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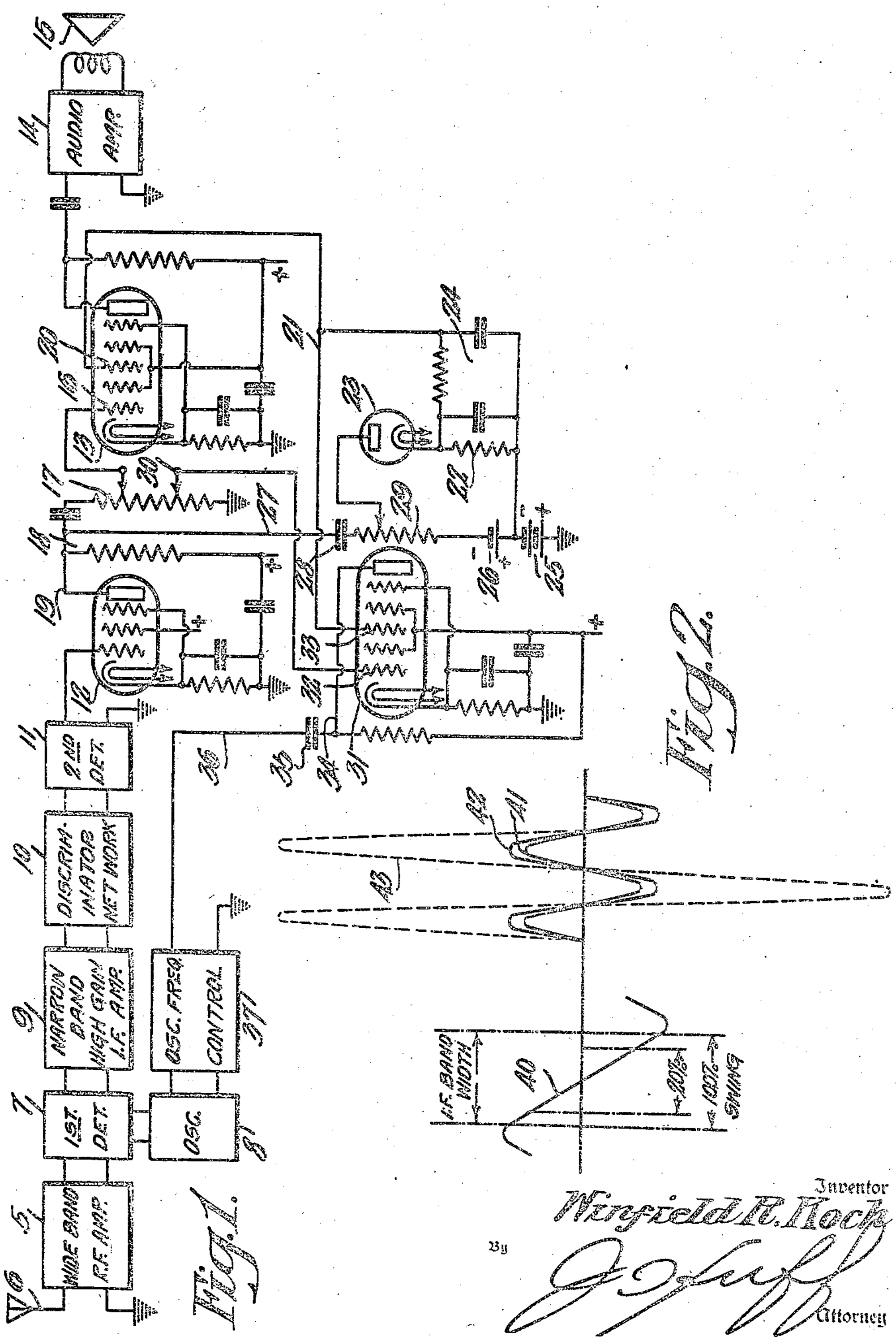

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WIDE BAND FREQUENCY MODULATION RECEIVING SYSTEM

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10 Claims. (Cl. 250—20)

This invention relates to wide band frequency modulation receiving systems, and has for its primary object to provide an improved receiving system, providing noise and interference reduction with wide band frequency modulation.

It is a further object of the present invention to provide a frequency modulation receiving system having automatic band width control with wide band operation, and means therein for preventing audio frequency distortion.

It is a further object of the present invention to provide a frequency modulation receiving system having a wide band signal input circuit and a relatively narrow band intermediate frequency circuit in which a major portion of the band width of the intermediate frequency circuit may be utilized in the reception of signals having low modulation or frequency swing without exceeding said band width in receiving signals having full modulation or frequency swing, thereby to maintain a relatively high signal-to-noise ratio with variations in percentage modulation or frequency swing.

It is also a further object of the present invention to provide an improved wide band frequency modulation signal receiving system having means therein for varying the effective band width of the intermediate frequency circuits, with variations in percentage modulation or frequency swing, and in accordance with variations in the audio frequency output of the system as a measure of the frequency swing.

It is also an object of the present invention to provide means in a frequency modulation signal receiving system for varying a heterodyne oscillator frequency to maintain a received signal within the intermediate frequency pass band with variations in modulation above a predetermined percentage or frequency swing, while permitting the frequency swing or modulation to occupy at all times a major portion of the intermediate frequency pass band width.

For lowest background noise and minimum interference from other signals in a frequency modulation receiving system, it is desirable to provide a signal band width substantially equal to the pass band of the system. In accordance with the invention, for this purpose, instead of varying the intermediate frequency band width, the effective band width of the signal is altered by feedback voltage control through the heterodyne oscillator to cause the intermediate frequency signal to be maintained at all times at a band width covering a major portion of the pass band width of the intermediate frequency circuits, for example, eighty percent of the band width, and to cause the intermediate frequency swing or signal band width to be maintained within the band width limits of the intermediate frequency circuits for higher percentage modulation, without causing distortion of the audio frequency output signal.

It is, therefore, an object of the invention to provide means whereby the audio frequency amplification may be changed automatically with variations in the modulation or signal frequency swing above a predetermined value, preferably in the intermediate frequency circuits, to secure the proper audio frequency output level and dynamic operating range of the signal at the output circuit of the receiving system. This contemplates that both the effective band width of reception and the audio frequency gain in the system may be controlled automatically in response to variations in an audio frequency control voltage as a measure of the percentage modulation or frequency swing, thereby to permit the effective band width to vary without audio frequency distortion.

It is a still further object of the present invention to provide an improved frequency modulation receiving system having a wide band signal input circuit and a relatively narrow band intermediate frequency circuit and control means for utilizing a major portion of the band width of said last-named circuit for low modulation signals thereby to reduce noise and, with feedback control of the oscillator frequency in synchronism with the incoming signal, to prevent the intermediate frequency swing from exceeding the band width of the intermediate frequency circuit with full modulation.

While negative feedback control of the oscillator frequency may be provided to narrow the signal band, it may be desirable with low modulation levels to utilize positive feedback to widen the band of the signal to equal the pass band of the receiving system, in which case the audio frequency gain of the system should be correspondingly reduced to prevent distortion.

The invention will better be understood, however, 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 schematic circuit diagram of a signal receiving system embodying the invention, and

Figure 2 is a graph showing curves illustrating certain operating characteristics of the circuit of Fig. 1.

Referring to Fig. 1, the wide band frequency modulation receiving system shown comprises a wide band tunable r. f. or high frequency amplifier **5** coupled to a suitable signal source such as an antenna **6** for applying amplified frequency-modulated signals to a first detector or converter **7** in connection with which is provided a tunable oscillator **8**. Intermediate frequency signals from the converter **7** are applied through a narrow band, high gain intermediate frequency amplifier **9** and a frequency discriminator network **10** to the second detector **11** from which the audio frequency signals are passed through an audio frequency amplifier comprising a series of amplifier stages **12**, **13** and **14** to a suitable output device such as the loudspeaker **15**.

In the receiving system described, the amplifier stages **13** is a gain control amplifier stage which is preferably of the pentagrid type, having a signal input grid **16** coupled through a potentiometer **17** and an impedance coupling network **18**, to the output circuit **19** of the preceding amplifier stage **12**. A gain control grid **20** is also provided in the tube **13** as part of a volume control or expander means to control amplitude of signals transmitted through the stage. Variable gain controlling potential for the grid **20** is derived through a control circuit **21** from the output impedance **22** of a rectifier **23**, a suitable filter network **24** being included in the connection between the circuit **21** and the output impedance.

The rectifier **23** and the associated circuits include a suitable source of fixed biasing potential **25** for the control grid **20** and a delay bias potential source **26** for the rectifier **23** effective to prevent response of the rectifier to signals below a certain value of applied signal potential corresponding to a certain percentage modulation or swing. The percentage modulation or frequency swing is determined by the audio frequency output of the receiving system a portion of which is applied to the rectifier **23** from the first stage audio frequency amplifier output circuit **19** through a supply lead **27**, a coupling capacitor **28** and an input potentiometer device **29**.

Audio frequency signals are also derived from the output circuit **19** through the potentiometer device **17** and a variable tap connection **30** thereon for a feedback control or variable gain amplifier stage **31**, also of the pentagrid type having a control grid **32** connected with the tap **30** as shown, and having a gain control grid **33** connected with the bias supply lead **21** from the rectifier **23**.

The output circuit **34** of the amplifier stage **31** is coupled through a suitable coupling capacitor **35** and a circuit **36** with frequency control means **37** connected with the oscillator **8** in proper phase relation to cause the oscillator frequency to vary in synchronism with the incoming signal, above and below a normal frequency by an amount dependent upon the adjustment of the applied signal from the tap **30** and the bias control potential on the gain control grid **33** of the control amplifier **31**.

The audio frequency output from the discriminator network **10** through the second detector **11** and amplifier **12** to the tap **30** provides a measure of the percentage modulation or frequency swing of a received signal. This causes the feedback control amplifier **31** to have a negative feedback action on the oscillator frequency which then swings with the signal and in synchronism therewith, thereby to cause the effective band width of reception through the narrow band intermediate frequency amplifier **9** to vary with the percentage modulation.

Thus, if the signal at a mean intermediate frequency of 5 mc. is one hundred percent modulated to swing ± 100 kc., the oscillator may at the same time be caused to swing in frequency ± 75 kc., making a differential swing of 25 kc. in the i. f. amplifier signal for one hundred percent modulation. This tends to result in a reduction in the audio frequency output which is compensated as will hereinafter be pointed out.

With this arrangement, the intermediate frequency amplifier may provide a relatively high gain and a relatively narrow frequency response, while the input circuit or r. f. amplifier may have a desired wide band characteristic. Then, assuming further a 40 mc. signal-modulated ± 100 kc. at one hundred percent modulation, and ± 20 kc. for a relatively low modulation of twenty percent, the intermediate frequency amplifier may be made substantially only 50 kc. wide.

In accordance with the invention, the effective band width of the signal is altered by feedback control through the heterodyne oscillator to provide an i. f. signal which occupies substantially eighty percent of the i. f. band width with twenty percent modulation, for example, as indicated in connection with the output response curve **40** of the discriminator network and detector, while the remaining eighty percent change in percentage modulation causes a relatively slight increase in the effective use of the full band width of the amplifier **9**.

In other words, signals of relatively low percentage modulation are caused to occupy a major portion of the band width of the signal channel, preferably in a narrow band high gain i. f. circuit and negative feedback voltage control to the oscillator is provided and controlled to a degree to prevent the signal swing from exceeding the limits of the pass band of the i. f. amplifier up to substantially full modulation.

In Fig. 2, the curve **41** indicates the amplitude of the input and output signal of the gain control amplifier stage **13** with relatively low frequency swing, such as below twenty percent modulation, while the curve **42** indicates the input voltage with one hundred percent modulation and the resulting output signal voltage is indicated by the curve **43**. This additional output is provided by the control rectifier **23** which causes an increasing positive bias on both grids **33** and **20** and volume range expansion above 20 percent modulation in the present example.

This action prevents distortion of the audio frequency output which would otherwise result from altering the effective modulation of the intermediate frequency signal by variation of the oscillator frequency and includes controlling the effective band width of reception through the i. f. amplifier, with variations in swing of the signal and the gain of the audio frequency amplifier and feedback control path simultaneously, so that the output of the receiver faithfully follows the modulation changes above the predetermined low modulation level without exceeding the band width of the amplifier. At one hundred percent modulation, substantially the entire band is used and the audio frequency gain is maximum.

The rectifier **23** and its associated circuits have a time constant which provides for a rapid response and slow recovery characteristic thereby insuring that the system will respond to but will not follow the modulation frequency changes.

From the foregoing description, it will be seen that both the amount of feedback and the audio frequency gain may automatically be controlled from a rectifier operated by the audio voltages derived from the frequency modulation receiving system following the discriminator network, as a measure of the percentage modulation, thereby simultaneously making the effective band width of reception vary with the percentage modulation above a predetermined low percentage and compensating for the effective reduction in the audio frequency signal amplitude from the detector by increasing the gain in both the audio frequency and feedback control channels.

I claim as my invention:

1. In a radio signal receiving system, the combination with a signal amplifier having a predetermined fixed passband, of means for varying the effective band width of signals applied to said amplifier, a control circuit for said last-named means including an amplifier, an audio frequency amplifier, and means for simultaneously varying the gain of said audio frequency and control circuit amplifiers in response to variation in the signal amplitude above a predetermined value.

2. In a frequency modulation signal receiving system, the combination with an intermediate frequency amplifier having a predetermined frequency passband, of means for varying the effective band width of signals applied to said amplifier, a control circuit for said last-named means including an amplifier, an audio frequency amplifier, and means for simultaneously varying the gain of said amplifiers in the same sense with variations in frequency swing of a received signal, said last-named means including an audio frequency rectifier for deriving a gain control potential for said amplifiers.

3. In a frequency modulation signal receiving system, the combination with an intermediate frequency amplifier having a predetermined frequency passband, of means for varying the effective band width of signals applied to said amplifier, a control circuit for said last-named means including an amplifier, an audio frequency amplifier, and means for simultaneously varying the gain of said amplifiers in response to variation in the signal amplitude above a predetermined value.

4. In a frequency modulation signal receiving system, the combination of a variable frequency heterodyne oscillator, feedback control means responsive to the audio frequency output of said system for varying the frequency of said oscillator in synchronism with frequency variations in a received signal, said feedback means including an amplifier for feedback voltage, and means responsive to the audio frequency output of said system for varying the audio frequency gain in said system and the amplifier gain in said feedback control means in predetermined relation.

5. In a frequency modulation signal receiving system, the combination of a relatively narrow band intermediate frequency amplifier having a predetermined passband, a variable frequency heterodyne oscillator, feedback control means responsive to the audio frequency output of said system for varying the frequency of said oscillator in synchronism with frequency variations in a received signal, to limit the signal frequency band to the passband of said amplifier, said feedback means including an amplifier for feedback voltage, and means responsive to the audio frequency output of said system for varying the audio frequency gain in said system and the amplifier gain in said feedback control means in predetermined relation, whereby the fidelity of the audio frequency output of said system is enhanced.

6. In a frequency modulation receiving system, the combination of a relatively narrow band intermediate frequency amplifier circuit, means for causing the effective band width of reception through said amplifier circuit to vary with percentage modulation variation above a predetermined value, an audio frequency amplifier circuit, and means for causing the signal gain through said last-named circuit to vary conjointly with said band width variation, and in a sense to provide compensation in the signal output of said system for the effects of said band width variation.

7. In a radio signal receiving system, the combination of a first detector, a heterodyne oscillator coupled to said detector, an intermediate frequency amplifier coupled to said detector, an audio frequency signal channel coupled to said detector, means providing a feedback audio frequency control circuit between said audio frequency signal channel and said oscillator for varying the frequency of said oscillator in response to variations in the amplitude of audio frequency signals, and means for varying the gain through said audio frequency signal channel and the gain in said feedback circuit jointly and in the same sense in response to variations in the amplitude of audio frequency signals above a predetermined amplitude.

8. In a frequency modulation signal receiving system, the combination of means for deriving audio frequency output signals therefrom as a measure of the frequency swing of a received signal, means providing a variable-gain feedback oscillator frequency-control amplifier coupled to said last-named means, a variable-gain audio frequency amplifier for said system, means for adjusting the amplitude of the audio frequency signals applied to said audio frequency amplifier and to said variable-gain amplifier, and means including an audio frequency rectifier responsive to the audio frequency output of said system for applying to said variable-gain audio frequency amplifier and to said variable gain control amplifier a variable gain-controlling potential.

9. In a frequency modulation signal receiving system, the combination of means for deriving audio frequency output signals therefrom as a measure of the frequency swing of a received signal, means providing a variable-gain feedback oscillator frequency-control amplifier coupled to said last-named means, a heterodyne oscillator having a frequency control circuit coupled to said variable gain amplifier to cause the oscillator frequency to vary in synchronism with an incoming signal, a variable gain audio frequency amplifier for said system, means for adjusting the amplitude of the audio frequency signals applied to said audio frequency amplifier and to said variable gain amplifier, and means including an audio frequency rectifier responsive to the audio frequency output of said system for applying to said variable gain audio frequency amplifier and to said variable gain control amplifier a variable gain-controlling potential.

10. In a frequency modulation signal receiving system, the combination of an intermediate frequency amplifier providing a predetermined signal passband, a heterodyne oscillator, frequency

control means for said oscillator, a signal channel connected with said intermediate frequency amplifier and including an audio frequency amplifier circuit, means for deriving an audio frequency signal from said circuit, means providing a path including an amplifier for feeding back said derived audio frequency signal to said oscillator frequency control means to cause the oscillator frequency to vary from a normal value in synchronism with the frequency variation of a received signal, thereby to vary the effective band width of the signal through said intermediate frequency amplifier, and means for varying the gain in said feedback path and in said audio frequency amplifier circuit jointly with variation in the amplitude of audio frequency signals therein as a measure of said frequency variation of a received signal, and means for preventing operation of said last-named means for signal frequency variations below a predetermined value.

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