Dec. 31, 1946. W. L. CARLSON 2,413,543

REDUCTION OF SELECTIVE FADING DISTORTION

Filed Sept. 22, 1943 2 Sheets-Sheet 1

Fig. 1

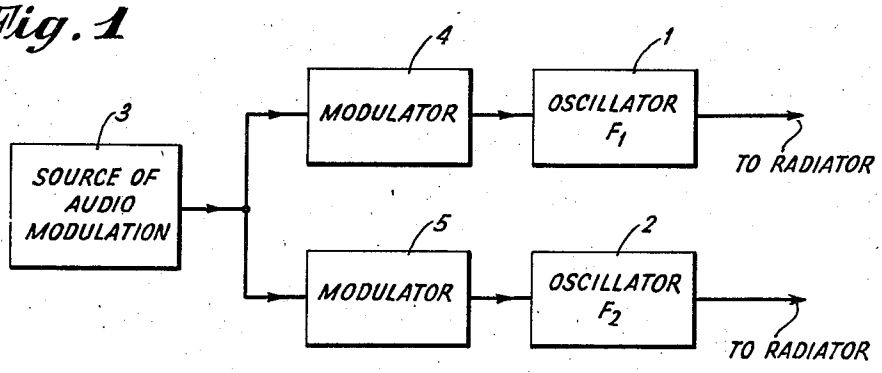


Fig. 2

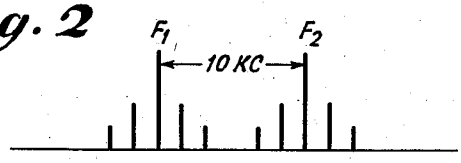
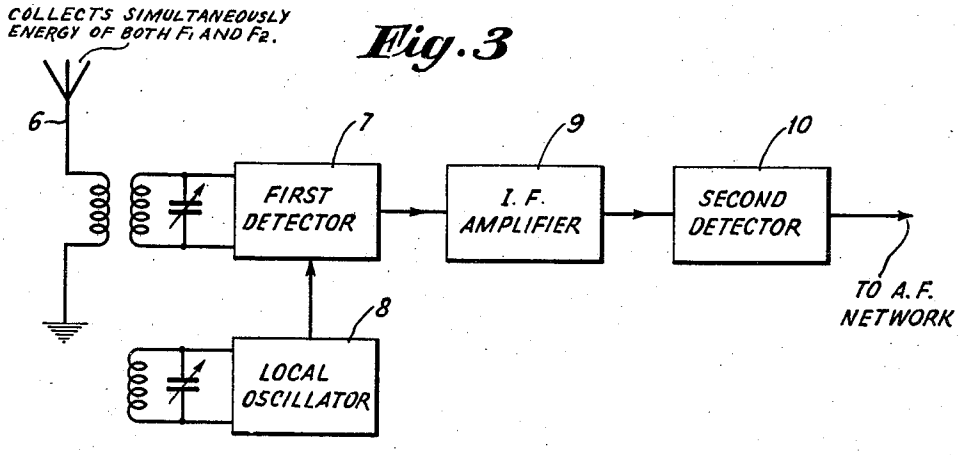


Fig. 3



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Fig. 4

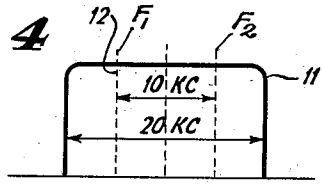
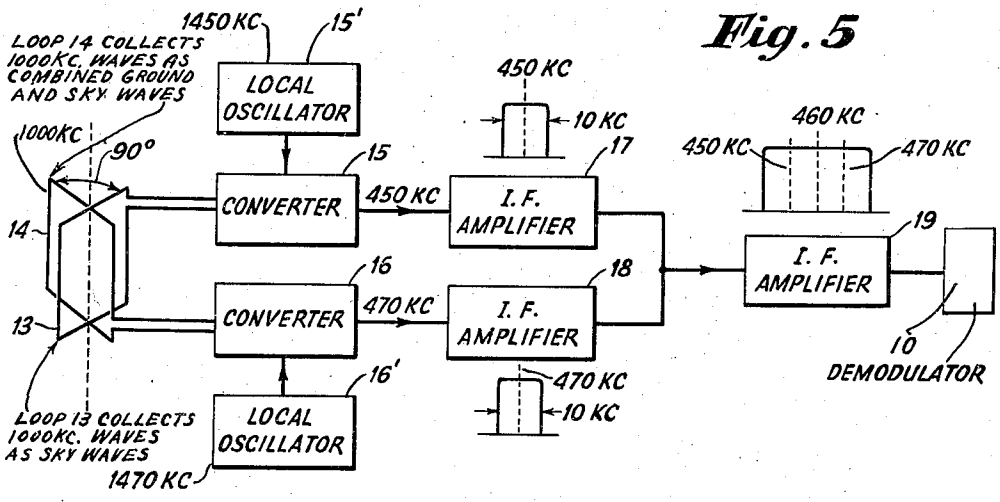


Fig. 5



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REDUCTION OF SELECTIVE FADING DISTORTION

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5 Claims. (Cl. 250—20)

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My present invention relates generally to systems for reducing selective fading distortion.

In areas fairly distant from standard broadcast stations (530–1700 kilocycle broadcast band) distortion occurs by virtue of the well-known phenomenon known as "selective fading." Distortion of this type is actually a distortion of audio frequency modulation due to interference of sky and ground waves at a particular signal wave collector of a receiver. Selective fading distortion is also encountered on the frequency bands higher than the broadcast frequency range.

One important object of my invention is to provide means for automatically rejecting a distorted signal and to select an undistorted signal.

Another important object of this invention is to provide a novel method of reducing selective fading distortion in receivers, wherein common audio frequency modulation signals are transmitted on adjacent channel carriers, the reception of such adjacent channel carriers being carried out in a system having a pass band wide enough to pass both carriers up to the demodulator whereby when one carrier fades substantially below the strength of the other carrier, then the efficiency of rectification is reduced for the fading carrier and the audio frequency output from the fading signal is abnormally reduced.

Still another important object of my invention is to provide a method of reducing distortion due to selective fading which is based on the observed phenomenon that at any given reception point where sky and ground waves from a given transmitter are of the same order of magnitude, combining these waves in two different phase relations will cause one of the resulting waves to be undistorted and strong while the other is distorted and weak. The method employed involves conversion of the two waves into two different intermediate frequency waves, and passing them through a wide transmission path to a detector, or to employ separate detectors for the two waves with means for increasing the difference in amplitudes of the signals impressed on the detectors.

A more specific object of one form of this invention is to provide a broadcast receiver with a pair of loops which are oriented so as to have their planes at right angles to each other; each of the loops feeding separate converter networks so as to provide intermediate frequencies located on adjacent frequency channels but having common modulation signals thereon, the demodulator of the system having a common transmission path from the pair of parallel intermediate frequency networks thereof, and which common path has a pass band which is sufficiently wide to pass each intermediate frequency with its modulation side bands.

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Still other objects of my invention are to improve generally the efficiency and reliability of systems for reducing distortion accompanying selective fading, and more especially to provide methods of reducing selective fading distortion which are economical so far as apparatus is concerned.

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 drawings in which I have indicated diagrammatically circuit organizations whereby my invention may be carried into effect.

In the drawings:

Fig. 1 schematically shows a transmitter system adapted to radiate a pair of adjacent channel carriers of common modulation,

Fig. 2 shows in a pictorial manner the modulated carriers radiated by the system of Fig. 1,

Fig. 3 schematically shows a receiver adapted to receive the radiated waves from the system of Fig. 1,

Fig. 4 shows the pass band curve of a receiver constructed in accordance with my invention,

Fig. 5 schematically illustrates a modified embodiment of the invention wherein a single channel carrier is received.

Referring now to the accompanying drawings, wherein like reference characters in the different figures designate similar circuit elements, I have shown in Fig. 1 in purely schematic manner a transmission system adapted to be employed in one method of reducing distortion caused by selective fading. In this transmitter system a pair of master oscillators 1 and 2 is utilized. These oscillators are constructed and designed to produce oscillations having frequencies on adjacent frequency channels. Thus, oscillator 1 operates at frequency F_1 whereas oscillator 2 operates at a frequency F_2. Assuming that the transmitter is producing modulated carrier waves in the standard broadcast band, it will be understood that F_1 and F_2 will be the carrier frequencies of immediately adjacent channels. These channels are normally spaced 10 kilocycles (kc.) apart.

The source of audio frequency modulation 3 is

utilized concurrently or synchronously to modulate the oscillations produced by each of oscillators 1 and 2. Thus, the modulator 4 is employed to modulate the oscillations of oscillator 1 in accordance with the modulation signals of source 3. The modulator 5 is adapted to modulate the oscillations of oscillator 2 in accordance with the modulation signals of source 3. The separate modulated carrier energy of oscillators 1 and 2 may then be transmitted to one or more separate stages of amplification, and finally the separate modulated carrier waves are radiated from separate radiators. There is shown in Fig. 2 in purely illustrative manner the relation which exists between the modulated carrier waves which are radiated from the separate radiators of the system of Fig. 1. It will be seen that there is a 10 kc. spacing between the carrier frequencies F_1 and F_2, whereas the modulation side band components are exactly the same for both carrier frequencies.

At the receiver, which is schematically represented in Fig. 3, there is shown a signal collector device 6 which may be the usual grounded antenna circuit. The receiving system is represented as being of the superheterodyne type, since the latter type of receiver is practically universally used to receive radio signals in the standard broadcast band. However, it is to be clearly understood that any other type of receiver, such as one of the tuned radio frequency amplifier type, or the superregenerative type, may be employed.

Assuming that the receiving system is of the superheterodyne type, there is employed the usual first detector or converter 7 which has a tunable input circuit so that the receiver may be tuned to frequencies F_1 and F_2. The usual local oscillator 8 is also tunable, and the locally produced oscillations of a predetermined frequency are applied to the first detector 7. In the output of the latter there is produced the intermediate frequency (IF) energy, which may be amplified by one or more stages of IF amplification 9. The amplified IF energy may then be applied to a second detector or demodulator 10 whose input is tuned to the operating IF value. The modulation output of the second detector 10 may then be transmitted through one or more stages of audio frequency amplification, and the amplified audio energy is then reproduced in any desired form of reproducer such as a loudspeaker.

It will be recognized that the aforedescribed networks of the receiver of Fig. 3 are purely conventional. Indeed, my invention is readily applied to any conventional receiver of the standard broadcast type. The only change that need be made in the conventional superheterodyne receiver is that the pass band characteristic of the receiver up to the input terminals of the second detector 10 be sufficiently wide so as to pass the energy of carriers F_1 and F_2 and their associated modulation side bands. In Fig. 4 I have shown an illustrative representation of the type of transmission characteristic which the receiving system of Fig. 3 should have. The full line curve 11 denotes the ideal transmission characteristic of the receiver up to the input terminals of the second detector. It will be noted that the pass band width is 20 kc. This means that the radiated carriers F_1 and F_2 and their modulation side bands may readily be passed through the various networks from the signal collector 6 to the input terminals of the demodulator 10. The dotted lines 12 in Fig. 4 show the positions of the carriers F_1 and F_2 and the 10 kc. spacing between each of the carriers F_1 and F_2 and their modulation side bands. In designing the receiving system in Fig. 3 it is to be understood that each of the selector transmission networks from the signal collector 6 to the input terminals of demodulator 10 should have a pass band width which will be sufficiently wide to pass a radio frequency band 20 kc. wide.

The demodulator 10 may be of any well-known form. That is to say, it can be a diode detector, a grid leak rectification type of detector, or a plate circuit rectification form of detector. It is a well known fact that with such detectors the stronger of two signals will dominate, and that the weaker signal will appear in the detector output only as frequencies resulting from the heterodyne beat from reaction with the stronger carrier. These beats will in this case all be of frequencies above 5,000 cycles, and, therefore, will be outside the pass band of the audio system employed. As one signal intensity falls, the detector efficiency falls at a rapid rate. This has the significance that when one of the signals F_1 or F_2 falls substantially below the strength of the other signal, then the efficiency of rectification is reduced for the fading signal and the audio frequency output derived from the fading signal is abnormally reduced. It will now be appreciated that a simple and effective manner of reducing distortion caused by selective fading is readily provided by my invention. Let it be assumed that the receiver of Fig. 3 is located at such a distance from the transmitter of Fig. 1 that severe selective fading occurs in that receiving locality.

If the ground wave and sky wave of carrier F_1 cancel at the position where collector 6 is located, it is most unlikely that the same cancellation will occur for carrier F_2. Indeed, actual observation demonstrates that simultaneous selective fading of adjacent carriers is most improbable. Hence, if, for example, carrier F_1 should fade sufficiently so that detection thereof at the demodulator 10 would cause audio distortion, with my invention such audio distortion will be greatly reduced and even substantially eliminated. This follows from the fact that when the carrier F_1 fades severely relative to its modulation side bands, the rectification efficiency of demodulator 10 will drop very rapidly and the audio output due to the carrier F_1 will substantially disappear. However, since the network which feeds the demodulator is sufficiently broad to pass the carrier F_2, it follows that the audio output reaching the loudspeaker will be sufficient because the audio output due to F_2 is the same audio output which would have been derived from F_1. It is emphasized that since F_2 is not fading relative to its modulation side bands, the detector efficiency with respect to the modulated carrier wave F_2 will be at a high value and unaffected by the reduction of the detector efficiency with respect to the wave F_1.

In the system of Fig. 5 there is employed a single carrier transmission channel in contrast to the dual channel transmission of Figs. 1 and 3. There is radiated from the broadcast transmitter the usual and standard modulated carrier wave having a channel width of about 10 kc. At the receiver there are located a pair of loops which are oriented 90° in respect to each other for reception of the broadcast band. It will be understood that the loops 13 and 14 can be rotated around a vertical axis, shown as a dotted line, and at any angle in respect to each other. One of these loops will collect the modulated carrier wave energy which appears as a ground wave and also as a sky wave, while the other

loop will collect solely the sky wave energy. Let it be assumed that there is being received the signals from a transmitter operating at 1000 kc.

One of the loops can be pointed toward the transmitting station, while the other loop is turned broadside to the station. With this condition the receiving channel connected to the loop pointing towards the station would have the highest average signal and less average distortion. Observation has shown that during periods when the transmitted signal faded and distortion occurred on this channel, the other channel with the loop broadside usually had strong non-distorted signals. It has been observed that the signal received by one of the loops which has its modulated carrier wave energy subject to selective fading is most probably subject to cancellation effects due to the combined action of the ground and sky waves. In that case the other loop most likely is collecting sky wave energy, and is providing a substantially uniform intensity of desired signals.

Each of the loops feeds its collected signal energy to a respective converter stage. Thus, loop 13 is connected to the converter 15. The local oscillator 15' feeds its locally produced oscillations to converter 15. The local oscillator 16' feeds its locally produced oscillations to converter 16. In the assumed case of reception of signals of 1000 kc., the local oscillator 15' is adjusted to frequencies of 1450 kc. while the oscillator 16' is adjusted to a frequency of 1470 kc. The output energy of converter 15 will have an IF value of 450 kc., while the IF value of converter 16 will have a value of 470 kc. Separate IF amplifiers 17 and 18 are utilized to amplify the separate modulated IF carrier waves. Above the amplifier 17 there is shown graphically the appearance of the pass band of the amplifier 17, and below the amplifier box 18 there is shown the pass band of that amplifier.

After separate amplification in networks 17 and 18, the combined energies of these two networks are fed to a common IF amplifier and transmission network 19 which has a pass band sufficiently wide to pass each of the IF carriers of 450 kc. and 470 kc. and the associated modulation side bands of each carrier. Above the network 19 there is shown in idealized form the appearance of the pass band characteristic of the network 19. It will be seen that it is sufficiently wide so as to pass the output energy of each of amplifiers 17 and 18. Subsequent to the network 19 the demodulator will be similar to the demodulator 10 of Fig. 3. The action is precisely the same. If there is selective fading of the energy collected by loop 14, then the demodulator efficiency for the modulated IF energy of 470 kc. will decrease sharply. Hence, the audio output will be that due to the 450 kc. energy, which is representative of the sky wave energy which was collected by loop 13.

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 organization shown and described, but that many modifications may be made without departing from the scope of my invention.

What I claim is:

1. In a receiver of modulated carrier waves, at least two directional signal collectors arranged in predetermined relation, means coupled to one collector to reduce modulated carrier waves to a first lower carrier frequency, means coupled to the second collector to reduce modulated waves of the same carrier frequency to a second lower carrier frequency different from the first lower frequency, means amplifying said waves of both lower carrier frequencies in a common amplifier stage, and a common demodulator coupled to the latter stage.

2. In a receiver of modulated carrier waves, at least two directional signal collectors arranged in predetermined angular relation, converter means coupled to one collector to reduce modulated carrier waves to a first lower carrier frequency, a second converter means coupled to the second collector to reduce modulated waves of the same carrier frequency to a second lower carrier frequency different from the first lower frequency, means amplifying said waves of both lower carrier frequences, and a common demodulator for the amplified waves.

3. In a receiving system for modulated carrier waves subject to selective fading of the carrier relative to the modulation side bands, means separately effecting at least two collections of said modulated carrier waves in space quadrature relation, means translating the separate waves to different frequencies, means separately amplifying the waves of different frequencies, means transmitting the amplified waves through a common path adapted to pass the separate waves, and means rectifying the latter waves in a common detector.

4. In a receiver of modulated carrier waves, at least two directional signal collectors arranged in 90 degree relation, means coupled to one collector to reduce modulated carrier waves to a first lower carrier frequency, means coupled to the second collector to reduce modulated waves of the same carrier frequency to a second lower carrier frequency different from the first lower frequency, means amplifying said waves of both lower carrier frequencies in a common amplifier stage, said amplifier stage having a pass band width chosen to include both lower frequencies, and a common demodulator coupled to the latter stage.

5. In a system for receiving a high frequency carrier modulated by signals of a predetermined frequency range, a pair of loop collectors arranged on a common axis in quadrature relation whereby one loop collects the sky wave and the other combined ground and sky waves, a first converter connected to one loop and adapted to convert received carrier frequency to a lower value, a second converter connected to the second loop and adapted to convert the received carrier energy to a lower value differing from the first lower value by the said modulation frequency range, separate amplifiers for respectively and separately amplifying the energies of lower frequency, means combining the separately amplified energies in an amplifier whose pass band is at least double said modulation frequency range and whose center frequency is a value between said two lower frequencies, and means for demodulating the combined energies.

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