Dec. 4, 1962 W. S. PERCIVAL 3,067,287

STEREOPHONIC SOUND TRANSMISSION SYSTEMS

Filed June 16, 1958

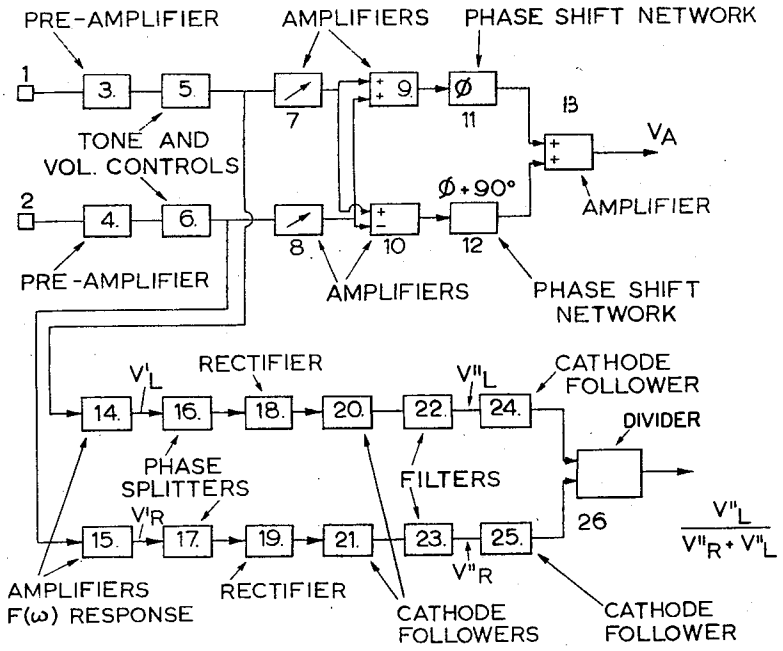

FIG. 1.

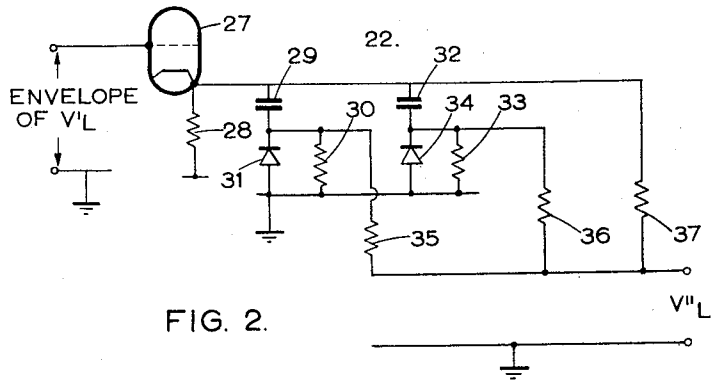

FIG. 2.

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United States Patent Office 3,067,287 Patented Dec. 4, 1962

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STEREOPHONIC SOUND TRANSMISSION SYSTEMS

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Filed June 16, 1958, Ser. No. 742,175
Claims priority, application Great Britain June 19, 1957
19 Claims. (Cl. 179—1)

This invention relates to stereophonic sound transmission systems.

A stereophonic sound transmission system has been proposed comprising means for deriving from sounds an audio frequency signal of relatively wide frequency range and representative of said sounds and a control signal representative of the directional or spatial significance of said sounds and such that said audio frequency signal in conjunction with said control signal can be employed to energise spaced sound reproducers to give stereophonic reproduction of said sounds. The two signals may be referred to as the sound signal and the control signal respectively and they may be recorded on a disc or magnetic tape record in separate tracks or in the same track but in separate frequency bands. They may also be recorded on a disc record in a single track by way of hill and dale recording and lateral recording in overlapping frequency bands, or by other complex cutting techniques. These signals may also be broadcast in a conventional radio transmission. At a reproducer or receiver the sound signal may be applied to two separate loudspeakers, or groups of loudspeakers, the gains of the channels leading to said loudspeakers being controlled differentially by the control signal to convey to a listener an impression of the relative positions of the sounds being produced.

In such a system it is desirable that the frequency band of the control signal should be small but that the stereophonic effect should be realistic, and capable of giving the impression of spaced sources sounding virtually simultaneously, without "pulling" of weak sounds by strong sounds, and the object of the present invention is to provide an improved system with a view to achieving these desirable results.

According to the present invention there is provided a stereophonic sound transmission system comprising means for deriving from sounds an audio frequency signal of relatively wide frequency range and representative of said sounds and a control signal representative of the direction or spatial significance of said sounds and such that said audio frequency signal in conjunction with said control signal can be employed to energise spaced sound reproducers to give stereophonic reproduction of said sounds, and wherein the means for deriving said control signal are arranged to emphasize signals corresponding to rapid variations in the amplitude of said sounds relative to slower variations in the amplitude thereof.

Rapid changes in the amplitude of the sounds are referred to as "transients." They correspond to transients in the envelope of the sound signals, as distinct from abrupt changes in the wave shape of the sound signals themselves and the invention is based on the observation by the inventor that the sense of directivity of sound waves is associated predominantly with transients. Moreover the sense of directivity appears to be associated especially with transients in high frequency tones, possibly because such transients tend usually to be steeper than transients in lower frequency tones. Experimental evidence suggests that the more rapid a transient the more clearly and acurately can the direction of the respective sound be determined. According to the invention therefore said means for deriving the control signal may be arranged to emphasize tones of high frequency relative to tones of low frequency.

Moreover rising transients appear to be more important

than falling transients, firstly because rapidly rising transients appear more often in music than falling transients and secondly because it has been found that the direction of the sound following rising transients is determined mainly by the apparent direction of the rising transients. The means for deriving said control signal may therefore be arranged to be substantially insensitive to falling transients.

In order that the present invention may be clearly understood and readily carried into effect, the invention will now be described with reference to the accompanying drawings, in which:

FIGURE 1 illustrates in block form, one example of a stereophonic sound transmission system according to the present invention, and

FIGURE 2 is a detailed view of part of FIGURE 1.

Referring to FIGURE 1, a pair of direction microphones 1 and 2, which may be disposed in a common housing, are arranged with their axes of maximum response mutually at right angles in a horizontal plane and each at approximately 45° to the medial plane of an area in which sounds are to be picked up from one or more sources. The signals derived from the microphones 1 and 2 will be considered as right and left signals respectively, denoted by V_L and V_R, and they are amplified respectively in pre-amplifiers 3 and 4 and applied thence to tone and volume control circuits 5 and 6. The signals V_L and V_R from the circuits 5 and 6 are applied respectively to further amplifiers 7 and 8 of adjustable gains and the outputs of the amplifiers 7 and 8 are then summed in an amplifier 9 and differenced in an amplifier 10 to form sum and difference signals V_L+V_R and V_L-V_R. The sum and difference signals are applied respectively to phase shift networks 11 and 12 designed to produce a relative delay of 90° between corresponding components of the respective signals over the full frequency range of the signals and the outputs of the phase shift networks 11 and 12 are then added in an amplifier 13 to produce a composite output signal denoted as V_A. The signal V_A is an audio frequency signal representative of the wave shape of the sounds picked up by the microphones 1 and 2 and is moreover of the form suitable not only for stereophonic reproduction when used in conjunction with the control signal about to be referred to, but also for monaural reproduction in conventional sound reproducer apparatus. An audio frequency signal representative of the sounds to be transmitted may however be formed in other ways, for example directly as the sum of the signals V_L and V_R, or from a separate microphone or microphones.

The signals V_L and V_R from the tone and volume control circuits 5 and 6 are also applied respectively to circuits 14 and 15 the responses of which rise substantially linearly with frequency. The circuits 14 and 15 may for example comprise amplifiers each of which has a gain substantially proportional to frequency. The circuits therefore emphasize tones of high frequency in the sounds picked up by the respective microphones 1 and 2 compared with tones of lower frequency, which has the effect inter alia of increasing the amplitude of transients in high frequency tones relative to those in lower frequency tones. The two output signals are denoted as V'_L and V'_R and they are applied respectively to phase splitting amplifiers 16 and 17 and thence, in push pull form, to rectifiers 18 and 19. The rectifiers 18 and 19 derive signals representing the envelope of V'_L and V'_R, and they may be full wave rectifiers, or "polyphase" rectifiers of the construction described in the specification of co-pending United States application Serial Number 689,431, filed Oct. 10, 1957. The rectifiers 18 and 19 may moreover be coupled by a spreader circuit in such a way as to exaggerate differences in the two envelope

signals, thereby to increase the apparent angular spread of the sources of sounds, which spread is represented by said differences. If such a spreader circuit is used, it may be of the construction described in the specification of co-pending United States application Serial No. 741,307, filed June 11, 1958. The output signals of the rectifiers 18 and 19 are applied by way of cathode followers 20 and 21 to filters 22 and 23 respectively which are arranged to emphasize transients in the sounds picked up by the microphones 1 and 2. The envelope signals after being subjected to transient emphasis, are denoted as V''_L and V''_R respectively, and they are applied by way of further cathode followers 24 and 25 to a dividing circuit 26 which is arranged to form a control signal representing $V''_L/(V''_R+V''_L)$. The construction of the dividing circuit may be as described in the first mentioned specification and for this reason will not be further described herein.

FIGURE 2 illustrates a preferred construction for one of the transient emphasizing filters, say the filter 22 of FIGURE 1. In this figure the valve 27 (which is only shown in part) and the resistor 28 constitute the cathode follower 20 and serve to apply the envelope of V'_L to the filter. The envelope of V'_L may have a cut off at, say, 100 c./s., and, having regard to the amplifiers 14 and 15 represents approximately the envelope of the derivative of V_L. The filter 22 comprises two high frequency emphasizing circuits connected in parallel, one consisting of the capacitor 29, resistor 30 and diode 31, and the other consisting of the capacitor 32, resistor 33 and diode 34. The outputs of these high frequency emphasizing circuits are combined via resistors 35 and 36 and they are also combined via a resistor 37 with a predetermined fraction of the original envelope signal set up at the cathode of the valve 27. The resultant of the three signals combined via the resistors 35, 36 and 37 forms the output of the filter 22 and constitutes the signal V''_L applied via the cathode follower 24 to the divider 26.

The capacitor 29 and resistor 30 operate virtually as a differentiating circuit and produce positive going pulses from rapid rising transients in the envelope signal appearing at the cathode of valve 27. The diode 31 removes the negative going pulses which would otherwise arise from rapid falling transients. The magnitudes of 29 and 30 are chosen to produce pulses with a time constant of say, 10 ms. The components 32, 33 and 34 also produce pulses in response to rising transients in the envelope signal and these components are dimensioned to produce longer pulses, say, as a time constant of 100 ms. The choice of the values of the resistors 35, 36 and 37 enables the three signals which contribute to the signal V''_L to be combined in predetermined ratio and this ratio is selected emperically to give the best results. In one practical case resistor 35 has the lowest value, resistor 36 has a higher value and resistor 37 has the highest value, and the effect of a positive square topped pulse in the envelope of V'_L is to give a large initial overswing in the signal V''_L, the latter signal then falling rapidly until the output of the capacitor 32 and resistor 33 becomes significant whereupon the rate of fall is reduced. The signal V''_L continues to fall however until the "D.C. component" provided by the resistor 37 is reached. It is found that good overall results may be obtained if transients in the sounds are emphasized by the order of 10 times as compared with the D.C. component.

The filter 23 has of course the same construction as the filter 22.

The effect of emphasizing high frequency tones and transients in the sounds picked up by the microphones 1 and 2 is to cause the control voltage eventually produced by the dividing circuit 26 to vary more rapidly and listening shows a substantial improvement of the stereophonic effect in many cases. In some cases however only the high frequency tones or only the transients may be emphasized, since it is found that substantial improvement can still be obtained even when only one type of emphasis is used. If however only one type of emphasis is used it is preferably transient emphasis.

It has been found however in some cases that the effect of very rapid changes of the control voltage on the loudspeakers of a reproducer may give rise to some distortion. This distortion maye be reduced by lengthening the pulses produced by the transient emphasizing filter whilst substantially preserving the leading edge of such pulses, with the aid of a pulse lengthening filter. Such a pulse lengthening filter has the main object of preventing the signal V''_L (or V''_R) from tending to zero between transients, whereby rapid changes of apparent position occur, mainly audible as distortion. It has been found for example that pulses produced by transient emphasis may be lengthened in duration by at least eight to twenty milliseconds without significantly impairing the stereophonic quality of reproduction. However in the absence of transient emphasis the control signal tends to have a relatively constant value for considerable periods corresponding to the general level of the sounds. It follows that the control voltage would, in the absence of the invention tend to give a relatively constant direction representing the approximate centre of the sounds. Hence, assuming that the sound sources are comprised in an orchestra the sound front appears considerably narrowed and serious pulling of weak sounds by strong sounds occurs. The present invention substantially reduces this tendency thereby increasing the width of the sound front and reducing pulling.

The arrangement illustrated may of course be modified in a variety of ways. For example in the filters 22 and 23 the components for emphasizing very rapid potential excursions, as compared with slower ones may be dispensed with, whilst still obtaining substantial widening of the sound front.

In another alternative arrangement, a fraction of the original envelope signal is retained as in FIGURE 2 to take account of slow variations in the respective envelope signal and in addition a further voltage is derived and added to this fraction of the envelope signal. This further voltage is obtained by passing the envelope signal through a high pass filter in order to boost the higher frequency components of the envelope signal. The output of the high pass filter is then rectified in a full wave rectifier or, preferably, in a polyphase rectifier as mentioned above. The output of this rectifier is smoothed, if necessary, to remove some of the ripple associated with the process of rectification, which smoothing may be performed by means of a pulse lengthening circuit. The further voltage obtained in this way differs from that obtained by the high frequency emphasizing circuits illustrated in FIGURE 2 in that transients in the envelope of V'_L (or V'_R as the case may be) are emphasized irrespective of their sense, that is emphasis is given to both rising and falling transients in the sounds.

As previously indicated, the audio signal VA and the control signal $V''_L/(V''_R+V''_L)$ may be recorded on a disc or other record or may be used to modulate a carrier wave for broadcast transmission. The reproducer for giving stereophonic sound reproduction may be of the construction described in the first mentioned complete specification. The invention is not however restricted to the form of the reproducer nor is it restricted to control signals having the specific composition indicated above.

What I claim is:

1. A stereophonic sound transmission system comprising means for deriving from sound an audio signal representing said sounds, means for deriving from the same sounds a control signal representing the direction or position of the source of said sounds, said latter means including transient emphasizing means for emphasizing signal components of said control signal corresponding to rapid variations in amplitude of said sounds relative to signal components corresponding to slower variations in

amplitude thereof, and means for transmitting said audio signal and control signal.

2. A system according to claim 1, said latter means further including frequency sensitive means for emphasizing signal components of said control signal corresponding to tones of high frequency in said sounds relative to signal components corresponding to tones of lower frequency therein.

3. A system according to claim 1, said transient emphasizing means including means for emphasizing signal components of said control signal corresponding to rapid increases in amplitude of said sounds relative to signal components corresponding to rapid decreases in amplitude of said sounds and relative to signal componets corresponding to slower variations in amplitude of said sounds.

4. A stereophonic sound transmission system comprising means for providing two audio signals representing sound and differing one from another in dependence upon the direction or position of the source of said sound, means for rectifying and filtering said audio signals to derive respective envelope signals confined to a relatively narrow range of low frequencies compared with said audio signals, transient emphasizing means for emphasizing transients in said envelope signals relative to other components thereof to derive modified envelope signals, means responsive to said modified envelope signals to derive a control signal representing the direction or position of the source of said sound, means for providing another audio signal representing said sound, and means for transmitting other audio signal and said control signal.

5. A system according to claim 4, said means for providing said first two audio signals comprises individual transducing means for deriving two initial signals from said sound which differ one from another in dependence upon the direction or position of the source of said sound and frequency sensitive means for emphasizing components of said initial audio signals corresponding to tones of high frequency relative to components corresponding to tones of lower frequency therein.

6. A system according to claim 4, said transient emphasizing means including a high frequency emphasizing circuit shunted by a unilaterally conductive device whose conductive direction is predetermined to render said transient emphasizing circuit more sensitive to rising transients than to falling transients.

7. A system according to claim 4, said transient emphasizing means comprising, for each envelope signal, two high frequency emphasizing circuits connected in parallel and having different time constants, and means for combining the outputs of said circuits in predetermined proportions to derive the respective modified envelope signal.

8. A system according to claim 4 said transient emphasizing means comprising, for each envelope signal, a high frequency emphasizing circuit and means for combining the output of said circuit in predetermined proportion with the respective envelope signal to derive said modified envelope signal.

9. A stereophonic sound transmission system comprising means for providing two audio signals representing sound and differing one from another in dependence upon the direction or position of the source of said sound, processing means for deriving respective modified signals from said audio signals, said processing means including transient emphasizing means for emphasizing signal components corresponding to rapid variation in the amplitude of said sound relative to signal components corresponding to slower variations in the amplitude thereof, means responsive to said modified signals to derive a control signal representing the direction position of the source or of said sound, means for providing another audio signal representing said sound, and means for transmitting said other audio signal and said control signal.

10. A system according to claim 9 wherein said processing means includes frequency sensitive means for emphasizing signal components corresponding to tones of high frequency in said sound relative to signal components corresponding to tones of lower frequency therein.

11. A system according to claim 10, said frequency sensitive means comprising circuits, one for each of said first two audio signals, having a response rising substantially linearly with frequency.

12. A system according to claim 9, said processing means comprising means for deriving respective envelope signals from said first two audio signals and means for emphasizing transients in said envelope signals relative to other components therein, thereby to emphasize said components corresponding to rapid variations in the amplitude of said sound relative to signal components corresponding to slower variations in the amplitude thereof.

13. A system according to claim 9, said processing means comprising means for deriving respective envelope signals from said first two audio signals, and means for emphasizing rising transients in said envelope signals relative to falling transients in said envelope signals and relative to other components in said envelope signals, thereby to emphasize signal components corresponding to rapid variations in the amplitude of said sound relative to signal components relative to slower variations in the amplitude thereof.

14. A system according to claim 12, said means for emphasizing transients comprising means for deriving derivatives of said envelope signals in which high frequency components in the envelope signals are emphasized to different extents relative to lower frequency components thereof, and means for combining said derivatives with the respective envelope signal in predetermined ratio.

15. A stereophonic sound transmission system comprising means for providing two audio signals representing sound and differing one from another in dependence upon the direction or position of the source of said sound, processing means for deriving respective modified signals from said audio signals, said processing means including frequency sensitive means for emphasizing signal components corresponding to tones of high frequency in said sound relative to signal components corresponding to tones of lower frequency therein, means responsive to said modified signals to derive a control signal representing the direction or position of the source of said sound, means for providing another audio signal representing said sound, and means for transmitting said other audio signal and said control signal.

16. A stereophonic sound transmission system comprising means for providing two audio signals representing sound and differing from one another in dependence upon the direction or position of the source of said sound, processing means for deriving respective modified signals from said audio signals, said processing means including means responsive to a sudden change in the respective audio signal from one amplitude to a greater amplitude for providing a pulse in the respective modified signal rising relatively rapidly to a peak level and thereafter falling more slowly to a lower level, means responsive to said modified signals for deriving a control signal representing the direction or position of the source of said sound, means for providing another audio signal representing said sound, and means for transmitting said other audio signal and said control signal.

17. A system according to claim 16 wherein said pulse deriving means includes means for arresting the fall of level of said pulse at a value corresponding to the instantaneous amplitude of the respective one of said first two audio signals.

18. A system according to claim 16, said means for deriving a control signal including means for deriving a signal being said control signal which is a function of the ratio of said modified signals.

19. A stereophonic sound transmission system comprising means for providing two audio signals representing sound and differing one from another in dependence upon the direction or position of the source of said sound, means for rectifying and filtering said audio signal to derive respective envelope signals confined to a relatively narrow range of low frequencies compared with said audio signals, transient emphasizing means for emphasizing transients in said envelope signals relative to other components thereof to derive modified envelope signals, means responsive to said modified envelope signals to derive a control signal which is a function of the ratio of said modified envelope signals and represents the direction or position of the source of said sound, means for providing another audio signal representing said sound, and means for transmitting said other audio signal and said control signal.

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