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DIRECTIONAL LOUDSPEAKER

(57)

A directional loudspeaker is described for use in the mid frequency range of the audio spectrum. The loudspeaker comprises: a housing comprising a front panel, side panels and a back panel, said housing comprising an acoustic resistive material; wherein at least one acoustic transducer is mounted to said front panel, said transducer being configured to drive a membrane for producing front waves at the front of said membrane and back waves at the back of said membrane; and, wherein one or more openings in said side panels, and, optionally, in said back panel allowing at least part of said back waves to exit said housing via said resistive material, said resistive material, said openings and said reflective back panel introducing for said back waves in the mid frequency range a phase delay, an attenuation and an amplitude such that an attenuation at the backside of said loudspeaker of 15 dB or more of the mid range frequencies is achieved.

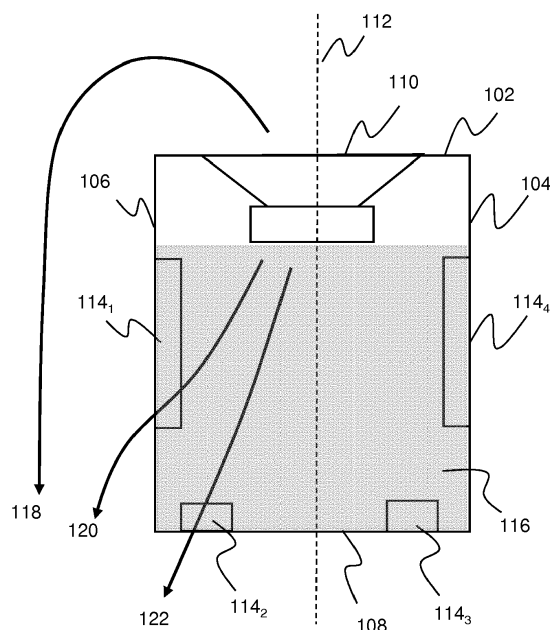


FIG. 1A

Description

Field of the invention

[0001] The invention relates to a directional loudspeaker, and, in particular, though not exclusively, to a directional loudspeaker for use in the mid frequency range of the audio spectrum and a directional loudspeaker system comprising one or more of such directional loudspeakers.

Background of the invention

[0002] Conventional loudspeakers exhibit frequency-dependent directivity of sound pressure: at low frequencies the sound waves behave omni-directional while at high frequencies the sound waves behave more directional. Hence, the sound levels of low-frequency sound at the back and the front of the speaker will be almost similar. When increasing the frequency (decreasing wavelength) the loudspeaker will start bundling the sound waves in the forward direction. The bundling effect will approximately start at wavelengths that are of the same order of (or smaller than) the dimensions of the front panel of the loudspeaker. The sound at the backside of the speaker is characterized by a low-pass characteristic, which is undesirable for various reasons.

[0003] Listeners that are not positioned in front of the loudspeaker will experience lower sound pressure levels at high frequencies. This will negatively influence the comprehensibility and the sound quality. Further, when a loudspeaker is placed in a room, the reflections at the walls will cause reverberation, which will be enhanced when sound waves are also radiated in the backward direction. Moreover, omni-directional radiated sound will cause more noise pollution for people that live close to an (outdoor) music event and will make it more difficult for event organisers to comply with the noise standards.

[0004] Ideally the directionality (directivity) of a loudspeaker should be frequency independent and in order to approximate such behaviour techniques exist that reduce the effect of omni-directional radiance of sound waves in the high and low frequency ranges of the acoustic spectrum which approximately runs from 20 to 20 KHz. Here, the term "high frequency" refers to sound waves that have a wavelength smaller than the smallest dimension of the front panel of the loudspeaker and/or the membrane of the transducer and the term "low frequency" refers to sound waves that have a wavelength such that the wavelength divided by two is larger than the largest dimension of the front panel of the loudspeaker and/or the membrane of the transducer. The frequencies between the high and low are of the midrange frequencies. Although there is no strict definition of these frequency ranges it can be said that the low frequency range approximately runs from 20 to 300 Hz, the mid frequency ranges runs 300 Hz up to 1,8 KHz and the high frequency ranges from 1,8 KHz up to 20 KHz. It is noted that these ranges do not have hard border lines so that effects dis-

cussed in this application are not strictly limited to one of these ranges.

[0005] The directionality of high-frequencies sound waves can be easily controlled by using a waveguide (typically a horn). Similarly, directionality for low-frequency sound waves can be achieved using actively controlled transducers e.g. a cardioid subwoofer configuration. In such configuration, a second transducer is configured to cancel the sound waves by a first transducer. For the middle frequency range however, the wavelengths are too big for using waveguides and too small for a cardioid subwoofer technique in order to create a predetermined directivity pattern. In more general, there are currently no loudspeakers in the middle frequency range available that have a high directivity, that can produce sufficient high sound pressure levels for music and that are sufficiently effective in suppressing backwards radiance of sound waves.

[0006] WO2010/108123 describes a loudspeaker of small dimensions with passive low frequency directional control, wherein the loudspeaker comprises an housing that is filled with a mineral wool and that has openings that are positioned in the side panel of the housing at a distance from that transducer that equals the diameter of cone diaphragm of the transducer. At the backside of the housing electronics are provided. A 10 dB attenuation of the front wave at the backside of the loudspeaker is claimed however it is not clear whether this attenuation is frequency independent for the mid frequency range of the audio spectrum, i.e. the part of the spectrum that is especially problematic in terms of directional control. Hence, there is a need in the art for improved directional loudspeakers that have a high degree of directionality in the mid range of the audio spectrum with a large degree of attenuation between the front and back waves.

Summary of the invention

[0007] It is an objective of the invention to reduce or eliminate at least one of the drawbacks known in the prior art. In an aspect the invention may relate to a directional loudspeaker comprising: a housing comprising a front panel, side panels and a reflective back panel, said housing comprising an acoustic resistive material; wherein at least one acoustic transducer is mounted to said front panel, said transducer being configured to drive a membrane for producing front waves at the front of said membrane and back waves at the back of said membrane; and, wherein one or more openings in said side panels, and, optionally, in said back panel allowing at least part of said back waves to exit said housing via said resistive material, said resistive material, said openings and said reflective back panel introducing for said back waves in the mid frequency range a phase delay, an attenuation and an amplitude such that an attenuation at the backside of said loudspeaker of 20 dB or more of the midrange frequencies is achieved. Preferably the directional loudspeaker is configured for use in the mid frequency range

of the audio spectrum.

[0008] Hence, the directional loudspeaker according to the invention provides forward bundling of sound waves in the mid frequency range while at the same time providing a strong attenuation of the back wave at the backside of the loudspeaker. The use of a substantially flat, reflective back panel together with the openings and the acoustic resistive material will provide excellent cancellation of the back waves. The housing comprising the resistive material and the openings provide an acoustic resistance box that allows strong attenuation of the front wave at the backside of the loudspeaker in a simple and passive way without the need of active drives as known from cardioid subwoofer techniques. The forward bundling of sound waves in the mid frequency range provides an improvement in sound quality and comprehensibility.

[0009] In an embodiment, the geometry and position of said back-panel with respect to the openings and the front-panel are selected such that said attenuation at the backside of said loudspeaker is maximized. Hence, the invention recognizes that the position of the back panel with respect to the front panel (i.e. the distance between the front and the back panel) is an important parameter in achieving maximum attenuation of the front wave at the backside of the loudspeaker.

[0010] In an embodiment, said acoustic material is a fibrous (thermoplastic) polymer material, preferably a polyester material, more preferably said polyester material comprising polyethylene terephthalate (PET). In an embodiment, said acoustic material is a fibrous polymer material, wherein the density of said fibrous polymer material is selected between 10 and 50 kg/m³. The inventors discovered that fibrous (thermoplastic) polymer material of certain densities have excellent acoustic properties for use in the acoustic resistance box. This material provides attenuation, delay and low pass filter characteristics that allow strong cancellation of the front wave at the backside of the loudspeaker.

[0011] In an embodiment, the ratio between the open surface of said openings and the total surface of a panel (a side panel or a back panel) is selected between 5 and 50%, preferably 10 and 40%. Depending on the geometry of the speaker housing, an opening geometry can be selected such that the back waves cancels the front waves at the backside of the loudspeaker.

[0012] In an embodiment, wherein said one or more openings are longitudinally shaped openings wherein said longitudinal axis of said longitudinal shaped openings are oriented in parallel to the central axis of said transducer. In a further embodiment, the openings may be positioned close to the front panel and extend towards the direction of the back panel. In an embodiment, the panels (side and/or back panels) may comprise longitudinally shaped openings having a width selected between 0,5 and 4 cm, preferably 1 and 3 cm and a length selected between 2 and 20 cm. In another embodiment, the panels (side and/or back panels) may comprise substantially circular or square openings having dimensions

selected between 0,5 and 4 cm. In a further embodiment, said openings may be configured as an array of openings in said side panel and/or said back panel.

[0013] In an embodiment, said mid range frequencies are selected between 100 and 2000 Hz, preferably 200 and 1000 Hz. In an embodiment, said side-panels are oriented under an angle with the central axis of said acoustic transducer.

[0014] In an embodiment, the dimensions of said housing (length, width, height) are selected between 10 and 100 cm, preferably 20 and 80 cm, more preferably between 30 and 70 cm.

[0015] In an embodiment, the frequency response for angles up to and including 70 degrees may be substantially the same as the frequency response at 0 degrees. The directional speaker according to the invention has an extremely constant beam width which is maintained throughout the entire audible spectrum. This means that an audience will perceive practically no variations in tonal balance.

[0016] In a further aspect, the invention may relate to a directional loudspeaker system comprising: a directional loudspeaker according to any of the embodiments described above, and; at least one horn loudspeaker for producing sound in the high frequency range, wherein the directionality of the high frequency sound of said horn loudspeaker substantially matches the directionality of the sound produced by said directional speaker.

[0017] In a further aspect, the invention may relate to a directional loudspeaker system comprising: a directional loudspeaker according to any of the embodiments described above, and; at least subwoofer that is configured to produce a cardioid response, wherein the directionality of the low frequency sound of said subwoofer substantially matches the directionality of the sound produced by said directional speaker.

[0018] In a further aspect, the invention may relate to a directional loudspeaker system comprising: a plurality of directional loudspeakers according to any of the embodiments described above, and, and; wherein said plurality of directional loudspeakers are configured as an acoustic line source (a line array).

[0019] Hence, the directional loudspeaker that is configured for use in the mid frequency range of the audio spectrum may be combined with one or more directional loudspeakers for the low and/or high frequency part of the audio spectrum. This way, a directional loudspeaker system can be formed that a forward bundling effect of sound waves over a substantial part of the audio spectrum and at the same time a substantial attenuation of the front wave at the backside of the loudspeaker system.

[0020] The invention will be further illustrated with reference to the attached drawings, which schematically will show embodiments according to the invention. It will be understood that the invention is not in any way restricted to these specific embodiments.

Brief description of the drawings

[0021]

Fig. 1A and 1B depict directional loudspeakers according to various embodiments of the invention.

Fig. 2 depicts the frequency characteristics of a loudspeaker according to the invention for three different distances between the back-panel and the front-panel.

Fig. 3A-3D depicts different views a directional loudspeaker according to a further embodiment of the invention.

Fig. 4 depicts the dispersion pattern of a directional loudspeaker according to an embodiment of the invention.

Detailed description

[0022] **Fig. 1A and 1B** depict directional loudspeakers according to various embodiments of the invention. In particular, **Fig. 1A** depicts a schematic cross-sectional view of a directional loudspeaker comprising an loudspeaker housing (an enclosure) formed by a front panel **102**, side panels **104** and a back panel **108**. The loudspeaker housing forms an acoustic chamber, wherein at least one acoustic transducer **110** is mounted to the front panel. The acoustic transducer may comprise a cone diaphragm, i.e. a membrane that is configured to generate sound pressure waves. Further, the acoustic chamber is filled with a material **116** of a predetermined acoustic resistivity. The acoustic chamber further comprises one or more openings **114_{1,4}** in the side panels. The openings may be symmetrically distributed over the side panels. Hence, the number, position and shape of the openings in the side panels are substantially similar. In an embodiment, also the back panel may comprise one or more openings **114_{2,3}**.

[0023] As will be described hereunder in more detail, the openings enable sound pressure waves that are generated at the backside of membrane, the so-called back-waves **120,122**, to exit the acoustic chamber via the acoustic resistive material. The back-waves are 180 degrees out-of-phase with the sound pressure waves produced at the front of the membrane. The acoustic enclosure, the resistive material and the position and size of the openings are configured such that the delayed and attenuated back-waves cancel the front-waves that arrive at the backside of the loudspeaker. This way, front-waves in the middle frequency range can be attenuated for more than 15 dB at the backside of said loudspeaker.

[0024] The front wave and the back wave need to cancel each other at the backside of the loudspeaker in order to achieve complete extinction at the backside. This means that the front and back waves need to be 180 degrees out of phase, they need to have the same period and amplitude characteristics at the location where the waves meet. Typically, the back-wave is already in an-

tipphase with the front-wave as the back-wave will be generated by the backside of the cone of the acoustic transducer. However, as the path length of the front wave to the backside of the loudspeaker is longer than the path length of the back-wave, the back-wave needs to be delayed. This can be achieved by leading the back-wave through an acoustic resistive material in which the propagation speed of sound is smaller than the propagation speed of sound in air. Preferably, such delay needs to be frequency independent and it needs to correspond with the difference in the path lengths that the front and back wave need to cover in order to reach the backside of the loudspeaker.

[0025] In particular, the delay of the propagation speed of sound in the acoustic material should satisfy the expression:

$$\bar{c}_{int} * \bar{D}_{int} = c_{ext} * \bar{D}_{ext}$$

wherein $\bar{c}_{int}$ is the average propagation speed of the sound through the acoustic material in the acoustic chamber, c_{ext} is the propagation speed of sound outside the loudspeaker which normally equals the speed of sound in air at room temperature, i.e. 343 m/s, $\bar{D}_{int}$ is the average path length that the back wave covers from an arbitrary point at the backside of the speaker membrane via the magnet of the acoustic transducer to an arbitrarily point on the surface of one of the openings in the side panels of the loudspeaker and $\bar{D}_{ext}$ is the average path length that is covered by the front wave from an arbitrarily point on the front side of the membrane of the loudspeaker, around the loudspeaker enclosure to an arbitrarily point on the surface of one of the openings. The interior surfaces of the enclosure are reflecting surfaces that allow reflection of the sound in the direction of the openings.

[0026] The size of the loudspeaker enclosure, the dimensions and position of the openings with respect to the front- and back-panel needs to be carefully designed in order to satisfy the expression described above. An alternative design of a loudspeaker housing for controlling $\bar{D}_{int}$ and $\bar{D}_{ext}$ is depicted in **Fig. 1B**. This embodiment is similar to the one described with reference to **Fig. 1A**, except for the fact that the side panels of the housing that comprise the openings are slightly tilted inwardly towards the central axis **112** of the loudspeaker. Tilting the orientation of the side panels relative will change the path lengths of the front- and back waves. Similarly, in a further embodiment (not shown), the side panels may be slightly tilted away for the central axis of the loudspeaker.

[0027] The average propagation speed of sound through the acoustic material $\bar{c}_{int}$ may be controlled by the quantity, type of material and the density of the acoustic material. The average path length in the acoustic chamber $\bar{D}_{int}$ may be controlled by the size and geometry of the acoustic chamber and by the size, geometry and

the position of the openings. Further, due to its size, the loudspeaker box will block more sound at higher frequencies so that it functions as a low pass filter for the front wave. Therefore, the front wave will have a low-pass function when it arrives at the backside of the loudspeaker housing.

[0028] The back-wave also needs to be corrected for this low-pass filtering effect of the front wave. This can be achieved by selecting an acoustic material that has a low-pass filter characteristic that substantially matches the loss-pass filtering characteristics of the loudspeaker housing as experienced by the front wave. In other words, the acoustic material needs to be selected such that at the location of the openings in the loudspeaker enclosure, the amplitude characteristics of the back wave substantially match the amplitude characteristics of the front wave. Finally, the front wave will be approximately 2 dB attenuated so that also a degree of attenuation of the back-wave is needed. Hence, the acoustic filling material has three functions, i.e.: 1) broadband delay of sound; 2) has a low-pass acoustic filter characteristic; and, 3) produces approximately 2,5 dB attenuation.

[0029] An acoustic filling material that meets the above criteria are fibers of a thermoplastic polymer resin of the polyester family polyester fiber material, e.g. fibers of (recycled) polyethylene terephthalate (PET). The density of the material may be selected within the range between 10 and 50 kg/m³. Instead of glass fiber material that is commonly used as acoustical material, thermoplastic polymer are not known to be cariogenic and to cause allergic reactions or respiratory failure. Moreover, fibers of a thermoplastic polymer resin do not produce dust.

[0030] Further, the inventors have found that the back-panel of the loudspeaker housing functions as a reflector and plays an important role in the optimization of strong attenuation of front waves in the mid frequency range at the backside of the loudspeaker housing. **Fig. 2** depicts the frequency characteristics of a loudspeaker as described with reference to **Fig. 1A** and **1B** for three different distances between the back-panel and the front-panel. Curve **204** represents the frequency characteristic of the front-wave for each of the three different distances. Hence, the position of the back-panel does not influence the forward frequency characteristics. In contrast, curves **206, 208, 210** represent the backward frequency characteristics wherein curve **206** represents a first back-panel position wherein the back-panel is closest to the front-panel and curve **208** represents a second back-panel position wherein the distance between the back-panel and the front-panel is the largest. Attenuation between 100 and 700 Hz of 15 dB or more is achieved by a third back-panel position that is located between the first and second back-panel position. These curves show that optimal attenuation can be achieved by careful selection of the distance between front and back-panel.

[0031] **Fig. 3A-3D** depicts different views a directional loudspeaker according to a further embodiment of the invention. The loudspeaker is configured to produce a

directional response with high attenuation in the mid frequency range (between 100 and 1200 Hz) at the backside of the loudspeaker. As shown in **Fig. 3A-3C**, the dimensions of the housing (width approximately 44 cm, depth approximately 40 cm and height approximately 65 cm) are of the same order as the wavelengths that need to be attenuated, i.e. frequencies in the range of 100 and 1000 Hz. **Fig. 3A** depicts the front side **302** of the loudspeaker housing. **Fig. 3B** provides a side view of the loudspeaker housing showing a side panel **304** comprising a linear array of longitudinal openings **306** wherein the longitudinal direction of the openings are parallel to the main axis **112** of the acoustic transducer. As shown in **Fig. 3C** and **3D** the side panels are slightly tilted inwardly towards the central axis **112** of the loudspeaker in order to control the path lengths of the front and back-wave. Although the openings are designed in **Fig. 3A-3D** as longitudinal openings, other opening shapes are also envisaged without departing the invention. For example, instead of a 1D array of longitudinally shaped openings, a 2D array of openings, e.g. square or circular shaped openings, is also foreseen. In an embodiment, the ratio between the surface of the openings and the total surface of a side panel may be selected between 5 and 50%, preferably between 10 and 40%.

[0032] It is further submitted that the directional loudspeaker may be used in combination with other directional loudspeakers. For example, a directional loudspeaker as described above with reference to **Fig. 1-3** may be used in combination with a directional loudspeaker for the high frequency part of the audio spectrum. For example, the directional loudspeaker may be used in combination with at least one horn loudspeaker for producing sound in the high frequency range, wherein the directionality of the high frequency sound of said horn loudspeaker substantially matches the directionality of the sound produced by said directional speaker.

[0033] Alternatively and/or in addition the directional loudspeaker as described above with reference to **Fig. 1-3** may be used in combination with a directional loudspeaker for the low frequency part of the audio spectrum. For example, the directional loudspeaker may be used in combination with at least one subwoofer that is configured to produce a cardioid response, wherein the directionality of the low frequency sound of said subwoofer substantially matches the directionality of the sound produced by said directional speaker.

[0034] In a further aspect, the invention may relate to a directional loudspeaker system comprising: a plurality of directional loudspeakers according to any of the embodiments described above, and; wherein said plurality of directional loudspeakers are configured as an acoustic line source (a line array).

[0035] Hence, the directional loudspeaker that is configured for use in the mid frequency range of the audio spectrum may be combined with one or more directional loudspeakers for the low and/or high frequency part of the audio spectrum. This way, a directional loudspeaker

system can be formed that a forward bundling effect of sound waves over a substantial part of the audio spectrum and at the same time a substantial attenuation of the front wave at the backside of the loudspeaker system.

[0036] Fig. 4 depicts the dispersion pattern of a directional loudspeaker according to an embodiment of the invention. In this plot, the x-axis represents the frequency of the sound, the left y-axis the angle in degrees wherein 0 degrees corresponds with a location right in front of the loudspeaker and the right y-axis indicates the sound level relative to the level at 0 degrees. The graph shows that the sound level at 0 degrees will decrease with increasing angles. At the backside of the loudspeaker the sound level is on average more than 20 dB attenuated with respect to the sound in front of the loudspeaker. Moreover, the sound level at larger angles gradually decreases with decreasing frequencies. This means that the frequency response for different angles is substantially the same as the frequency response at 0 degrees. Hence, sound originating up to 70 degrees will sound similar to the sound as the sound at 0 degree. Only the sound level will be different.

[0037] The ideal loudspeaker radiation pattern is a single forward beam that is wide enough to cover the entire audience, yet radiates almost no sound energy outside that beam. Just as important, the beam should have a similar width for all frequencies, so that those who are not right in front of the loudspeaker hear the same, well-balanced sound. Conventional loudspeaker systems are unable to achieve this as their dispersion pattern varies with frequency. As shown in Fig. 4, the directional speaker according to the invention has an extremely constant beam width and, more importantly, maintains it throughout the entire audible spectrum. This means that an audience will perceive practically no variations in tonal balance.

[0038] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" 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.

[0039] The corresponding structures, materials, acts, and equivalents of all means or step plus function elements in the claims below are intended to include any structure, material, or act for performing the function in combination with other claimed elements as specifically claimed. The description of the present invention has been presented for purposes of illustration and description, but is not intended to be exhaustive or limited to the invention in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the

art without departing from the scope and spirit of the invention. The embodiment was chosen and described in order to best explain the principles of the invention and the practical application, and to enable others of ordinary skill in the art to understand the invention for various embodiments with various modifications as are suited to the particular use contemplated.

10 Claims

1. A directional loudspeaker for use in the mid frequency range of the audio spectrum comprising:
 - a housing comprising a front panel, side panels and a back panel, said housing comprising an acoustic resistive material;
 - wherein at least one acoustic transducer is mounted to said front panel, said transducer being configured to drive a membrane for producing front waves at the front of said membrane and back waves at the back of said membrane; and,
 - wherein one or more openings in said side panels, and, optionally, in said back panel allowing at least part of said back waves to exit said housing via said resistive material, said resistive material, said openings and said reflective back panel introducing for said back waves in the mid frequency range a phase delay, an attenuation and an amplitude such that an attenuation at the backside of said loudspeaker of 15 dB or more, preferably 20 dB or more, of the midrange frequencies is achieved.
2. Directional loudspeaker according to claim 1 wherein the geometry and position of said back-panel with respect to the openings and the front-panel are selected such that said attenuation at the backside of said loudspeaker is maximized.
3. Directional loudspeaker according to claims 1 or 2 wherein the said acoustic material is a fibrous (thermoplastic) polymer material, preferably a polyester material, more preferably said polyester material comprising polyethylene terephthalate (PET).
4. Directional loudspeaker according to any of claims 1-3 wherein said acoustic material is a fibrous polymer material, wherein the density of said fibrous polymer material is selected between 10 and 50 kg/m³.
5. Directional loudspeaker according to any of claims 1-4 wherein the ratio between the open surface of said openings and the total surface of a side panel is selected between 5 and 50%, preferably 10 and 40%.

6. Directional loudspeaker according to any of claims 1-5 wherein said one or more openings are longitudinally shaped openings wherein said longitudinal axis of said longitudinal shaped openings are oriented in parallel to the central axis of said transducer. 5
7. Directional loudspeaker according to any of claims 1-6 wherein said openings are configured as an array of openings in said side panel and/or said back panel. 10
8. Directional loudspeaker according to any of claims 1-7 wherein said midrange frequencies are selected between 100 and 1000 Hz, preferably 200 and 800 Hz. 15
9. Directional loudspeaker according to any of claims 1-8 wherein said side-panels are oriented under an angle with the central axis of said acoustic transducer. 20
10. Directional loudspeaker according to any of claims 1-9 wherein the dimensions of said housing (length, width, height) are selected between 10 and 100 cm, preferably 20 and 80 cm, more preferably between 30 and 70 cm. 25
11. Directional loudspeaker according to any of claims 1 to 10 wherein the frequency response for angles up to and including 70 degrees is substantially the same as the frequency response at 0 degrees. 30
12. A directional loudspeaker system comprising:
 - a directional loudspeaker according to any of claims 1-11, and; at least one horn loudspeaker for producing sound in the high frequency range, wherein the directionality of the high frequency sound of said horn loudspeaker substantially matches the directionality of the sound produced by said directional speaker. 35 40
13. A directional loudspeaker system comprising:
 - a directional loudspeaker according to any of claims 1-11, and; at least one subwoofer that is configured to produce a cardioid response, wherein the directionality of the low frequency sound of said subwoofer substantially matches the directionality of the sound produced by said directional speaker. 45 50
14. A directional loudspeaker system comprising:
 - a plurality of directional loudspeakers according to any of claims 1-11, and; wherein said plurality of directional loudspeakers are configured as a acoustic line source (a line array). 55

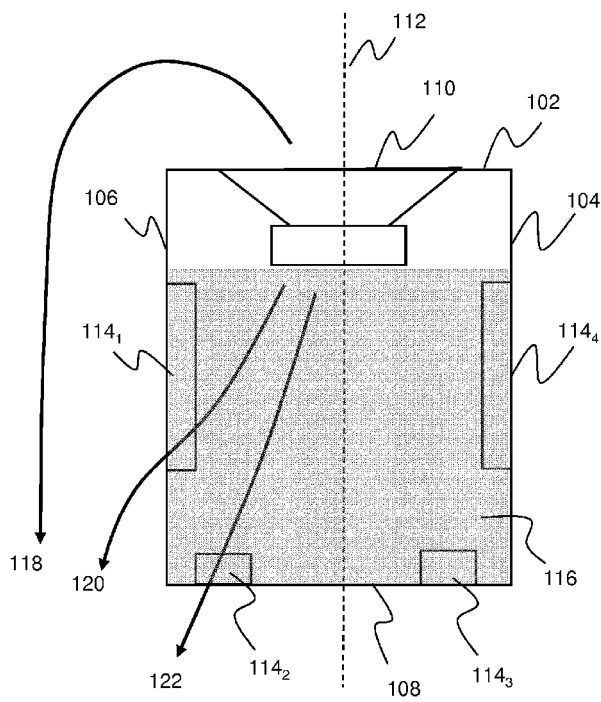


FIG. 1A

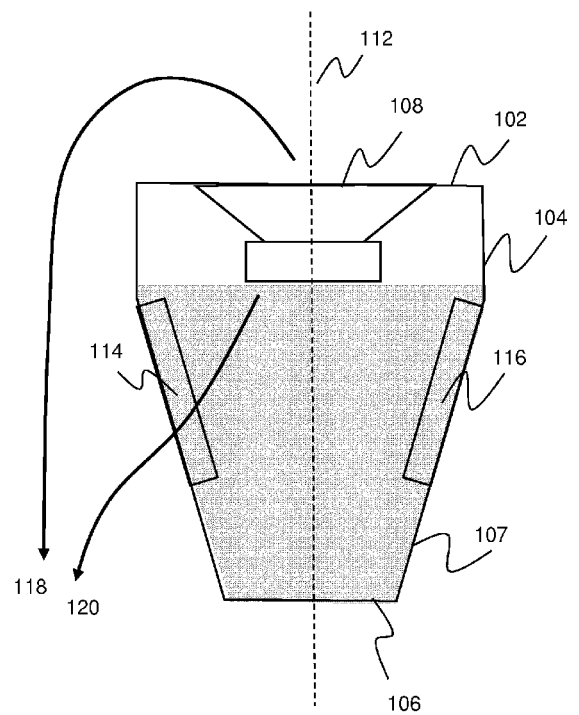


FIG. 1B

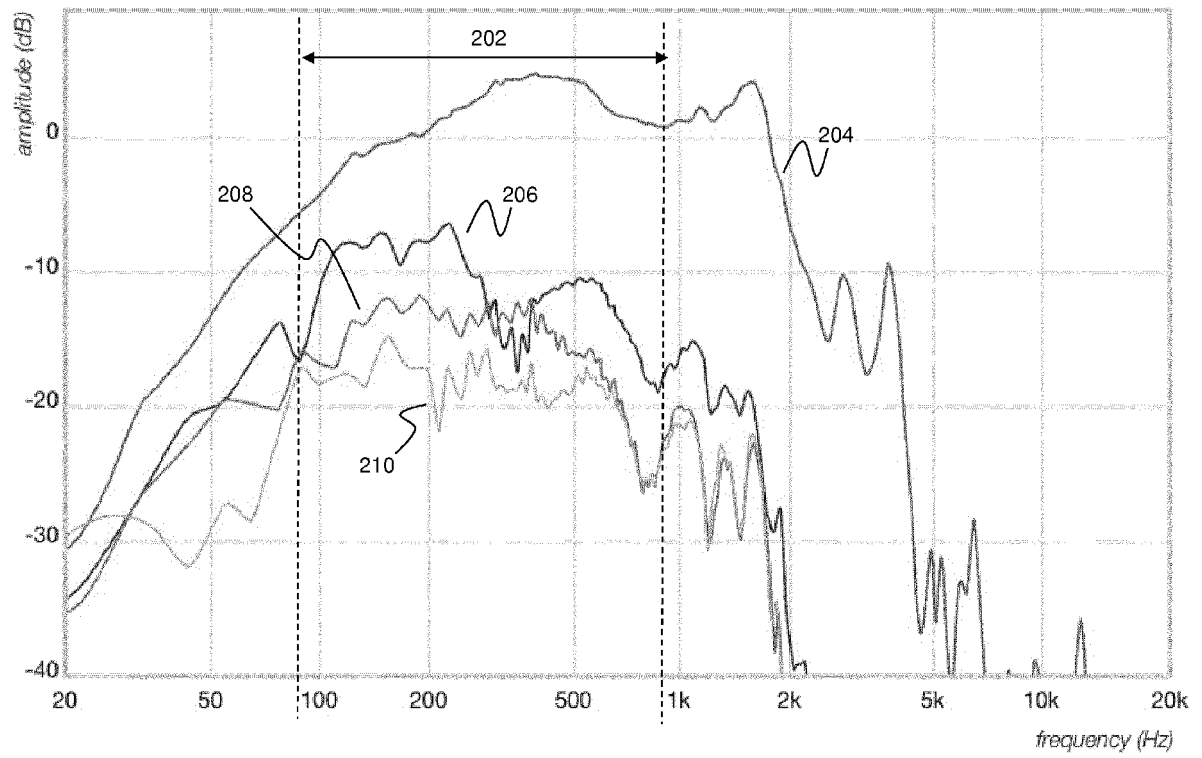
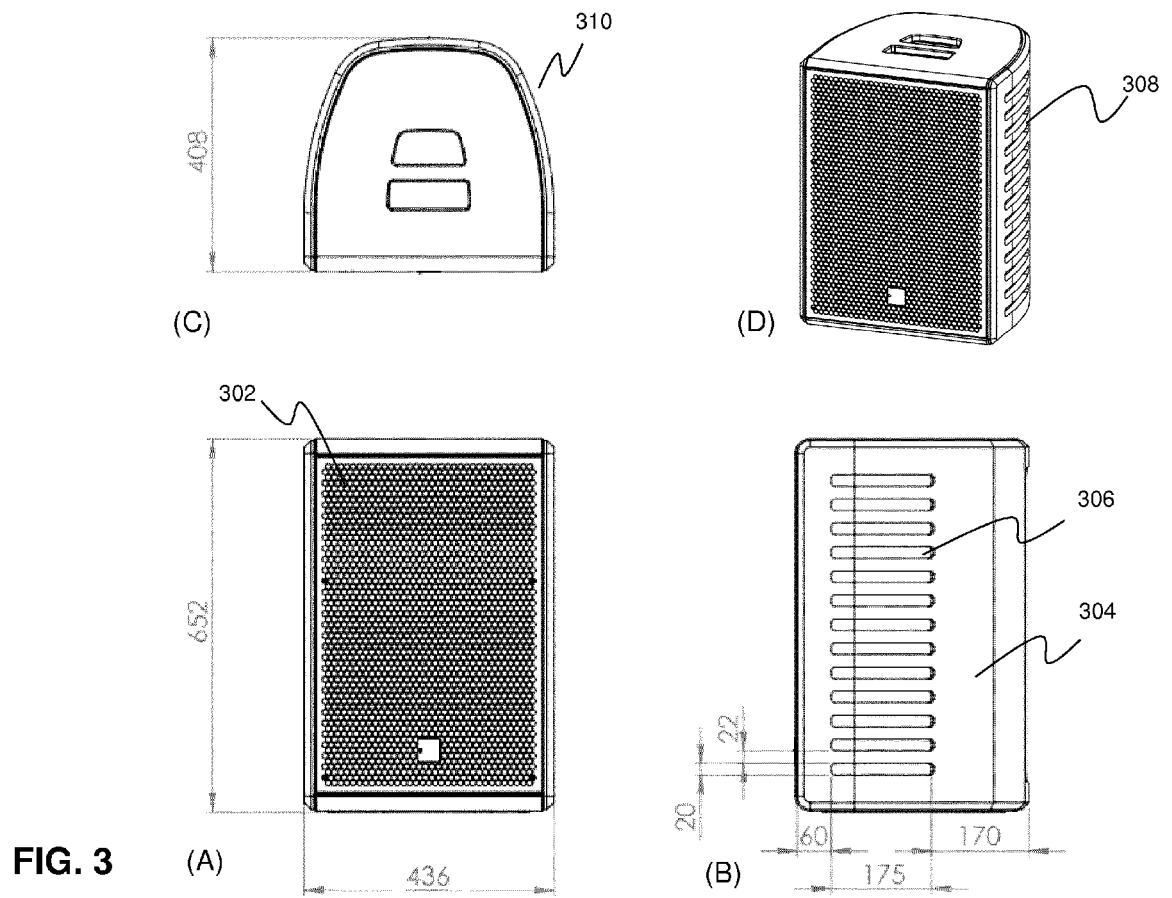


FIG. 2



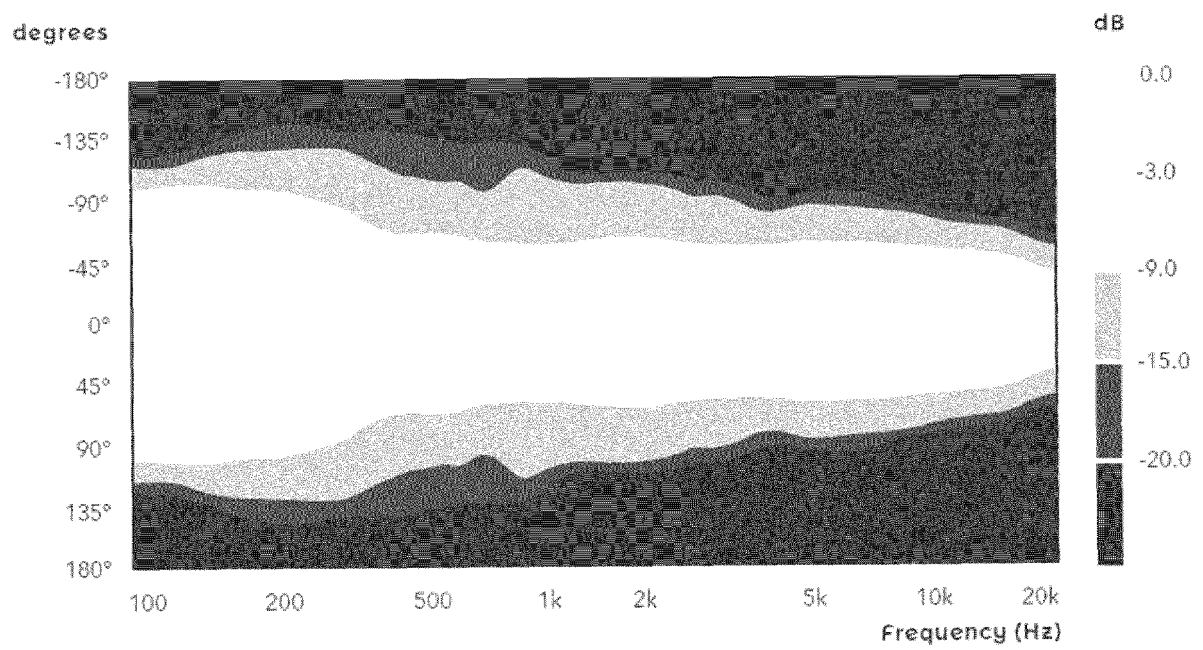


FIG. 4



EUROPEAN SEARCH REPORT

Application Number
EP 15 19 2976

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A,D	WO 2010/108123 A1 (MEYER SOUND LAB INC [US]) 23 September 2010 (2010-09-23) * para. 1-8; para. 25-53 *	1-14	INV. H04R1/34
A	US 3 722 616 A (BEAVERS B) 27 March 1973 (1973-03-27) * col. 1, l. 3-5; col. 2, l. 21-col. 5, l. 36 *	1-14	
A	US 6 628 793 B1 (PORZILLI MARK G [US] ET AL) 30 September 2003 (2003-09-30) * col. 1, l. 10-col. 2, l. 8; col. 2, l. 40-col. 3, l. 3; col. 4, l. 53-col. 6, l. 21 *	1-14	
A	US 4 054 748 A (BALOGH GEZA) 18 October 1977 (1977-10-18) * col. 1, l. 1-col. 4, l. 68 *	1-14	
			TECHNICAL FIELDS SEARCHED (IPC)
			H04R
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 24 February 2016	Examiner Peirs, Karel
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