

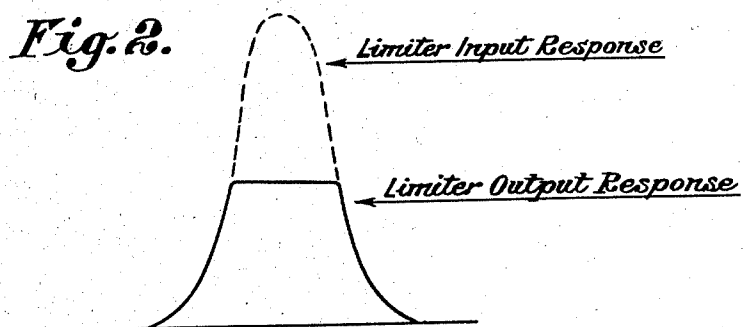
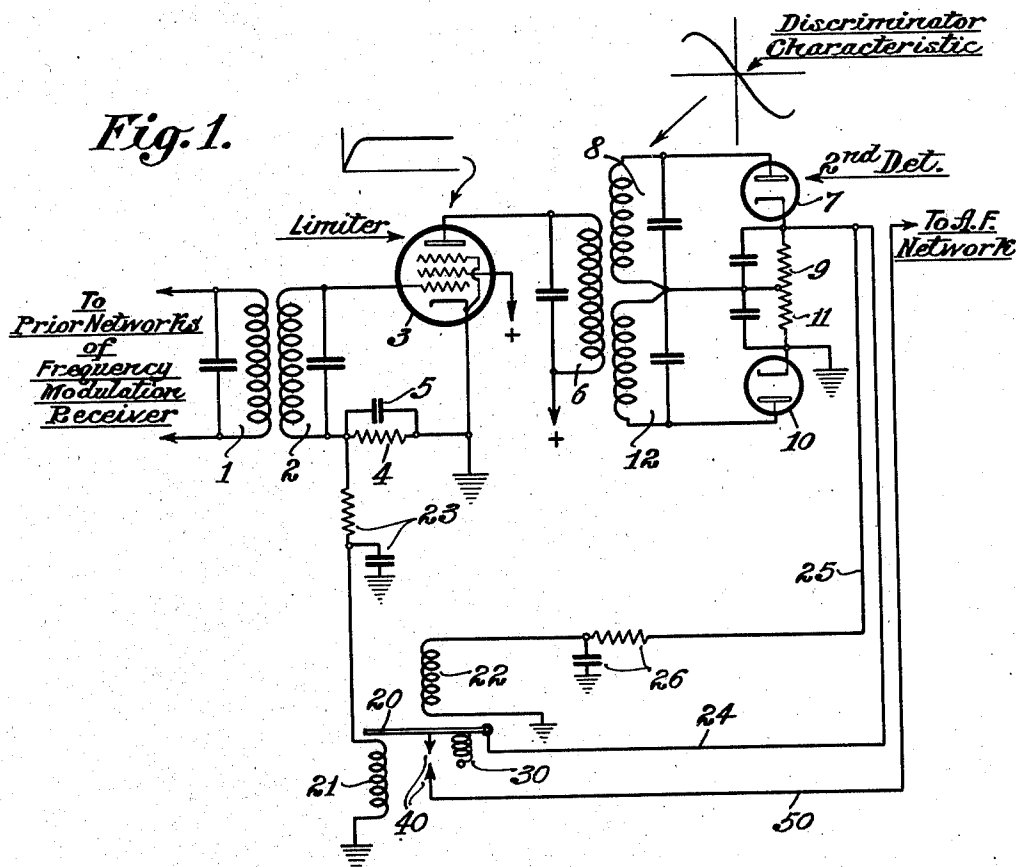
Sept. 15, 1942.

D. E. FOSTER

2,296,101

FREQUENCY MODULATION RECEIVER TUNING INDICATOR

Filed Oct. 25, 1940



INVENTOR
Dudley E. Foster
 BY *H. S. Snover*
 ATTORNEY

UNITED STATES PATENT OFFICE

2,296,101

FREQUENCY MODULATION RECEIVER TUNING INDICATOR

Dudley E. Foster, South Orange, N. J., assignor to
Radio Corporation of America, a corporation of
Delaware

Application October 25, 1940, Serial No. 362,705

9 Claims. (Cl. 250—20)

My present invention relates to frequency modulated carrier wave receivers, and more particularly to a device for audibly indicating accurate tuning of a frequency modulation receiver.

The frequency modulation broadcast range at the present time is in the 43 to 50 megacycle band. It has been found necessary in this band to utilize visual tuning indicator devices for informing the operator when a desired broadcasting station has been accurately tuned in. Visual indicators are necessary because experience demonstrates that when the receiver is even slightly mistuned from the desired carrier frequency grave distortion occurs. This distortion arises by virtue of the fact that a substantially S-shaped characteristic is utilized at the discriminator of the receiver, and the mid-point of the characteristic is the carrier frequency of the desired station. Tuning the receiver by ear has been found difficult, because of the fact that the receiver is being operated in an ultrahigh frequency range. This is particularly true at low volume passages. However, it is highly desirable to indicate tuning of the receiver by listening to the output thereof, and yet be able accurately to adjust the tuning of the receiver.

Accordingly, it may be stated that it is one of the main objects of my present invention to provide an audible tuning indicator device for a receiver of frequency modulated carrier waves, the device permitting accurate tuning of the signal selector circuits of the receiver to the carrier, or center, frequency of the received frequency modulated carrier waves.

Another important object of this invention is to provide in a receiver adapted to detect frequency-variable carrier waves, a device which is responsive to the detector output circuit in such a manner that reproduction of the detected signals is impaired unless the receiver is tuned exactly to the carrier frequency of the desired signals.

Another object of the invention is to provide in a frequency modulation receiver a device which is responsive to both the limiter network and the discriminator network in such a manner that transmission of signals through the audio network of the receiver is prevented unless the receiver is accurately tuned to the center frequency of received frequency modulated carrier waves.

Still other objects of the invention are to improve generally the simplicity and efficiency of tuning indicators for frequency, or phase, modulated carrier wave receivers, and more especially

to provide an audible tuning indicator for a frequency modulation receiver which is not only reliable in operation, but is economically assembled in the receiver.

The novel features which I believe to be characteristic of my invention are set forth in 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 a circuit organization whereby my invention may be carried into effect.

In the drawing:

Fig. 1 shows a receiving system embodying the invention,

Fig. 2 shows the response characteristics existing at the input and output circuits of the limiter of a frequency modulation receiver.

Referring now to Fig. 1, there is shown only those networks of a frequency modulation receiver which are essential to a proper understanding of this invention. Since, at the present time, the superheterodyne type of receiver is used to receive frequency modulated carrier waves in the 43 to 50 megacycle band, it will be assumed that the numeral 1 denotes the resonant output circuit of an intermediate frequency amplifier which feeds the resonant input circuit 2 of the limiter tube. Each of circuits 1 and 2 will, of course, be tuned to the operating intermediate frequency, and the latter may be chosen from a range of 2 to 20 megacycles. It is stated by way of illustration that a value of 2.175 megacycles may be utilized.

It is not believed necessary to explain the nature of the networks preceding the circuit 1, since those skilled in the art are fully aware of the specific nature of the prior networks in a superheterodyne receiver. Generally speaking one or more tunable radio frequency amplifiers may be included between the signal collector and the signal input circuit of the first detector network. The various tunable circuits are each resonated to the carrier frequency of the desired station. The local oscillator has its tunable tank circuit adjusted through a frequency range such that at each setting of the usual uni-control tuning means the first detector output circuit, which is tuned to the operating intermediate frequency value, develops frequency modulated carrier voltage whose center frequency is at the operating intermediate frequency value.

Of course, the circuit 1 may be the tuned out-

put circuit of the first detector tube, or it may be located in the plate circuit of an intermediate frequency amplifier tube. The limiter network follows the usual construction well known to those skilled in the art. It may employ a tube 3, for example a sharp cut-off pentode tube, whose signal input grid is connected to the grounded cathode through the coil of input circuit 2 in series with the resistor 4, the latter being shunted by condenser 5. The network 4-5 has a very short time constant, and the resistor 4 develops direct current voltage thereacross in response to grid current flow in the limiter tube. Since the tube operates with little, or no, bias, grid current flows in the grid circuit when signals are received. It is, also, pointed out that the resonance curve of the input circuit of limiter tube 3 is single-peaked. In Fig. 2 there is illustrated in a graphic manner, and by the dotted line, the response at the input circuit of the limiter tube.

The plate circuit of the limiter tube includes the resonant circuit 6 which is tuned to the operating intermediate frequency. It is not believed necessary to describe the function of the limiter in detail. The limiter tube has an input-output characteristic as shown by the curve directly above the limiter tube. For signals above a predetermined carrier amplitude there occurs no further increase in limiter output. This prevents any carrier amplitude variation from appearing at the discriminator. Since the discriminator-detector must be a device capable of converting solely frequency variation of the carrier into corresponding audio modulation, it is essential that there be no carrier amplitude variation at the discriminator. Passage of the signals through the various tuned networks up to the limiter, noise impulses and fading may introduce carrier amplitude variation. It is necessary, therefore, to utilize a limiter network prior to impression of the signals upon the discriminator. Fig. 2 shows the relatively broadened response characteristic which exists at the limiter output circuit. The gain of the limiter determines the relative amplitudes of the two curves in Fig. 2. The output response could readily be greater, for example, than the input response amplitude.

The discriminator-detector may be of any well known form. It can be of the type utilizing a pair of rectifiers having output loads in phase opposition, and a common input circuit tuned to the operating intermediate frequency as disclosed by S. W. Seeley in U. S. Patent No. 2,121,103 granted June 21, 1938. It may comprise, alternatively, the type of detector which utilizes a pair of rectifiers whose output loads are in polarity opposition, but whose resonant input circuits are oppositely mistuned by equal frequency values from the operating intermediate frequency value. Merely by way of illustration this latter type of detector is shown in Fig. 1.

The detection network comprises one diode rectifier 7 whose anode is connected to ground through a path which includes the coil of its resonant input circuit 8 and the resistor 9. The load resistor 9 is by-passed for intermediate frequency current. The second diode 10 has a load resistor 11 arranged in series with resistor 9, resistor 11 being by-passed for intermediate frequency currents. The anode of diode 10 is connected to the low potential side of input circuit 8 through the coil of resonant input circuit 12.

The cathode end of resistor 11 is established at ground potential, and hence the voltages developed across resistors 9 and 11 are in polarity opposition.

Circuits 8 and 12 are resonated to frequencies which are located on different sides of the center frequency of the impressed frequency modulated waves. It is not believed necessary to specify the particular mistuning to be employed. It is believed sufficient for the purpose of this application to point out that the circuits 8 and 12 will be oppositely detuned by equal frequencies to a sufficient extent from the center frequency such that a substantial voltage is developed across either of load resistors 9 or 11 when the center frequency shifts towards the frequencies of the respective input circuits 8 and 12. The discriminator characteristic which is depicted above the push-pull connected diodes graphically shows the relation between center frequency deviation and rectified voltage output of the detection network. As is well known to those skilled in the art the characteristic is an inclined S-shaped curve.

The upper and lower spaced peaks of the curve are the resonant frequencies of the tuned circuits 8 and 12. When the signal energy applied from circuit 6 has its center frequency equal to the mean frequency of circuits 8 and 12 then the uni-directional voltage output of the detector is zero. It is not believed necessary to describe in detail the functioning of the detector circuit, since those skilled in the art are fully aware of the fact that the uni-directional voltages across load resistors 9 and 11 are in polarity opposition. By grounding the cathode end of resistor 11 there is derived from the cathode end of resistor 9 rectified voltage which corresponds to the modulation signals applied to the carrier at the transmitter. In other words, the audio voltage taken off from the cathode end of resistor 9 corresponds to the frequency modulation of the transmitted carrier wave produced by the audio waves at the transmitter.

In order to tune the receiving system by ear, and yet secure an accurate tuning adjustment, there is provided a relay device which comprises a magnetic armature 20. The latter is disposed adjacent a pair of high resistance windings 21 and 22. The winding 21 is connected between the grid end of resistor 4 and ground. The connection includes a filter network 23 for removing any alternating current voltage components. The pivoted end of armature 20 is connected by lead 24 to the cathode end of resistor 9. The winding 22 is connected between the cathode end of resistor 9 and ground through a path including lead 25 and the filter network 26. The latter filter is also used to suppress any alternating current components. Hence, it will be seen that there flows through windings 22 and 21 solely direct currents.

A spring 30 is arranged to maintain the armature 20 in substantially mid-position between windings 21 and 22. In this position the contacts 40 are normally open, or spaced apart. One of the contact elements is electrically connected to the armature 20, while the other contact element is connected by lead 50 to the input circuit of the following audio frequency amplifier network. The audio frequency amplifier may include one or more stages of audio amplification followed by an audio reproducer.

When no current flows through the windings 21 and 22 the armature 20 assumes the position

shown in Fig. 1, and the contacts 40 are in open-circuit position. In other words the transmission path, comprising 24—40—50, to the audio network is open, and the reproducer will not reproduce signals. Hence, in the absence of received signals, or in the presence of signals whose amplitude is too low to cause voltages from appearing across resistor 4 or across resistors 9 and 11, there will be no reproduction of even noise impulses. As the receiver is tuned to a desired station a certain amount of grid current flow is produced through resistor 4. However, the magnitude of the current is not a maximum by virtue of the response characteristic at the input circuit 2. From Fig. 2 it is seen that the response characteristic is rather sharp. Unless the receiver is accurately tuned to the center frequency of the frequency modulated waves, the current flow through resistor 4 has a value less than the peak value at center frequency resonance.

While grid current flow through resistor 4 will energize the winding 21, and, therefore, tend to pull the armature 20 towards it against the biasing action of spring 30, this action is opposed by the energization of winding 22. The winding 22 is energized so long as the mean, or center, frequency of the applied frequency modulated signals is different from the predetermined mean frequency of the resonant frequencies of circuits 8 and 12. The latter predetermined center frequency is the operating intermediate frequency. Unless the receiver is accurately tuned to the center frequency of the collected frequency modulated signals, the uni-directional current component of the rectified voltages appearing across resistors 9 and 11 has a magnitude depending on the amount of frequency displacement between the predetermined intermediate frequency and the center frequency of the applied signals. Not only will this unidirectional current flow through winding 22 by virtue of the frequency difference mentioned, but it will be seen from the limiter output response characteristic in Fig. 2 that the effect of the limiter is to give an apparent broadening of the response curve which exists at the input circuit of the limiter. Hence, there will be a substantial energization of winding 22 as long as there is a frequency difference between the center frequency of the frequency modulated intermediate frequency energy and the predetermined intermediate frequency value. In general, winding 22 will have sufficient energization for any detuning near the signal to overcome the effect of winding 21. This can be adjusted by limiter gain, detector sensitivity and relative effect of windings 21 and 22.

This energization of winding 22 is sufficient to pull the armature 20 away from winding 21, and thus maintain the contacts 40 in spaced relation. In other words the audio transmission path is disabled. Hence, the operator knows that the receiver is not accurately tuned. However, as soon as the receiver is accurately adjusted to the point where the center frequency of the frequency modulated intermediate frequency energy is equal to the predetermined intermediate frequency value, then the unidirectional voltage developed across resistors 9 and 11 is zero and coil 22 is de-energized. Simultaneously the grid current flow through resistor 4 is a maximum, and armature 20 is attracted to winding 21 so as to close contacts 40. This results in transmission of the audio voltage between the detector output load and the audio amplifier input terminals.

The operator now knows that he has accurately tuned the receiver, since he is able to develop audio output from the system. Should he wish to tune to another station there will be a rapid impairment of audio reproduction. Upon slight detuning the current flow through resistor 4 drops, and the compressed spring 30 will immediately urge armature 20 away from winding 21 thereby opening contacts 40. As explained before, winding 22 will be energized upon detuning and thereby aid in the immediate opening of contact elements 40.

It will be appreciated that the magnitudes of coils 21 and 22 may be adjusted to provide varying speeds of actuation of armature 20 depending on the will of the operator. In place of voltage windings 21 and 22 there may be used current windings in series with the loads. Furthermore, the biasing spring 30 may be replaced by any other device. For example, the relay armature 20 may be arranged to open on accurate tuning if desired. In such case the contacts 40 would be in shunt with the audio network. The contacts 40 could operate to change a normal cut-off bias on an audio amplifier tube. Again, in place of a mechanical relay an electronic device, such as an electron discharge tube, may be used to change a normal cut-off bias existing on an audio amplifier tube in the absence of accurate tuning. In such case audio frequency transmission will occur solely when the limiter tube is energized and the output voltage across the detector load resistors is substantially zero as explained previously.

If it be assumed that in the absence of signal a portion of the audio amplifier is biased to cut-off, winding 22 can be replaced by two tubes so arranged that if either is energized audio bias will be at cut-off, and in series therewith a third tube replacing winding 21 and arranged so that in the absence of signal (when both tubes replacing 22 would be de-energized allowing normal bias on the audio) it will place cut-off bias on the audio tube. The requirements for audio transmission will then only be met on correct tune when the two tubes replacing 22 have no net effect, and the tube replacing 21 has maximum effect.

Furthermore, it will be appreciated that winding 21 may be replaced by a spring which normally pulls armature 20 into position to close contacts 40, and in such case the armature 20 would be pulled away in a direction to open contacts 40 as long as winding 22 was energized by the uni-directional voltage output of the detector. In general, then, it will be seen that there has been provided by this invention a device adapted audibly to indicate accuracy of tuning in a frequency modulation receiver by maintaining audio reproduction impaired except when the center frequency of the received frequency modulated carrier waves is exactly equal to the predetermined frequency corresponding to the desired station carrier frequency.

While I have indicated and described a system 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 organization 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. In a receiver of frequency modulated carrier waves of the type provided with a frequency modulation detector and a utilization network

for detected waves, the method which includes deriving from the detected waves a uni-directional voltage whose magnitude is a function of the frequency difference between the center frequency of the frequency modulated carrier waves applied to said detector and a predetermined frequency value, and impairing the transmission of said detected waves to said utilization network with said uni-directional voltage, deriving a second uni-directional voltage from the frequency modulated carrier waves applied to said detector and regulating said transmission in an opposing sense with said second voltage in response to the latter assuming a maximum value.

2. In a receiver of frequency modulated carrier waves of the type provided with a frequency modulation detector and a utilization network for detected waves, the method which includes deriving from the detected waves a uni-directional voltage whose magnitude is a function of the frequency difference between the center frequency of the frequency modulated carrier waves applied to said detector and a predetermined frequency value, regulating the transmission of said detected waves to said utilization network with said uni-directional voltage, and automatically regulating said transmission in a sense opposed to said first regulation in response to maximization of the amplitude of the center frequency of the frequency modulated carrier waves applied to said detector.

3. In a receiving system of the type provided with a frequency modulation detector having an input circuit to which are applied frequency modulated carrier waves, and a modulation voltage transmission network following the detector; the improvement which includes means for deriving from the detector a direct current voltage which is a function of frequency difference between the center frequency of the frequency modulated carrier waves at said input circuit and a predetermined frequency value of said input circuit, means responsive to said direct current voltage for impairing the transmission of modulation voltage through said transmission network, means for deriving a uni-directional voltage from the waves at said input circuit, and means responsive to solely a maximum value of said uni-directional voltage for opposing the effect of said impairing means.

4. In a receiving system of the type provided with a frequency modulation detector having an input circuit to which are applied frequency modulated carrier waves, and a modulation voltage transmission network following the detector; the improvement which includes means for deriving from the detector a direct current voltage which is a function of frequency difference between the center frequency of the frequency modulated carrier waves at said input circuit and a predetermined frequency value of said input circuit, means responsive to said direct current voltage for impairing the transmission of modulation voltage through said transmission network, and means responsive to the amplitude of the center frequency of said modulated carrier waves at said input circuit for opposing the effect of said impairing means.

5. In a receiving system of the type provided with a frequency modulation detector having an input circuit to which are applied frequency modulated carrier waves, and a modulation voltage transmission network following the detector; the improvement which includes means for de-

riying from the detector a direct current voltage which is a function of frequency difference between the center frequency of the frequency modulated carrier waves at said input circuit and a predetermined frequency value of said input circuit, and means responsive to said direct current voltage for impairing the transmission of modulation voltage through said transmission network, said input circuit comprising a carrier wave amplitude limiter provided with a resonant input circuit tuned to said predetermined frequency value, and means responsive to uni-directional voltage developed in said resonant input circuit from said modulated waves for opposing the action of said impairing means.

6. In a receiver of frequency, or phase, modulated carrier waves of the type provided with a detector and a utilization network for detected waves, the method which includes deriving from the detected waves a direct current voltage whose magnitude is a function of the difference between the center frequency of the modulated carrier waves applied to said detector and a predetermined frequency value, inhibiting the transmission of said detected waves to said utilization network with said voltage, deriving a second voltage from the modulated carrier waves applied to said detector, and controlling said transmission in an opposing sense with said second voltage in response to the latter assuming solely a maximum value.

7. In a receiver of frequency, or phase, modulated carrier waves of the type provided with a detector and a utilization network for detected waves, the method which includes deriving from the detected waves a direct current voltage whose magnitude is a function of the difference between the center frequency of the modulated carrier waves applied to said detector and a predetermined frequency value, controlling the transmission of said detected waves to said utilization network with said voltage, and automatically controlling said transmission in a sense opposed to said first control in response to an increase in the amplitude of the center frequency of the modulated carrier waves applied to said detector.

8. In a receiving system of the type provided with a frequency modulated detector having an input circuit to which are applied frequency modulated carrier waves, and an audio voltage transmission network following the detector; the improvement which includes means for deriving from the detector a direct current voltage which is proportional in magnitude to the frequency difference between the center frequency of the frequency modulated carrier waves at said input circuit and a predetermined frequency value of said input circuit, means responsive to said direct current voltage for impairing the transmission of audio voltage through said transmission network, means for deriving a direct current voltage from the waves at said input circuit, and means responsive to maximization of said latter voltage for opposing the effect of said impairing means.

9. In a receiver of angular velocity-modulated carrier waves, a limiter tube having input and output electrodes, a wave input circuit coupled to said input electrodes and being tuned to the mid-band frequency of applied waves, said input circuit having a single-peaked resonance curve, a discriminator-detector network having an input network coupled to said output electrodes,

said input network having resonance curve which is relatively broad, means adapted to apply the modulation voltage output of said detector to a utilization circuit, said discriminator-detector network being constructed and arranged to produce a uni-directional voltage whose magnitude is a function of the difference between the mid-band frequency of applied waves and a predetermined frequency, means responsive to pro-

duction of said uni-directional voltage for impairing operation of said applying means, means for deriving a second uni-directional voltage from said limiter input circuit which maximizes at said single peak frequency, and means responsive to the second voltage for opposing the action of said impairing means.

DUDLEY E. FOSTER.