

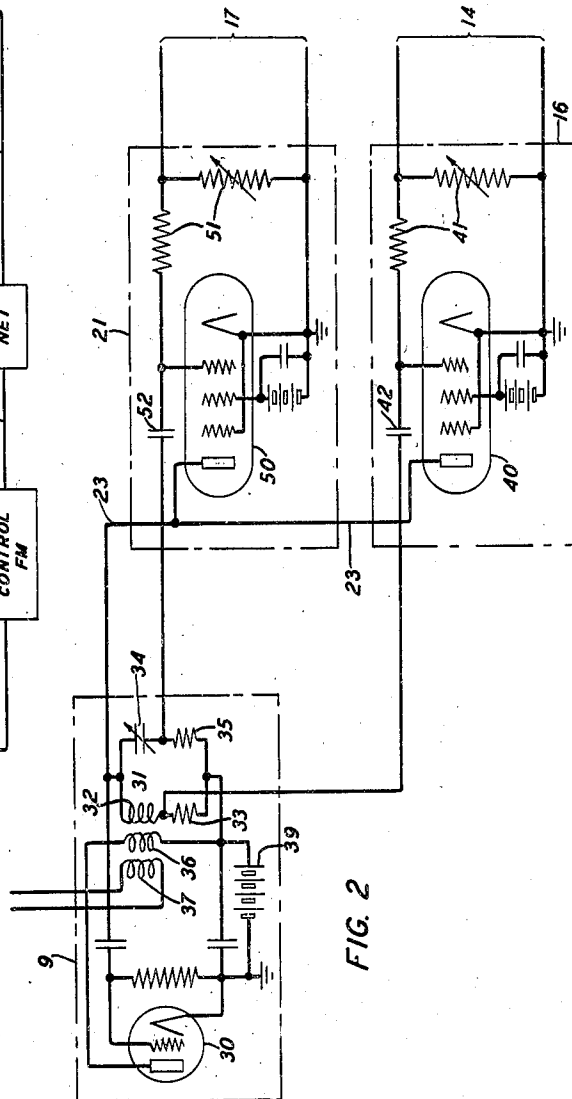
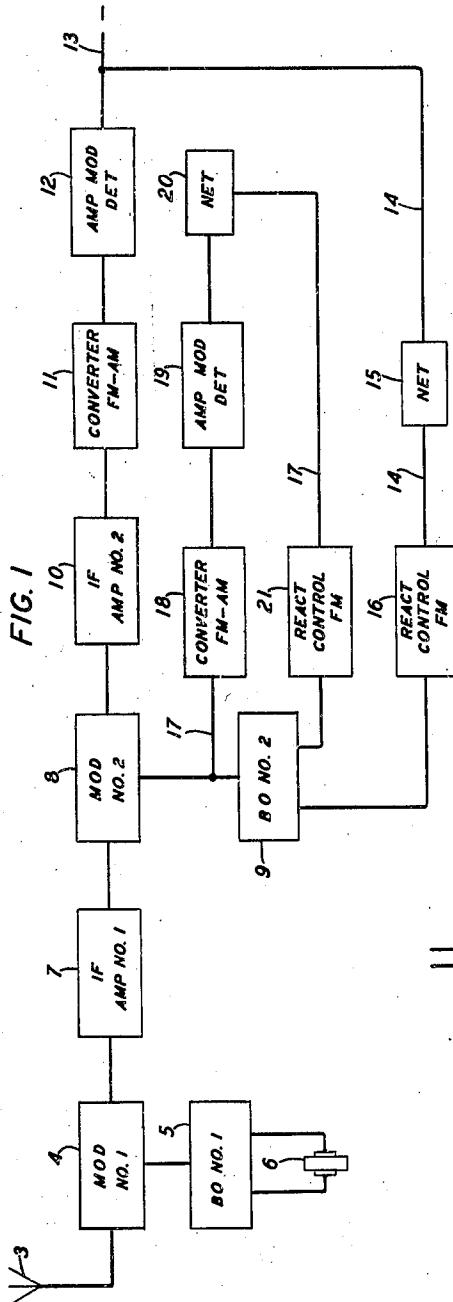
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FREQUENCY MODULATION RECEIVER

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FREQUENCY MODULATION RECEIVER

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4 Claims. (Cl. 250—20)

This invention relates to receivers for frequency modulated waves and particularly to such receivers of the type employing negative feedback for the purpose of reducing noise and distortion as disclosed and claimed in United States Patent 2,075,503 to J. G. Chaffee, March 30, 1937.

An object of the invention is to improve the operation of such receiving systems, in particular with respect to the reduction of distortion.

In receiving systems of the type to which this invention is directed the received frequency modulated wave is modulated by local oscillations that are themselves frequency modulated by the detecting signal in such phase that the frequency swing of the resultant combination product is less than the frequency swing of the received wave. Such operation has been found to result in decided advantages including reduction of noise and increased fidelity of reproduction. However, these results are dependent on the operating characteristics of the elements of the feedback path. This portion of the circuit includes, among other elements, the beating oscillator and the circuits for frequency modulating its output. Any distortion produced in the modulating operation of this portion of the circuit will be reflected in the output and detract from the possible advantages to be gained by the use of the negative feedback.

In accordance with a feature of the present invention such defects are overcome by employing a second feedback path around the oscillator and its modulating circuit. This second feedback path includes a means for detecting the oscillator output to obtain signal oscillations representative of the modulations and a circuit for utilizing these signal oscillations to modulate the frequency of the oscillator output in phase opposite to the frequency modulation produced by the detected signal from the main signal path. The effect of this second feedback in the correction of distortion and reduction of disturbances will be similar to the effect of the main feedback on the main signal path of the receiver. Of course, the degree of correction and improvement attainable will depend on the fidelity of detector used in the feedback path. However, since the output of that detector modulates the oscillator output in an opposite sense to the modulation produced by the output of the main signal detector, similar distortions produced by the two detectors will tend to cancel out. Therefore, if the two detectors are of the same type, tending to produce the same inherent distortion, their effects will, in general, counteract each other.

The invention may be more fully understood from the following detailed description in connection with the drawing, in which:

Fig. 1 is a functional block schematic diagram of one embodiment of the invention in a radio receiver; and

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

Frequency modulated waves received in the antenna 3 are supplied to the heterodyne modulator or detector 4 wherein they are combined with oscillations from the local oscillator 5. This oscillator is indicated as being controlled by a piezo-electric crystal 6 for determining the frequency of its output which is advantageous where the receiver is to be used for the reception of frequency modulated waves of a fixed mean frequency.

The difference frequency resulting from the combination of the waves received in the antenna 3 and the oscillations from the oscillator 5 in the modulator 4 are selected and amplified in the intermediate frequency amplifier 7. Oscillations from a second local beating oscillator 9 are also supplied to the modulator 8. The difference frequency combination product resulting from the action of the modulator 8 are selected in an intermediate frequency amplifier 10 and amplified therein. The output of this amplifier is supplied to a converter 11 which may be of any of the well-known types operating to produce amplitude modulations corresponding to the frequency modulations of the input thereto. The resultant amplitude modulated currents are impressed on a detector 12 which operates to reproduce the modulating signal therefrom. The resultant signal currents are taken out through a circuit 13 for application to the usual amplifying and indicating devices.

The detected signal current output of the detector 12 is also applied to the local oscillator 9 to modulate the frequencies of the oscillations generated therein. For this purpose there is provided a circuit 14 including a network 15 designed to give the feedback currents the desired amplitude and phase characteristics. A reactance control device 16, which is described in detail hereinafter, is also shown as included in this circuit. This device provides means for modulating the frequency of the oscillations generated by the beating oscillator 9, though of course its function may be included in the oscillator circuit per se, for example, by the use of an oscillator of the Barkhausen type.

As so far described, the receiving circuit of

Fig. 1 is of the type generally similar to the receiver of the Chaffee Patent 2,075,503, mentioned above, wherein there is explained the action of the feedback circuit in reducing the frequency modulation and diminishing the effects of distortion and noise producing disturbances.

In accordance with the present invention there is provided a second feedback circuit 17. The frequency modulated output oscillations of the beating oscillator 9 are supplied to the circuit 17. These are impressed on the input of a converter 18 in which there is produced amplitude modulations corresponding to the frequency modulations of the input. The resulting amplitude modulated currents are detected in the detector 19 and the resulting signal currents supplied through the network 20 to the reactance control device 21 through which the signal currents operate to modulate the frequency of the output of the beating oscillator 9. These circuit arrangements and connections are so designed that the frequency modulations of the beating oscillator 9 produced by the reactance control device 21 are of opposite phase to the frequency modulations produced by the reactance control device 16. In other words, the modulation effected by the connection 17 and its associated circuit elements provides a negative feedback path around the frequency modulated oscillator 9. As a result that frequency modulation of the output of the oscillator 9 will be the difference in the frequency modulations produced by the two control devices 16 and 21 so that the effect of the modulation produced by the control device 21 will be to reduce any distortion inherent in the operation of the control device 16. The operation in this respect being analogous to the operation of the main feedback circuit as explained in the Chaffee patent referred to above.

Fig. 2 shows a detailed schematic circuit of the frequency modulated oscillator 9 and the reactance control devices 16 and 20 for effecting the frequency modulation. The oscillator 9 comprises a triode vacuum tube 30 having a frequency determining circuit 31 connected between its grid and cathode. The circuit 31 comprises two parallel branches, one including an inductance coil 32 and a resistor 33 in series and the other including a condenser 34 and a resistor 35 in series. An inductance coil 36 coupled to the inductance coil 32 is connected between the anode and cathode of the tube 30 to provide the feedback for generating oscillations. A third inductance coil 37 coupled to the coils 32 and 36 provides the output circuit.

In the reactance control device 16, the feedback circuit 14 is connected to the grid circuit of the pentode tube 40 through the voltage regulating potentiometer 41. The plate of the tube 40 is connected through the connection 23 to the high alternating voltage side of the circuit 31. This connection also supplies plate potential for the tube 40 from the same battery 39 which supplied plate potential for the oscillator tube 30. The grid of the tube 40 is connected through a direct current blocking condenser 42 to the junction of resistor 33 and inductance coil 32. The circuit is of the general type described by Travis in the article entitled "Automatic frequency control" in the Proceedings I. R. E., volume 23, No. 10, October 1935, pages 1125 to 1141, particularly Fig. 8, page 1135.

With circuit connections of this type the reactance control tube 40 looks like a reactance to the oscillator circuit 31 as described in detail

in the Travis article. The magnitude of this effective reactance varies inversely with the mutual conductance of the tube 40 and consequently with the control potential impressed on the control grid of the tube 40 from the circuit 14. Consequently the effective resonant frequency of the circuit 31 varies directly from the mutual conductance of the tube 40. As a result, the voltage variation in the circuit 14 affecting voltage variations of the grid of the tube 40 produce variations or modulations in the frequency of the oscillations produced by the oscillator 9.

The reactance control circuit 21 is similar to the reactance control circuit 16 employing a pentode tube 50 having its control grid connected through the variable potentiometer 51 to the feedback circuit 17. The plate of the tube 50 is connected to the high alternating current side of the circuit 31. The control grid of the tube 50 is connected through the direct current blocking condenser 52 to the junction of resistor 35 and condenser 34. Like the tube 40, tube 50 appears to the circuit 31 like a reactance which varies with the mutual conductance of the tube 50 and consequently with the voltage of its control grid. The essential difference in the action of the control devices 16 and 21 is that with the connection from the control grid of the tube 50 to the resistor 33 included in the capacitive leg of the circuit 31 instead of in the inductive leg as for the tube 40, the tube 50 will appear as a resistance capacity arm across the tank circuit and variations in the mutual conductance of the tube 50 will produce inverse variations in the effective resonant frequency of the circuit 31. Thus an increase in the mutual conductance of the tube 50 will lower the oscillator frequency (Travis article page 1136).

It will thus be seen that variations in the voltage of the circuit 14 will produce effects in the frequency of the oscillator 9 which are opposite to the effects produced by variations in the voltage of the circuit 17 which is what is desired in order that the two circuits may produce frequency modulations of opposite phase as discussed above.

While the circuit of Fig. 2 shows particular types of reactance control devices employed for modulating the frequency of the output from oscillator 9, it should be understood that other types of circuits may be employed for accomplishing the same purpose. Also other modifications may be made; for example instead of operating the oscillator 9 at the frequency required for the conversion process in modulator 8, the oscillator may be operated at a lower frequency at its output subjected to a frequency multiplication process before being supplied to modulator 8.

What is claimed is:

1. A receiver for waves modulated in frequency in accordance with a signal comprising a source of beating oscillations, means for combining oscillations from said source with the received waves, means for detecting the output of the combining means to reproduce the signal, a first modulation means for modulating the frequency of said beating oscillations in accordance with the reproduced signal and in such phase that the frequency modulations of the output of said combining means are lower than those of the received wave input, a second detection means for reproducing the signal modulations of said beating oscillations, and a second modulation means for modulating the frequency of the beat-

ing oscillations in accordance with the signal output of said second detection means and in opposite phase to the modulations produced by said first modulation means.

2. A receiver for waves modulated in frequency in accordance with a signal comprising a source of beating oscillations, means for combining oscillations from said source with the received waves, means for detecting the output of said combining means to reproduce said signal, a first modulation means for modulating the frequency of said beating oscillations in accordance with the reproduced signals and in such phase that the frequency modulations of the output of said combining means are lower than those of the received wave input thereto, a second detection means for reproducing the signal modulations of said beating oscillations, and a second modulating means for modulating the frequency of said beating oscillations in accordance with the signal output of said second detection means and in opposite phase but less extent than the modulations produced by said first modulation means.

3. A receiver for waves modulated in frequency in accordance with a signal comprising a source of heterodyne oscillations, means for combining said heterodyne oscillations with the received waves, means for selecting a frequency modulated component from the resulting combination products, a first detection means for reproducing the modulating signal from said selected frequency modulated component, a first modulation means for modulating the frequency of said heterodyne oscillations by said reproduced signal in such sense that the degree of frequency modulation in

said selected component it less than in said received waves, means for detecting said heterodyne oscillations, means for modulating said heterodyne oscillations in accordance with the output of the last-mentioned detecting means in such sense and such degree as to counteract distortions and disturbances which would otherwise be produced by the action of said first modulation means.

4. A receiver for waves modulated in frequency in accordance with a signal comprising a source of heterodyne oscillations, means for combining said heterodyne oscillations with the received waves, means for selecting a frequency modulated component from the resulting combination products, a pair of detection means each operating to reproduce the modulating signal from a frequency modulated wave with the same order of fidelity of operation, a circuit for supplying said selected frequency modulated component to one of said pair of detection means, means for modulating the frequency of said heterodyne oscillations in accordance with the output of said one of said pair of detection means in such sense that the degree of frequency modulations of said selected component is less than that of said received waves, a circuit for supplying said heterodyne oscillations to the other of said pair of detection means, and means responsive to the output of said other of said pair of detection means for modulating the frequency of said heterodyne oscillations in the opposite sense to the frequency modulations thereof by the first-mentioned modulating means.

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