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(54) **Audio management device for sending and/or receiving sound waves**

(57) Audio management device (1) comprising a sound wave reflector (4) having a sound wave reflecting surface part (19) with at least one paraboloidal reflecting surface part (20,34) and at least one speaker (5) which is directed towards the at least one paraboloidal reflecting surface part (20,34) and which is positioned on the central axis (AA') of that paraboloidal reflecting surface part (20,34), wherein the sound wave reflector (4) has a tubular surface part (21) comprising sound wave absorbing means (22) which extends from the sound wave reflecting surface part (19) to a limiting edge (25) in a direction parallel to a central axis (AA') of the at least one paraboloidal reflecting surface part (19).

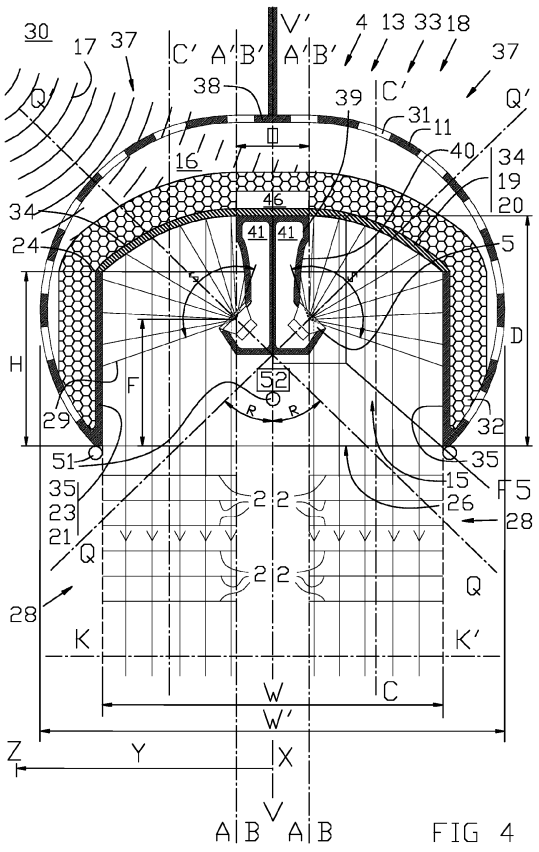

FIG 4

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Description

[0001] The present invention relates to an audio management device for sending and/or receiving sound waves.

[0002] In particular, the present invention relates to such an audio management device comprising a sound speaker device with a sound wave reflector having at least one reflecting surface part for reflecting sound waves and at least one speaker which is directed towards the at least one sound wave reflecting surface part.

[0003] Still more in particular, said sound wave reflecting surface part comprises at least one paraboloidal reflecting surface part, the speaker being positioned on the central axis of that paraboloidal reflecting surface part.

[0004] Such a type of audio management devices comprising such speaker devices is known according to the state of the art, for example in order to realize so-called sound wave lenses intended to direct sound to a listener.

[0005] Indeed, sound waves sent in all kinds of directions by a speaker which is located in the focal point of the paraboloidal reflecting surface part are reflected as a bundle of plane sound waves with restricted scope corresponding to the size of the paraboloidal reflecting surface part and moving in a direction parallel to the central axis of the paraboloidal reflecting surface part.

[0006] In that way, the sound produced by the speaker can be directed in a direction corresponding to the direction of the central axis of the paraboloidal reflecting surface part and is restricted to a restricted area.

[0007] A disadvantage however of the known audio management devices and of their speaker system is that they are designed without taking into account surround noise or sound waves which do originate from sound wave sources different from the speaker and which are incident on the sound wave reflector.

[0008] This means that sound produced by the speaker, and which is intended to be sent to the listener, as well as random disturbing sound produced by devices in the surrounding environment or noise sources and which is not intended to be sent to the listener, are mixed up and are both reflected by the sound wave reflector towards the listener.

[0009] As a consequence, the sound heard by the listener is contaminated by noise of the environment and the concentration of the sound of the speaker into a sound bundle which is directed towards the listener does not result in the desired signal-to-noise ratio.

[0010] The sound waves sent to the listener are not sufficiently isolated from the surrounding noise.

[0011] In the known audio management devices background noise is often also reflected on the sound wave reflecting surface part further into the environment.

[0012] These disadvantages of the known audio management devices under discussion are in particular important in environments wherein there is a lot of background noise, such as telephone call centers, large offices and so on.

[0013] Another disadvantage of the known audio management devices is that the sound sent by the speaker of the speaker device is partly scattered directly or reflected indirectly into the environment, so that the audio management device itself contributes to the background noise of other listeners.

[0014] A part of the sound produced by the speaker which is scattered into the environment can originate directly from the speaker, for example when it is not incident on the sound wave reflector.

[0015] However, another important source of sound causing spillover, is usually neglected and consists of the so-called third order reflection of the sound produced by the speaker.

[0016] Indeed, as explained, the first reflection of the sound produced by the speaker is reflected on the sound wave reflector resulting in a bundle of plane sound waves.

[0017] These plane sound waves are themselves reflected on the floor of the concerned room or a desk or the like and redirected towards the reflector as a reflected plane sound wave of second order.

[0018] A characteristic of a paraboloid reflecting surface is that such a reflected second order plane sound wave travelling to the paraboloid reflecting surface in the direction of its central axis is reflected towards the focal point of that paraboloid reflecting surface, so to be scattered in all kinds of directions into the surrounding environment, which is of course a very disturbing aspect.

[0019] It is therefore an objective of this invention to overcome one or more of the above-mentioned drawbacks or possibly other non-mentioned drawbacks of the known audio management devices.

[0020] In particular, it is an aim of the present invention to provide an audio management device with a sound source which is located at a certain distance from a listener and which is capable of directing sound produced by the sound source towards the listener, while reducing interference with background noise from the environment, so to provide an isolated bundle of sound to the listener.

[0021] Another aim of the invention is to ensure that sound produced by the sound source of the audio management system is not scattered or only in a very reduced way into the surrounding environment outside the above mentioned range of the bundle of plane sound waves in order to prevent that sound produced by the audio management device would become a source of noise for other listeners in the environment.

[0022] It is in particular an aim of the invention to avoid spillover of so-called third order reflections of the sound waves produced by the speaker.

[0023] To this end, the invention proposes an audio management device for sending and/or receiving sound waves of a type described in the preamble of claim 1, wherein additionally the sound wave reflector has a tubular surface part comprising sound wave absorbing means and which extends from a rim of the sound wave reflecting surface part to a limiting edge of the sound

wave reflector in a direction parallel to a central axis of the at least one paraboloidal reflecting surface part.

[0024] One of the big advantages of such an audio management device is that the tubular surface part with sound wave absorbing means which extends from the reflecting surface part is forming a kind of sound wave absorbing screen.

[0025] On the one hand, this screen prevents that undesired background noise coming from noise sources in the environment of the sound management device can reach the sound wave reflecting surface to be reflected towards the listener or further into the surrounding environment.

[0026] On the other hand, this screen also prevents that sound waves produced by the speaker of the audio management device and which are not incident on the sound wave reflecting surface can escape towards the environment around the audio management device without being at least strongly weakened in strength or completely adsorbed by the sound wave adsorbing means of the tubular surface part.

[0027] In a similar way, the tubular surface part also forms a screen or sound wave absorption means for capturing the above-mentioned third order sound wave reflections.

[0028] So, an audio management device is obtained comprising a speaker that provides multi-directional sound which is reflected towards the listener as a bundle of plane sound waves, the plane sound waves of the bundle not being mixed up with surrounding noise and therefore being isolated from the environment more efficiently than with the known audio management devices.

[0029] In a preferred embodiment of an audio management device in accordance with the invention, the sound wave absorbing tubular surface part has a certain height and the at least one paraboloidal reflecting surface part has a focal point which is positioned on the central axis of that reflecting surface part at a distance from an opening formed by the aforementioned limiting edge of the sound wave reflector, the distance to the focal point being smaller than the height of the tubular surface part and being larger than half said height.

[0030] This means that the focal point is positioned within a space which is laterally surrounded by the tubular surface part and which is at a position on the central axis somewhat towards the sound wave reflecting surface part, rather than towards the opening formed by the limiting edge.

[0031] In that way, multi-directional sound sent by the speaker can easily cover the entire sound wave reflecting surface, while third order sound wave reflections are at the same time captured by the sound wave absorbing tubular surface part.

[0032] According to another aspect of an audio management device in accordance with the invention, the sound wave reflector has a concave inner surface with a certain depth and additionally the sound wave absorbing tubular surface part of the audio management device extends over a substantial part of that depth.

[0033] According to the invention, preferably, the sound wave absorbing tubular surface part extends over at least a third of that depth of the concave inner surface, more preferably over at least half of that depth and even still more preferably over 75% or more of that depth.

[0034] An audio management device in accordance with one of said embodiments is very efficient in directing sound to a listener and for preventing surrounding background noise from interfering with the sound waves to be sent to the listener, as well as for preventing scattering of sound to be sent to the listener or reflections of that sound into the environment.

[0035] In another preferred embodiment of an audio management device according to the invention, the sound wave reflector has a hollow body formed by a reflector wall, a first reflector wall part of which forming a convex outer surface and a second reflector wall part of which forming a concave inner surface, the first reflector wall part and second reflector wall part being separated from one another by means of an inside cavity, and wherein sound wave absorbing means are formed by perforations in concerned parts of the reflector wall giving access to the inside cavity and by sound absorbing material applied in the inside cavity.

[0036] Such an embodiment of an audio management device in accordance with the invention is provided with sound wave absorbing means which are very adequate, since the sound waves which are captured into the cavity have no or almost no opportunity to escape and are not reflected back into the environment and are therefore completely or almost completely absorbed.

[0037] In a preferred embodiment of an audio management device according to the invention the sound wave reflector has a convex outer surface comprising at least one spherical surface part and the entire convex outer surface is provided with sound wave absorbing means.

[0038] A spherical surface part is advantageous over other surface shapes in that it provides a maximal effective surface for catching background noise and in that it allows exposition to all directions, so that background noise coming from all kinds of directions can be captured in a very effective way.

[0039] In still another embodiment, an audio management device according to the invention is provided with an active noise cancelling system comprising one or more microphones for measuring an incoming noise source to be canceled; one or more noise cancelling speakers for sending anti-noise that cancels at least partly the incoming noise; and a controller for creating an anti-noise signal to be sent by the noise canceling speaker(s).

[0040] Such an embodiment allows for a still more effective reduction of background noise heard by the listener.

[0041] In particular, such an active noise cancelling system can be very interesting in environments wherein the background noise has a kind of repetitive and pre-

dictable character, such as noise produced by photocopiers, printers, coffee machines and so on, since in such environments the processing time for producing the anti-noise to be sent can be reduced considerably.

[0042] With the intention of better showing the characteristics of the invention, hereafter, as example without any limitative character, some preferred embodiments are described of an audio management device in accordance with the invention, with reference to the accompanying drawings, wherein:

figure 1 represents a schematic perspective view of a first embodiment of an audio management device according to the invention, applied in a room wherein a listener is sitting at his desk;
figure 2 is a partial sectional view on the same audio management device indicated by line II-II' in figure 1;
figure 3 represents a schematic perspective view of a second embodiment of a part of an audio management device according to the invention, displayed in a three dimensional Cartesian coordination system;
figure 4 is a sectional view through the second embodiment in the cross-sectional plane indicated by arrows IV-IV' in figure 3; and,
figure 5 is a partial perspective view on the part indicated by F5 in figure 4.

[0043] The audio management device 1 according to the invention, a first embodiment of which being represented in figures 1 and 2, is intended for sending sound waves 2 and possibly also for receiving sound waves.

[0044] For that purpose it is provided with a speaker device 3 which is, in the embodiment represented in figures 1 and 2, a monophonic speaker device 3.

[0045] This speaker device 3 comprises a sound wave reflector 4 and a speaker 5 which is directed towards the reflector 4.

[0046] The speaker device 3 is, in the illustrated embodiment, executed as an overhead speaker device 3 which is hung from the ceiling 6 of a room 7 by means of a cable or rod 8 above a person 9 which is sitting at his desk 10.

[0047] The sound wave reflector 4 is in the represented case executed as a hollow body formed by a reflector wall 11.

[0048] A first reflector wall part 12 of this reflector wall 11 is forming a convex outer surface 13 of the sound wave reflector 4, while a second reflector wall part 14 of the sound wave reflector 4 is forming a concave inner surface 15.

[0049] The first reflector wall part 12 and second reflector wall part 14 are separated from one another by means of an inside cavity 16.

[0050] According to the invention the convex outer surface 13 of the sound wave reflector 4 is intended for absorbing incoming background noise waves 17 and is for that purpose provided with sound wave absorbing means 18 which are preferably spread over the entire convex outer surface 13.

[0051] In the embodiment represented in figures 1 and 2, the convex outer surface 13 is formed by a surface part of spherical shape.

[0052] The concave inner surface 15 of the sound wave reflector 4 comprises on the one hand, a sound wave reflecting surface part 19, which is, in the embodiment of figures 1 and 2, formed by a single sound wave reflecting surface part 19 which is a single paraboloidal reflecting surface part 20 having a circular paraboloidal shape, and on the other hand, a surface part 21 which is provided with sound wave absorbing means 22 and which is bordering the sound wave reflecting surface part 19 and which is according to the invention a tubular surface part 21.

[0053] The paraboloidal sound wave reflecting surface part 19 is preferably made of a material that typically does not absorb sound waves and has therefor a very low sound wave absorption coefficient in a big range of frequencies.

[0054] For example, such a material can be any kind of plastics or a resin or the like.

[0055] Furthermore, the paraboloidal sound wave reflecting surface part 19 is preferably non-porous, smooth and sealed, so to ensure a good reflection of incident sound waves on the sound wave reflecting surface part 19.

[0056] In the embodiment of figures 1 and 2, the tubular surface part 21 is formed by a cylinder mantle 23.

[0057] The paraboloidal reflecting surface part 19 has a central axis AA' which coincides with the central axis BB' of cylinder mantle 23.

[0058] The tubular surface part 21 extends from a rim 24 of the sound wave reflecting surface part 19 to a limiting edge 25 of the sound wave reflector 4 in a direction parallel to the central axis AA' of the paraboloidal reflecting surface part 20.

[0059] The limiting edge 25 forms the circumference of a circular opening 26 which gives access to the concave inner surface 15 and defines the boundary 25 between the first reflector wall part 12 and the second reflector wall part 14.

[0060] The monophonic speaker 5 is directed towards the paraboloidal reflecting surface part 20 and is positioned on the central axis AA', preferably, as is the case in figures 1 and 2, in the focal point 27 of that paraboloidal reflecting surface part 20 and preferably directed towards the top of the that paraboloidal reflecting surface part 20.

[0061] In that way, multi-directional sound waves 2 produced by the speaker 5 which are sent in all kinds of directions and which are incident on the paraboloid reflecting surface part 20, are reflected as a plane sound wave in a direction CC' which is parallel to the central axis AA'.

[0062] As a result, the sound waves 2 produced by the speaker 5 are sent as a bundle 28 of plane sound waves 2 towards the listening person 9 sitting under the overhead speaker device 3, so that the sound is targeted

towards the receptor.

[0063] The dimensions of the sound wave reflector 4 are important and are preferably according to the invention such that the opening 26 formed by the limiting edge 25 has a maximum width W between 50 and 60 cm, while the convex outer surface 13 has a maximum width W' of not more than 90 cm.

[0064] By providing a sufficiently wide opening 26, it is ensured that the bundle 28 of plane sound waves 2 always reaches both ears of the person 9 even when the person 9 is slightly moving his head, as in normal cases when a person 9 is sitting at his desk 10.

[0065] On the other hand, the limited size W' of the convex outer surface 13, allows for an easy application in offices.

[0066] Still another important aspect of the speaker device 3 of the audio management device 1 according to the invention is that the sound wave reflector 4 has a concave inner surface 13 with a certain depth D and the sound wave absorbing tubular surface part 21 of the audio management device 1 has a height H, both dimensions being adapted to one another.

[0067] Hereby, the tubular surface part 21 preferably extends over at least a third of the depth D of the concave inner surface 13, more preferably over half of that depth D and still more preferably over 75% or more of that depth D, as is the case in figures 1 and 2, so to form an effective screen for sound waves provided at the rim 24 of the sound wave reflecting surface part 18.

[0068] It is clear that by increasing the height H of the tubular surface part 21 in further equal conditions a higher sound isolation ratio can be obtained.

[0069] In order to profit to a maximum of the space available, it is therefore good to maximize the height H of the tubular surface part 21 within the limits of the convex outer surface 13.

[0070] The focal point 27 is positioned on the central axis AA' of the reflecting surface part 20 at a distance F from the opening 26.

[0071] This distance F is preferably somewhat smaller than the height H of the tubular surface part 21, so that the focal point 27 is located within the cylindrical part formed by the cylinder mantel 23.

[0072] A plane sound wave which is travelling towards the sound reflector 4 along the central axis AA' (typically a reflected sound wave of second order) is reflected towards the focal point 27 as a third order sound wave reflection.

[0073] The height H of the tubular surface part 21 and the distance F to the focal point 27 should therefore at least be such that such a third order reflected sound wave is incident on the sound wave absorbing tubular surface part 21.

[0074] This will be the case when the distance F from the opening 26 to the focal point 27 is larger than half the height H of the tubular surface part 21.

[0075] Furthermore, in this first embodiment the monophonic speaker 5 preferably produces a good, uniform sound in directions within a cone 29, the central axis QQ' of which corresponding to the central axis AA' of the paraboloidal reflecting surface part 20 and having a top angle S in the focal point 27 which is sufficiently large in order to cover at least the entire sound reflecting surface part 19.

[0076] In that way it is ensured that sound waves 2 sent by the speaker 5 to the listener 9 form a bundle of plane sound waves 28 having a width W corresponding to the maximum width W of the opening 26 and that the listener 9 is exposed to a sound field of homogeneous sound quality and sound pressure at both ears.

[0077] Sound waves 2 produced by the speaker 5 which are not incident on the paraboloidal reflecting surface part 20 or reflected by the sound wave reflector 4 into a direction which is not parallel with the central axis AA' are captured by the tubular surface part 21, which is for that purpose provided with sound wave absorbing means 22, so that the produced sound is not scattered into the environment 30.

[0078] The sound wave absorbing means 18 of the convex outer surface 13, as well as the sound wave absorbing means 22 of the tubular surface part 20 of the concave inner surface 15 can be executed in all kinds of different ways.

[0079] Simulations were made wherein the total sound pressure level (SPL) and the sound pressure level for direct sound were compared between a central position X on the central axis AA' at the head of the person 9 and a radial position Z at a distance Y of 1 meter away from the central position X.

[0080] These simulations resulted in a 5:1 sound isolation ratio for SPL of the total sound and a 9:1 sound isolation ratio for SPL of direct sound, i.e. without influence of the room.

[0081] In order to realize the sound wave absorbing means 22 of the tubular surface part 21, the tubular surface part 21 of the second reflector wall part 14 is, in the case represented in figures 1 and 2, executed in a material which is known for its good sound wave absorbing characteristics, such as a non-dense, fibrous material, e.g. mineral wool, felt or fiberglass, or a sound wave absorbing foam, such as melamine or polyurethane acoustic foam, having a high sound wave absorption coefficient and high noise reduction coefficient (NRC).

[0082] Furthermore, according to the invention the noise reduction coefficient of the sound wave absorbing material is preferably at least 0.7 and even more preferably at least 0.8.

[0083] The sound wave absorbing means 18 of the convex outer surface 13 are executed somewhat differently.

[0084] First of all, the entire first reflector wall part 12 of the sound wave reflector 4 is provided with perforations or openings 31 (which are only illustrated in figure 2) giving access to the inside cavity 16 inside the hollow sound wave reflector 4.

[0085] Inside the cavity 16 a sound absorbing material

32 is applied, which consists for example of a mineral wool having a sufficiently large thickness T of preferably 10 cm or more.

[0086] In that way, background sound waves 17, coming from the environment 30 and which are incident on the convex outer surface 13 at a position provided with a perforation 31, will penetrate into the cavity 16, these background sound waves 17 being absorbed by the sound wave absorbing material 32.

[0087] Additionally, the entire convex outer surface 13 formed by the entire first reflector wall part 12 is executed in a sound wave absorbing material having sound wave absorbing characteristics similar to the characteristics of the tubular surface part 21, so to absorb also background sound waves 17 incident on the convex outer surface 13 at positions not provided with perforations 31 and thus further increase the performance of the sound wave absorbing means 18 intended for capturing background sound waves 17.

[0088] By adapting the size, shape and amount of openings or perforations 31 in the first reflector wall part 12 the sound wave absorbing characteristics of the sound wave absorbing means 18 can be easily adapted.

[0089] Of course, it is also not excluded from the invention to provide the tubular surface part 21 with perforations 31 in order to adapt the sound wave absorbing characteristics of the sound wave absorbing means 22 and/or on the contrary to execute the convex outer surface 13 without perforations 32 and so on.

[0090] According to the invention, the sound wave absorbing material is preferably coated for health and safety reasons.

[0091] According to the invention, the perforations 31 can be provided with an edge formed by a hollow cylindrical tube, so to form so-called Helmholtz resonators.

[0092] By adapting the size of the hollow tubes, the Helmholtz resonators can be tuned to the desired frequency or frequency range.

[0093] The passive noise reduction provided by the outer surface part 13 as well as by the tubular surface part 21 results in a lower level of reverberation in the room.

[0094] Background noise will not be canceled completely however, due to the still remaining direct path between a background noise source and the listener 9.

[0095] Figure 3 to 5 illustrate another embodiment of an audio management device 1 according to the invention, which is different form the first embodiment in that it comprises a speaker device 3 which is a stereophonic speaker device 33 intended for creating two separated bundles 28 of targeted sound.

[0096] The stereophonic speaker device 33 is executed, as in the preceding case, with a sound wave reflector 4 having a convex outer surface 13 provided with sound wave absorbing means 18 and a concave inner surface 15 with a sound wave reflecting surface part 19 and a tubular surface part 21 provided with sound wave absorbing means 22.

[0097] The reflecting surface part 19 of the concave inner surface 15 is however somewhat different and comprises in this case a pair of paraboloidal reflecting surface parts 34 each shaped as a half of a single circular paraboloidal reflecting surface part 20.

[0098] These paraboloidal reflecting surface parts 34 are spaced apart from one another by a certain offset distance O and are positioned symmetrically at opposite sides of an intermediate plane VV'.

[0099] The tubular surface part 21 extends in this case between the rim 24 at sound wave reflecting surface part 19 and the limiting edge 25 of the sound wave reflector 4 and comprises two semi-cylindrical surface parts 35 each shaped as a half of a single cylindrical mantle 23.

[0100] These semi-cylindrical surface parts 35 are separated from one another by a pair of surface parts 36 of rectangular shape having a width O corresponding to the abovementioned offset distance O and are also positioned symmetrically with respect to the intermediate plane VV'.

[0101] The axis BB' of each semi-cylindrical surface part 35 coincides with the central axis AA' of the corresponding adjacent paraboloidal reflecting surface part 34.

[0102] Furthermore, the convex outer surface 13 comprises a pair of hemi-spherical surface parts 37 which are each shaped as a half of a single spherical surface part.

[0103] These hemi-spherical surface parts 37 are again spaced apart from one another by the same offset distance O, and are connected to one another by an intermediate strip 38 which completes the outer convex surface 13.

[0104] As in the preceding case, the entire convex outer surface 13 is provided with sound wave absorbing means 18, realized on the one hand by perforations 31 (only represented in figure 4) which give access to an inside cavity 16 inside the hollow sound wave reflector 4, the cavity 16 being provided with sound wave absorbing material 32, and, on the other hand, by applying a sound wave absorbing material at the convex outer surface 13 formed by the first reflector wall 12.

[0105] The stereophonic speaker device 33 furthermore comprises a pair of monophonic speakers 5, whereby each speaker 5 is positioned on the central axis AA' of one the pair of paraboloidal reflecting surface parts 34 and is directed towards the concerned paraboloidal reflecting surface part 34.

[0106] Each speaker 5 is preferably positioned in the corresponding focal point 27 of the concerned paraboloidal reflecting surface part 34.

[0107] The dimensions of the sound wave reflector 4 are similar as in the first embodiment, the opening 26 formed by the limiting edge 25 having a maximum width W between 50 and 70 cm, while the convex outer surface 13 has a maximum width W' of not more than 90 cm.

[0108] Also the height H of the tubular surface part 21 extends preferably again over at least half of the depth

D of the concave inner surface 13 and more preferably over 75% or more of that depth D, while the distance F of each focal point to the opening 26 is preferably somewhat smaller than the height H of the tubular surface part 21, but larger than half that height H/2.

[0109] In order to obtain a good sound isolation ratio or a more equal sound at the listener 9, it is also important to choose a correct position of the focal point 27.

[0110] This position is defined by the focal distance (D-F in the figures), which is the distance between the focal point 27 and the vertex of the corresponding paraboloidal reflecting surface part 20.

[0111] It is clear that this distance D-F can vary depending on the degree of curvature of the paraboloidal reflecting surface part 20 and is actually a design parameter.

[0112] Let us now take the example of a paraboloidal reflecting surface part 20 which has a size corresponding to a width W of the opening 26 of 0.5 m.

[0113] According to the invention the focal distance D-F is in that case preferably between 0.125 m and 0.16 m.

[0114] Furthermore, the monophonic speakers 5 are incorporated into a wall 39 of the sound wave reflector 4 having a thickness P corresponding to the aforementioned offset distance O and which wall 39 partly fills the gap between the two paraboloid reflecting surface parts 34.

[0115] Each speaker 5 is intended for providing the sound source of one of the targeted sound bundles 28, i.e. a left and right channel respectively for the left and the right ear of the person 9.

[0116] The wall 39 is positioned symmetrically and is executed symmetrically with respect to the aforementioned intermediate plane VV' and the monophonic speakers 5 are mounted in the wall at opposite sides of the plane VV'.

[0117] Furthermore, the wall 39 is provided with sound wave absorbing means 40, which are in the represented case realized in a similar way as the tubular surface part 21 by means of a sound wave absorbing material, which is provided on the outside of it in order to avoid uncontrolled reflections that would diminish the targeted sound effect.

[0118] In order to decouple acoustically the speakers 5, the wall 39 is preferably internally separated into two chambers or cavities 41.

[0119] According to the invention it is, as an alternative or additionally, also not excluded to realize the wall 39 in a way similar to the convex outer surface 13 with perforations 31 giving access to a cavity or chamber 40 in which sound absorbing material is provided.

[0120] The monophonic speakers 5 are mounted symmetrically with respect to the intermediate plane VV' and are directed in a direction QQ' somewhat skew under an angle R with respect to the aforementioned intermediate plane VV', as is clearly illustrated for example in figure 5.

[0121] According to the invention the surrounding surface parts 42 of the wall 39 surrounding each speaker 5 of the stereophonic speaker device 33 are adapted for a good projection of the sound towards each paraboloid reflecting surface part 34.

[0122] To this aim, this surrounding surface part 42 is executed near the free edge 43 of the wall 39 with a somewhat raised part 44 compared to the flat wall surface 39, while a somewhat lowered part 45 compared to the flat wall surface 39 is provided in the surrounding part 42 in directions towards the paraboloid reflecting surface parts 34.

[0123] Additionally, in this second embodiment each monophonic speaker 5 preferably produces a good, uniform sound in directions within a cone 29, the central axis of which corresponding this time to the skew direction QQ' and having a top angle S in the corresponding focal point 27 of the concerned paraboloidal reflecting surface part 34 which angle S is for the same reasons as in the first embodiment sufficiently large in order to cover at least the concerned paraboloidal reflecting surface part 34, so to form a pair of homogeneous bundles of plane sound waves 28 directed towards the corresponding ear of the listener 9.

[0124] Using this design, a stereo separation of the channels or bundles 28 of up to 12 dB at the ears could be measured in the simulations, which is much more than the stereo separation of only approximately 2 dB that can be achieved with a classical two speaker stereo setup.

[0125] In the embodiments represented in the figures 1 to 5 each speaker of the stereophonic speaker device 33 of the audio management device 1 is positioned fixedly in a focal point 26 of the concerned paraboloidal reflecting surface part 20 or 34.

[0126] As an alternative, it is not excluded from the invention to provide the speaker device 3 with speakers 5 which are somewhat movable along the central axis AA' of the concerned paraboloidal reflecting surface part 20 or 34 out of the focal point 27.

[0127] Preferably, such a movement is allowed over only a few cm, the position of the speakers 5 being adjustable very accurately.

[0128] In that way, the sound field created at the position of the listener 9 can be broadened somewhat or on the contrary rendered somewhat more narrow.

[0129] As in the represented cases, the sound wave reflector 4 is preferably an overhead reflector 4, so that the spatial sound image is created from above the listener, i.e. in the vertical plane VV'.

[0130] It is however not excluded from the invention to make other arrangements, wherein the sound wave reflector is oriented otherwise.

[0131] Nevertheless, in some embodiments wherein the sound wave reflector 4 is executed as an overhead reflector 4, it can be interesting that the audio management device 1 comprises a digital signal processing unit 46 for converting the spatial sound image sent by the pair of monophonic speakers 5, from a vertical plane VV' to a horizontal plane KK'.

[0132] Using digital signal processing one can virtually

move the spatial sound image to the front of the listener 9, i.e. to the horizontal plane KK' at the level of the ears, which spatial sound is more comparable to traditional 2-speaker stereo sound reproduction.

[0133] For that purpose two digital filters are preferably employed.

[0134] First of all, the electric incoming signal which is fed to the speakers 5 for creating sound is preferably passed through a first filter representing the inverse of the transfer function related to the perception of sound coming from above.

[0135] After filtering the incoming unmodified electric signal with this first filter an intermediate, modified electric signal is formed by which the speakers 5 would create a sound which would appear as coming from inside the head, because the spatial localization cue has been removed from the incoming electric signal.

[0136] By passing the intermediate, modified electric signal to a second filter, representing the transfer function related to sound coming from the front, a finally modified electric signal is created which results in a sound effect, when fed to the speakers 5, corresponding to sound coming from the front.

[0137] In some applications, typically in applications wherein the background noise has a more or less predictable character, it can be interesting to provide the audio management device 1 with an active noise cancelling system 47.

[0138] Such an active noise canceling system 47 comprises preferably one or more microphones 48 for measuring an incoming noise source to be canceled, one or more noise cancelling speakers 49 for sending anti-noise that cancels at least partly the incoming noise; and a controller 50 for creating an anti-noise signal to be sent by the noise canceling speaker(s) 49.

[0139] In a possible embodiment of an audio management device 1 in accordance with the invention at least one of the speakers 5 on the central axis AA' of a paraboloidal reflecting surface part 20 or 34 of the audio management device 1 is both, i.e. a speaker 5 for streaming sound to be transmitted to a listener 9 as well as a noise cancelling speaker 49, anti-noise created by the controller 50 being superposed on the sound to be transmitted to the listener.

[0140] In order to increase the functionality of an audio management device 1 in accordance with the invention, non-audio applications can be integrated in the audio management device 1.

[0141] For example, as is illustrated in the figures, a lighting 51 can be provided on the sound wave reflector 4 consisting of one or more light sources 51, which can be light sources of all kinds, such as RGB LED lights, a halogen bulb and so on.

[0142] The light sources 51 can be provided on the convex outer surface 13 as well as on the concave inner surface 15 and can be of kind to increase the intensity of light received on the desk 10 in a direct way as well as in an indirect way, for example through reflection on the ceiling 6.

[0143] The free side of the intermediate wall 39 is for example a very suitable place for mounting LED lighting 51, as is illustrated by way of example in figure 5.

[0144] Another possible functionality which could be very interesting when integrated in the sound wave reflector 4, is a projector device 52 which is capable of projecting static images or moving images, for example on the desk 10 in front of the person 9 or on a wall or on whatever other surface.

[0145] The desk 10, wall or other surface can for that purpose be provided with a projection screen 53.

[0146] In a particular interesting embodiment of an audio management device 1 according to the invention, such a projection screen 53 provided on a desk 10 is provided with very good sound wave absorbing properties, so to contribute to the reduction of third order reflections of the sound waves 2 produced by the speakers 5.

[0147] The projector device 52 can be integrated in a computing system so that the person 9 can work at the desk 10 without the need of a computer screen.

[0148] The integration of audio parts with non-audio parts enables the realization of a multi-media device with increased sound quality, for example including blue tooth connectivity and audio-video streaming and so on.

[0149] In that way, the space available in the room, wherein the audio management device 1 is applied, is also used in a very efficient way.

[0150] In order to increase the channels provided to the person 9 it is not excluded from the invention to increase the number of speakers 5 and the number of corresponding paraboloid reflecting surface parts 20, for example in order to form an audio management device 1 with the functionality of a "five point one" surround sound multichannel audio system.

[0151] In another possible embodiment according to the invention, multiple additional tubular surface parts comprising sound wave absorbing means 22 are provided inside the sound wave reflector 4, concentric with the tubular surface part 21 extending from the rim 24 of the sound wave reflecting surface part 19 to the limiting edge 25.

[0152] In that way, incoming and outgoing sound waves which are not traveling in a direction AA'-BB'-CC' are captured by the additional tubular surface parts so to further increase the isolation ratio of the audio management device 1. The present invention is by no means limited to an audio management device 1 according to the invention described as examples and illustrated in the drawings, but such an audio management device 1 according to the invention can be realised in all kinds of variants, without departing from the scope of the invention.

Claims

1. Audio management device (1) for sending and/or re-

ceiving sound waves (2) comprising a speaker device (3,33) with at least the following elements:

- a sound wave reflector (4) having at least one sound wave reflecting surface part (19) comprising at least one paraboloidal reflecting surface (20,34) part having a central axis (AA'); and,
- at least one speaker (5) which is directed towards the at least one paraboloidal reflecting surface part (20,34) and which is positioned on the central axis (AA') of that paraboloidal reflecting surface part (20,34);

characterized in that the sound wave reflector (4) has a tubular surface part (21) comprising sound wave absorbing means (22) and which extends from a rim (24) of the sound wave reflecting surface part (19) to a limiting edge (25) of the sound wave reflector (4) in a direction parallel to a central axis (AA') of the at least one paraboloidal reflecting surface part (20,34).

2. Audio management device (1) according to claim 1, **characterized in that** the sound wave absorbing tubular surface part (21) of the audio management device (1) has a height (H) and that the at least one paraboloidal reflecting surface part (20,34) has a focal point (27) which is positioned on its corresponding central axis (AA') of the concerned paraboloidal reflecting surface part (20,34) at a distance (F) from an opening (26) formed by the limiting edge (25) of the sound wave reflector (4), the distance (F) to said focal point (27) being smaller than the height (H) of the tubular surface part (21) and being larger than half that height (H).

3. Audio management device (1) according to claim 1 or 2, **characterized in that** the sound wave reflector has a concave inner surface (15) with a certain depth (D) and **in that** the sound wave absorbing tubular surface part (21) of the audio management device (1) has a height (H) which extends over at least a third of that depth (D), preferably over half of that depth (D) and still more preferably over 75% or more of that depth (D).

4. Audio management device (1) according to any of the preceding claims, **characterized in that** the sound wave reflector (4) comprises a convex outer surface (13) provided with an opening (26) formed by the limiting edge (25) and a concave inner surface (15) provided in the opening (26) connected to the convex outer surface (13) at the limiting edge (25) and **in that** the at least one sound wave reflecting surface part (19) and the tubular surface part (21) are constituent parts of the concave inner surface (15) and **in that** the at least one paraboloidal reflecting surface part (20) has a shape corresponding to a part of a circular paraboloid (20).

5. Audio management device (1) according to claim 4, **characterized in that** the entire convex outer surface (13) is provided with sound wave absorbing means (18).

6. Audio management device (1) according to any of the preceding claims, **characterized in that** it comprises a monophonic speaker device (3) comprising:

- a concave inner surface (15) formed by a single sound wave reflecting surface part (19) being a paraboloidal reflecting surface part (20) having a circular paraboloidal shape (20) and which is bordered by a tubular surface part (21) shaped as a cylinder mantle (23), the axis (BB') of which coinciding with the central axis (AA') of the paraboloidal reflecting surface part (20) and which tubular surface part (21) is provided with sound wave absorbing means (22);
- a convex outer surface (13) which has a spherical shape and which is provided with sound wave absorbing means (18); and,
- a monophonic speaker (3) positioned on the central axis (AA') of the paraboloidal reflecting surface (20) and directed towards the top of the paraboloidal reflecting surface (20).

7. Audio management device according to any one of claims 1 to 5, **characterized in that** it comprises a stereophonic speaker device (33) comprising:

- a concave inner surface (15) having, on the one hand, a sound wave reflecting surface part (19) which comprises a pair of paraboloidal reflecting surface parts (34) each shaped as a half of a single circular paraboloidal reflecting surface part (20), the paraboloidal reflecting surface parts (34) spaced apart from one another by a certain offset distance (O) and positioned symmetrically at opposite sides of an intermediate plane (VV'), and, on the other hand, a tubular surface part (21) extending between a rim (24) at the sound wave reflecting surface part (19) and the limiting edge (25) of the sound wave reflector (4), which comprises two semi-cylindrical surface parts (35) each shaped as a half of a single cylindrical mantle (23), the axis (BB') of each semi-cylindrical surface part (35) coinciding with the central axis (AA') of a corresponding adjacent paraboloidal surface part (34), which tubular surface part (21) is provided with sound wave absorbing means (22); and,
- a convex outer surface (13) comprising a pair of hemi-spherical surface parts (37) each shaped as a half of a single spherical surface part, spaced apart from one another by the same offset distance (O), the convex outer surface (13) provided with sound wave absorbing

means (18); and,

- a pair of monophonic speakers (5), each speaker (5) positioned on a central axis (AA') of one of the pair of paraboloidal reflecting surface parts (34) and directed towards the concerned paraboloidal reflecting surface part (34).

8. Audio management device (1) according to claim 7, **characterized in that** the sound wave reflector (4) comprises a wall (39) having a thickness (P) corresponding to the aforementioned offset distance (O), which is symmetrical with respect to the aforementioned intermediate plane (VV'), the monophonic speakers (5) being mounted in the wall (39) and **in that** the wall (39) is provided with sound wave absorbing means (40).

9. Audio management device (1) according to claim 7 or 8, **characterized in that** the monophonic speakers (5) are mounted symmetrically with respect to the intermediate plane (VV') and are directed in a direction (QQ') somewhat skew under an angle (R) with respect to the aforementioned intermediate plane (VV').

10. Audio management device (1) according to any of claims 7 to 9, **characterized in that** the sound wave reflector (4) is an overhead reflector (4) and **in that** the audio management device (1) comprises a digital signal processing unit (46) for converting the spatial sound image sent by the pair of monophonic speakers (5), from a vertical plane (VV') to a horizontal plane (KK').

11. Audio management device (1) according to any of the preceding claims, **characterized in that** its speakers (5) are positioned fixedly in a focal point (27) of the concerned paraboloidal reflecting surface part (20,34).

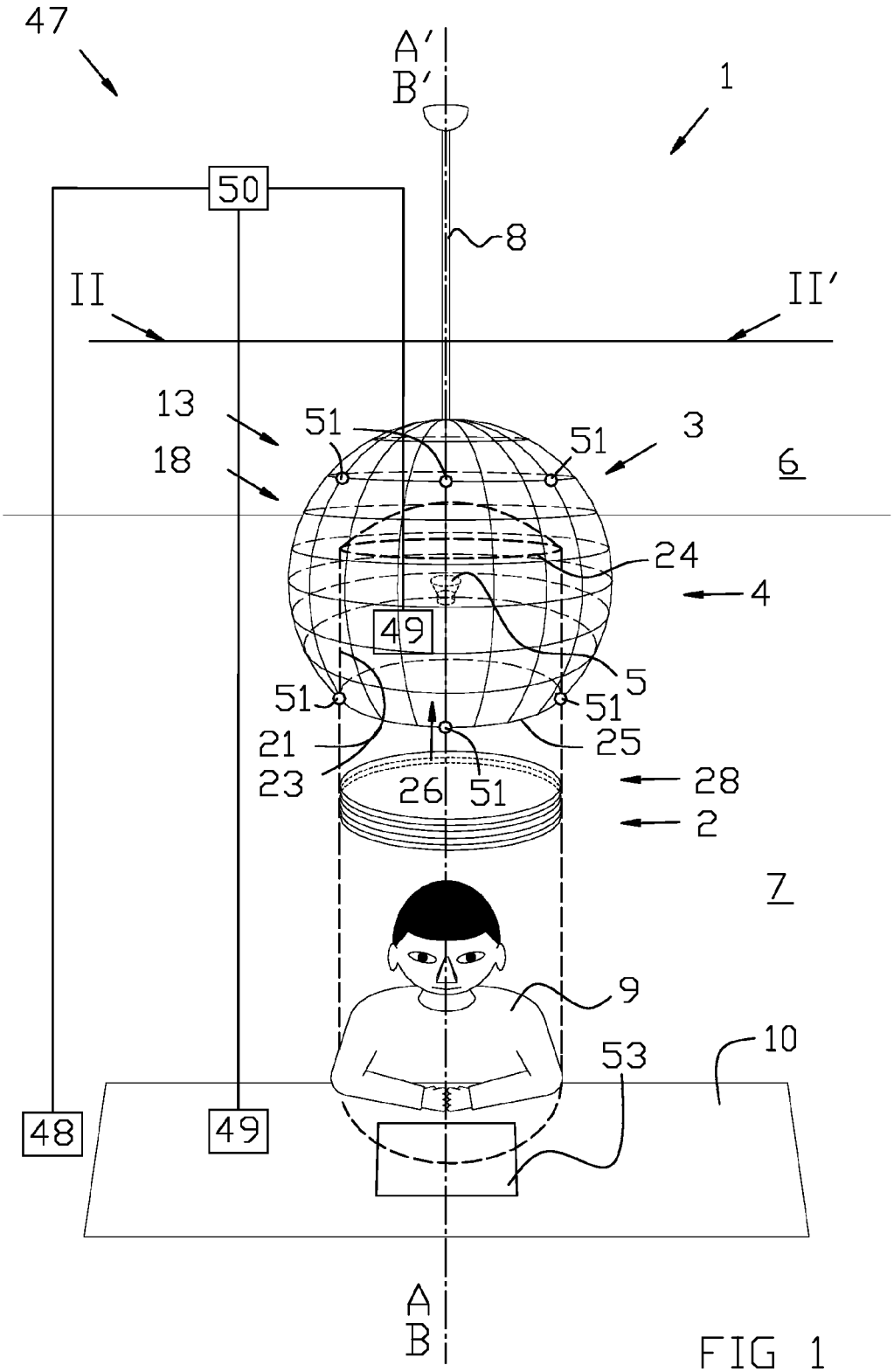
12. Audio management device (1) according to any of claims 1 to 10, **characterized in that** its speakers (5) are movable along the central axis (AA') of the concerned paraboloidal reflecting surface part (20,34).

13. Audio management device (1) according to any of the preceding claims, **characterized in that** the opening (26) formed by the limiting edge (25) has a maximum width (W) between 50 and 70 cm and that the convex outer surface (13) has a maximum width (W') of not more than 90 cm.

14. Audio management device (1) according to any of the preceding claims, **characterized in that** the sound wave reflector (4) has a hollow body formed by a reflector wall (11, 39), a first reflector wall part (12) of which forming a convex outer surface (13) and a second reflector wall part (14) of which forming a concave inner surface (15), the first reflector wall part (12) and second reflector wall part (14) being separated from one another by means of an inside cavity (16, 41), and **in that** one or more of the aforementioned sound wave absorbing means (18,22,40) are formed by perforations (31) in concerned parts of the reflector wall (11,39) giving access to the inside cavity (16,40) and by sound absorbing material (32) applied in the inside cavity (16,40).

15. Audio management device (1) according to any of the preceding claims, **characterized in that** it is provided with an active noise cancelling system (47) comprising:

- one or more microphones (48) for measuring an incoming noise source to be canceled;
- one or more noise cancelling speakers (49) for sending anti-noise that cancels at least partly the incoming noise; and,
- a controller (50) for creating an anti-noise signal to be sent by the noise canceling speaker(s) (49).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8
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II'
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9
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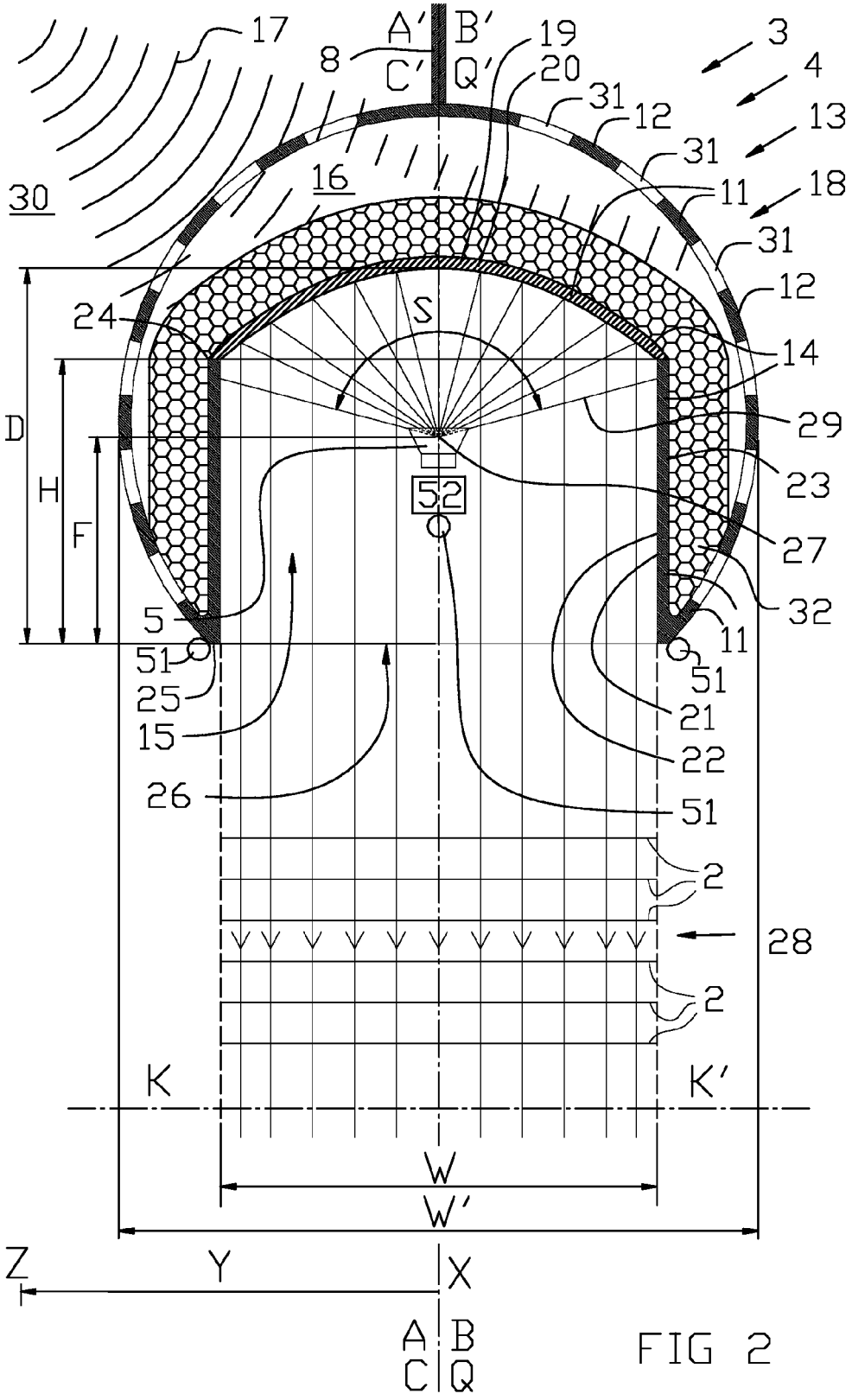
53
48
49
A
B

FIG 1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24
S
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D
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H
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F
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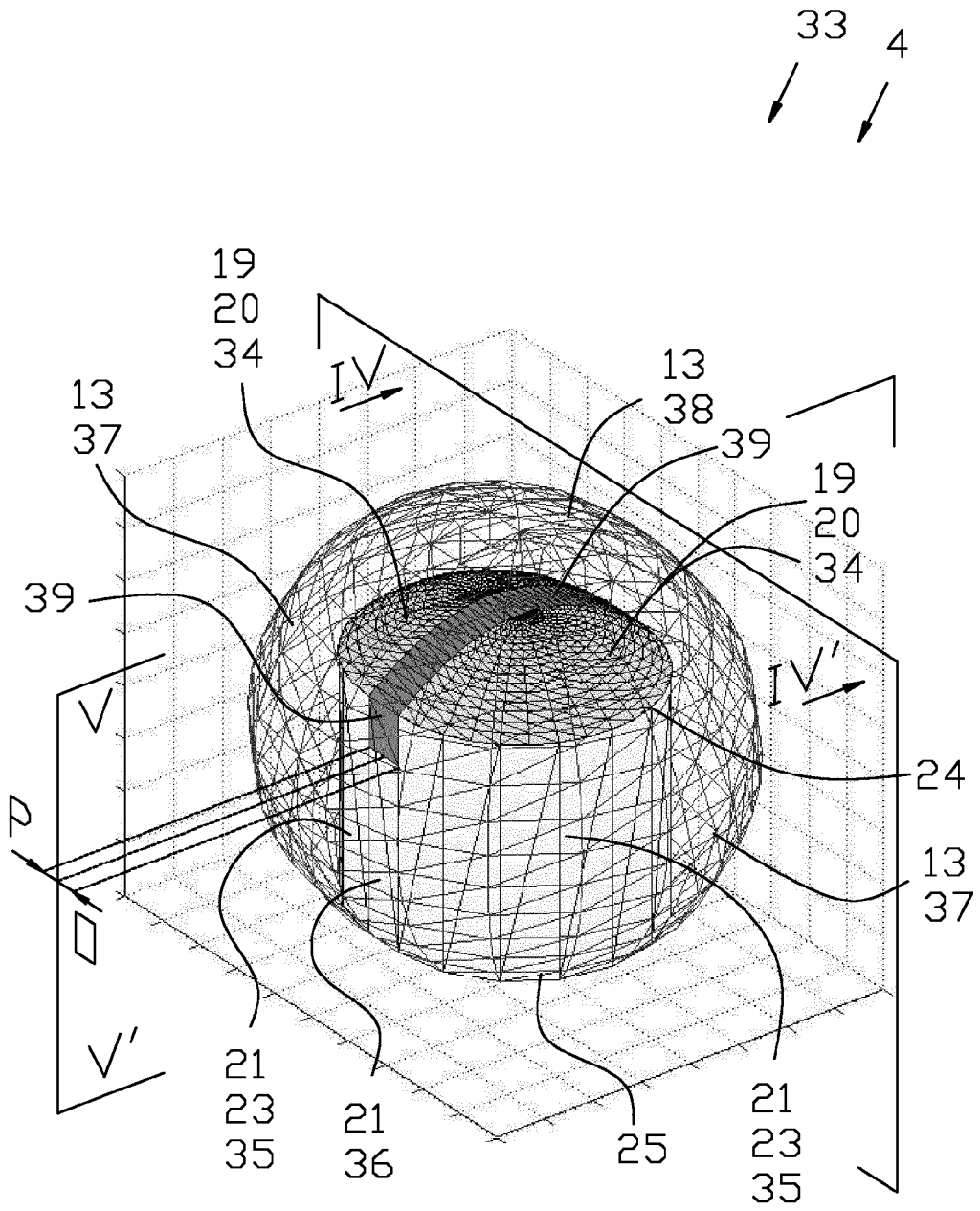
FIG 2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34
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34
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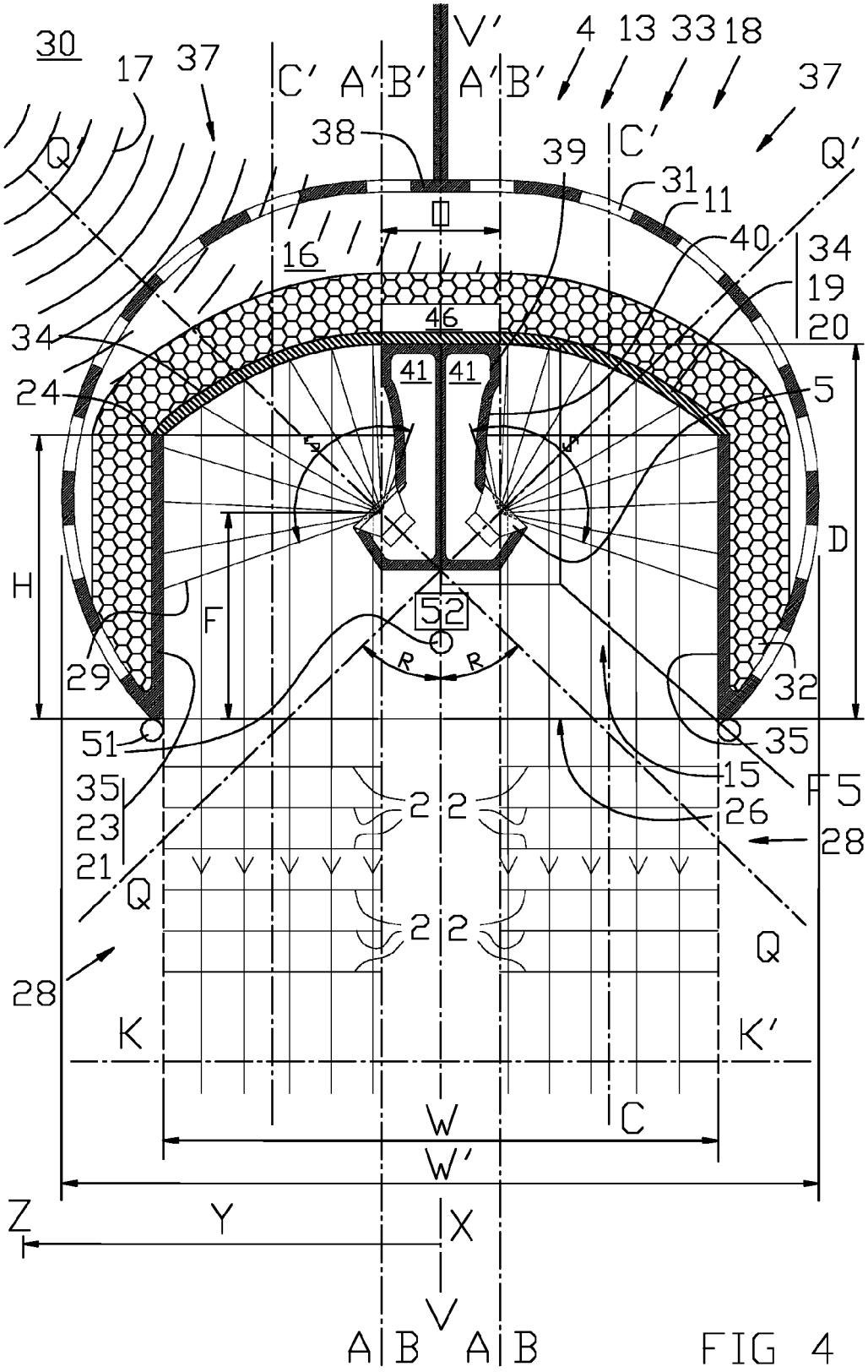
FIG 3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32
51
35
15
F5
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V
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B

FIG 4

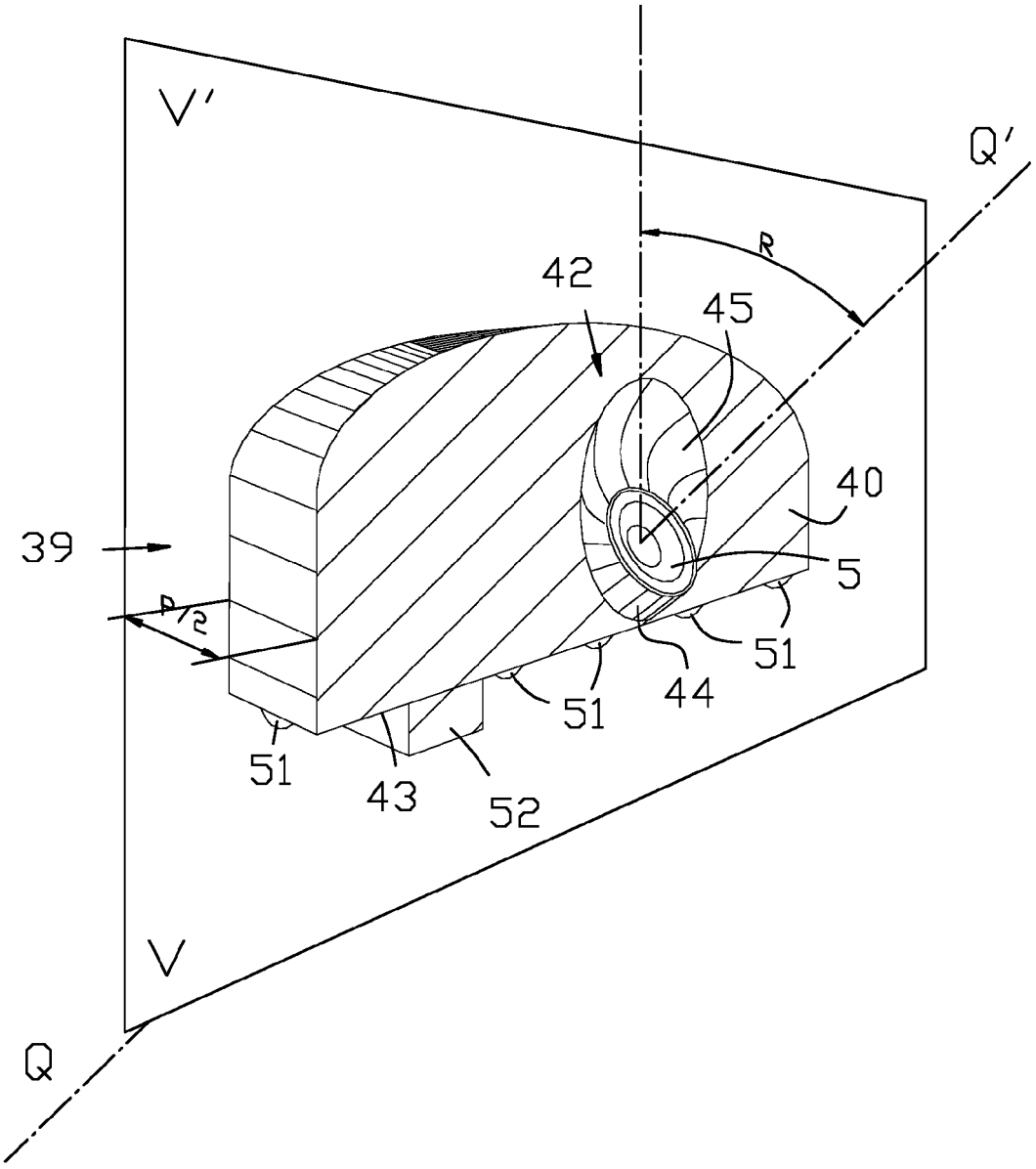

FIG 5

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EUROPEAN SEARCH REPORT

Application Number
EP 13 15 7282

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	12 August 2013	Borowski, Michael

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