

Description

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to stereophonic speaker systems, and more particularly concerns an improved combination of speaker characteristics with speaker driving component signals to provide improved stereophonic sound.

2. Description of Related Art

In reproduction of stereophonic sound, electrical signals generally representing left and right channel stereo input sounds are combined or processed and fed to left and right channel speaker systems or to various combinations of speaker systems, with the goal of reproducing for the listener a sound that most realistically depicts sound heard during an actual, live performance. In attempts to achieve this goal, electrical stereophonic signals have been combined and processed in various manners. Major efforts have been made in careful design and manufacture of recording, mixing and production equipment so that the electrical end product will reflect as closely as possible precisely what performing artists, engineers, mixers or producers wish to convey to the listener. Signals have been fed to speakers positioned in various locations and in various groups, and speakers have been energized by various combinations of stereo signals in further attempts to improve realism of the sound. Artificial time delays, reverberation techniques and deliberate reflections from various walls have been employed, often at the expense of introduction of extraneous information of a type not originally present, thus actually changing the effect of the original performance. Yet, all the prior effort has not resulted in attainment of the goal of realistic reproduction of the sound of a live performance.

The spatial acoustical field produced in a live performance varies in accordance with acoustics of the performance area, and, importantly, in accordance with the type or nature of the performer or performers. For example, a solo vocalist or instrumentalist positioned at center stage will primarily provide sound known as direct field sound, that is radiated directly to the listeners in the audience. However, where performers are spread across a wide stage, for example, as in a performance of a large choral group or a large symphony orchestra, significant portions of sound received by the audience are reflected from various parts of the theater so that the audience receives a mixture of direct field sound, radiated directly from the performers, and sound known as reverberant field

sound, that is reflected from the walls of the theater. In the case of some sounds, such as the immense organ chords of a Saint-Saens organ symphony, the music resounds and reverberates from surfaces in all areas of the theater.

Various combinations of speaker systems, including those that reflect a majority of sound from a wall behind the speaker, do not adequately reproduce all desired sounds with sufficient realism. Moreover, speaker systems arranged for one particular location or environment are not readily scaled up or down to operate in other environments so that, for example, a speaker system designed for a living room environment is not properly operable in an automobile, theater, or even outdoors.

Accordingly, it is an object of the present invention to provide a loudspeaker system that avoids or minimizes problems of prior systems and produces a spatial acoustical field which is more realistically representative of the live performance, and, moreover, is flexible in its application to different environments.

SUMMARY OF THE INVENTION

In a first aspect, the invention provides a method of reproducing sound from an electrical stereo input signal which contains components representing direct field sounds and reverberant field sounds, comprising radiating direct field components of the stereo signal through a first loudspeaker arrangement, and radiating reverberant field components through a second loudspeaker arrangement, characterised in that the reverberant field sound components are radiated in a pattern having a wider omnidirectional dispersion in a frequency range than the radiation pattern of the direct field sound components in the frequency range.

In a second aspect, the invention provides apparatus for producing sound from an electrical stereo input signal which contains components representing direct field sounds and reverberant field sounds, comprising a first loudspeaker arrangement for radiating direct field components of the stereo signal, a second loudspeaker arrangement for radiating reverberant field components of the stereo signal, and means for providing signals representing the direct and reverberant field components to drive the loudspeaker arrangements, characterised in that the second loudspeaker arrangement has a radiation pattern with a wider omnidirectional dispersion in a frequency range than the first loudspeaker arrangement.

Arrangements according to the precharacterising parts of the invention are known from US-A 4594729 and US-A 3849600.

In carrying out principles of the present invention, in accordance with a preferred embodiment thereof, direct field sounds are radiated from a front radiating speaker system and reverberant field sounds are projected from a speaker system having a wider dispersion pattern. According to a specific feature of the invention, a front radiating speaker system having a narrow dispersion pattern is energized from a signal representing the sum of left and right stereo input signals and a pair of companion speaker systems, having wide dispersion patterns, is energized from signals representing difference between left and right stereo signals. Direct field sound representing a stereo sum signal, and radiated in a narrow dispersion pattern, is combined acoustically with reverberant field sound representing difference signals, and radiated in a wide dispersion pattern.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. 1 is a block diagram illustrating a loud-speaker system embodying principles of the present invention;

FIG. 2 schematically depicts an arrangement of speakers in accordance with principles of the present invention;

FIG. 3 illustrates a modified speaker arrangement;

FIG. 4 illustrates a single cabinet incorporating a set of speakers;

FIGS. 5, 6 and 7 illustrate still further arrangements and organizations of speaker systems; and

FIG. 8 shows a modification of the speaker arrangement particularly adapted for an automobile.

DESCRIPTION OF A PREFERRED EMBODIMENT

Principles of the present invention are based upon a combination of control of (a) radiation of direct and reverberant field sounds and (b) the electronic processing of stereophonic left and right signals.

With respect to radiation of sound, the present invention takes advantage of the fact that a front radiating speaker system is effective for reproduction of direct field sound, but is relatively ineffective for reproduction of reflected or reverberant field sound. Further, an omnidirectional or wide dispersion speaker system is just the opposite, effective in reproduction of reverberant field sound, but ineffective for reproduction of direct field sound, which appears to be strangely disembodied by an omnidirectional speaker system.

With respect to electronic processing of the stereophonic left and right signals L and R, it is known that these signals may be broken down into their sum $(L + R)$ and difference $(L - R)$ or $(R - L)$ components. It is also known that such components may be electrically remixed in various manners so as to reassemble the original stereophonic signals. For example, $(L + R) + (L - R) = 2L$, and $(L + R) + (R - L) = 2R$. Further, in my prior copending application for Stereo Enhancement System, filed March 27, 1986, Serial No. 844,929, I describe various methods for specifically processing sum and difference signals (according to various frequency bands) and producing stereo left and right channel output signals for application to a speaker system by various mixtures of processed sum and difference signals with the stereophonic left and right input signals. However, in no prior case has there been an attempt to obtain separate reverberant field and direct field signals and to radiate sound based upon such signals in a manner that is optimum for the respective signal types. It has not been previously recognized that direct field sound and reverberant field sound can be separately projected from speaker systems respectively optimized for the particular type of sound, and that the sound types can then be acoustically recombined in space and transmitted to the ear-brain system of the listener.

The sum of the stereophonic left and right signals, namely the sum signal $(L + R)$, itself essentially represents the direct field sound, namely that sound heard by the listener at a performance of a solo vocalist or instrumentalist, positioned in the center of the theater stage. The difference signals, namely $(L - R)$ and $(R - L)$, uniquely represent reverberant field sound which significantly include sound heard by the listener but which is reflected from or reverberating between the theater walls. Direct field sound from a center stage soloist, for example, reaches the listener in a direct line, whereas the reverberant field sound reaches the listener after various reflection in the theater. Thus, according to a feature of the present invention, a speaker system is set up to similarly provide direct field sound to the listener via a direct path and reverberant field sound to the listener via direct or reflective paths, or a combination of both direct and reflective paths.

Referring now to FIG. 1, there is shown a stereo source 10 of left and right stereophonic input signals L and R which may be derived from a radio broadcast receiver, AM, FM or television, or from a stereo playback system whether grooved record, magnetic, optical (laser "compact" disc) or the like. These stereophonic input signals L and R may be derived directly from the playback system or may be processed in some suitable arrange-

ment, as for example, in the stereo enhancement system of my prior application above identified. Thus the signals L and R of FIG. 1 may be derived from the mixer output signals of the enhancement system of such prior co-pending patent application. The signals L and R are fed to respective sum and difference circuits 12,14, which respectively provide the sum signal ($L + R$) and the difference signal ($L - R$), which are the sum and difference of the input signals L and R. These sum and difference signals are fed to a multi-channel power amplifier 16, which also receives the output of an inverter 18 which inverts the ($L - R$) signal to provide a second difference signal ($R - L$). Thus the power amplifier provides as its output, amplified versions of the sum signal ($L + R$), which represents direct field sound of the stereo input, and the two difference signals ($L - R$) and ($R - L$), which represent the reverberant field sounds of the stereo input.

A set of speakers is provided to project sound based upon the three outputs of the amplifier 16. The terms speaker, speaker system or loudspeaker, loudspeaker system are used herein to denote systems having one or more electrical to acoustic transducers, each uniquely operable over a selected frequency range. For example, the term speaker may refer to a system having a woofer, tweeter and mid-range transducer or any group or combination thereof. FIG. 1 shows the set as being composed of three speakers, but greater numbers of speakers may be used, as shown in other drawings of the present application, and as described below. A first speaker 20 is energized with the sum signal ($L + R$) and projects its sound in a relatively narrow dispersion pattern. Speaker 20 is a front radiating speaker having a dispersion pattern of not greater than 60° . The difference signals ($L - R$) and ($R - L$) are fed to second and third speakers of the set, namely speakers 22 and 24, which are omnidirectional speakers or speakers having a wide dispersion pattern, which is a pattern of dispersion of at least 120° . Thus each of speakers 22 and 24 may have a dispersion pattern in the range of 120° to 360° , whereas speaker 20 has a dispersion pattern of not more than about 60° .

Speakers with wide dispersion patterns and omnidirectional speakers are known and readily available for use in the present invention. Wide dispersion is relatively easy to achieve below about 800 Hertz, but as wave lengths become shorter in relation to diameter of the radiating area of the speaker transducer, angular dispersion becomes narrower until at frequencies above about 3 Kilohertz, for cone type midrange speakers, and above about 10 Kilohertz for dome type tweeters, the dispersion pattern becomes a narrow beam of sound. It has been found that higher frequencies

require maximum angular dispersion to properly reproduce the reverberant field sound based upon difference channel signals. Therefore many speakers do not have a dispersion pattern that is sufficiently wide, over the desired frequency band, to be suitable for projecting reverberant field sound. However, wide dispersion speakers for use in the present invention may be provided by using conventional techniques of wide dispersion horns or arrays of multiple transducers. Although a wide dispersion horn will operate only over a discrete band of frequencies and becomes physically large as cutoff frequency is lower, the horn operates quite satisfactorily at the higher frequencies, and dispersion angle may be made quite large with horns of reasonable dimension.

A dispersive element in the form of an uniquely shaped baffle is disclosed in my co-pending application for Loudspeaker System with Conical Baffle. This dispersive element may be used with most forms and sizes of speaker transducers, and is highly efficient, small and inexpensive to manufacture. Angle of dispersion may be designed into the speaker and baffle, and thus a simple conventional cone-type speaker when used with such dispersive element may provide the wide dispersion pattern desirable for the reverberant field speakers, such as speakers 22 and 24 of FIG. 1. Examples of other wide dispersion speakers are shown in U.S. Patents 4,580,654 and 4,348,549.

Illustrated in FIG. 2 is an exemplary physical arrangement of a set of four speakers which illustrates operation of the present invention. The speaker set shown in FIG. 2 comprises two pairs of speakers. For example a left pair comprises a wide dispersion pattern speaker 26 and a narrow dispersion front radiating speaker 28. A right pair comprises a similar pair of speakers, including a wide dispersion pattern speaker 30 and a narrow dispersion pattern front radiating speaker 32. Each of the wide dispersion range speakers 26 and 30 is energized with a difference signal, the left difference signal ($L - R$) being fed to speaker 26, and the right difference signal ($R - L$) being fed to speaker 30. Each of the front radiating speakers 28 and 32 is fed with the same sum signal ($L + R$). The arrows pointing away from the various speakers schematically represent the relatively narrow and relatively wide dispersion patterns. Sound projected from the wide and narrow dispersion pattern speakers is directed, at least in part, to a common area for acoustic recombination. Illustrated in FIG. 2, by boxes 34 and 36, is the acoustic recombination of the sounds from the speakers of the respective pairs. Thus, box 34 depicts acoustic recombination of the ($L - R$) and ($L + R$) components from speakers 26,28 to provide the left stereophonic signal sound 2L. Similarly box 36 represents the

acoustic combination of the right channel direct field and reverberant field sound from speakers 32,30, which respectively radiate sound based on the sum signal ($L + R$) and the difference signal ($R - L$), which sounds provide, when combined acoustically, the acoustic equivalent of the right channel signal 2R. The arrangement is such that the listener may be in a wide range of locations without losing advantages of the improved realism of the sound.

FIG. 3 illustrates a modified arrangement of speakers in which wide dispersion pattern speakers 38,40 are positioned on either side of a centrally located narrow dispersion pattern front radiating speaker 42, with speakers 38 and 40 being fed with the difference signals ($L - R$) and ($R - L$) respectively, and the center speaker, which is a direct radiating narrow dispersion pattern speaker that cooperates in common with each of the wide dispersion pattern speakers, being fed with the sum signal $2(L + R)$. Again the direct field and reverberant field sounds of the speakers are acoustically combined by the listener. In one typical arrangement, the three speakers 38, 40 and 42 may be arranged in a line at the center of and along one wall of a room, being spaced at least one foot from the wall to allow for the reflection of the widely dispersed sound from speakers 38 and 40.

FIG. 4 illustrates a slightly modified version of the speaker arrangement of FIG. 3 wherein all three speakers are mounted in a single cabinet with direct front radiating speaker 42' being mounted directly between wide dispersion speakers 38', 40'. The narrow and wide dispersion pattern speakers are energized in the manner described in connection with FIG. 3. In the arrangement of FIG. 4 the center front radiating speaker 42' is provided with a dispersion pattern of not more than about 60° , whereas each of the side speakers 38' and 40' is provided with a wide dispersion pattern in the order of about 270° as illustrated by the pattern of arrows in this figure. The central axes of the radiation pattern of the side speakers 38', 40' are substantially perpendicular to the central axes of the radiation pattern of the center speaker 42'.

The speaker arrangements of FIGS. 2, 3 and 4, which are arranged primarily for a living room or the like, may be modified as illustrated in FIG. 5 for use in an automobile. FIG. 5 shows a front radiating narrow dispersion pattern speaker 50 energized by the sum signal $2(L + R)$ mounted at the center of the dashboard of an automobile and flanked by wide dispersion pattern speakers 52 and 54 respectively energized with difference signals ($L - R$) and ($R - L$) and positioned either in opposite doors of the automobile at opposite sides of the driver, or in the respective extreme corners of the automobile dashboard. The direct field speaker 50 has a dis-

persion pattern of not more than about 60° and the reverberant field speakers 52,54 have wide dispersion patterns of more than 180° .

FIG. 6 illustrates a speaker arrangement for a theater wherein a stage at the front of the theater supports a screen 60, for example, and the audience is seated in areas indicated generally at 62,64. In such an arrangement a narrow dispersion pattern speaker 66, energized by the sum signal $2(L + R)$ is mounted at the center of the stage, and wide dispersion pattern speakers 68,70, energized by difference signals ($L - R$) and ($R - L$), are mounted on either side of the speaker 66 at opposite sides of the screen 60. Mounted on one side of the theater, such as the left side of the theater, is a pair of additional wide dispersion pattern speakers 72,74 near the front and near the rear respectively of the left side of the theater, each energized with the difference signal ($L - R$). On the right side of the theater, at front and back portions respectively, is mounted a second pair of wide dispersion pattern speakers 76,78, each energized with the difference signal ($R - L$). The wide dispersion pattern speakers in the arrangement of FIG. 6 may have a dispersion pattern of about 180° , whereas the front radiating direct field narrow dispersion pattern speaker 66 again has a narrow dispersion pattern of not more than about 60° .

In some theaters separate stereo sound systems are employed for the front and rear so that, in general, a front system energized with front stereophonic left and right signals is provided at the front of the theater, and a rear system energized with rear stereophonic left and right signals is provided at the rear of the theater. Principles of the present invention are applicable to such a total immersion theater sound system, which includes both front and rear sound systems surrounding seating areas 62,64, in a manner illustrated in FIG. 7. Again a narrow dispersion front radiating speaker 80 is energized by the sum signal $2(L + R)_F$, which is the sum signal of the front stereo system, and is positioned at the center of the front mounted screen 82. At opposite sides of the theater, at the sides of the screen, are mounted wide dispersion pattern speakers 84,86, energized with the front sound system difference signals ($L - R$)_F and ($R - L$)_F respectively.

At the rear of the theater, in the center, is mounted a second narrow dispersion front radiating speaker 88, energized with the sum signal $2(L + R)_R$ of the rear sound system. On either side of speaker 88, at the opposite sides of the rear of the theater, are mounted wide dispersion speakers 90,92, respectively energized with difference signals ($L - R$)_R and ($R - L)_R of the rear stereo signals. In the exemplary system of FIG. 7 along each side of the theater are mounted three additional wide$

dispersion pattern speakers 94, 96, and 98 on one side, and wide dispersion pattern speakers 100, 102 and 104 on the other side, the speakers on each side being mounted at front, back and center respectively of the theater sides. Speakers at the front of the theater sides, that is speakers 98 and 104, are energized with the difference signals $(L - R)_F$ and $(R - L)_F$ of the front sound system, whereas speakers at the rear of the sides, speakers 94 and 100, are energized with the difference signals $(L - R)_R$ and $(R - L)_R$ of the rear sound system. Speakers 96 and 102 at the center portions of the theater sides are energized with signals representing a combination of the front sound system difference signals and the rear sound system difference signals. Thus speaker 96 is energized with the difference signal $(L - R)_F + R$ and speaker 102 is energized with the difference signal $(R - L)_F + R$ where $(L - R)_F + R = (L - R)_F + (L - R)_R$ and where $(R - L)_F + R = (R - L)_F + (R - L)_R$.

The speakers 88, 90 and 92 at the rear of the theater are all energized with stereophonic left and right signal sum and difference signals of the rear sound system, with center rear speaker 88 being energized with the rear sound system sum signal $2(L + R)_R$ and the side speakers 90, 92 at the rear being respectively energized with the difference signals $(L - R)_R$ and $(R - L)_R$ of the rear sound system. In this arrangement of FIG. 7, as in the arrangement of FIG. 6, the narrow dispersion pattern speakers 80, 88 have a dispersion pattern of not more than about 60° , whereas each of the other speakers has a wide dispersion pattern of about 180° .

The arrangement of FIG. 5, as described above, is a simplified version of the present system for use in an automobile. In use of this system for an automobile, as distinguished from use of the system in a larger area, such as a music room, living room, theater or the like, position of the speakers with respect to the listener becomes important. Position of the listener with respect to the speakers is important in an automobile because of the very small area of the interior of the automobile, as compared to the area of a normal living room or theater. In such a situation, referring to the arrangement of FIG. 5, for example, the driver of the automobile would be sitting considerably closer to the left side of the car, and thus would be positioned very close to the speaker 52 in the left door and relatively further away from the speaker 54 in the right door. Accordingly, sound from the much closer speaker 52 not only reaches the driver before the corresponding sound from the more remote speaker 54, but is less attenuated because of the considerably shorter distance traveled. In such an arrangement, the driver will hear a sound that is less realistic, since it is a combination of the

direct field sound from narrow pattern speaker 50 and reverberant field sound primarily from the wide dispersion speaker 52. Of course a similar situation occurs with the passenger, who hears the reverberant field sound from the right side speaker 54 at a much higher amplitude level than sound from the left side speaker 52.

In order to avoid this limitation in the very close confines of an automobile, principles of the invention may be applied to an automobile speaker arrangement, such as is illustrated in FIG. 8. In this arrangement door mounted speakers 110 and 112 are mounted in the left and right automobile doors, generally at a lowermost portion of the door in order to accommodate the vertically movable door window, and are of the reverberant field type having a wide, preferably 180° or more, dispersion pattern, as previously mentioned in connection with speakers 52 and 54 of FIG. 5. These speakers are fed with the difference signals $(L - R)$ and $(R - L)$ respectively for speakers 110 and 112 (which are modified with direct field signals $(L + R)$ in a manner to be described below). Instead of using a single narrow pattern direct field speaker, as in the arrangement of FIG. 5, a pair of such speakers 114, 116 is employed, each mounted at a corner of the automobile dash-board and pointed upwardly to direct sound to be reflected toward the listeners from the windshield. Speakers 114, 116 are narrow pattern speakers, having a pattern width of about 60° , as previously mentioned. In this situation a second pair of reverberant field speakers 118, 120 is mounted on a center console 122 that projects rearwardly from the dash, with speaker 118 being a wide dispersion pattern speaker of the type previously mentioned, energized with the difference signal $(R - L)$, modified as described below, and pointed directly at and aligned with speaker 110. Similarly, speaker 120 is a wide dispersion pattern speaker energized with the difference signal $(L - R)$ (modified with an $(L + R)$ component as will be described below) and positioned directly opposite and pointed at the speaker 112.

The wide dispersion pattern speakers 110, 112, 118 and 120 are all mounted relatively low, and their high frequency components tend to be absorbed to varying degrees, depending upon the acoustics of the automobile interior and the sound absorption qualities of the automobile upholstery. Particularly for plush upholstery other than vinyl or leather, high frequency sound of these speakers that are mounted at a relatively low position in the automobile tends to be absorbed. Thus the wide dispersion speakers 110, 112, 118 and 120 is each made with a cross-over network and provided with a tweeter to handle the wide dispersion radiation of the higher frequencies, employing a cross-over frequency in the order of about 1,000 Hertz. To this

end there are provided wide dispersion reverberant field high frequency tweeters 124,126,128, and 130 respectively coupled with cross-over networks of wide dispersion speakers 110,118,120, and 112 respectively. The tweeters are mounted as indicated on portions of the dash horizontally adjacent the respective low frequency wide dispersion speakers with which they are associated, with tweeters 124 and 130 being positioned at rear corners of the dash pointing upwardly toward the windshield, and tweeters 126,128 being positioned on the top of the dash again, also pointed upwardly at the windshield, but positioned adjacent respective associated low frequency wide dispersion speakers 118, 120. Of course the signals fed to the low frequency wide dispersion speakers 110,118,120 and 112 are also fed to the corresponding tweeters, 124,126,128 and 130, respectively.

In the arrangement illustrated in FIG. 8 and described to this point, the driver, indicated at "D", hears direct field sound from narrow pattern speaker 114, which is energized with a signal $(L + R)$, and a combination of reverberant field sound from speakers 110 and 118, which are energized with the signals $(L - R)$ and $(R - L)$ (as modified by $(L + R)$ as described below). The high frequencies of the reverberant field sound from speakers 124 and 126 are also heard by the driver. Similarly, the passenger on the right side of the car, identified as P1, hears direct field sound from narrow pattern speaker 116, energized by $(L + R)$ and reverberant field sound from speakers 120,112 and tweeters 128,130.

A passenger (not shown) seated in the center of the front seat will hear direct field sound from both speakers 114,116, which produces an apparent source of direct field sound midway between the two. The center passenger also hears the reverberant field sound from speakers 110,112 and tweeters 124,130. Insofar as the center passenger is concerned, sound from the console mounted speakers 118,120, which are mounted very close to one another, and from the tweeters 126 and 128, which are also mounted very close to one another, is effectively cancelled because these speakers effectively radiate sound to the center passenger in the same space. Accordingly, the center passenger hears the image, which is a combination of direct field sound from speakers 114 and 116 and effectively hears only the reverberant field sound from the wide pattern side speakers 110,124 on the left and 112,130 on the right.

Because the sound from the direct field speakers 114,116 is pointed upwardly and reflected from the windshield, and the side door mounted speakers 110,112 are generally required to be mounted at a lower point on the door, there is a relatively

large vertical distance between the apparent source of direct field sound and the apparent source of reverberant field sound. Console mounted speakers 118 and 120 are similarly required by the physical constraints of the usual automobile to be mounted at a relatively low portion of the console. When the narrow pattern speakers are energized with sum signal $(L + R)$, and the wide pattern speakers are energized only with the difference signals $(L - R)$ and $(R - L)$, this difference in elevations of direct and reverberant field sound provides an apparent separation of the direct field sound, causing the latter to appear to emanate from a point higher than the reverberant field sound. The direct field sound is that of the soloist, for example, and the reverberant field sound is that of the background orchestra, all as previously described. In order to decrease the effect of this relative difference in elevation which is imposed upon the system by physical constraints of the automobile structural interior, a portion of the direct field sound, the signal $(L + R)$, is fed electrically to the wide dispersion pattern speakers, which also receive the $(L - R)$ and $(R - L)$ components, respectively. In a particular example this portion of $(L + R)$ is approximately fifty percent. However, according to principles of the invention, this portion may vary between twenty-five and seventy-five percent of the direct field sound signal $(L + R)$, depending upon acoustics of the automobile interior and particularly on the nature of the sound absorption qualities of the interior upholstery. Thus, although the speakers 114 and 116 are fed with the direct field signal components $L + R$, just as previously described, speaker 110 actually receives a combination of $(L + R)$ and $(L - R)$, and, more specifically, the signal $1/2 (L + R) + (L - R)$, and the speaker 112 actually receives the signal $1/2 (L + R) + (R - L)$. In other words, one-half of the sum signal is electrically added to each difference signal. This addition of a part of the direct field sound component $(L + R)$ to the wide reverberant field speakers provides a greatly improved realism and apparent increase in realistic positioning of both the direct and reverberant field sounds. This addition of the $L + R$ component to the wide dispersion speakers 110,118, 120 and 112 lowers the apparent position of the image of the direct field sound source and decreases dominance of the direct field sound source, which might otherwise tend to occur.

For the rear passengers, identified as P2, P3 and P4, sitting in a back seat 134, narrow pattern direct field sound speakers 140 and 142 are mounted on opposite sides on a shelf behind the rear seat and pointed upwardly toward the car ceiling or sloping rear window. In forward lower portions of the left and right rear doors are mounted wide dispersion reverberant field speakers of broad fre-

quency range, indicated at 146,148, facing toward each other. Direct field sound speakers 140 and 142 add to the sound heard by all passengers in the car, including those in both front and back seats. Generally, as is well known, the rear speakers mounted on the shelf will provide improved low frequency sound because of their ability to use the automobile trunk as a resonant cavity. The wide dispersion pattern reverberant field speakers 118,120 mounted in the console are sufficiently loud to provide the desired effect for the passengers in the rear seat, who thus get the same effect from the center console mounted speakers. Thus passenger P2 will hear sound from both the front and rear direct field narrow pattern speakers 114,140 and will hear reverberant field sound (L - R) and (R - L) (as modified by a suitable percentage of (L + R)) from wide dispersion pattern speakers 146, 124, 126 and 118. Similarly passenger P4, on the right side of the rear seat, will hear direct field sound from the narrow pattern speakers 116,142 and reverberant field sound from speakers 120,128,130,148, which provide the difference signals (L - R) and (R - L) (both modified by an appropriate percentage of (L + R)). The center rear passenger P3 hears sound just as does the center passenger in the front seat, hearing an image from a point between the front direct field sound speaker pair 114,116 and an image from a point midway between rear mounted direct field speakers 140,142. The center back seat passenger also hears reverberant field sound from the side mounted rear speakers 146,148, but hears little sound from the console mounted wide dispersion pattern speakers 118,120. Wide pattern speakers 146,148 are also fed with a combination of one-half the sum signal with the difference signals, just as are all the wide pattern speakers.

The described speaker arrangements, in most listening situations where the speakers are mounted in a room or area of reasonably large size, are independent of listener position, so that the significant advantages of the system may be enjoyed by a listener regardless of his position with respect to the speakers. This advantage of flexible listener position is somewhat diminished in the close confinement of the interior of an automobile. For such a close space the speaker arrangement is preferably modified to suit the specifically predetermined listener position, which, of course, is dictated by the automobile seating arrangement.

The speaker systems described herein are tolerant of walls and other reflective surfaces because the front radiating speaker or speakers provide sound directly to the listener, whereas the wide dispersion pattern speakers provide sound that is not adversely affected by reflection from walls of the room, inasmuch as such sound is heard as a

reflection or reverberation in the live performance.

Furthermore, as can be seen from the exemplary speaker arrangements illustrated in FIGS. 4, 5, 6, 7 and 8, the speaker choice and arrangement can actually be designed to take advantage of various room sizes, situations and the walls of the room, but is not dependent on such surfaces for its operation, nor is it dependent upon relative location of listener and speakers, except for the confining situation of an automobile where the listener is very close to the speakers, and the described special speaker arrangement is preferred. Accordingly the system is operable outside of any building where no reflective surfaces exist.

As previously mentioned, the described system is compatible with and complementary to the stereo enhancement system described in the above-identified co-pending patent application for Stereo Enhancement System. Desirable effects of the enhancement system of such co-pending application are augmented by the use of the split mode system described herein in the place of ordinary loudspeakers. Although neither the present invention nor that described in the co-pending application requires use of the other, use of the two together considerably enhances operation of both. As previously mentioned, the outputs L_{IN} and L_{OUT} of the enhancement system of my copending application for Stereo Enhancement System may be employed as the inputs L and R of the system illustrated in FIG. 1. Alternatively, the sum, difference and inverting circuits and also the amplifier, if necessary or desirable, of the system of FIG. 1 may be readily incorporated into output portions of the enhancement system of my prior application so that such enhancement system would provide the sum and difference outputs (L + R), (L - R), and (R - L), all based upon signals enhanced as provided in the system of my prior application.

The loudspeaker arrangement illustrated and described herein provides almost complete freedom of listener position. Even in the close confinement of an automobile, all passengers and the driver will benefit from these advantages. This freedom of listener position is of particular importance in application of this system to a theater, where many listeners are seated in various different areas.

Claims

1. A method of reproducing sound from an electrical stereo input signal which contains components (L + R, L - R, R - L) representing direct field sounds and reverberant field sounds, comprising radiating direct field components of the stereo signal through a first loudspeaker arrangement (28,32;42;42';50),



quency range, indicated at 146,148, facing toward each other. Direct field sound speakers 140 and 142 add to the sound heard by all passengers in the car, including those in both front and back seats. Generally, as is well known, the rear speakers mounted on the shelf will provide improved low frequency sound because of their ability to use the automobile trunk as a resonant cavity. The wide dispersion pattern reverberant field speakers 118,120 mounted in the console are sufficiently loud to provide the desired effect for the passengers in the rear seat, who thus get the same effect from the center console mounted speakers. Thus passenger P2 will hear sound from both the front and rear direct field narrow pattern speakers 114,140 and will hear reverberant field sound (L - R) and (R - L) (as modified by a suitable percentage of (L + R)) from wide dispersion pattern speakers 146, 124, 126 and 118. Similarly passenger P4, on the right side of the rear seat, will hear direct field sound from the narrow pattern speakers 116,142 and reverberant field sound from speakers 120,128,130,148, which provide the difference signals (L - R) and (R - L) (both modified by an appropriate percentage of (L + R)). The center rear passenger P3 hears sound just as does the center passenger in the front seat, hearing an image from a point between the front direct field sound speaker pair 114,116 and an image from a point midway between rear mounted direct field speakers 140,142. The center back seat passenger also hears reverberant field sound from the side mounted rear speakers 146,148, but hears little sound from the console mounted wide dispersion pattern speakers 118,120. Wide pattern speakers 146,148 are also fed with a combination of one-half the sum signal with the difference signals, just as are all the wide pattern speakers.

The described speaker arrangements, in most listening situations where the speakers are mounted in a room or area of reasonably large size, are independent of listener position, so that the significant advantages of the system may be enjoyed by a listener regardless of his position with respect to the speakers. This advantage of flexible listener position is somewhat diminished in the close confinement of the interior of an automobile. For such a close space the speaker arrangement is preferably modified to suit the specifically predetermined listener position, which, of course, is dictated by the automobile seating arrangement.

The speaker systems described herein are tolerant of walls and other reflective surfaces because the front radiating speaker or speakers provide sound directly to the listener, whereas the wide dispersion pattern speakers provide sound that is not adversely affected by reflection from walls of the room, inasmuch as such sound is heard as a

reflection or reverberation in the live performance.

Furthermore, as can be seen from the exemplary speaker arrangements illustrated in FIGS. 4, 5, 6, 7 and 8, the speaker choice and arrangement can actually be designed to take advantage of various room sizes, situations and the walls of the room, but is not dependent on such surfaces for its operation, nor is it dependent upon relative location of listener and speakers, except for the confining situation of an automobile where the listener is very close to the speakers, and the described special speaker arrangement is preferred. Accordingly the system is operable outside of any building where no reflective surfaces exist.

As previously mentioned, the described system is compatible with and complementary to the stereo enhancement system described in the above-identified co-pending patent application for Stereo Enhancement System. Desirable effects of the enhancement system of such co-pending application are augmented by the use of the split mode system described herein in the place of ordinary loudspeakers. Although neither the present invention nor that described in the co-pending application requires use of the other, use of the two together considerably enhances operation of both. As previously mentioned, the outputs L_{IN} and L_{OUT} of the enhancement system of my copending application for Stereo Enhancement System may be employed as the inputs L and R of the system illustrated in FIG. 1. Alternatively, the sum, difference and inverting circuits and also the amplifier, if necessary or desirable, of the system of FIG. 1 may be readily incorporated into output portions of the enhancement system of my prior application so that such enhancement system would provide the sum and difference outputs (L + R), (L - R), and (R - L), all based upon signals enhanced as provided in the system of my prior application.

The loudspeaker arrangement illustrated and described herein provides almost complete freedom of listener position. Even in the close confinement of an automobile, all passengers and the driver will benefit from these advantages. This freedom of listener position is of particular importance in application of this system to a theater, where many listeners are seated in various different areas.

Claims

1. A method of reproducing sound from an electrical stereo input signal which contains components (L + R, L - R, R - L) representing direct field sounds and reverberant field sounds, comprising radiating direct field components of the stereo signal through a first loudspeaker arrangement (28,32;42;42';50),



- and radiating reverberant field components through a second loudspeaker arrangement (26,30;38,40;38',40';52,54), characterised in that the reverberant field sound components are radiated in a pattern having a wider omnidirectional dispersion in a frequency range than the radiation pattern of the direct field sound components in the frequency range.
2. A method according to claim 1, wherein the reverberant field is radiated through the second loudspeaker arrangement in a pattern having a dispersion of not less than about 120 degrees.
 3. A method according to claim 1 or 2 wherein the direct field is radiated through the first loudspeaker arrangement in a pattern having a dispersion of not more than about 60 degrees.
 4. A method according to claim 1, 2 or 3, wherein the reverberant field sound components are radiated from at least two mutually spaced locations.
 5. A method according to claim 4, wherein the direct field sound components are radiated from a location or locations between the two mutually spaced locations.
 6. A method according to claim 4 or 5 wherein the reverberant field sound components are radiated by driving speakers of the second loudspeaker arrangement at the two mutually spaced locations with opposite phase signals (L-R, R-L) representing the reverberant field sound components.
 7. A method according to claim 4, 5, or 6, wherein the reverberant field sound component radiated from one or each of the mutually spaced locations is radiated in a pattern having a dispersion of not less than about 120 degrees, and the direct field sound component is radiated in pattern having a dispersion of not more than about 60 degrees.
 8. A method according to any preceding claim, wherein the stereo input signal comprises left (L) and right (R) signal components, and the method further comprises combining the left and right signal components to form a sum signal (L+R) representing the direct field component of the signal, and combining the left and right signal components to form a difference signal (L-R, R-L) representing the reverberant field component of the signal.
 9. A method according to claim 8, further comprising adding a portion of the sum signal (L+R) to the difference signal (L-R, R-L) to form the reverberant field component for driving the second loudspeaker arrangement.
 10. A method according to any preceding claim wherein at least parts of the radiated direct field and reverberant field sound components are directed toward a common area (34,36).
 11. Apparatus for producing sound from an electrical stereo input signal which contains components representing direct field sounds and reverberant field sounds, comprising a first loudspeaker arrangement (28,32;42;42';50) for radiating direct field components of the stereo signal, a second loudspeaker arrangement (26,30;38,40;38',40';52,54) for radiating reverberant field components of the stereo signal, and means (12,14,16,18) for providing signals (L+R, L-R, R-L) representing the direct and reverberant field components to drive the loudspeaker arrangements, characterised in that the second loudspeaker arrangement has a radiation pattern with a wider omnidirectional dispersion in a frequency range than the first loudspeaker arrangement.
 12. Apparatus according to claim 11, wherein the radiation pattern of the second loudspeaker arrangement has a dispersion of not less than about 120 degrees.
 13. Apparatus according to claim 11 or 12, wherein the radiation pattern of the first loudspeaker arrangement has a dispersion of not more than about 60 degrees.
 14. Apparatus according to claim 11,12,or 13 wherein the second loudspeaker arrangement comprises speakers (26,30;38,40;38',40';52,54) for radiating sound from two mutually spaced locations.
 15. Apparatus according to claim 14, wherein the first loudspeaker arrangement comprises a speaker (42;42';50) or speakers (28,32) for radiating sound from a location or locations between the two mutually spaced locations.
 16. Apparatus according to claim 14 or 15 wherein the providing means drives the mutually spaced speakers of the second loudspeaker arrangement with opposite phase signals (L-R, R-L) representing the reverberant field sound components.



17. Apparatus according to claim 15 or 16, wherein the first loudspeaker arrangement comprises a first speaker (28;32;42;42';50), and the second loudspeaker arrangement comprises second (26;38;38';52) and third (30;40;40';54) speakers positioned on opposite sides of the first speaker. 5
18. Apparatus according to claim 17 wherein the first loudspeaker arrangement has a radiation pattern with a dispersion of not more than about 60 degrees, and one or each of the second and third speakers has a radiation pattern with a dispersion of not less than about 120 degrees. 10 15
19. Apparatus according to claim 17 or 18 wherein the first speaker (28;32) comprises first (28) and second (32) narrow dispersion speakers, the first narrow dispersion speaker being positioned adjacent to the second speaker (26) having a wide dispersion pattern, and the second narrow dispersion speaker being positioned adjacent to the third speaker (30) having a wide dispersion pattern. 20
20. Apparatus according to claim 17, wherein the first (42'), second (38') and third (40') speakers are mounted in a cabinet, the second and third speakers being arranged with their axes of radiation extending at a significant angle with respect to the axis of radiation of the first speaker. 30
21. Apparatus according to claim 20, wherein each of the second (38') and third (40') speakers has a radiation pattern with a dispersion of not less than about 180 degrees, and the first speaker (42') has a radiation pattern with a dispersion of not more than about 60 degrees. 35 40
22. Apparatus according to claim 17 or 18, wherein the speakers are mounted adjacent to but spaced from a wall of a room. 45
23. Apparatus according to any of claims 11 to 22, wherein the stereo input signals comprise left (L) and right (R) signal components, and the providing means comprises means (12) for combining the left and right signal components to form a sum signal (L+R) representing the direct field component of the signal, and means (14) for combining the left and right signal components to form a difference signal (L-R, R-L) representing the reverberant component of the signal. 50 55
24. Apparatus according to claim 23, wherein the providing means further comprises means for adding a portion of the sum signal (L+R) to the difference signal (L-R, R-L) to form the reverberant field component for driving the second loudspeaker arrangement.
25. A theatre sound reproduction system including an apparatus as set forth in claim 23 or 24, the first loudspeaker arrangement comprising a first speaker (66;80) and the second loudspeaker arrangement comprising second (68;84) and third (70;86) speakers, the first speaker being responsive to the sum signal (L+R) and being positioned at a central portion of the front of the theatre, the second speaker being responsive to a first difference signal (L-R) and being positioned on one side of the first speaker at the front of the theatre, and the third speaker being responsive to a second difference signal (R-L) and being positioned on the other side of the first speaker at the front of the theatre.
26. A system according to claim 25, further comprising a fourth speaker (72;98) having a wide dispersion pattern positioned at one side of the theatre rearwardly of the front of the theatre and being responsive to the first difference signal (L-R), and a fifth speaker (76;104) having a wide dispersion pattern positioned at the other side of the theatre and being responsive to the second difference signal (R-L).
27. A system according to claim 26, wherein said first mentioned stereo input signal comprises front stereo input signals L_F and R_F provided from a front sound system, and including a rear sound system providing rear left and rear right stereo input signals L_R and R_R , said first (80), second (84), third (86), fourth (98) and fifth (104) speakers being responsive to signals from said front sound system, said set of speakers including a first rear speaker (88) having a narrow dispersion pattern and second (90) and third (92) rear speakers having wide dispersion patterns, said first rear speaker (88) being responsive to a sum signal $(L+R)_R$ representing the sum of the rear left and rear right stereo input signals, said second rear speaker (90) being responsive to a difference signal $(L-R)_R$ representing a difference between the rear left and rear right stereo input signals, said third rear speaker (92) being responsive to a difference signal $(R-L)_R$ representing the difference between the rear right and rear left stereo input signals, said first rear speaker (88) being positioned at the centre of



the rear of the theatre, and said second (90) and third (92) rear speakers being positioned at the rear of the theatre on either side of the first rear speaker (88).

28. A system according to claim 27, including first (96) and second (102) combined front and rear speakers each having a wide dispersion pattern and positioned respectively on opposite sides of the theatre, the first combined front and rear speaker (96) being responsive to a combined difference signal $(L-R)_{F+R}$ representing the sum of a difference signal of the front sound system and difference signal of the rear sound system, and the second combined front and rear speaker (102) being responsive to a combined difference signal $(R-L)_{F+R}$ representing the sum of a difference signal of the front sound system and a difference signal of the rear sound system.

29. An automobile sound reproduction system including an apparatus as set forth in claim 23 or 24, the first loudspeaker arrangement comprising a first speaker mounted in a central portion of the dashboard of the automobile, and the second loudspeaker arrangement comprising second and third loudspeakers positioned adjacent opposite sides of the automobile.

30. An automobile sound reproduction system including an apparatus as set forth in claim 23 or 24, the first loudspeaker arrangement comprising a first speaker (114) mounted adjacent to one end of the dashboard of the automobile and the second loudspeaker arrangement comprising second (110,124) and third (118,126) speakers, the second speaker (110,124) being mounted at a first side of the automobile at a first distance from the driver seat, and the third speaker (118,126) being mounted at a distance from the driver seat substantially equal to the first distance.

31. A system according to claim 30 further including a fourth speaker (116) having a narrow dispersion pattern and fifth (112,130) and sixth (120,128) speakers having wide dispersion patterns, said fourth speaker (116) being mounted on the dashboard adjacent to a passenger seat position, said fifth speaker (112,130) being mounted at a second side of the automobile at second distance from the passenger seat position, and wherein said sixth speaker (120,128) is mounted between the first and second sides at a distance from the passenger position substantially equal to said second distance.

32. A system according to claim 31, wherein each of the second (124), third (126), fifth (130) and sixth (128) speakers includes a tweeter, each of said tweeters being mounted on the dashboard.

33. A system according to claim 32, wherein the automobile includes a rear passenger seat and a rear shelf behind the rear passenger seat, and including a seventh speaker (140) having a narrow dispersion pattern mounted at one side of the rear shelf and an eighth speaker (142) having a narrow dispersion pattern mounted on a second side of the rear shelf, a ninth speaker (146) having a wide dispersion pattern mounted at first side adjacent to the rear passenger seat and a tenth speaker (148) having a wide dispersion pattern mounted at the second side adjacent to the rear passenger seat, and means responsive to the stereo input signal for providing the sum signal to the seventh (140) and eighth (142) speakers and for providing difference signals to the ninth (146) and tenth speakers.

Patentansprüche

1. Ein Verfahren zum Reproduzieren eines Tons von einem elektrischen Stereoeingangssignal, welches Komponenten $(L + R, L - R, R - L)$ enthält, die Direktfeld-Töne und Widerhallfeld-Töne repräsentieren, welches das Austrahlen von Direktfeld-Komponenten des Stereosignals durch eine erste Lautsprecheranordnung (28, 32; 42; 42'; 50) und Austrahlen von Widerhallfeld-Komponenten durch eine zweite Lautsprecheranordnung (26, 30; 38, 40; 38', 40'; 52, 54) umfaßt, **dadurch gekennzeichnet**, daß

die Widerhallfeld-Tonkomponenten in einem Muster ausgestrahlt werden, welches eine breitere nach allen Richtungen ausgehende Verteilung in einem Frequenzbereich als das Strahlungsmuster der Direktfeld-Tonkomponenten in dem Frequenzbereich aufweist.

2. Ein Verfahren nach Anspruch 1, worin das Widerhallfeld durch die zweite Lautsprecheranordnung in einem Muster ausgestrahlt wird, welches eine Verteilung von nicht weniger als etwa 120° aufweist.

3. Ein Verfahren nach Anspruch 1 oder 2, worin das Direktfeld durch die erste Lautsprecheranordnung in einem Muster ausgestrahlt wird, welches eine Verteilung von nicht mehr als etwa 60° aufweist.



4. Ein Verfahren nach Anspruch 1, 2 oder 3, worin die Widerhallfeld-Tonkomponenten von wenigstens zwei wechselseitig beabstandeten Anordnungen abgestrahlt werden.

5. Ein Verfahren nach Anspruch 4, worin die Direktfeld-Tonkomponenten von einer Stelle oder von Stellen zwischen den zwei wechselseitig beabstandeten Stellen abgestrahlt werden.

6. Ein Verfahren nach Anspruch 4 oder 5, worin die Widerhallfeld-Tonkomponenten durch ansteuernde Lautsprecher der zweiten Lautsprecheranordnung an den zwei wechselseitig beabstandeten Stellen mit entgegengesetzten Phasensignalen (L - R) ausgestrahlt werden, welche die Widerhallfeld-Tonkomponenten repräsentieren.

7. Ein Verfahren nach Anspruch 4, 5 oder 6, worin die Widerhallfeld-Tonkomponente, welche von einer oder jeder der wechselseitig beabstandeten Stellen ausgestrahlt wird, in einem Muster ausgestrahlt wird, welches eine Verteilung von nicht weniger als 120° aufweist, und die Direktfeld-Tonkomponente in einem Muster ausgestrahlt wird, welche eine Verteilung von nicht mehr als etwa 60° aufweist.

8. Ein Verfahren nach irgendeinem der vorhergehenden Ansprüche, worin das Stereoeingangssignal linke (L) und (R) Signalkomponenten aufweist und das Verfahren des weiteren ein Kombinieren der linken und rechten Signalkomponenten umfaßt, um ein Summensignal (L + R) zu bilden, welches die Direktfeld-Komponente des Signals repräsentiert, und Kombinieren der linken und rechten Signalkomponenten, um ein Differenzsignal (L - R, R - L) zu bilden, welches die Widerhallfeld-Komponente des Signals repräsentiert.

9. Ein Verfahren nach Anspruch 8, welches des weiteren ein Hinzufügen eines Teils des Summensignals (L + R) zu dem Differenzsignal (L - R, R - L) umfaßt, um die Widerhallfeld-Komponente zum Ansteuern der zweiten Lautsprecheranordnung zu bilden.

10. Ein Verfahren nach irgendeinem der vorhergehenden Ansprüche, worin wenigstens Teile der ausgestrahlten Direktfeld- und Widerhallfeld-Tonkomponenten auf ein gemeinsames Gebiet (34, 36) gerichtet sind.

11. Vorrichtung zum Erzeugen eines Tons aus einem elektrischen Stereoeingangssignal, welches Komponenten enthält, die Direktfeld-Töne

und Widerhallfeld-Töne repräsentieren, mit einer ersten Lautsprecheranordnung (28, 32; 42; 42'; 50) zum Ausstrahlen von Direktfeld-Komponenten des Stereosignals, einer zweiten Lautsprecheranordnung (28, 30; 38, 40; 38', 40'; 52, 54) zum Ausstrahlen von Widerhallfeld-Komponenten des Stereosignals und eine Einrichtung (12, 14, 16, 18) zum Bereitstellen von Signalen (L + R, L - R, R - L), welche die Direkt- und Widerhallfeld-Komponenten repräsentieren, zum Ansteuern der Lautsprecheranordnungen, dadurch gekennzeichnet, daß

die zweite Lautsprecheranordnung ein Strahlungsmuster mit einer breiteren in alle Richtungen ausgehende Verteilung in einem Frequenzbereich als die erste Lautsprecheranordnung aufweist.

12. Vorrichtung nach Anspruch 11, worin das Strahlungsmuster der zweiten Lautsprecheranordnung eine Verteilung von nicht weniger als etwa 120° aufweist.

13. Vorrichtung nach Anspruch 11 oder 12, worin das Strahlungsmuster der ersten Lautsprecheranordnung eine Verteilung von mehr als etwa 60° aufweist.

14. Vorrichtung nach Anspruch 11, 12 oder 13, worin die zweite Lautsprecheranordnung Lautsprecher (26, 30; 38, 40; 38', 40'; 52, 54) zum Ausstrahlen eines Tones von zwei wechselseitig beabstandeten Stellen umfaßt.

15. Vorrichtung nach Anspruch 14, worin die erste Lautsprecheranordnung einen Lautsprecher (42; 42'; 50) oder Lautsprecher (28, 32) zum Ausstrahlen eines Tones von einer Stelle oder von Stellen zwischen den zwei wechselseitig beabstandeten Stellen umfaßt.

16. Eine Vorrichtung nach Anspruch 14 oder 15, worin die Bereitstellungseinrichtung die wechselseitig beabstandeten Lautsprecher der zweiten Lautsprecheranordnung mit entgegengesetzten Phasensignalen (L - R, R - L) ansteuert, welche die Widerhallfeld-Tonkomponenten repräsentieren.

17. Vorrichtung nach Anspruch 15 oder 16, worin die erste Lautsprecheranordnung einen ersten Lautsprecher (28, 32; 42; 42'; 50) umfaßt und die zweite Lautsprecheranordnung zweite (26; 38; 38'; 52) und dritte (30; 40; 40'; 54) Lautsprecher umfaßt, welche auf entgegengesetzten Seiten des ersten Lautsprechers positioniert sind.



18. Vorrichtung nach Anspruch 17, worin die erste Lautsprecheranordnung ein Strahlungsmuster mit einer Verteilung von nicht mehr als etwa 60° aufweist und ein oder jeder der zweiten und dritten Lautsprecher ein Strahlungsmuster mit einer Verteilung von nicht weniger als etwa 120° aufweist. 5
19. Vorrichtung nach Anspruch 17 oder 18, worin der erste Lautsprecher (28, 32) erste (28) und zweite (32) Lautsprecher mit enger Verteilung umfaßt, der erste Lautsprecher mit enger Verteilung benachbart zu dem zweiten Lautsprecher (26) positioniert ist, welcher ein breites Verteilungsmuster aufweist, und der zweite Lautsprecher mit enger Verteilung benachbart dem dritten Lautsprecher (30) positioniert ist, welcher ein breites Verteilungsmuster aufweist. 10 15
20. Vorrichtung nach Anspruch 17, worin die ersten (42'), zweiten (38') und dritten (40') Lautsprecher in einen kleinen Raum angebracht sind, die zweiten und dritten Lautsprecher sich mit ihren Strahlungsachsen in einem signifikanten Winkel hinblicklich der Strahlungsachse des ersten Lautsprechers erstreckend angeordnet sind. 20 25
21. Vorrichtung nach Anspruch 20, worin jeder der zweiten (38') und dritten (40') Lautsprecher ein Strahlungsmuster mit einer Verteilung von nicht weniger als etwa 180° aufweist und der erste Lautsprecher (42') ein Strahlungsmuster mit einer Verteilung von nicht mehr als etwa 60° aufweist. 30 35
22. Vorrichtung nach Anspruch 17 oder 18, worin die Lautsprecher benachbart jedoch von einer Wand eines Raumes beabstandet angebracht sind. 40
23. Vorrichtung nach irgendeinem der Ansprüche 11 bis 22, worin die Stereoeingangssignale linke (L) und rechte (R) Signalkomponenten umfassen und die Bereitstellungseinrichtung eine Einrichtung (12) zum Kombinieren der linken und rechten Signalkomponenten umfaßt, um ein Summensignal ($L + R$) zu bilden, welches die Direktfeld-Komponente des Signals repräsentiert, und eine Einrichtung (14) zum Kombinieren der linken und rechten Signalkomponenten, um ein Differenzsignal ($L - R$, $R - L$) bilden, welches die Widerhall-Komponente des Signals repräsentiert. 45 50 55
24. Vorrichtung nach Anspruch 23, worin die Bereitstellungseinrichtung des weiteren eine Einrichtung zum Addieren eines Teils des Summensignals ($L + R$) zum dem Differenzsignal ($L - R$, $R - L$) umfaßt, um die Widerhallfeld-Komponente zum Ansteuern der zweiten Lautsprecheranordnung zu bilden.
25. Ein Theater-Tonreproduktionssystem, welches eine Vorrichtung nach Anspruch 23 oder 24 aufweist, wobei die erste Lautsprechereinrichtung einen ersten Lautsprecher (66; 80) und die zweite Lautsprecheranordnung zweite (68; 84) und dritte (70; 86) Lautsprecher umfaßt, wobei der erste Lautsprecher auf das Summensignal ($L + R$) anspricht und an einem Zentralteil der Vorderseite des Theaters positioniert ist, der zweite Lautsprecher auf ein erstes Differenzsignal ($L - R$) anspricht und auf einer Seite des ersten Lautsprechers an der Vorderseite des Theaters positioniert ist und der dritte Lautsprecher auf ein zweites Differenzsignal ($R - L$) anspricht und auf der anderen Seite des ersten Lautsprechers an der Vorderseite des Theaters positioniert ist.
26. Ein System nach Anspruch 25, welches des weiteren einen vierten Lautsprecher (72; 98) umfaßt, welcher ein breites Verteilungsmuster aufweist, an einer Seite des Theaters rückwärtig der Vorderseite des Theaters positioniert ist und auf das erste Differenzsignal ($L - R$) anspricht, und einen fünften Lautsprecher (76; 104), welcher ein breites Verteilungsmuster aufweist, an der anderen Seite des Theaters positioniert ist und auf das zweite Differenzsignal ($R - L$) anspricht.
27. Ein System nach Anspruch 26, worin das erste erwähnte Stereoeingangssignal vordere Stereoeingangssignale L_F und R_F umfaßt, welche von einem Vorderseiten-Tonsystem bereitgestellt werden, und welches ein Rückseiten-Tonsystem enthält, welches rückseitig linke und rückseitig rechte Stereoeingangssignale L_R und R_R vorsieht, wobei die ersten (80), zweiten (84), dritten (86), vierten (98) und fünften (104) Lautsprecher auf Signale von dem Vorderseiten-Tonsystem ansprechen, wobei der Lautsprechersatz einen ersten Rückseitenlautsprecher (88) enthält, welcher ein enges Verteilungsmuster aufweist, und einen zweiten (90) und dritten (92) Rückseitenlautsprecher, welche breite Verteilungsmuster aufweisen, wobei der erste Rückseitenlautsprecher (88) auf ein Summensignal ($L + R$)_R anspricht, welches die Summe der rückseitigen linken und rückseitigen rechten Stereoeingangssignale repräsentiert, wobei der zweite Rückseitenlautsprecher (90) auf ein Differenzsignal ($L - R$)_R anspricht, welches eine Differenz zwischen dem rücksei-



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28. Ein System nach Anspruch 27, welches erste (96) und zweite (102) kombinierte Vorderseiten- und Rückseitenlautsprecher enthält, welche jeweils ein breites Verteilungsmuster aufweisen und jeweils auf entgegengesetzten Seiten des Theaters positioniert sind, wobei der erste kombinierte Vorderseiten- und Rückseitenlautsprecher (96) auf ein kombiniertes Differenzsignal $(L - R)_{F+R}$ anspricht, welches die Summe eines Differenzsignals des Vorderseitentonsystems und ein Differenzsignal des Rückseitentonsystems repräsentiert, und wobei der zweite kombinierte Vorderseiten- und Rückseitenlautsprecher (102) auf ein kombiniertes Differenzsignal $(R - L)_{F+R}$ anspricht, welches die Summe eines Differenzsignals des Vorderseitentonsystems und eines Differenzsignals des Rückseitentonsystems repräsentiert.
29. Ein Automobil-Tonreproduktionssystem, welches eine Vorrichtung nach Anspruch 23 oder 24 enthält, wobei die erste Lautsprecheranordnung einen ersten Lautsprecher umfaßt, welcher in einem Zentralteil des Armaturenbrettes des Automobils angebracht ist, und die zweite Lautsprecheranordnung zweite und dritte Lautsprecher umfaßt, welche benachbart entgegengesetzten Seiten des Automobils positioniert sind.
30. Ein Automobil-Tonreproduktionssystem, welches eine Vorrichtung nach Anspruch 23 oder 24 enthält, wobei die erste Lautsprecheranordnung einen ersten Lautsprecher (114) umfaßt, welcher benachbart einem Ende des Armaturenbrettes des Automobils angebracht ist, und die zweite Lautsprecheranordnung zweite (110, 124) und dritte (118, 126) Lautsprecher umfaßt, wobei der zweite Lautsprecher (110, 124) an einer ersten Seite des Automobils in einer ersten Distanz von dem Fahrersitz angebracht ist und der dritte Lautsprecher in einer Distanz von dem Fahrersitz im wesentlichen gleich zu der ersten Distanz angebracht ist.
31. Ein System nach Anspruch 30, welches des weiteren einen vierten Lautsprecher (116) umfaßt, welcher ein enges Verteilungsmuster aufweist, und fünfte (112, 130) und sechste (120, 128) Lautsprecher, welche ein breites Verteilungsmuster aufweisen, wobei der vierte Lautsprecher (116) auf dem Armaturenbrett benachbart zu einer Passagiersitzposition angebracht ist, wobei der fünfte Lautsprecher (112, 130) an einer zweiten Seite des Automobils in einer zweiten Distanz von der Passagiersitzposition angebracht ist, und worin der sechste Lautsprecher (120, 128) zwischen den ersten und zweiten Seiten in einer Distanz von der Passagierposition im wesentlichen gleich der zweiten Distanz angebracht ist.
32. Ein System nach Anspruch 31, worin jeder der zweiten (124), dritten (126), fünften (130) und sechsten (128) Lautsprecher einen Hochtonlautsprecher umfaßt, wobei jeder der Hochtonlautsprecher auf dem Armaturenbrett angebracht ist.
33. Ein System nach Anspruch 32, worin das Automobil einen Rückseitenpassagiersitz und einen Rückseitensockel hinter dem Rückseitenpassagiersitz umfaßt und einen siebenten Lautsprecher (140) umfaßt, welcher ein enges Verteilungsmuster aufweist und an einer Seite des Rückseitensockels angebracht ist, und einen achten Lautsprecher (142), welcher ein enges Verteilungsmuster aufweist und auf einer zweiten Seite des Rückseitensockels angebracht ist, einen neunten Lautsprecher (146), welcher ein breites Verteilungsmuster aufweist und an der ersten Seite benachbart zu dem Rückseitenpassagiersitz angebracht ist, und einen zehnten Lautsprecher (148), welcher ein breites Verteilungsmuster aufweist und an der zweiten Seite benachbart zu dem Rückseitenpassagiersitz angebracht ist, und eine Einrichtung, welche auf das Stereoeingangssignal anspricht, zum Bereitstellen des Summensignals für die siebenten (140) und achten (142) Lautsprecher und zum Bereitstellen von Differenzsignalen für die neunten (146) und zehnten Lautsprecher.

Revendications

1. Un procédé de reproduction de son à partir d'un signal d'entrée stéréophonique électrique qui contient des composantes $(L + R, L - R, R - L)$ représentant des sons de champ direct et des sons de champ de réverbération, comprenant les opérations qui consistent à rayonner des composantes de champ direct du signal stéréophonique par l'intermédiaire d'une première



- configuration de haut-parleurs (28, 32; 42; 42'; 50), et à rayonner des composantes de champ de réverbération par l'intermédiaire d'une seconde configuration de haut-parleurs (26,30; 38, 40; 38', 40'; 52, 54), caractérisé en ce que les composantes de sons de champ de réverbération sont rayonnées selon un diagramme ayant une dispersion omnidirectionnelle plus large, dans une gamme de fréquence, que le diagramme de rayonnement des composantes de sons de champ direct dans la gamme de fréquence.
2. Un procédé selon la revendication 1, dans lequel le champ de réverbération est rayonné par l'intermédiaire de la seconde configuration de haut-parleurs selon un diagramme ayant une dispersion qui n'est pas inférieure à environ 120 degrés.
 3. Un procédé selon la revendication 1 ou 2, dans lequel le champ direct est rayonné par l'intermédiaire de la première configuration de haut-parleurs selon un diagramme ayant une dispersion qui n'est pas supérieure à environ 60 degrés.
 4. Un procédé selon la revendication 1, 2 ou 3, dans lequel les composantes de sons de champ de réverbération sont rayonnées à partir d'au moins deux emplacements mutuellement espacés.
 5. Un procédé selon la revendication 4, dans lequel les composantes de sons de champ direct sont rayonnées à partir d'un emplacement ou de plusieurs emplacements situés entre les deux emplacements mutuellement espacés.
 6. Un procédé selon la revendication 4 ou 5, dans lequel les composantes de sons de champ de réverbération sont rayonnées en attaquant des haut-parleurs de la seconde configuration de haut-parleurs aux deux emplacements mutuellement espacés, avec des signaux en opposition de phase (L-R, R-L) représentant les composantes de sons de champ de réverbération.
 7. Un procédé selon la revendication 4, 5 ou 6, dans lequel la composante de son de champ de réverbération qui est rayonnée à partir de l'un ou de chacun des emplacements mutuellement espacés, est rayonnée avec un diagramme ayant une dispersion qui n'est pas inférieure à environ 120 degrés, et la composante de son de champ direct est rayonnée avec un diagramme ayant une dispersion qui n'est pas supérieure à environ 60 degrés.
 8. Un procédé selon l'une quelconque des revendications précédentes, dans lequel le signal d'entrée stéréophonique comprend des composantes de signal gauche (L) et droite (R), et le procédé comprend en outre la combinaison des composantes de signal gauche et droite pour former un signal de somme (L + R) représentant la composante de champ direct du signal, et la combinaison des composantes de signal gauche et droite pour former un signal de différence (L-R, R-L) représentant la composante de champ de réverbération du signal.
 9. Un procédé selon la revendication 8, comprenant en outre l'ajout d'une partie du signal de somme (L + R) au signal de différence (L-R, R-L), pour former la composante de champ de réverbération pour attaquer la seconde configuration de haut-parleurs.
 10. Un procédé selon l'une quelconque des revendications précédentes, dans lequel des parties au moins des composantes de sons rayonnées du champ direct et du champ de réverbération sont dirigées vers une zone commune (34, 36).
 11. Appareil pour produire du son à partir d'un signal d'entrée stéréophonique électrique qui contient des composantes représentant des sons de champ direct et des sons de champ de réverbération, comprenant une première configuration de haut-parleurs (28, 32; 42; 42'; 50), pour rayonner des composantes de champ direct du signal stéréophonique, une seconde configuration de haut-parleurs (26, 30; 38, 40; 38', 40'; 52, 54) pour rayonner des composantes de champ de réverbération du signal stéréophonique, et des moyens (12, 14, 16, 18) pour produire des signaux (L + R, L-R, R-L) représentant les composantes de champ direct et de champ de réverbération, pour attaquer les configurations de haut-parleurs, caractérisé en ce que la seconde configuration de haut-parleurs a un diagramme de rayonnement avec une dispersion omnidirectionnelle plus large, dans une gamme de fréquence, que celle de la première configuration de haut-parleurs.
 12. Appareil selon la revendication 11, dans lequel le diagramme de rayonnement de la seconde configuration de haut-parleurs a une dispersion qui n'est pas inférieure à environ 120 degrés.



13. Appareil selon la revendication 11 ou 12, dans lequel le diagramme de rayonnement de la première configuration de haut-parleurs a une dispersion qui n'est pas supérieure à environ 60 degrés. 5
14. Appareil selon la revendication 11, 12 ou 13, dans lequel la seconde configuration de haut-parleurs comprend des haut-parleurs (26, 30; 38, 40; 38', 40'; 52, 54) qui sont destinés à rayonner du son à partir de deux emplacements mutuellement espacés. 10
15. Appareil selon la revendication 14, dans lequel la première configuration de haut-parleurs comprend un haut-parleur (42, 42'; 50) ou des haut-parleurs (28, 32) pour rayonner du son à partir d'un emplacement ou de plusieurs emplacements se trouvant entre les deux emplacements mutuellement espacés. 15
16. Appareil selon la revendication 14 ou 15, dans lequel les moyens produisant des signaux attaquent les haut-parleurs mutuellement espacés de la seconde configuration de haut-parleurs avec des signaux de phase opposées (L-R, R-L) représentant les composantes de sons de champ de réverbération. 20
17. Appareil selon la revendication 15 ou 16, dans lequel la première configuration de haut-parleurs comprend un premier haut-parleur (28, 32; 42, 42'; 50), et la seconde configuration de haut-parleurs comprend des second (26; 38, 38'; 52) et troisième (30; 40, 40'; 54) haut-parleurs qui sont placés de part et d'autre du premier haut-parleur. 25
18. Appareil selon la revendication 17, dans lequel la première configuration de haut-parleurs a un diagramme de rayonnement avec une dispersion qui n'est pas supérieure à environ 60 degrés, et l'un ou chacun des second et troisième haut-parleurs a un diagramme de rayonnement avec une dispersion qui n'est pas inférieure à environ 120 degrés. 30
19. Appareil selon la revendication 17 ou 18, dans lequel le premier haut-parleur (28, 32) comprend des premier (28) et second (32) haut-parleurs à dispersion étroite, le premier haut-parleur à dispersion étroite étant placé en position adjacente au second haut-parleur (26) ayant un diagramme à dispersion large, et le second haut-parleur à dispersion étroite étant placé en position adjacente au troisième haut-parleur (30) ayant un diagramme à dispersion large. 35
20. Appareil selon la revendication 17, dans lequel les premier (42'), second (38') et troisième (40') haut-parleurs sont montés dans une enceinte, les second et troisième haut-parleurs étant disposés avec leurs axes de rayonnement orientés selon un angle notable par rapport à l'axe de rotation du premier haut-parleur. 40
21. Appareil selon la revendication 20, dans lequel chacun des second (38') et troisième (40') haut-parleurs a un diagramme de rayonnement avec une dispersion qui n'est pas inférieure à environ 180 degrés, et le premier haut-parleur (42') a un diagramme de rayonnement avec une dispersion qui n'est pas supérieure à environ 60 degrés. 45
22. Appareil selon la revendication 17 ou 18, dans lequel les haut-parleurs sont montés de façon à être adjacents à une paroi d'une pièce, mais en étant espacés de cette paroi. 50
23. Appareil selon l'une quelconque des revendications 11 à 22, dans lequel les signaux d'entrée stéréophoniques comprennent des composantes de signal gauche (L) et droite (R), et les moyens produisant des signaux comprennent des moyens (12) destinés à combiner les composantes de signaux gauche et droite pour former un signal de somme (L+R) représentant la composante de champ direct du signal, et des moyens (14) pour combiner les composantes de signal gauche et droite pour former un signal de différence (L-R, R-L) représentant la composante de réverbération du signal. 55
24. Appareil selon la revendication 23, dans lequel les moyens produisant des signaux comprennent en outre des moyens destinés à ajouter une partie du signal de somme (L+R) au signal de différence (L-R, R-L), pour former la composante de champ de réverbération pour attaquer la seconde configuration de haut-parleurs.
25. Un système de reproduction sonore pour salle de concert, comprenant un appareil selon la revendication 23 ou 24, la première configuration de haut-parleurs comprenant un premier haut-parleur (66; 80) et la seconde configuration de haut-parleurs comprenant des second (68; 84) et troisième (70; 86) haut-parleurs, le premier haut-parleur réagissant au signal de somme (L+R) et étant positionné dans une partie centrale de l'avant de la salle de concert, le second haut-parleur réagissant à un premier signal de différence (L-R) et étant po-



sitionné d'un côté du premier haut-parleur, à l'avant de la salle de concert, et le troisième haut-parleur réagissant à un second signal de différence (R-L) et étant positionné de l'autre côté du premier haut-parleur à l'avant de la salle de concert.

26. Un système selon la revendication 25, comprenant en outre un quatrième haut-parleur (72; 98) ayant un diagramme à dispersion large, qui est placé d'un côté de la salle de concert, vers l'arrière par rapport à l'avant de la salle de concert, et qui réagit au premier signal de différence (L-R), et un cinquième haut-parleur (76; 104) ayant un diagramme à dispersion large, qui est positionné de l'autre côté de la salle de concert et qui réagit au second signal de différence (R-L).

27. Un système selon la revendication 26, dans lequel le signal d'entrée stéréophonique mentionné en premier comprend des signaux d'entrée stéréophoniques avant L_F et R_F qui sont fournis par un système sonore avant, et comprenant un système sonore arrière qui produit des signaux d'entrée stéréophoniques gauche arrière et droit arrière, L_R et R_R , les premier (80), second (84), troisième (86), quatrième (98) et cinquième (104) haut-parleurs réagissant à des signaux qui proviennent du système sonore avant, cet ensemble de haut-parleurs comprenant un premier haut-parleur arrière (88) ayant un diagramme à dispersion étroite, et des second (90) et troisième (92) haut-parleurs arrière ayant des diagrammes à dispersion large, le premier haut-parleur arrière (88) réagissant à un signal de somme $(L+R)_R$ qui représente la somme des signaux d'entrée stéréophoniques gauche arrière et droit arrière, le second haut-parleur arrière (90) réagissant à un signal de différence $(L-R)_R$ qui représente une différence entre les signaux d'entrée stéréophoniques gauche arrière et droit arrière, le troisième haut-parleur arrière (92) réagissant à un signal de différence $(R-L)_R$ qui représente la différence entre les signaux d'entrée stéréophoniques droit arrière et gauche arrière, le premier haut-parleur arrière (88) étant positionné au centre de l'arrière de la salle, et les second (90) et troisième (92) haut-parleurs arrière étant positionnés à l'arrière de la salle, de chaque côté du premier haut-parleur arrière (88).

28. Un système selon la revendication 27, comprenant des premier (96) et second (102) haut-parleurs avant et arrière combinés, ayant chacun un diagramme à dispersion large, et étant

respectivement positionnés sur des côtés opposés de la salle de concert, le premier haut-parleur avant et arrière combiné (96) réagissant à un signal de différence combiné $(L-R)_{F+R}$ représentant la somme d'un signal de différence du système sonore avant et d'un signal de différence du système sonore arrière, et le second haut-parleur avant et arrière combiné (102) réagissant à un signal de différence combiné $(R-L)_{F+R}$ représentant la somme d'un signal de différence du système sonore avant et d'un signal de différence du système sonore arrière.

29. Un système de reproduction sonore d'automobile, comprenant un appareil selon la revendication 23 ou 24, la première configuration de haut-parleurs comprenant un premier haut-parleur qui est monté dans une partie centrale du tableau de bord de l'automobile, et la seconde configuration de haut-parleurs comprenant des second et troisième haut-parleurs qui sont placés dans des positions adjacentes aux côtés opposés de l'automobile.

30. Un système de reproduction sonore d'automobile comprenant un appareil selon la revendication 23 ou 24, la première configuration de haut-parleurs comprenant un premier haut-parleur (114) qui est monté en position adjacente à une extrémité du tableau de bord de l'automobile, et la seconde configuration de haut-parleurs comprenant des second (110, 124) et troisième (118, 126) haut-parleurs, le second haut-parleur (110, 124) étant monté sur un premier côté de l'automobile, à une première distance du siège du conducteur, et le troisième haut-parleur (118, 126) étant monté à une distance du siège du conducteur qui est pratiquement égale à la première distance.

31. Un système selon la revendication 30, comprenant en outre un quatrième haut-parleur (116) ayant un diagramme à dispersion étroite et des cinquième (112, 130) et sixième (120, 128) haut-parleurs ayant des diagrammes à dispersion large, le quatrième haut-parleur (116) étant monté sur le tableau de bord en position adjacente à la position d'un siège de passager, le cinquième haut-parleur (112, 130) étant monté sur un second côté de l'automobile, à une seconde distance de la position de siège de passager, tandis que le sixième haut-parleur (120, 128) est monté entre les premier et second côtés, à une distance de la position de passager qui est pratiquement égale à la seconde distance.



32. Un système selon la revendication 31, dans lequel chacun des second (124), troisième (126), cinquième (130) et sixième (128) haut-parleurs comprend un haut-parleur d'aigus, chacun de ces haut-parleurs d'aigus étant monté sur le tableau de bord. 5

33. Un système selon la revendication 32, dans lequel l'automobile comprend un siège de passager arrière et une plage arrière derrière le siège de passager arrière, et comprenant un septième haut-parleur (140) ayant un diagramme à dispersion étroite, qui est monté d'un côté de la plage arrière, et un huitième haut-parleur (142) ayant un diagramme à dispersion étroite qui est monté d'un second côté de la plage arrière, un neuvième haut-parleur (146) ayant un diagramme à dispersion large, monté du premier côté en position adjacente au siège de passager arrière, et un dixième haut-parleur (148) ayant un diagramme à dispersion large, monté du second côté, en position adjacente au siège de passager arrière, et des moyens qui réagissent au signal d'entrée stéréophonique en appliquant le signal de somme aux septième (140) et huitième (142) haut-parleurs, et en appliquant des signaux de différence aux neuvième (146) et dixième haut-parleurs. 10 15 20 25

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