desired, be included in the circuit between cathode and anode in order to obtain the desired indication of changes in the signaling current. By reason of the fact that the secondary of transformer 10 is common to the two circuits as described and that a change of current in one circuit is accompanied by an equal and opposite change in current in the other circuit the current through the secondary of transformer 10 will be substantially independent of the signaling potential.

While I have described the preferred embodiment of my invention, it will be apparent that my invention is by no means limited to the particular circuit arrangements or form of apparatus used, but that many modifications therein may be made without departing from the scope of my invention as set forth in the appended claims.

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

1. The combination in a signal receiving system of a circuit upon which signaling potentials may be impressed, a negative resistance in said circuit, and a local source of current which is produced independently of the negative resistance of said circuit for periodically varying the value of said negative resistance independently of the signaling potentials.

2. The combination in a signal receiving system of a circuit upon which signaling potentials may be impressed, a negative resistance in said circuit comprising an electron discharge device and means for producing by said electron discharge device independently of the negative resistance of said circuit an alternating potential for periodically varying the value of said negative resistance independently of the signaling potentials.

3. The combination in a signal receiving system of an electron discharge device, a circuit associated therewith upon which signaling potentials may be impressed, said circuit including a negative resistance, a second circuit associated with said electron discharge device, and means for producing in said second circuit by the action of said electron discharge device and independently of the negative resistance of said first circuit an alternating potential for periodically varying the value of said negative resistance.

4. The combination in a signal receiving

system of an electron discharge device having a plurality of electrodes, a circuit associated with two of said electrodes upon which signaling potentials may be impressed, said circuit including a negative resistance, a second circuit associated with two of said electrodes and means for producing independently of the negative resistance of the first circuit an alternating potential in said second circuit for varying the value of the negative resistance in the first circuit.

5. The combination in a signal receiving system of an electron discharge device having a plurality of electrodes, a circuit associated with two of said electrodes upon which signaling potentials may be impressed, said circuit including a negative resistance, a second circuit associated with two of said electrodes, said second circuit also including a negative resistance which is independent of the negative resistance of the first circuit, and means for producing an alternating potential in said second circuit for varying the value of the negative resistance of the first circuit.

6. The combination in a signal receiving system of an electron discharge device having an electron emitting cathode, an anode, a third electrode and a discharge controlling member, means for producing an emission of secondary electrons from both the third electrode and the discharge controlling member sufficient to produce a negative resistance characteristic between cathode and both of said electrodes, a resonant circuit connected between cathode and discharge controlling member which is tuned to a frequency different from that of the signal to be received and means for varying the potential of the cathode with respect to both anode and third electrode in accordance with the signals to be received.

7. The combination in a signal receiving system of an electron discharge device having an electron emitting cathode, and three other electrodes, means for producing an emission of secondary electrons from two of said electrodes sufficient to produce a negative resistance characteristic between cathode and each of said electrodes, circuit connections from said cathode to each of said other electrodes, means associated with one of said circuit connections for producing oscillations of a frequency differing from that of the signals to be received and means for impressing the signals to be received upon one of the other circuits.

8. The combination in a signal receiving system of an electron discharge device having an electron emitting cathode, an anode, a third electrode and a discharge controlling member, circuit connections between said cathode and each of said other electrodes, sources of potential connected in said circuit connections of such values that a negative resistance characteristic will be produced between cathode and both the third electrode and the discharge controlling member, means for varying the potential of the cathode with respect to both anode and third electrode in accordance with the signals to be received, and means for varying the resistance between cathode and third electrode at a frequency differing from the frequency of the signals to be received.

9. The combination in a signal receiving system of an electron discharge device having a plurality of electrodes, at least two independent circuits associated with said device, one of said circuits including a negative resistance, means for impressing signaling potentials upon a second of said circuits, and means for utilizing the negative resistance of the first circuit for producing an alternating potential for periodically varying the value of the resistance of the second circuit.

10. The combination in a signal receiving system of an electron discharge device having an electron emitting cathode, an anode, a third electrode and a discharge controlling member, circuit connections between said cathode and each of said other electrodes, means for impressing signaling potentials upon the circuit between cathode and third electrode, and means associated with the circuit between cathode and discharge controlling member for varying the resistance of the circuit between cathode and third electrode.

11. The combination in a signal receiving system of an electron discharge device having an electron emitting cathode, an anode, a third electrode and a discharge controlling member, circuit connections between said cathode and each of said other electrodes, means for impressing signaling potentials upon the circuit between cathode and third electrode and means associated with the circuit between cathode and discharge controlling member for protruding oscillations therein and thereby varying the resistance of the circuit between cathode and third electrode.

12. The combination in a signal receiving system of an electron discharge device having an electron emitting cathode, an anode, a third electrode and a discharge controlling member, circuit connections between said cathode and each of said other electrodes, means for impressing signaling potentials upon the circuit between cathode and third electrode, means for producing a negative resistance in the circuit between cathode and discharge controlling member, and means for utilizing this negative resistance to produce an alternating potential for periodically varying the resistance of the circuit between cathode and third electrode.

13. The combination in a signal receiving system of an electron discharge device hav-

ing an electron emitting cathode, an anode, a third electrode and a discharge controlling member, circuit connections between said cathode and each of said other electrodes, means common to the circuits between cathode and anode and between cathode and third electrode for impressing signaling potentials upon said circuits and means associated with the circuit between cathode and discharge controlling member for varying the resistance of the circuit between cathode and third electrode.

14. The combination in a signal receiving system of an electron discharge device having an electron emitting cathode, an anode, a third electrode and a discharge controlling member, circuit connections between said cathode and each of said other electrodes, means common to the circuits between cathode and anode and between cathode and third electrode for impressing signaling potentials upon said circuits, and means associated with the circuit between cathode and discharge controlling member for varying the resistance of the circuit between cathode and third electrode at a frequency slightly different from the frequency of the signals.

15. The combination in a signal receiving system of an electron discharge device having an electron emitting cathode, an anode, a third electrode and a discharge controlling member, circuit connections between said cathode and each of said other electrodes, means for producing a negative resistance characteristic in the circuit between cathode and third electrode, means common to the circuits between cathode and anode and between cathode and third electrode for impressing signaling potentials upon said circuits, and means associated with the circuit between cathode and discharge controlling members for varying the resistance of the circuit between cathode and third electrode.

16. The combination in a signal receiving system of an electron discharge device having an electron emitting cathode, an anode, a third electrode and a discharge controlling member, circuit connections between said cathode and each of said other electrodes, means for producing a negative resistance characteristic in the circuit between cathode and third electrode and in the circuit between cathode and discharge controlling member, means common to the circuits between cathode and anode and between cathode and third electrode for impressing signaling potentials upon said circuits, and means associated with the circuit between cathode and discharge controlling members for varying the resistance of the circuit between cathode and third electrode.

17. The combination in a signal receiving system of an electron discharge device having an electron emitting cathode, an anode, a third electrode and a discharge controlling member, circuit connections between said cathode and each of said other electrodes, means for producing a negative resistance characteristic in the circuit between cathode and discharge controlling member, means common to the circuits between cathode and anode and between cathode and third electrode for impressing signaling potentials upon said circuits, and means associated with the circuit between cathode and discharge controlling member for varying the resistance of the circuit between cathode and third electrode.

18. The combination in a signal receiving system of an electron discharge device having an electron emitting cathode, an anode, a third electrode and a discharge controlling member, circuit connections between said cathode and each of said other electrodes, means for producing a negative resistance characteristic in the circuit between cathode and discharge controlling member, means common to the circuits between cathode and anode and between cathode and third electrode for impressing signaling potentials upon said circuits, the circuit between cathode and discharge controlling member being resonant to a frequency different from the frequency of the signals.

19. The combination in a signal receiving system of an electron discharge device having an electron emitting cathode, an anode, a third electrode and a discharge controlling member, circuit connections between said cathode and each of said other electrodes, means common to the circuits between cathode and anode and between cathode and third electrode for impressing signaling potentials upon said circuits, and means associated with the circuit between cathode and discharge controlling member for varying the resistance of the circuit between cathode and third electrode, the system being so proportioned that the current flowing in the means common to the circuits between cathode and anode and cathode and third electrode is substantially independent of the signaling potentials impressed thereon.

20. The method of operating an electron discharge device comprising an electron emitting cathode, an anode, a third electrode and a discharge controlling member to detect radio signals which consists in producing an emission of secondary electrons from both third electrode and discharge controlling member sufficient to give the device a negative resistance characteristic between cathode and both third electrode and discharge controlling member, producing oscillations by means of said device, supplying the oscillations thus produced to the discharge controlling member and thereby varying the negative resistance between

cathode and third electrode and varying the potential of the third electrode in accordance with the signals to be detected.

21. The method of operating an electron discharge device comprising an electron emitting cathode, an anode, a third electrode and a discharge controlling member to detect radio signals which consists in producing an emission of secondary electrons from both third electrode and discharge controlling member sufficient to give the device a negative resistance characteristic between cathode and both third electrode and discharge controlling member periodically varying the potential of the discharge controlling member and thereby varying the negative resistance between cathode and third electrode and varying the potential of the third electrode in accordance with the signals to be detected.

22. The method of operating an electron discharge device comprising an electron emitting cathode, an anode and a third electrode which consists in producing an emission of electrons from the third electrode sufficient to give the device a negative resistance characteristic between cathode and third electrode, varying the potential of said third electrode in accordance with signals to be detected and periodically varying the negative resistance of the device.

23. The method of operating an electron discharge device comprising an electron emitting cathode, an anode and a third electrode which consists in producing an emission of electrons from the third electrode sufficient to give the device a negative resistance characteristic between cathode and third electrode, varying the potential of said third electrode in accordance with signals to be detected and periodically varying the negative resistance of the device at a frequency slightly different from the frequency of the signals.

24. The method of operating an electron discharge device comprising an electron emitting cathode, an anode, a third electrode and a discharge controlling member to detect radio signals which consists in producing an emission of secondary electrons from both third electrode and discharge controlling member sufficient to give the device a negative resistance characteristic between cathode and third electrode, periodically varying the potential of the discharge controlling member and thereby varying the negative resistance between cathode and third electrode, and varying the potential of the third electrode in accordance with the signals to be detected.

25. The method of operating an electron discharge device comprising an electron emitting cathode, an anode, a third electrode and a discharge controlling member to detect radio signals which consists in producing an emission of secondary electrons from both third electrode and discharge controlling member sufficient to give the device a negative resistance characteristic between cathode and both third electrode and discharge controlling member, periodically varying the potential of the discharge controlling member at a frequency slightly different from that of the signals to be detected, and thereby varying the negative resistance between cathode and third electrode and varying the potential of the third electrode in accordance with the signals to be detected.

26. The method of operating an electron discharge device comprising an electron emitting cathode, an anode, a third electrode and a discharge controlling member and having an oscillatory circuit connected between cathode and discharge controlling member which consists in producing an emission of secondary electrons from the third electrode sufficient to give the device a negative resistance characteristic between cathode and third electrode, producing high frequency oscillations in said oscillatory circuit and varying the potential of the third electrode in accordance with the signals to be detected.

27. The method of operating an electron discharge device comprising an electron emitting cathode, an anode, a third electrode and a discharge controlling member to detect radio signals which consists in producing an emission of secondary electrons from the discharge controlling member sufficient to give the device a negative resistance characteristic between cathode and discharge controlling member, producing oscillations by means of said device, supplying the oscillations thus produced to the discharge controlling member and thereby varying the resistance between cathode and third electrode and varying the potential of the third electrode in accordance with the signals to be detected.

28. The method of operating an electron discharge device comprising an electron emitting cathode, an anode, a third electrode and a discharge controlling member and having an oscillatory circuit connected between cathode and discharge controlling member which consists in producing an emission of secondary electrons from the discharge controlling member sufficient to give the device a negative resistance characteristic between cathode and discharge controlling member, producing high frequency oscillations in said oscillatory circuit and varying the potential of the third electrode in accordance with the signals to be detected.

29. An electron discharge device having an electron emitting cathode, an anode, a third electrode and a discharge controlling

member, and means for producing an emission of secondary electrons from both the third electrode and the discharge controlling member sufficient to produce a negative resistance characteristic between cathode and both of said electrodes.

30. An electron discharge device having an electron emitting cathode and three cooperating electrodes, circuit connections between the cathode and each of the other electrodes, and means for producing an emission of secondary electrons from two of said other electrodes sufficient to produce a negative resistance characteristic in the circuits connected thereto.

31. An electron discharge device having an electron emitting cathode and three cooperating electrodes, circuit connections between the cathode and each of the other electrodes, means for producing an emission of secondary electrons from two of said other electrodes sufficient to produce a negative resistance characteristic in the circuits connected thereto, means for producing oscillations in one of the circuits having a negative resistance characteristic and thereby varying the negative resistance of the other circuit having a negative resistance characteristic.

32. An electron discharge device having an electron emitting cathode and three cooperating electrodes, circuit connections between the cathode and each of the other electrodes, means for producing an emission of secondary electrons from two of said other electrodes sufficient to produce a negative resistance characteristic in the circuits connected thereto, means for impressing signaling potentials upon one of said circuits having a negative resistance characteristic and means associated with one of the other circuits from the cathode to one of the other electrodes for producing an indication of signals.

33. An electron discharge device having an electron emitting cathode, an anode, a third electrode and a discharge controlling member, circuit connections between the cathode and each of the other electrodes, means for producing an emission of secondary electrons from both the third electrode and the discharge controlling member sufficient to produce a negative resistance characteristic in the circuits connected thereto, means for impressing signaling potentials upon one of said circuits having a negative resistance characteristic, and means associated with one of the other circuits from the cathode to one of the other electrodes for producing an indication of signals.

34. An electron discharge device having an electron emitting cathode, an anode, a third electrode and a discharge controlling member, circuit connections between the cathode and each of the other electrodes, means for producing an emission of secondary electrons from both the third electrode and the discharge controlling member sufficient to produce a negative resistance characteristic in the circuits connected thereto, means for impressing signaling potentials upon one of said circuits having a negative resistance characteristic, and means associated with the circuit connected to the anode for producing an indication of signals.

In witness whereof, I have hereunto set my hand this 28th day of February, 1921.

ALBERT W. HULL.