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FREQUENCY MODULATION RECEIVER TUNING AID
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My present invention relates to improvements in tuning aids for modulated carrier wave receivers, and more particularly to circuits for providing improved receiver tuning and reduced interstation noise reproduction.

In receiving amplitude modulated (AM) carrier waves it is customary to tune the receiver, in the absence of a visual indicator, by listening to the audio output. Accurate tuning is indicated by maximum sound output; the volume falling off appreciably on either side of resonance. However in the case of the reception of angular velocity-modulated carrier waves, such as frequency modulated (FM) waves, uniform sound output is obtained over a considerable range with respect to a given mid-band, or center, frequency. The need for accurate tuning is greater in the case of FM receivers than for AM receivers. This follows from the fact that detection occurs in the former case along an S-shaped curve which is symmetrical relative to the center frequency. Tuning the FM receiver off the center frequency gives rise to distortion and noise.

Accordingly, it is one of the main objects of my present invention to provide a receiver of angular velocity-modulated carrier waves, wherein maximum sound output occurs only on correct tuning.

Another important object of my invention is to provide in combination with an FM detector having a predetermined operating frequency corresponding to the center, or mid-band, frequency of a desired station; a device for rendering ineffective transmission through the receiving system in response to the mean frequency of applied FM waves differing from said operating frequency.

Still another important object of my invention relates to a receiver adapted to receive modulated waves of a variable frequency; an audio amplifier being employed to amplify the detected waves, and means being utilized to cause audio amplification to be operative solely when the receiver is tuned to the center, or mid-band, frequency of waves of a desired station.

Yet other objects of my invention are to improve the tuning of FM receivers, and more especially to provide tuning aids for FM receivers which are durable, reliable in operation and economically manufactured and assembled.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawing in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawing:

Fig. 1 shows a circuit diagram of one form of the invention,

Fig. 2 illustrates a modification,

Fig. 3 shows a variation of the arrangement of Fig. 2.

Referring now to the accompanying drawing, wherein like reference characters in the different figures designate similar circuit elements, there is shown in Fig. 1 only so much of an FM receiver which is necessary to a proper understanding of the present invention. Those skilled in the art are fully aware of the fact that in FM broadcast reception the superheterodyne type of reception is employed. The FM waves cover an assigned band of 42-50 megacycles (mc.). The channel width for each FM station is 200 kilocycles (kc.). Actually, however, the FM transmitter deviates the frequency of the modulated waves up to a maximum of 75 kc. to either side thereof in accordance with the amplitude of the modulation signals. Of course, the rate of carrier frequency deviation is determined by the frequencies of the modulation signals themselves. The present invention is not limited to this 42-50 mc. band, nor is it limited to the reception of FM waves. The term "angular velocity-modulated carrier waves" used herein generically is to be understood as covering phase modulated or frequency modulated carrier waves.

The collected FM waves are amplified in one or more stages of tunable radio frequency amplification prior to impression of the collected waves upon the tunable input circuit of the first detector or converter stage. As is well known, the local oscillator has its tank circuit tunable over a range of local oscillation frequencies which differ from the signal frequency range by the value of the operating intermediate frequency (I.F.). The latter may be chosen from a range of 4 to 20 mc.; as for example, 4 mc. The I.F. energy is amplified in one or more I.F. amplifiers. In order to minimize amplitude variations that may exist on the modulated carrier waves, a limiter stage is usually employed prior to detection of the amplified I.F. energy.

Of course, each of the tuned transmission networks in the receiving system will have a pass band of 200 kc. so as to pass efficiently the modulated carrier waves applied to each stage. It is
to be understood that the numeral 1 designates the resonant I. F. circuit connected to the plate of the limiter tube, or to the plate of the last I. F. amplifier tube if no limiter is employed. The detector tube itself is designated by numeral 2, and may be a double diode rectifier of the 6H6 type. The anodes of the two diodes are connected to opposite sides of the resonant input circuit 3 which is tuned to the operating I. F. value. Circuits 1 and 3 are magnetically coupled, and have a phase relationship of substantially 180°.

The high potential side of resonant circuit 1 is connected by the direct current blocking condenser 4 to the midpoint of the coil of input circuit 3. It will be recognized that the discriminator-rectifier circuit shown in Fig. 1 is substantially of the type disclosed and claimed by S. W. Seely in his U. S. Patent No. 2,121,103 granted June 21, 1938. It is believed sufficient for the purposes of this patent application to point out that the function of the discriminating network 1—4—3 is to derive from the waves of constant amplitude and variable frequency waves of variable amplitude. In other words, the FM waves applied to the circuit 1 are applied to the anodes of the opposed diodes with an amplitude variation representative of the modulation of the received carrier waves.

The cathode of the opposite diodes are connected in series by resistors 5 and 6, the cathode end of resistor 6 being connected to ground by an audio frequency by-pass condenser 7. The resistors 5 and 6, which are the load resistors of the detector, are each by-passed by condensers 8 and 9 respectively for I. F. currents. The modulation signal voltage developed across the load resistors 5 and 6 is applied to the control grid of the audio frequency amplifier tube 10. The choke coil 3' connects the junction of 5—6 to the midpoint of the coil of circuit 3 thereby providing a return path for the diodes.

The grid 11 of audio amplifier tube 10 is connected to the cathode end of resistor 5 by the audio coupling condenser 12. The cathode of tube 18 is connected to ground by the grid biasing network 13. Series resistors 10 and 14 are connected from grid 11 to ground. An audio filter network couples the electrodes of the muting diodes to the load resistors 5—6. Thus, diodes 16 and 17 are arranged in opposition; the cathodes thereof being connected in common to ground. The anodes of diodes 18 and 11 are connected to associated ends of resistors 5 and 6 through the respective filter resistors 8' and 9'.

A diode 18 has its cathode connected to the anode of diode 16, while its anode is connected to the junction of resistors 14 and 15. A diode 19 has its anode connected to the anode of diode 18, while the cathode of the former is connected to the anode of diode 17. The plate circuit of audio amplifier 10 may be coupled to further stages of audio amplification, and the latter may terminate in any desired form of reproducer.

Before explaining the specific operation of my invention, it is explained that accurate tuning of the system results in having the I. F. energy applied to discriminator 1—3 properly centered about a mid-frequency which is equal to the operating value of the I. F. Those skilled in the art realize that the S-shaped discriminator curve is symmetrical relative to the center frequency (the I. F. value) and that if the mid-frequency of the applied signal energy shifts relative to said center frequency there may result high distortion and noise. Further, since there is applied to grid 11 the resultant of the voltages developed across resistors 5 and 6, these voltages are equal and of opposite phase when the applied signal energy has a center frequency equal to the resonant frequency of circuits 1—3. If the center frequency deviates from the said resonant frequency, as would be the case in detuning in a given station channel, voltage will be developed which can be used in 15 for reducing the gain of the limiter. In Fig. 3, the arrangement of Fig. 2 is shown.
modified to the extent of having diodes 16 and 17 reversed with the common anode connection to the junction of resistors 14' and 15'. Also, the junction of resistors 14' and 15' is connected through a grid return resistor to the control grid of audio amplifier 18, as in Fig. 1. In Figs. 2 and 3 one diode shorts the positive end of resistors 20-21 to ground, leaving the negative end connected to the grid through resistors 14' or 15'. In Fig. 3 one diode shorts the negative end of the resistors 20-21 to the grid leaving the positive end connected to ground through resistors 20 or 21. In all three forms of the invention herein disclosed any unbalance in the direct current output of the discriminator is rectified, and used to reduce the gain and audible output of the receiver.

While I have indicated and described several systems for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organizations shown and described, but that many modifications may be made without departing from the scope of my invention, as set forth in the appended claims.

What I claim is:

1. A method of reception which includes detecting frequency modulated waves to produce modulation signals, deriving a direct current voltage from said waves whose polarity changes in response to a directional shift of the center frequency of the waves from a predetermined frequency value, producing solely a constant polarity direct current in response to said voltage, and reducing to a substantial extent the volume of reproduction of the modulation signals with a direct current voltage solely derived from said constant polarity current.

2. In a frequency modulated carrier wave receiver, including means for rendering the output amplitude substantially independent of the carrier amplitude; a method of reducing the output amplitude in accordance with the amount of mistuning of the receiver, including deriving a direct current which varies in polarity with the direction of mistuning, translating said direct current into solely a direct current potential of constant polarity but varying in amplitude with mistuning, and controlling solely with said potential the gain of the preamplifier stages of the receiver.

3. In a frequency modulated carrier wave receiver which is not responsive to variations in amplitude of the carrier; a method of securing response to mistuning, which includes deriving a direct current of either polarity in mistuned condition, translating said direct current into solely a constant polarity direct current, deriving a constant polarity potential from said constant polarity direct current, and controlling the receiver output level with solely said constant polarity potential.

4. In a receiver of angular velocity-modulated carrier waves free of amplitude variations; the method of reducing the receiver volume in accordance with mistuning of the receiver which includes producing a unidirectional current whose polarity varies in accordance with the sense of mistuning, deriving from said current solely a direct current of constant polarity but whose amplitude varies with mistuning, and controlling the receiver gain with solely said potential.

5. In a frequency modulation receiver, the method of audibly indicating mistuning of the receiver, which includes from receiver waves a direct current whose polarity is dependent upon the sense of mistuning, deriving from the current solely a direct current voltage of constant polarity and variable amplitude, and controlling the receiver output amplitude in response to solely said voltage.

6. In a receiver of frequency modulated carrier waves, means for detecting said waves to produce modulation signals and a direct current whose magnitude is dependent upon the departure of the mean frequency of said waves from a predetermined reference frequency, at least two opposed diode rectifiers operatively associated with the detecting means for deriving a direct current voltage of constant polarity and variable amplitude from said direct current, and means responsive to solely said voltage for controlling transmission through the receiver in a predetermined sense.

7. In a frequency modulation receiver provided with a demodulator having a pair of load resistors through which flow direct currents of polarity dependent upon the sense of mistuning of the receiver, means for utilizing the demodulated wave energy, at least two diodes arranged in opposition, said two diodes being connected across said resistors whereby said direct currents may flow therethrough, a resistive load common to the space current path of each diode for developing from said currents a direct current voltage of constant polarity but variable amplitude, and means controlling said utilization means with solely said voltage.

8. In a receiver of frequency modulated carrier waves provided with a detector capable of providing a direct current voltage whose polarity is dependent upon the direction of frequency shift of the waves from a reference frequency, means to provide a muting voltage comprising at least two diodes arranged in polarity opposition, means for establishing the common junction of like electrodes of the diodes at an invariable potential, means for applying said direct current voltage to a respective one of the diodes depending upon the polarity of the voltage, a load element in circuit with each diode for developing a constant polarity direct current voltage from diode space current, and means for utilizing said last voltage as said muting voltage.

9. In a receiver of frequency modulated carrier waves provided with a detector capable of providing a direct current voltage whose polarity is dependent upon the direction of frequency shift of the waves from a reference frequency, means to provide a muting voltage comprising at least two diodes arranged in polarity opposition, means for establishing the common junction of like electrodes of the diodes at an invariable potential, means for applying said direct current voltage to a respective one of the diodes depending upon the polarity of the voltage, a load element in circuit with each diode for developing a constant polarity direct current voltage from diode space current, and additional means for utilizing said last voltage for control of the receiver gain prior to said detector.

10. In a receiver of frequency modulated carrier waves provided with a detector capable of providing a direct current voltage whose polarity is dependent upon the direction of frequency shift of the waves from a reference frequency, means to provide a muting voltage comprising at least two diodes arranged in polarity opposition, means for establishing the common junction of like electrodes of the diodes at an invariable potential, means for applying said direct current voltage to
a respective one of the diodes depending upon the polarity of the voltage, a load element in circuit with each diode for developing a constant polarity direct current voltage from diode space current, means for utilizing said last voltage as said muting voltage, and a separate diode in a series circuit with a respective one of said opposed diodes and said load element.

11. In a receiver of frequency modulated carrier waves provided with a detector capable of providing a direct current voltage whose polarity is dependent upon the direction of frequency shift of the waves from a reference frequency; means to provide a muting voltage comprising at least two diodes arranged in polarity opposition, means for establishing the common junction of like electrodes of the diodes at an invariable potential, means for applying said direct current voltage to a respective one of the diodes depending upon the polarity of the voltage, a load element in circuit with each diode for developing a constant polarity direct current voltage from diode space current, means for utilizing said last voltage as said muting voltage, a modulation signal amplifier having a signal control element, means to apply modulation signals produced by said detector upon said amplifier, and muting voltage utilizing means consisting of a connection to said signal control element.

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