Feb. 28, 1933. L. LEVY 1,899,622

FREQUENCY CHANGER

Filed Oct. 29, 1928

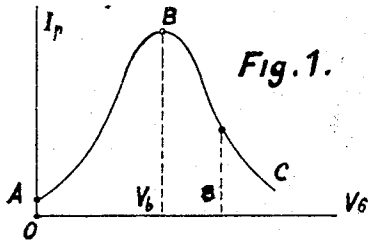

Fig. 1.

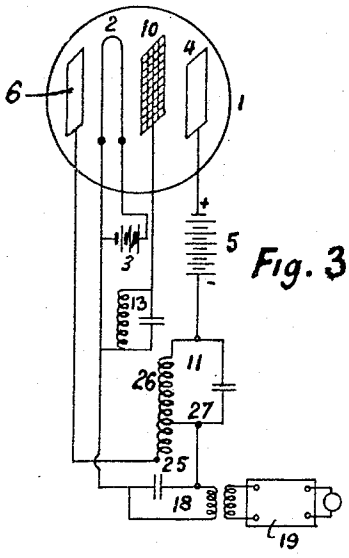

Fig. 3.

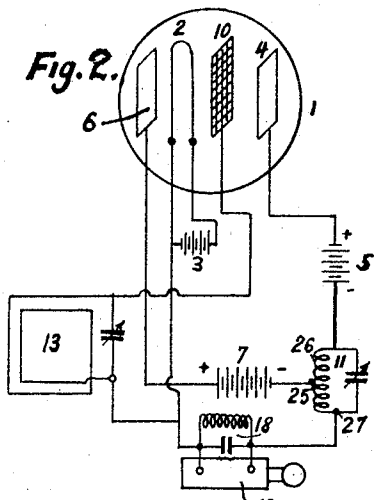

Fig. 2.

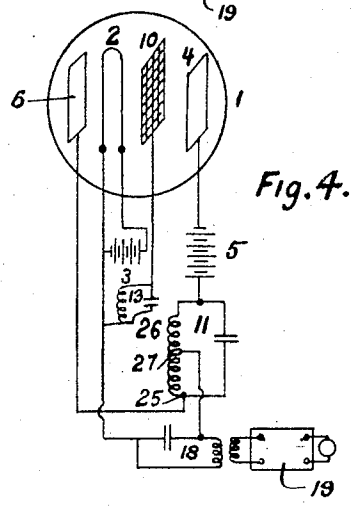

Fig. 4.

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UNITED STATES PATENT OFFICE

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FREQUENCY CHANGER

Application filed October 29, 1928, Serial No. 315,843, and in France June 4, 1927.

Applications for this invention have been filed in France, June 4, 1927, and October 22, 1927.

My invention relates to a frequency changer designed primarily for receiving wireless waves by the superheterodyne method.

This frequency changer uses a vacuum tube like the one disclosed in my prior application Ser. No. 280,354 filed May 24, 1928, and entitled "Electron discharge device", and the invention relates to new ways of connecting the electrodes of said tube with different circuits in order to obtain a frequency changer operating under better conditions than does the one described in my prior application.

On the accompanying drawing:

Fig. 1 is a characteristic curve representing the operation of the vacuum tube.

Figs. 2 to 4 show wiring diagrams according to the invention.

The vacuum tube is comprised of a bulb 1 (Figs. 2, 3, or 4) inside which a vacuum is produced, and containing a cathode 2 constituted by a filament heated by a battery 3, an anode 4, a grid 10, and an auxiliary electrode 6 placed at the opposite side of the cathode from the anode and nearer to said cathode 2 than is the anode plate 4.

If, in said vacuum tube, suitable potentials with reference to the cathode 2 are impressed on the grid 10 and on the anode 4, and if the potential of the auxiliary electrode 6 varies with reference to said cathode 2, the current flowing between the cathode 2 and the anode 4 will also vary, since the auxiliary electrode 6, owing to its close proximity to the cathode, has a great influence on the space charge and can, either, if its potential is negative and of sufficiently great value, prevent the electrons from flowing from the filament, or attract to itself all the electrons, if its potential is positive and of sufficiently great value. Consequently, the curve representing the anode current I_p plotted against the potential V_6 of the auxiliary electrode will be asymptotic to the axis of the abscissæ and will be shaped as shown in Fig. 1.

It is obvious that said curve depends on the potentials impressed on the grid and on the anode, but its general shape always remains the same.

Owing to the proximity of the auxiliary electrode to the filament, a slight variation in the potential of said electrode may cause a very great variation of the anode current; this can be seen on the characteristic curve plotted in Fig. 1, wherein the two branches AB and BC are greatly inclined on the axis of the abscissæ. In consequence the effect of the auxiliary electrode may be considered as a relay effect similar to that of a grid.

If now, under such conditions, we impress on the auxiliary electrode a potential such that the corresponding point on the characteristic curve be on the descending branch BC, and if said auxiliary electrode is connected to the anode circuit in such manner that an increase of the anode current tends to increase the potential of the auxiliary electrode, the anode current will oscillate at a frequency depending on the particular features of the device.

Oscillations may also be obtained if the point which is representative of the operation is on the ascending branch AB of the characteristic curve; to accomplish that end, it is sufficient to reverse the connections of the auxiliary electrode and the plate circuit, in such manner that the potential of the auxiliary electrode 6 has a tendency to decrease while the anode current increases.

Variations of the grid potential may be overlaid upon those created in the above disclosed manner, and the beats produced by interference of these oscillations can be selected, the device thus really operating as a frequency changer.

Fig. 2 shows a wiring diagram of a frequency changer using the descending branch BC of the characteristic curve. The grid 10 is connected to the filament through the intermediary of a device 13 receiving the incoming waves, and tuned to the frequency F of said waves; the cathode 2 is connected to the anode 4 by a circuit wherein are inserted in series:

1. A first oscillating circuit 11 constituted by an inductance coil 26 and a condenser con-

nected in parallel, and tuned to a frequency F′,

2. A second oscillating circuit 18 tuned to the frequency F—F′ and which can be connected to or coupled with a receiving set 19 of any suitable type,

3. A battery 5, the positive pole of which is connected with the anode 4.

The auxiliary electrode 6 is connected with the positive pole of a battery 7, the negative pole of which is connected with an intermediate point 25 of the inductance coil 26 of the first oscillating circuit. The battery 7 impresses on the auxiliary electrode 6 a positive potential such that the representative point will be on the branch BC of the characteristic curve, its abscissæ being for instance 8, as shown in Fig. 1.

It is obvious that an increase of the anode current will produce an increase of the potential of the point 25 and thus, as explained above, oscillations will be created at the frequency F′ of the oscillating circuit 11; the beats at the frequency F—F′ selected and received in the second oscillating circuit, will then actuate the receiving set.

Figs. 3 and 4 show two forms of execution of the reversed coupling between the two circuits for using the left hand part AB of the characteristic. On said figures, the corresponding numerals of Fig. 2 have been employed for indicating the same elements of the device. In the diagram shown, the connections of the oscillating circuit 11 with the wires leading to the control plate and to the filament are modified; on Fig. 3 the control circuit is connected at 25 with the end of the induction coil 26 of the circuit 11; the wire closing this latter circuit, and to which the anode-filament circuit connects at 27, being connected with a point disposed towards the middle of the induction coil. On Fig. 4 on the contrary the point 27 through which the circuit 11 is connected with the filament is towards the middle of the induction coil 26 and the point 25 connecting the oscillating and control circuits is disposed on the wire inserted in the latter circuit and leading as in Fig. 3 to the end of the induction coil 26.

What I claim is:

1. An electric wave frequency changer comprising a vacuum tube, comprised of a cathode, a grid, a plate, and an auxiliary cathode placed at the opposite side of the cathode from the plate and nearer to said cathode than is the plate; an input circuit for said tube connected to the grid and cathode, said input circuit having means for impressing thereon oscillations at a frequency F; an output circuit for said tube including a first circuit oscillating at a frequency F′; a second oscillating circuit tuned to the difference frequency F—F′, and a source of direct current, all connected in series; and means for coupling the said auxiliary electrode of the vacuum tube with the first oscillating circuit in such manner that the variations of potential of said auxiliary electrode are shifted with the current variation, in order to generate oscillations at the frequency F′ in the first oscillatory circuit.

2. An electric wave frequency changer, comprising a vacuum tube comprised of a cathode, a grid, a plate, and an auxiliary electrode placed at the opposite side of the cathode from the plate and nearer to said cathode than the plate; an input circuit for said tube connected to the grid and cathode, said input having means for impressing thereon oscillations at a frequency F; an output circuit for said tube including a first circuit oscillating at the frequency F′, the said first oscillating circuit comprising an inductance coil and capacitance in parallel, a second circuit tuned to the difference frequency F—F′, and a source of direct current potential, the positive pole of which is connected to the plate, all connected in series; and a second source of direct current potential, the positive pole of which is connected to the auxiliary electrode and the negative pole of which is connected to an intermediate point of the said inductance coil of the first oscillatory circuit.

3. An electric wave frequency changer, comprising a vacuum tube comprised of a cathode, a grid, a plate, and an auxiliary electrode placed at the opposite side of the cathode from the plate and nearer to the said cathode than the plate; an input circuit for said tube connected to the grid and cathode, said input circuit having means for impressing thereon oscillations at a frequency F; and an output circuit for said tube including a first circuit oscillating at the frequency F′; the said first oscillatory circuit comprising an inductance coil and a capacitance in parallel; a second circuit tuned to the difference frequency F—F′, and a source of direct current potential all connected in series; the auxiliary electrode being connected to a point intermediate of the first and second oscillatory circuits, said auxiliary circuit including an inductance coupled to the said inductance coil of the first oscillatory circuit, the inductance coil of said first circuit having one end connected to the auxiliary electrode and an intermediate point connected to the second oscillating circuit.

4. An electric wave frequency changer, comprising a vacuum tube comprised of a cathode, a grid, a plate, and an auxiliary electrode placed at the opposite side of the cathode from the plate and nearer to said cathode than the plate, an input circuit for said tube connected to the grid and cathode, said input circuit having means for impressing thereon oscillations at a frequency F; an output circuit for said tube including a first circuit oscillating at a frequency F′, the said first oscil-

lating circuit having an inductance coil and a capacitance in parallel, a second oscillating circuit tuned to the difference frequency F—F′, and a source of direct current potential, the positive pole of which is connected to the plate, all connected in series; means for connecting the second oscillating circuit with the cathode and with an intermediate point of the inductance coil of the first oscillating circuit, and means for connecting said first circuit on one side thereof with the negative pole of the source of direct current potential and on the other side with the auxiliary electrode.

In testimony whereof I have signed my name to this specification.

LUCIEN LEVY.