

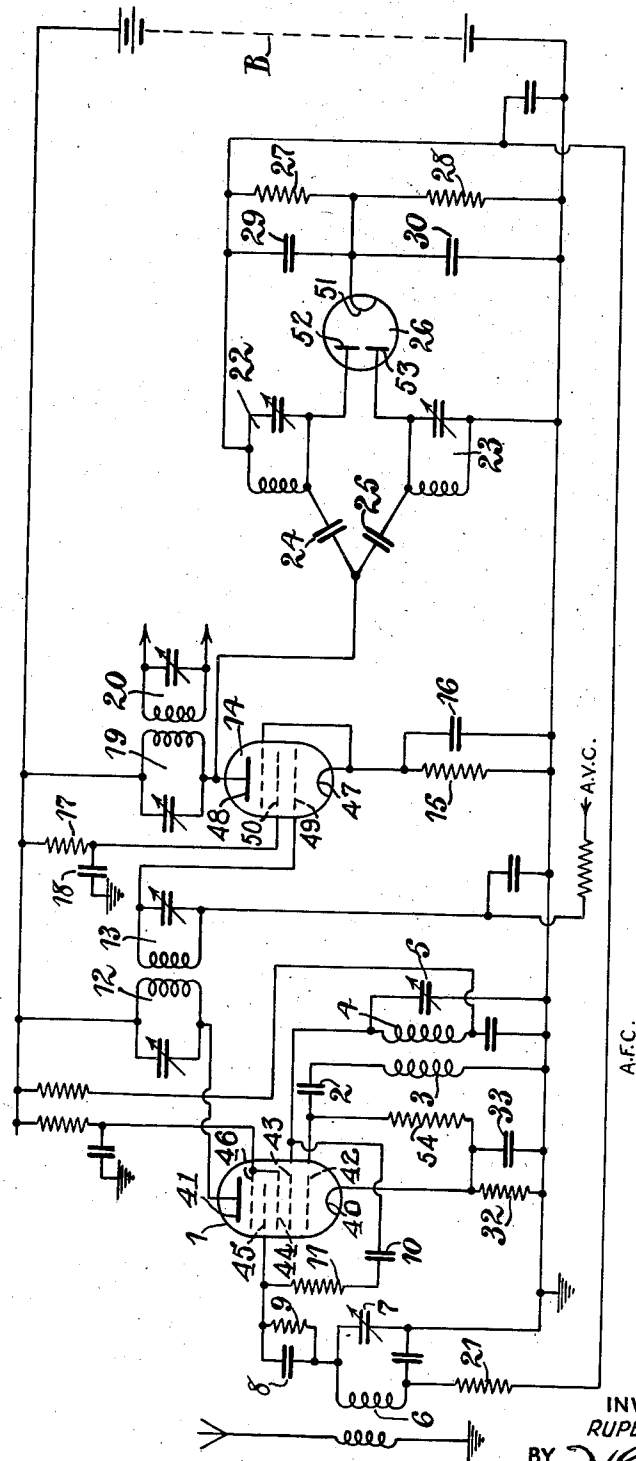
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AUTOMATIC FREQUENCY CONTROL CIRCUITS FOR CARRIER WAVE RECEIVERS

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AUTOMATIC FREQUENCY CONTROL CIRCUITS FOR CARRIER WAVE RECEIVERS

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The invention relates to automatic frequency control circuits which are employed for the purpose of automatically correcting mis-tuning of a carrier wave receiver, such circuits being frequently termed "pull-in" tuning circuits.

Usually, "pull-in" tuning circuits as applied to superheterodyne receivers employ a double-diode discriminator valve associated with two circuits tuned respectively above and below the correct intermediate frequency, the double-diode being fed with intermediate frequency currents from an intermediate frequency amplifier for the purpose of obtaining control potentials, which latter are fed to a control valve shunted across a local oscillator circuit and serve to vary the effective shunting capacity or inductance of the valve according to the initial setting of the tuning control above or below the point of resonance. In one particular form of frequency control circuit, the control valve has shunted across its anode and cathode a reactance, and a proportion of the voltage developed across the reactance is fed to the grid of the valve. By varying the slope of the valve as a varying bias is applied to the grid the magnitude of the feed-back can be controlled and hence the effective reactance across the anode and cathode of the valve is also controlled which, according to the magnitude of the bias, serves to vary the frequency of the local oscillator circuit.

In superheterodyne receivers it is frequently the practice to employ single valve frequency changers for the purpose of producing the intermediate frequency and it is found in such valves that mutual conductance exists between the input signal grid of the valve and the electrode which functions as the oscillator anode of the valve. This mutual conductance occurs in single frequency changer or mixer valves, such as heptode valves and such a property is employed in the present invention which has for its object the provision of an improved circuit affording automatic frequency control without the necessity of employing the additional valve as has been necessary in the prior proposals.

According to the invention a superheterodyne carrier wave receiver is provided employing a single valve frequency changer in which mutual conductance exists between the signal grid and the oscillator anode of the valve and wherein, for the purpose of affording automatic frequency control, a part of the voltage developed across the local oscillator anode circuit is applied to the signal grid to enable the effective reactance presented to the local oscillator circuit to be varied when a biasing potential is applied to the signal

grid of a magnitude and polarity dependent upon the degree and direction in which the receiver is lacking in resonance whereby the change of frequency of the local oscillations so produced is such as substantially to correct automatically for the mis-tuning of the receiver. Preferably, the valve employed in the circuit is a heptode valve, since such a valve is found to have more pronounced mutual conductance between the signal grid and the oscillator anode, and hence is more suitable for use in the present invention.

The biasing potentials applied to the signal grid may be obtained from a circuit similar to that used in normal automatic frequency control circuits in which two rectifiers, or a double-diode, are associated with two circuits tuned respectively above and below the correct intermediate frequency, the rectified output of the double diode being used to bias the signal grid of the heptode. The voltage developed across the local oscillator circuit may be fed to the signal grid by connecting the oscillator anode through a blocking condenser and resistance to the signal grid and providing a suitable impedance in the signal grid circuit across which the oscillator voltage may be developed. The amount of feed back so obtained is usually about $\frac{1}{20}$ of the oscillator voltage.

In order that the said invention may be clearly understood and readily carried into effect the same will now be more fully described with reference to the accompanying drawing which illustrates a part of a typical circuit of a superheterodyne receiver embodying the invention and employing a heptode frequency changer valve.

In the drawing the reference numeral 1 indicates the heptode frequency changer which is, as usual, provided with five grids disposed between the cathode 40 and anode 41, the first grid 42 adjacent the cathode constituting the input grid of the oscillator section and being coupled to earth through a condenser 2 and a coil 3, whilst the oscillator anode i. e. the second grid 43 from the cathode, is coupled to earth through a local oscillator circuit comprising a coil 4 shunted by a variable condenser 5, the coils 3 and 4 being coupled together in the usual way. The third and fifth grids 44 and 45 of the heptode are connected together and connected through a resistance as shown to a suitable source of positive potential shown diagrammatically as battery B whilst the fourth grid 45 which functions as the signal input grid is connected through a condenser 8 and shunting resistance 9, to the tuned input circuit comprising a coil 6 and variable

condenser 7. The oscillator anode is also connected through a blocking condenser 10 and resistance 11 to the signal grid. The cathode of valve 1 is biased by a resistance 32 shunted by a by-pass condenser 33. The resistor 54 is connected between grid 42 and the cathode end of resistor 32, and functions as the oscillator grid leak resistor to maintain the grid 42 at a negative bias with respect to cathode 40.

The anode of valve 1 is connected to the positive terminal of battery B through a tuned output circuit 12 which is coupled to a tuned input circuit 13 connected between the input grid 49 and earth of a pentode intermediate frequency amplifier valve 14. The cathode 47 of this valve is biased by a resistance 15 shunted by a by-pass condenser 16, whilst the screening grid 50 of the valve is connected through a resistance 17 to the positive terminal of battery B and is decoupled to earth through condenser 18. The anode 48 of valve 14 is connected to the positive terminal of the battery B through a tuned circuit 19 which is coupled to a further tuned circuit 20 which is connected to further detection and amplifying stages in known manner. Biasing potentials are applied to the signal grid of the heptode valve 1 through a resistance 21, the biasing potentials being derived from the usual type of discriminator circuit. As shown, the discriminator circuit comprises two tuned circuits 22 and 23 which are tuned respectively above and below the correct intermediate frequency and are fed with intermediate frequency currents from the intermediate frequency amplifier valve 14 through two condensers 24 and 25. The circuits 22 and 23 are connected to the anodes 52 and 53 of a double diode detector valve 26 the cathode 51 of which is connected between two resistances 27 and 28 shunted by condensers 29 and 30, the arrangement functioning so that according to the particular degree by which the receiver is lacking in resonance so potentials are developed across the resistances 27 and 28, the algebraic sum of which is applied to the frequency changer valve 1. The values of the resistance 11 and the condenser 8 are so chosen that only about $\frac{1}{20}$ of the voltage developed across the oscillator circuit is transferred to the signal grid. The resistance 9 is employed to form a direct current path for applying the voltage from the resistances 27 and 28 to the signal grid of valve 1. Usually, the oscillator frequency is higher than the frequency of the signals applied to the input grid and, consequently, the input circuit including the coil 6 and condenser 7 will appear as a capacity. The effect of feeding back a part of the voltage developed in the oscillator circuit to the signal grid is to cause the effective reactance of the oscillator anode to the current flowing through the oscillator circuit to appear as a negative inductance the value of which varies inversely with the mutual conductance between the signal grid and the oscillator anode. In some valves the mutual conductance aforesaid is about $\frac{1}{2}$ milliamperes per volt, and it can be shown that sufficient frequency control can be obtained by applying two or three volts change of bias on the signal grid of the heptode for medium waves and long waves.

I claim:

1. In combination with a tube of the type including a cathode, an anode and at least three cold electrodes in the electron stream therebetween, a resonant tank circuit coupling two of said electrodes and providing an oscillator network, a signal input circuit coupled to the third

of said electrodes, an output circuit connected to said anode tuned to the difference of the signal frequency and the tank frequency, a path of low impedance to oscillator voltage coupling the said third electrode to a point in said oscillator network, and means, responsive to a frequency departure of the output circuit energy from said difference frequency, for varying the direct current potential of said third electrode.

2. In combination with a source of modulated carrier signals, a frequency changer network including a tube provided with a cathode, a plate and at least three successive electrodes arranged in the electron stream to the plate, said source being coupled to one of the electrodes, a tunable tank circuit coupled to the other two electrodes to provide local oscillations of a frequency different from the carrier frequency, an output circuit, connected to the plate, tuned to the difference frequency of said oscillation and carrier frequencies, a discriminator network coupled to said tuned output circuit and deriving a direct current voltage from the difference frequency energy upon a frequency departure of the latter from an assigned frequency value, means for feeding to said one electrode at least a portion of the oscillation voltage developed across said tank circuit, and means applying said direct voltage to said one electrode.

3. In a superheterodyne receiver of the type comprising a tube provided with a cathode, plate and at least three cold electrodes, a signal input circuit coupled to one of the cold electrodes, an oscillation generating circuit coupled to the other two cold electrodes, a tuned intermediate frequency circuit coupled to the plate, and means for developing from intermediate frequency energy a direct current voltage whose polarity and magnitude is a function of the sense and amount of frequency shift of the intermediate frequency energy from an assigned frequency value; the improvement which includes means for feeding to said one cold electrode at least a part of the oscillation voltage developed across said oscillation circuit, and means for applying said direct current voltage to said one electrode to vary the effect of said oscillation voltage feed upon the frequency of said generating circuit.

4. In a superheterodyne receiver of the type comprising a converter tube provided with a cathode, plate and at least three grids arranged in succession between the cathode and plate, a signal input circuit coupled to the grid adjacent the plate, a tank circuit, tuned to a frequency higher than the signal frequency, connected to the intermediate grid, means coupling the grid adjacent to the cathode to said tank circuit to provide oscillations in the latter, an output circuit coupled to said plate and tuned to the frequency difference between the signal and tank circuit frequency, a discriminator network having a common input circuit, tuned to the difference frequency, coupled to the output circuit, said discriminator having an output circuit adapted to produce a direct current voltage whose value is a function of the frequency departure of the energy in said output circuit from said difference frequency; the improvement which includes a path of low impedance to oscillation voltage coupling said tank circuit to said signal grid, and means for applying said direct current voltage to said signal grid.

5. In combination with a tube of the type including a cathode, an anode and at least three cold electrodes in the electron stream therebetween,

tween, a resonant tank circuit coupling two of said electrodes and providing an oscillator network, a signal input circuit coupled to the third of said electrodes, an output circuit connected to said anode tuned to the difference of the signal frequency and the tank frequency, a reactive path of low impedance to oscillator voltage coupling the said third electrode to a point in said oscillator network, and means, responsive to a frequency departure of the output circuit energy from said difference frequency, for varying the direct current potential of said third electrode, said reactive path including a resistor, said signal circuit being coupled to said third electrode by a condenser, and said resistor and condenser being so chosen that a predetermined portion of the oscillator voltage is applied to said third electrode.

6. In a radio receiver comprising a tube provided with a cathode and a plurality of cold electrodes, a signal input circuit coupled to one of the cold electrodes, an oscillation-producing circuit

coupled to at least two of the cold electrodes other than said one cold electrode, a beat frequency circuit coupled to a cold electrode other than said above cold electrodes, means applying oscillation voltage developed in said oscillation circuit to said one electrode, and means for varying the direct current potential of said one electrode with respect to said cathode.

7. In a radio receiver comprising a tube provided with a cathode and a plurality of cold electrodes, a signal input circuit coupled to one of the cold electrodes, an oscillation-producing circuit coupled to at least two of the cold electrodes other than said one cold electrode, a beat frequency circuit coupled to a cold electrode other than said above cold electrodes, means applying oscillation voltage developed in said oscillation circuit to said one electrode, and means responsive to frequency shifts of the beat frequency energy for varying the direct current potential of said one electrode with respect to said cathode.

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