July 29, 1941.

E. FRANKE ET AL

2,250,526

OSCILLATOR CONTROL CIRCUIT

Filed Jan. 28, 1938

2 Sheets-Sheet 1

Fig. 1

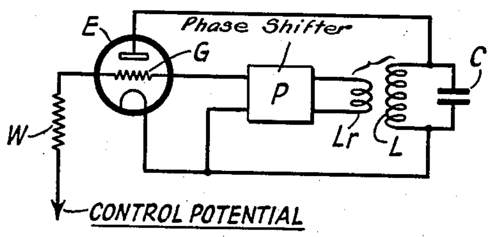

Fig. 2

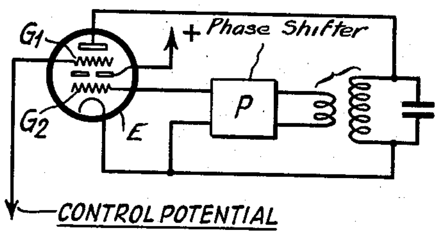

Fig. 3

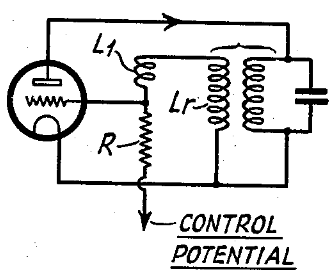

Fig. 4

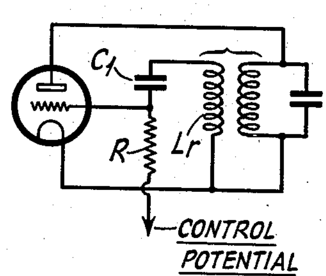

Fig. 5

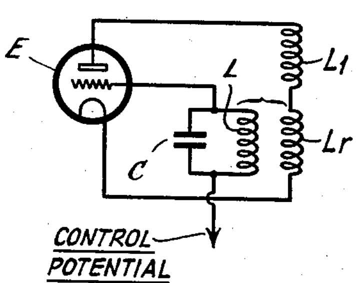

Fig. 6

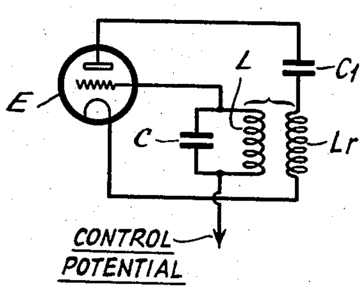

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Fig. 7

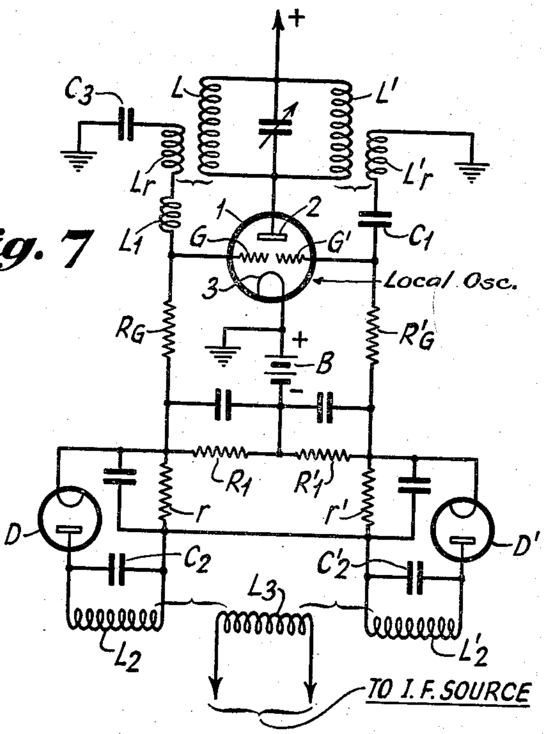


Fig. 8

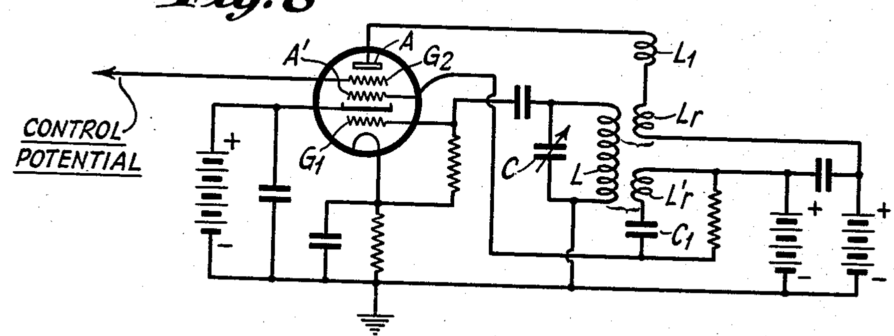
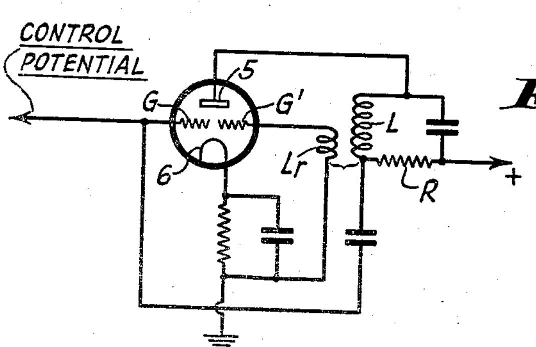


Fig. 9



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UNITED STATES PATENT OFFICE

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OSCILLATOR CONTROL CIRCUIT

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7 Claims. (Cl. 250—36)

As is already known, in order to provide automatic sharp tuning, the local oscillator of a superheterodyne receiver is influenced in such a manner in its frequency by a control potential produced through the deviation of the intermediate frequency from its desired value, that the intermediate frequency remains approximately constant. This control of the frequency was hitherto carried out in that a special frequency control tube, exerting a wattless feedback upon the oscillatory circuit of the oscillator, was controlled as to gain by the control potential.

In accordance with the present invention a return-coupled tube oscillator has its frequency influenced in that the feedback contains a damping-reducing component of purely regenerative phase, and a wattless component, and that it can be controlled through variation of the amplification of the oscillator tube; or more generally, by variation of a part of the system of the oscillator tube which is used for feeding back a wattless component. Thus, an advantage is obtained in the saving of a special frequency control tube.

In the drawings—

Fig. 1 shows an oscillator embodying the invention,

Figs. 2 to 6 inclusive show respectively different modifications of the circuit of Fig. 1,

Fig. 7 shows a frequency control circuit applied to a superheterodyne receiver,

Fig. 8 illustrates a modification,

Fig. 9 shows a modified form of circuit of the type illustrated in Fig. 7.

An example of construction according to the invention is shown in Fig. 1. The voltage induced in the feedback coil L_r through the coil L in the plate circuit of the oscillator, instead of being applied directly to the control grid G of the oscillator tube E, is applied thereto across the phase shifting four-pole device P. At the same time, the grid receives across the leak resistor W a control potential that is more or less negative. The phase rotation may be for instance 20–30° so that the feedback contains a purely regenerative phase component, and a wattless component that is still rather appreciable and displaced relative to the first component by 90°. The variation of the wattless component of the feedback due to the control of the amplification determines the amount of change of the oscillation frequency.

In order to ameliorate the danger of the oscillations being cut off by large negative values of control voltage, it is advisable to apply, as shown in Fig. 2, the feedback voltage and the control voltage to two separate grids G_1 and G_2 which are arranged in succession between the cathode and plate of tube E′, and separated by a screen grid.

For the sake of simplification, only a single grid is represented in the oscillator tube shown in each of Figures 3 to 6. The phase shifting device P may be such that there is placed in series to the feedback coil L_r a series connection formed of a resistor R and coil L_1, as in Fig. 3, or capacity C_1 as in Fig. 4. The lower end of the resistor R can be connected directly to the control voltage source whose other pole is placed at the cathode of the oscillator tube, and which represents, eventually through the shunting of a large capacity, practically a short circuit as regards high frequency.

Obviously, arrangements may also be used in which the oscillatory circuit is placed in the grid circuit, and a feedback coil in the plate circuit. At resonance of the oscillatory circuit the feedback coil L_r behaves, at 100% coupling with the oscillatory circuit coil, like a negative resistance with respect to the plate current. In order to provide the necessary slight phase displacement relative to the plate current, it is only necessary to connect, as shown in Figs. 5 and 6 respectively, an inductance L_1 or a capacity C_1 in series to the feedback coil L_r. In many cases, the stray inductance of the transformer comprising the oscillatory circuit and the feedback coil will take the place of the coil L_1. The connections for the direct current potentials are not shown in Figs. 1–6 for reasons of simplicity.

The arrangements as hitherto described have the disadvantage that at a variation in the amplification not only the wattless component of the feedback will be varied, but also the regenerative component, and, hence, also the amplitude of the oscillation. This may not be of importance in many cases, but in certain other cases the output voltage of the oscillator will preferably be maintained constant to a fair degree, by inserted amplitude limiting means. However, it is also possible to maintain the regenerative component of the feedback independent of a constant value at the control of the amplification in that a tube having several partial electrode systems is employed.

Thus two feedback paths, for instance, may be provided each across a respective partial electrode system, and the amplifications of the two partial systems are so controlled in opposite senses that the sum of the purely regenerative components of the two feedbacks remains approximately constant within the range of control, while the sum of the wattless componets varies.

An example of construction of such an arrangement is shown in Fig. 7. The oscillator tube 1 has an anode 2, a cathode 3 and two grids G and G' which are so arranged that voltage variations at one grid do not influence to an appreciable degree the electron current flowing through the other grid. The grids are preferably disposed parallel side by side, and may be separated from each other by a screen grid. The coil of the oscillatory circuit in the plate circuit is divided up into two parts L and L', each of which is coupled with a respective feedback coil L_r and L'_r. Each of them applies feedback potentials to the grids G and G' respectively, across the coil L_1 and capacity C_1, said potentials having purely regenerative components of same sense (damping reduction) but the wattless components thereof have opposite directions. Now, if both grids are controlled in opposite senses, so that the degree of amplification of the one system increases while that of the other system decreases, with the result that the purely regenerative feedback component of the one system increases while that of the other system decreases. By suitable dimensioning, the sum of the purely regenerative components and thus the oscillation amplitude can be maintained constant with rather close approximation. It can be shown that this requirement can be quite accurately complied with if the characteristics representing the variation of mutual conductance with variations of bias voltage are identical for both grids and represent a hyperbola in the proximity of the working point.

Since the wattless components of both feedbacks have opposite senses, then at a control of the amplification in opposite directions, the resultant wattless component varies to a high degree and a considerable change in the oscillator frequency occurs. This result will, however, also be obtained if, for instance, only one feedback path contains a wattless component. The arrangement with oppositely directed wattless feedback components herein shown provides, however, an approximately doubled amount of control.

It is advisable so to dimension the two wattless components that they are exactly equal in opposite directions in the absence of a control potential, i. e. when both grids have the same initial biasing potential (supply by the battery B in Fig. 7). In the absence of the control potential therefore the oscillator oscillates at its actual natural frequency. Especially in superheterodyne receivers with automatic sharp tuning this condition has the advantage that the necessary tracking relation between the oscillator circuit and the high-frequency circuits can be more readily maintained throughout the tuning range and at different wave ranges.

In the arrangement according to Fig. 7 the value of the wattless feedback component depends, however, on the frequency, and equality can as such be exactly obtained only in case of a single frequency. But, many arrangements known as such are possible by means of which the amount of frequency control can be rendered independent of the frequency. Thus, there may be placed in series to the capacity C_1 a coil for instance, which is so chosen that the obtained series-resonance circuit is tuned to a frequency which lies slightly below the lowest frequency of the range covered by the oscillator. In this way, the increase in the influence of the capacity at lower frequencies is counter-balanced. On the contrary, the branch consisting of L_1 and L_r would have to be tuned to a frequency lying above the said range, for instance by the condenser C_3 which serves in the arrangement at the same time as a blocking condenser for the direct current voltage. In the absence of control potential, the regenerative components of the feedbacks have preferably the same values.

The control potential source is constructed according to Fig. 7, in a manner known from superheterodyne receivers with a controlled local oscillator. The currents of intermediate frequency which are oppositely detuned as regards the desired intermediate frequency value, and induced in the circuits L_2—C_2 and L'_2—C'_2 respectively, are detected by means of the diodes D and D'. At the resistors r and r' direct current voltages are produced which are equal only when the intermediate frequency energy conforms to its desired I. F. value. The difference between the two voltages produced at the upper ends of the resistors r and r' connected with each other, is halved by the resistors R_1 and R'_1 of same size. The connection point between the two resistors R_1 and R'_1 lies at the negative pole of the grid battery B. The two halves of the control potential are thus applied in opposite senses to the grids G and G' across the leak resistors R_G and R'_G.

The frequency control of the tank circuit of oscillator tube 1 is secured by virtue of the reactance reflected across the circuit L—L' by the wattless feedback. The wattless feedback through one path, say C_1, produces a capacity effect across the tank circuit; the wattless feedback through the other path, L_1, produces an inductive effect across the tank circuit. At the resonsant frequency (I. F.) of circuit L_3 these reactive effects are equal and opposite.

This follows from the fact that diodes D and D' produce equal direct current voltages across r and r', since the rectifier input circuits are oppositely mistuned from the I. F. by equal frequency values. Hence when the signals at L_3 are of the I. F. value grids G and G' have equal voltage values. The reflected reactive effects are then opposite and equal and cancel out, while the purely regenerative components are additive. Now, if the signal energy at L_3 shifts in frequency from the I. F. value, due to tuning to or from a desired station for example, the voltages applied to grids G and G' will be unequal. Hence, one of the reflected reactance effects across L—L' will dominate and cause the tank frequency to shift. The reflected reactive effects will be such that the corrective frequency shift will be in a sense to restore the I. F. value whenever the signal energy at L_3 departs from the predetermined I. F. value.

A similar action can be obtained by means of an ordinary tube when using the arrangement according to Fig. 8. Herein, a mixer hexode serves as the oscillator tube. The oscillatory circuit LC is connected to the inner grid G_1, the two feedback coils L_r and L'_r are connected to the anode A and auxiliary anode A' respectively. In order to provide a phase displacement in opposite directions, impedances L_1 and C_1 are connected in series to the feedback coils. In addition to an initial biasing potential of suitable value, the control potential depending on the detuning is applied to the current distribution grid G_2 located between anode A and the auxiliary anode.

In accordance with the sign, the distribution grid biasing voltage becomes higher or lower. In the first case, the plate current decreases, while the current of the auxiliary plate A' increases; in the second case, the opposite takes place. In this way at one time it is the auxiliary anode A' and at another time it is the anode A, that has the greater action, whereby the frequency will be controlled in the manner elucidated above. In place of the mixer hexode, also an ordinary duo-grid tube may be employed in which the first grid (space charge grid) is connected in the same manner as the auxiliary anode in Fig. 8, while the second grid has the control potential as well as the potential of the oscillatory circuit applied thereto.

Finally, a further arrangement is shown in Fig. 9, in which again the amplitude of the oscillator output is maintained constant during control. This arrangement operates as in the case of the arrangement of Fig. 7 with a tube having a common anode 5 and a common cathode 6 and two separate grids G and G' each of which does not appreciably influence the electron current passing through the other one. There is applied to the one control grid G' in the usual manner, the feedback potential having approximately a purely regenerative phase and which is induced in the feedback coil L_r, this feedback potential being in series to a fixed biasing potential. The other grid has applied thereto a feedback potential having a phase displacement of as nearly as possible 90° which can be derived for instance from the resistor R placed in series to the coil L of the oscillatory circuit, and, furthermore, a control potential is applied to the said grid. In this way, only the wattless component of the feedback will be controlled, while the purely regenerative component remains constant. Also, in this case, it will be advisable to shield the two control grids against each other by means of screen grids.

What is claimed is:

1. In an oscillator network provided with an oscillation generator tube including at least a cathode, control grid and anode, a resonant circuit tuned to a desired oscillation frequency and being included in a reactive coupling path between said anode and grid, said path including a phase shifting element such that a substantial reactive effect is produced across said resonant circuit, at least one auxiliary electrode disposed in the electron stream between the cathode and anode, a second phase shifting element, of opposite sign to said first element, reactively coupling said auxiliary electrode to said resonant circuit thereby to produce a reactive effect of opposite sign to the first effect across said resonant circuit, and means for varying the space current flow to the anode to an extent sufficient substantially to change the magnitude of said reactive effect and thereby vary the frequency of said resonant circuit.

2. In an oscillator network provided with an oscillation generator tube including at least a cathode, control grid and anode, a resonant circuit tuned to a desired oscillation frequency and being included in a reactive coupling path between said anode and grid, said path including a phase shifting element, at least one auxiliary electrode disposed in the electron stream between the cathode and anode, a second reactive coupling path between said anode and auxiliary electrode including said resonant circuit, said second path including a phase shifting element of opposite sign to said first element and means for varying the potential of at least said auxiliary electrode over a range of values sufficient substantially to change the frequency of said resonant circuit.

3. In an oscillator network provided with a tube including at least a cathode, control grid and anode, a resonant circuit tuned to a desired oscillation frequency and being included in a reactive coupling path between said anode and grid, said path including a phase shifting element, at least one auxiliary electrode disposed in the electron stream between the cathode and anode, means for varying the direct current potential of at least said auxiliary electrode over a range of values sufficient substantially to change the frequency of said resonant circuit, said grid being disposed in the electron stream, a second anode electrode disposed in the said stream, and a second reactive coupling path, including said resonant circuit, between said second anode and said first grid.

4. In a superheterodyne receiver of the type including a tunable local oscillator, an intermediate frequency network and means for deriving from the intermediate energy a direct current potential whose polarity and magnitude depend on the sense and amount of frequency departure of said energy from an assigned frequency value; the improvement which comprises a tube in said oscillator provided with a cathode, an anode and at least two control grids, a tunable oscillation circuit connected between said anode and cathode, a reactive coupling path between said tunable circuit and one grid, a second reactive coupling path of opposite sign between said tunable circuit and the second grid, and direct current voltage connections between said deriving means and said grids.

5. In an oscillator network comprising an oscillation generator tube having a cathode, anode and two control grids, a resonant circuit, tuned to a desired oscillation frequency, connected between said anode and cathode, and independent reactive coupling paths of opposite sign between said resonant circuit and each of said grids, and means for varying the direct current potential of at least one of said grids.

6. In an oscillator network comprising an oscillation generator tube having a cathode, anode and two control grids, a resonant circuit, tuned to a desired oscillation frequency, connected between said anode and cathode, and independent reactive coupling paths of opposite sign between said resonant circuit and each of said grids, and means for varying the direct current potential of each of said grids thereby to adjust the frequency of said resonant circuit in opposed senses.

7. In an oscillator, an oscillation generator tube having at least a cathode, anode and two control grids, a resonant tank circuit coupled to the anode and cathode, separate reactive coupling paths between each grid and the tank circuit, said paths being coupled to said tank circuit, said paths being so relatively constructed that a pair of reactive effects of opposite sign are simulated across the tank circuit, and means for varying the relative potentials of said grids thereby to vary the relative magnitudes of said effects with resultant variation of the tank circuit frequency.

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