Nov. 4, 1941. W. R. KOCH 2,261,374

FREQUENCY MODULATION RECEIVING SYSTEM

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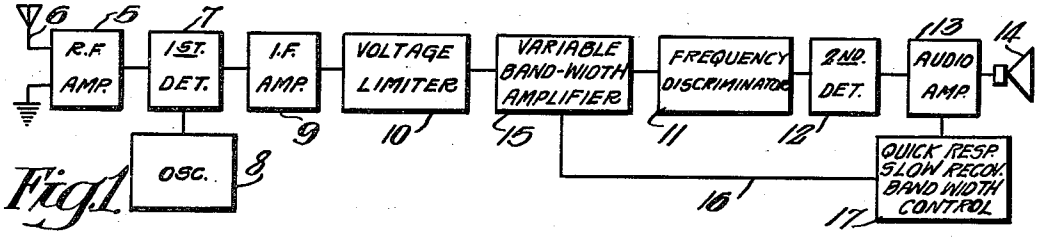


Fig. 1

Fig. 2.

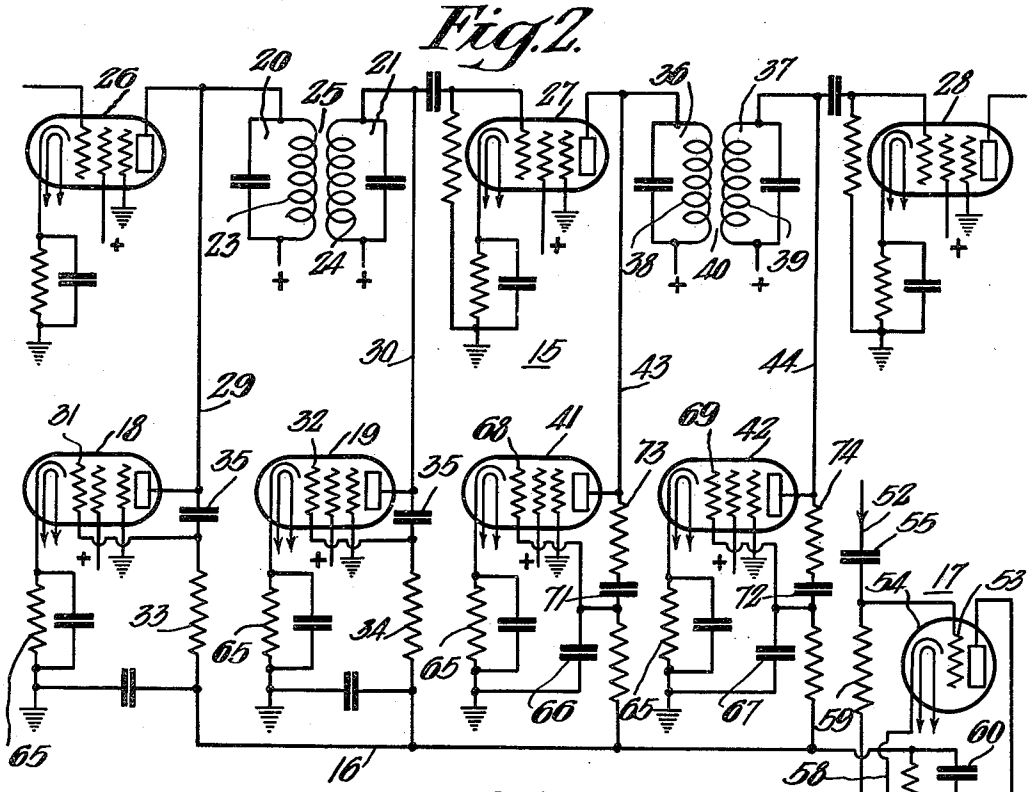
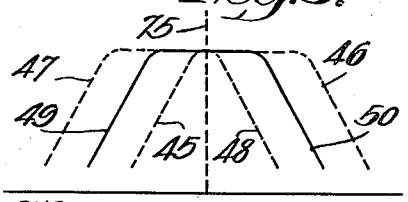


Fig. 3.



CHANGE IN SELECTIVITY OF ADJUSTABLE BAND WIDTH AMPLIFIER

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FREQUENCY MODULATION RECEIVING SYSTEM

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3 Claims. (Cl. 250—20)

This invention relates to frequency modulation receiving systems having a relatively wide frequency band response, and has for its primary object to provide an improved system of the character referred to for automatically controlling the frequency band width of the intermediate frequency amplifying portions thereof preceding the frequency discriminator network and second detector, thereby to provide effective noise reduction in the operation of said system.

It is also a further object of the present invention, to provide a frequency modulation receiving system having a variable band width amplifier preceding the frequency discriminator network and means responsive to variations in the percentage modulation or signal frequency swing for controlling said amplifier.

It is a further object of the present invention, to provide means responsive to variations in the amplitude of the audio frequency signals resulting from conversion of frequency modulated to amplitude modulated signals, to control the band width of an intermediate frequency portion of the system, thereby to reduce the band width when the percentage modulation or frequency swing of the received signal is relatively low, and to cut off noise components accompanying a desired signal.

It has been found that this system for noise reduction in a wide band frequency modulation receiving system is most effective when the band width control is provided subsequent to the usual signal voltage limiter and preceding the frequency discriminator network provided in connection with the second detector for the frequency modulation conversion.

In the normal operation of a receiving system, responsive to frequency modulated signals, a relatively low percentage modulation is normally present. With wide band frequency modulation this requires that a relatively wide frequency response band be provided in the system to convey the signals when modulated to a maximum degree. This relatively wide frequency band permits interference signals to be received and also permits noise components with low modulation signals to pass through to the second detector and to beat with each other, causing background noise in the receiving system.

It is, therefore, a further object of the present invention to provide a frequency modulation receiving system having improved means for automatically controlling the band width of the frequency response of the system in accordance with variation in the percentage modulation or frequency swing and in a direction to reduce said band width during periods of low percentage modulation.

The invention will, however, be better understood from the following description when considered in connection with the accompanying drawing and its scope is pointed out in the appended claims.

In the drawing, Figure 1 is a block diagram of a frequency modulation receiving system,

Figure 2 is a schematic circuit diagram of a portion of the system of Fig. 1 showing certain of the circuits in detail, and

Figure 3 is a graph showing curves illustrating an operating characteristic of the system of Figs. 1 and 2.

Referring to Fig. 1, the frequency modulation receiving system shown includes the usual tunable high frequency amplifier 5 coupled to a signal input circuit such as an antenna circuit 6 and followed by the first detector 7 and oscillator 8 for providing the intermediate frequency signal which is applied to the intermediate frequency amplifier 9. The intermediate frequency signals from the amplifier 9 are passed through a suitable signal voltage limiter indicated at 10 and a frequency discriminator network 11 in connection with the second detector 12 thereby converting the frequency modulated signals into amplitude modulated signals which are detected and converted to audio frequency for the usual audio frequency amplifier 13 and output device or loudspeaker 14.

A variable band width amplifier is interposed in the signal transmission channel of the receiving system preceding the frequency discriminator network and preferably following the voltage limiter. In the present example, the variable band width amplifier is indicated at 15 and is of a type responsive to a variable control voltage applied thereto through a control circuit 16 from a control system 17 connected with the audio frequency amplifier, as indicated, whereby the control voltage applied to the variable band width amplifier and the band width of said amplifier vary in accordance with variations in the amplitude of the audio frequency signals.

The audio frequency signals are derived from the second detector through the discriminator network, and may be taken as a measure of the percentage modulation or swing of the frequency modulated signal. Therefore the band width of the intermediate frequency amplifier may be varied thereby proportionally with variations in the percentage modulation or swing and in a direction to cause the band width to be reduced

during periods of low percentage modulation or frequency swing.

In a preferred embodiment of the invention, the variable band width amplifier may be arranged as shown in Fig. 2 and connected with a quick response, slow recovery band width control circuit.

Referring to Fig. 2, the variable band width amplifier includes a plurality of tuned band pass circuits of which two are shown at 20 and 21 and may be provided by the tuned primary and secondary windings 23 and 24, respectively, of an interstage intermediate frequency coupling transformer 25 interposed between an input amplifier tube 26 and a second stage amplifier tube 27.

The tuned circuits 20 and 21 are coupled through the transformer arrangement and are variably tunable by means of control tubes 18 and 19, the anode circuits 29 and 30, respectively, of which are connected through the windings 23 and 24, as indicated, whereby the anode circuit impedance of the tubes is substantially in shunt with the tuned circuits.

The control grids of the tubes 18 and 19, indicated at 31 and 32, respectively, are connected through suitable resistors 33 and 34, respectively, to the bias supply or control lead 16 from the band width control system 17. The grids are also coupled to their respective anode circuits through coupling capacitors indicated at 35, these capacitors providing a relatively large capacitive reactance with respect to the resistance of the resistors 33 and 34, thereby providing a voltage on the grids 31 and 32 which leads the plate voltage of the tube by substantially 90°. As the bias potential applied thereto from the lead 16 is varied, the anode current and the effective reactance of the tubes varies to shift the tuning of the band pass filter comprising the circuits 20 and 21.

The variable band width amplifier includes a second variable band pass filter comprising a pair of tuned coupled circuits 36 and 37 provided by the tuned primary and secondary windings, respectively, of an intermediate frequency interstage coupling transformer 40. This is provided between the second amplifier stage 27 and an output amplifier stage 28.

In connection with the second band pass filter, two selectively control tubes 41 and 42 are provided, with anode circuits 43 and 44, respectively, connected through the windings 38 and 39, respectively, for controlling the tuning of the circuits 36 and 37 in response to variation in biasing potential from the control lead 16 in the same manner as for the first described band pass filter, the tubes being variable reactance tubes as before, but connected for response to the same variation in biasing potential and in the same direction to vary the reactance load on the circuits in an opposite sense, thereby to shift the tuning of the second band pass filter in an opposite direction to that of the first band pass filter.

The shifting of the pass bands of the two filters is shown in Fig. 3, the curve 45—46 representing the selectivity of one filter section, such as the circuits 20—21 and the curve 47—48 representing the selectivity of the other filter section, such as the circuits 36—37, while the full line curve 49—50 represents the over-all selectivity in response to substantially full modulation, or the full band selectivity of the variable band width amplifier 15.

The audio frequency voltage from the audio frequency amplifier 13 is derived therefrom through a supply lead indicated at 52 and is applied to the control grid 53 of a band width control amplifier stage including a tube 54, through a coupling capacitor 55. Grid bias is applied to the grid 53, from a self-bias resistor 57 in the cathode lead 58, through a grid resistor 59. The control lead 16 is connected to the cathode or positive end of the resistor 57 through a filter comprising a resistor 56 and a by-pass capacitor 60, while the negative terminal 61 is connected to ground. A suitable by-pass capacitor 63 is provided for the cathode resistor 57. The resistor 57 in the cathode circuit is of such a value that the tube 54 is biased substantially to cut-off in the absence of audio frequency signals, and an increase in the applied signal causes the anode current to increase, thereby reducing the anode-cathode impedance of the selectivity control tubes 18, 19, 41 and 42 in accordance with the signal strength which, in the case of a frequency modulation receiver, is substantially in accordance with the percentage modulation or frequency variation of the received signal. It will be noted that a suitable residual bias is provided on the selectivity control tubes by self-bias resistors indicated at 65.

In connection with the selectivity control tubes 41 and 42, the capacitive reactances represented by the capacitors 66 and 67 are relatively low with respect to the resistance of the resistors 73 and 74 inserted between the anode circuits 43 and 44 and the respective control grids 68 and 69 of the control tubes 41 and 42, thereby causing the signal voltage applied to said grids to lag substantially 90° behind the plate voltage. With a capacitive reactance at 66 and 67 which is relatively low with respect to the series grid resistor 73 and 74, the tubes 41 and 42 control the selectivity or frequency shift of the circuits 36 and 37 in an opposite sense from the control exercised by the tubes 18 and 19 on the circuits 20 and 21. The coupling capacitors 71 and 72 between the plate circuits and grids of the tubes 41 and 42 are relatively large in capacity value, having no appreciable capacitive reactance in the circuit at the frequencies transmitted therethrough.

In the system shown, the reactance or selectivity control tubes are utilized to shift the tuning of one band pass filter to a higher frequency, while the reactance tubes across the other band pass filter shift the tuning to a lower frequency in the absence of a control voltage from the control amplifier 17. This causes the over-all selectivity response characteristic to approach the middle or intermediate frequency 75 of the resultant curves of Fig. 3, and the gain will remain the same throughout the intermediate frequency amplifier. The selectivity characteristic thus becomes relatively narrow, as indicated by the curves 45 and 48 substantially without change in gain.

When the audio frequency output voltage and hence the frequency swing or modulation of a received signal reaches a predetermined value corresponding to the minimum frequency band width established in the variable band width amplifier, the control tube 54 will conduct current, making the cathode more positive, and this voltage applied to the control grids of the reactance tubes causes them to pass more reactive current, thus tuning the filters to different frequencies, in this case tending to shift them toward the I. F. frequency 75 of Fig. 3 and thereby effectively widening the band width to per-

mit higher percentage modulation signals to be received and passed through to the discriminator network.

The control tube circuit is such as to give a quick response, to permit the frequency band to be widened rapidly and thus avoid distortion during rapid increases in percentage modulation or frequency swing of received signals. It should also have a slow recovery characteristic to keep the band width from varying at the modulation frequency and thereby introducing distortion.

While the invention has been shown and described in connection with a receiving system having a variable band width amplifier controllable by variable reactance tubes, it should be understood that the variable band width control may be provided by any suitable means responsive to the audio frequency output of the signal channel. This may, preferably, have a relatively rapid response and slow recovery characteristic to provide a variable controlling biasing potential for a variable band width amplifier as shown.

In any case, however, it should be noted that a band width variation preceding the frequency discriminator network is provided and is made responsive to the variations in swing or percentage modulation and directly in accordance with the amplitude of the demodulated signal from the second detector. Thus, the band width may be maximum for low modulation signals without introducing noise and interference signals, and for strong modulation or frequency swing in the received signal, the band width is automatically increased as required to prevent distortion.

Although the system disclosed and described is a preferred arrangement of a frequency modulation system embodying the invention, it may be applied to other frequency modulation receiving systems and may be carried out by any suitable means having the features hereinbefore referred to.

I claim as my invention:

1. In a frequency modulation receiving system, the combination with a voltage limiter and a frequency discriminator network, of a variable band width amplifier interposed in the signal channel of the receiving system between said limiter and discriminator network and comprising two variable frequency portions resonant on opposite sides of a mean pass band frequency, a signal detector coupled to the discriminator network, means for deriving audio frequency signals from said detector, and means responsive to said audio frequency signals for shifting the frequencies of said portions of said variable band width amplifier in the direction of said mean pass band frequency.

2. In a frequency modulation signal receiving system, the combination of a pair of band pass filter circuits tuned off resonance to a mean band pass frequency, reactance control tubes connected with said circuits and responsive to a single variable control potential for shifting the tuning of one band pass filter circuit to a higher frequency and the tuning of another band pass filter circuit to a lower frequency in the absence of a control voltage, and means responsive to the audio frequency output of said signal receiving system providing a control voltage for said control circuit which varies in accordance with variations in the percentage modulation of a received signal, thereby to cause the tuning of said filter circuits to be shifted with respect to a mean band pass frequency and widening the effective band width to permit the signal with increased modulation to pass therethrough without distortion.

3. A frequency modulation signal receiving system comprising, in combination, a frequency discriminator network, a variable band width amplifier preceding said network and including a pair of tuned interstage coupling transformers responsive to signals at differing mean frequencies, one on each side of a mean pass band frequency, means providing a variable reactance load on said circuits responsive to a controlling potential for shifting the frequency of said circuits in the direction of said mean pass band frequency, means for deriving an audio frequency potential from said frequency discriminator network, and means for applying a portion of said potential to said variable reactance load means to shift the tuning of said circuits in the presence of signals having a predetermined percentage modulation.

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