

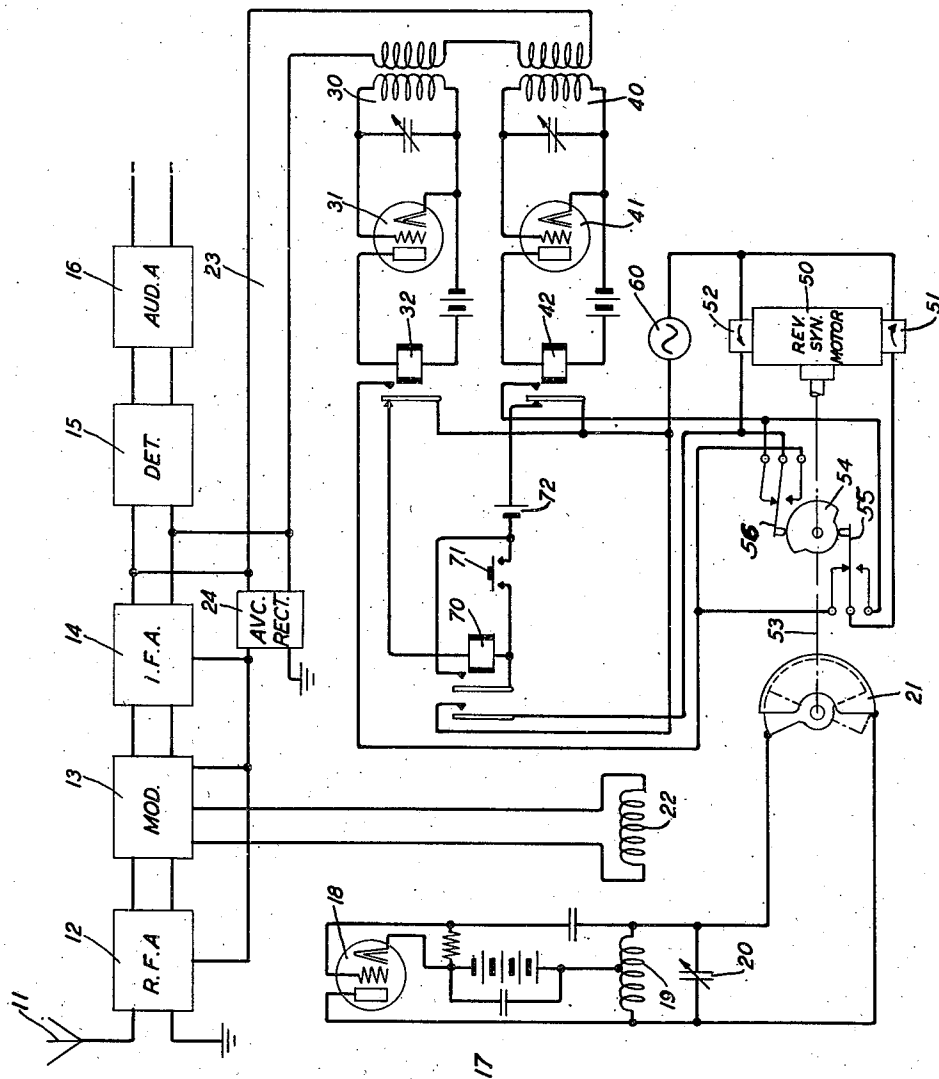
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AUTOMATIC TUNING

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AUTOMATIC TUNING

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This invention relates to frequency control systems and particularly to automatic tuning systems for radio receivers.

It is often desirable to provide a control for automatically regulating the tuning of a radio receiver to compensate for variations in the receiver circuit or in the frequency of the received wave itself. Such control systems are made responsive to small frequency variations in either direction from the required value. They are not usually responsive to large variations such as might occur during a shutdown period of the receiver or during an interruption of the operation of the transmitter.

In the case of the superheterodyne type of radio receiver most of the selectivity is attained in the intermediate frequency amplifier. For this reason the automatic tuning is effected preferably by regulating the frequency of the beating oscillator to maintain the intermediate frequency at the desired value. The voltage for operating the control is taken from the intermediate frequency amplifier and, if the frequency variation of either the incoming signal wave or the beating oscillator is such as to throw the signal at intermediate frequency outside of the range of the intermediate frequency filter, no voltage will be available for operating the control system.

An object of the invention is to improve the operation of automatic frequency control systems particularly with respect to wide departures from the required frequency.

A further object of the invention is to provide an automatic frequency control which will operate over a wide range of frequency variations and also be highly sensitive to small departures from the required frequency.

In accordance with a feature of the present invention there is provided in a superheterodyne radio receiver equipped with an automatic tuning system (responsive to small variations of the intermediate frequency from the required value) a system for continuously varying the frequency of the beating oscillator over a range of frequencies sufficiently wide to bring the intermediate frequencies into the range of response of the automatic tuning system and responsive to the operation of the latter system to interrupt the continuous variation of the beating oscillator frequency.

While the invention is particularly described herein as applied to a radio receiver it is clear that it is not limited to such application but may be utilized in many other situations where automatic control of frequency is desired. In the case of radio receivers it has been found particularly useful in the ultra-short wave field where frequency variations of considerable absolute magnitude are more likely to occur and where

the station spacing is sufficiently wide so that the continuous variation of the tuning can be carried out without tuning in an adjacent station.

These and other objects and features of the invention may be more fully understood from the following description of one specific application of the invention in a radio receiver as shown in the schematic circuit diagram constituting the drawing.

In this radio receiver the signal waves received in the antenna 11 are amplified in the radio frequency amplifier 12 and then combined in the modulator or first detector 13 with oscillations from a beating oscillator 17. The resultant intermediate frequency currents are amplified in the selective intermediate frequency amplifier 14 and detected in the second detector 15. The detected signal component is amplified in the audio or signal amplifier 16.

A portion of the intermediate frequency output of amplifier 14 is supplied to an automatic volume control rectifier 24. The direct current voltage developed by this rectifier is supplied to the radio frequency amplifier 12, the modulator 13 and the intermediate frequency amplifier 14 to regulate the gain of those stages as is well known in the art.

The oscillator 17 comprises a triode vacuum tube 18 connected as the well-known Hartley type oscillator. The frequency is determined by the inductance coil 19 connected in parallel with the condensers 20 and 21. The output of the oscillator is taken off through a pick-up coil 22 coupled to the inductance coil 19. The frequency of the output of the oscillator 17 is regulated by a mechanism for controlling the variable condenser 21.

The automatic frequency control is effected by the output voltage of the intermediate frequency amplifier 14 taken off through the connections 23. This voltage is applied to two tuned circuits 30 and 40, the circuit 30 being tuned to a frequency just below the lower edge of the intermediate frequency band and the circuit 40 to a frequency just above the upper edge of the band. The resonant frequencies of the circuits 30 and 40 are such that their resonance characteristics cross at the intermediate frequency carrier point. Therefore at any other frequency in the band of the intermediate frequency amplifier the voltage across one circuit will always be higher than that across the other. These two tuned circuits 30 and 40 are connected to the grids of the triode amplifiers 31 and 41, respectively, which have their plate circuits connected to the windings of the relays 32 and 42, respectively.

The relays 32 and 42 provide means for controlling the adjustment of the condenser 21 to

regulate the frequency of the output of the oscillator 17 so as to maintain the intermediate frequency carrier at the mid-point of the intermediate frequency band, that is, between the resonant frequencies of the tuned circuits 30 and 40. This control is effected by means of the motor 50 which drives the shaft 53 on which is mounted the rotor plate section of the variable condenser 21. The motor 50 is an alternating current motor provided with two windings 51 and 52 for driving in opposite directions. Thus the operation of relay 32 will establish a circuit from the left-hand terminal of the alternating current source 60, through armature and inner contact of relay 32, upper contact and arm 55 to motor winding 51. The operation of relay 42 closes a similar circuit to the winding 52 causing the operation of the motor 50 in the opposite direction.

Since there are two symmetrical positions of the rotor of condenser 21 for each capacity value and since the rotor must be moved in opposite directions from each of such positions for capacity increase or decrease, the cam switch 54 is mounted on the shaft 53. This cam switch 54 causes the reversal of the direction of rotation of the shaft 53 at each extreme active position of the rotor plates of condenser 21. This provides that each of the relays 32 and 42 will always produce the rotation of the rotor plates of condenser 21 in such a direction as to correct for the frequency deviation which produces the operation of the relay.

This action is provided by means of the switch arms 55 and 56 operated by the cam 54 and the contacts associated with the arms. Thus in the position shown in the drawing, the inner contact of relay 32 is connected through the upper contact and arm 55 to the motor winding 51. Accordingly the operation of relay 32 would cause the rotation of the motor and the apparatus on the shaft 53 in the direction indicated by the arrow associated with the winding 51 to increase the condenser capacity. Similarly, the inner contact of relay 42 is connected through the upper contact and arm 56 to the motor winding 52 so that the operation of relay 42 causes the rotation of condenser 21 in the direction opposite to that produced by the relay 32 to decrease the condenser capacity. When the rotor plate of the condenser 21 reaches either extreme condition, that is either completely meshing with the stator plate or completely out of mesh therewith, the action of the cam 54 causes the connections of the relays 32 and 42 to the respective motor windings 51 and 52 to be reversed. Thus, when either extreme position is reached the arms 55 and 56 will be operated by the surfaces of the cam 54 opposite to that shown in the drawing. The inner contact of relay 32 will then be connected through lower contact and arm 56 to motor winding 52 and the inner contact of relay 42 will be connected through lower contact and arm 55 to motor winding 51.

With this mechanism and circuit arrangement the action is such that when the rotor plates are in the other of the symmetrical positions, as shown by the dash-dot line, in which the condenser capacity is the same as shown by the full line, the operation of the relay 32 or the relay 42 will still be such as to cause the capacity change in the same direction (though in each case the rotation of the condenser in the opposite direction will be required for such a capacity change). This arrangement is necessary for

the reason that the hunting or sweeping control to be described immediately following will act to stop the rotor plates of condenser 21 in either of such two symmetrical positions in which the capacity is the same.

A relay 70 is provided for producing a hunting or sweeping control of the tuning. Thus when the frequency of the output of the oscillator 17 is such that there is produced no output of the modulator 13 within the intermediate frequency band, the mechanism may be caused to continuously rotate the condenser 21 to vary the frequency of the oscillator 17 until it reaches such a value that there is produced an intermediate frequency output within the band of intermediate frequency filter. At such a point the operation of the hunting mechanism is interrupted and the relays 32 and 42 take control to hold the intermediate frequency carrier at the desired value.

This hunting or sweeping action is produced by operating the pushbutton 71. This closes a circuit from the negative terminal of battery 72 through pushbutton 71, winding of relay 70, outer contact and armature of relay 32, armature and outer contact of relay 42 to the positive terminal of battery 72. Current flowing through this circuit causes the operation of relay 70. The operation of relay 70 completes two circuits: one to the inner armature and contact of relay 70 to close a holding circuit for the relay 70 in shunt to the push button 71 so that the button need be depressed only momentarily to put the sweep circuit into action; the other from the left-hand terminal of the alternating current source 60 through the contact and outer armature of relay 70 to the motor winding 52. This causes the continuous rotation of the condenser 21 to continuously vary or sweep the frequency of the oscillator 17. If during this sweeping period there is produced in the output of modulator 13 a current of frequency in the intermediate frequency band one of the relays 32 or 42 will be operated. Such an operation of either of the relays 32 and 42 will open the circuit from the positive terminal battery 72 to the winding of relay 70 at the outer contact of the operated relay 32 or 42, thus releasing relay 70 and opening the connection to the motor winding 52 through its outer armature. After such an operation the relays 32 and 42 take over the control of the motor 50 to regulate the tuning of the oscillator 17 to maintain the intermediate frequency at the desired value as described above.

Although the invention has been illustrated and described in connection with one particular type of system for automatic frequency regulation it is understood that it is equally applicable to many of the other types known in the art. It will also be evident that many other modifications in the system may be made without departing from the spirit and scope of the invention.

What is claimed is:

1. A heterodyne detector system comprising a source of oscillations, means for combining the received oscillations with oscillations from said source, means for selecting from the output of the combining means, the combination products in a narrow frequency range, regulating means responsive to variations of frequency of the output of the selecting means within said narrow frequency range for so changing the frequency of the oscillations produced by said source as to maintain the output from said selecting means at a substantially fixed frequency in said narrow

frequency range, means for cyclically varying the frequency of the output of said source over a range wider than said narrow frequency range, and means responsive to the operation of said regulating means to arrest the cyclic variation of the frequency of the output of said source.

2. A radio receiver comprising a source of beating oscillations, a detector for combining the received waves with oscillations from said source, a variable reactor for regulating the frequency of the oscillations produced by said source, a motor for operating said variable reactor, a first relay having a normally closed contact and a normally open contact and responsive to outputs from said detector above a predetermined frequency for closing said normally open contact to cause the operation of said motor to vary the frequency of the oscillations produced by said source in such a direction as to restore the output of said detector to said predetermined frequency, a second relay having a normally closed contact and a normally open contact and responsive to outputs from said detector below said predetermined frequency for closing said normally open contact to cause the operation of said motor to vary the frequency of the oscillations produced by said source in such a direction as to restore the output of said detector to said predetermined frequency, a third relay including a normally open contact adapted when closed to complete a circuit to operate said motor to continuously operate said variable reactor and produce cyclic variations in the frequency of the oscillations produced by said source, and a circuit including the normally closed contacts of both said first and second relays for causing the operation of said third relay.

3. A radio receiver comprising a source of beating oscillations, a detector for combining received waves with said beating oscillations, a selective intermediate frequency amplifier for amplifying the intermediate frequency output of said detector, regulating means responsive to the selected intermediate frequency output of said amplifier for varying the frequency of the beating oscillations from said source to maintain the intermediate frequency at a substantially constant frequency within the selected band, means for continuously varying the frequency of said beating oscillations over a range of frequencies wider than the selected band of said intermediate frequency amplifier, and means responsive to the operation of said regulating means for arresting the continuous variation of the frequency of said beating oscillations.

4. A radio receiver comprising a source of beating oscillations, a detector for combining the received waves with oscillations from said source, a variable reactor for regulating the frequency of the oscillations produced by said source, a motor for operating said variable reactor, a selective intermediate frequency amplifier for amplifying the output of said detector within a fixed intermediate frequency band, a first relay having a normally closed contact and a normally open contact and being responsive to outputs of said intermediate frequency amplifier in the upper portion of said fixed frequency band to the exclusion of outputs in the lower portion thereof, a circuit adapted to be completed through the normally open contact of said relay for causing the operation of said motor to reduce the frequency of the output of said detector, a second relay having a normally closed contact and a normally open contact and being responsive to outputs in the lower frequency portion of said

fixed frequency band to the exclusion of outputs in the upper portion thereof, a circuit adapted to be completed through the normally open contact of said second relay for operating said motor to increase the frequency of the output of said detector, a third relay including a normally open contact, a circuit adapted to be completed by the closing of the normally open contact of said third relay for operating said motor to continuously operate said variable reactor and produce cyclic variations in the frequency of the oscillations produced by said oscillator and in the output of said detector, and a circuit including the normally closed contacts of both said first and second relays for causing the operation of said third relay.

5. In a carrier-wave signal receiver, an automatic control system comprising, a network the output of which varies in response to variation of a given characteristic of a signal input thereto over a given range of variation of said characteristic, means responsive to the output of said network for maintaining said given characteristic of said signal input to said network approximately at a predetermined value within said given range of variation when said characteristic of said input wave has any value within said given range, additional means for periodically sweeping the value of said characteristic of said signal input over a range which is wider than and which overlaps said given range, and means responsive to the resulting characteristic of the signal input to said network for rendering said additional means inoperative when said resulting characteristic has a value within said given range.

6. An automatic frequency control system comprising, a discriminator network the output of which varies in response to variation of the frequency of a signal input thereto over a given frequency range, means responsive to the output of said network for maintaining the frequency of said signal input to said network approximately at a predetermined frequency within said given frequency range when said frequency of said signal input falls within said given frequency range, additional means for periodically varying the frequency of said signal input over a frequency range which is wider than and which overlaps said given frequency range, and means responsive to the resulting frequency of the signal input to said network for rendering said additional means inoperative when said resulting frequency has a value within said given frequency range.

7. An automatic frequency control system comprising, a discriminator network the output of which varies in response to variation of the frequency of a signal input thereto over a given frequency range, means responsive to the output of said network for adjusting the frequency of said signal input to said network to a frequency within a desired small frequency range within said given frequency range when said frequency of said signal input is within said given frequency range, additional means for periodically varying the frequency of said signal input so that it sweeps at a frequency lower than any frequency within said given frequency range and over a frequency range which is wider than and which overlaps said given frequency range, and means responsive to the resulting frequency of the signal input to said network for rendering said additional means inoperative when said resulting frequency has a value within said given frequency range.

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