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ACOUSTIC PLAYBACK SYSTEM HAVING IMPROVED CANCELLATION COMPENSATION

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Disclosed herein is an acoustic playback system comprising a housing having a first side, a second side opposite the first side, and a plurality of walls connecting the first side with the second side; at least one amplifier configured to receive an electrical signal representative of an audio and output an amplified audio signal; a primary driver configured to receive the amplified audio signal and output a primary audio, based on the amplified
- audio signal, from the first side; a filler driver configured to receive the amplified audio signal and output a secondary audio, based on the amplified audio signal, from the second side; and a filter in communication with the filler driver and configured to apply a filter to the electrical signal and/or the amplified audio signal; wherein the primary driver output is spaced away from the filler driver output.

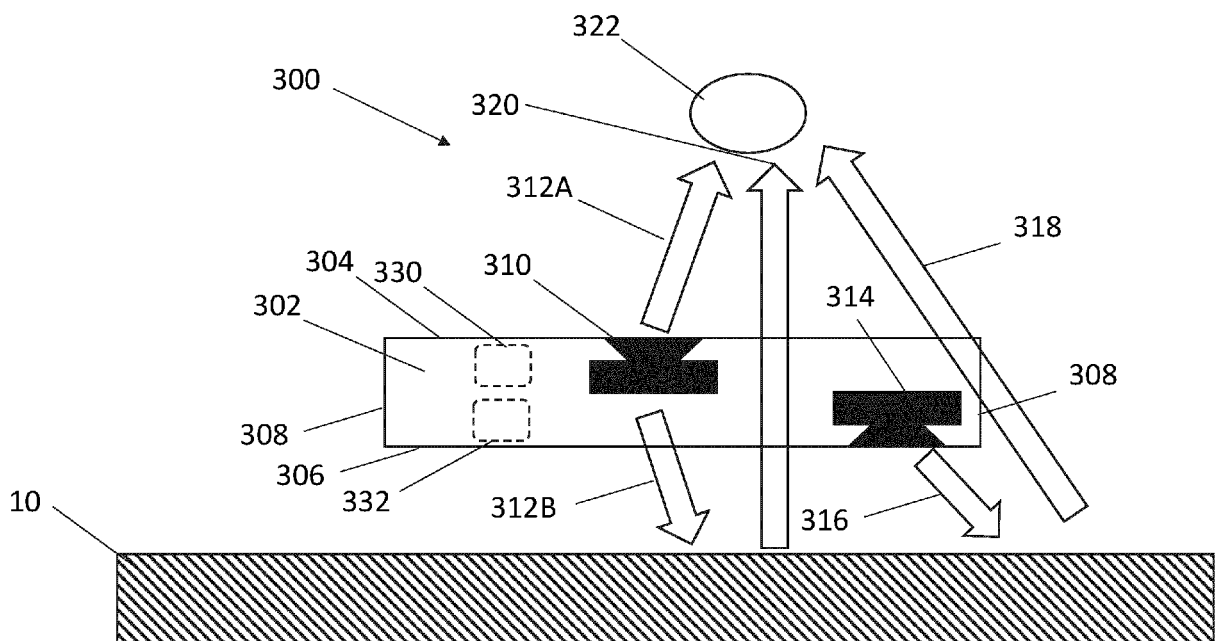


FIG. 3

Description

TECHNICAL FIELD

[0001] The present application relates to the field of acoustic playback systems. In particular, the present application relates to the compensation of cancellation effects that occur in an acoustic playback system.

SUMMARY

An acoustic playback system:

[0002] In an aspect of the present application, an acoustic playback system is disclosed. The acoustic playback system includes a housing. The housing has a first side. The housing has a second side opposite the first side. The housing has a plurality of walls connecting the first side with the second side. The acoustic playback system includes at least one amplifier. The at least one amplifier is configured to receive an electrical signal representative of an audio and output an amplified audio signal. The acoustic playback system includes a primary driver. The primary driver is configured to receive the amplified audio signal. The primary driver is configured to output a primary audio, based on the amplified audio signal, from the first side. The acoustic playback system includes a filler driver. The filler driver is configured to receive the amplified audio signal. The filler driver is configured to output a secondary audio, based on the amplified audio signal from the second side. The acoustic playback system includes a filter. The filter can be in communication with the filler driver. The filter is configured to apply a filter to the electrical signal and/or the amplified audio signal. The primary driver output is spaced away from the filler driver output.

[0003] Advantageously, embodiments of the disclosed acoustic playback system can avoid and/or reduce the cancellation effect normally experienced by an acoustic playback system located near a wall, or other acoustically reflecting surface. The reflections by the wall lead to destructive interference, thereby creating dead zones of acoustic cancellation (e.g., dips), where the acoustic output of the acoustic playback system will not be heard. By including a secondary driver, e.g., a filler driver, the disclosed acoustic playback system can reduce or eliminate such a dead zone thereby providing an improved hearing experience to a user. Further, the filler driver can contribute to overall sound pressure.

[0004] Disclosed herein are embodiments of an acoustic playback system (e.g., acoustic playback device, acoustical playback system, audio reproduction system, audio reproduction device). In one or more example acoustic playback systems, the acoustic playback system can be one of a sound bar, a speaker, a video bar, a loudspeaker, and a subwoofer. The acoustic playback system can include a communication bar, a satellite speaker, a Bluetooth speaker, a built-in monitor and/or

television speaker, and a speaker phone. The acoustic playback system can include one or more speakers.

[0005] The acoustic playback system can be configured to be located and/or mounted and/or installed at a location near an acoustically reflective surface, such as a wall. For example, the acoustic playback system can include one or more components configured to connect the acoustic playback system to and/or near a wall. In certain examples, the acoustic playback system can be configured to be received within a frame or other component for locating the acoustic playback system near a wall. As used herein, a wall can be any surface which is acoustically reflective.

[0006] The acoustic playback system can include a housing. The housing can be configured to retain one or more electrical and/or acoustic components of the playback system. The housing can have a plurality of different shapes, and the general shape of the housing is not limiting. For example, the housing can be one of a rectangular prism, a triangular prism, a cylinder, a cone, etc. The housing can be formed from one or more housing components. In certain examples, the housing can define an outer surface of the acoustic playback system. The housing can include one or more apertures for allowing audio to be expressed from the acoustic playback system.

[0007] In one or more examples, the housing can retain one or more of the at least one amplifier, the primary driver, the filler driver, and the filter. Further, the housing can retain at least one processor and at least one microphone. The housing can further retain further components, such as electrical components.

[0008] The housing has a first side. The housing has a second side opposite the first side. The housing can have a plurality of walls connecting the first side with the second side. The housing can have at least one wall connecting the first side with the second side. The first side may be generally opposite the second side, such as if the housing is not symmetric. The second side may be a continuation of the first side. For example, the housing may be spherical. The first side, the second side, and the plurality of walls may define the outer surface of the housing.

[0009] The first side may be considered a front side. For example, the first side may be configured to be located away from a wall (e.g., a standing wall, a rear wall, a structural wall), such as a wall of a location (e.g., room) that the acoustic playback system is in. The first side may be configured to be located towards a user of the acoustic playback system.

[0010] The second side may be considered a back side. For example, the second side may be configured to be located towards a wall (e.g., a standing wall, a rear wall, a structural wall), such as a wall of a location (e.g., room) that the acoustic playback system is in. The second side may be configured to be located away from a user of the acoustic playback system.

[0011] The acoustic playback system can include at

least one amplifier. For example, the at least one amplifier is located in the housing. The at least one amplifier can be configured to receive an electrical signal representative of an audio (e.g., audio signal, audio stream). The at least one amplifier can be configured to output an amplified audio signal. The at least one amplifier can be configured to output an amplified audio signal based on the audio. The at least one amplifier can be configured to output an amplified audio signal based on the electrical signal. For example, the at least one amplifier can apply an amplification to the electrical signal. The at least one amplifier can apply gain to the electrical signal. The at least one amplifier can be configured to output the amplified audio signal to the primary driver and/or the filler driver.

[0012] The acoustic playback system can include a plurality of amplifiers. For example, a first amplifier can provide a first amplified audio signal to the primary driver and a second amplifier can provide a second amplified audio signal to the filler driver.

[0013] The acoustic playback system can include a primary driver. As used herein, a driver can be, for example, a transducer and/or an audio source. For example, the primary driver can be a speaker. The primary driver can be at least partially located within the housing. The primary driver can be configured to receive the amplified audio signal. The primary driver can be configured to output a primary audio signal. The primary driver can be configured to output a primary audio signal, based on the amplified audio signal from the first side. The primary audio signal may be an audio signal configured for listening by a user of the acoustic playback system.

[0014] For example, the primary driver can have its output (e.g., the location where the primary audio is leaving the primary driver) directed towards the first side of the housing. In other words, the primary driver can output the primary audio from the first side of the housing.

[0015] In one or more example acoustic playback systems, the primary driver is an omnidirectional audio source. In other words, the primary driver is an audio source with significant forwards and rearward radiation. In one or more example acoustic playback systems, the primary driver is a directional primary driver. The primary driver can have an audio outlet directed towards the first side.

[0016] The acoustic playback system can include a filler driver. As used herein, a driver can be, for example, a transducer and/or an audio source. For example, the filler driver can be a speaker. The filler driver can be at least partially located within the housing. The filler driver can be configured to receive the amplified audio signal. The filler driver can be configured to output a secondary audio signal. The filler driver can be configured to output a secondary audio signal, based on the amplified audio signal from the second side.

[0017] In other words, the acoustic playback system can include at least two drivers (e.g., a plurality of drivers).

[0018] For example, the filler driver can have its output

(e.g., the location where the secondary audio is leaving the filler driver) directed towards the second side of the housing. In other words, the filler driver can output the secondary audio from the second side of the housing. For example, the output of the filler driver can be directed generally opposite that of the primary driver. The filler driver may have an audio outlet directed towards the second side.

[0019] In one or more example acoustic playback systems, the filler driver is an omnidirectional filler driver. In one or more example acoustic playback systems, the filler driver is a directional filler driver.

[0020] The acoustic playback system can include a filter (such as a filter bank). The filter can be in communication with the filler driver. The filter can be in communication with the primary driver. The filter can be configured to apply a filter (e.g., attenuate, boost, pass, apply an equalization, configured to filter) to the electrical signal and/or the amplified audio signal. The filter can be, for example, a high-pass filter, a low-pass filter, band-pass filter, etc.

[0021] The acoustic playback system can include at least one filter. The acoustic playback system can include a plurality of filters.

[0022] The filter can be located in different signal pathways of the acoustic playback system. For example, the filter can be located before the at least one amplifier. In such embodiments, the filter is applied to the electrical signal.

[0023] In certain examples, the filter is located after the at least one amplifier. In such embodiments, the filter is applied to the amplified audio signal.

[0024] The primary driver output is spaced away from the filler driver output. In other words, an output location of the primary driver is spaced away from an output location of the filler driver. For example, the primary audio leaves the primary driver at a location spaced away from where the secondary audio leaves the secondary driver.

[0025] In one or more example acoustic playback systems, the primary driver and the filler driver are spaced away from one another.

[0026] For example, the filler driver output is spaced away from the first side from the primary driver output. In other words, the filler driver and the primary driver are not located on the same side of the housing. This can prevent further destructive interference between the primary driver and the filler driver.

[0027] In one or more examples, the filler driver and the primary driver are not aligned. For example, the filler driver and the primary driver are not aligned in a line between the first side and the second side. For example, the filler driver and the primary driver are not aligned in a line between the plurality of walls.

[0028] The filler driver and the primary driver can be facing away from one another. For example, the output location of the filler driver and the primary driver can be facing away from one another.

[0029] The primary driver output can be spaced away

from the filter driver output between the first side and the second side.

[0030] In one or more examples, the primary driver can be located closer to the first side than the filler driver. In one or more examples, the filler driver can be located closer to the second side than the primary driver.

[0031] The filler driver can be configured to add an acoustic signal (e.g., the secondary audio) in the frequency range where the cancellation occurs. To do this the filler driver can be placed in a - in terms of acoustic wavelength - significantly different distance from the wall than the primary driver.

[0032] In one or more example acoustic playback systems, the primary audio and the secondary audio are the same audio. In other words, the primary driver and the filler driver are both outputting the same audio. For example, primary audio and the secondary audio are at the same volume and/or the same gain and/or the same frequency. For example, the primary driver and the filler driver receive the same amplified audio signal.

[0033] In one or more example acoustic playback systems, the primary audio and the secondary audio are different audio. For example, the filter can modify the electrical signal and/or the amplified audio signal so that the amplified audio signal received by the primary driver and the filler driver are different. In other words, a low-pass filter can be applied for the primary driver and a high-pass filter can be applied for the filler driver. Further, at least one processor can be configured to process the electrical signal and/or the amplified audio signal for modifying between the primary driver and filler driver.

[0034] In one or more example acoustic playback systems, the secondary audio has a lower gain than the primary audio. In other words, the primary audio may have a higher gain than the secondary audio. In other words, the primary audio may be louder than the secondary audio.

[0035] For example, the secondary audio may have a lower volume than the primary audio. As potentially any audio which enters the cancellation zone of the primary audio can be reduce and/or eliminate any cancellation, the secondary audio may not need to be as loud as the primary audio for its effects to be felt by a user of the acoustic playback system. Cancellation zone can include cancellation band and/or cancellation range. The cancellation zone can be a band in audio frequency.

[0036] In one or more example acoustic playback systems, the filler driver is configured to add an acoustic signal for the secondary audio into a frequency range where a cancellation in the primary audio occurs. For example, the reflective cancellation may occur with the primary audio at a certain frequency while other frequencies are not cancelled. The secondary audio may be output in the frequency that is cancelled.

[0037] The acoustic signal can be within the frequency band of the cancellation. For example, the acoustic signal can be identical to the primary signal. However it can have another amplitude or phase as a function of the

filters that is applied prior to the amplifier, after the amplifier or the transfer function of the driver itself which may not be identical to the primary driver. The signal is no different from the primary signal in terms of linearity except that it in practice might be closer to the noise floor, e.g., the signal information - again in the relevant frequency range - is preserved.

[0038] The acoustic play back system can be configured to be mounted to a wall. For example, the acoustic playback system can include a mounting frame. The acoustic playback system can include one or more mounting components configured to be affixed to a wall. The housing can include one or more mounting components configured to be affixed to a wall.

[0039] In one or more example acoustic playback systems, upon mounting of the acoustical playback system, the filler driver is configured to face a wall. In other words, upon mounting, the second side may face the wall.

[0040] In one or more example acoustic playback systems, the filler driver is configured to reduce a comb-filter effect of the primary driver. In one or more example acoustic playback systems, the filler driver is configured to eliminate a comb-filter effect of the primary driver. The comb-filter effect occurs due to destructive interference of the primary audio of the primary driver caused by reflection of the primary audio. Through the use of the filler driver, by adding the secondary audio, the cancellation of the primary audio may be overcome.

[0041] In one or more example acoustic playback systems, the filler driver is configured to produce the secondary audio at a same signal as the primary audio in low frequencies and a different signal as the primary audio in high frequencies. In other words, one method to increase output in a loudspeaker is to use two drivers (e.g., primary driver and filler driver) at low frequencies. This increases their dynamic capabilities. The outputs of the two drivers will sum and, since the frequencies are low, the wavelength is long, and summing will be close to ideal (adding 6dB).

[0042] In one or more example acoustic playback systems, the at least one amplifier comprises a primary amplifier in communication with the primary driver and a filler amplifier in communication with the filler driver. For example, the acoustic playback system can include a plurality of amplifiers. In certain examples, the primary amplifier and the filler amplifier receive the same electrical signal.

[0043] The primary amplifier may output a primary amplified audio signal. The primary driver can be configured to receive the primary amplified audio signal and output a primary audio, based on the primary amplified audio signal, from the first side.

[0044] The filler amplifier may output a secondary amplified audio signal. The filler driver can be configured to receive the secondary amplified audio signal and output a secondary audio, based on the secondary amplified audio signal, from the second side.

[0045] The primary amplifier and the filler amplifier may

be the same type of amplifier. The primary amplifier and the filler amplifier may be different types of amplifiers.

[0046] The primary amplifier may provide a first amplification to the electric signal. The filler amplifier may provide a second amplification to the electric signal. The first amplification may be the same as the second amplification. The first amplification may be different than the second amplification. The first application may be greater than the second amplification.

[0047] In one or more example acoustic playback systems, the filter can be located (e.g., positioned) between the at least one amplifier and the primary driver and/or the filler driver. For example, the filter can be used on the amplified audio signal.

[0048] In one or more example acoustic playback systems, the filter is a conditioning filter, and wherein the filler amplifier is positioned between the conditioning filter and the filler driver.

[0049] A conditioning filter can be a filter which conditions a signal. As discussed herein, the filter can condition the signal to be as good as possible at adding signal to the cancellation frequency range. In certain examples, the conditioning filter can be any type of filter.

[0050] In one or more example acoustic playback systems, the conditioning filter is an adaptive conditioning filter. An adaptive filter can be a filter that adapts automatically to achieve an optimized state. For example, the wall can have different properties (e.g., absorption coefficients) or the acoustic playback system can be placed close to a TV-screen affecting the reflection, or the acoustic playback system is placed on some kind of stand away from a wall, and thus adaptiveness can be an advantage.

[0051] In one or more acoustic playback systems, the acoustic playback system is configured to determine the state of the location of the acoustic playback system. For example, the acoustic playback system can be configured to receive user input indicative of the state of the location. In some examples, the acoustic playback system can include one or more microphones, and the state of the location can be determined by the acoustic feedback playback through feedback received by the one or more microphones.

[0052] In one or more example acoustic playback systems, the filter is a low-pass filter positioned between the at least one amplifier and the filler driver. In other words, the filter only applies the low-pass filtration to the filler driver.

[0053] A different filler can be in communication with the primary driver. In some instances, no filter is in communication with the primary driver.

[0054] In certain example acoustic playback system, the filter is a high-pass filter positioned between the at least one amplifier and the primary driver. In other words, the filter only applies the high-pass filtration to the filler driver.

[0055] In certain example acoustic playback system, the filter includes a primary filter and a filler filter. The primary filter can be a high pass filter in communication

with the primary driver. The filler filter can be a low pass filter in communication with the filler driver.

[0056] In one or more example acoustic playback systems, the filler driver has a higher impedance than the primary driver. For example, the primary driver may have an impedance between 4-8ohms. Advantageously, the filler driver may have an impedance of at least 4-8 times higher than the primary driver in order to not influence the primary audio (e.g., the output) of the primary driver. For example, the filler driver can have an impedance of 16-32 ohms. The filler driver may have an impedance of 32-64 ohms. The filler driver can have an impedance of 16-64 ohms.

[0057] In one or more example acoustic playback systems, wherein the primary audio and the secondary audio are in non-overlapping frequency ranges. For example, a high pass filter can be applied to the primary audio and a low pass filter can be applied to the secondary audio. Alternatively, a high pass filter can be applied to the secondary audio and a low pass filter can be applied to the primary audio.

[0058] For example, a high pass filter can be applied to the amplified audio signal directed to the primary driver and a low pass filter can be applied to the amplified audio signal directed to the filler driver. Alternatively, a high pass filter can be applied to the amplified audio signal directed to the filler driver and a low pass filter can be applied to the amplified audio signal directed to the primary driver.

[0059] In one or more example acoustic playback systems, the acoustic playback system further comprises at least one microphone. In one or more example acoustic playback systems, the acoustic playback system further comprises at least one processor. In one or more example acoustic playback systems, the at least one processor is configured to determine, based on input received from the at least one microphone, a position of the acoustical playback system with respect to a wall. In one or more example acoustic playback systems, the at least one processor is configured to operate the acoustic playback system, depending on the position, in an on-wall setting or an away-from-wall setting. In other words, the at least one processor can be used to determine whether the acoustic playback system is located near a wall.

[0060] The at least one microphone can be configured to receive an input including the primary audio and/or the second audio. The processor can be configured to determine the position of the acoustic playback system with respect for a wall. For example, in accordance that the input has a reverberation effect of greater than a reverberation threshold, the at least one processor can determine the position of the acoustic playback system as near a wall. For example, in accordance that the input has a reverberation effect of equal to or less than a reverberation threshold, the at least one processor can determine the position of the acoustic playback system as not near a wall.

[0061] For example, the acoustic playback system

could have a calibration mode. Through the user of a speaker-to-mic response, the acoustic playback system can have a characteristic clearly indicating nearby boundaries. In certain examples, a high-resolution estimation of the primary driver impedance would indicate the reflection. In certain examples, the acoustic playback system can include an echo cancelling filter, which can indicate a significant reflection - or a lack of it.

[0062] When the system is not close to the wall, the notch from the main driver disappears (or is pushed very low in frequency) and the summed response can potentially end up having a peak instead of being flat.

[0063] In this case filtering out the filler drivers output around the notch could correct the response to being flat. In other words, the rear wall reflection should be visible. The main state of the acoustic playback device would be to have an equalizer applied to the filler driver that compensates for the dip. So the secondary use case is when actuation will be needed, and the microphone response would be indicative of a difference when the device is away from the wall.

[0064] For example, the away-from-wall setting may deactivate the filler driver. As the acoustic playback system is not affected by the reflected audio from a wall, it may be advantageous for power savings to not use the filler driver. The on-wall setting may activate the filler driver.

[0065] In some examples, the processor can be configured to tune the filler driver between the away-from-wall setting and on-wall setting. For example, the processor could tune the filler driver to complement the primary driver to enable louder playback and/or less distortion. At low frequencies, tuning the primary driver and the filler driver can be performed to reproduce the signal in phase will simply result in constructive summing. On the wall, generally, some shaping of the phase and amplitude might be used to ensure not only sound pressure right at the notch but also a favorable summed response around the notch.

[0066] The invention is set out in the appended set of claims.

BRIEF DESCRIPTION OF DRAWINGS

[0067] The aspects of the disclosure may be best understood from the following detailed description taken in conjunction with the accompanying figures. The figures are schematic and simplified for clarity, and they just show details to improve the understanding of the claims, while other details are left out. Throughout, the same reference numerals are used for identical or corresponding parts. The individual features of each aspect may each be combined with any or all features of the other aspects. These and other aspects, features and/or technical effect will be apparent from and elucidated with reference to the illustrations described hereinafter in which:

FIG. 1 shows a typical acoustic playback system,

FIG. 2 shows an amplitude graph of the acoustic playback system of FIG. 1,

FIG. 3 illustrates an example embodiment of an acoustic playback system according to the disclosure,

FIG. 4 shows an amplitude graph of the acoustic playback system of FIG. 3,

FIG. 5 illustrates an example embodiment of an acoustic playback system according to the disclosure,

FIG. 6 illustrates an example embodiment of an acoustic playback system according to the disclosure,

FIG. 7 illustrates an example embodiment of an acoustic playback system according to the disclosure,

FIG. 8 illustrates an example embodiment of an acoustic playback system according to the disclosure, and

FIG. 9 shows cancellation effects of an example embodiment of an acoustic playback system of FIG. 8 according to the disclosure.

[0068] The figures are schematic and simplified for clarity, and they just show details which are essential to the understanding of the disclosure, while other details are left out. Throughout, the same reference signs are used for identical or corresponding parts.

[0069] Further scope of applicability of the present disclosure will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the disclosure, are given by way of illustration only. Other embodiments may become apparent to those skilled in the art from the following detailed description.

DETAILED DESCRIPTION OF EMBODIMENTS

[0070] The detailed description set forth below in connection with the appended drawings is intended as a description of various configurations. The detailed description includes specific details for the purpose of providing a thorough understanding of various concepts. However, it will be apparent to those skilled in the art that these concepts may be practiced without these specific details. Several aspects of the apparatus and methods are described by various blocks, functional units, modules, components, circuits, steps, processes, algorithms, etc. (collectively referred to as "elements"). Depending upon particular application, design constraints or other rea-

sons, these elements may be implemented using electronic hardware, computer program, or any combination thereof.

[0071] The electronic hardware may include micro-electronic-mechanical systems (MEMS), integrated circuits (e.g. application specific), microprocessors, micro-controllers, digital signal processors (DSPs), field programmable gate arrays (FPGAs), programmable logic devices (PLDs), gated logic, discrete hardware circuits, printed circuit boards (PCB) (e.g. flexible PCBs), and other suitable hardware configured to perform the various functionality described throughout this disclosure, e.g. sensors, e.g. for sensing and/or registering physical properties of the environment, the device, the user, etc. Computer program shall be construed broadly to mean instructions, instruction sets, code, code segments, program code, programs, subprograms, software modules, applications, software applications, software packages, routines, subroutines, objects, executables, threads of execution, procedures, functions, etc., whether referred to as software, firmware, middleware, microcode, hardware description language, or otherwise.

[0072] The present application relates to the field of acoustic playback systems.

[0073] FIG. 1 shows a typical acoustic playback system 100 located near a wall 10 (or any other audio reflective surface). As shown, the acoustic playback system 100 includes an audio driver 102. The audio driver 102 outputs an audio generally in a first direction 104 towards where the audio driver 102 is facing. However, the audio driver 102 also outputs the audio in a second direction 106 as well (and in fact, many other directions). The audio in the second direction 106 can reflect off the wall 10 thus creating a reflected audio 108. This reflected audio 108 may be phase shifted due to the delay in time caused by the reflection off the wall 10, which can lead to destructive interference 100 between the audio in the first direction 104 and the reflected audio 108.

[0074] In other words, when acoustic playback system 100 is placed close to a wall 10 of significant proportions this wall 10 will reflect sound (e.g., as reflected audio 108) radiated from the rear of the playback system 100. As most playback systems are approaching omnidirectionality at low frequencies, this radiation towards the wall 10 can be significant. This results in a reflection from the wall 10 that is close to the amplitude of the acoustical signal radiated forward 104 away from the wall 10. These two wavefronts meet 110 and interact with both constructive and destructive interference due to and determined by the delay of the reflected signal 108. This interference causes a so-called comb filtering effect in the entire frequency band where there is significant rearward radiation from the playback system 100.

[0075] The cancellation due to the comb filtering effect can affect some or all of the frequency of the audio in the first direction 104. This can lead to dead spots or incorrect sounding audio to a user at the location where the two wavefronts meet 110. As this is typically in front of the

acoustic playback system 100, the effect of the reflected audio can significantly affect the audio quality for a user of the acoustic playback system 100.

[0076] FIG. 2 shows an amplitude graph of the acoustic playback system of FIG. 1. As shown, cancellation (or notch) 202 can occur, for example at the lowest in frequency. For a typical collaboration bar this can be in the range from 400-1000Hz depending on the distance from the wall. The subsequent higher order reflections are typically much less significant due to the increasing directionality of the acoustic playback system.

[0077] FIG. 2 is a based on white noise which is summed with a delayed and low passed filtered version of itself. The low pass element is meant to emulate the directionality of the driver while the delay corresponds to the distance to the rear wall times two.

[0078] For a user, the downside of known acoustic playback devices is a reduction in general perceived sound quality, speech intelligibility, and even localization. In certification context the product might not pass frequency response limits.

[0079] FIG. 3 illustrates an example embodiment of an acoustic playback system according to the disclosure. Advantageously, the disclosed acoustic playback system 300 can reduce and/or eliminate the cancellation that occurs with the system 100 shown in FIG. 1. Further internal processing can be shown in the embodiments of FIGS. 5-8.

[0080] As shown, the acoustic playback system 300 can include a housing 302. The housing has a first side 304 and a second side 306 opposite the first side 304. The housing 302 can further include a plurality of walls 306 connecting the first side 304 with the second side 306. The acoustic playback system 300 includes at least one amplifier (Shown in FIGS. 5, 6, and 8) configured to receive an electrical signal representative of an audio and output an amplified audio signal.

[0081] The acoustic playback system 300 can include a primary driver 310. The primary driver 310 is configured to receive the amplified audio signal and output a primary audio 312A, 312B, based on the amplified audio signal, form the first side 304.

[0082] The acoustic playback system 300 can include a filler driver 314. The filler driver 314 can be configured to receive the amplified audio signal and output a secondary audio 316, based on the amplified audio signal, from the second side 306. The filler driver 314 can be an omnidirectional audio source.

[0083] The acoustic playback system 300 can further include a filter (shown in FIGS. 5, 6, and 9) in communication with the filler driver 316 and configured to apply a filter to the electrical signal and/or the amplified audio signal.

[0084] As shown, the primary driver 310 output is spaced away from the filler driver 316 output.

[0085] In particular, the primary driver 310 can output the primary audio 312A, 312B towards a user (e.g., shown by primary audio 312A), though certain primary

audio 312 is directed towards the wall 10. This leads, similar to what is shown in FIG. 1, to primary reflected audio 320. The primary reflected audio 320 may interfere, such as through destructive interference, with the primary audio 312A leading to a cancellation zone 322.

[0086] The acoustic playback system 300 further includes the filler driver 314. The filler driver 314 is configured to output secondary audio 316 from the second side 306 of the housing 302. As shown, upon mounting of the acoustic playback system 300, the filler driver 314 is configured to face the wall 10. The secondary audio 316 also reflects off of wall 10, which leads to secondary reflected audio 318. However, due to the placement and/or the direction of the filler driver 314, the secondary reflected audio 318 would overcome the cancellation zone 322, and thus a user would properly hear the audio from the acoustic playback system 300. Specifically, the filler driver 314 is configured to reduce a comb-filter effect of the primary driver 310.

[0087] The primary audio 312A, 312B and the secondary audio 316 can be the same audio. In other words, the filler driver 314 and the primary driver 310 can output the same audio. However, it can be advantageous for the primary audio 312A, 312B and the secondary audio 316 to be different. For example, the secondary audio 316 can have a lower gain than the primary audio 312A, 312B. The filler driver 314 can be configured to add an acoustic signal for the secondary audio 316 into a frequency range where a cancellation of the primary audio 312A, 312B occurs, such as cancellation zone 322. The filler driver 314 can also be configured to produce the secondary audio 316 at a same signal as the primary audio 312A, 312B in low frequencies and a different signal as the primary audio 312A, 312B in high frequencies. The primary audio 312A, 312B and the secondary audio 316 can be in non-overlapping frequency ranges.

[0088] Further, the acoustic playback system 100 can optionally include at least one microphone 330. The at least one microphone 330 can be configured to obtain audio input from the environment. For example, the at least one microphone 330 can obtain the primary audio 312A and the secondary audio 316.

[0089] Further, the acoustic playback system 100 can optionally include at least one processor 332. The at least one processor 332 can be configured to adjust and/or modify one or more of the components of the acoustic playback system 100.

[0090] The at least one processor 332 can be configured to determine, based on input received from the at least one microphone 330, a position of the acoustical playback system 300 with respect to a wall 10, and wherein the at least one processor 332 is configured to operate the acoustical playback system 300, depending on the position, in an on-wall setting or an away-from-wall setting.

[0091] FIG. 4 shows an amplitude graph of the acoustic playback system of FIG. 3.

[0092] The solid-line curve simulates the frequency re-

sponse of an acoustic playback system 300 with the primary driver 310 approximately 130mm from the rear wall 10. In this case it results in a severe cancellation at 700Hz, such as shown in FIG. 2. The dashed-line curve simulates the summed response when the filler driver 314 is placed closer to the wall 10 playing the same signal but low passed. At low frequencies the signals are added in phase resulting in a 6dB higher amplitude while at 700Hz the amplitude is increased more than 20dB. With the added filler driver 314, the acoustic playback system 300 can eliminate the cancellation that occurs by any reflected audio by the wall 10.

[0093] FIG. 5 illustrates an example embodiment of an acoustic playback system according to the disclosure. The acoustic playback system 500 of FIG. 5 can include any and/or all of the components of the acoustic playback system 300 of FIG. 3. FIG. 5 illustrates a simplified set of components for convenience.

[0094] As shown, the acoustic playback system 500 can include a housing 502. The housing can retain at least one amplifier 504 and a filter 506. Further, the acoustic playback system 500 can include a primary driver 508 and a filler driver 510.

[0095] The at least one amplifier 504 can receive an electrical signal 520 representative of an audio and can output an amplified audio signal 522. The filter 506 receives the amplified audio signal 522 and apply a filter. As shown in FIG. 5, the filter 506 is associated with the filler driver 510.

[0096] The filter 506 shown in FIG. 5 can be a low-pass filter. Thus, the filter 506 is a low-pass filter positioned between the at least one amplifier 504 and the filler driver 510. For example, a 6dB gain can be achieved at low frequencies if the at least one amplifier 504 can drive it at the same voltage as the primary driver 508. The low pass filter 506 can be designed to achieve a minimum of cancellation around the main dip due to potential phase mismatch. The filler driver 510 can be identical to the primary driver 508, but this is not necessarily critical as it can be advantageous to provide signal at low frequencies but not necessarily match the primary driver 508.

[0097] Alternatively, the filter 506 of FIG. 5 can be a conditioning filter. The filler driver 510 can be a high impedance driver as compared to the primary driver 508. The filler driver 510 can have a high Q factor and resonance frequency at the location of any cancellation effect (e.g., dip).

[0098] The filler driver 510 can be placed in parallel with the primary driver 508 without affecting its output significantly. The very low damping at the resonance (tuned to the dip-position) will enable it to deliver substantial output at this frequency causing the requested increase in summed amplitude. A relatively high impedance driver (filter driver 510) could also be bandpass filtered via filter 510 without needing excessively large filter components, making it feasible to further limit its operating area in frequency to where it is needed. The relatively high resonance frequency could be achieved both

through driver design and/or by placing it in a relatively small volume.

[0099] FIG. 6 illustrates an example embodiment of an acoustic playback system according to the disclosure. The acoustic playback system 600 of FIG. 6 can include any and/or all of the components discussed with respect to acoustic playback system 300 of FIG. 3. The housing 602 can contain the components of the acoustic playback system.

[0100] As shown, the acoustic playback system 600 can include a primary amplifier 604 in communication with the primary driver 608 and a filler amplifier 606 in communication with the filler driver 610.

[0101] Advantageously, using an extra amplifier channel can achieve more flexibility in filtering and amplitude matching.

[0102] The filter 603 can be a conditioning filter. The filler amplifier 606 is positioning between the filter 603 and the filler driver 610. The filter 603 can be an adaptive conditioning filter. As shown, the filter 603 is configured to apply a filter to the electrical signal 620. The at least one amplifier 606, 604 is configured to receive the electrical signal (either filtered for filler amplifier 606 or unfiltered for primary amplifier 604) for outputting an amplified audio signal 607A, 607B.

[0103] FIG. 7 illustrates an example embodiment of an acoustic playback system according to the disclosure. The acoustic playback system 700 of FIG. 7 can include any and/or all of the components discussed with respect to acoustic playback system 300 of FIG. 3. The housing 702 can contain the components of the acoustic playback system.

[0104] As shown, the primary driver 704 can be placed perpendicular to a wall 10. It can be preferably if the primary driver 704 has a substantial size compared to the relevant wavelength. The primary driver 704 can be located on the top, bottom or in the side of the acoustic playback system 700. Then the cancellation will occur at a wider frequency band as the speaker diaphragm has varying distance to the rear wall.

[0105] Only the direct sound of the primary audio 710A, 710B is illustrated but the reflections will also have different times of arrival all contributing to the smoothing of the amplitude response and diminishment of any cancellation area 712.

[0106] FIG. 8 illustrates an example embodiment of an acoustic playback system according to the disclosure. The acoustic playback system 800 of FIG. 8 can include any and/or all of the components discussed with respect to acoustic playback system 300 of FIG. 3. The housing 802 can contain the components of the acoustic playback system 800.

[0107] As shown, the at least one amplifier 804 is configured to receive the electrical signal 820 for provision of an amplified audio signal 822. Further, the filter can be a primary filter 806 and a filler filter 808, each which receive the amplified audio signal 822. The primary filter 806 can be a high pass filter in communication with the

primary driver 810. The filler filter 808 can be a low pass filter in communication with the filler driver 812.

[0108] The filters 806, 808 could just as well be implemented on line-level signals prior to two separate amplifier channels or in a digital signal processor.

[0109] FIG. 9 shows cancellation effects of an example embodiment of an acoustic playback system shown in FIG. 8.

[0110] As shown in FIG. 9, each of the drivers can have their own frequency range, such as through the use of a filter 806, 808 for each of the primary driver 810 and the filler driver 812. Line 902 illustrates the low-passed filler driver 812 and line 904 illustrates the high-passed primary driver 810.

[0111] By high pass filtering the primary driver 810 at a higher frequency than where the cancellation would appear, the dip can be completely avoided. When it comes to the filler driver 812, which is closer to the wall, the lowest frequency cancellation frequency would appear much higher.

[0112] Until now the problem and solutions has been presented for a 90-degree angle, e.g., perpendicular to the wall on which the sound reproduction device is mounted. However, when the listener is positioned at non-90 degree angles the above problem and the solutions are still valid. The only change in this scenario is that the distance the reflection must travel is increased resulting in lower cancellation frequencies.

[0113] As discussed herein, the acoustic playback system 300, 500, 600, 700, 800 can be sound bar, a speaker, a video bar, a loudspeaker, and a subwoofer.

[0114] It is intended that the structural features of the devices described above, either in the detailed description and/or in the claims, may be combined with steps of the method, when appropriately substituted by a corresponding process.

[0115] As used, the singular forms "a," "an," and "the" are intended to include the plural forms as well (i.e. to have the meaning "at least one"), unless expressly stated otherwise. It will be further understood that the terms "includes," "comprises," "including," and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. It will also be understood that when an element is referred to as being "connected" or "coupled" to another element, it can be directly connected or coupled to the other element, but an intervening element may also be present, unless expressly stated otherwise. Furthermore, "connected" or "coupled" as used herein may include wirelessly connected or coupled. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. The steps of any disclosed method are not limited to the exact order stated herein, unless expressly stated otherwise.

[0116] It should be appreciated that reference through-

out this specification to "one embodiment" or "an embodiment" or "an aspect" or features included as "may" means that a particular feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment of the disclosure. Furthermore, the particular features, structures or characteristics may be combined as suitable in one or more embodiments of the disclosure. The previous description is provided to enable any person skilled in the art to practice the various aspects described herein. Various modifications to these aspects will be readily apparent to those skilled in the art.

[0117] The claims are not intended to be limited to the aspects shown herein but are to be accorded the full scope consistent with the language of the claims, wherein reference to an element in the singular is not intended to mean "one and only one" unless specifically so stated, but rather "one or more." Unless specifically stated otherwise, the term "some" refers to one or more.

Claims

1. An acoustic playback system comprising:

a housing having a first side, a second side opposite the first side, and a plurality of walls connecting the first side with the second side;
at least one amplifier configured to receive an electrical signal representative of an audio and output an amplified audio signal;
a primary driver configured to receive the amplified audio signal and output a primary audio, based on the amplified audio signal, from the first side;
a filler driver configured to receive the amplified audio signal and output a secondary audio, based on the amplified audio signal, from the second side; and
a filter in communication with the filler driver and configured to apply a filter to the electrical signal and/or the amplified audio signal;
wherein the primary driver output is spaced away from the filler driver output.

2. Acoustic playback system of claim 1, wherein the filler driver is an omnidirectional audio source.

3. Acoustic playback system of any one of claims 1-2, wherein the primary audio and the secondary audio are the same audio.

4. Acoustic playback system of any one of claims 1-2, wherein the secondary audio has a lower gain than the primary audio.

5. Acoustic playback system of any one of the previous claims, wherein the filler driver is configured to add

an acoustic signal for the secondary audio into a frequency range where a cancellation in the primary audio occurs.

6. Acoustic playback system of any one of the previous claims, wherein, upon mounting of the acoustic playback system, the filler driver is configured to face a wall.

7. Acoustic playback system of any one of the previous claims, wherein the filler driver is configured to produce the secondary audio at a same signal as the primary audio in low frequencies and a different signal as the primary audio in high frequencies.

8. Acoustic playback system of any one of the previous claims, wherein the at least one amplifier comprises a primary amplifier in communication with the primary driver and a filler amplifier in communication with the filler driver.

9. Acoustic playback system of claim 8, wherein the filter is a conditioning filter, and wherein the filler amplifier is positioned between the conditioning filter and the filler driver.

10. Acoustic playback system of claim 9, wherein the conditioning filter is an adaptive conditioning filter.

11. Acoustic playback system of any one of the previous claims, wherein the filter is a low-pass filter positioned between the at least one amplifier and the filler driver.

12. Acoustic playback system of any one of the previous claims, wherein the filler driver has a higher impedance than the primary driver.

13. Acoustic playback system of any one of the previous claims, wherein the primary audio and the secondary audio are in non-overlapping frequency ranges.

14. Acoustic playback system of any one of the previous claims, wherein the acoustic playback system further comprises at least one microphone and at least one processor, wherein the at least one processor is configured to determine, based on input received from the at least one microphone, a position of the acoustic playback system with respect to a wall, and wherein the at least one processor is configured to operate the acoustic playback system, depending on the position, in an on-wall setting or an away-from-wall setting.

15. Acoustic playback system of any one of the previous claims, wherein the acoustic playback system is one of a sound bar, a speaker, a video bar, a loudspeaker, and a subwoofer.

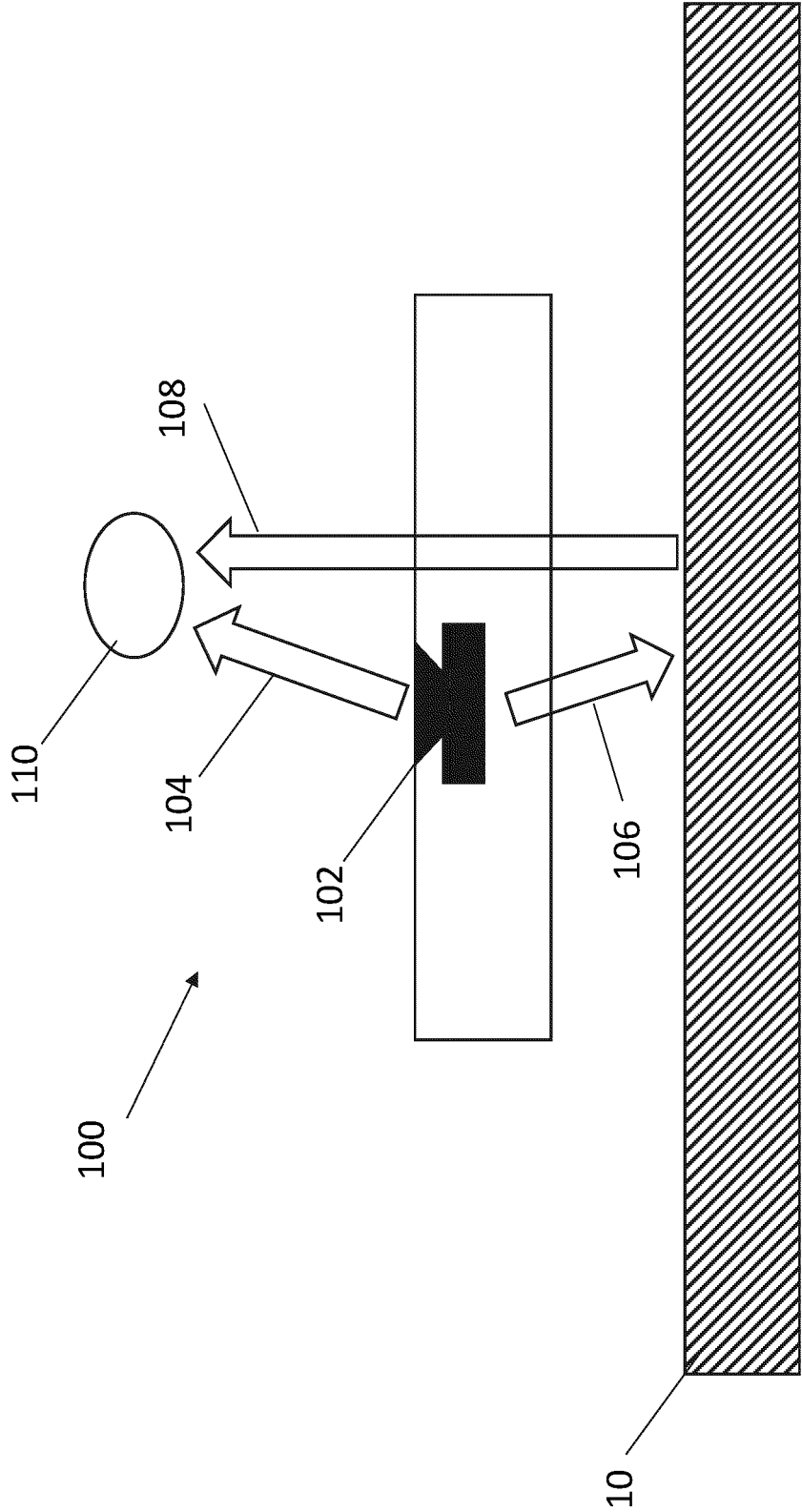


FIG. 1

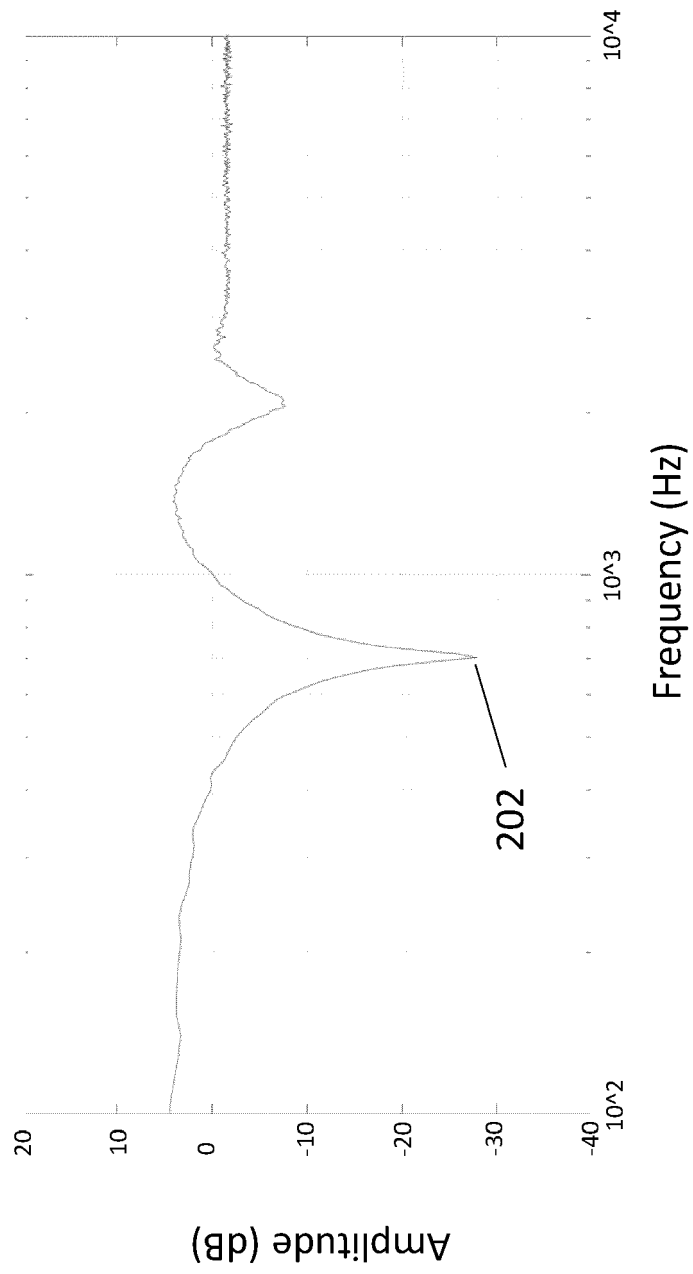


FIG. 2

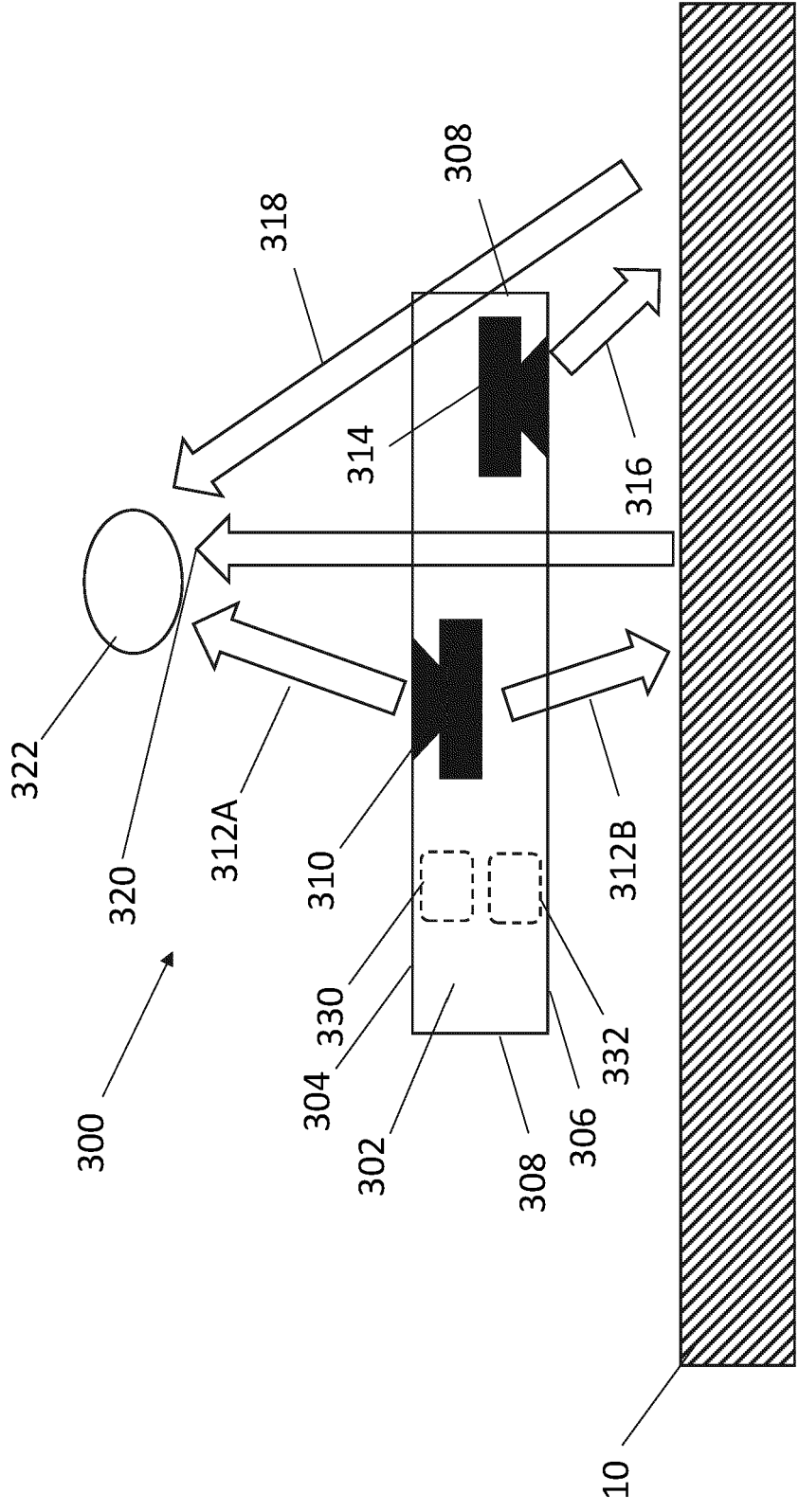


FIG. 3

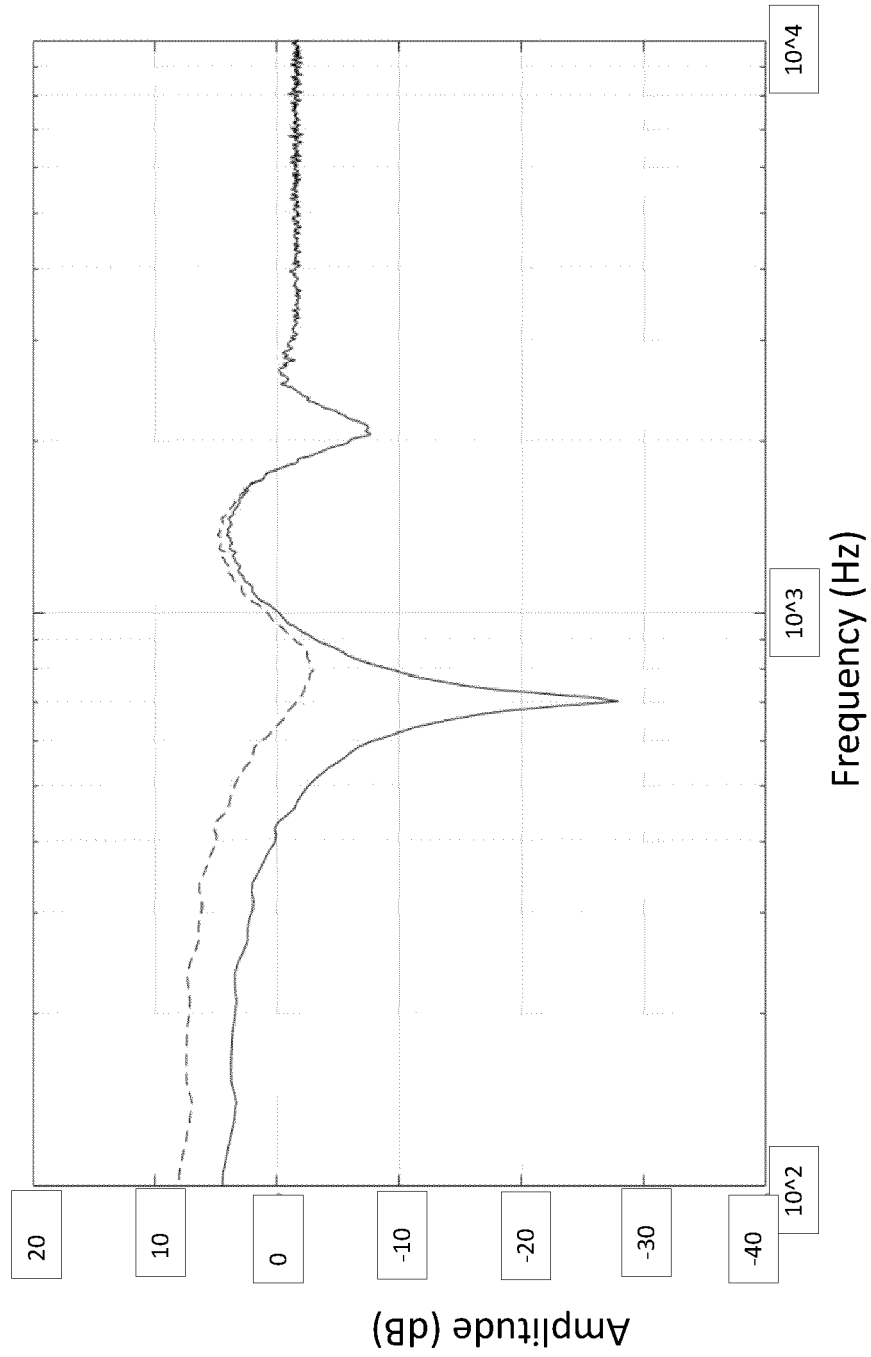


FIG. 4

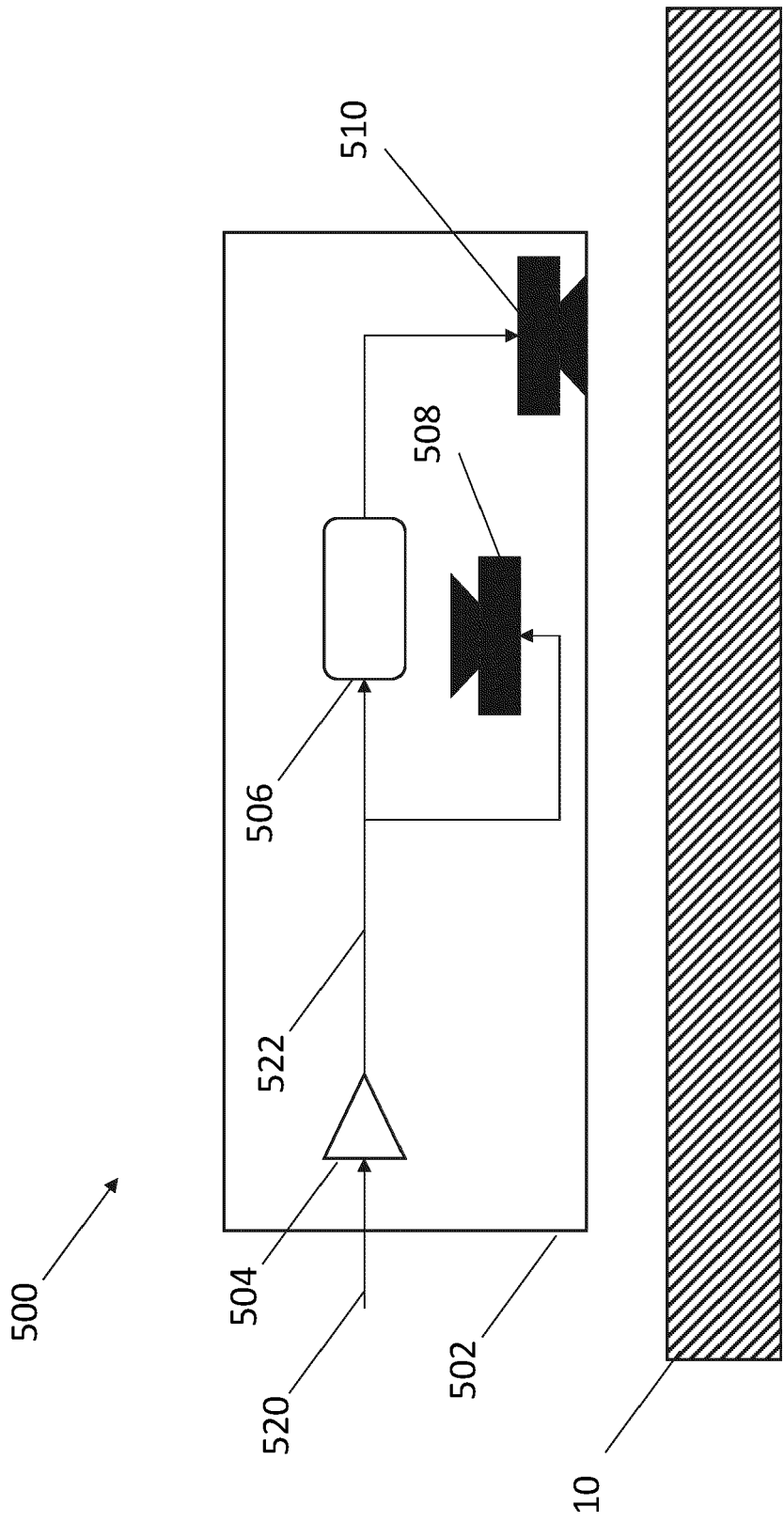


FIG. 5

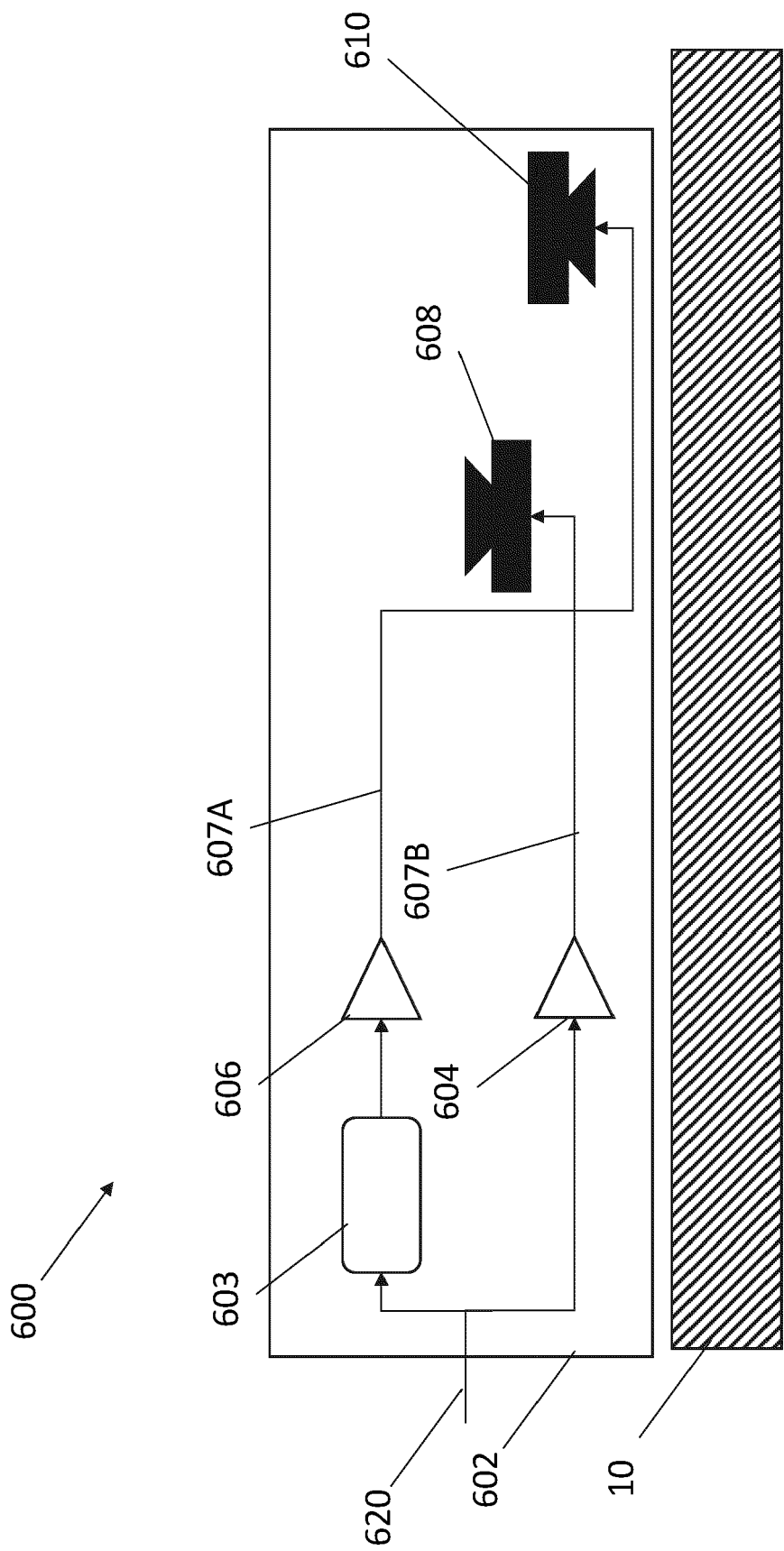


FIG. 6

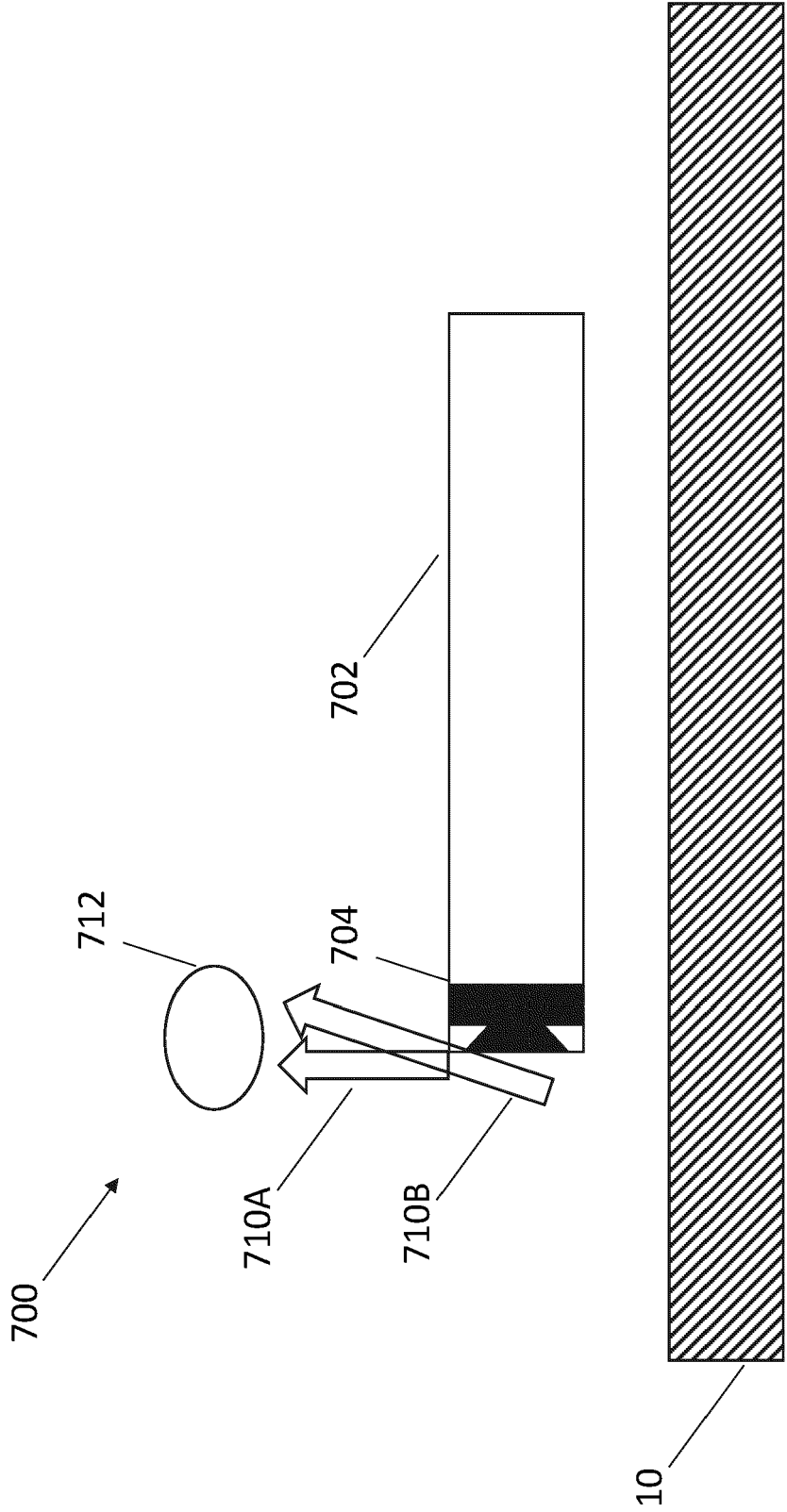


FIG. 7

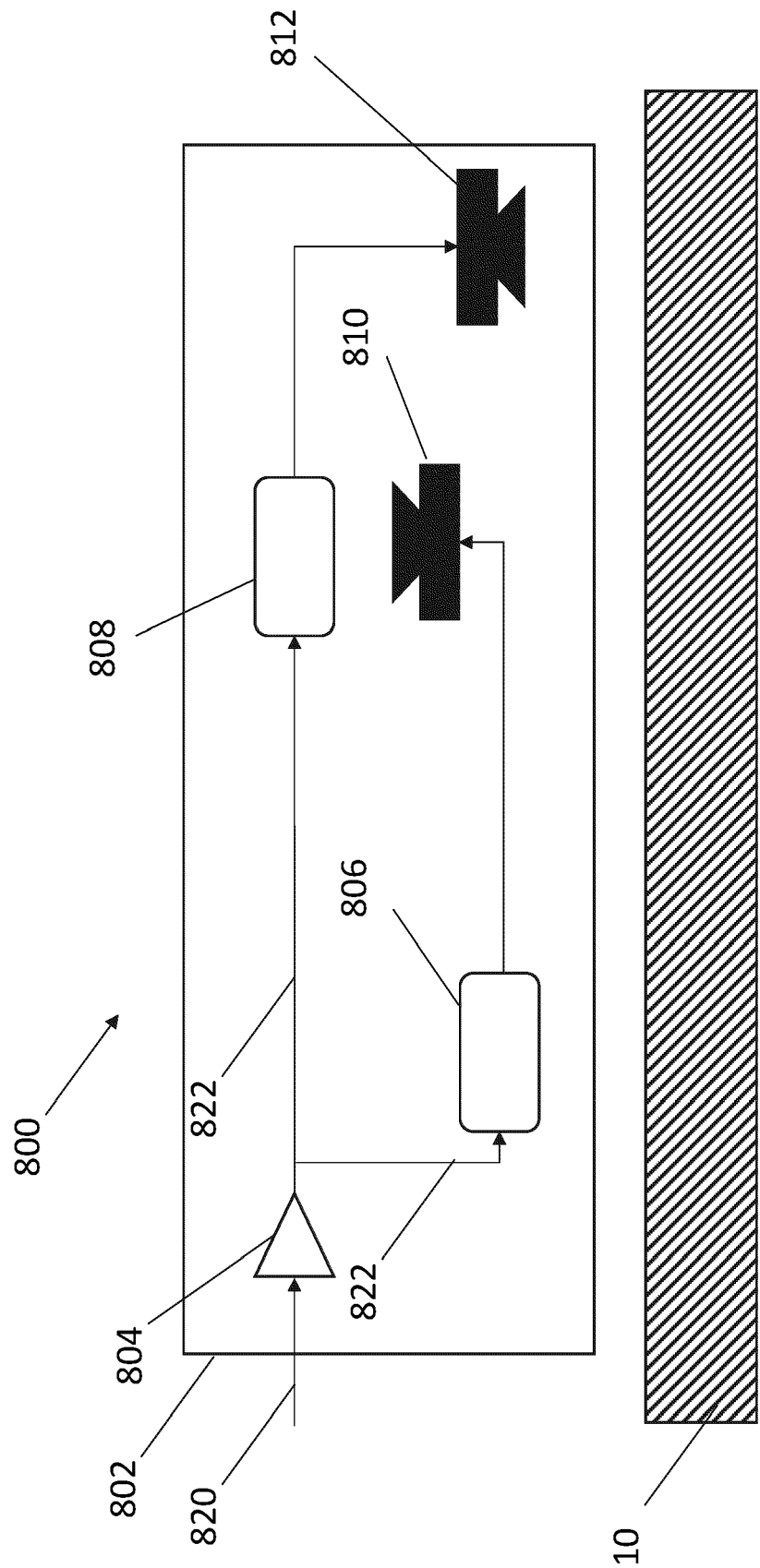


FIG. 8

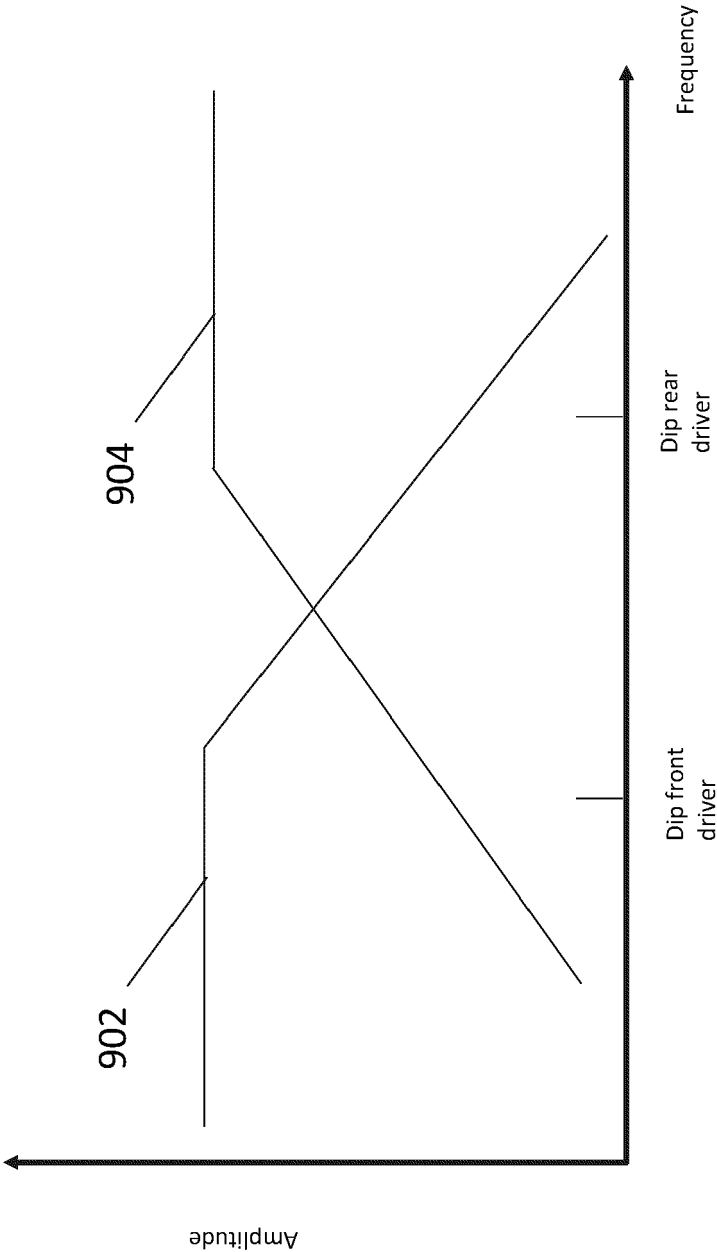


FIG. 9



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			H04R H04S
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 5 March 2024	Examiner Moscu, Viorel
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

**ANNEX TO THE EUROPEAN SEARCH REPORT
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