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2,122,283

FREQUENCY CONVERTER

Filed March 9, 1937

2 Sheets-Sheet 1

Fig. 1

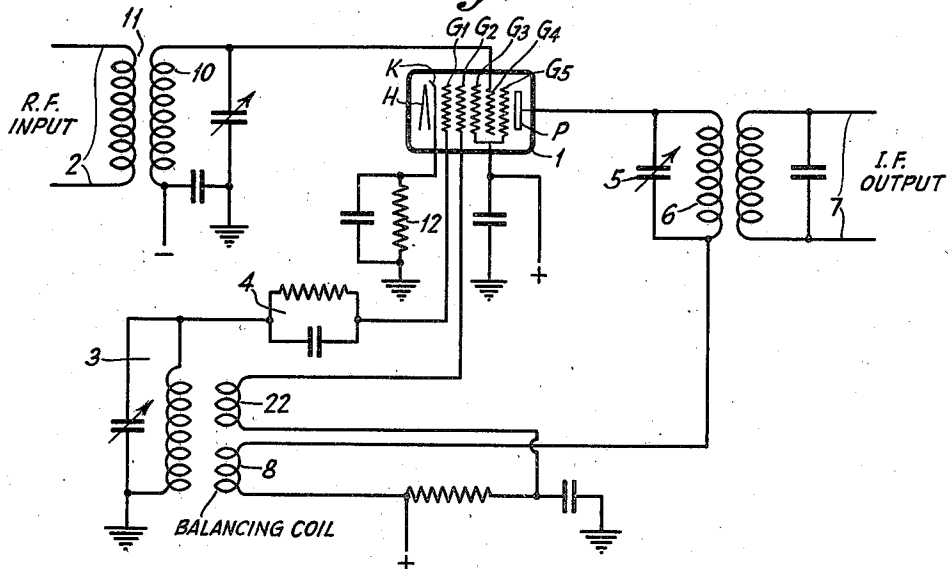
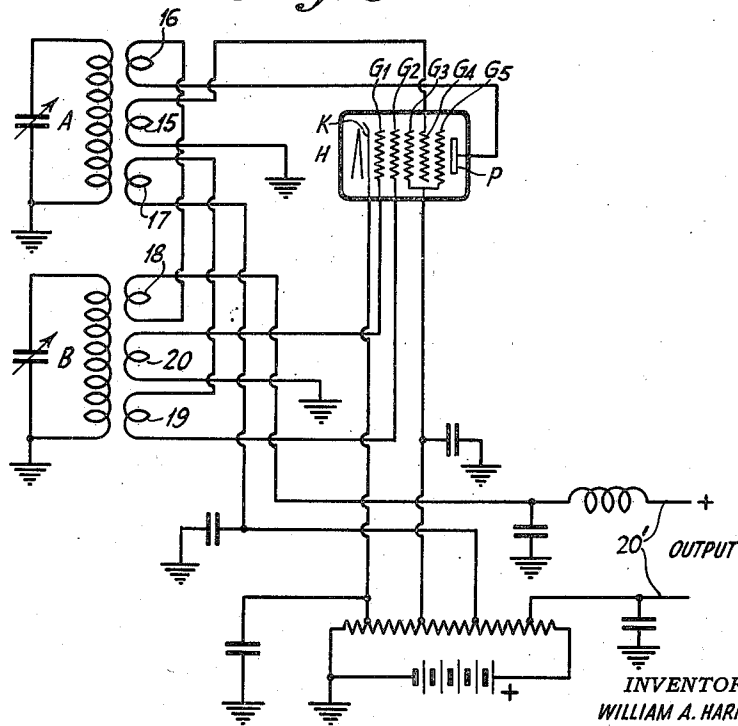


Fig. 2



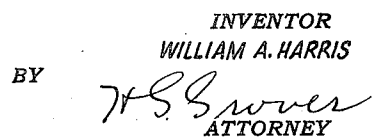
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UNITED STATES PATENT OFFICE

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FREQUENCY CONVERTER

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6 Claims. (Cl. 250—20)

This invention relates to vacuum tube circuits and more particularly to such circuits wherein oscillations from two sources or channels are united through a suitable mixing means to provide a beat or common output signal.

It is customary, in certain types of receivers, such as a super-heterodyne circuit, to employ a multi-grid converter or frequency changing tube to combine two different signals, such as a radio signal and the local oscillator signal, and to apply the resultant beat frequency signal to an output circuit, such as the intermediate frequency amplifier. In these frequency changing circuits difficulties have heretofore been experienced in preventing interaction between the circuits. Where the multi-grid tube is used as a beat frequency oscillator, it is of special importance that the two oscillator circuits be unaffected by each other, in order to prevent the circuits from pulling together when the separation of the frequencies is small.

Accordingly, one of the objects of the present invention is to provide an improved signal transmission system wherein oscillations from two signal channels may be combined and provided with an output circuit, without interaction the one upon the other, whereby said channels function independently of each other.

A more specific object is to provide an improved detector-oscillator system for a heterodyne type of receiver employing a single pentagrid electric discharge device as a combined detector and oscillator.

A further object is to provide an improved beat frequency oscillator wherein two signal channels, either or both of which may be a local regenerative oscillator, are mixed in a single multi-grid electric discharge device, the beat frequency being obtained in an output circuit, while each signal channel is maintained electrically independent with respect to the other.

In accordance with the invention, two signal channels are combined in a pentagrid electron discharge device which has, in the order named, a cathode, a first signal grid, an anode-grid, a shielding grid, a second signal grid, another shielding grid, and an output anode. The two signal grids are at negative potentials and the two shielding grids at a positive potential with respect to the cathode. The grids are interposed in the electronic stream between the cathode and output-anode in series relation to each other, whereby the electronic stream traverses first the one signal grid and then the other. For eliminating or reducing the effect of the signal voltage

from one signal channel upon the other signal channel, there is provided, in one embodiment, a coil in series with the output anode circuit for inducing in said other channel a voltage which neutralizes or balances out the components produced in the signal grid directly associated with said other channel by the first channel. According to another embodiment of the invention, there is provided in circuit with each signal channel, a separate coil associated with the electronic path of the electric discharge device for eliminating or reducing the effect of the signal voltage on said channel produced by the other channel. Stated in other words, and more specifically in accordance with the invention, two preferably negative and high input impedance signal grids are arranged in a common envelope of an electric discharge device to control, in series relation to each other, a common electronic stream, the grids being shielded one from the other by another electrode, or other electrodes, at a positive potential, said signal grids being utilized to operate at different signal frequencies, there being provided means external of the electric discharge device for preventing interaction of the input circuits upon one another.

One feature of the invention lies in the use of an additional balancing coil which is magnetically coupled to the output anode circuit for eliminating or reducing the undesired effects of the oscillator frequency voltage in the output.

A more detailed description of the invention follows, accompanied by drawings wherein:

Fig. 1 illustrates the invention in simplified form, as applied to a superheterodyne receiving system;

Fig. 2 illustrates another embodiment of the invention as applied to a beat frequency oscillator having two regenerative local oscillators connected to the signal grids and supplied with energy from the single electric discharge device; and

Fig. 3 illustrates a modification of the embodiment of Fig. 1 provided with an additional coil coupled to the output circuit for reducing the undesired effects of the oscillator frequency upon the output circuit.

Referring to Fig. 1, there is shown coupled to a combined first detector and oscillator pentagrid electric discharge device 1, a radio frequency signal input channel 2 connected to a signal grid G4, a local oscillatory regenerative circuit 3 coupled to a signal grid G1 through a grid leak and condenser combination 4, and an output circuit comprising a condenser 5 and an induct-

ance coil 6 coupling the anode P on one end to an intermediate frequency signal output channel 7, and on the other end to the oscillatory circuit 3 through a balancing coil 8.

5 The device 1 is a multi-grid device of the 2A-7 or 6A-7 type having within an evacuated envelope the usual cathode K heated by heater element H and an anode P between which, in series relation, along the electronic stream, are
10 interposed five other electrodes or grid elements G1, G2, G3, G4, and G5, being respectively a negative signal grid, a positive anode-grid, a positive screen grid, a negative signal grid, and a positive screen grid, both screen grids G3 and
15 G5 being directly connected together, as shown. The second signal grid G4 is connected with the signal or radio frequency input channel through the secondary 10 of the input transformer 11, and the grid circuit therefor is returned to the
20 cathode K through ground and a suitable biasing resistor 12.

The first control grid G1 is coupled through a suitable grid leak 4 to the local oscillatory circuit 3 which is regeneratively coupled back
25 through coil 22 to the positive anode-grid G2, for obtaining therefrom suitable exciting potentials. Local oscillatory circuit 3 is tuned to a desired frequency in order to produce in the output circuit 5, 6 the desired intermediate frequency.
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The screen grid electrodes G3, G5, are interposed between the control electrodes G1 and G4, and also between G4 and the output anode P, and are operated at a positive potential from a suitable
35 source, as indicated.

It should be noted that any increase in the positive potential on signal grid G4 will increase the flow of electrons to the output-anode P. We can thus say that the transconductance between signal
40 grid G4 and output anode P is positive, because of increase in electron flow to anode P upon a positive increment of voltage on G4. Expressed in another way, $S_{mG4, P}$ is positive. Simultaneously an increase in the positive potential
45 on G4 will cause a decrease in the flow of electrons to the anode-grid G2. It will thus be seen that the transconductance between signal grid G4 and anode-grid G2 is negative. Putting it
50 another way, $S_{mG4, G2}$ is negative. On the other hand, an increase in the positive potential on G1 will cause an increase in the electron flow to the output-anode P and also an increase in the electron flow to grid-anode G2. Thus, $S_{mG1, P}$ and
55 $S_{mG1, G2}$ are both positive. To overcome the reaction of the radio frequency input signal applied to signal grid G4 on the oscillator circuit 3 connected to grid G1, there is provided a balancing coil 8 which is conductively connected to the
60 output-anode P through coil 6 and is magnetically coupled to the inductance of the oscillatory circuit 3 for producing in the local oscillatory circuit, neutralizing or balancing potentials of such phase and magnitude as to eliminate or
65 reduce the effect of the radio frequency signal voltage on the oscillatory circuit applied to the oscillatory circuit through the interaction in the device. Coil 8 tends to increase the desired component of voltage of oscillatory frequency while eliminating the undesired component of
70 signal frequency because of the positive and negative transconductances mentioned above.

Fig. 2 shows a beat frequency oscillator comprising two local oscillatory circuits generating different frequencies and so coupled to the electric
75 discharge device 1 as to prevent one oscillatory

circuit from interacting upon the other, thus obviating any tendency for the two oscillators to pull or entrain together. This tendency of the oscillatory circuits to pull together is especially noticeable when the frequencies generated by the separate channels are very close together. The principle of operation is similar to that which has been described above in connection with Fig. 1.

In Fig. 2 both oscillatory circuits A and B are shown as consisting of a parallel combination of inductance coil and condenser, the inductance coil of each circuit being inductively coupled to three other coils, one of which is connected to a signal grid, the second of which to the output-anode circuit for obtaining regenerative potentials
15 therefrom, and a third of which is provided for producing the balancing or neutralizing effect to overcome interaction caused by the device.

Oscillatory circuit A is coupled through coil 15 to the signal grid G4 of the electric discharge device 1, and obtains its regenerative potential from the output anode P through coil 16, and also from anode-grid G2 through coil 17. When coils 16 and 17 are connected in this regenerative sense, a voltage on signal grid G1 produces an effect
25 in circuit A, through the anode P and coil 16. At the same time the voltage on signal grid G1 will produce an opposite effect in circuit A, through the anode-grid G2 and coil 17. These two effects are made to be equal in magnitude by
30 adjustment of the coupling or number of turns on the coils and since the effects are of opposite phase, the net voltage produced on circuit A by the voltage on signal grid G1 is zero. Oscillatory circuit B is shown coupled to signal grid G1 by
35 means of coil 20, and obtains its regenerative potentials from the anode P through coil 18 and also from anode-grid G2 through coil 19. When coils 18 and 19 are connected in this regenerative sense, a voltage on grid G4 produces an effect in
40 circuit B through the anode P and coil 18. At the same time the voltage on signal grid G4 will produce an opposite effect in circuit B through the anode-grid G2 and coil 19. These two effects are made to be equal in magnitude and since they
45 are of opposite phase, the net voltage produced in circuit B by the voltage on signal grid G4 is zero.

The foregoing neutralizing effects of one signal channel on the other was obtained by coupling
50 coils 16 and 17 in opposite senses to circuit A, and by coupling coils 18 and 19 in the same sense to circuit B.

In practice, when the system of Fig. 2 is set up, the various coils are coupled to the circuits
55 A and B to give the desired amount of regeneration, whereupon adjustments are made first in one circuit, either A or B, to produce the balancing or neutralizing voltages to offset the effect of the other circuit, after which the adjustments
60 are made in the other circuit to produce balancing or neutralizing voltages to offset the effect of the first circuit.

Although oscillatory circuits A and B are shown inductively coupled to the control grids
65 G4 and G1, respectively, it is to be understood that, if desired, such inductive coupling coils 15 and 20 may be eliminated and a direct coupling provided between the circuits A and B and the control grids in a manner somewhat similar to
70 that shown in Figs. 1 and 3.

One advantage in the particular arrangement shown resides in the fact that the balancing circuits 17 and 19 tend to increase the desired component of voltage in the associated oscillatory
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circuits while eliminating the undesired component of signal frequency.

For deriving the beat frequency output from the oscillator there are shown a pair of leads 5 20', but it will be apparent that the invention is not limited to this particular manner of obtaining the difference frequency since other means of coupling an output circuit to the oscillator may be used instead, such as by coupling 10 to anode-grid G2.

Fig. 3 illustrates an embodiment very similar to Fig. 1 with the addition of a second balancing coil 21 arranged in series with coil 8 and inductively coupled to the output-anode coil 6 and the intermediate frequency output 7 for eliminating 15 or reducing the effect of undesired components of the voltage from the oscillatory circuit 3 in the output circuit.

In operation, the circuit of Figure 3 is substantially like that of Figure 1 except for a more complete neutralization of the effects of one signal circuit upon the other occasioned by the connection of the second balancing coil 21 which is arranged in series relation with feedback coil 22 25 connected to the anode-grid G2 and in magnetic coupling relation to the output circuit 6. Whatever reaction between the two input signal circuits that may appear in the output 6 is transferred through the balancing coil 21 to the feedback coil 22 and anode-grid G2 in such phase as 30 to neutralize such reaction.

What is claimed is:

1. In combination, an electron discharge device having a cathode, first, second, third and 35 fourth grids, and a plate, in the order named; a first signal channel applied between said first grid and cathode; a second signal channel applied between said fourth grid and cathode; means for applying suitable positive potentials to said second and third grids and to said plate, 40 said first and fourth grids being at a negative potential with respect to said cathode; and a coil in series relation with the anode of said device and magnetically coupled to said first signal channel for balancing out the effect in said 45 first channel of the alternating current voltage applied to said fourth grid by said second channel; and another coil in series with said first coil and anode and magnetically coupled to the second signal channel for balancing out the effect 50 in said second channel of the alternating current voltage applied to said first grid by said first channel.

2. A system in accordance with claim 1, characterized in this that said first signal channel is an oscillatory circuit for locally generating oscillations, and said second signal channel is an external source of radio frequency signals.

3. A system in accordance with claim 1, characterized in this that said first and second signal-channels are oscillatory circuits for locally generating separate oscillations of different frequencies.

4. In combination, an electron discharge device having within an evacuated envelope a cathode, first, second, third, fourth and fifth grids, 65 and a plate, in the order named; a first signal

channel for applying external radio frequency signals to said fourth grid; a second signal channel comprising an oscillatory circuit for locally generating oscillations connected to said first 5 grid, a regenerative feed-back circuit between said second grid and cathode and coupled to said oscillatory circuit; means for applying suitable positive potentials relative to said cathode to said second, third and fifth grids and to said plate, 10 said first and fourth grids being at a negative potential relative to said cathode; an output circuit comprising an inductance coil and condenser combination coupled between said plate and cathode; and a coil in series with said output inductance coil and coupled to the oscillatory circuit 15 for balancing out the effect in said oscillatory circuit of the radio frequency signals applied to said fourth grid; and another coil in series with said feed-back path and coupled to said output circuit for balancing out undesired effects of said 20 oscillator frequency voltages in said output circuit.

5. In combination, an electron discharge device having a cathode, first, second, third and fourth grids, and a plate, in the order named, 25 there being a positive transconductance between each of said first and fourth grids and said plate, a positive transconductance between said first and second grids and a negative transconductance between said second and fourth grids, a 30 first signal channel applied between said first grid and cathode; a second signal channel applied between said fourth grid and cathode; means for applying suitable positive potentials to said second and third grids and to said plate, said 35 first and fourth grids being at a negative potential with respect to said cathode; and a coil in series relation with the anode of said device and magnetically coupled to said first signal channel for balancing out the effect in said first channel 40 of the alternating current voltage applied to said fourth grid by said second channel; and another coil in series with said first coil and anode and magnetically coupled to the second signal channel for balancing out the effect in said second 45 channel of the alternating current voltage applied to said first grid by said first channel.

6. In a signalling system, the combination with two input signal circuits and a common output circuit therefor, of an electric discharge device 50 having two signal grids connected with said input circuits, an anode connected with said output circuit, and a screen electrode between said signal grids, one of said signal grids being more adjacent to the anode than the other, means for 55 negatively biasing each of said signal grids and applying a positive potential to said screen electrode, a positive anode-grid intermediate said screen grid and that one of the signal grids which is farthest from said anode, and a pair of inductance coils connected in series to said anode-grid, 60 each being magnetically coupled respectively to one of the input signal circuits and to the common output circuit in such manner as to balance out the interaction in each of said input circuits 65 caused by the other circuit.

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