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AUTOMATIC FREQUENCY CONTROL SYSTEM

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Fig. 1.

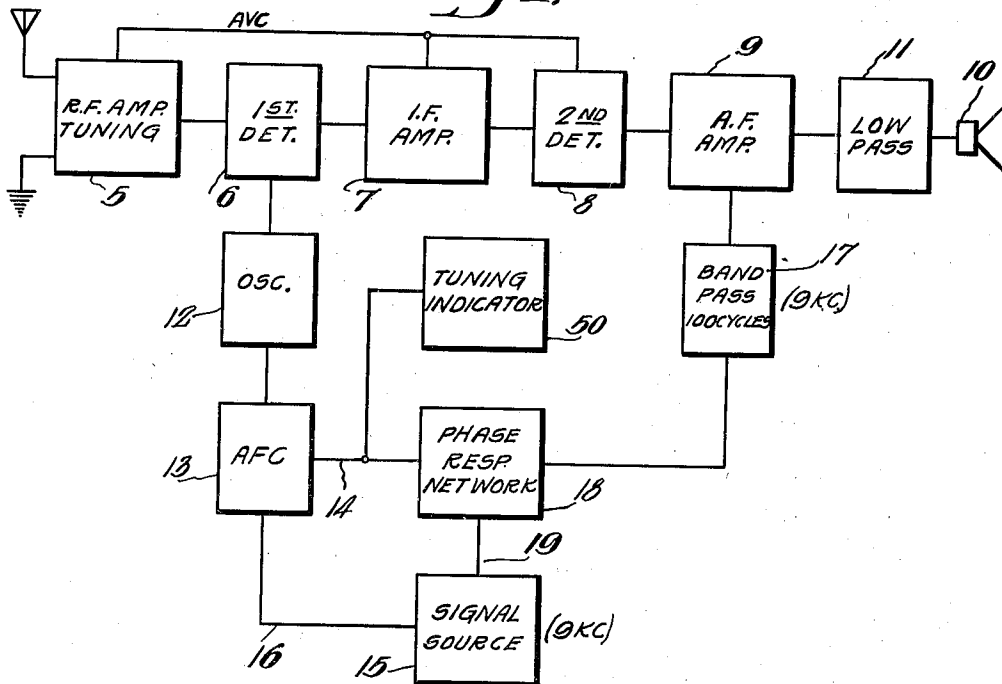
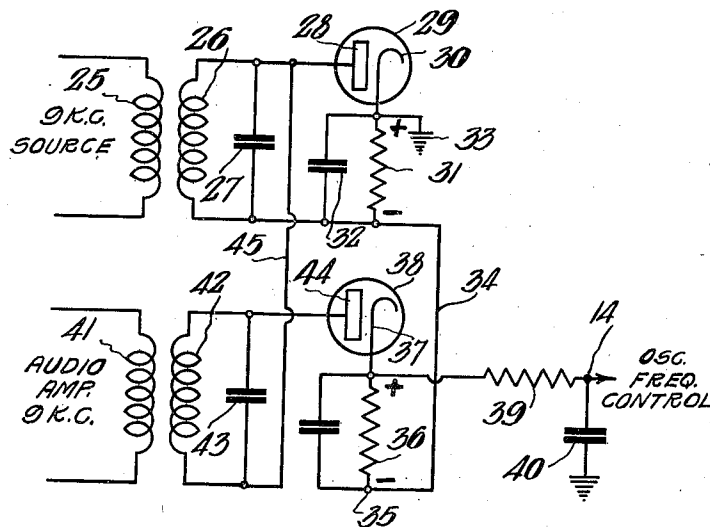


Fig. 2.



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AUTOMATIC FREQUENCY CONTROL
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5 Claims. (Cl. 250—40)

The present invention relates to automatic frequency control systems for superheterodyne receivers and the like embodying a signal amplifier, such as an intermediate frequency amplifier, and has for its primary object to provide a system of the character referred to which utilizes the overall selectivity of the said amplifier to secure automatic frequency control, for tuning indication, and the like.

In present systems for securing automatic frequency control or tuning indication, circuits are provided which depend upon a single pair of tuned circuits, such as a single intermediate frequency transformer, which may or may not contribute to the total selectivity of the receiving system or the intermediate frequency selectivity as the reference frequency for exact tuning. If this single pair of tuned circuits becomes mistuned the automatic frequency control or tuning indication dependent thereon also tends to become mistuned. To aid in overcoming this tendency, it is desirable to utilize the selectivity of the entire amplifier system for automatic frequency control or tuning indication purposes, and to this end it is a further object of the present invention to provide an automatic frequency control or tuning system which adds to the input of the amplifier a signal which may be compared with itself at the output of the system, this potential being provided by frequency modulation of the input signal, and the overall selectivity of the amplifier thus being effective.

The invention will be described, by way of example, in connection with a superheterodyne receiver as shown in the accompanying drawing in which—

Figure 1 is a block diagram of a superheterodyne radio receiving system embodying the invention, and

Figure 2 is a schematic circuit diagram of a portion of the circuit of Fig. 1.

The scope of the invention is defined by the appended claims.

Referring to Fig. 1, a conventional superheterodyne receiver is illustrated, in which element 5 is the R. F. amplifier and tuning means coupled to a first detector 6 and having an intermediate frequency amplifier 7 for supplying signals to a second detector 8. This is followed in the signal channel by an audio frequency amplifier 9 and a loudspeaker or output device 10 with a low pass filter 11 interposed between said device and the amplifier 9.

The heterodyne oscillator is indicated at 12, coupled to the first detector and controlled by

suitable automatic frequency control means 13 responsive to a control potential supplied thereto through a direct current connection 14 along with a signal potential from a signal source 15 through a connection represented at 16.

The heterodyne oscillator 12 is frequency modulated by the frequency control means 13, the rate at which the frequency is varied being determined by the frequency of the source 15. This results in frequency modulation of the intermediate frequency signals, the frequency being varied at a rate corresponding to the frequency of the source 15. The amount of signal or voltage applied from the source 15 is sufficient to provide frequency modulation of an incoming signal at the intermediate frequency with a small amount of frequency variation but at a rate of variation such that the two side bands resulting from this frequency modulation will be reduced in amplitude by the sides of the intermediate frequency amplifier selectivity curve. At resonance, therefore, the side bands of the modulated carrier frequency will be equal in amplitude and no modulation frequency output of the second detector will occur.

Under such conditions, it is desired that the A. F. C. control voltage applied to the oscillator shall be zero in a preferred embodiment of the invention. Therefore, the signal source 15 may provide a signal frequency for modulating the carrier which is of a frequency equal to substantially one-half of the width of the pass band of the intermediate frequency amplifier and preferably below 50 percent amplitude.

Change of tuning of the oscillator or signal will then cause one side band to become much stronger than the other because of the selectivity of the intermediate frequency amplifier and will result in a signal having the frequency of the source 15 being delivered through the audio frequency circuits.

This signal is prevented from reaching the loudspeaker or output device by the low pass filter 11 and a portion thereof is derived from the audio frequency amplifier and taken through a band pass filter 17 to a phase responsive network 18. Signals from the source 15 are also applied to the phase responsive network as indicated by the connection 19, the arrangement of the network being such that when the oscillator is correctly tuned, the direct current biasing potential applied to the A. F. C. system at resonance through the connection 14 is substantially zero.

The signal source 15 operates preferably at a relatively low frequency such as a frequency within the audio frequency range and with present

broadcasting systems a frequency below 10 kc. and above the normal audio frequency response range of the usual receiving system is preferred. As the normal response range of present receiving systems is below 8 kc. a preferred signal source frequency is substantially 9 kc., in which case the incoming received signals are frequency modulated at that frequency and a 9 kc. signal is derived from the audio frequency amplified through the band pass filter 17, which is designed to pass a band at least 100 cycles wide.

The circuit arrangement of the phase responsive network 18 is shown in Fig. 2 to which attention is now directed along with Fig. 1. The 9 kc. source input to the network may be taken through the primary 25 of an input transformer, the secondary 26 of which is tuned to 9 kc. by a capacitor 27. The secondary is connected at the high potential side to the anode 28 of a diode rectifier 29 having a cathode 30 connected through an output resistor 31 to the low potential side of the input circuit 26—27. A by-pass capacitor 32 is provided for the output resistor 31. In response to signals from the 9 kc. source the direct current output across the resistor 31 has a polarity as indicated and the positive terminal is connected to ground or chassis as indicated at 33.

The negative terminal of the resistor 31 is connected through a lead 34 with the negative terminal 35 of a second diode output resistor 36, the positive terminal of which is connected to the cathode 37 of a second diode rectifier 38 and to the output connection 14 for the A. F. C. circuit through a suitable filter resistor 39 provided with a filter capacitor 40.

The second diode rectifier 38 is connected with the audio frequency amplifier 9 kc. band pass filter 17, through a tuned input transformer similar to that for the 9 kc. source and comprising a primary 41 and a secondary 42 provided with a shunt tuning capacitor 43 for tuning the second diode circuit to the same 9 kc. signal.

As in the case of the first diode rectifier, the high potential side of the circuit is connected to the anode 44 of the rectifier 38 and the low potential side thereof is connected through a lead 45 with the high potential side of the first diode input circuit so that signals received from the 9 kc. source 15 is applied to both rectifier devices in opposition, whereby, in the absence of signals from the audio frequency amplifier, the output potential applied to the connection 14 is substantially zero by reason of the opposed series connection between the output resistor 31 and the output resistor 36.

In the presence of a received signal in the receiving system, frequency modulation thereof from the signal source is effected, and resulting in the application of the 9 kc. signal from the audio frequency amplifier to the diode rectifier 38 and to the output resistor 36. This output potential developed across the resistor 36 may be in opposition to or in aiding relation to the fixed voltage existing in the resistor 31 from the 9 kc. source and serves to cause the connection 14 to vary from zero potential in a positive or a negative direction, thereby to control the A. F. C. connection for the oscillator and to maintain the tuning of the system to the desired signal in the usual manner for A. F. C. systems, the polarity of the output and the magnitude of the controlling D. C. potential derived through the connection 14 depending upon which side band of the 9 kc. signal is passed through the I. F. amplifier and the

amount of departure from resonance of the received signal.

Analyzing the circuit of Fig. 2, it will be seen that the tuned circuit in connection with the signal source 15 is connected in parallel with the anodes of the two diode rectifiers, while the cathodes of the rectifiers are connected with the oscillator frequency control circuit across a tapped resistance comprising the resistors 31 and 36 in series, the tap being substantially at the center of the resistance and connected to the low potential side of the 9 kc. tuned circuit for the 9 kc. source.

The audio frequency signal is connected through a second tuned circuit inserted adjacent to the anode in series therewith for the second rectifier 38 so that signals received from the audio frequency amplifier through the band pass filter 17 add vectorially to the signals from the 9 kc. source.

A tuning indicator device is represented at 50, Fig. 1, and is connected in the usual manner to the output connection 14 for receiving the controlling D. C. potential which varies in magnitude and polarity when off resonance. The tuning indicator may be of any suitable type and if used alone without A. F. C. it will be seen that the signal source may be deenergized except during tuning manually or automatically.

An advantage of the system lies in the fact that the overall selectivity of the receiving system and in particular the I. F. amplifier of a superheterodyne receiver is utilized in controlling the tuning of the system or in providing an indication of the tuning. The circuit will operate satisfactorily with band pass intermediate frequency amplifiers or with substantially any type of selectivity characteristic in the amplifier, if the modulating frequency is properly chosen, so that at the normal operating frequency, the side bands are within the selectivity curve sufficiently to give some degree of transmission through the receiving system.

I claim as my invention:

1. In a superheterodyne radio receiving system, the combination with a tunable intermediate frequency signal amplifier, of means including an oscillator and first detector for applying a selected signal to the input of said amplifier, means connected with the oscillator and responsive to a variable control potential for controlling the frequency of the oscillator, means providing a modulating signal source, means for applying a modulating signal through said frequency controlling means from said source to the oscillator to produce frequency modulation of the selected signal, means for deriving a signal at the modulating frequency from the output of said amplifier, whereby the overall selectivity of said amplifier is utilized in providing said signal, a phase-responsive network comprising two circuits tuned to said modulating signal frequency, means for applying said modulating signal to one of said circuits, means for applying said derived signal to the other of said circuits, a signal rectifier connected with each of said circuits and having an output impedance, one of said rectifiers being connected serially with both tuned circuits and said output impedances being connected serially in polarity opposition and so related in impedance value that in the absence of signals the output therefrom is substantially zero and in the presence of signals the output potential therefrom varies in polarity and magnitude from zero with variations of a received signal from resonance with said amplifier, and means for applying said

output potential to said frequency controlling means for the oscillator.

2. In a radio receiving system, the combination with a tunable signal amplifier, of means for applying a selected signal to the input of said amplifier, means for applying a modulating signal to said first named signal to produce frequency modulation thereof, means for deriving a signal at the modulating frequency from the output of said amplifier, a phase-responsive network, means for applying said derived modulating signal to said network, and means in said network for deriving therefrom a controlling potential which varies in polarity and magnitude with variations of a received signal from resonance with said amplifier, said modulating frequency being substantially equal to one-half of the width of the passband of said amplifier at a low amplitude level, thereby to permit one sideband only of the modulation frequency to pass through the amplifier with appreciable amplitude, when a received signal varies from resonance with said amplifier.

3. In a radio receiving system, the combination with a tunable signal amplifier, of means for applying a selected signal to the input of said amplifier, means for applying a modulating signal to said first named signal to produce frequency modulation thereof, means for deriving a signal at the modulating frequency from the output of said amplifier, a phase-responsive network, means for applying said derived modulating signal to said network, and means in said network for deriving therefrom a controlling potential which varies in polarity and amplitude with variations of a received signal from resonance with said amplifier, said phase-responsive network providing two tuned input circuits each resonant to said modulation frequency, a rectifier device coupled to one of said circuits to receive the signal output therefrom and having an output impedance, a second rectifier coupled to said circuits in series to receive signal output from said circuits jointly, and said means for deriving a control potential from said network, including said output impedances connected in polarity opposition one with respect to the other.

4. In a superheterodyne receiving system, the combination of tuning means therefor, a first detector and an oscillator, an intermediate frequency amplifier having a predetermined band-pass characteristic, a second detector, a signal output circuit connected with said second detector and including a low pass filter, automatic frequency control means for said system responsive to a controlling potential which varies in polarity and amplitude, means for generating a

signal in an audio frequency range above the normal audio frequency output range of said receiving system, means for applying said signal at a point in said system preceding said intermediate frequency amplifier to produce frequency modulation of an incoming signal, means for deriving the modulation frequency from said output circuit, a phase-responsive network having a tuned input circuit resonant to said modulation frequency and connected with said last named means, a bandpass filter in said last named connection, said network further including a second tuned circuit resonant to said modulation frequency and connected with modulation frequency generating means, a rectifier device connected with the first-named tuned circuit of said network and having an output impedance for the rectified direct current component of the modulation signal, a second rectifier connected serially with said tuned circuits to receive the signal output therefrom and having an output impedance for deriving a direct current component of the modulation signal from each of said tuned circuits, said output impedances being connected in series opposing, to provide a resultant controlling potential for the automatic frequency control means provided across said output impedances, and means for applying said potential to said control means for the system.

5. In a superheterodyne receiving system, the combination with tuning means therefor including a first detector and an oscillator, of an intermediate frequency amplifier having a predetermined bandpass characteristic, a second detector, a signal output circuit connected with said second detector, means for generating a modulating signal in an audio frequency range above the normal audio frequency output range of said receiving system, means for applying said modulating signal at a point in said system preceding said intermediate frequency amplifier to produce frequency modulation of an incoming signal at a rate determined by said modulating signal, means for deriving a signal at the modulating signal frequency from said output circuit, a phase-responsive network having an input circuit resonant to said modulation frequency and connected with said last named means, said network further including a second input circuit resonant to said modulation frequency and connected with the modulation frequency generating means, rectifier means connected with the input circuits of the network and having an output circuit for deriving a resultant control potential therefrom.

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