

PATENT SPECIFICATION

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(54) LOW FREQUENCY AM STEREOPHONIC BROADCASTING SYSTEM

(71) We, THE MAGNAVOX COMPANY, a corporation organised and existing under the laws of the State of Delaware, United States of America, of 1700 Magnavox Way, Fort Wayne, County of Allen, State of Indiana, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a stereophonic system for AM broadcast transmitters and receivers. Specifically, apparatus is provided which is compatible with present AM modulated transmitting and receiving apparatus for transmitting two channels of information.

Two channel transmission incorporating FM modulation techniques are well known and widely used at frequencies above 50 MHz. It has been proposed by numerous authors to transmit two channels of information by means of amplitude modulation on a low frequency wave. The AM stations currently operating in the region of 550 KHz to 1600 KHz are not operated as stereo transmitting systems but remain as transmitters of monophonic information only. Therefore, it would be desirable to upgrade the quality of low frequency (550 KHz to 1600 KHz) amplitude modulated signals by including a second channel of information which could be received and demodulated to provide two channels of information for stereophonic reception.

Stereophonic systems for low frequency AM modulated transmitters must be compatible with present day transmitters and receivers of low frequency amplitude modulated signals. This is necessary in order to accommodate the millions of receivers in current use with new proposed stereophonic broadcasts.

A number of two channel systems have been proposed in the past which are compatible with monophonic transmitting and receiving equipment. One such system is described in *I.E.E.E. Transactions on Broadcasting*, Volume BC-17, No. 2, June 1971, pages 50—55. The system described in this particular paper transmits two signals comprising an L-R signal and an L+R signal. The L-R signal is phase shifted and then applied to a balanced modulator. A carrier signal is supplied to the balanced modulator and a double sideband, suppressed carrier signal is produced. The double sideband, suppressed carrier signal is added to a carrier signal which has been shifted 90 degrees. This composite signal comprising a carrier shifted at 90 degrees and a double sideband suppressed carrier signal is used as the basis for deriving an RF signal to be modulated with still another source of information, L+R. The double sideband signal plus phase shifted carrier is frequency multiplied to a suitable carrier frequency for transmission.

The frequency multiplied signal is AM modulated with a second source of signal, L+R, which is also phase shifted. The resulting composite signal includes a first sideband containing the left signal and a second sideband containing the right signal.

The transmitted two channel signal may be received by tuning two separate receivers to the first sideband and to the second sideband. By tuning in this manner, the L and R signals are recovered.

The system, however, does not achieve a high degree of isolation between channels, and cross talk is evident. The I.F. filter bandwidth and skirt slope is such that a portion of the upper sideband would necessarily enter the receiver passband

which was tuned to the lower sideband. To achieve better isolation between information channels, the I.F. filter bandwidth must have very sharp skirts and a high stop band attenuation level.

Another system which has been described for transmitting stereophonic AM signals comprises an FM signal for carrying one signal channel, and a true AM modulation on the resulting FM modulated signal by the remaining signal channel. The modulated FM is derived by frequency modulating a carrier signal with pre-emphasized audio signal. A pre-emphasis network imparts a higher level to higher frequency audio signals than to lower frequency audio signals. The transfer function for the pre-emphasis network is directly proportional to the frequency of an input audio signal over the effective pre-amphasis bandwidth. In actual practice, the pre-emphasis network may be realized by operating an R—C high pass filter in the skirt region where the frequency response of the filter increases linearly. This gives a positively increasing slope to the amplitude-frequency response of an audio signal which is used to modulate an FM modulator. The modulated signal has the characteristic of a PM signal rather than FM over the limited region of effectual pre-emphasis.

The resulting frequency modulated signal is supplied to an AM full carrier double sideband transmitter where it is modulated with a second audio signal. The composite FM/AM signal appears over a limited audio frequency range as a phase modulated signal with AM modulation impressed upon it, and as an FM signal with AM modulation over a limited low audio frequency range.

A shortcoming with the pre-emphasized FM/AM system has been experienced in that the pre-emphasis is obtained over a limited region of the input audio frequency spectrum. Where pre-emphasis is not effective, wide band FM occurs which is a potential source of distortion. The wide band FM resulting from limited pre-emphasis tends to cause FM-to-AM conversion in the tuned circuitry of the receiver. The conversion results from slope detection of the FM signals produced by the wide deviation of the audio signals in the FM system where pre-emphasis is not effective. The slope detection phenomenon causes the low frequency FM to be converted to an AM signal. The AM derived through slope detection of an FM signal thereafter will be detected in both channels thereby reducing the isolation between channels. Also, a true phase detector used to detect the PM component, where pre-emphasis is effective will produce a nonlinear output where pre-emphasis is not effective. The principles of systems of this type are embodied in U.S. Patent No. 3,068,475 and other references.

In accordance with one aspect of the present invention there is provided a stereophonic radio broadcasting system in which a transmitter operating in the 550 KHz to 1,600 KHz range transmits a single RF carrier to at least one receiver, the carrier having a frequency of W_c and being frequency modulated with a low frequency signal identifying the transmission as a stereophonic transmission to produce a frequency modulated carrier $\cos(W_c t + A \cos W_o t)$ where W_o is the frequency and A is the amplitude of the identifying signal, the phase of the frequency modulated signal being linearly modulated with a modulation index B by a difference audio signal $L(t) - R(t)$ to produce a phase-frequency modulated signal

$$\cos[W_c t + B((L(t) - R(t)) + A \cos W_o t)],$$

and the phase frequency modulated signal being amplitude modulated with a modulation index M by a summation audio signal $R(t) + L(t)$, whereby the transmitted signal has an amplitude, phase and frequency defined by

$$[1 + M(L(t) + R(t))] \cos[W_c t + B(L(t) - R(t)) + A \cos W_o t].$$

In accordance with a further aspect of the present invention there is provided a stereophonic radio broadcasting system in which a transmitter operating in the 550 KHz to 1,600 KHz range transmits a single RF carrier to at least one receiver, the carrier being frequency modulated by a low frequency signal identifying the transmission as a stereophonic transmission, the frequency modulated signal being linearly phase modulated by a difference audio signal $L(t) - R(t)$ obtained by subtractively combining signals derived from first and second audio sources, and the phase-frequency modulated signal being amplitude modulated by a second audio signal $L(t) + R(t)$ obtained by summing signals derived from the first and second audio sources, the broadcast signal having two sets of sidebands, the first set

representing the summation signal and the second set representing the difference signal, each of the sideband sets being symmetrical with respect to the carrier.

A receiver for use in such a broadcasting system comprises an amplitude detector for detecting the amplitude modulation of the broadcast signal, a phase detector for detecting variations in the phase of the broadcast signal, a frequency demodulator for detecting the identifying signal to provide an output indicating that a stereophonic transmission is being received, and means for combining the output of the phase detector with the output from the amplitude detector to reproduce the L(t) and R(t) signals.

A transmitter for use in such a broadcasting system comprises means for summing signals from first and second audio sources to form the summation audio signal L(t)+R(t), means for subtracting the signals from the first and second audio sources to form the difference audio signal L(t)-R(t), means for frequency modulating an RF carrier signal with a low frequency signal identifying the transmission as a stereophonic transmission, means for linearly phase modulating the frequency modulated carrier signal with the difference audio signal, and a double sideband full carrier modulator for amplitude modulating the phase-frequency modulated carrier signal with the summation audio signal.

The low frequency identifying signal may comprise a simple tone signal having a frequency of substantially 5 Hz or it may comprise a data signal having a low frequency data rate, the data being used, for example, to identify a particular broadcasting station.

By way of example only, an embodiment of the invention will now be described with reference to the accompanying drawings in which:—

Figure 1 is a block diagram illustrating transmitting and receiving apparatus in one embodiment of this invention, and

Figure 2 is a block diagram illustrating one method for generating a phase modulated carrier.

Referring now to Figure 1, there is shown both a transmitter and a receiver for transmitting stereophonic AM broadcasts at low frequencies. Two channels of stereophonic information L(t) and R(t) are applied to the inputs of the transmitter for modulating a carrier. A matrix circuit 11 combines both channels of information to form a sum channel signal comprising (L(t)+R(t)) and a difference channel signal (L(t)-R(t)). L(t)-R(t) is applied to a limiting response and delay compensation network 13 whereby differences in group delay experienced by the summation and difference signals may be compensated. Similarly the summation signal (L(t)+R(t)) is compensated by a limiting response and delay compensation network 12. These networks may compensate for any nonlinearity in either phase or amplitude experienced during either the transmission process or the receiving process of the summation and difference signals and prevent transmitter overmodulation. The output signal from the response and delay compensation network 13 is applied to the control input of a phase lock loop phase modulator 14. The phase lock loop modulator 14 comprises a phase detector, voltage control oscillator (hereinafter referred to as "VCO") and a loop filter. A temperature compensated crystal oscillator 15 (hereinafter referred to as TCVCXO) is compared by the phase detector in the phase lock loop 14 with the output of the VCO. The TCVCXO 15 in the embodiment shown is frequency modulated with a 5Hz signal tone. The peak deviation of the TCVCXO is substantially 20 Hz. The output from the phase lock loop modulator 14 may be represented by the following equation:

$$\cos[W_c t + \beta((L_t - R_t) + A \cos W_o t)]$$

W_c is the carrier frequency

β is the highest PM modulation index for an audio signal to be modulated, and

A is the amplitude of the pilot tone having a frequency of W_o .

The signal produced by the phase lock loop modulator 14 is supplied to the input of a standard broadcast transmitter 17 operating in the 550 KHz to 1600 KHz range.

The resulting phase modulated signal is thereafter amplitude modulated with the summation signal (L(t)+R(t)) by means of a double sideband, full carrier modulator 16. Accordingly, the broadcast signal has two sets of side bands, the first set representing L(t)-R(t), and the second set representing L(t)+R(t), each of the side band sets being symmetrical with respect to the carrier. The antenna feed network and antenna used for transmitting this composite AM and PM modulated

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signal must be designed so that the phase response as well as the frequency response over the bandwidth of interest is substantially flat to minimize distortion of the PM signal components which have been added to a standard AM carrier. By designing the antenna networks for constant group delay and linear phase response, distortions which may be added to the PM signal components are kept to a minimum.

The phase lock loop modulator scheme shown in Figure 1 may be more completely understood by reference to Figure 2. Figure 2 illustrates in detail the combination of a phase lock loop modulator and a temperature compensated voltage controlled crystal oscillator (TCVCXO) for producing a signal which a voltage controlled oscillator (VCO) is made to follow. The phase lock loop shown in Figure 2 is a second order phase lock loop having a loop bandwidth sufficient that the highest audio frequency in the modulating signal will cause a linear phase deviation of the VCO. A low pass filter 33 is used as the loop filter and its lead-lag characteristics are selected to yield the proper loop bandwidth. A VCO 30 has a control input connected to the output of the loop filter 33. The frequency and phase of the VCO 30 are controlled by the voltage supplied by the loop filter 33. A signal which ultimately determines the phase and frequency of VCO 30 is derived from the phase detector 31 which compares the phase of the TCVCXO 15 with the phase and frequency of VCO 30. As was previously indicated with reference to Figure 1, TCVCXO 15 is frequency modulated with a signal tone of 5 Hz at a peak deviation of 20 Hz. VCO 30 in the embodiment shown will track this frequency modulation and the frequency of VCO 30 at any given moment will be that of TCVCXO 15. The phase of VCO 30 will, however, change according to the audio input applied to the summation circuit 32. The phase detector used should be linear over $\pm 90^\circ$. Many digital phase detectors are available today which will yield the required phase linearity. The audio signal applied has frequency components below the loop bandwidth of the phase lock loop, therefore, the phase of VCO 30 will change linearly with the applied audio signal. The resulting output signal defined by the previous equation is thereafter applied to the AM carrier transmitter in a manner known to those in the art.

Although the specific embodiment contemplated the use of a phase lock loop for linearly modulating the phase of the carrier, other modulating schemes may be employed for this purpose. The general requirement for the modulator is that it produce a linear phase shift for a change in modulating voltage. Maintaining linearity is important in keeping distortion of the information being transmitted to a minimum.

Phase linearity can be improved by employing a phase modulator with a frequency multiplier. The phase modulator may be operated at a low deviation where phase linearity is best. Frequency multiplying the low deviated signal multiplies the phase deviation without a substantial increase in nonlinearity. Although the phase lock loop is sufficiently linear as a modulator, the possibility of improving linearity is to be noted by using the aforementioned frequency multiplication technique.

The phase modulated signal is thereafter amplitude modulated by the summation channel $L(t)+R(t)$ signal to produce the following signal for transmitting:

$$[1+m(L(t)+R(t))]\cos[(W_c(t)+\beta(L(t)-R(t))+A\cos W_o(t)]$$

where m is the modulation index of the double sideband full carrier signal. Other terms of the equation have been previously defined. This signal is amplified in a known manner before applying the signal to an antenna for broadcasting.

Referring again to Figure 1, a receiver for receiving the transmitted phase and amplitude modulated signal is shown. An antenna 21 directs the low frequency AM broadcasting signals to an rf amplifier and preselection circuit 22. The rf amplifier and preselection circuit 22 used in this receiver is similar to those in standard AM receivers. To preserve channel separation, the bandwidth for each tuned circuit should be greater than that of standard AM receivers so as to minimize loss of components in the PM signal which are distributed over a wider bandwidth than components of a standard AM signal. The preselection circuitry should be designed to have constant group delay over the passband in order to minimize any PM-to-AM conversion which a tuned circuit may cause. The output of the rf amplifier preselection circuit 21 goes to a standard mixer circuit 23 where it is heterodyned with the local oscillator signal from local oscillator 26. The local

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oscillator 26 should have better short-term stability than standard AM receivers would normally have in order to reduce phase noise which limits the signal-to-noise ratio of a recovered phase modulated signal. An ideal short-term stability for the local oscillator of less than 1/1000 of a radian above 100 Hz is desired. Although this represents a design goal, considerably less stability will produce an acceptable demodulated audio signal.

The heterodyned output from the mixer 23 is applied to a standard IF amplifier 24 which has a passband sufficient to accommodate the sidebands produced by the PM modulation, and has a substantially constant group delay to reduce the possibility of PM to AM conversion. The IF amplifier is controlled by an AGC voltage as is the rf amplifier. This AGC control is standard in most AM receivers today. An AM detector and AGC detector 27 derive the AGC voltage from the IF amplifier 24 in a known way. The AM detector signal $L(t)+R(t)$ is thereafter supplied to a Matrix circuit 32.

The IF amplifier also supplies a limiter-squelch circuit 25 with a composite AM and PM modulated signal. The limiter is a standard limiter found in many FM receivers today. The limiter effectively removes most of the amplitude modulation which appears on the signal supplied by IF amplifier 24. The output of the limiter containing a phase modulated signal is applied to a phase detector 28. The phase detector 28 is employed in a phase lock loop comprising VCO 29 and low pass filter 30. The phase lock loop is a second order loop known to those skilled in the art with a loop bandwidth of approximately 50 Hz. The low-pass filter is selected to give the lead lag characteristics sufficient to attain this bandwidth. The phase lock loop keeps VCO 29 locked in frequency and phase to the incoming signal. Because the loop filter bandwidth was selected to be 50 Hz, the VCO will track the frequency modulated signal tone which is being transmitted. The phase modulated audio which is transmitted will appear at the output of phase detector 28. The VCO 29 will not track the phase modulated audio to the extent that the low frequency signal tone is tracked because of the limited loop bandwidth. The phase lock loop is separately claimed in our copending Application No. 8,028,136, Serial No. 1,600,549.

A tone detector 33 which may consist of a filter (analog or digital) tuned to the 5 Hz signal tone frequency is used to supply an output indicative of the reception of a stereo broadcast from the AM transmitter. This tone detector output is supplied to a summation circuit 34 where it is summed with the output from the squelch circuit 41.

The low frequency audio having been recovered by phase detector 28 is amplified by amplifier 31. The amplified signal which may be represented by $L(t)-R(t)$ is combined with $L(t)+R(t)$ in Matrix 32 to yield the $L(t)$ and $R(t)$ signal. The $L(t)$ signal is supplied through a stereo mono switch 35 to an amplifier 37 and speaker 39. This constitutes one signal of the stereophonic transmission. The gain of amplifier 31 must be adjusted so that the matrix 32 will provide an $R(t)$ signal and $L(t)$ signal by combining the summation signal $L(t)+R(t)$ in a known way with difference signal $L(t)-R(t)$. Those skilled in the art will recognize that the amplification factor of amplifier 31 will depend in part upon the level of signal being supplied by the AM detector. An AGC circuit which has a wide dynamic range will tend to minimize the changes in the AM detector output level, thereby allowing the amplification factor for amplifier 31 to be a constant. Those skilled in the art will also recognize that the gain of amplifier 31 may also be made a function of AGC level thereby automatically compensating for changes in the level of signal produced by the AM detector.

During the reception of a PM modulated signal, this Matrix 32 derives the first and second information signals in a stereophonic broadcast. The limiter-squelch circuit 25 provides an output when the limiter has dropped out of limiting due to a loss of signal, or due to high negative peaks in the AM modulation. This loss of signal results in no signal being supplied to the phase detector 28. Accompanying this loss of signal will be the generation of a burst of noise which will be objectionable when processed through the amplifier 36 and speaker 38. Therefore, a squelch circuit having very rapid response time is used to provide a signal for disabling the stereo reception mode and enabling the receiver to receive monophonic information. The summation circuit 34 will cause the stereo mono switch 35 to make the requisite change to a monophonic reception when the tone detector detects that only a monophonic transmission is being originated by the transmitter, or when the aforementioned loss of signal occurs at the limiter output. Either of these two conditions will cause an indicator 40 to indicate the lack of

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stereo broadcast and will also cause the stereo mono switch to connect the summation signal $L(t)+R(t)$ derived from the AM detector to the inputs of amplifiers 36 and 37.

Those skilled in the art will recognize other circuits for causing the receiver to switch from a stereophonic to a monophonic mode of operation. For instance, a matrix network may be used which receives a first input of $(L(t)+R(t))$ and a second input $(L(t)-R(t))$. As long as both inputs are receiving a signal, the matrix provides an output of $R(t)$ and $L(t)$. However, when the $L(t)-R(t)$ signal is zero, the matrix will provide two output signals of $L(t)+R(t)$.

Thus, there has been described with respect to both a transmitter and receiver a system for providing stereophonic AM broadcasts at low frequencies. The technique is fully compatible with standard AM broadcasts which are not stereophonic, and receivers now in existence which are strictly monophonic will receive the AM component of the transmitted stereo signal of this invention as before, and the additional channel will remain undetected. This compatibility, between the stereophonic broadcasts of this invention and the AM broadcasts of monophonic information currently in use will be appreciated by those skilled in the art.

The invention has been described in this embodiment with reference to a signal tone which is a five cycle sine wave which may be used to identify that a stereo transmission is being received. It will be appreciated that signal tone could be replaced by an information carrying signal at a very low frequency data rate. The information carrying signal could be used to transmit the call letters or some other information which would be received over a long time period thus in effect giving three channels of information rather than two as previously described.

WHAT WE CLAIM IS:—

1. A stereophonic radio broadcasting system in which a transmitter operating in the 550 KHz to 1,600 KHz range transmits a single RF carrier to at least one receiver, the carrier having a frequency of W_c and being frequency modulated with a low frequency signal identifying the transmission as a stereophonic transmission to produce a frequency modulated carrier $\cos(W_c t + A \cos W_o t)$ where W_o is the frequency and A is the amplitude of the identifying signal, the phase of the frequency modulated signal being linearly modulated with a modulation index B by a difference audio signal $L(t)-R(t)$ to produce a phase-frequency modulated signal

$$\cos[W_c t + B(L(t)-R(t)) + A \cos W_o t],$$

and the phase frequency modulated signal being amplitude modulated with a modulation index M by a summation audio signal $R(t)+L(t)$, whereby the transmitted signal has an amplitude, phase and frequency defined by

$$[1 + M(L(t)+R(t))] \cos[W_c t + B(L(t)-R(t)) + A \cos W_o t].$$

2. A stereophonic radio broadcasting system in which a transmitter operating in the 550 KHz to 1,600 KHz range transmits a single RF carrier to at least one receiver, the carrier being frequency modulated by a low frequency signal identifying the transmission as a stereophonic transmission, the frequency modulated signal being linearly phase modulated by a difference audio signal $L(t)-R(t)$ obtained by subtractively combining signals derived from first and second audio sources, and the phase-frequency modulated signal being amplitude modulated by a second audio signal $L(t)+R(t)$ obtained by summing signals derived from the first and second audio sources, the broadcast signal having two sets of sidebands, the first set representing the summation signal and the second set representing the difference signal, each of the sideband sets being symmetrical with respect to the carrier.

3. A receiver for use in the broadcasting system of Claim 1 or Claim 2, the receiver comprising an amplitude detector for detecting the amplitude modulation of the broadcast signal, a phase detector for detecting variations in the phase of the broadcast signal, a frequency demodulator for detecting the identifying signal to provide an output indicating that a stereophonic transmission is being received, and means for combining the output of the phase detector with the output from the amplitude detector to reproduce the $L(t)$ and $R(t)$ signals.

4. A receiver according to Claim 3 further comprising a tuned amplifier circuit for receiving the broadcast signal; means for converting the broadcast signal to an intermediate frequency signal; an amplifier for amplifying the intermediate

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stereo broadcast and will also cause the stereo mono switch to connect the summation signal $L(t)+R(t)$ derived from the AM detector to the inputs of amplifiers 36 and 37.

Those skilled in the art will recognize other circuits for causing the receiver to switch from a stereophonic to a monophonic mode of operation. For instance, a matrix network may be used which receives a first input of $(L(t)+R(t))$ and a second input $(L(t)-R(t))$. As long as both inputs are receiving a signal, the matrix provides an output of $R(t)$ and $L(t)$. However, when the $L(t)-R(t)$ signal is zero, the matrix will provide two output signals of $L(t)+R(t)$.

Thus, there has been described with respect to both a transmitter and receiver a system for providing stereophonic AM broadcasts at low frequencies. The technique is fully compatible with standard AM broadcasts which are not stereophonic, and receivers now in existence which are strictly monophonic will receive the AM component of the transmitted stereo signal of this invention as before, and the additional channel will remain undetected. This compatibility, between the stereophonic broadcasts of this invention and the AM broadcasts of monophonic information currently in use will be appreciated by those skilled in the art.

The invention has been described in this embodiment with reference to a signal tone which is a five cycle sine wave which may be used to identify that a stereo transmission is being received. It will be appreciated that signal tone could be replaced by an information carrying signal at a very low frequency data rate. The information carrying signal could be used to transmit the call letters or some other information which would be received over a long time period thus in effect giving three channels of information rather than two as previously described.

WHAT WE CLAIM IS:—

1. A stereophonic radio broadcasting system in which a transmitter operating in the 550 KHz to 1,600 KHz range transmits a single RF carrier to at least one receiver, the carrier having a frequency of W_c and being frequency modulated with a low frequency signal identifying the transmission as a stereophonic transmission to produce a frequency modulated carrier $\cos(W_c t + A \cos W_o t)$ where W_o is the frequency and A is the amplitude of the identifying signal, the phase of the frequency modulated signal being linearly modulated with a modulation index B by a difference audio signal $L(t)-R(t)$ to produce a phase-frequency modulated signal

$$\cos[W_c t + B(L(t)-R(t)) + A \cos W_o t],$$

and the phase frequency modulated signal being amplitude modulated with a modulation index M by a summation audio signal $R(t)+L(t)$, whereby the transmitted signal has an amplitude, phase and frequency defined by

$$[1 + M(L(t)+R(t))] \cos[W_c t + B(L(t)-R(t)) + A \cos W_o t].$$

2. A stereophonic radio broadcasting system in which a transmitter operating in the 550 KHz to 1,600 KHz range transmits a single RF carrier to at least one receiver, the carrier being frequency modulated by a low frequency signal identifying the transmission as a stereophonic transmission, the frequency modulated signal being linearly phase modulated by a difference audio signal $L(t)-R(t)$ obtained by subtractively combining signals derived from first and second audio sources, and the phase-frequency modulated signal being amplitude modulated by a second audio signal $L(t)+R(t)$ obtained by summing signals derived from the first and second audio sources, the broadcast signal having two sets of sidebands, the first set representing the summation signal and the second set representing the difference signal, each of the sideband sets being symmetrical with respect to the carrier.

3. A receiver for use in the broadcasting system of Claim 1 or Claim 2, the receiver comprising an amplitude detector for detecting the amplitude modulation of the broadcast signal, a phase detector for detecting variations in the phase of the broadcast signal, a frequency demodulator for detecting the identifying signal to provide an output indicating that a stereophonic transmission is being received, and means for combining the output of the phase detector with the output from the amplitude detector to reproduce the $L(t)$ and $R(t)$ signals.

4. A receiver according to Claim 3 further comprising a tuned amplifier circuit for receiving the broadcast signal; means for converting the broadcast signal to an intermediate frequency signal; an amplifier for amplifying the intermediate



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frequency signal, the amplitude detector removing the summation audio signal from the intermediate frequency signal; limiter means for maintaining the amplitude of the intermediate frequency signal constant; the phase detector providing a signal in response to a change in phase of the limiter means output signal and having an output signal proportional to the difference audio signal; and means for maintaining the phase detector output signal at a fixed amplitude with respect to the amplitude detector output signal.

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5. A receiver according to Claim 4 further comprising means for amplifying the reproduction of the L(t) signal to drive an electroacoustical transducer.

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6. A receiver according to Claim 4 or Claim 5 further comprising means for amplifying the reproduction of the R(t) signal to drive an electroacoustical transducer.

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7. A receiver according to Claim 6 further comprising squelch means for detecting when the limiter is not providing an output signal, and means for supplying the summation audio signal to the means for amplifying the reproduction of the L(t) signal and to the means for amplifying the reproduction of the R(t) signal in response to the squelch means.

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8. A receiver according to Claim 3 wherein the phase detector compares the phase of a voltage controlled oscillator with the phase of the broadcast signal to detect the difference signal, a low pass filter also receives the phase detector output signal to supply a control voltage to the oscillator, and means for detecting the low frequency identifying signal detects the frequency modulation of the control voltage.

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9. A transmitter for use in the broadcasting system of Claim 1 or Claim 2, the transmitter comprising means for summing signals from first and second audio sources to form the summation audio signal $L(t)+R(t)$, means for subtracting the signals from the first and second audio sources to form the difference audio signal $L(t)-R(t)$, means for frequency modulating an RF carrier signal with a low frequency signal identifying the transmission as a stereophonic transmission, means for linearly phase modulating the frequency modulated carrier signal with the difference audio signal, and a double sideband full carrier modulator for amplitude modulating the phase-frequency modulated carrier signal with the summation audio signal.

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10. A transmitter according to Claim 9 in which the low frequency identifying signal is a 5 Hz signal and the carrier signal has a peak frequency deviation of substantially 20 Hz.

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11. A transmitter according to Claim 9 in which the low frequency identifying signal further comprises a data signal.

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12. A transmitter according to Claim 11 in which the data identifies a particular broadcasting station.

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13. A transmitter according to any one of the Claims 9 to 12 further comprising an oscillator for producing the carrier frequency signal, the oscillator having an input for receiving the low frequency modulating signal; a phase detector for comparing the phase of the carrier frequency oscillator with the frequency and phase of a further voltage controlled oscillator; a summation circuit for combining the difference audio signal with the phase detector output signal, and a filter connected to the summation circuit for providing a control voltage for the further voltage controlled oscillator whereby it produces a signal having a frequency proportional to the modulating signal applied to the carrier frequency oscillator and a phase proportional to the difference audio signal.

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14. A broadcasting system according to Claim 1 and substantially as herein described with reference to the accompanying drawings.

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15. A receiver according to Claim 3 and substantially as herein described with reference to the accompanying drawings.

16. A transmitter according to Claim 9 and substantially as herein described with reference to the accompanying drawings.

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