

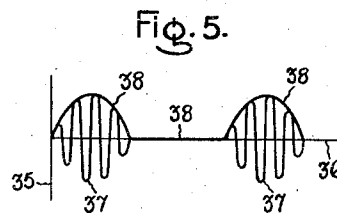
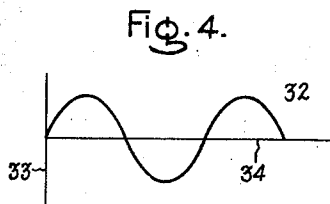
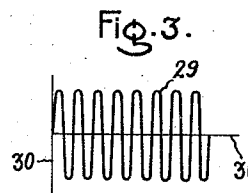
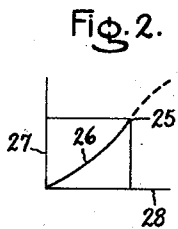
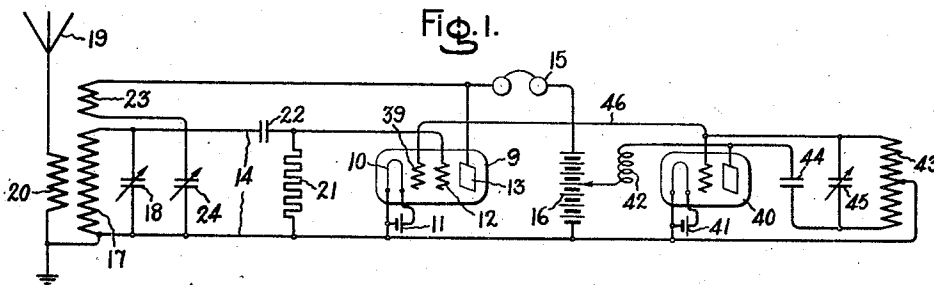
Nov. 24, 1931.

J. T. McLAMORE

1,833,788

HIGH FREQUENCY ELECTRICAL APPARATUS

Filed May 18, 1928



Inventor:
John T. McLamore,
by *Charles E. Tuller*
His Attorney.

UNITED STATES PATENT OFFICE

JOHN T. McLAMORE, OF SCOTIA, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK

HIGH FREQUENCY ELECTRICAL APPARATUS

Application filed May 18, 1928. Serial No. 278,896.

My invention relates to high frequency electrical apparatus employing electron discharge devices, the plate and grid circuits of which are coupled in any suitable manner to provide a feed back of energy or regeneration. More particularly my invention relates to radio receiving apparatus so arranged that the degree to which regeneration may be carried determines in a large measure its degree of response or sensitivity to signal energy.

In regenerative apparatus of this character heretofore provided, the response or sensitivity has been limited by the tendency of the electron discharge device furnishing the regeneration to set up a sustained oscillation in the circuits connected with it when the regeneration was increased beyond a certain point. The sustained oscillation causes distortion or loss of the signal being received and thus while it occurs before the full limit of regeneration is reached, it sets up a definite limit to the actual use of regeneration in such apparatus. The well known regenerative detector arrangement used in broadcast reception furnishes a good example of apparatus of this character.

Various methods and means have been resorted to heretofore in order to carry the effective regeneration to a higher maximum beyond the point of oscillation but without permitting the oscillation to occur, or without permitting it to interfere with the reception of desired signals. This is commonly known as superregeneration, but in accordance with the methods and means heretofore employed, it has in each instance been subject to certain disadvantages and for this reason its use has been limited.

In conjunction with tuned circuits, for example, where it should find the greatest use, superregeneration or the means employed to obtain it has resulted in a damping of the tuned circuits to which it applied and an undesirable broadening of the tuning of such circuits, together with such instability as to render circuits embodying it unsuited for general commercial use.

Appreciating the advantages of superregeneration and realizing the inherent defects in methods and means heretofore known, I have succeeded in providing an improved method, and means for carrying out the method whereby full advantage may be taken in high frequency apparatus embodying regenerative electron discharge devices, of the regeneration possibilities beyond the point at which oscillation would normally occur, and without damping or broadening the tuning of connected or associated tuned circuits and without interfering with the reception of signals.

My invention will be better understood from the following description when considered in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

In the drawings, Fig. 1 is a wiring diagram of a regenerative circuit for an electron discharge device arranged in accordance with my invention, and Figs. 2 to 5 inclusive are curves illustrating the operation of such a circuit.

Referring to Fig. 1, 9 is an electron discharge device having a filament or cathode 10 excited from a suitable source, such as a battery 11, a control grid 12 and a plate or anode 13. The control grid is connected with an input or grid circuit 14 for receiving signals to be amplified or transmitted through the electron discharge device to a receiving device or apparatus, represented in the present example by telephone receivers 15, the latter being connected between the plate 13 and a source of plate voltage represented by a battery 16. With this arrangement the receiving device is actuated in response to signal voltage impressed upon control grid 12 as is well known and understood.

In the present example the grid circuit 14 includes a tuning means, such as a coil or inductance 17 and shunt variable condenser or capacity 18 which together with coil 17 represents any suitable tuning means and is coupled to an antenna 19 for receiving signals therefrom. The grid circuit is also indicated as being provided with means for operating the electron discharge device as a detector for the rectification of signals. For this purpose a usual grid leak and stopping condenser, 21

and 22 respectively, are provided in the circuit.

Regeneration is effected by suitably coupling the plate and grid circuits, and in the present example is produced by a feed-back coil 23 connected with the plate and inductively coupled with tuning or grid coil 17 as indicated. A variable condenser 24 in circuit with the coil serves to control the feed-back of energy or coupling between the plate and grid circuits, and with the circuit shown represents one of several well known arrangements for obtaining and controlling regeneration in connection with an electron discharge device.

Together with the tuning circuit and output or receiving device 15, the arrangement thus far described is a common and simple form of regenerative receiver such as may be used for broadcast reception for example, and represents any regenerative circuit arrangement embodying an electron discharge device capable of operating in such a circuit.

With this arrangement as is well known, useful regeneration may be carried up to the point of oscillation which may be represented at 25 on curve 26 shown in Fig. 2, the curve being plotted against the degree of sensitivity along ordinate 27 and against regeneration along abscissa 28. The dotted portion of the curve represents the further available range of sensitivity beyond the point of oscillation, with increased regeneration.

When the circuit connected with the electron discharge device regenerates beyond the point indicated at 25 the oscillation is of a sustained nature indicated by voltage curve 29 in Fig. 3 when plotted against voltage amplitude along ordinate 30 and time along abscissa 31. This sustained oscillation, of the frequency to which circuit 14 is tuned, causes distortion of the signal and is undesirable particularly in the reception of modulated radio frequency signals used in broadcasting.

Regeneration may, however, be carried into the range of superregeneration beyond the normal point of oscillation by suppressing the oscillation so that it is no longer sustained or continuous in character, and in accordance with my invention this result is accomplished in such a manner and by such means that the tuning or receiving circuit of the electron discharge device is not damped or appreciably broadened in its response to signal frequencies.

In accordance with my invention an electron discharge device having a space charge grid subjected to a variable or controlled frequency oscillation voltage to vary the space charge at a certain frequency is utilized. This frequency may be above, below or within the audible range, depending upon the frequency of the received signal and the type of reception that is desired. This controlled frequency

oscillation may be fixed for any type of reception and signal frequency. For broadcast reception for example as applied to the circuit of Fig. 1, this frequency should preferably be slightly above the audible range and is represented by voltage curve 32 on Fig. 4 and plotted against amplitude along ordinate 33 and time along abscissa 34.

When applied to a regenerative electron discharge device to vary the space charge therein, the variation or controlled frequency oscillation voltage applied to the space charge control grid will alternately buck and boost the effect of the space charge. When the space charge grid is at a positive potential, the effect of the space charge will be reduced and in some cases may be entirely overcome depending upon the magnitude of the variation frequency voltage.

When the electron discharge device is in this state and regeneration is carried above the oscillating point, it will function in the manner described in connection with Figs. 1, 2 and 3 and will start to oscillate. The strength or magnitude of the oscillation will increase as the positive potential on the space charge grid increases. When this potential starts to increase in a negative direction the magnitude of the oscillation will decrease and when the potential has reached a sufficiently negative value the oscillation will stop.

In Fig. 5 is shown the resultant frequency oscillation obtained by varying the space charge of an electron discharge device in accordance with a frequency indicated in Fig. 4, when the device is providing regeneration sufficient to set up a sustained oscillation indicated in Fig. 3. The curves are plotted along coordinates 35 and 36 corresponding to those of Figs. 3 and 4, curves 37 being the suppressed oscillation frequency voltage and curve 38—38—38 being the resultant oscillation frequency voltage.

Since the oscillation builds up and is suppressed periodically depending upon the variation frequency oscillation, there is no sustained oscillation and only a resultant frequency oscillation below the desired frequency range and above the audible range. Hence it causes no interference, and regeneration beyond the normal point of oscillation into the range of superregeneration indicated by the dotted portion of curve 26, Fig. 2 is made practically possible.

Electron discharge devices suitable for carrying out my invention for obtaining superregeneration are available commercially and have proved satisfactory in operation. One type of such device is a four element vacuum tube having a double grid, one grid being immediately adjacent or surrounding the cathode or filament and the other being located between the first grid and the anode or plate. The latter grid is used as the ordinary con-

trol grid while the grid adjacent the filament is used as the space charge grid.

Any suitable means for impressing a controlled frequency voltage on the space charge grid may be used with any suitable electron discharge device having this and the other required elements for regeneration. By way of example a suitable arrangement embodying the space charge grid and means for applying the variation frequency voltage thereto is shown in connection with the regenerative detector means of Fig. 1.

Referring again to Fig. 1, 39 is a space charge grid or space charge control grid arranged in the electron discharge device 9 adjacent the filament. This in no way changes its operation as hereinbefore described. This device may be the available commercial type of four element double grid device which is known commercially as a screen-grid tube. This is provided with an outer or screen grid which in carrying out my invention I use as the control grid 12 and an inner grid which I use as the space charge or space charge control grid 39. However any other suitable electron discharge device having a space charge control means may be used.

Connected with grid 39 to provide the controlled frequency voltage variation is a local oscillator or generator of sustained oscillations comprising a three element electron discharge device 40 having a filament supply 41 and taking plate current from source 16 through a choke coil 42. 43 is the oscillator coil connecting the grid and plate of the tube through a stopping condenser 44. The oscillator coil is tuned by a variable capacity or condenser 45 to the desired variation frequency. In the present example the voltage variation at this frequency in the oscillator coil is impressed upon space charge grid 39 through a connection 46 with the oscillator grid. The local oscillator or oscillation generator arrangement is a common and well understood form of this type of device and is thought to require no further explanation. It represents any suitable means for impressing a voltage on space charge grid 39 at a controlled frequency.

By thus utilizing in a regenerative circuit arrangement an electron discharge device having a space charge grid, and impressing thereon a suitable voltage at a controlled frequency differing from and preferably below the frequency range of received signals sustained oscillations therein in the range of superregeneration are suppressed periodically and received signals are correspondingly amplified and carried through the circuit without distortion or interference and wholly without appreciably damping the tuned or grid circuit of the electron discharge device or appreciably broadening the tuning response of said circuit.

In the reception of telegraph signals at

a fixed audio frequency, this method is particularly desirable since the variation frequency may be set within the audible range to produce a resultant frequency having a fixed audible note.

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

1. The combination with an electron discharge device having regeneration means associated therewith and having a space charge grid, of means connected with said grid for varying the space charge in said device at a controlled frequency, said regeneration means being arranged to produce regeneration of a predetermined amount and said second-named means being arranged to vary said space-charge through a predetermined amplitude, periodically to permit said regeneration to increase above the point of oscillation and to cause said regeneration to decrease below the point of oscillation.

2. The combination with an electron discharge device having regeneration means associated therewith and having a space charge grid, said regeneration means being arranged to produce a predetermined normal degree of regeneration, of means for varying said regeneration periodically, said means including means connected with said grid for applying thereto an alternating voltage at a controlled frequency, to cause groups of oscillations to occur in said device, the group frequency of said oscillations being equal to that of said alternating voltage.

3. In a regenerative apparatus, the combination of an electron discharge device and a tuned regenerative circuit connected therewith for producing a predetermined normal degree of regeneration, said device having a space charge control grid, and an oscillator connected with said space charge control grid, periodically to permit said regeneration to increase above the point of oscillation and to cause said regeneration to decrease below the point of oscillation.

4. The combination with an electron discharge device having a control grid, an anode and a space charge grid, of an anode circuit, a circuit tunable over a range of frequencies connected with said control grid, means providing a regenerative coupling between the tunable circuit and the anode circuit, said regenerative coupling means being arranged to provide a predetermined degree of regeneration between said anode circuit and said tunable circuit, and means for varying said regeneration periodically including means connected with said space charge grid for applying an alternating voltage thereto at a controlled frequency, to cause groups of oscillations to occur in said device, the group frequency of said oscillations being equal to that of said alternating voltage.

5. The combination with an electron discharge device having a control grid, an anode

and a space charge grid, of an anode circuit, a tuned circuit connected with the control grid, means providing a variable regenerative coupling between said tuned circuit and said
5 anode circuit, said regenerative coupling means being arranged to provide predetermined degrees of regeneration between said anode circuit and said tuned circuit, and means for varying said regeneration periodically,
10 said means including means connected with said space charge grid for applying an alternating voltage thereto at a controlled frequency, to cause groups of oscillations to occur in said device, the group
15 frequency of said oscillations being equal to that of said alternating voltage.

6. The combination with an electron discharge device having a grid circuit and a plate circuit, and means for variably coupling
20 said circuits to produce a normally sustained oscillation in said grid circuit, of means for suppressing periodically said normally sustained oscillation including a space charge grid in the electron discharge device and a
25 generator of sustained oscillations of a differing frequency connected with said last-named grid for impressing thereon a voltage at said differing frequency, the frequency of suppression of said normally sustained oscillations being equal to that of the sustained oscillations provided by said generator.

7. The combination with an electron discharge device having a control grid, an anode and a cathode, of a tuned regenerative circuit connected with said electrodes of the
35 device, and means for periodically suppressing normally sustained oscillations in said regenerative circuit including a second grid arranged to control the space charge of said
40 device and an oscillation generator connected with said grid, said generator being tunable to apply an alternating voltage to said second grid at a frequency differing from that to which said regenerative circuit is
45 tuned.

In witness whereof, I have hereunto set my hand this 17th day of May, 1928.

JOHN T. McLAMORE.

50

55

60

65