

March 22, 1938.

W. VAN B. ROBERTS

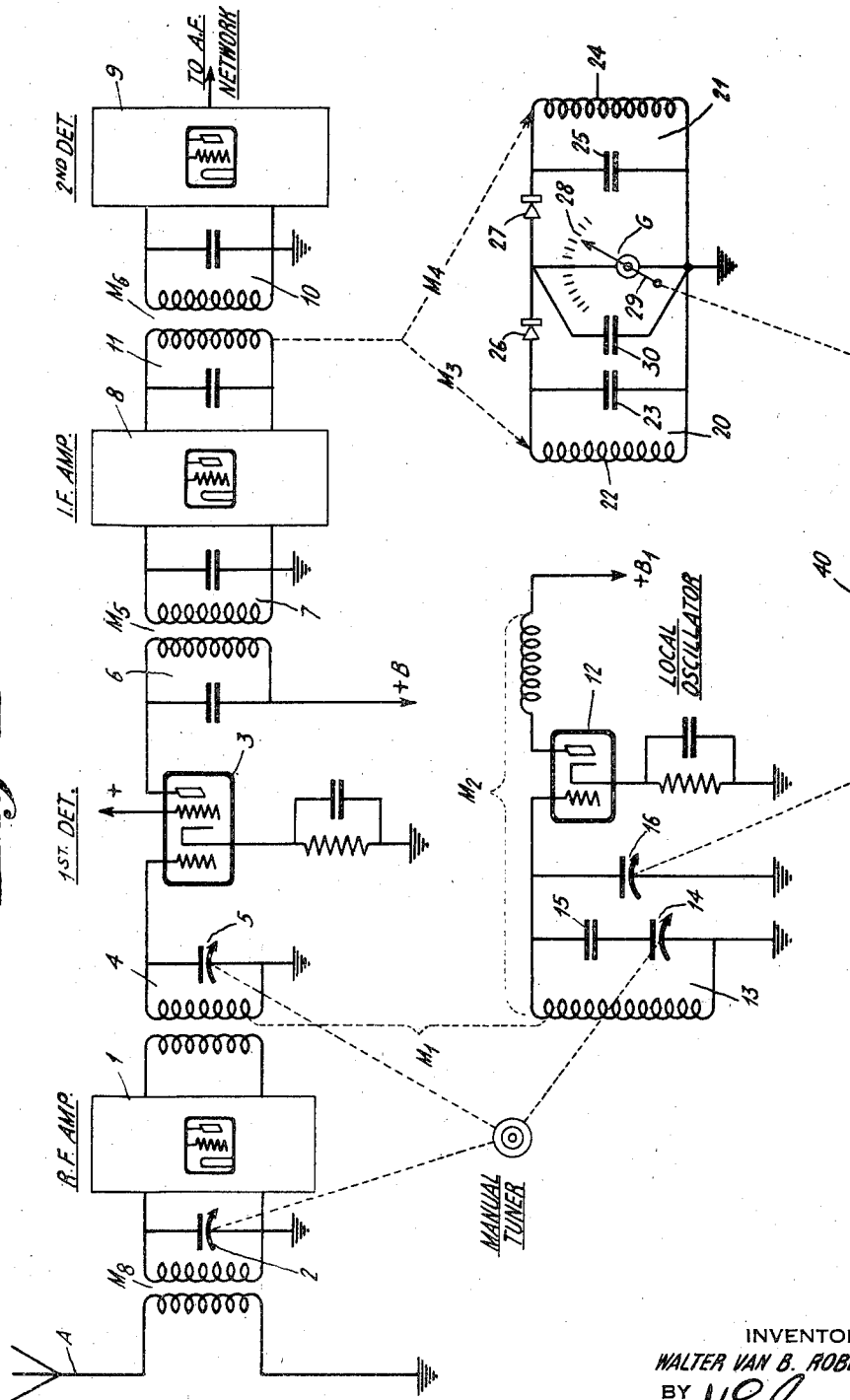
2,111,737

LOCAL OSCILLATOR CIRCUIT TUNING DEVICE

Original Filed Oct. 17, 1934

2 Sheets-Sheet 1

Fig. 1



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Fig. 2

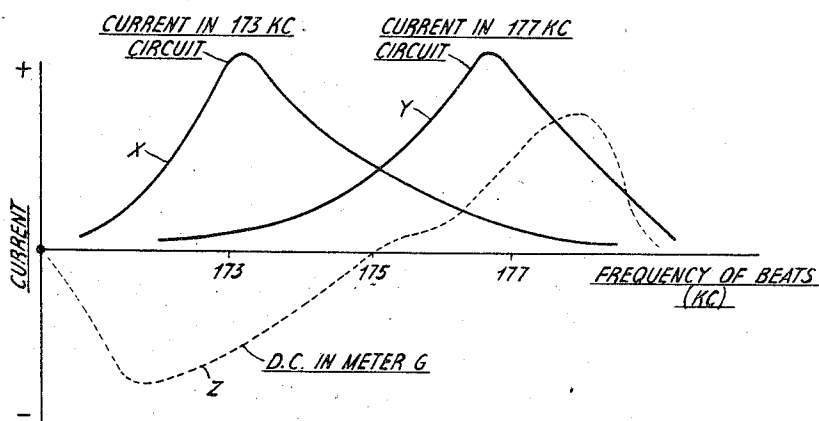
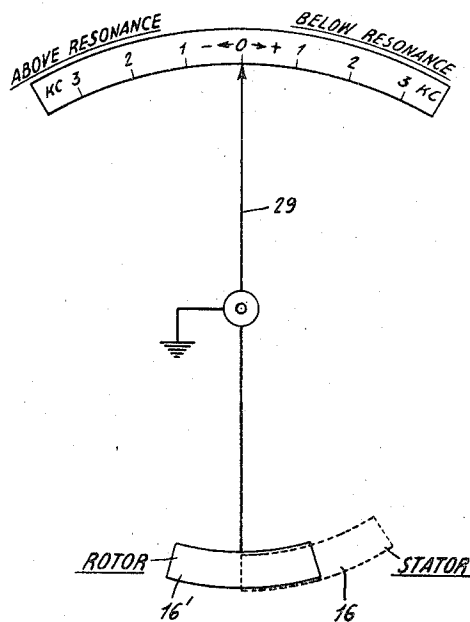


Fig. 3



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LOCAL OSCILLATOR CIRCUIT TUNING
DEVICEWalter van B. Roberts, Princeton, N. J., as-
signor to Radio Corporation of America, a
corporation of DelawareApplication October 17, 1934, Serial No. 748,609
Renewed March 24, 1936

2 Claims. (Cl. 250—20)

My present invention relates to tuning devices for superheterodyne receivers, and more particularly to a method of, and means for, automatically insuring and/or indicating exact tuning of that type of receiver.

The superheterodyne type of radio receiver is a highly selective receiver of broadcast signals. Tuning of such a receiver has been accomplished by the set operator by utilizing the ear to determine whether the set is sharply tuned to the desired carrier frequency. Tuning meters have been proposed as a substitute for the operator's ear. In the case of sets equipped with automatic volume control a mechanical substitute for the ear is essential. However, such tuning meters employed in the past have generally been unsatisfactory because they have not indicated the direction and magnitude of detuning.

It is one of the primary objects of this invention to provide a tuning indicator for a radio receiver of the superheterodyne type, the indicator being constructed to exactly register a resonant condition of the receiver, and, additionally, to indicate the direction and frequency magnitude off resonance when the receiver is detuned.

Another important object of the invention may be said to reside in a tuning meter construction for a superheterodyne receiver which comprises a pair of rectifier circuits, tuned equal frequency amounts to either side of the operating intermediate frequency, whose outputs are balanced at the intermediate frequency, an indicator responsive to the direct current output of the rectifier circuits being utilized to indicate the resonance condition of the receiver.

Another problem is encountered in superheterodyne receiver operation. The local oscillator circuit of the receiver is tuned through a frequency range differing at all times from the signal circuit frequency range by the operating intermediate frequency. For one reason or another the predetermined relation between oscillator frequency and tuning dial settings may vary. In general, let it be assumed that it is difficult to secure exact tuning by mere adjustment of the manually adjustable tuning device.

Accordingly, it is pointed out that another important object of my invention is to provide a novel method of, and means for, automatically insuring exact tuning of a superheterodyne receiver wherein variations in frequency of the converter output of the receiver result in reactance adjustments in the local oscillator network.

Another object of the invention is to provide in combination with the local oscillator network

of a superheterodyne receiver, a frequency control network, responsive to variations in frequency of the converter output energy, whose function it is to change the capacitative reactance of the local oscillator in a sense to keep the said output energy at a substantially constant frequency value, and the control network including a tuning indicator to show exactly the resonance condition of the receiver.

Still other objects of the invention are to improve generally the reliability and efficiency of superheterodyne receivers, and more especially to provide tuning indicators and/or automatic local oscillator tuning means for such receivers which are not only dependable in operation, but economically assembled in the receivers.

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 drawings in which I have indicated diagrammatically one circuit organization whereby my invention may be carried into effect.

In the drawings:—

Fig. 1 illustrates a circuit diagram of a superheterodyne receiver embodying the invention.

Fig. 2 graphically illustrates the operation of the indicator and frequency control mechanism of Fig. 1.

Fig. 3 is a schematic representation of a mechanical embodiment of an indicator and frequency changer mechanism embodying the present invention.

Referring now to the accompanying drawings, wherein like reference characters designate similar circuit elements in the different figures, there is shown in Fig. 1 in purely schematic manner a superheterodyne receiver of the type including a signal collector, such as a grounded antenna circuit A, a radio frequency amplifier 1, first detector, an intermediate frequency amplifier and a second detector. The radio frequency amplifier 1 may comprise one, or more, stages of tuned radio frequency amplification. Each amplifier, as is well known to those skilled in the art, may include a tube of the screen grid or pentode type, or even of the variable mu type. The numeral 2 is to be understood as symbolizing the variable tuning condensers employed for tuning an amplifier of the tuned radio frequency type. The signal collector A is coupled, as at M_s, to the tuned input circuit of the amplifier 1.

The first detector is shown including a screen grid tube 3 which includes a tunable signal input circuit, and in the input circuit is provided a variable tuning condenser 5 of the same type as the condenser 2. The plate circuit of tube 3 includes a resonant circuit 6, tuned to the operating intermediate frequency, the circuit being magnetically coupled, as at M_5 , to the resonant input circuit of the intermediate frequency amplifier 8. The amplifier 8 may include one, or more, stages of amplification, and it will be understood that the input and output circuit of each of these amplifiers is maintained fixedly tuned to the operating intermediate frequency.

The second detector 9 has its resonant input circuit 10 coupled to the tuned output circuit 11 of amplifier 8 through the coupling M_5 . The detected output of the second detector is to be utilized in any desired manner, and this may be accomplished by impressing the detected output upon an audio frequency amplifier, of one or more stages, which is followed by a reproducer. Locally produced oscillations, of a frequency intended to differ at all times from the frequency to which the signal circuits are tuned by the operating intermediate frequency, are produced by the tube 12 and its associated circuits. The local oscillator tube 12 has the resonant circuit 13 connected between its grid electrode and cathode. The circuit 13 includes the variable tuning condenser 14. The plate circuit of tube 12 is magnetically coupled to the input circuit 13, as by coupling M_2 , and the rotors of condensers 2, 5 and 14 are arranged for mechanical uni-control, shown by the dotted lines in Fig. 1.

The uni-control device is designated as a "manual tuner", and it will be understood that the condensers 14, 5 and 2 are mechanically arranged in a gang condenser; these variable units are preferably similar. The frequency of the local oscillator is maintained substantially constantly different from the frequency of the signal circuits by means of the padding condensers 15 and 16. The condenser 15 is arranged in series with the tuning condenser 14, and the condenser 16 is arranged in shunt with the series condensers 15 and 14. The magnitudes of condensers 15 and 16 are so chosen with respect to the magnitude of condenser 14 that the frequency of the local oscillator will differ from the frequency of the signal circuits by the operating intermediate frequency at any setting of the manual tuner. It is not believed necessary to explain in any further detail the relations between condensers 14, 15 and 16 since this is well known to those skilled in the art, and has moreover been fully described by W. L. Carlson in U. S. Patent 1,740,331 of December 17, 1929.

The oscillations produced by the local oscillator are impressed upon the first detector in any well known manner, as for example through the coupling M_1 . The various circuit elements described to this point are all conventional; those skilled in the art are fully aware of the details of construction of such a superheterodyne receiver, and sufficient has been stated in connection with such a receiver to show fully the advantages of the present invention, which will now be described in detail. A pilot, or control, network is provided, and this control network includes a pair of resonant circuits 20 and 21. Circuit 20 comprises the coil 22 shunted by condenser 23, and circuit 21 includes the coil 24 shunted by condenser 25. The low alternating potential sides of circuits 20 and 21 are connect-

ed together and grounded. The high alternating potential sides of circuits 20 and 21 are connected together through a pair of alternating current rectifiers 26 and 27, the rectifiers being arranged in series relation. These rectifiers may be, for example, of the copper oxide type, and are devices well known to those skilled in the art; they are elements possessing asymmetrical conductivity. The junction of the rectifiers 26 and 27 is connected to the grounded side of circuits 20 and 21 through meter G having a scale 28 and a movable indicator needle 29. The meter G is shunted by a radio frequency by-pass condenser 30.

The circuits 20 and 21 are tuned to frequencies on either side of the operating intermediate frequency by an equal amount. Thus, if the operating intermediate frequency is 175 kilocycles, then circuit 20 is tuned, for example, to a frequency of 173 kilocycles, and circuit 21 is tuned to a frequency of 177 kilocycles. The circuits 20 and 21 are, moreover, magnetically coupled to one of the intermediate frequency circuits, such as circuit 11, by a coupling device desired to be employed, and conventionally represented by the symbols M_3 and M_4 . In other words, energy having a nominal frequency of 175 kilocycles is impressed upon the circuit 20 which is tuned substantially two kilocycles to one side of the desired 175 kilocycle intermediate frequency, and intermediate frequency energy is also impressed upon circuit 21 which is tuned substantially 2 kilocycles off resonance to the other side of the desired intermediate frequency.

The couplings M_3 and M_4 are equal, and the circuits 20 and 21 are as sharply tuned to their respective frequencies as possible. Let it be assumed, for the moment, that the dotted line coupling 40 is absent from the receiver system; the function of this dotted line coupling will be explained at a later point. From Fig. 2, which is a graphic representation of the current relations in the control network, it will be seen that if the manual tuner is adjusted so as to produce a beat frequency lower than the operating intermediate frequency of 175 kilocycles, then the meter G will deflect in one direction. On the other hand, if the manual tuner is adjusted to produce beats higher than 175 kilocycles the meter G will deflect in the other direction. When the tuning is correct, the meter G does not deflect at all. Also, if the tuning is so far off that only small amounts of current pass the intermediate frequency circuits, the meter G will not be appreciably deflected. Thus, the meter indication will show in the vicinity of proper tuning whether the manual tuner is on one side or the other of the proper tuning adjustment. The correct adjustment causes the meter to indicate zero regardless of the signal strength. Hence, the meter constitutes an ideal tuning indicator.

Curve X of Fig. 2 represents the current flow in the 173 kilocycles circuit 20, frequency of beats being plotted against current. The curve Y denotes the current in the 177 kilocycles circuit. The dotted line curve Z represents the direct current flow through the meter G as the beat frequency varies. The construction of the meter G is not shown in detail because those skilled in the art are fully aware of the mechanical construction of such a meter. Merely by way of reference it is pointed out that the meter G can be any type of galvanometer which includes the usual magnetic poles. A current equal to the

difference between the rectified current outputs of rectifiers 26 and 27 flows through meter G, whose indicator, or needle, 29 will be deflected thereby in a sense determined by the direction and magnitude of the difference current. If, for example, the manual tuner is adjusted to a point such that the beat energy impressed on circuit 11 is less than 175 kilocycles, the needle 29 will be deflected to the right, and the amount of deflection will be an indication of the kilocycles off resonance. This effect arises because when the beat frequency is below 175 kilocycles, the 173 kilocycle circuit 20 will be more nearly in tune with such beat frequency, and will cause a flow of direct current through the galvanometer G, and this will deflect the needle 29 to the right.

When the beat frequency rises above 175 kilocycles the circuit 21 will be more nearly in tune with such beat frequency, and will cause the needle 29 to swing to the left of the zero point of the meter G. In this way the user of the set is not only able to see at a glance, and without having to listen to the loud speaker, whether or not the receiver is in tune to the desired station, but, if not, in which direction the tuning should be readjusted. Furthermore, if automatic volume control is used so that the output of intermediate frequency amplifier 8 is substantially constant, the number of division deflections of meter G will be proportional to the amount by which the I. F. departs from the desired value; at least when the tuning is near enough to being correct so that signals are heard with normal strength.

Such a visual tuning indicator is of particular value in a receiver utilizing automatic volume control. An automatic volume control network is not shown in the circuit diagram because those skilled in the art are fully aware of such volume control circuits, and can readily find information for the construction of such a volume control circuit. Reference is made to my Patent No. 1,913,959 of June 13, 1933, for an automatic volume control arrangement which may be employed in a superheterodyne receiver system of the type shown in Fig. 1. As is well known, the use of automatic volume control in a radio receiver makes it difficult to tune the receiver by ear. The utilization of a visual tuning indicator of the type disclosed in this application will facilitate the tuning of a receiver employing automatic volume control.

The control network which includes circuits 20 and 21 may further be utilized for automatically tuning the receiver. This is readily accomplished by constructing the shunt condenser 16 so as to include a stator and a rotor plate. The rotor of condenser 16 may be mechanically coupled, as shown by dotted line 40, to the indicator of the meter G. It is only necessary to correlate the movement of the indicator of meter G with the displacement of the rotor of condenser 16 to secure tuning of the local oscillator network. In Fig. 3 is shown an enlarged view of such a mechanical correlation of the indicator mechanism of meter G and the condenser 16. In this figure the rotor 16' of the shunt condenser 16 is shown mechanically fixed to the indicator mechanism of meter G so that when the indicator needle 29 moves to one or the other side of the zero indication of scale 28, a predetermined displacement will be secured between the stator 16 and the rotor 16' of the local oscillator shunt padding condenser.

It will be observed that the scale of the meter in Fig. 3 is calibrated in kilocycles off resonance below and above the operating intermediate frequency of 175 kilocycles. The zero mark indicates that the manual tuner has been adjusted to tune in the desired station, and that the beat frequency is equal to the intermediate frequency of 175 kilocycles. When the needle 29 indicates zero on the scale, the relation between the stator and rotor of condenser 16 is substantially as shown in Fig. 3. Let it be assumed that the manual tuner is adjusted to a station setting. If the tuning adjustment is incorrect, and such that the beat frequency is less than 175 kilocycles, the needle 29 will swing to the right along the scale and to such a point as to indicate the number of kilocycles that the receiver is below resonance.

Simultaneously, and from Fig. 3 this will be clear, it will be seen that the rotor 16' is displaced to the left, and the capacity value of condenser 16 is reduced. This reduction in value of condenser 16 results in a rise in the frequency of the local oscillator. Of course the relation between capacity changes of condenser 16 and the movement of needle 29 is a predetermined one. For any given accurate setting of the manual tuner the zero setting of the condenser 16 is that setting at which the local oscillator network is correctly tuned. When the needle 29 swings to the left on the scale, the rotor 16' will swing to the right and increase the capacity value of condenser 16, and thus decrease the local oscillator frequency at the particular setting of the manual tuner.

The mechanical linkage 40, generally shown in Fig. 1, is adjusted so that at zero meter deflection the small shunt capacity 16 is of the proper value to make the local oscillator "track" with the radio frequency signal tuning. If the manual tuner is not set correctly the meter G deflects, and changes the value of the condenser 16 in such a direction as to change the local oscillator frequency in that sense which makes the beat frequency approach more nearly to the desired value of 175 kilocycles. As the beat frequency approaches 175 kilocycles the current through the galvanometer meter G decreases, so that at a certain amount off tune the galvanometer current just balances the restoring force (which may be the well known restoring spring of the galvanometer of the meter). By making this restoring force small, and the change of capacity of condenser 16 with respect to movement of the mechanical linkage large, this equilibrium position can be made to occur at a beat frequency differing very little from the desired intermediate frequency of 175 kilocycles.

Thus, it will be seen that if the manual tuner will be set to any position close enough to the correct position to bring in the signal at all, the automatic tuning action will function to bring the tuning to a sufficiently close value to avoid detuning distortion. This assumes, of course, that the radio frequency selectivity is not sufficiently sharp to cause detuning distortion when the manual tuner is set closely enough to bring in the signals through the highly selective intermediate frequency system at all.

It will be obvious to one skilled in the art that damping means may be included in the meter G to prevent swinging "hunting" if such occurs. Such damping is often included in galvanometers, and is usually electrical, although it is also possible to arrange the moving part of G to move in a viscous medium, or air, in such a way as to in-

introduce into the system a frictional resistive force proportional to velocity.

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. In combination in a superheterodyne receiver of the type including a tunable signal circuit and a single tunable local oscillator circuit, means for simultaneously tuning both signal and oscillator circuits through frequency ranges which constantly differ by a predetermined beat frequency, an auxiliary network comprising a pair of resonant circuits, each resonant circuit including a rectifier, means for impressing the beat frequency energy upon said resonant circuits, one of said resonant circuits being tuned to a frequency differing from the beat frequency by a predetermined frequency value, the other resonant circuit being tuned to a frequency differing from the beat frequency by the same frequency value but in an opposite direction, means for utilizing the differential direct current output of said rectifiers for indicating the magnitude and direction of flow of the rectified currents, an auxiliary tuner device electrically connected to the oscillator circuit, and means responsive to operation of the indicating means for actuating said auxiliary device.

2. A radio receiving system comprising means

for collecting a modulated carrier wave, a first detector having an output circuit, a local oscillator coupled to said first detector for heterodyning said carrier wave to an intermediate frequency signal, said oscillator including a variable reactance device for varying its frequency, a tuning device mechanically connected to said variable reactance whereby the frequency of said oscillator may be varied by moving said tuning device to adjust the magnitude of the reactance, an auxiliary adjustable reactance electrically connected with said first reactance device, said auxiliary reactance comprising a variable condenser having a stator and rotor, an intermediate frequency utilization network coupled to the output circuit of said first detector and tuned to a predetermined intermediate frequency, and means for holding the carrier frequency of said intermediate frequency signal substantially constant in the region of said predetermined frequency while moving said tuning device through a predetermined distance, said frequency holding means comprising an electro-mechanical device, said last device including an adjustable element adapted to be displaced, a visual resonance indicator including said adjustable element as an indicator, the rotor of said auxiliary reactance being affixed to said adjustable element for displacement therewith as a unit, means for deriving a uni-directional current from said intermediate signal when the latter shifts in frequency from said predetermined frequency, and said electro-mechanical device being connected to said deriving means so as to be responsive to said uni-directional current.

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