Oct. 14, 1930. I. LANGMUIR 1,778,456

MEANS FOR PRODUCING ALTERNATING CURRENTS

Filed Oct. 29, 1913

Fig. 1.

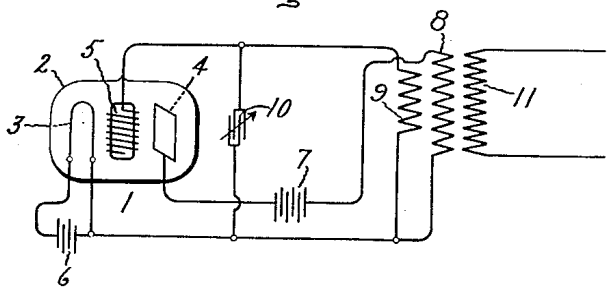


Fig. 2.

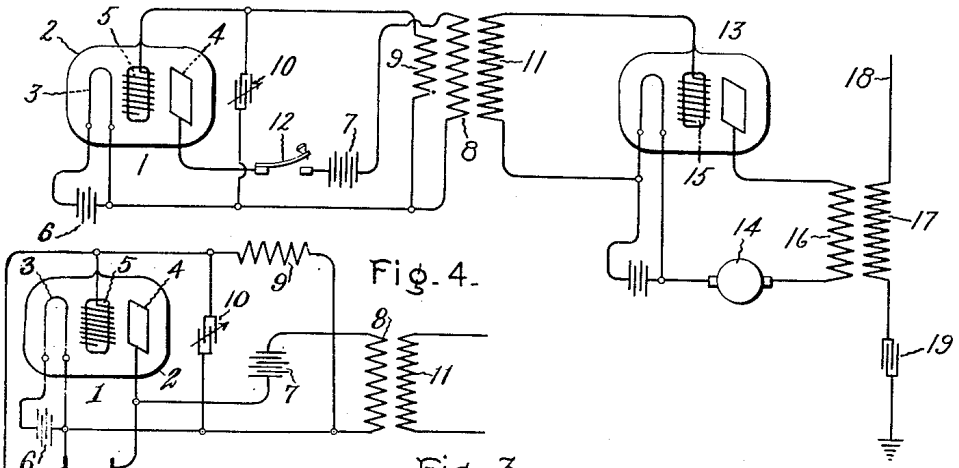
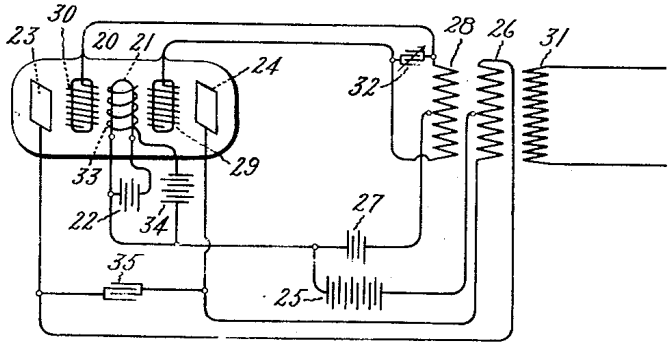


Fig. 4.

Fig. 3.



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UNITED STATES PATENT OFFICE

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MEANS FOR PRODUCING ALTERNATING CURRENTS

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My invention relates to the production of alternating currents of any frequency desired from any suitable source of either direct or alternating current, and more particularly to the production of high frequency currents.

In carrying my invention into effect, I make use of certain agencies arranged in cooperative relation with an "electron discharge tube". By the term "electron discharge tube" I mean to imply the use of a highly exhausted envelope containing at least two electrodes one of which is provided with means for causing it to emit electrons and in which the flow of current with any voltage which may be applied is independent of any conductivity of a gas. A device of this nature when connected to a source of current operates selectively in such a manner as to allow current to flow between the electrodes in only one direction, that is, there will be a flow of negative electricity from the electron emitting electrode to the other electrode or electrodes, but no flow in the opposite direction. The flow of current in such case will be the result of what may be termed a "pure electron discharge".

If a body charged with a negative potential is placed in proximity to the electrodes the flow of current is impeded, and if the negative potential is made high enough it may be stopped entirely. This effect is greatest when the body is placed between the electrodes and the most useful results are obtained when the conducting body takes the form of a grid.

The nature of my invention will be best understood by reference to the accompanying drawing in which Fig. 1 shows diagrammatically one way in which my invention may be carried into effect; Fig. 2 shows the application of high frequency current obtained in this way for use in sending out signals in wireless telegraphy; Fig. 3 shows the application of a different form of electron discharge tube from that used in Fig. 1 and Fig. 4 shows a modification of the circuit connections slightly different from that shown in Fig. 1.

In the drawing 1 represents an electron discharge tube which comprises an evacuated tube 2 in which is placed a cathode 3, an anode 4, which in some cases may be in the form of a plate, and a conducting body 5, which is preferably in the form of a grid, interposed between the cathode and anode. The cathode used is preferably in the form of a filament which may be raised to incandescence by current from any convenient source as the battery 6. While this is the preferred method for causing the cathode to emit electrons, other methods may be used. The two electrodes are connected by an oscillatory circuit containing an external source of current 7, which may be a battery as shown, or may be either a direct or alternating current generator, and an inductance 8; the circuit thus formed for convenience in description I call the plate circuit. The cathode is also connected externally with the grid 5 through an inductance 9. The oscillatory circuit thus formed I designate the grid circuit. The two circuits are preferably coupled together by placing the inductance 8 in inductive relation to the inductance 9. This coupling may be a very loose one or may be omitted entirely as the capacity between the electrodes and the grid 5 may electrostatically couple the two circuits together sufficiently to produce a current in the grid circuit whenever there is a change in the current flowing in the plate circuit. If desired the electrostatic coupling may be increased by connecting the electrodes and grid to plates 3′, 4′ and 5′ placed in inductive relation to each other as indicated in Fig. 4. If the grid were absent there would be a steady flow of current in the plate circuit between the electrodes. With the grid circuit connected, however, as soon as current starts to flow in the plate circuit a current is induced in the grid circuit. If the inductances 8 and 9 are wound in the same direction when current in the plate circuit begins to build up current tends to flow in the opposite direction in the grid circuit and the grid becomes negatively electrified. This cuts down the flow of current in the plate circuit and as the current decreases the

grid loses its negative potential and becomes positive. This allows the current to increase again in the plate circuit. These changes may take place with great rapidity, their frequency depending upon the natural periods of the two circuits. The frequency of the current changes may be readily varied by varying the constants of the grid circuit and by so doing current of any frequency desired may be obtained in the coil 11, which should be closely coupled to the coil 8, and the current so obtained may be used for any purpose desired. One convenient way of varying the frequency is by the use of an adjustable condenser 10 in the grid circuit.

In Fig. 2 I have shown a way in which high frequency oscillations produced after the manner shown in Fig. 1 may be applied for transmitting signals by wireless telegraphy. In order to be able to break up the oscillations into successive wave trains as required to produce signals, I provide a key 12 in the plate circuit. The oscillations produced might be applied directly to the antenna of the wireless system, but in some cases it may be found desirable to amplify them. The method which I have shown for their amplification consists in using a second electron discharge tube 13, similar to the first one. In the plate circuit of the second tube however, I employ as a source of current a high voltage generator 14, although a battery may be used as the source of current. The oscillations produced in the coil 11, which is connected to the grid circuit of the second tube, produce alternately positive and negative potentials on the grid 15. When the grid potential is negative the current in the plate circuit is interrupted and when the grid potential becomes positive current flows through the plate circuit and the primary 16 of a transformer whose secondary 17 is connected directly in the circuit of antenna 18. The antenna is connected to earth through the condenser 19 in the usual manner. By this means it will be seen that oscillations of the same frequency as those set up in the coil 11 will be impressed upon the antenna. It will of course be understood that this method of amplifying oscillations will be useful whether the oscillations are produced by the system which I have disclosed or by other methods, such for example as by a high frequency alternator.

In Fig. 3 I have shown another form of electron discharge tube for producing oscillations which operates much more efficiently than the simple form shown in Figs. 1 and 2. The tube 20 in this arrangement is provided with a cathode 21 with heating means 22 and two anodes, 23 and 24. The circuits shown in Fig. 1 are in this case duplicated, one plate circuit comprising the cathode 21, the source of power 25, one-half of the coil 26, and the anode 24, while the other plate circuit comprises the cathode 21, the source of power 25, the second half of the coil 26, and the anode 23. One grid circuit comprises the cathode 21, a battery 27 for impressing an extra negative potential on the grids, one-half of the coil 28 and the grid 29; the second grid circuit comprises the cathode 21, the battery 27, the second half of coil 28 and the grid 30. The operation of the two circuits is the same as that of the single circuit shown in Fig. 1. When one of the grids is negative the other grid is positive and vice-versa, and as a result when the current is decreasing in one plate circuit it is increasing in the other. As a result the current induced in the coil 31 which is closely coupled with the coil 26 is much greater than it would be if only one circuit were in operation. An adjustable condenser 32 may be connected in the grid circuits to vary the natural period of the circuits as in the arrangement shown in Fig. 1.

To improve the efficiency of the device I provide a conducting body in proximity to the cathode. This may take the form of a grid 33 surrounding the cathode. Upon this conducting body I impress a positive potential from the battery 34. I also find that in some cases the efficiency of operation of the device is greatly increased by the use of a condenser 35 in the plate circuit.

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

1. A source of electrical oscillating energy including an exhausted vessel containing one hot and three cold electrodes, each of said cold electrodes being located at a relatively different distance from said hot electrode, a work circuit and means to transmit the generated oscillations to said work circuit comprising circuits associated with said electrodes.

2. A source of electrcal oscillating energy including an exhausted vessel containing hot and two cold electrodes, a work circuit, and means to transmit the generated oscillations to said work circuit, and a control electrode therefor, each of said cold electrodes and said control electrode being located at a relatively different distance from said hot electrode.

3. A source of electrical oscillating energy including an exhausted vessel containing one hot and three cold electrodes, each of said cold electrodes being located at a relatively different distance from said hot electrode, the hot electrode and one cold electrode being electrically connected and the other two cold electrodes being electrically connected together, a work circuit, and means to transmit the generated oscillations to said work circuit comprising circuits associated with said electrodes.

4. A source of electrical oscillating energy including an exhausted vessel containing hot

and cold electrodes, and a control electrode therefor, each of said cold electrodes being located at a relatively different distance from said hot electrode, the hot electrode and one cold electrode being connected together and the other cold electrode and said control electrode being connected together, a work circuit, and means to transmit the generated oscillations to said work circuit.

5. A source of electrical oscillating energy including an exhausted vessel containing one hot and three cold electrodes, each of said cold electrodes being located at a relatively different distance from said hot electrode and an oscillating circuit connecting two of said electrodes, circuits for the remaining electrodes, a work circuit, and means to transmit the generated oscillations to said work circuit comprising circuits associated with all of said electrodes.

6. A source of electrical oscillating energy including an exhausted vessel containing a hot and two cold electrodes, a control electrode interposed between said cold electrodes, each of said cold electrodes and said control electrode being located at a relatively different distance from said hot electrode, a work circuit, and means for transmitting the generated oscillations to said work circuit comprising circuits associated with all of said electrodes.

7. The combination in a system for producing oscillations, of means for producing two electron streams, two separate anodes for receiving the electron streams and two separate grids for controlling the electron streams, and an oscillating system comprising an inductance having two points therein connected to the two grids and a second inductance coupled to the first and having two points therein connected to the two anodes.

8. The combination in a system for producing oscillations, of means for producing two electron streams, two separate anodes for receiving the electron streams and two separate grids for controlling the electron streams, and an oscillating system comprising an inductance having two points therein connected to the two grids and a second inductance inductively coupled to the first and having two points therein connected to the two anodes.

9. The combination in a system for producing oscillations, of means for producing two electron streams, two separate anodes for receiving the electron streams and two separate grids for controlling the electron streams, and an oscillating system comprising an inductance having two points therein connected to the two grids, a second inductance coupled to the first and having two points therein connected to the two anodes, and a capacity in shunt to one of said inductances.

10. The combination in a system for producing oscillations, of means for producing two electron streams, two separate anodes for receiving the electron streams and two separate grids for controlling the electron streams, and an oscillating system comprising an inductance having two points therein connected to the two grids, a second inductance coupled to the first and having two points therein connected to the two anodes, and a capacity in shunt to each of said inductances.

11. The combination in a system for producing oscillations, of an evacuated vessel containing an electron emitting cathode, two separate anodes and two separate grids, and an oscillating system comprising an inductance having two points therein connected to the two grids and a second inductance coupled to the first and having two points therein connected to the two anodes.

12. The combination in a system for producing oscillations, of an evacuated vessel containing an electron emitting cathode, two separate anodes and two separate grids, and an oscillating system comprising an inductance having two points therein connected to the two grids, a second inductance coupled to the first and having two points therein connected to the two anodes, and a capacity in shunt to one of said inductances.

13. The combination in a system for producing oscillations, of an evacuated vessel containing an electron emitting cathode, two separate anodes and two separate grids, and an oscillating system comprising an inductance having two points therein connected to the two grids, a second inductance coupled to the first and having two points therein connected to the two anodes, and a capacity in shunt to each of said inductances.

14. The combination in a system for producing oscillations, of an evacuated vessel containing an electron emitting cathode, two separate anodes and two separate grids, and an oscillating system comprising an inductance having two points therein connected to the two grids, a second inductance coupled to the first and having two points therein connected to the two anodes, and connections from the cathode to a third point in each of said inductances.

In witness whereof, I have hereunto set my hand this 27th day of October, 1913.

IRVING LANGMUIR.