Aug. 11, 1936. W. VAN B. ROBERTS 2,050,807

SUPERHETERODYNE RECEIVER

Original Filed June 2, 1932

Fig. 1

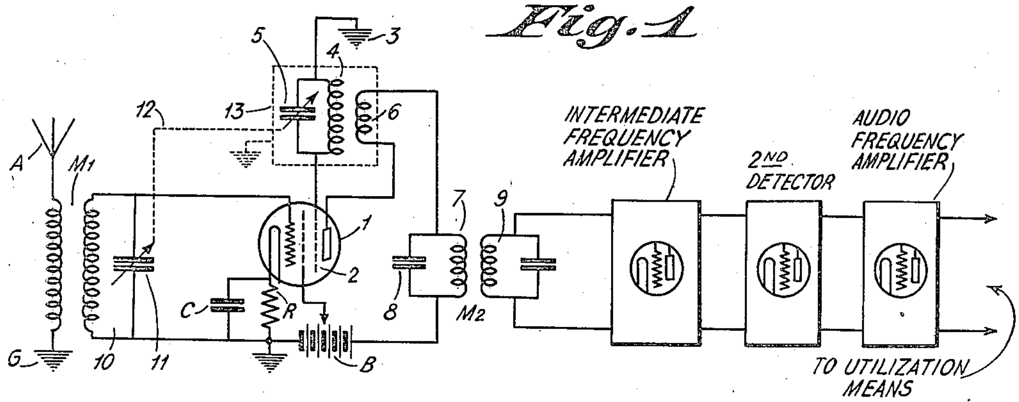


Fig. 2

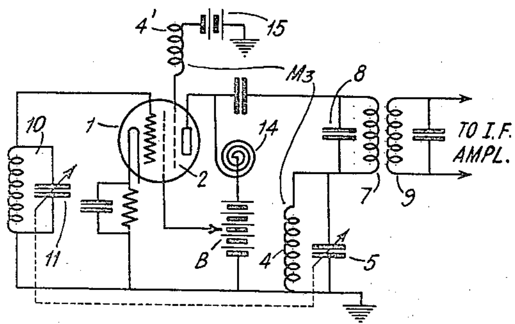


Fig. 3

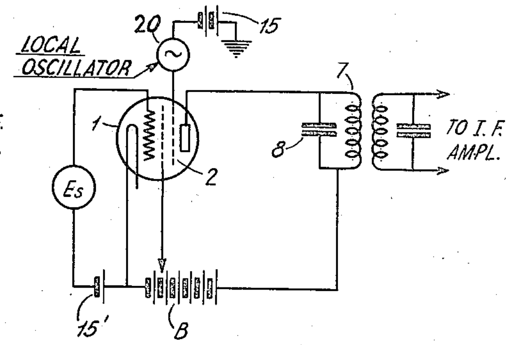


Fig. 4

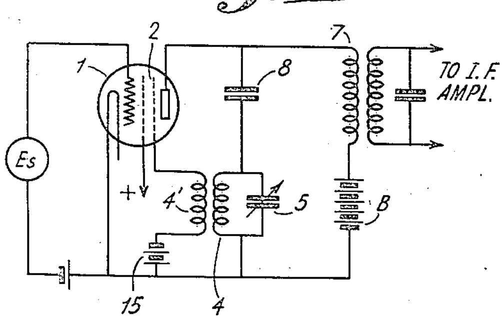
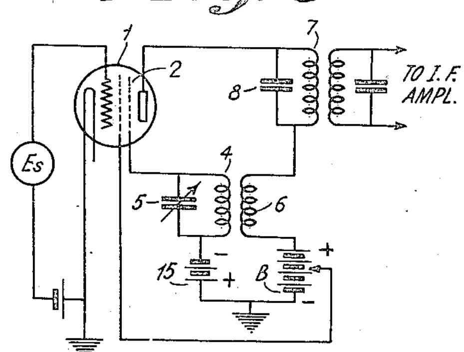


Fig. 5



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SUPERHETERODYNE RECEIVER

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6 Claims. (Cl. 250—20)

My present invention relates to heterodyne systems, and more particularly to a superheterodyne receiver including a novel type of frequency changer.

A modern type of multi-electrode electron discharge tube which is known as a radio frequency pentode tube utilizing a suppressor grid, lends its self in an effective manner to utilization in the frequency changer circuit of a superheterodyne receiver. This type of suppressor grid tube briefly comprises the usual cathode, control electrode and anode, a positive screen grid being disposed between the control grid and the anode for shielding the anode, the suppressor grid consisting of a grid disposed between the screen grid and the anode, and usually surrounding the screen grid, the suppressor grid being maintained at negative potentials with respect to cathode potential.

Now, I have discovered that the suppressor grid of this type of pentode tube can be readily used, in the frequency changer circuit of a superheterodyne receiver, as a control electrode of an electronic system including the screen grid, functioning simultaneously as a source of electrons, and the anode.

Accordingly, it may be stated that it is one of the main objects of my present invention to provide a composite detector-oscillator for a heterodyne receiving system, the composite detector-oscillator, or frequency changer, including an electron discharge tube having its cathode and control electrode coupled to a source of signal energy, and having a suppressor grid disposed between a positive screen grid and an anode, the suppressor grid being arranged to have local oscillations impressed thereon, and the control electrode functioning to modulate the action of the suppressor grid and the anode, while the screen grid not only functions as an electrostatic shield between the suppressor grid and anode and the input electrodes, but also as a virtual cathode with respect to the suppressor grid and anode.

Another important object of the present invention is to provide a frequency changer circuit for a superheterodyne receiver, which circuit comprises but a single tube upon whose input electrodes is impressed desired modulated signal energy, the anode of the tube being regeneratively coupled with an outer grid which is operated at negative potentials with respect to cathode potential, a middle grid, being disposed between the control electrode and the outer grid, functioning as a screen electrode as well as a virtual cathode for the outer grid and the anode.

Another object of the present invention is to provide a radio receiver of the superheterodyne type which comprises an intermediate frequency amplifier having its input coupled to the output circuit of a single tube frequency changer, the tube being a radio frequency pentode tube employing a grounded suppressor grid, the anode circuit of the tube being coupled to the suppressor grid, a source of signal energy being coupled between the control electrode and a cathode which is at a positive potential with respect to the control electrode and suppressor grid.

Still other objects of the present invention are to improve generally the simplicity and efficiency of frequency changer circuits, and to particularly provide a superheterodyne receiver which includes a composite first detector-oscillator which is not only durable and reliable in operation, but economically manufactured and assembled.

The novel features which I believe to be characteristic of my invention are set forth in particularity in the appended claims, the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawing in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawing,

Fig. 1 diagrammatically shows a circuit embodying the present invention,

Fig. 2 shows another form of the invention,

Fig. 3 shows another embodiment of the invention wherein an external source of local oscillations is employed,

Fig. 4 shows still another modification, and

Fig. 5 is still another embodiment of the invention.

Referring now to the accompanying drawing in which like characters of reference indicate the same circuit elements in the different figures, there is shown diagrammatically in Fig. 1 a conventional type of superheterodyne receiver which comprises the usual grounded antenna circuit A, G, which is coupled, as at M_1 to the tunable input circuit of the composite detector-oscillator which forms the subject matter of the present invention.

The composite detector-oscillator includes a tube 1 which is known as a radio frequency pentode tube and employs a suppressor grid 2. This suppressor, or outer, grid is grounded, as at 3, and includes in series therewith a tunable anti-resonant oscillation circuit comprising an inductance coil 4 and a variable tuning condenser 5. The anode of tube 1 is connected to the positive terminal of a source of current B through an inductance coil 6, inductively coupled to the coil 4, and an anti-resonant oscillation circuit comprising an inductance coil 7 and a fixed condenser 8.

The circuit 7, 8 is maintained fixedly resonant to the desired intermediate frequency, as is well known to those skilled in the art, and this circuit is coupled, as at M_2, to a second oscillation circuit 9 which is connected in the input of the usual intermediate frequency amplifier. The output of the intermediate frequency amplifier is shown connected to a second detector, an audio frequency amplifier and to any type of utilization means, such as a loud speaker, head phones, or the like. It is to be clearly understood that these elements following the composite detector-oscillator tube 1 are conventional in nature, and are well known to those skilled in the art, the present invention residing in the tube 1 and its associated circuits.

The control grid of tube 1 is connected to the high potential side of the tunable input circuit 10 of tube 1, while the cathode is connected to the low potential side thereof. The variable tuning condenser 11 is arranged to be mechanically operated with the condenser 5, and any arrangement well known to those skilled in the art may be employed for this purpose, it being pointed out that the dotted lines 12 designate a mechanical uni-control device for operating the rotors of condensers 11 and 5 in such a manner that a constant difference frequency is maintained between the tuned circuits 10 and 5, 4 throughout the tuning range of the receiver.

One method of maintaining such a constant difference frequency between the two circuits is disclosed by W. L. Carlson in U. S. Patent 1,740,331 of December 17, 1929.

It will be understood, of course, that the circuit 5, 4 is tuned to the different local oscillation frequencies desired for the heterodyning purpose. The cathode circuit includes the usual grounded control grid bias resistor R, shunted by a radio frequency by-pass condenser C. In order to electrostatically shield the tuned circuit 5, 4 and the feed-back coil 6, a grounded metallic screen 13 may be disposed around these last mentioned circuit elements.

In considering the functioning and operation of the arrangement shown in Fig. 1, it should be understood that, in general, the grid nearest the anode, that is the grid 2, may be operated at low, or negative, potentials, and thus functions in the manner of a control grid. The inner grid, that is the usual control grid, then acts to "modulate" the action of the outer grid 2 and anode, while the middle grid, or screen grid, acts as an electrostatic screen as well as a virtual cathode for the outer electrodes, that is the suppressor grid 2 and the anode. It is not believed necessary to go into the details of the physical and electrical phenomena which occur in the operation of tube 1. It is believed sufficient to point out that the functioning of the composite detector-oscillator circuit is along the following lines:

Any convenient oscillator circuit of the feedback type, such as formed by elements 4, 5 and 6 of Fig. 1, is arranged to produce oscillations in cooperation with the grid 2 acting as control grid on the electron stream to plate 1, said stream issuing from the screen grid which thus may be considered as a virtual cathode. The strength of oscillations thus generated depends upon the strength of the electron stream above mentioned, and this in turn depends upon the potential of the inner grid, that is, the grid next to the actual cathode. Thus the oscillation strength is varied in accordance with the signal voltage impressed on the inner grid which results, as is well known in the art, in the production of currents in the plate circuit of frequencies equal to the sum and difference of the signal and oscillation frequencies. Either the sum or the difference (but usually the difference) may be used as the intermediate frequency to which circuit 7, 8 is tuned.

In Fig. 2 there is shown a modified form of the invention, the tube 1 having its input electrodes coupled between opposite sides of the tuned circuit 10, as in Fig. 1, and the output oscillation circuit 7, 8 being coupled to the input of the intermediate frequency amplifier in the same manner as in Fig 1. The arrangement shown in Fig. 2 differs from that shown in Fig. 1 in that the tunable local oscillation circuit 4, 5 is disposed in the anode circuit of the tube, whereas in Fig. 1 it is connected in the suppressor grid circuit. Positive potential is supplied to the anode through a radio frequency choke 14, a direct current blocking condenser being connected between the anode and the inductance coil 7.

In order to provide local oscillations, the coil 4, one side of which is grounded, is inductively coupled, as at M_3, to the coil 4′ connected in series with the suppressor grid 2. It will be noted that the suppressor grid 2 is maintained at a more negative potential with respect to the cathode than is the inner grid by means of a biasing source 15 having its negative potential connected to one side of the coil 4′, while its positive terminal is grounded. This arrangement is used because I have found this additional bias advantageous with some tubes. The operation of this form of invention is substantially identical with that described in connection with Fig. 1.

Still another form of the invention is shown in Fig. 3, and in this form of the invention the suppressor grid 2 of the tube 1 has impressed upon it local oscillations from an external local oscillator 20. One side of the local source of voltage 20 is connected to the negative terminal of the biasing source 15, while the positive terminal of the source 15 is grounded. The control grid of tube 1 is shown biased by a negative biasing source 15′ and the source of signal energy is shown connected between the control grid and cathode of tube 1, it being conventionally designated by the symbol E_s. In this form of the invention it is not of course, necessary to couple the anode circuit to the suppressor grid circuit. However, the action of the circuit including tube 1 is still the same as in the case of Figs. 1 and 2. Here, as in the last mentioned two figures, the suppressor grid 2 functions in the manner of a control grid, and the usual control grid functions to modulate the action of the suppressor grid, the screen grid again operating as a virtual cathode for the anode and outer grid 2, while also acting as an electrostatic screen.

In Fig. 4 is shown another modification wherein the source of anode potential B has its negative terminal connected to one side of the tunable local oscillation circuit 4, 5, the coil 4 being inductively coupled with the inductance coil 4′ connected in series between the suppressor grid 2 and the negative terminal of the biasing source 15. The positive terminal of the source 15 is connected to the cathode side of tube 1. It will be observed that this arrangement is quite similar to that shown in Fig. 2 since the tunable oscillation circuit is disposed in the anode circuit of tube 1, while the suppressor grid is maintained at a more negative potential than the cathode of tube 1.

The difference between this arrangement and that shown in Fig. 2 resides in the fact that coil 7 of the intermediate frequency tuned circuit is of sufficient inductance, usually, to allow it to act as a choke for the oscillation frequency while the condenser 8 acts as the blocking condenser which prevents the plate direct current potential from reaching the tuning condenser **5** and coil **4**. Where the intermediate frequency is sufficiently low to permit this arrangement it is preferable because it does not require an additional choke and blocking condenser. It will be obvious to one skilled in the art that the oscillator tuning condenser **5** may be equally well connected across coil **4'**, or between the "live" ends of coils **4** and **4'**, in Figs. 2 and 4.

In Fig. 5 is shown a form of the invention wherein, as shown in Fig. 1, the tunable oscillation circuit **5**, **4** is disposed in series with the suppressor grid, one side of the circuit being connected to the negative terminal of the suppressor grid biasing source **15**. The anode circuit of tube **1** includes a feed-back coil **6** which is inductively coupled with the coil **4**, and it will be noted that the negative terminal of the source B is grounded in common with the positive terminal of source **15**. The difference between this circuit and that shown in Fig. 1 resides in the fact that the intermediate frequency circuit and coil **6** are interchanged in series position, and extra bias is shown on the suppressor grid.

While I have indicated and described several systems for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organizations shown and described, but that many modifications may be made without departing from the scope of my invention as set forth in the appended claims.

What I claim is:

1. An oscillator-converter comprising a tube provided with a cathode, a signal grid, an anode, a local oscillation grid, and an auxiliary grid between said signal and local oscillation grids, a tunable signal circuit between the signal grid and cathode, a tunable local oscillator circuit electrically associated with said oscillation grid, an intermediate frequency circuit in said anode circuit, means for maintaining said oscillation grid negative with respect to said cathode, said auxiliary grid acting as an electrostatic screen between said signal and oscillation grids, and as a virtual cathode, said oscillator circuit being connected between the anode and cathode and being included in said intermediate frequency circuit.

2. An oscillator-converter comprising a tube provided with a cathode, a signal grid, an anode, a local oscillation grid, and an auxiliary grid between said signal and local oscillation grids, a tunable signal circuit between the signal grid and cathode, a tunable local oscillator circuit electrically associated with said oscillation grid, an intermediate frequency circuit in said anode circuit, means for maintaining said oscillation grid negative with respect to said cathode, said auxiliary grid acting as an electrostatic screen between said signal and oscillation grids, and as a virtual cathode, said intermediate frequency circuit including a condenser and a coil, said local oscillator circuit being arranged in series with said coil and condenser.

3. Means for producing oscillation including a plate, grid and electron stream source, means for maintaining said grid substantially more negative than said source, means for controlling the strength of said oscillations in accordance with a signal, comprising a second grid, the first grid being maintained at a substantially more negative potential than said second grid, and the latter being it a substantial negative bias with respect to said source, and means for shielding one grid from the other comprising a third grid interposed between them, and utilization means associated with said anode for utilizing currents of frequency equal to the difference of the oscillation and signal frequencies, said utilization means including a coil shunted by a condenser, and a tunable local oscillator circuit connected in series between the cathode and said utilization means.

4. In a modulated carrier wave receiver, a mixer network comprising an electron discharge tube of the type including at least an electron emitter, a positive output anode, a control grid, a resonant wave input circuit connected between the emitter and grid, an oscillation circuit connected between the anode and emitter, said oscillation circuit being tuned to a frequency differing from the wave frequency, a second oscillation circuit, tuned to the difference frequency, connected between the anode and emitter, a cold electrode disposed within the tube to affect the electron stream thereof, means reactively coupling the cold electrode to the anode, means for maintaining said cold electrode and control grid at negative direct potentials with respect to the emitter, and a positive cold electrode disposed between the control grid and cold electrode.

5. In a modulated carrier wave receiver, a mixer network comprising an electron discharge tube of the type including at least an electron emitter, a positive output anode, a control grid, a resonant wave input circuit connected between the emitter and grid, an oscillation circuit connected between the anode and emitter, said oscillation circuit being tuned to a frequency differing from the wave frequency, a second oscillation circuit, tuned to the difference frequency, connected between the anode and emitter, a cold electrode disposed within the tube to affect the electron stream thereof, means reactively coupling the cold electrode to the anode, means for maintaining said cold electrode and control grid at negative direct potentials with respect to the emitter, and a positive cold electrode disposed between the control grid and cold electrode, said positive electrode being at the same alternating potential as the emitter whereby it acts as an electrostatic screen.

6. In a modulated carrier wave receiver, a mixer network comprising an electron discharge tube of the type including at least an electron emitter, a positive output anode, a control grid, a resonant wave input circuit connected between the emitter and grid, an oscillation circuit connected between the anode and emitter, said oscillation circuit being tuned to a frequency differing from the wave frequency, a second oscillation circuit, tuned to the difference frequency, connected between the anode and emitter, a cold electrode disposed within the tube to affect the electron stream thereof, means reactively coupling the cold electrode to the anode, means for maintaining said cold electrode and control grid at negative direct potentials with respect to the emitter, and a positive cold electrode disposed between the control grid and cold electrode, said negative cold electrode being disposed between the anode and the positive cold electrode.

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