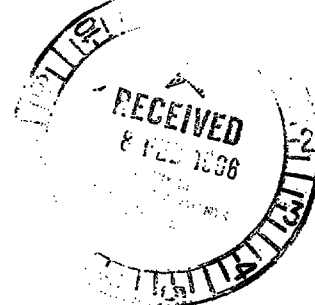


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STEREOPHONIC REPRODUCTION METHOD AND APPARATUS

FIELD OF THE INVENTION

TECHNICAL FIELD

This invention relates to the reproduction of stereophonic sound, and is more in particular directed to an improved method and apparatus enabling the stereophonic effect to more accurately represent the sound of the originating sound source, as well as increasing the area within which a listener can experience true stereophonic sound.

BACKGROUND ART

In order to enable a better understanding of the invention and the differences between the invention and known systems, a brief description of various known sound reproduction techniques will first be given, as follows:

BINAURAL SOUND - In this reproduction technique, sound is recorded with two microphones positioned to simulate the positions of ears of a human head, to thereby produce a plurality of signals. In order to preserve the binaural effect, during sound reproduction, the listener must wear a set of earphones that are spaced apart the same distance as the recording microphones. Both the amplitude and phase of the sound produced by the earphones are identical to the sound received by the recording microphones. This technique requires a closed circuit system and has the disadvantage that the listener must wear earphones.

MONAURAL SOUND - This sound reproduction technique is also a closed circuit technique, and is similar to the Binaural technique except that it uses only one recording channel. This technique is exemplified by conventional telephone systems.

MONOPHONIC SOUND - As in the case of Monaural sound, only one sound channel is provided in this technique. The system is not a closed system, however, and the reproduction device, however, is in the form of one or more loudspeakers, each of which is energized to emit sound corresponding to the signals on the single channel.

STEREOPHONIC SOUND - This technique employs two (or more) channels, corresponding to sound received directly by microphones at two (or more) spaced apart locations. The optimal stereo recording arrays are known as "ORTF" miking, coincidence miking, near coincidence miking, spaced miking, "SASS" miking and "AMBIPHONIC" miking.

By recording with these techniques, we can "capture" the sounds being recorded in a fashion that better approximates how we hear sounds, while keeping enough differentiating and complementary information.

Another trend of the recording industry, with what is known as a multi (mono) miking and multi (mono) track recording process, is to artificially "locate" the sound of different instruments and sampled sounds by using "panoramic positioners" on the mixers used to feed a two track recording unit. The recording industry calls this a stereo technique, when in effect it should be distinguished as multi track directed mono recordings.

For optimum reproduction, the signals energize separate loudspeakers located at spaced geometrical positions ideally corresponding to the locations of the respective recording microphones' pickup arrays. In this technique, as well as in monophonic sound techniques, the acoustics of the recording location and reproducing location both influence the sound that the user hears, with the result that the sound that is heard even if it should be ideally the same, is not the same as the sound originating from the recorded sound source. Typically about 90% of the sound that is heard in the

environment in which the recording was made is reflected sound.

Due to these reflections, the direct musical waves (approximately 10%) give the precision of localization of the origins of the sound of the instruments (e.g. flutes, violins and percussion) while the reflected sounds (approximately 90%) give the ambience of the hall, the depth perception of the soundstage and the richness of the musical experience. The musical emotional experience that a listener, who is in the environment in which the recording was done, has, is due to a complex combination of these reflections of musical information. These are what allow the listener to perceive his environment.

Now remember that the goal of high fidelity is to recreate the musical experience of being present at a concert (regardless of the type of music; jazz, classical, blues, etc.). The only way to accomplish this is to render all the possible sonic information to the brain by the tools that are our ears via a sound reproduction system and also, by consequence, via the most appropriately capable recording processes and techniques.

Assuming that the recordings to be reproduced are capable of "capturing" all the information to be reproduced, and that the more the sound reproduction system is neutral, realistically dynamic and capable of rendering proper transience (including the loudspeakers), the better it should be able to give the basic information that is essential to determine the spacial localization, i.e. the depth and width of the sound stage and even its height. (Our ears/brain combination is indeed capable of indicating if a sound comes from above or below and also what height it originates from. However, it would be trivial to continue at this point on this subject, since it is not relevant to the ability of the present invention to allow the listeners to perceive the

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information required to locate and hear sounds on the height plane as well.)

What exactly is the effect produced by the sum of this vital information? With his eyes closed, the listener who is relaxed and attentive should see himself "brought" to the location of the recording.

The problem is that both loudspeakers send (ideally with a great neutrality and quality) some complementary information in a less than complementary fashion.

The information sent by each loudspeaker has to be interdependent, at least from a listener's point of view, in order to recreate the spacial coherence and a realistic musical experience.

One type of conventional stereophonic system employs two positioned identical loudspeakers that are energized to provide sound pressure and phase along the plane of symmetry between the two speakers that is the same as at the location of the microphones that were used to record the signal. The plane of symmetry is the central plane that is perpendicular to the line joining the two speakers. In such systems, when the user is not located at the plane of symmetry, the fundamental information is out of phase since the listener is not at a position that is equidistant from the two speakers, and the stereophonic effect is thereby absent.

The fundamental shortcomings of the current trends are the modification of the sounds and the vital micro-information (which are in the harmonic domain) because of the reflection of these on the walls, ceiling, furniture and other objects before their arrival to the ears of the listener. Also, these loudspeakers send the fundamental information out of phase one relative to the other, because the listener is practically never equidistant to the speakers and also because of the reflections of sonic information on all the elements that are in his or her environment.

The result can be a beautiful sound, yes, but not yet recreating, unfortunately, in any way the musical experience perceived by this same listener as if he is situated at the recording location. The goal of high fidelity is therefore not yet achieved.

A good analogy is as follows: the colors are nicely distorted and over and/or undersaturated (depending on the observing point of view and the sampled part of a broad color spectrum) and the image is grossly out of focus and proportion.

Here, we must understand that the human ear locates the point of origin of the sounds that it receives, thanks to the stereophonic perception of our two ears combined together. A sound generated from point "x" (see Fig. 1A) will be perceived simultaneously by the two ears of listener "y". If the point "x" is located right ahead of him, the brain will not register a difference in time perception between the right ear and the left ear because the sound arrives at the same time to both ears. Thanks to this the brain knows that the sound comes from ahead. For sounds coming from the back, there is a difference of perception that the brain is capable of noticing. This difference is due mostly to the shape of the ears that reflect, in a complex manner, the sounds before sending them in towards the tympanies. If, on the other hand, the point "x" is situated on a radius of two o'clock relative to the positioning of "y" (see Fig. 1B) the sound that hits the left ear arrives with a slight delay compared with the sound that the right ear perceives. This is due to the fact that sound travels at about 345 meters per second. The delay is only a few milliseconds. Yet this is enough for the brain to notice the difference and after a fast, automatic subconscious calculation it can determine from where the sound comes. All this is done and noticed thanks to the relative

difference in arrival times of the sounds perceived by the right and left ears.

(There are other factors involved in our sonic spacial perceptual abilities. They are related to the "pitch" ("Doppler effect" domain) and "timbre" domain as well as the amplitude domain.)

In conventional stereophonic systems, the left and right reproducing speakers are energized to produce sound waves of the relative same phase as the sound waves recorded by the left and right recording microphones, respectively, in order for the sound produced at the plane of symmetry to duplicate the recorded sound. Application of the signals to the reproducing speakers with phases that are off axis, relative to the phases of the original signals, will not fully simulate the original sound, and hence will not result in faithful reproduction of the recorded sound, even assuming the absence of reflections at the reproduction site.

An example of a conventional system of this type is illustrated in Fig. 1, wherein left and right speakers 10, 11 are spaced apart a distance that preferably represents the distance between the microphones employed to originally record the sound. The speakers 10, 11 are oriented with their major axes parallel to one another, and are energized by the left and right output signals of a conventional stereo amplifier 12. The line 13 in this figure is perpendicular to and centrally intersects a line extending directly between the tips of the cones of the speakers, the line 13 thereby simulates the plane of symmetry of the two speakers. Since every point on the line 13 is equidistant from the two speakers, the temporal relationship of the direct sounds from the two speakers at that point simulates the temporal (as well as the amplitude) relationship of the sound as received by microphones employed to originally record the sound. This temporal relationship is lost, however, at points displaced

from the line 13, the divergence from the relationship increasing as the distance from the line 13 increases. It should also be reiterated that in terms of micro-information, there are practically no "sweet spots". This translates into a major shortcoming of currently accepted stereo reproduction/perception and other compromising notions. In systems of this type, the axes of the speakers may alternatively be directed at equal acute angles to the line 13, but such orientation does not generally affect the temporal relationships between sound as above discussed.

In the past, speakers have been positioned at locations that did not simulate the geometry of the recording microphones. For example, U. S. Patent No. 4,673,057 discloses a system having an assemblage of speakers arranged on each of the faces of a polyhedron, to emit sound in a direction perpendicular to the respective faces, with speakers on one side of an equatorial plane of the polyhedron being energized with the right stereophonic signals and all of the speakers on the other side of the equatorial plane being energized with the left stereophonic signals. The sound pattern produced by such a large number of speakers is very complex, and due to the physical size of the polyhedron, the sound emitted from the opposite sides of the polyhedron simulates sound from a plurality of spaced apart sources. The phase and timing of the sound generated by the speakers hence is quite different than the sound received by the recording microphones.

In one embodiment of the present invention, a sound reproduction system is provided that employs a pair of identical speakers that are mounted "back-to-back". Such a physical arrangement of loudspeakers has been disclosed, for example in U. S. Patent Nos. 4,268,719 and 4,585,090, only for monophonic systems. U. S. Patent No. 4,016,953 discloses a system employing a pair of speakers directed toward one

another, and energized with identical signals of opposite polarity, in order to provide a push-pull effect for monophonic signals.

DISCLOSURE OF INVENTION

The invention is directed to the provision of a method and apparatus for the reproduction of stereophonic sound, wherein:

1. The stereophonic effect is not limited to the plane of symmetry of a pair of speakers, but is clearly apparent in a region that is substantially independent of the location of a listener.

2. The effects of the acoustics of a sound reproduction room may be cancelled in a simple manner, so that the sound heard by a listener can accurately represent the sound that was recorded.

The invention is thus directed to a method and apparatus of phase coherent sonic transmission embodied as a single loudspeaker transmission system. This single complementary transmission system allows the transmission of the left and right channel complementary musical information in a phase coherent and time aligned fashion in order to allow the listeners, regardless of their positions in a listening room, to perceive the music in 4D lifelike fashion.

With the present invention, the right and left complementary sonic information (that is required to be perceived in a time aligned fashion by the listener in order to reconstruct a proper sound stage) is transmitted from the same point source, from a one and only loudspeaker assembly needed to do so. This means that the right and left music signals travel to the listener in a practically parallel and time aligned pattern. This allows the listener to sit or

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stand wherever he or she wants to in the listening room (with the exception of the 4D generating field zone) and perceive the whole sound stage much more accurately than with a normal loudspeaker array.

The basic benefit of this system is that the one loudspeaker then needed will seem to disappear to the listener while leaving the musical experience of being right where the music was originally recorded. The music will appear and be felt as "live", a definitively more natural experience when listening to music.

Briefly stated, in accordance with the invention, a sound system includes a point source transmission system. First and second complementary monophonic signals, such as left and right complementary monophonic signals, are applied to the transducers in a complementary manner, to result in the temporal alignment and phase coherence of the sound generated by the two complementary signals. The emitted sound produces an interference pattern. It has been found that the brain of the listener is responsive to such a sound pattern in a manner that the listener experiences stereophonic hearing in a region that surrounds the transducer, i.e. not just a region in the vicinity of a plane of symmetry as in known systems.

The transducer may be formed of a pair of speakers mounted back to back, to separately receive the two different mono signals in a complementary manner. When the transmission system is formed of more than one electromagnetic transducer, as in this case, the spacing between the effective points of emission of the two complementary interacting transducers, must be no greater than a critical value. When the transducers are of the cone type, the effective points of emission are considered to be the apices of the transducers' cones (usually near the "spider" suspension).

The invention is also directed to the provision of an improved microphone system for the production of

stereophonic signals. The improved microphone system includes a pair of microphone transducers mounted so that the apogees of the respective field of polar response patterns substantially face at 180° to one another. The microphones together are effectively located at a single point, i.e. they are spaced, either physically or by simulation, so that their spacing is (ideally) not greater than the equivalent to the wavelengths of the frequency range of the transducers.

In further embodiments of the invention, since the sound emitting transducers are effectively point source emitters, it is feasible to provide a sound cancellation system to cancel the acoustic trace signature of the room in which the emitters are located. In addition, the phase, amplitude and/or timing of the signals applied to the complementary transducer may be varied in order to "move" the apparent source of the sound.

BRIEF DESCRIPTION OF DRAWINGS

In order that the invention may be more clearly understood, it will now be disclosed in greater detail with reference to the accompanying drawings, wherein:

Fig. 1 is a simplified sketch illustrating a conventional stereophonic reproduction system;

Figs. 1A and 1B illustrate the reception of sound by a listener at two different positions, in a conventional stereophonic reproduction system;

Fig. 2 is a simplified sketch of an ideal system in accordance with the invention;

Fig. 3 is a sketch illustrating the independence of the location of the listener, in a 4D system in accordance with the invention;

Fig. 4 is an illustration of a two complementary transducer system in accordance with the invention;

Fig. 5 illustrates the time alignment of a two complementary transducer system in accordance with the invention;

Fig. 6 illustrates a critical dimension of a two complementary transducer system in accordance with the invention;

Fig. 7 illustrates a critical dimension of multiple complementary transducers in accordance with the invention, employing a pair of tweeters;

Figs. 8 and 9 are front and side views, respectively, of one complementary transducer arrangement in accordance with the invention;

Figs. 10 and 11 are front and side views, respectively, of another complementary transducer arrangement in accordance with the invention;

Figs. 12 and 13 are front and side views, respectively, of still another complementary transducer arrangement in accordance with the invention;

Fig. 14 is a perspective view of a further arrangement of complementary transducers in accordance with the invention;

Figs. 15 and 16 are front and side views, respectively, of one embodiment of a complementary microphone transducer in accordance with the invention;

Figs. 17 and 18 are front and side views, respectively, of another embodiment of a complementary microphone transducer in accordance with the invention;

Figs. 19 and 20 are front and side views, respectively, of still another embodiment of a complementary microphone transducer in accordance with the invention; and

Fig. 21 is a block diagram of a sound cancellation system in accordance with the invention.

MODES FOR CARRYING OUT THE INVENTION

In the following disclosure, the term "4D" will be employed with reference to the present invention since the invention is based upon the principle of maintaining absolute integrity of reproduction of sound in the four domains of width, height, depth and time, to achieve operation in a controlled fourth dimensional audio temporal and spacial aligned domain.

In accordance with one aspect of the present invention, a stereophonic reproduction system is provided wherein conventional "left" and "right" stereophonic signals are employed to produce sound in a manner that simulates generation of the sound at a "point source transducer", in such a manner that the sound generation resulting from the left and right signals is complementary. The term "complementary", as used herein, refers to the condition in which the two signals energize the complementary transducers to reinforce any common components of sound in the two signals, in substantially every direction of transmission from the transducer, whereby the different phase components of the sound resulting from the two signals is synchronized.

Fig. 2 is a simplified illustration of an ideal system in accordance with the invention. In this arrangement, a "point source transducer" 20 is energized in a complementary manner with the left and right stereo signals from the amplifier 12. It is apparent that every point in the space surrounding the transducer 20 is equidistant from the points at which each of the left and right sound signals is generated.

In a system of the type illustrated in Fig. 2, it has been found that the sound generated by the two signals results in the production of an interference pattern, creating a sound hologram, which results from the time coherence of the

complementary information of both channels and the coherence of the two signals. It has further been surprisingly found that this information of the two signals is transmitted effectively in parallel with time alignment to each position surrounding the source 20, such as to the listeners 24, in Fig. 3, at various distances and directions from the transducer 20, such that the listeners mental processes derive the time and phase information to fully experience the stereophonic effect of the signals. Disregarding the effect of acoustics of the reproduction space, the system of the invention thereby aurally simulates binaural sound without the disadvantage of requiring the use of earphones by the listener, since the 4D recreated sound stage coherence effect that is produced is independent of the position of the listener in the sound field of the transducer.

As above discussed, the two most important criteria of a system and method in accordance with the invention, are that the transducer arrangement simulates, as closely as possible, a point source from which sound corresponding to both of the signals is emitted, and that the complementary transducers are energized by the two complementary channels' signals in a complementary manner. The stereophonic amplifier, as well as the stereophonic signals, may themselves be conventional.

In accordance with one embodiment of the invention, the point source transmission system may be comprised of a pair of identical speakers 30, 31, mounted back to back, as closely as possible, as illustrated in Fig. 4. As above discussed, the speakers are energized from the stereo amplifier 12 in a complementary manner, i.e., such that common components of the sound, from the two signals, reinforce one another in the combined sound pattern. The effective sound patterns from the speakers is illustrated in Fig. 5, wherein equal diameter circles 30', 31' are illustrated centered at

the apexes of the cones of these two speakers. The small distance between the two circles depicts the time difference between the arrival of sound from the two speakers, at the respective locations. A small arcuate region 34 adjacent the plane of symmetry of the speakers represents a cross talk zone that can be minimized by mounting the speakers as close together as possible.

Fig. 6 illustrates a two speaker system of the above described type, wherein the dimension A represents the distance between the apexes of the cones of the two speakers, i.e. the effective distance between the point sources of sound of the two speakers. In this speaker system the speakers are each connected to reproduce the full range of frequencies of the signals output by the amplifier. It has been found that, for effective stereophonic reproduction of sound in accordance with the invention, the distance A must be no greater than the equivalent wavelength of the highest frequency to be reproduced by the respective speakers. The speaker assembly thus comprises a point source of sound. Greater distances than this result in noticeable degradation of the 4D recreated sound stage coherence effect experienced by the listener. This frequency limitation can be expected to be about 9.5 KHz in conventional speakers.

While, in the above discussed arrangement of two speakers, the speakers have a common axis and emit sound in directions away from one another along the same axis, if the above frequency limitation is maintained they may be arranged to emit sound toward one another. In addition, the axes of the two speakers may be at an angle to one another, for example at 45° again if the above frequency limitation is maintained. An angular relationship between the axes of the speakers facilitates the cancellation of the acoustic trace signature of the listening room, as will be discussed.

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In some speaker systems, in addition to low range speakers 30, 31, tweeters 36, 37 are also provided, as illustrated in Fig. 7. In this type of system, since the distance B between the effective sound source of the tweeters is less than the distance A of the low range speakers, the distance B must be no greater than the equivalent wavelength of the highest frequency to be reproduced. The frequency limitations (in the 4D domain), which are imposed by the traditional design of conventional tweeters, is (depending upon the actual tweeter transducers utilized) about (give or take a few KHz) 12 kHz. The narrower the gap between the point source of both complementary tweeter transducers, in order to achieve the benefits of the present invention, the better the results. This also will translate in a reduction of upper frequency limitations of the invention.

When two speakers are employed to simulate a single point source transducer, the further condition is present, in accordance with the invention, that the "point sources" of the two speakers must be matched to be within the physical distance equivalent wavelengths of the frequency range of the speakers. Thus, if the speakers designed to produce sound up to about 10 kHz, with a wavelength of about 1.3 inches, the distance between the apexes of the cones of the speakers must be no greater than about 1.3 inches.

The invention is not limited to the use of two or more complementary transducers, as discussed above, in the provision of a point source transmission system, and other devices and arrangements may be alternatively employed for this purpose. It is necessary, however, that the transmission system simulate a complementary point source transmission within the above discussed constraints, in order to generate a complementary interference pattern for the listener that his or her brain can interpret to enable the listener to experience the 4D recreated sound stage coherence effect

during listening. Thus, for example, a signal processor can be programmed to provide a phase and/or time corrector circuit that simulates a point source of left and right channel information, even if the complementary transducers are spaced at a greater distance than as above discussed.

The complexity of the pattern emitted from a 4D transmission system in accordance with the invention is not sufficiently great that effects of reflection of the sound that is produced cannot be electronically cancelled without great difficulty.

When a plurality of complementary transducers are employed, to cover different frequency ranges, they may be mounted in various arrangements. For example, Figs. 8 and 9 depict the side and front view of a "Dappolito" arrangement having a high frequency complementary transducer 50 mounted on top of a lower frequency complementary transducer 51, and another low complementary transducer 52 mounted on top of the high frequency unit 50. Figs. 10 and 11 illustrate the side and front view of a "three voice" arrangement wherein a high frequency complementary transducer 60 is mounted on a mid frequency complementary transducer 61, which is in turn mounted on top of a low frequency unit 62.

In a still further arrangement, Figs. 12 and 13 illustrate the side and front views of a two voice arrangement wherein a high frequency complementary transducer 65 is mounted on top of a low frequency complementary transducer 66. In a still further arrangement, as illustrated in Fig. 14, a high frequency complementary transducer 70 is mounted on a separate stand 71, adjacent a low frequency complementary transducer 72. This latter embodiment illustrates that, when the different complementary transducers primarily emit sound in different frequency ranges, some tolerance may be permitted in the spacing of the complementary transducers without interfering with the quality of the sound.

While, as above discussed, the complementary transducer reproduction system provides greatly improved high fidelity 4D characteristics independent of the location of the user, even with conventional stereophonic signals, the results can be still further improved by recording the original signals in accordance with a further embodiment of the invention. In the 4D domain, all the aural information must be recorded and codified in a temporal and spacial complementary configuration. In order to "capture" all of the vital complementary information relating to the 4D domain, it has been found desirable to put together, as close as possible, an axially aligned pair of complementary microphone transducers. These transducers should have the apogee of their respective fields of polar (plot) response patterns facing precisely at 180° to one another.

There are, however, alternate transducer configurations that are acceptable, including some where the transducers are not positioned in such a way as to have the apogee of their respective fields of polar (plot) response patterns precisely at 180° to one another, provided that it is ensured that the transducers are within the confines of the critical 4D boundaries, in accordance with the following two requirements:

1. Whatever type of microphone transducer is being used, they must be arranged in such a manner that their left and right channel "point sources" are matched within the physical distance equivalent to the wavelengths of the frequency range of the transducers that are used.

2. Alternatively, if a "phase and/or time" corrector circuit, processor or unit is provided that can permit the simulation of a point source of the left and right channel information in a 4D fashion, even if the transducers for the two channels are spaced apart a distance greater than

specified in the first condition, the simulation must meet the first requirement as above discussed.

Figs. 15 and 16 are front and side views, respectively of one embodiment of a complementary microphone transducer system of the invention, wherein a pair of microphone capsules 80 are mounted at the centers of opposite sides of a separation/boundary disk 81. The separation boundary disk 81 has a size and shape determined by the required optimization of the system, using the specific microphone capsules. This disk is thus of a size and shape to prevent each microphone from receiving sound originating at the opposite side of the disk, insofar as possible. The disk is preferably of a material that has a minimum sound reflection.

In addition, a "distinction padder" 82 is affixed to each side of the disk 81. These padders are selected to have a size and shape, and reflectivity characteristic, to optimize the recorded sound fidelity. For example, these padders may be of a conventional sound absorbing material, and of a size and shape to minimize reception of sound from undesired directions.

In the modified complementary microphone transducer arrangement of Figs. 17 and 18, a PZM microphone 85 is provided on each side of the disk 81, and in the modified microphone transducer arrangement of Figs. 19 and 20, a ribbon microphone 86 is provided on each side of the disk 81.

Since, as above discussed, the complementary reproduction sound transducers are essentially point sources, the present invention permits the cancellation of sound reflections in a listening room, in order to enable the higher fidelity reproduction of the sound that was actually heard when the sound was recorded. For example, as illustrated in Fig. 21, a complementary transducer 90 is positioned in a listening room and energized with the left and right output

signals of a stereo signal source 91, as discussed above. In addition, a point source microphone 92 is located adjacent the complementary transducer 90, to receive sound from the entire listening room. This received sound is applied to a signal processor 94, which subtracts therefrom signals corresponding to the left and right signals originating at the stereo amplifier, in order to avoid interference of the cancellation signal with the desired interference signal. The resultant signal is inverted in the processor and output to the stereo amplifier for application to both the left and right sides of the complementary transducer 90. As a result, the effect of reflections, etc., of the listening room are cancelled. It is of course apparent that more sophisticated arrangements may be alternatively employed in order to improve the sound cancellation effect, i.e. to remove the acoustic trace signature of the listening room.

In a still further embodiment of the invention, it is apparent that the relative phase, amplitude and delay of the stereophonic signals may be controlled in order to "move" sound around listeners, regardless of their listening position. Thus, the source of complementary stereophonic signals may include a processing arrangement to control the phase, amplitude and delay of the respective signals for this purpose.

While the invention has been disclosed and described with reference to a limited number of embodiments, it will be apparent that variations and modifications may be made therein, and it is therefor the aim of the present invention to cover each such variation and modification as falls within the true spirit and scope of the invention.

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WHAT IS CLAIMED IS:

1. A sound system comprising point source transducer means, a source of first and second different stereophonic signals, means applying said first and second stereophonic signals to said transducer means to actuate said transducer means to emit sound corresponding to said first and second signals, said means for applying signals to said transducer means comprising means for energizing said transducer means with complementary left and right stereophonic signals.

2. The sound system of claim 1 wherein said point source transducer means comprises first and second transducers mounted back to back, said means for applying signals to said transducer means comprising means for applying said first signals to said first transducer and means for applying said second signals to said second transducer.

3. The sound system of claim 2 wherein said first and second transducers are mounted with their effective point sources of sound spaced a distance less than the effective wavelength of the maximum frequency of said signals.

4. The sound system of claim 3 wherein said transducers have cones, and said effective point sources are the apices of said cones.

5. The sound system of claim 1 wherein said transducer means is arranged to transmit sound along a single axis.

6. A sound system comprising point source transducer means, means for energizing said transducer with first and second stereophonic signals to actuate said





transducer means to emit temporally aligned and phase coherent sound corresponding to said first and second signals.

7. The sound system of claim 6 wherein said point source transducer means comprises first and second transducers mounted back to back on a common axis, and means for separately applying said first and second signals to said first and second transducers, said transducers having effective sound emission points, the effective sound emission points of said transducers being spaced a distance that is no greater than the effective wavelength of the highest frequency of said first and second signals.

8. The sound system of claim 1 wherein said point source transducer means comprises first and second spaced reproduction transducer means for emitting sound at different frequencies, and said means for applying signals comprises means for energizing each of said first and second reproduction transducer means with said complementary left and right stereophonic signals.

9. A method for reproducing stereophonic sound corresponding to first and second stereophonic signals comprising energizing a point source electromechanical transducer with said first stereophonic signals, and energizing said transducer with said second stereophonic signal in a manner complementary to said first stereophonic signal.

10. The method of claim 9 wherein said step of energizing a transducer with a first signal comprises energizing a first transducer with said first signal, and said means for energizing a transducer with a second signal comprises means for energizing a second transducer mounted back to back with said first transducer.

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11. A microphone system for producing stereo signals comprising first and second axially aligned microphone transducers mounted with the apogees of their respective fields of polar response patterns facing substantially at 180° to one another.

12. The microphone system of claim 11 wherein said microphones are spaced apart a distance no greater than the physical distance equivalent to the wavelengths of the frequency range of said microphone transducers.

13. The microphone system of claim 12 further comprising a separation/boundary disk between said microphone transducers for separating sound directed to said first and second microphone transducers.

14. The microphone system of claim 13 further comprising distinction padder means on both sides of said disk for modifying the pattern of sound applied to said microphone transducers.

15. The microphone system of claim 11 wherein said first and second transducers are microphone capsules.

16. The microphone system of claim 11 wherein said first and second transducers are PZM microphones.

17. The microphone system of claim 11 wherein said first and second transducers are ribbon microphones.

18. A sound system for reproducing sound signals, comprising a point source sound emitter, means applying sound signals to said point source sound emitter, means for receiving sound from a region surrounding said sound emitter,

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means for deriving cancellation signals from said received sound, and means for applying said cancellation signals to said sound emitter for cancelling the acoustic trace signature of said region.

19. The sound system of claim 18 wherein said point source sound emitter comprises a complementary transducer, and said means applying signals to said complementary transducer comprises means applying left and right stereophonic signals to said transducer.

20. A sound system comprising a source of first and second different stereophonic signals, transducer means, and means for applying said first and second stereophonic signals to said transducer means to actuate said transducer means to emit sound effectively originating at a point source.

21. The sound system of claim 20 wherein said source of first and second stereophonic signals comprises a source of complementary left and right stereophonic signals.

22. The sound system of claim 21 wherein said transducer means comprises a point source transducer means.

23. The sound system of claim 20 wherein said means for applying said first and second stereophonic signals to said transducer means comprises means for modifying said signals to shift the effective location of emanation of sound corresponding thereto.

24. The sound system of claim 23 wherein said means for modifying said signals comprises means for shifting the effective location of emanation of sound corresponding thereto to said point source.

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25. A method for recording sound to produce first and second stereophonic signals, comprising arranging first and second microphone transducers with the apogees of their respective fields of polar response patterns of the first and second transducers facing substantially at 180° to one another, and recording sound with said transducers so positioned.

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ABSTRACT OF THE DISCLOSURE

A method and apparatus for stereophonic reproduction uses conventional left and right stereophonic signals to energize a point source transducer in a complementary manner. The resultant interference sound pattern is interpreted by the brain of a listener to enable the listener to experience stereophonic hearing in a wide region surrounding the transducer, not just in the region of the plane of symmetry. A point source transducer may be simulated by a plurality of transducers positioned with the spacing therebetween less than a determinable maximum distance. While conventional stereophonic signals may be employed in the reproduction of sound, improved reproduction is obtained by producing the signals by recording sound with a pair of microphones arranged with the apogees of their respective field of polar response patterns facing substantially at 180° to one another.

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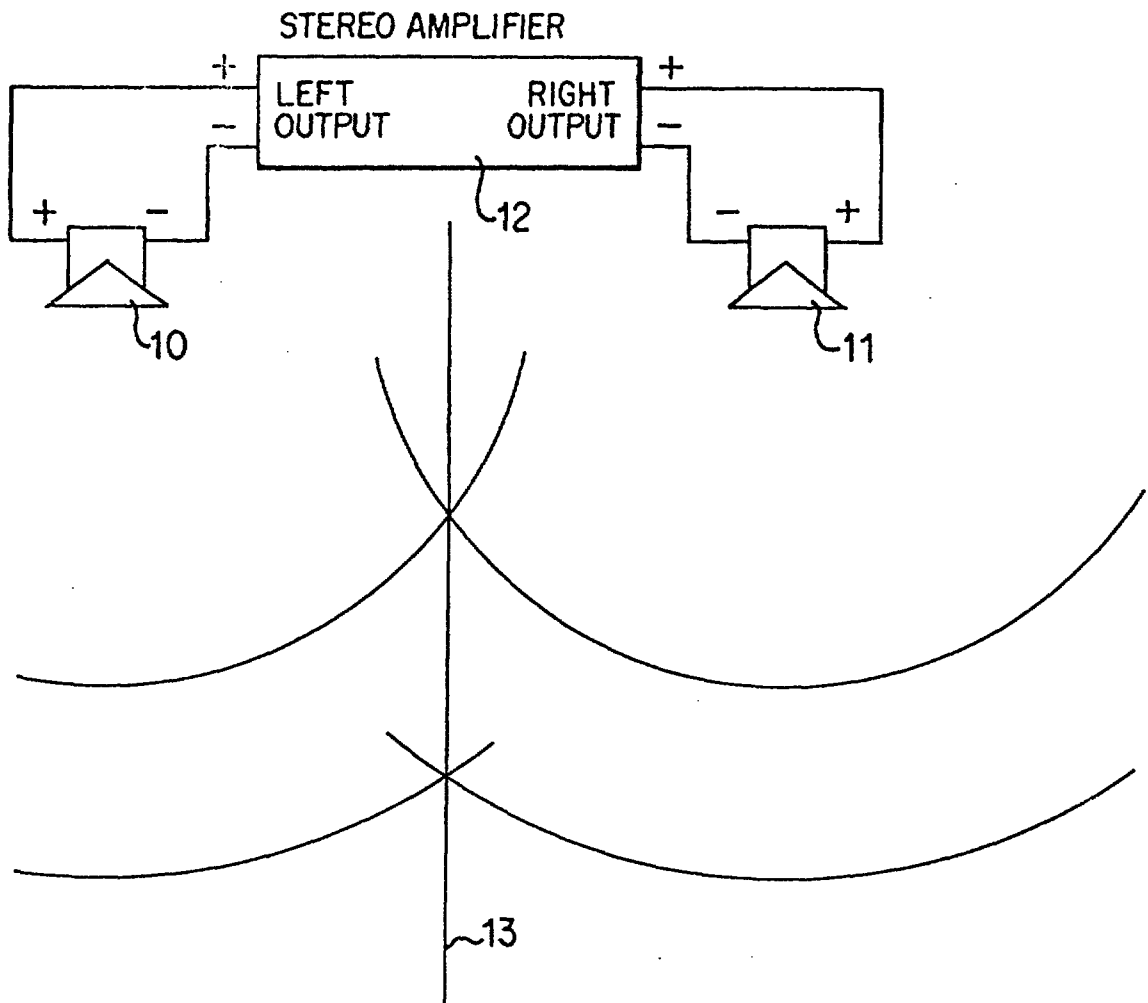


FIG. 1 PRIOR ART

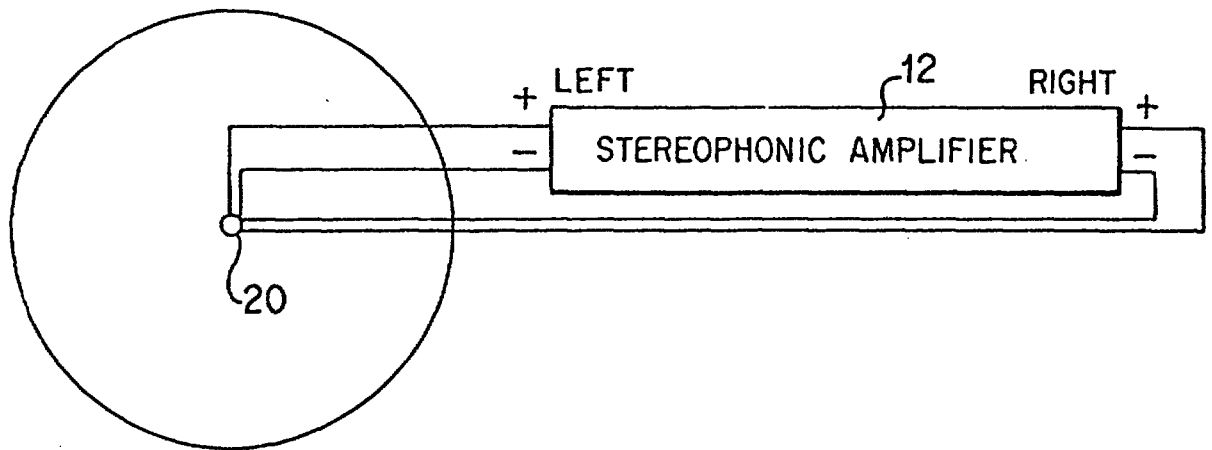


FIG. 2

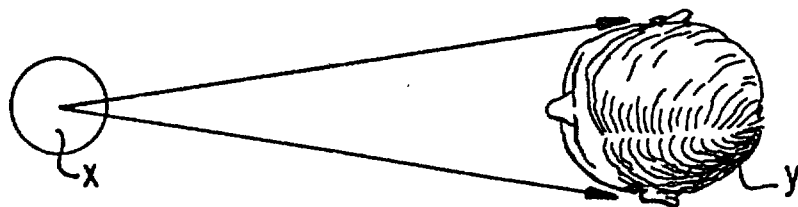


FIG. 1A

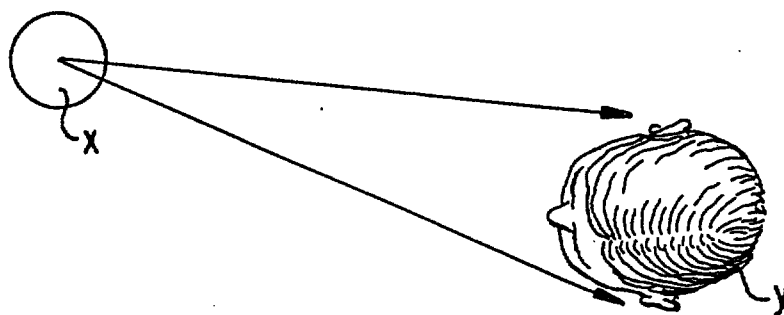


FIG. 1B

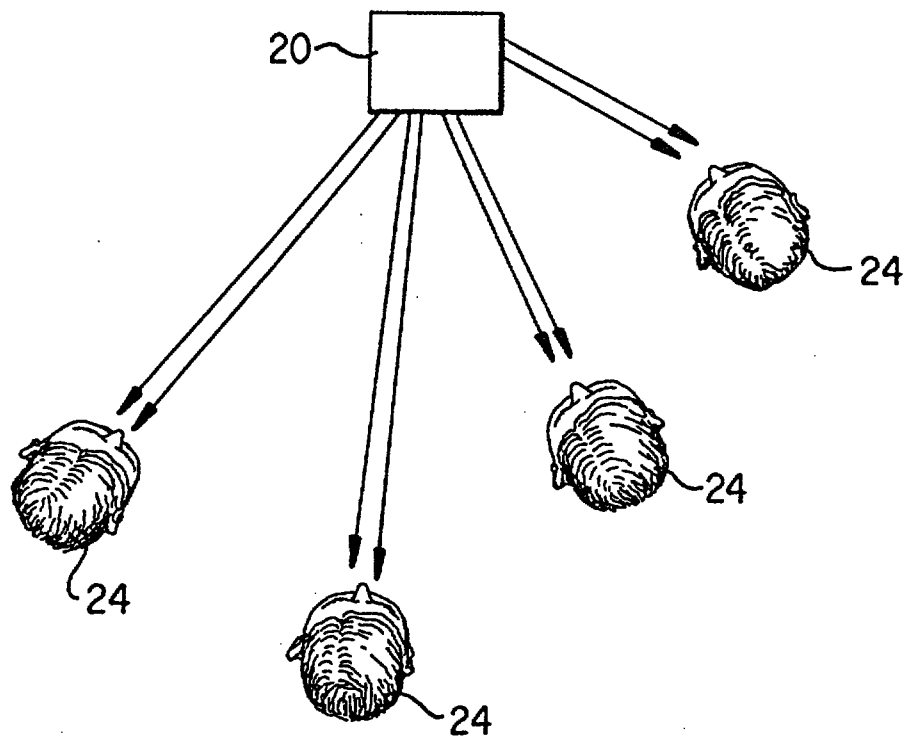


FIG. 3

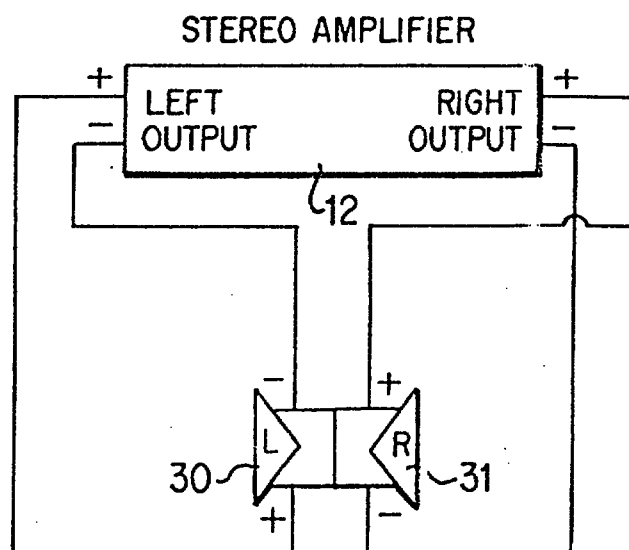


FIG. 4

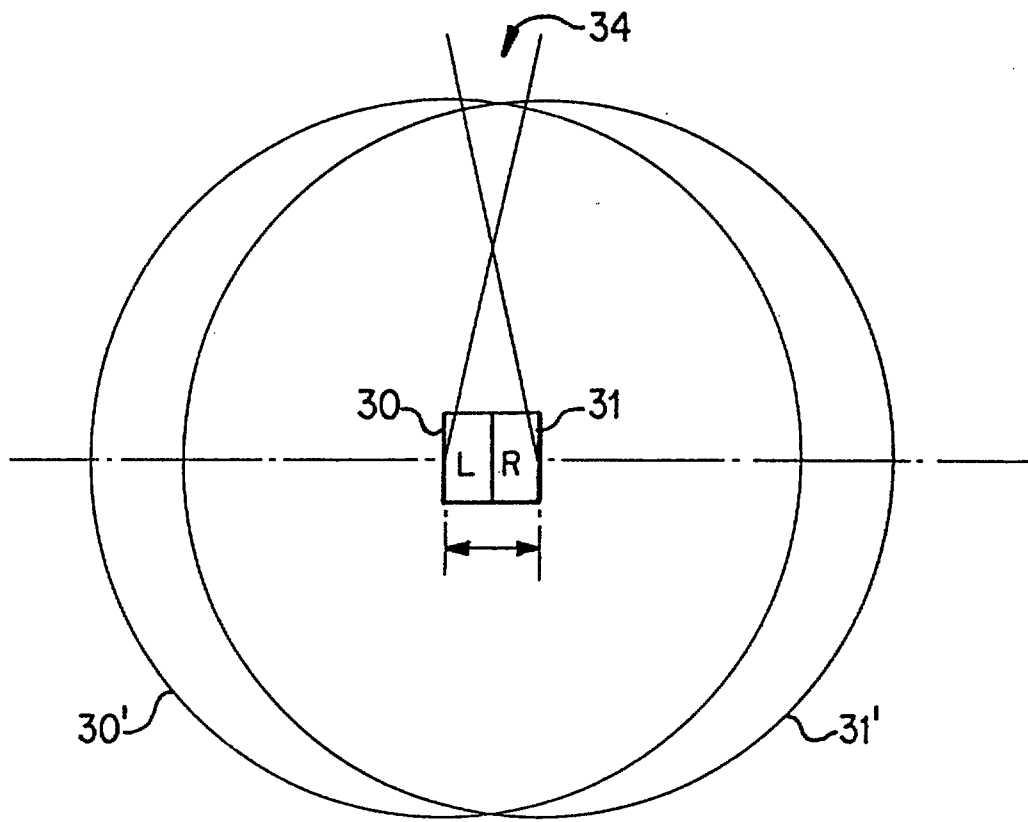


FIG. 5

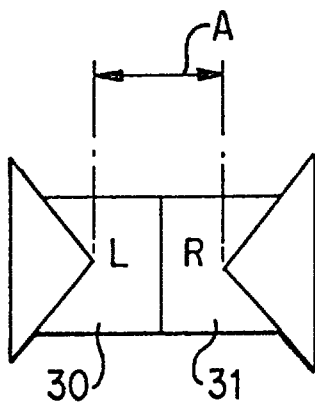


FIG. 6

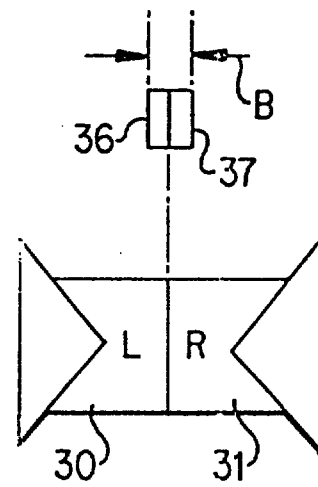


FIG. 7

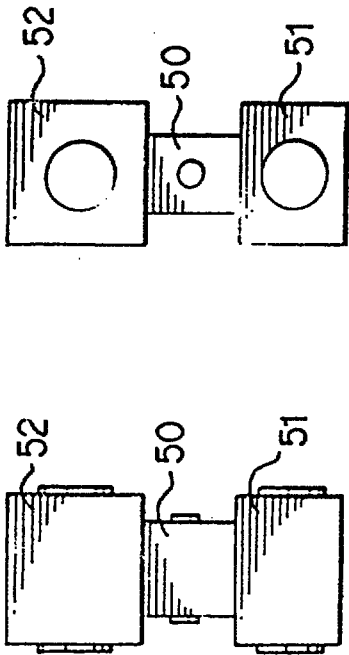


FIG. 8

FIG. 9

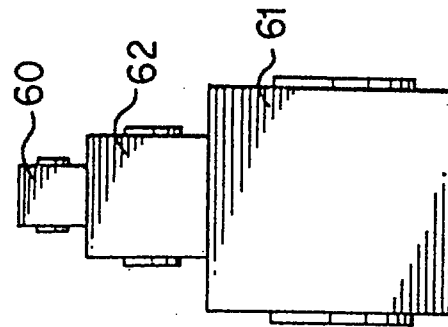


FIG. 10

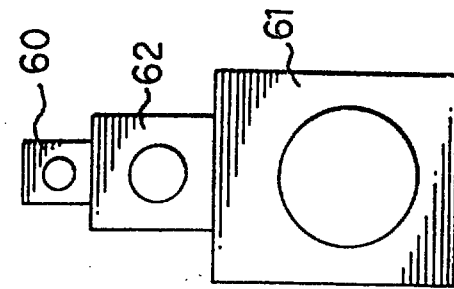


FIG. 11

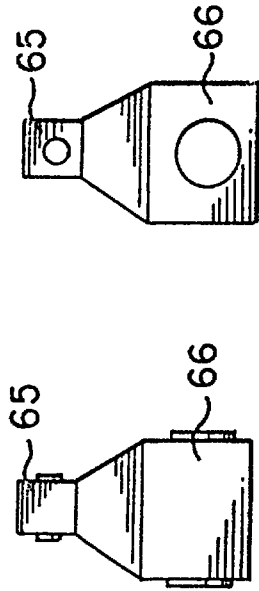


FIG. 12

FIG. 13

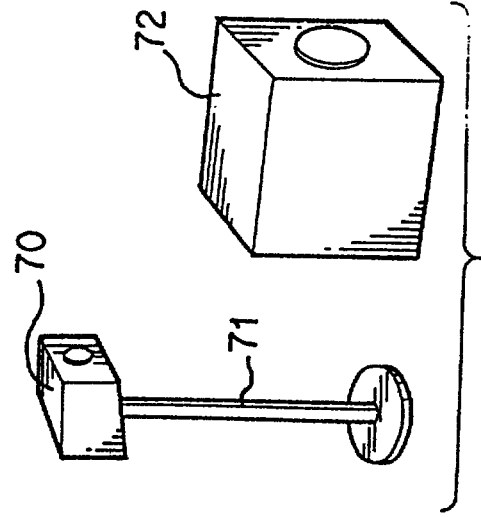


FIG. 14

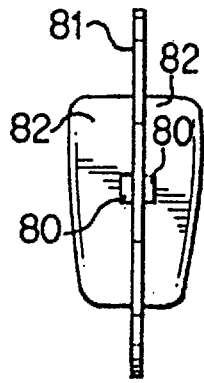


FIG. 15

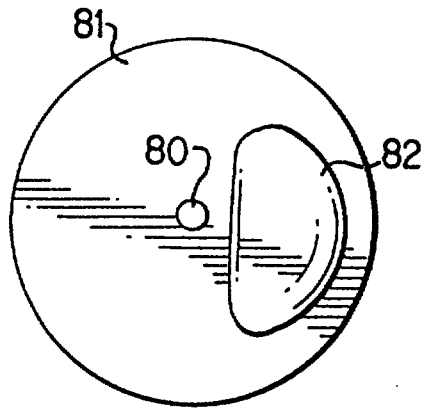


FIG. 16

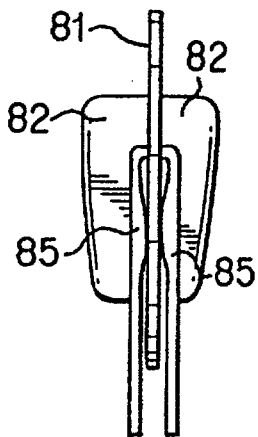


FIG. 17

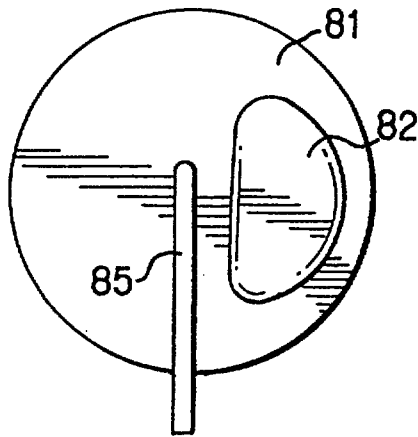


FIG. 18

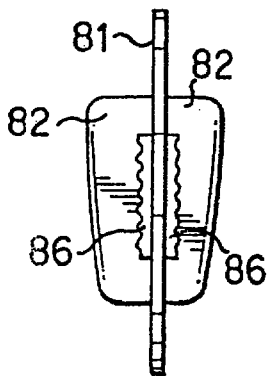


FIG. 19

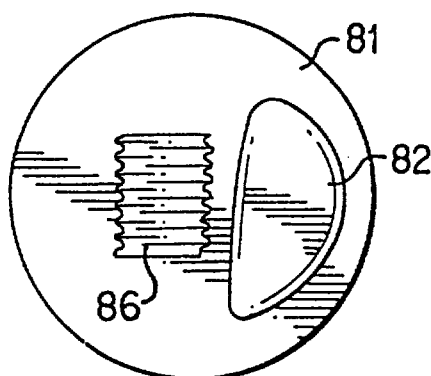


FIG. 20

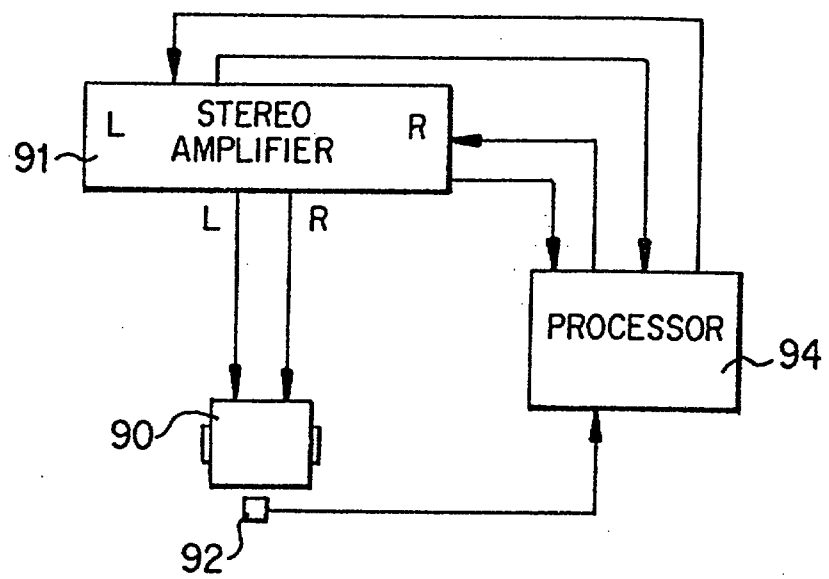
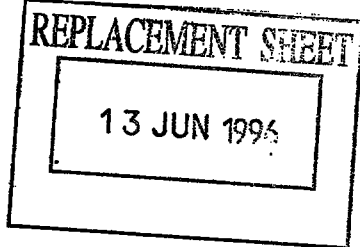


FIG. 21



environment in which the recording was made is reflected sound.

Due to these reflections, the direct musical waves (approximately 10%) give the precision of localization of the origins of the sound of the instruments (e.g. flutes, violins and percussion) while the reflected sounds (approximately 90%) give the ambience of the hall, the depth perception of the soundstage and the richness of the musical experience. The musical emotional experience that a listener, who is in the environment in which the recording was done, has, is due to a complex combination of these reflections of musical information. These are what allow the listener to perceive his environment.

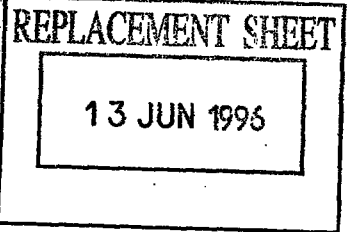
Now remember that the goal of high fidelity is to recreate the musical experience of being present at a concert (regardless of the type of music; jazz, classical, blues, etc.). The only way to accomplish this is to render all the possible sonic information to the brain by the tools that are our ears via a sound reproduction system and also, by consequence, via the most appropriately capable recording processes and techniques.

Assuming that the recordings to be reproduced are capable of "capturing" all the information to be reproduced, and that the more the sound reproduction system is neutral, realistically dynamic and capable of rendering proper transience (including the loudspeakers), the better it should be able to give the basic information that is essential to determine the spacial localization, i.e. the depth and width of the sound stage and even its height. (Our ears/brain combination is indeed capable of indicating if a sound comes from above or below and also what height it originates from. However, it would be trivial to continue at this point on this subject, since it is not relevant to the ability of the present invention to allow the listeners to perceive the

the apexes of the cones of these two speakers. The small distance between the two circles depicts the time difference between the arrival of sound from the two speakers, at the respective locations. A small arcuate region 34 adjacent the plane of symmetry of the speakers represents a cross talk zone that can be minimized by mounting the speakers as close together as possible.

Fig. 6 illustrates a two speaker system of the above described type, wherein the dimension A represents the distance between the apexes of the cones of the two speakers, i.e. the effective distance between the point sources of sound of the two speakers. In this speaker system the speakers are each connected to reproduce the full range of frequencies of the signals output by the amplifier. It has been found that, for effective stereophonic reproduction of sound in accordance with the invention, the distance A must be no greater than the equivalent wavelength of the highest frequency to be reproduced by the respective speakers. The speaker assembly thus comprises a point source of sound. Greater distances than this result in noticeable degradation of the 4D recreated sound stage coherence effect experienced by the listener. This frequency limitation can be expected to be about 9.5 KHz in conventional speakers.

While, in the above discussed arrangement of two speakers, the speakers have a common axis and emit sound in directions away from one another along the same axis, if the above frequency limitation is maintained they may be arranged to emit sound toward one another. In addition, the axes of the two speakers may be at an angle to one another, for example at 45° again if the above frequency limitation is maintained. An angular relationship between the axes of the speakers facilitates the cancellation of the acoustic trace signature of the listening room, as will be discussed.



STEREOPHONIC REPRODUCTION METHOD AND APPARATUS

ABSTRACT OF THE DISCLOSURE

A method and apparatus for stereophonic reproduction uses conventional left and right stereophonic signals to energize a point source transducer in a complementary manner. The resultant interference sound pattern is interpreted by the brain of a listener to enable the listener to experience stereophonic hearing in a wide region surrounding the transducer, not just in the region of the plane of symmetry. A point source transducer may be simulated by a plurality of transducers positioned with the spacing therebetween less than a determinable maximum distance. While conventional stereophonic signals may be employed in the reproduction of sound, improved reproduction is obtained by producing the signals by recording sound with a pair of microphones arranged with the apogees of their respective field of polar response patterns facing substantially at 180° to one another.

Figure 4

REPLACED SHEETS		SG
☒	Description : paged 22a to paged 22b	
☒	Claim(s) : paged 22a to paged	
☐	Drawing(s) : paged to paged	
☐	Abstract : paged to paged	
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another, and energized with identical signals of opposite polarity, in order to provide a push-pull effect for monophonic signals.

A radially broadcasting speaker system is disclosed in U.S. Patent 3,350,514. The system provides two transducers with conical membranes for radiating sound waves from convex sides of the conical membranes. The convex wave generating sides of the conical membranes are oriented facing each other so that sound waves produced by either conical membrane are directed at the opposing conical membrane and reflect off the opposing conical membrane in a radial pattern. Accordingly, the two transducers are mounted in a "front-to-front" orientation.

Another stereophonic speaker system described in German Patent No. 27 09 952 has two speakers mounted in a housing in a "back-to-back" orientation with an undisclosed spacing therebetween. Each housing appears to be responsible for reproducing one stereo channel wherein one of the two speakers of the housing has the signal for a stereo channel signal applied in an opposite phase relationship compared to a stereo channel signal applied to the other speaker in the housing. Essentially, both speakers receive the same signal except one of the signals is inverted with respect to the other.

A stereophonic speaker system is disclosed in U.S. Patent No. 5,109,416 wherein a pair of speakers are mounted apart an undisclosed distance in a housing and each speaker of the pair faces in a direction opposite that of the other. The housing containing the pair of speakers is used in conjunction with other housings containing single speakers. The housings containing single speakers receive either left or right

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stereo channels while the housing containing the pair of speakers receives a signal representing a difference
5 signal of the left and right stereo channels. The difference signal is applied to one speaker of the pair 180° out of phase with relation to the application of the difference signal applied to the other speaker of the pair. Thus, the housing containing the pair of
10 speakers does not produce left and right channel acoustic waves.

A microphone system used to effect noise cancellation is disclosed in U.S. Patent No. 3,995,124. The microphone system has two microphone transducers
15 mounted in a "back-to-back" orientation which are wired together in an out of phase relationship. Uniform background noise reaching both microphone transducers simultaneously is cancelled in the final output because the hard-wiring of the system takes essentially the
20 difference output of the two microphone transducers to produce a single signal.

DISCLOSURE OF INVENTION

The invention is directed to the provision of a method and apparatus for the reproduction of
25 stereophonic sound, wherein:

1. The stereophonic effect is not limited to the plane of symmetry of a pair of speakers, but is clearly apparent in a region that is substantially independent of the location of listener.

30 2. The effects of the acoustics of a sound reproduction room may be cancelled in a simple manner, so that the sound heard by a listener can accurately represent the sound that was recorded.

The invention is thus directed to a method
35 and apparatus of phase coherent sonic transmission embodied as a single loudspeaker transmission system.



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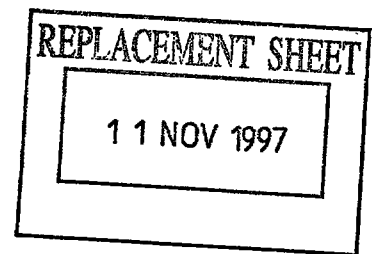
- 8b -

This single complementary transmission system allows the transmission of the left and right channel complementary musical information in a phase coherent and time aligned fashion in order to allow the listeners, regardless of their positions in a listening room, to perceive the music in 4D lifelike fashion.

With the present invention, the right and left complementary sonic information (that is required to be perceived in a time aligned fashion by the listener in order to reconstruction a proper sound stage) is transmitted from the same point source, from a one and only loudspeaker assembly needed to do so. this means that the right and left music signals travel to the listener in a practically parallel and time aligned pattern. This allows the listener to sit or

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signals of a stereo signal source 91, as discussed above. In addition, a point source microphone 92 is located adjacent the complementary transducer 90, to receive sound from the entire listening room. This received sound is applied to a signal processor 94, which subtracts therefrom signals corresponding to the left and right signals originating at the stereo amplifier, in order to avoid interference of the cancellation signal with the desired interference signal. The resultant signal is inverted in the processor and output to the stereo amplifier for application to both the left and right sides of the complementary transducer 90. As a result, the effect of reflections, etc., of the listening room are cancelled. It is of course apparent that more sophisticated arrangements may be alternatively employed in order to improve the sound cancellation effect, i.e. to remove the acoustic trace signature of the listening room.

In a still further embodiment of the invention, it is apparent that the relative phase, amplitude and delay of the stereophonic signals may be controlled in order to "move" sound around listeners, regardless of their listening position. Thus, the source of complementary stereophonic signals may include a processing arrangement to control the phase, amplitude and delay of the respective signals for this purpose.

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WHAT IS CLAIMED IS:

1. A sound system wherein first and second acoustic transducers (30, 31) are disposed proximate each other and radiate in opposite directions characterized by:

a transducer means for producing first and second acoustic waves, in accordance with first and second stereophonic signals applied thereto, to effect a virtual point source acoustic pattern as perceived at a listening distance;

said transducer means having said first and second acoustic transducers (30, 31) for producing said first and second acoustic waves respectively;

means for fixing said first and second acoustic transducers (30, 31) apart from each other a distance up to and not greater than a wavelength at substantially a highest operational frequency of said transducer means;

said means for fixing disposing said first and second acoustic transducers (30, 31) along a substantially common axis and with said first and second transducers (30, 31) each having respective backsides facing each other and radiating in opposite directions away from each other; and

means for applying first and second different stereophonic signals to first and second acoustic transducers (30, 31) to emit said first and second acoustic waves in correspondence with said first and second different stereophonic signals respectively.

2. The sound system of claim 1 further characterized in that:

said first and second acoustic transducers (30, 31) each have substantially conical transducer membranes; and



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said conical transducer membranes have apex areas disposed apart from each other a distance up to and not greater than a wavelength at substantially a highest operational frequency of said first and second
5 acoustic transducers.

3. A sound system wherein first and second transducer means (30, 31) are disposed proximate each other and radiate in opposite directions, characterized
10 by:

at least said first and second transducer means (30, 31) for producing independent acoustic wave patterns;

means for disposing said at least first and
15 second transducer means (30, 31) back to back within a distance of each other of not greater than a wavelength of an upper frequency of temporally aligned and phase coherent operation of said first and second transducer means (30, 31) such that said acoustic wave patterns
20 have virtual effective point sources spaced apart a distance not greater than said wavelength as perceived at an average listening distance;

said first and second transducer means (30, 31) each radiating said acoustic wave patterns in
25 opposite directions away from each other; and

means for energizing said first and second transducer means (30, 31) with first and second stereophonic signal to actuate said first and second transducer means (30, 31) to emit said acoustic wave
30 patterns in correspondence with said first and second stereophonic signals.

4. A method for reproducing sound wherein first and second acoustic transducers (30, 31) are
35 disposed proximate each other and radiate in opposite directions, the method characterized by:



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energizing said first transducer (30) with a first stereophonic signal to produce a first acoustic wave pattern;

energizing said second transducer (31) with a
5 second stereophonic signal to produce a second acoustic wave pattern; and

disposing said first and second transducers (30, 31) back to back within a distance not greater than a wavelength at an upper frequency of operation to
10 radiate said first and second acoustic wave patterns in opposite directions, respectively, and away from said second and first transducers, respectively.

5. A microphone system wherein first and
15 second microphone axially aligned transducers are mounted in opposite directions and spaced apart a distance no greater than a physical distance equivalent to shortest wavelengths of the frequency range of said microphone transducers (80, 85, 86) characterized by:

20 said first and second axially aligned microphone transducers (80, 85, 86) being mounted with the apogees of their respective fields of polar response patterns back to back and facing substantially at 180° to one another; and

25 said first and second axially aligned microphones having outputs for delivering first and second stereophonic signals.

6. The microphone system of claim 5
30 further characterized by a separation/boundary disk between said microphone transducers (80, 85, 86) for separating sound directed to said first and second microphone transducers.

35 7. The microphone system of claim 6 further characterized by distinction padder means on



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both sides of said disk for modifying the patterns of sound applied to said microphone transducers.

8. The microphone of claim 5 characterized
5 in that said first and second transducers (80, 85, 86) are microphone capsules (80).

9. The microphone system of claim 5
characterized in that said first and second transducers
10 (80, 85, 86) are PZM microphones (85).

10. The microphone system of claim 5
characterized in that said first and second transducers
(80, 85, 86) are ribbon microphones (86).

15

11. The sound system according to claim 1
characterized in that said upper frequency ranges up to
9.5 kHz and defines an upper limit of width, height,
depth and time coherent operation.

20

12. The sound system according to claim 11
further characterized by means for producing
stereophonic acoustic waves at frequencies above said
upper frequency.

25

13. The sound system according to claim 1
characterized in that said upper frequency ranges up to
10 kHz and defines an upper limit of width, height,
depth and time coherent operation.

30

14. The sound system according to claim 13
further characterized by means for producing
stereophonic acoustic waves at frequencies above said
upper frequency.

35





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15. The sound system according to claim 1 characterized in that said upper frequency ranges up to 12 kHz and defines an upper limit of width, height, depth and time coherent operation.

5

16. The sound system according to claim 15 further characterized by means for producing stereophonic acoustic waves at frequencies above said upper frequency.

10

17. A sound system wherein at least said first and second transducers (30, 31) are disposed proximate each other and radiate in opposite directions, characterized by:

15 transducer means (30, 31) for producing first and second acoustic wave patterns characterizable at a listening distance as having first and second effective point sources respectively; and

20 said transducer means (30, 31) including said first and second transducers (30, 31) for producing said first and second acoustic wave patterns respectively;

25 means for applying first and second stereophonic signals to said first and second transducers (30, 31) respectively;

30 means for disposing said first and second transducers (30, 31) back to back and within a distance of each other not greater than a limiting distance equal to or less than a wavelength of an upper operating frequency of said transducer means (30, 31) to virtually align said first and second effective point sources within said limiting distance of each other as perceivable at a listening distance; and

35 said first and second transducers (30, 31) being disposed back to back to radiate said first and second acoustic wave patterns in opposite directions



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and away from said second and first transducers respectively.

18. The sound system of claim 17 further
5 characterized in that:

said first and second transducers are substantially conical transducers (30, 31);

said first and second effective point sources are virtually located substantially at apex areas of
10 said first and second substantially conical transducers (30, 31); and

said means for disposing said apex areas within a distance of each other not greater than said limiting distance.

15

19. The sound system of claim 17 further characterized in that said upper frequency ranges up to 9.5 kHz and defines an upper limit of width, height, depth and time coherent operation.

20

20. The sound system according to claim 17 further characterized in that said upper frequency ranges up to 10 kHz and defines an upper limit of width, height, depth and time coherent operation.

25

21. The sound system according to claim 17 further characterized in that said upper frequency ranges up to 12 kHz and defines an upper limit of width, height, depth and time coherent operation.

30

22. A sound reproduction apparatus wherein at least first and second transducers (30, 31) are disposed proximate each other and radiate in opposite directions, characterized by:



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audio transducers (30, 31) for reproducing sound waves from at least first and second stereophonic audio signals;

5 said audio transducers (30, 31) including at least said first and second transducers (30, 31) accepting said first and second stereophonic audio signals respectively;

means for mounting said first and second transducers (30, 31) in substantially opposing
10 directions with backs thereof facing each other and such that said first and second transducers (30, 31) radiate substantially away from said second and first transducers (30, 31) respectively; and

said means for mounting disposing said first
15 and second transducers (30, 31) a distance apart not greater than a wavelength at an upper operational frequency limit of said first and second transducer means (30, 31) to produce corresponding audio wave fronts in substantial synchronization.

20

23. The apparatus according to claim 22 characterized by:

said first and second transducer means (30, 31) including at least first and second substantially
25 conical transducers (30, 31), respectively, each having an apex area; and

said means for mounting including means for fixing said apex areas within a distance of each other not greater than a wavelength at an upper operational
30 frequency limit of said first and second transducer means (30, 31).

24. The sound system according to claim 22 further characterized by said upper operational
35 frequency limit ranging up to 9.5 kHz.



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25. The sound system according to claim 22 further characterized by said upper operational frequency limit ranging up to 10 kHz.

5 26. The sound system according to claim 22 further characterized by said upper operational frequency limit ranging up to 12 kHz.



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stereo channels while the housing containing the pair of speakers receives a signal representing a difference signal of the left and right stereo channels. The difference signal is applied to one speaker of the pair 180° out of phase with relation to the application of the difference signal applied to the other speaker of the pair. Thus, the housing containing the pair of speakers does not produce left and right channel acoustic waves.

A microphone system used to effect noise cancellation is disclosed in U.S. Patent No. 3,995,124. The microphone system has two microphone transducers mounted in a "back-to-back" orientation which are wired together in an out of phase relationship. Uniform background noise reaching both microphone transducers simultaneously is cancelled in the final output because the hard-wiring of the system takes essentially the difference output of the two microphone transducers to produce a single signal.

DISCLOSURE OF THE INVENTION

In accordance with a first aspect of the present invention a method for reproducing sound wherein first and second acoustic transducers are disposed proximate each other and radiate in opposite directions, the method characterized by:

energizing said first transducer with a first stereophonic signal to produce a first acoustic wave pattern;

energizing said second transducer with a second stereophonic signal to produce a second acoustic wave pattern; and

disposing said first and second transducers back to back within a distance not greater than a wavelength at about 9.5kHz.

In accordance with a second aspect of the present invention a sound system wherein at least said first and second transducers are disposed proximate each other and radiate in opposite directions, characterized by:

transducer means for producing first and second acoustic wave patterns characterizable at a listening distance as having first and second effective point sources respectively;

said transducer means including said first and second transducers for producing said first and second acoustic wave patterns respectively;

means for applying first and second stereophonic signals to said first and second transducers respectively;

means for disposing said first and second transducers back to back and within a distance of each other not greater than a limiting distance equal to or less than a wavelength an operating frequency of said transducer means of about 9.5kHz to virtually align said first and second effective point sources within said limiting distance of each other as perceivable at said listening distance; and

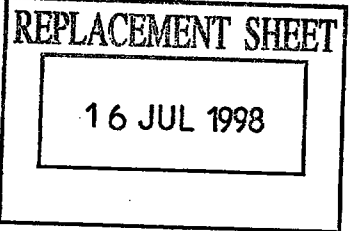
said first and second transducers being disposed back to back to radiate said first and second acoustic wave patterns in opposite directions and away from said second and first transducers respectively.

The invention is directed to the provision of a method and apparatus for the reproduction of stereophonic sound, wherein:

1. The stereophonic effect is not limited to the plane of symmetry of a pair of speakers, but is clearly apparent in a region that is substantially independent of the location of listener.

2. The effects of the acoustics of a sound reproduction room may be cancelled in a simple manner, so that the sound heard by a listener can accurately represent the sound that was recorded.

The invention is thus directed to a method and apparatus of phase coherent sonic transmission embodied as a single loudspeaker transmission system.



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This single complementary transmission system allows the transmission of the left and right channel complementary musical information in a phase coherent and time aligned fashion in order to allow the listeners, regardless of their positions in a listening room, to perceive the music in 4D lifelike fashion.

With the present invention, the right and left complementary sonic information (that is required to be perceived in a time aligned fashion by the listener in order to reconstruction a proper sound stage) is transmitted from the same point source, from a one and only loudspeaker assembly needed to do so. This means that the right and left music signals travel to the listener in a practically parallel and time aligned pattern. This allows the listener to sit or



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energizing said first transducer (30) with a first stereophonic signal to produce a first acoustic wave pattern;

energizing said second transducer (31) with a second stereophonic signal to produce a second acoustic wave pattern; and

disposing said first and second transducers (30, 31) back to back within a distance not greater than a wavelength at about 9.5kHz.

10

5. A microphone system wherein first and second microphone axially aligned transducers are mounted in opposite directions and spaced apart a distance no greater than a physical distance equivalent to shortest wavelengths of the frequency range of said microphone transducers (80, 85, 86) characterized by:

said first and second axially aligned microphone transducers (80, 85, 86) being mounted with the apogees of their respective fields of polar response patterns back to back and facing substantially at 180° to one another; and

said first and second axially aligned microphones having outputs for delivering first and second stereophonic signals.

6. The microphone system of claim 5 further characterized by a separation/boundary disk between said microphone transducers (80, 85, 86) for separating sound directed to said first and second microphone transducers.

7. The microphone system of claim 6 further characterized by distinction padder means on



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15. The sound system according to claim 1 characterized in that said upper frequency ranges up to 12 kHz and defines an upper limit of width, height, depth and time coherent operation.

5

16. The sound system according to claim 15 further characterized by means for producing stereophonic acoustic waves at frequencies above said upper frequency.

10

17. A sound system wherein at least said first and second transducers (30, 31) are disposed proximate each other and radiate in opposite directions, characterized by:

15 transducer means (30, 31) for producing first and second acoustic wave patterns characterizable at a listening distance as having first and second effective point sources respectively;

20 said transducer means (30, 31) including said first and second transducers (30, 31) for producing said first and second acoustic wave patterns respectively;

25 means for applying first and second stereophonic signals to said first and second transducers (30, 31) respectively;

means for disposing said first and second transducers (30, 31) back to back and within a distance of each other not greater than a limiting distance equal to or less than a wavelength an
30 operating frequency of said transducer means (30, 31) of about 9.5kHz to virtually align said first and second effective point sources within said limiting distance of each other as perceivable at said listening distance; and

35 said first and second transducers (30, 31) being disposed back to back to radiate said first and second acoustic wave patterns in opposite directions