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THREE SPEAKER STEREOPHONIC AUDIO SYSTEM

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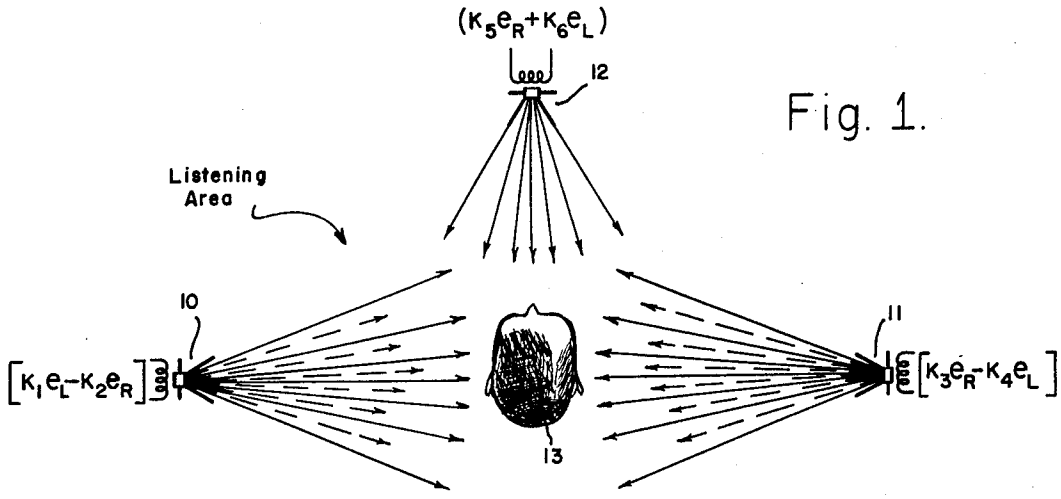

Fig. 1.

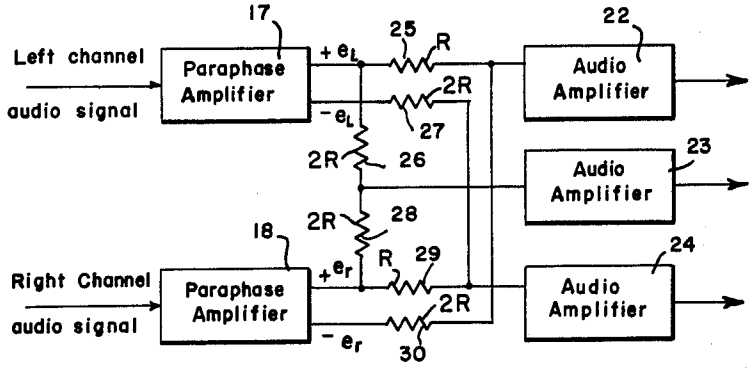

Fig. 3.

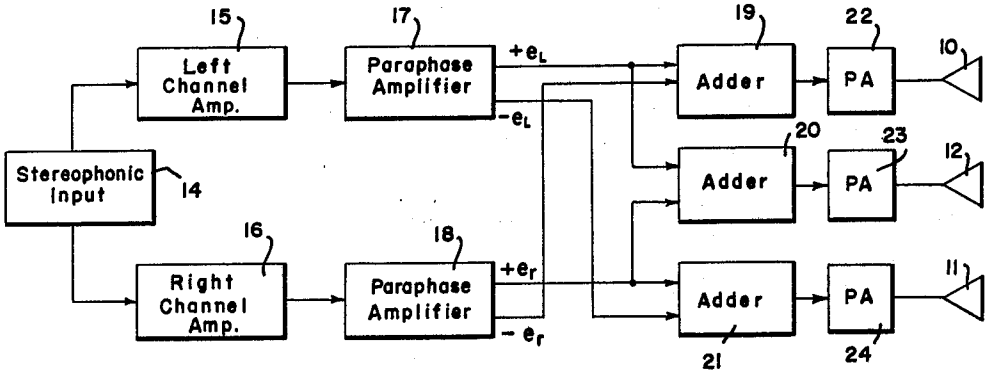

Fig. 2.

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THREE SPEAKER STEREOPHONIC AUDIO SYSTEM

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ABSTRACT OF THE DISCLOSURE

A stereophonic audio system is described using three speakers located in a triangular arrangement. Sound from two opposing speakers is directed into a listening area in such a manner that opposite phased identical signals are cancelled. Mixing of the signals feeding the speakers or mixing the sound in the listening area is possible. The third speaker directs sound derived equally from each of said opposing speakers into said listening area.

This invention relates to an audio transducing system arrangement and more particularly to a stereophonic system using at least three loud speakers in a preferred relationship that enhances the sound to a listener located in a defined listening area.

In this invention, at least two transducer system each having a frequency response and necessary cross over networks desired by the listener are located substantially opposite each other to define a listening area. The listener is located in the listening area between said pair of transducers that are preferably facing each other. A third transducer system having substantially the same characteristics as each of said other transducers is located facing said listening area from a remote location along a plane that is intermediate and preferably equi-distant of said first and second transducer system.

The problem solved by this invention is in the esoteric field of reproducing sound having the same realism as generated in the concert hall. High fidelity is of course desired and is a function of the individual components used and the matching of these components to each other. This invention is not concerned with any individual component for improving the high fidelity but rather in the location of the transducer systems and the combining of stereophonic signals to achieve a true realism not heretofore available. Improved fidelity is usually assured in any sound reproduction system whether it is monaural or stereophonic by using matched quality components.

The invention has primary usefulness in a stereophonic sound reproduction system in which two separate signals representing a left and right signal are produced. In the prior art, each signal is fed to a left and right audio transducer system respectively which do not face each other but rather face the listener. The loudspeakers are usually placed in front of the listener and are separated by 8 to 12 feet. Each loudspeaker reproduces only one signal; that is, a left signal for the left louspeaker and a right signal for the right loudspeaker. These prior art systems produce excellent stereo effects when separate earphones are used for the two ears, but fall short when loudspeakers ar used. It is believed that each ear actually hears sound coming from both loudspeakers which has the effect of degrading the system. The stereophonic effect is further reduced whenever the individual loudspeakers are spaced beyond 8 to 12 feet from each other as mentioned above. The sound seems to come from the vicinity of each loudspeaker which produces the effect known as a "hole in the middle." Many attempts have been made to fill this gap by using an extra loudspeaker between the regular loudspeakers also facing the listener and arranged

to receive portions of both the left and right signals. This practice does fill the void; however, the stereophonic effect is again degraded since the middle speaker is effectively adding a monaural sound.

The present invention is a stereophonic sound reproduction system using only two signals and at least three transducer systems arranged in the defined relationship to each other for reproducing a stereo effect that produces a seemingly or virtual wide angle sound source. The sound in the listening area seems to come from virtual sound sources distributed through a wide angle listening angle.

The defined right and left signals may be generated from stereo records or from a tuner having separate channels to develop a right and left signal. An algebraic combiner, such as a voltage adder, combines the right signal with an out-of-phase portion of the left signal and similarly combines the left signal with an out-of-phase portion of the right signal. The combined right signal is fed to one of the pair of opposed transducer system and the combined left signal to the other opposed transducer system. The claimed advantages for the defined system is believed to result in the cancellation of only opposite phased identical audio signals emanating from said pair of opposed transducer systems. The adder networks which may be combined or separate also feed a signal that is proportioned to the algebraic sum of the original left and right signals to the defined third transducer.

Further objects and advantages will be made more apparent by referring now to the accompanying drawings wherein:

FIGURE 1 is a pictorial representation illustrating the listening area as defined by the three transducers;

FIGURE 2 is a block diagram of the electrical connections for generating and feeding the combined signals to the three transducers; and

FIGURE 3 is a schematic diagram of a preferred adder network for combining the stereophonic signals.

The following drawings and description more fully disclose how the following invention improves the reproduction of stereophonic sound. Referring now to FIGURE 1, there is shown an arrangement for locating three audio transducers that enhances the stereophonic effect to more nearly approach the preferred binaural effect produced when two separate earphones are used. The usual left and right loudspeakers are replaced by loudspeakers **10**, **11**, and **12**, located in a preferred relationship. For example, loudspeakers **10** and **11** are located substantially opposite each other in such a manner that sound emanates from speaker **10** toward speaker **11** and conversely sound emanates from speaker **11** toward speaker **10**. In addition, loudspeakers **10** and **11** are spaced apart to thereby define a listening area. The third loudspeaker **12** is preferably located along a plane that is substantially intermediate a line drawn between loudspeakers **10** and **11** and in a position whereby the sound emanating from the loudspeaker **12** is directed towards the defined listening area.

A listener **13** is located in the defined listening area and is arranged to substantially face loudspeaker **12** with his left ear facing loudspeaker **10** and his right ear facing loudspeaker **11**. The electrical input signals being fed to each of the individual loudspeakers may be derived from a stereophonic source such as a magnetic tape, record, or live performance in which separate stereophonic signals, that is a separate left signal and a separate right signal, are generated. Each speaker is fed with a combined or mixed signal according to the teaching of this invention. For example, the left loudspeaker **10** is fed with a signal $[k_1e_l - k_2e_r]$ while the right loudspeaker is fed with a signal $[k_3e_r - k_4e_l]$ where k represents a proportionality factor which may be different for each loudspeaker and e_r and e_l represent the right and left stereo-

phonic signals respectively. The loudspeaker **12** is arranged to receive the combined signal $[k_5e_r+k_6e_l]$. With input signals as shown the listener hears the resulting sound field at each ear representing the combination of left and right signals fed to all the loudspeakers **10**, **11**, and **12**. The magnitude of the signals fed to each loudspeaker is adjusted to assure that the sound coming from the center, left, and right loudspeakers is not heard as individual sounds but rather as sounds that seem to come from a widely spread-apart sound source in front of the listener. Experiment has shown that the angular spread of the apparent sound source depends on the relative magnitudes of the signals fed to the center left and right loudspeakers. The relative magnitudes of the signals is a function of the values of k indicated above. Typical values of k that have produced the desired results vary from ⅔ to ¾.

Referring now to FIGURE 2, there is shown a block diagram comprising a stereophonic input **14** which may be a record, tape, or live hookup using a pair of microphones. Binaural outputs from the stereophonic input **14** are fed to a left channel amplifier **15** and a right channel amplifier **16**. The output from each channel amplifier is fed to a paraphase amplifier **17** and **18** respectively in order to arrive at the proper phase relationship between the individual output signals. The left and right signals are combined in adders **19**, **20**, and **21** to produce the proper combined signals for transmission to the individual speakers. For example, adder **19** combines a portion of the right signal with the left signal as follows: $[k_1e_l-k_2e_r]$; while adder **21** combines a portion of the left signal with the right signal as follows $[k_3e_r-k_4e_l]$; and adder **20** combines equal portions of the right and left signal as follows $[k_5e_r+k_6e_l]$. If required by the size of the system and the power required, the individual outputs from the adders **19**, **20**, and **21** are fed to power amplifiers **22**, **23**, and **24** respectively which in turn feed speakers **10**, **11**, and **12**.

Referring now to FIGURE 3, there is shown in more detail a purely resistive network for combining the signals as shown in FIGURES 1 and 2. The output lines from paraphase amplifier contain two lines identified as $+e_l$ and $-e_l$. The $+e_l$ line is connected through a resistor **25** having a resistance of R to the amplifier **22** and also through a resistor **26** having a resistance 2R to the amplifier **23**. The $-e_l$ line is connected through a resistor **27** having a resistance of 2R to amplifier **24**. In a similar manner, the output of paraphase amplifier **18** contains two leads identified as $+e_r$ and $-e_r$. The $+e_r$ lead is connected through a resistor **28** having a resistance of 2R to the junction of resistor **26** and the amplifier **23** and also through a resistor **29** having a resistance of R to the junction of resistor **27** and amplifier **24**. The $-e_r$ lead is connected through resistor **30** having a resistance of 2R to the junction of resistor **25** and amplifier **22**. A review of the resistor network will show that right amplifier **24** receives two times the amount of right signal as left signal. Similarly, left amplifier **22** receives two times the amount of left signal as right signal. The middle amplifier **23** receives equal amounts of right and left signals.

This completes the description of the embodiment illustrated herein. However, this invention is not limited to the particular details of construction, materials, and processes described as many equivalents will suggest themselves to those schooled in the art. For example, in certain combinations, it may be more desirable to combine the signals acoustically rather than electrically as shown. In addition, the combining of the signals may occur at any place or location in the amplifying chain. It is accordingly desired that the appended claims be given a broad interpretation commensurate with the scope of the invention within the art.

What is claimed is:

1. In combination,

at least three audio transducer systems located substantially in a triangle which thereby defines a listening area,

a stereophonic audio generating source for generating a right and left signal,

a combiner for combining said right signal with an out-of-phase portion of said left signal and said left signal with an out-of-phase portion of said right signal,

said combined right signal being fed to one of said transducer systems and said combined left signal being fed to a second one of said transducer systems,

and a second combiner for combining and feeding said right and left signals to said third transducer system in selected proportions.

2. A combination according to claim **1** in which equal portions of said right and left signals are fed to said third transducer system.

3. In combination,

a first, second, and third audio transducer system spaced apart from each other to thereby define a listening area,

said first and second transducer system located substantially opposite each other,

a stereophonic audio generating source for generating a right and a left signal,

a combining circuit for combining said right signal with an out-of-phase portion of said left signal and said left signal with an out-of-phase portion of said right signal,

said combined right signal being fed to said first transducing system and said combined left signal being fed to said second transducing system,

said third transducer system facing said listening area and located along a plane that is intermediate said first and second transducer systems,

and a second combining circuit for combining and feeding a signal that is proportional to the sum of said right and left signal.

4. A combination according to claim **2** in which said right signal is represented as e_r and said left signal is represented as e_l,

and said combined left signal fed to said left transducer system is $k_1e_l-k_2e_r$, said combined right signal fed to said right transducer system is $k_3e_r-k_4e_l$ where each k represents a proportionality factor and the combined signal fed to the third transducer system is $k_5e_r+k_6e_l$.

5. A combination according to claim **3** in which each of said three transducer systems are identical.

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