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RECEIVER FOR FREQUENCY-MODULATED WAVES

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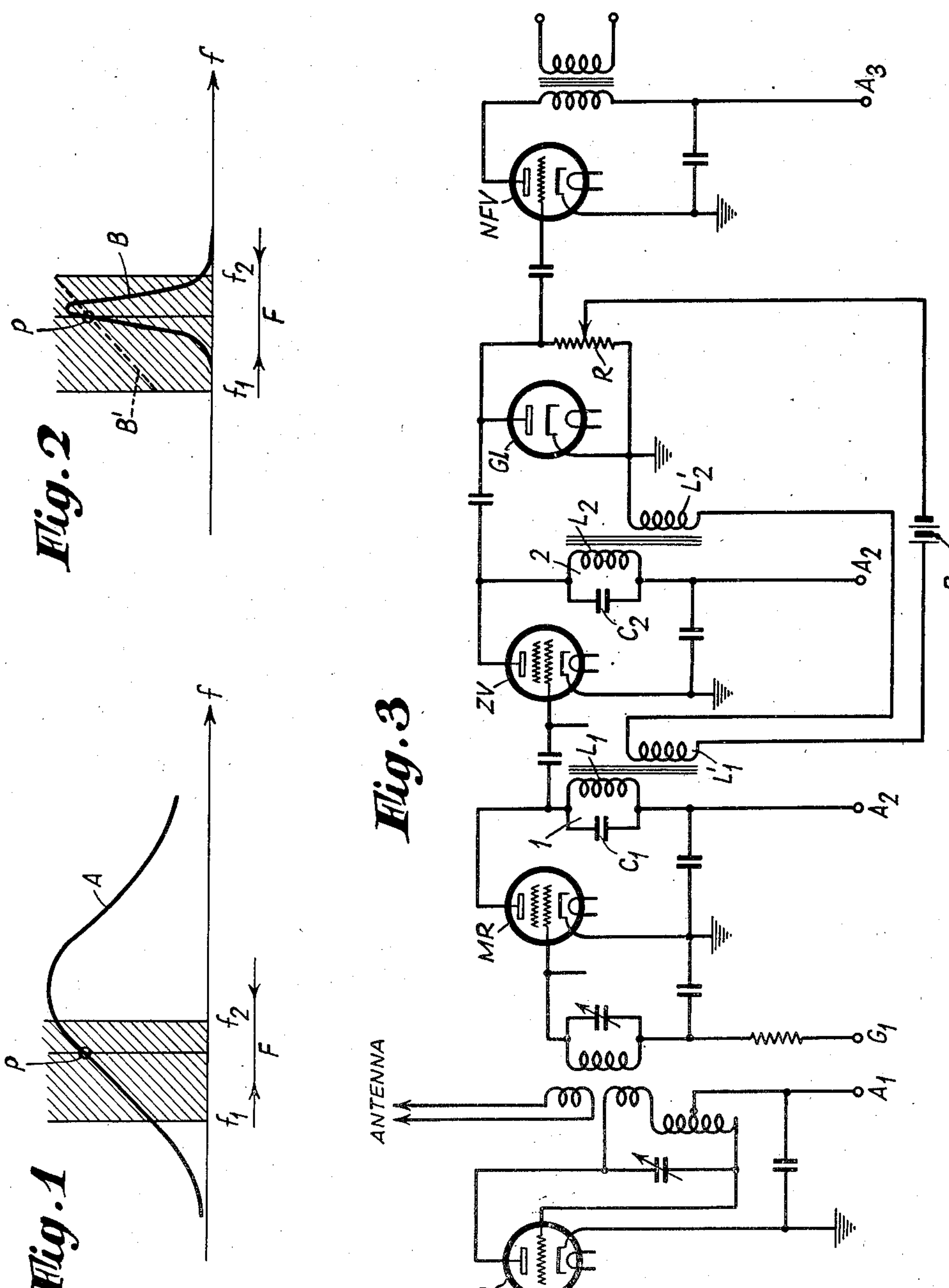

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RECEIVER FOR FREQUENCY-MODULATED WAVES

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In signal transmission on frequency modulated waves, as is well known in practice, one slope of the resonance curve is used for demodulation, with the result that the frequency variations are reconverted into amplitude modulations, the current after rectification or detection resulting in the AF modulation. In order that in frequency modulation the relation between the current and the frequency variation may be unequivocal, the width of the slope of the resonance curve must at least be equal to the aggregate frequency variation; for this reason, also the width of the resonance curve measured between the two half values, must be at least equal to this frequency range.

For instance, for ultra-short waves this situation results in very broad curves inasmuch as in this case, speaking in absolute values, very large frequency shifts are involved. For example, for a wave of 50 cm., in the presence of a plate voltage variation by modulation of a few percent, the frequency variation often amounts to over 100 kc.; hence, also one-half of the resonance curve must be at least of this width.

Now, the present invention is predicated upon this fact that the noise level due to (tube) noises of the receiver is a function of the width of the resonance curve. It is known that the noise voltage of a receiver which permits of the constant transmission of a frequency band having a width Δf is proportional to $\sqrt{\Delta f}$.

This noise may be considered as consisting of beat frequencies between noise voltages lying within the radio-frequency acceptance band. Of course, only such beat frequencies as fall within the audio-frequency band of the receiver are passed by the audio-frequency system. It is easily seen that, in general, the total noise at the receiver output will be greater as the radio-frequency and audio-frequency pass bands are larger, the first because more noise components are admitted, and the second because a wider range of beat frequencies can pass the audio-frequency system.

In case, however, the radio-frequency band passed by the receiver filter is narrower than the audio-frequency band, the highest beat frequency that can be formed between components that pass the radio-frequency filter is equal to the radio-frequency band width, so that it would make no difference if the audio-frequency band were much larger. Hence, in case the radio-frequency acceptance band is narrower than the audio-frequency band we have the situation that the total noise depends only on the radio-frequency band width.

Now, according to the invention a receiver of lower noise voltage level applicable to frequency-modulated waves is created in that the width of the receiver filter is small compared with the aggregate frequency variation, while an unequivocal relationship between the output potential or current and frequency is established by a feedback. By the use of a narrow frequency curve the noise voltage is lessened. However, the use thereof becomes possible only by virtue of the feedback since with a narrow resonance curve the existing frequency range would be, in contrast, say, 300 kc.

By regenerating, for instance, part of the rectifier output, the resonance frequency of the receiver circuit could be re-set as a function of the output potential or current in the same sense as the incoming frequency. Re-setting of the frequency, in superheterodyne receivers could also be effected by controlling the resonance curve of the IF from the rectifier output in accordance with the frequency variation of the transmitter so that as the frequency increases, there is an increase in the resonance frequency of the oscillatory circuit or circuits in the I. F. section, and vice versa.

Instead of shifting the resonance point of the I. F., with the oscillator frequency assumed to be stable, re-adjustment of the frequency could be accomplished also by keeping the resonance point of the I. F. stable, while the oscillator frequency is subjected to control by the rectified current in such a way that with growth of the transmitter frequency, there occurs an increase in the frequency of the oscillator circuit. This control action could be effected, for instance, by causing the rectified current to alter the plate potential of the oscillator and incidentally its frequency.

In describing my invention in detail reference will be made to the attached drawing wherein Figure 1 is a resonance curve of a frequency modulated wave receiver using circuits covering a considerable band of frequencies. Figure 2 is the resonance curve of a frequency modulated receiver in which by the use of my invention the resonance characteristic has been narrowed, while; Figure 3 illustrates a receiver arranged in accordance with my invention and includes means for shifting the point of operation of the receiver up and down the sharp resonance characteristic thereof.

Referring to the drawing, Fig. 1, A indicates the resonance curve of a receiver designed for frequency-modulated waves. The frequency range F extends from f_1 to f_2. For demodulation is used the slope of the resonance curve between f_1 and f_2. The operating point P shifts, as will be seen, along the slope of the resonance curve between f_1 and f_2.

Fig. 2 by way of example shows a narrow resonance curve B of the receiver, that is, a curve as used according to the disclosure with a view of securing a low noise voltage. The resonance curve B is plotted for a frequency f_x lying between f_1 and f_2. Inasmuch as the resonance curve of the receiver is changed in the same sense as the transmitter frequency, the operation point P shifts along the working characteristic B′, shown by broken lines, across the family of resonance curves rather than along the slope of the resonance curve properly so-called. This shift of the resonance curve occurs at AF rate; hence, the building-up periods can be kept sufficiently small.

By way of example, the principle hereinbefore described may be carried into practice by shifting the resonance curve, for instance, by causing the rectified current to alter the biasing magnetization (magnetic bias) and thereby the inductance of the oscillatory circuit in a way as illustrated in Fig. 3.

Fig. 3 illustrates a conventional type of heterodyne receiver for frequency-modulated waves in which the object of the present invention has been incorporated by shifting the resonance curve of the I. F. The output of the oscillator O and of the antennae are fed to the mixer tube MR. After the mixing stage follows an I. F. stage ZV, the rectifier G_1 and the AF stage NFV. The rectifier G_1 has in its output circuit a resistance R_1 in which a potential is produced by rectification of the amplitude variations on the intermediate-frequency energy passed by circuits 1 and 2. These amplitude variations are produced due to the sloping characteristics of the circuits and correspond to frequency variations on the received wave. The oscillatory circuit 1 comprising inductance L_1 and condenser C_1 and the oscillatory circuit 2 comprising inductance L_2 and condenser C_2 according to this invention have a narrow resonance curve. The resonance curve of the oscillatory circuits is shifted by tapping part of the rectifier output voltage across R and this is used to regulate or control the biasing or tuning coils L_1' and L_2', if desired, after the AF components have been filtered out. By the change of the biasing magnetization the inductance of the oscillatory circuit is changed. The circuit containing the coils causing a change in the bias may also include a biasing or polarizing voltage battery B_2.

What is claimed is:

1. In a frequency modulated wave receiver, means for heterodyning a frequency modulated wave to a lower frequency, an intermediate frequency amplifier of a relatively narrow band width coupled to said first means, detecting means coupled to said amplifier and means controlled by potentials derived from said detecting means for varying the mean frequency of response of said intermediate frequency amplifier in accordance with potentials derived from said detecting means.

2. The method of demodulating frequency modulated wave energy and reducing noise components in the demodulated output which includes the steps of amplifying said frequency modulated wave energy in an amplifier having a relatively narrow band width, and varying the position of said band width in the frequency spectrum in accordance with frequency modulations on said wave energy.

3. In a frequency modulated wave receiver, means for heterodyning a frequency modulated wave to wave energy of lower frequency, an electron discharge tube amplifier having input and output circuits, said circuits having a resonance characteristic of a width less than the width of said frequency modulated wave of lower frequency, means for impressing said wave energy of lower frequency on said input circuit, a rectifier having an input coupled to said output circuit said rectifier having an output including an impedance wherein potentials characteristic of the frequency modulations on the wave are developed, and means coupled to said impedance and associated with said input and output circuits for varying the tuning of said circuits in accordance with the amplitude of the potentials developed in said impedance.

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