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(54) **Acoustic lens and acoustic diffuser comprising said acoustic lens**

(57) This is an acoustic lens (10; 10'; 110; 210; 310; 410; 510) for the refraction of acoustic waves generated by an acoustic source (70; 72; 170; 270; 371; 470; 471;

570).

In addition, it is a diffuser comprising an acoustic lens (10; 10'; 110; 210; 310; 410; 510).

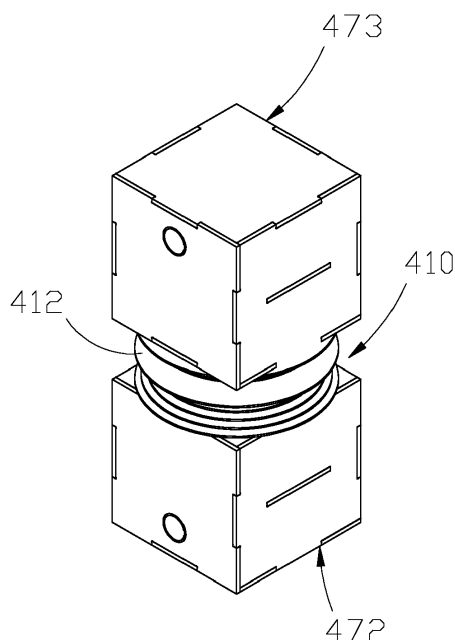


Fig. 15

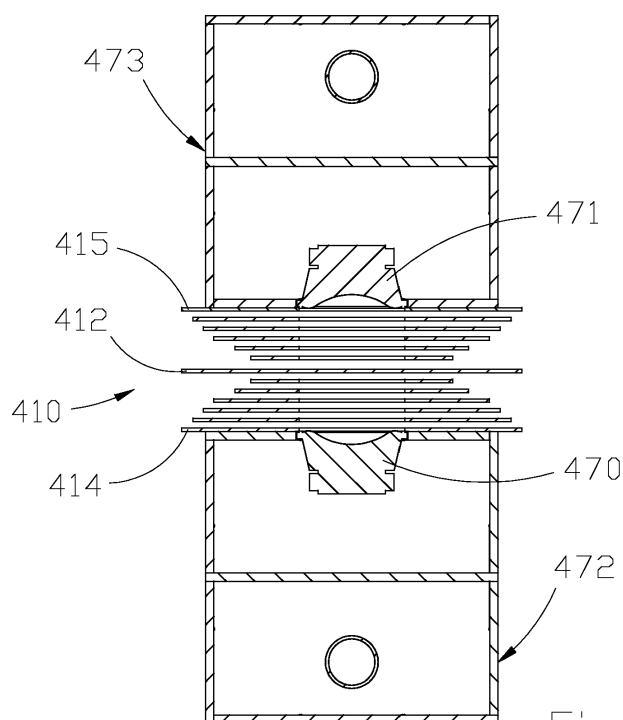


Fig. 16

Description

[0001] This invention relates in general to an acoustic lens and an acoustic diffuser comprising said acoustic lens. In particular, this is an acoustic lens and an acoustic diffuser able to modify the diffusion and propagation of acoustic waves with which it comes in contact.

[0002] As known, different types of acoustic lenses, studied to alter acoustic wave propagation with respect to standard propagation due to the medium in which they propagate, are available on the market.

[0003] These acoustic lenses, with work with refraction systems and/or sound wave deviation, have a structure of elements similar to one another, forming the paths for the propagation of sound waves.

[0004] The behaviours of the sound waves that can be achieved with these acoustic lenses are similar to the behaviours of the electromagnetic waves obtained with optical lens systems.

[0005] The actual refractive index of these lenses is given by the ratio between the distance that an acoustic wave is compelled to run, through a path defined by the elements of the lens, between a point of entry and a point of exit of the chosen path and the distance that the wave would run between the same two points if there were no acoustic lens.

[0006] An example of an acoustic lens is shown in figures 1 to 3, where L indicates an acoustic lens including four slats S, of which only one is indicated in figures 2 and 3.

[0007] A carving M with two edges B with a parabolic progress is present on each slat S.

[0008] The acoustic lens L is set in front of an acoustic driver C, so that the four slats S are inclined at an angle A with respect to the acoustic axis E.

[0009] The acoustic lens L acts as a plano-concave sound refractor, obtaining divergent behaviour, or rather behaviour similar to the divergent optical lenses.

[0010] Considering, in fact, acoustic waves that propagate from acoustic driver C in the direction of acoustic axis E, these will be compelled to deviate from their own path when they meet acoustic lens L, propagating inside the spaces including between each pair of slats S, so that their path is longer than the path they would have followed if they had not come across acoustic lens L.

[0011] If carvings M had not been present, acoustic propagation through the slats S would cause localised deviation of the acoustic waves, resuming the original direction of propagation once acoustic lens L was passed.

[0012] The effect of inclination on the slats S is in fact that of imposing a path with a length greater than the acoustic waves to thus obtain a delay in their propagation.

[0013] Also considering the presence of the carvings M on the slats S, we obtain a deviation of the acoustic waves that is differentiated with respect to what is obtained in the absence of the same carvings M.

[0014] An acoustic wave that travels the space be-

tween the slats S where carvings M are not housed travels the first path, while the same acoustic wave that travels the space between the slats S and comes out from the same at the meeting point of the parabolic edges B, therefore in correspondence to the deepest point of the carvings M, travels a second path, such that this second path appears to be shorter than the first path considered previously.

[0015] We can assess the behaviour of the acoustic lenses considering an analogy with optical lenses, with light refraction in different length paths leading to phenomena of convergence in the case of convex lenses and phenomena of divergence with concave lenses.

[0016] Also with acoustic waves, in fact, when we travel acoustic lens L, a phenomena of refraction is undergone, leading to a diverging exit for the acoustic waves.

[0017] This behaviour makes wider diffusion of high frequencies possible, for example, as they would tend to propagate mainly in the direction of acoustic axis E and not therefore propagate in other directions. The presence of acoustic lens L thus allows us to obtain increased and targeted diffusion of acoustic waves generated by acoustic driver C in the environment.

[0018] The acoustic lenses according to the prior art allow us to obtain propagation of acoustic waves in a single direction, corresponding to the one defined by the acoustic axis, causing only a convergence or divergence of the acoustic waves themselves on a single plane.

[0019] When a plane P, passing through acoustic axis E, is defined, as seen in figure 3, and considering the remaining planes identified by acoustic axis E itself, acoustic lens L allows us to obtain an acoustic refraction effect only on the plane that is perpendicular to the previously described plane P, while the acoustic refraction effect does not take place on the remaining planes. In fact, the refraction effect of acoustic lens L does not take place along plane P. Further artifices, for example horn speakers, are necessary if you wish to obtain a targeted diffusion also on different planes with respect to the plane perpendicular to plane P. These artifices however also cause further reduction of the acoustic power emitted.

[0020] The purpose of this invention is to obtain greater flexibility in the implementation of acoustic lenses.

[0021] Another purpose of this invention is to allow for a reduction in the directionality of acoustic waves generated by a localised source.

[0022] Another purpose of this invention is to reduce the directionality, maintaining the original acoustic power generated by the source as much as possible. These and other advantages are all obtained, according to this invention, by an acoustic lens for the refraction of acoustic waves generated by an acoustic source, these acoustic waves, developing along an acoustic axis, this acoustic lens, including:

- a frame
- three or more elements fixed to the frame, each having their respective entry ends and respective exit

ends

[0023] The three or more elements delimit, between each pair of elements, one or more first spaces of refraction and one or more second spaces of refraction, all developing in one or more directions inclined with respect to the acoustic axis and being adapted to be crossed by the acoustic waves generated by the acoustic source.

[0024] The one or more spaces of refraction form a first path of refraction having a first length and including an entry portion defined by the entry end of the first pair of three or more elements, and a first exit portion defined by the exit end of a first pair of three or more elements.

[0025] The one or more second spaces of refraction form a second path of refraction having a second length and including a second entry portion defined by the entry end of the second pair of three or more elements, and a second exit portion defined by the exit end of a second pair of three or more elements. The second length exceeds the first length to thus obtain a refraction of the acoustic waves at the first exit portion and the second exit portion.

[0026] The acoustic lens includes an acoustic collector which collects and convoys the acoustic waves to the first entry portion and to the second entry portion. This acoustic collector comprises a volume in which the acoustic waves develop.

[0027] The acoustic lens is characterised by the fact that the acoustic collector is delimited only by the entry end of the three or more elements.

[0028] In this way, the elements that make up the refraction also act as an acoustic collector for their portion. Further components that perform the function of acoustic collector are not therefore necessary.

[0029] Advantageously, the exit ends of the three or more elements that define the exit portions of the spaces of refraction can have a parabolic progress.

[0030] Thanks to the presence of the acoustic collector and of the volume of development of the acoustic waves, we are able to firstly obtain the development of the acoustic waves to later refract them, thanks to the passage of the same acoustic waves in the spaces of refraction obtained between the elements included in the acoustic lens. In addition, the parabolic progress of the ends of the three or more elements that define the exit portions allows us to obtain a refraction effect of the acoustic waves similar to that obtained thanks to the optical lenses. In other words, the sound waves emitted by each space of refraction do not dirty each other, or rather they do not interfere with one another, worsening the quality of the sound output.

[0031] In addition, one or more through-holes can be obtained in one or more of the three or more elements and the collector can include these one or more holes. In other words, they are the same one or more through-holes that act as an acoustic collector, without the need for further components that define the acoustic collector.

[0032] One of the three or more elements can act as

the border of the acoustic collector to thus obtain a blind hole in the acoustic lens. The acoustic collector can thus be closed by at least one of the three or more elements.

[0033] In addition, the progress of the ends of the three or more elements can be reversed to a point of the acoustic axis, to thus obtain a divergent effect or a convergent effect, thus being able to obtain a still more marked analogy with optical lenses due to the refraction effect obtained on the acoustic waves.

[0034] Advantageously, the acoustic collector can be delimited by a guide, thus reducing the reflection of the acoustic waves by the element that acts as a border of the acoustic collector.

[0035] In addition, the guide can have a parabolic profile to thus further improve the progress of the acoustic waves inside the acoustic lens.

[0036] Advantageously, one or more of the three or more elements can be different from the others in shape and/or size. In addition, the end edge of one or more of the three or more elements can include two or more points which are symmetric to each other with respect to the acoustic axis.

[0037] In this way, we configure a symmetry with respect to the acoustic axis, which allows us to obtain a refraction that present symmetries with respect to the acoustic axis.

[0038] Advantageously, one or more of the three or more elements can be at least partially disc-shaped. In addition, two or more of the three or more elements can be arranged parallel to each other.

[0039] In addition, two or more of the three or more elements can be arranged perpendicularly to the acoustic axis, so that one or more of the two or more spaces develops in a perpendicular plane to the acoustic axis. Advantageously, a divisor can prevent propagation of the acoustic waves in the direction in which it is positioned, limiting diffusion of the acoustic waves into the surrounding environment, limited to a predetermined angle of diffusion.

[0040] In addition, a separation element can separate the acoustic collector in a first portion and in a second portion. Thanks to this structure, we can obtain multiple portions of the acoustic collector to process acoustic emissions from various acoustic sources.

[0041] All these advantages and others are also achieved by an acoustic diffuser including one or more acoustic sources and one or more acoustic lenses according to the previously defined invention.

[0042] In particular, one or more acoustic sources can be positioned with respect to one or more acoustic lenses in a predetermined position based on the structure of one or more acoustic lenses, to thus obtain the desired sound effect.

[0043] In fact, the sound effect varies depending on the structure of one or more of the acoustic lenses utilised and on the relative position of one or more acoustic sources with respect to one or more acoustic lenses.

[0044] In this way, we can obtain a complete acoustic

diffuser able to diffuse divergent and/or convergent acoustic waves into the surrounding environment.

[0045] In addition, an acoustic diffuser can include two or more acoustic sources and one or more acoustic lenses according to the invention, with each of the two or more acoustic sources being controlled by a special audio signal. Advantageously, the two or more acoustic sources can each be controlled by a stereophonic audio signal to thus obtain stereophonic diffusion in the surrounding environment, for example obtaining a spherical type acoustic field.

[0046] In addition, an acoustic diffuser can include a collector made of rigid material, paired with an acoustic lens according to the invention to thus obtain greater compactness of the acoustic lens, reducing its dimensions. In addition, thanks to the rigid material collector, simple vibrations can be transformed into sound waves.

[0047] Advantageously, a vibration induction transducer can be set in contact with a collector made of rigid material to thus obtain greater compactness of the acoustic source and further decrease the dimensions of the entire acoustic diffuser.

[0048] For exemplary and non-exhaustive purposes, the invention's additional specifications and features are provided in greater detail within the description below, as well as within the attached diagrams, which include:

Fig. 1 shows an acoustic lens element made according to the prior art.

Figures 2 and 3 show an acoustic lens made with a series of elements in figure 1 paired with an acoustic driver according to the prior art.

Figures 4 and 5 show a perspective view and a section view of the first acoustic lens made according to the invention.

Figure 5a shows a section view of the acoustic lens in figure 4 and 5 including an additional element according to a variant of the invention.

Figures 6 and 8 show, respectively, a prospective view, a view from above and a section view of the acoustic lens in figure 4 and 5 paired with a case and an acoustic source according to the invention.

Figures 9 and 10 show, respectively, a prospective view and a section view of a second acoustic lens paired to a case and an acoustic source according to a further variant of the invention.

Figures 11 and 12 show, respectively, a prospective view and a section view of a third acoustic lens paired to an acoustic source according to a further variant of the invention.

Figures 13 and 14 show, respectively, a prospective view and a section view of a fourth acoustic lens paired to an acoustic source according to a further variant of the invention.

Figures 15 and 16 show, respectively, a prospective view and a section view of a fifth acoustic lens paired to a case and an acoustic source according to a further variant of the invention.

Figures 17 and 18 show, respectively, a lateral view and a prospective view of the acoustic field generated by the acoustic lens in figure 15 and 16, according to the invention.

Figures 19 and 20 show, respectively, a lateral view and a section view of a sixth acoustic lens paired to a case and an acoustic source according to a further variant of the invention.

[0049] With reference to figures 4 and 5 with 10, an acoustic lens according to the invention is indicated, including a cover disc 12, a beating disc 14 and a series of intermediate discs, described in detail below.

[0050] Three rods 16 perpendicularly cross the series of intermediate discs from the beating disc 14 to the cover disc 12, allowing each to stay configured with respect to the other, at a distance defined as the inter-disc distance which is constant for all discs on the acoustic lens 10.

[0051] Below we will refer to the space defined between one generic disc and another as an inter-disc distance.

[0052] Naturally, a single rod or two rods can be used and the distances between the discs can be different and therefore not constant, depending on the desired behaviour of the acoustic lens.

[0053] The series of intermediate discs includes a first series 30 of discs, a middle disc 32 and a second series 44 of discs.

[0054] The first series 30 includes five discs, each indicated respectively with 18, 20, 22, 24 and 26 in figure 5, starting from disc 18, then to beating disc 14 until reaching disc 26, next to middle disc 32.

[0055] Similarly, the second series 44 includes five discs, each indicated respectively with 34, 36, 38, 40 and 42 in figure 5, starting from disc 34, then to middle disc 32 until reaching disc 42, next to middle disc 12.

[0056] The cover disc 12 has a maximum outer diameter, the same for beating disc 14, while the middle disc 32 has a minimum outer diameter, less with respect to the maximum external diameter.

[0057] The outer diameters of the first series 30 of discs have dimensions that go between the maximum outer diameter and the minimum outer diameter, decreasing with parabolic progress starting from the outer diameter of disc 42 up to the outer diameter of disc 34. The latter is however higher in minimum outer diameter than middle disc 32.

[0058] Similarly, the outer diameters of the second series 44 of discs have dimensions that go between the maximum outer diameter and the minimum outer diameter, decreasing with parabolic progress starting from the outer diameter of disc 18 up to the outer diameter of disc 26. The latter is however higher in minimum outer diameter than middle disc 32.

[0059] With the exception of cover disc 12, which is a full disc, the remaining discs on the acoustic lens 10 have a circular centre hole.

[0060] Each circular centre hole is concentric to the

outer circumference of each disc and therefore defines an inner circumference, to which reference will be made below by means of the corresponding inner diameter.

[0061] The progress of the inner diameters of the discs on the acoustic lens 10 is different from the progress of the outer diameters of the same described previously.

[0062] The volume included in the set of holes created in the discs on the acoustic lens 10 defines a collector 50, limited to its end from the cover disc 12.

[0063] The holes created in the discs on the first series 30 have the same inner diameter, common also to the beating disc 14 and to the middle disc 32, to which reference will be made below as a minimum inner diameter.

[0064] The holes created in the discs on the second series 44 instead have a gradually increasing inner diameter, starting from disc 34 up to disc 42, which has a maximum inner diameter.

[0065] As seen in figure from 6 to 8, the acoustic lens 10 can be paired to an acoustic driver 70, conveniently but not limited to being installed on a bass reflex case 72, including a chord channel 74 made according to prior art.

[0066] The presence of the case 72, shaped according to a bass reflex type construction, helps diffusion of the low frequencies produced by the acoustic driver 70, while the acoustic lens 10 in this exemplifying configuration best diffuses medium and high frequencies produced by the same acoustic driver 70. The acoustic lens 10 is conveniently positioned with the beating disc 14 in contact with the case 72 and with the circular centre hole positioned near the acoustic driver 70.

[0067] Thanks to this positioning, the acoustic lens 10, the direct acoustic emission of the acoustic driver 70 is collected inside the collector 50. From inside the collector 50, the acoustic waves then propagate in the inter-disc spaces to exit to the outside and continue propagation in the surrounding environment. For example, a generic acoustic wave generated by an acoustic driver 70 and directed according to the acoustic axis of said acoustic driver 70, is channelled into the collector 50 is subsequently diverted to a substantially right angle to then follow into the inter-disc spaces and exit from the acoustic lens 10.

[0068] We thus obtain substantially perpendicular propagation to the original direction, which was parallel to the acoustic axis of the acoustic driver 70.

[0069] Thanks to the parabolic progress of the outer diameters with which the discs making up the acoustic lens 10 were created, we can obtain an effect of refraction of the acoustic waves that is similar to that obtained thanks to the optical lenses.

[0070] In particular, the configuration of the acoustic lens 10, which is presented with the previously described parabolic progress and is shown in figure 8, the effect of refraction obtained is that of waves that diverge from the acoustic lens 10 when they exit from the inter-disc spaces along the entire circumference of the discs.

[0071] Thanks to this circular diffusion at a perigon, we can obtain an effect of diffusion that is different with re-

spect to the acoustic lenses of the prior art, which are focused in a single direction or a single plane, both linked to the direction of the acoustic axis of the source.

[0072] The acoustic lens 10, thanks to the parabolic progress of the outer diameters, can be indicated as divergent lens. An equivalent focus, which allows us to place the concavity of the parabolic progress of the outer diameters in correlation to the distance of the focus of the symmetry axis of the acoustic lens 10, can also be defined.

[0073] We thus obtain a degree of divergence that is therefore a property of the acoustic lens 10.

[0074] Solely for purposes of explanation, the functioning of the acoustic lens 10 according to the invention can be understood by an analogy with the concave optical lenses and with the menisci.

[0075] The inter-disc distance and, as a result, the inter-disc space between discs are preferably optimised depending on the efficiency that you desire to obtain from the acoustic lens 10 and to the loss of decibel detected.

[0076] In other words, a reduced inter-disc distance allows us to obtain a more defined and appreciable refraction effect, but at the same time entails a higher loss of decibels. On the other hand, a higher inter-disc distance allows for a less defined refraction effect, but at the same time entails less loss of decibels.

[0077] The growing progress of the internal diameters, starting from disc 34 up to disc 42, allows us to compensate for the difference in length of the inter-disc path between discs that have different distances from the acoustic driver 70, as the optimal condition for obtaining a divergent effect would be that of having an inter-disc path length that is equal depending on the desired angle of divergence. For example, the previously described compensation allows us to obtain similar paths between the delimited path between the beating disc 14 and disc 18 and the delimited path between disc 42 and cover disc 12.

[0078] As seen in figure 5a, an acoustic lens 10' can also include a guide 60 with a cuspid and circular symmetrical shape with respect to the symmetrical axis of the acoustic lens 10' itself. The walls 62 of the guide 60 should preferably have a parabolic progress. In addition, the guide 60 should preferably be made with hard material to reflect the acoustic waves.

[0079] Thanks to the presence of the guide 60, the acoustic lens 10' has a behaviour that is different than the acoustic lens 10, as the reflection of the acoustic waves by the portion of the cover disc 12 facing onto the collector 50 can be greatly reduced.

[0080] According to a variant of the invention, as seen in figures 9 and 10, an acoustic lens 110 can include a cover disc 112, a middle disc 132, a beating disc 114 and a series of intermediate discs.

[0081] The discs on the acoustic lens 110 should preferably be spaced by a pre-set inter-disc distance, for example similar to the previously described inter-disc distance of the discs on the acoustic lens 10, or else it can be different. Similarly to as described above, the acoustic

lens 110 includes three rods 116 which allow us to keep the discs at the desired inter-disc distance.

[0082] The outer diameter of the cover disc 112 and the beating disc 114 should preferably be similar, or for example equal, with the result thus being a minimum outer diameter or at least outer diameters with lower dimensions with respect to the remaining discs on the acoustic lens 110.

[0083] The outer diameter of the middle disc 132 instead has a maximum outer diameter that is higher with respect to that of the remaining discs on the acoustic lens 110.

[0084] The outer diameters of the intermediate discs 110 have dimensions included between the maximum outer diameter of the middle disc 132 and the minimum outer diameter of the cover disc 112 or of the beating disc 114, increasing with the parabolic progress starting from the minimum outer diameter of the cover disc 112 up to reaching an outer diameter that is however lower than the maximum outer diameter of the middle disc 132. The parabolic progress of the outer diameter should preferably be symmetrical with respect to the middle disc 132.

[0085] Similarly to as described above for the acoustic lens 10, also the discs on the acoustic lens 110 have a circular centre hole, defined by means of its own inner diameter, with the exception of the cover disc 112. Preferably, but not limited to, the inner diameters of the discs on the acoustic lens 110 are equal to one another.

[0086] The volume included in the set of holes created in the discs on the acoustic lens 110 defines a collector 150, limited to its end from the cover disc 112. The acoustic lens 110 can be conveniently paired to an acoustic driver 170, conveniently but not limited to being installed on a case 172.

[0087] The acoustic lens 110 is conveniently positioned with the beating disc 114 in contact with the case 172 and with the circular centre hole positioned near the acoustic driver 170.

[0088] Thanks to this positioning, the acoustic lens 110, the direct acoustic emission of the acoustic driver 170 is collected inside the collector 150. From inside the collector 150, the acoustic waves then propagate in the inter-disc spaces to exit to the outside and continue propagation in the surrounding environment. The particular refraction effect obtained by means of the acoustic lens 110 is that of acoustic waves that converge from the acoustic lens 110 when they exit from the inter-disc spaces along the entire circumference of the discs. For example, the acoustic waves can converge toward a concentric circumference to the discs on the acoustic lens 110, with said circumference having a diameter that depends on the previously described parabolic progress seen in figure 10.

[0089] The particular structure of the inner and outer diameters of the discs on the acoustic lens 110 thus allow us to obtain a similar effect to that of the convergent lens.

[0090] A focus equivalent to that of optical lenses, which allows us to place the convexity of the parabolic

progress of the outer diameters in correlation with the distance of focus from the symmetry axis of the acoustic lens 110, or with the diameter of the circumference at which the acoustic waves processed by the acoustic lens 110 can converge, can also be defined.

[0091] The considerations described previously regarding the dimensions chosen to size the acoustic lens 10 also hold true for the acoustic lens 110.

[0092] According to a further variant of the invention, as seen in figures 11 and 12, an acoustic lens 210 can include a cover disc 212, a middle disc 232, a beating disc 214 and a series of intermediate discs.

[0093] The discs on the acoustic lens 210 are portions of the discs made similarly to the discs on the acoustic lens 10. In particular, the discs on the acoustic lens 210 are sectioned along a plane that is parallel to the symmetry axis of the discs, identified in figure 11 by a divisor 280.

[0094] The discs on the acoustic lens 210 should also preferably be spaced by a pre-set inter-disc distance, for example similar to the previously described inter-disc distance of the discs on the acoustic lens 10, or else it can be different.

[0095] Similarly to as described above, the acoustic lens 210 includes rods, not seen in the figure, which allow us to keep the discs at the desired inter-disc distance.

[0096] As seen in figure 12, the acoustic lens 210 can be paired with an acoustic driver 270, being able to process the sound waves produced, thus collected in a collector 250.

[0097] The particular refraction effect obtained by means of the acoustic lens 210 is that of acoustic waves that diverge from the acoustic lens 210 when they exit from the inter-disc spaces along the entire portion of the circumference of the discs.

[0098] The presence of the divisor 280 prevents propagation of the acoustic waves in the direction in which it is positioned, thus allowing, when desired, diffusion of the acoustic waves into the surrounding environment, limited to a predetermined angle of diffusion.

[0099] The same considerations regarding the acoustic lens 10 hold true for acoustic lens 210, in particular with respect to the parabolic progress of the outer disc diameters and the divergent behaviour due to the diffusion of the acoustic waves generated by the acoustic driver 270.

[0100] A further variant of the invention is described below, with reference to figures 13 and 14. In this, an acoustic lens 310 includes the previously described acoustic lens 210, this paired to an acoustic lens 311 made in a mirror with respect to the divisor 280.

[0101] The acoustic lens 311 can therefore be paired with an acoustic driver 371 which generates, for example, acoustic waves independently from the acoustic driver 270.

[0102] An example of use is the diffusion into the environment of a stereo audio signal, allocating for example the right audio channel to the acoustic driver 270 and the

left audio channel to the acoustic driver 370.

[0103] According to another variant of the invention, seen in figures 15 and 16, an acoustic lens 410 includes a cover disc 412, a first beating disc 414, a second beating disc 415 and a series of intermediate discs.

[0104] The first beating disc 414 is preferably paired with an acoustic driver 470 and a case 472, while the second beating disc 415 is preferably paired with an acoustic driver 471 and a case 473.

[0105] The outer diameter of the discs is configured according to the parabolic progress. In particular, the outer diameter reduces starting from both beating discs 414 and 415 up to the discs near the cover disc 412, which is conveniently constructed with an outer diameter higher than that of the other discs on the acoustic lens 410.

[0106] The particular structure and configuration of the acoustic lens 410, paired with the previously described acoustic drivers and the cases, allows us to obtain a diffusion of the acoustic waves into the surrounding environment with geometric characteristics seen in figures 17 and 18.

[0107] In particular, the resulting acoustic diffusion conforms as two acoustic toroids which, in the event that a stereo audio signal is used to govern the acoustic driver 470 and the acoustic driver 471, ensures stereophonic perception over the entire environment surrounding the acoustic lens 410.

[0108] In fact, though there is an acoustic source localised in a single point, we are able to obtain a stereophonic effect without being forced to use bi or multi point systems like systems pertaining to the prior art, like for example two or more acoustic cases set at a certain distance from each other in order to obtain a stereophonic effect.

[0109] Thanks to this effect, also found experimentally, and to the dual toroidal shape of the acoustic diffusion, we can essentially obtain an acoustic field with the same stereophonic and acoustic power qualities in all points pertaining to a sphere whose centre is in the acoustic lens 410.

[0110] Unlike the prior art in which you can only get a divergence that is structured as a front cone or however as a divergence according to a single direction, a divergent acoustic lens according to the invention allows us to obtain acoustic divergence in more than one direction, depending on the desired result. The acoustic divergence, according to the structure of the acoustic lens itself as previously described, can be extended to reach a divergence of the acoustic waves in all direction, thus obtaining the effect of an acoustic field with the same stereophonic qualities and acoustic power in all parts pertaining to a sphere whose centre is in the acoustic lens.

[0111] The possibility of obtaining a spherical type acoustic field by using an acoustic lens according to the invention also allows us to overcome obstacles that are interposed between the acoustic lens and the receiver of the emitted acoustic waves, thanks to the toroidal diffusion of the acoustic waves which therefore allows for

moving around obstacles, also conserving acoustic power and the extension of transmitted frequencies.

[0112] We also experimentally found a slight deviation from the spherical diffusion in the points indicated with 491 and 492 in figure 17, in which, due to the exemplified progress of the acoustic toroids, the acoustic emission of one acoustic driver is slightly lower with respect to the other, comparing them to other points equidistant from the acoustic lens 410. For example, in point 491, the noise emission of the acoustic driver 470 contained in the case 472 is slightly attenuated, while the acoustic emission of the acoustic driver 471 contained in the case 473 is not attenuated.

[0113] According to a further variant of the invention, as seen in figures 19 and 20, an acoustic lens 510 includes a cover disc 512, a beating disc 514, a middle disc 532 and a series of intermediate discs. The configuration of the discs and, in particular, the parabolic progress of the outer diameters is similar to that described previously for the acoustic lens 10.

[0114] The discs on the acoustic lens 510 are integral with a rigid collector 550, preferably made with a high mechanical stiffness material, like for example with hard steel, glass, stone or other.

[0115] A vibration induction transducer 570 is set in contact with the rigid collector 550 to thus transmit a vibration to the rigid collector 550 which in turn transmits to the discs on the acoustic lens 510.

[0116] We are thus able to obtain a divergent effect similar to that of the previously described acoustic lens 10, also including the advantages of the vibration induction transducers.

[0117] The discs on the acoustic lens 510, being integral with rigid collector 550, also become a source of acoustic emission, in some cases allowing us to obtain an acoustic yield in the surrounding environment that is even better with respect to the variants including traditional acoustic drivers.

[0118] Another advantage of this solution is the increased compactness due to the small size of the vibration induction transducers 570 with respect to the size of other acoustic drivers.

[0119] The material with which the acoustic lens is constructed according to the invention is preferably, but not limited to, with high stiffness. For example, material should have at least the stiffness required for maintaining its characteristics essentially unchanged, such as its size, shape and position when forces are applied from the acoustic waves that have to be refracted. In fact, the more rigid or hard the material used to create the discs of the acoustic lenses according to the invention is, permitting elastic collisions, the more the acoustic power emitted by the reference source is preserved.

[0120] The presence of the collector is preferable to obtain optimal functioning of the acoustic lenses according to the invention, due to the fact that most of the shape of the wave of the acoustic emission is able to essentially develop in the collector itself, which therefore as subse-

quently deviated inside the inter-disc spaces in order to be directed, thus avoiding the formation of undesired harmonics and maintaining a sound that is free as much as possible of noise. Variants to be included in the scope of the invention, defined by the following claims, like for example discs with different shapes with respect to circles, such as polygons with three or more sides, systems for maintaining an inter-disc distance different from the rods and different combinations of characteristics with respect to those presented in the respective variants of the invention as described, can also be provided.

Claims

1. Acoustic lens (10; 10'; 110; 210; 310; 410; 510) for the refraction of the acoustic waves generated by an acoustic source (70; 170; 270; 371; 470, 471; 570), said acoustic waves developing along an acoustic axis, said acoustic lens (10; 10'; 110; 210; 310; 410; 510) comprising:

- a frame (16; 116);
- at least three elements (12, 14, 18, 20, 22, 24, 26, 30, 32, 34, 36, 38, 40, 42, 44; 60; 112, 114, 132; 212, 214, 232; 312; 412, 414, 415; 512, 514, 532) fixed to the frame (16; 116), each having a respective entry end a respective exit end; said at least three elements delimiting, between each pair of said at least three elements, at least one first space of refraction and at least one second space of refraction, both spaces of refraction developing in at least one direction inclined with respect to the acoustic axis and being adapted to be crossed by the acoustic waves generated by the acoustic source (70; 170; 270; 371; 470, 471; 570);
- said at least one first space of refraction forming a first path of refraction having a first length and including a first entry portion defined by the entry end and a first pair of said at least three elements, and a first exit portion defined by the exit end of the first pair of said at least three elements;
- said at least one second space of refraction forming a second path of refraction having a second length and including a second entry portion defined by the entry end and a second pair of said at least three elements, and a second exit portion defined by the exit end of the second pair of said at least three elements;
- said second length exceeding the said first length to thus obtain a refraction of the acoustic waves at the first exit portion and the second exit portion;
- an acoustic collector being included (50; 150; 250; 550) that collects and conveys the acoustic waves to the first entry portion and to the second

entry portion, said acoustic collector (50; 150; 250; 550) comprises a volume in which the acoustic waves develop;

characterized by the fact of the acoustic collector is delimited only by the entry end of the at least three elements.

2. Acoustic lens according to claim 1, in which the exit ends of the at least three elements (12, 14, 18, 20, 22, 24, 26, 30, 32, 34, 36, 38, 40, 42, 44; 60; 112, 114, 132; 212, 214, 232; 312; 412, 414, 415; 512, 514, 532) have a parabolic progress.
3. Acoustic lens (10; 10'; 110; 210; 310; 410; 510) according to one of the previous claims in which the acoustic collector (50; 150; 250; 550) comprises at least a through-hole made in at least one of the three elements, and in which the acoustic collector is closed by at least one of the at least three elements (12; 60; 112; 312; 412; 512).
4. Acoustic lens (10; 10'; 110; 210; 310; 410; 510) according to one of the previous claims, in which the progress of the ends of the at least three elements (12, 14, 18, 20, 22, 24, 26, 30, 32, 34, 36, 38, 40, 42, 44; 60; 112, 114, 132; 212, 214, 232; 312; 412, 414, 415; 512, 514, 532) reverses to a point of the acoustic axis, so as to obtain a divergent effect or a convergent effect.
5. Acoustic lens (10; 10'; 110; 210; 310; 410; 510) according to one of the previous claims, in which a guide (60) is included which delimits the acoustic collector (50; 150; 250; 550).
6. Acoustic lens (10; 10'; 110; 210; 310; 410; 510) according to one of the previous claims, in which the guide (60) has walls (62) with a parabolic profile.
7. Acoustic lens (210; 310) according to one of the previous claims, in which a divisor (280) is included to prevent propagation of the acoustic waves in the direction in which it is positioned, limiting diffusion of the acoustic waves into the surrounding environment, limited to a predetermined angle of diffusion.
8. Acoustic lens (410) according to one of the previous claims, in which a separation element (412) is included which separates the acoustic collector in a first portion and in a second portion.
9. Acoustic diffuser comprising at least one acoustic source and at least one acoustic lens (10; 10'; 110; 210; 310; 410; 510) according to one of the previous claims, **characterised by** the fact of the acoustic source is positioned with respect to at least one acoustic lens in a pre-set position depending on the structure of at least one acoustic lens.

10. Acoustic diffuser according to the previous claim in which the acoustic source is positioned in the geometric centre of the acoustic collector of the acoustic lens. 5
11. Acoustic diffuser according to claims 9 and 10 in which at least two acoustic sources (470, 471) and at least one acoustic lens (10; 10'; 110; 210; 310; 410; 510) are included, each of said at least two acoustic sources being controlled by a special audio signal. 10
12. Acoustic diffuser according to the previous claim in which the at least two acoustic sources (470, 471) are controlled respectively by the two audio channels of a stereophonic signal. 15
13. Acoustic diffuser according to claims from 9 to 12 in which a rigid collector (550) paired with an acoustic lens (10; 10'; 110; 210; 310; 410; 510) is included, the rigid collector (550) being made of rigid material. 20
14. Acoustic diffuser according to the previous claim in which a vibration induction transducer (570) set in contact with a rigid collector (550) is included. 25

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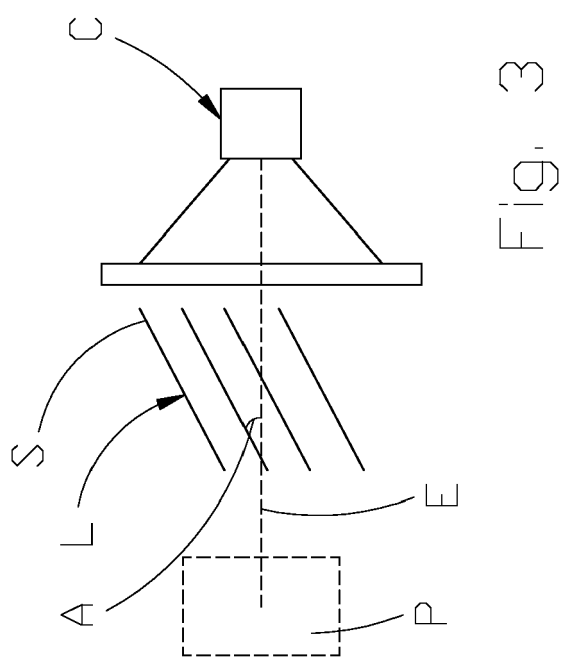
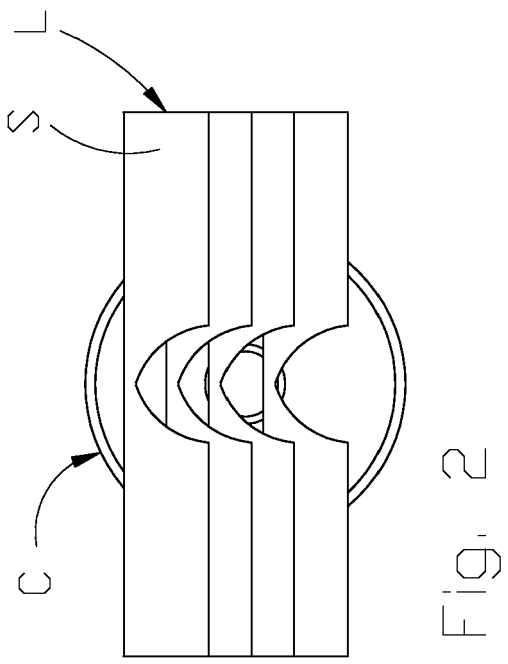
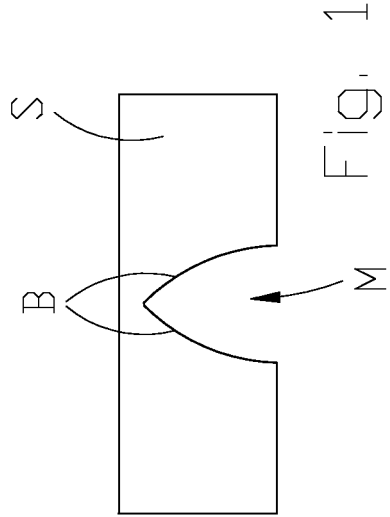
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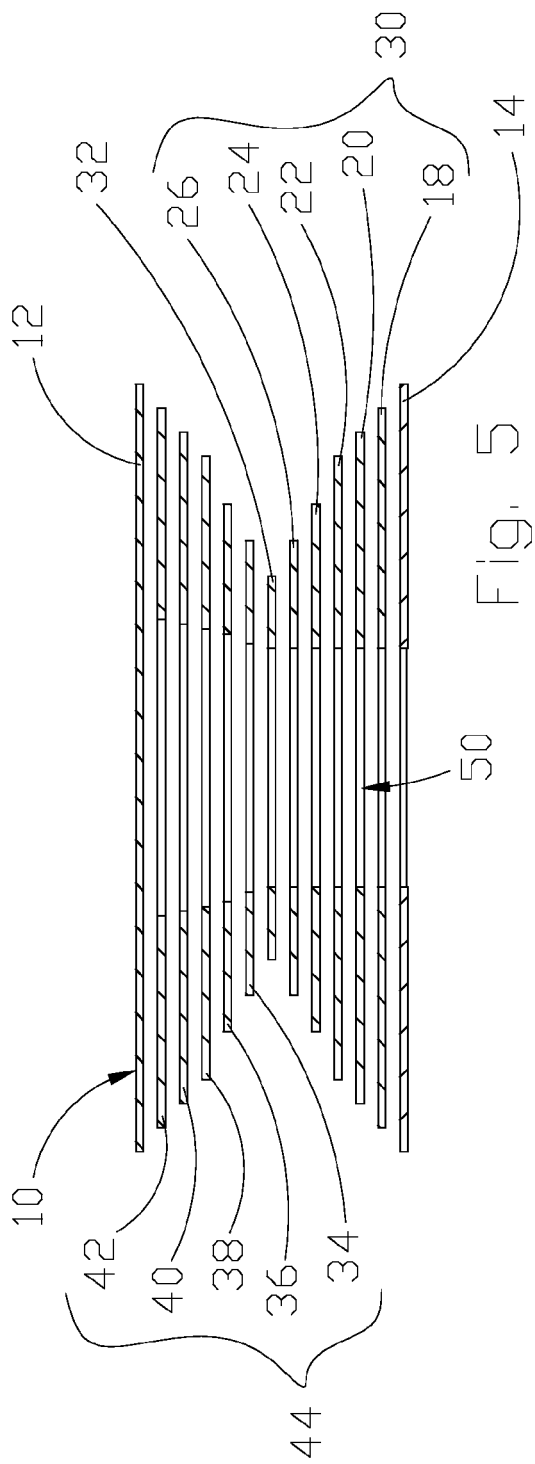


Fig. 5

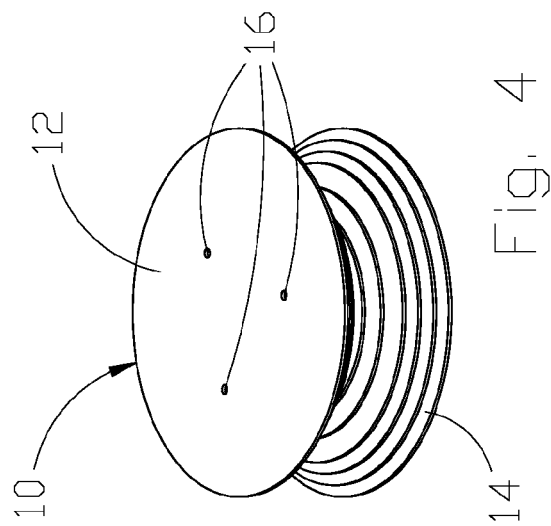


Fig. 4

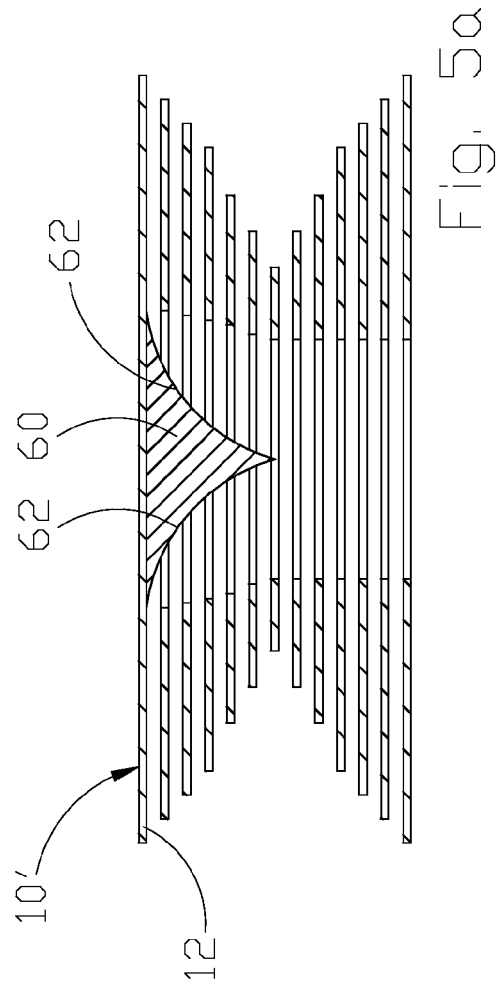
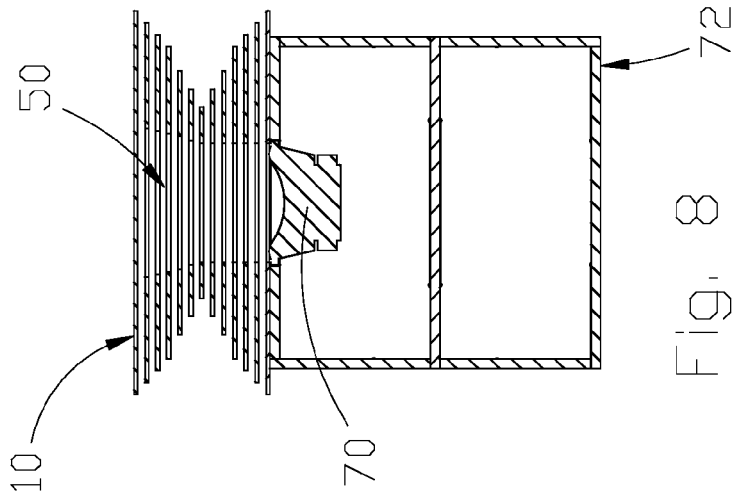
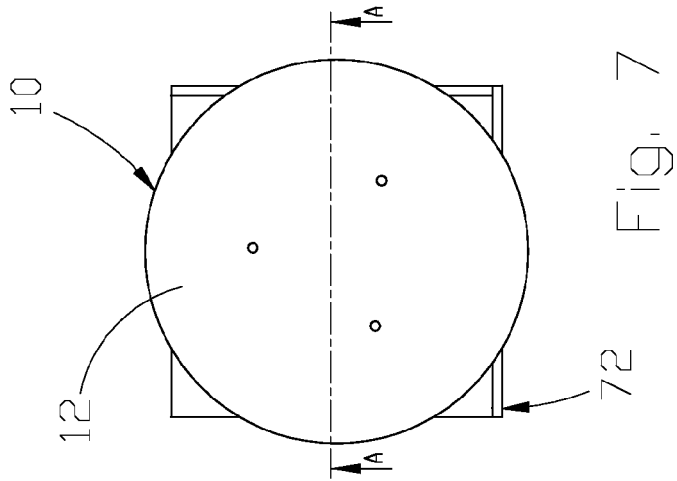
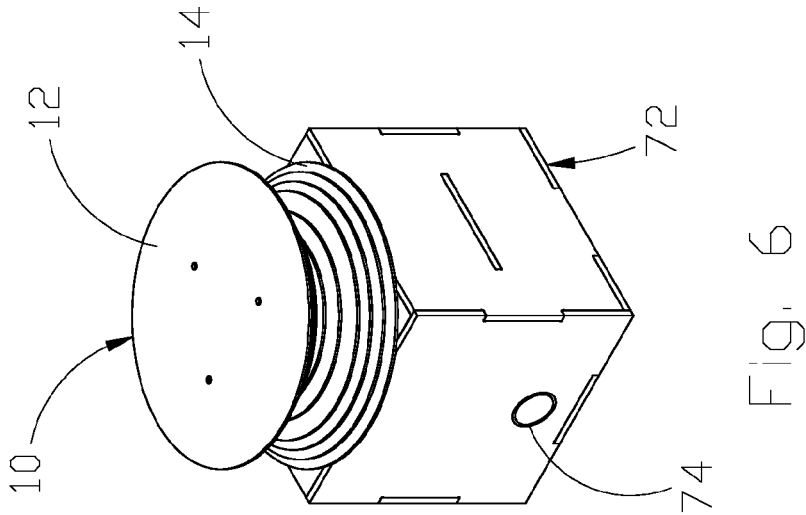
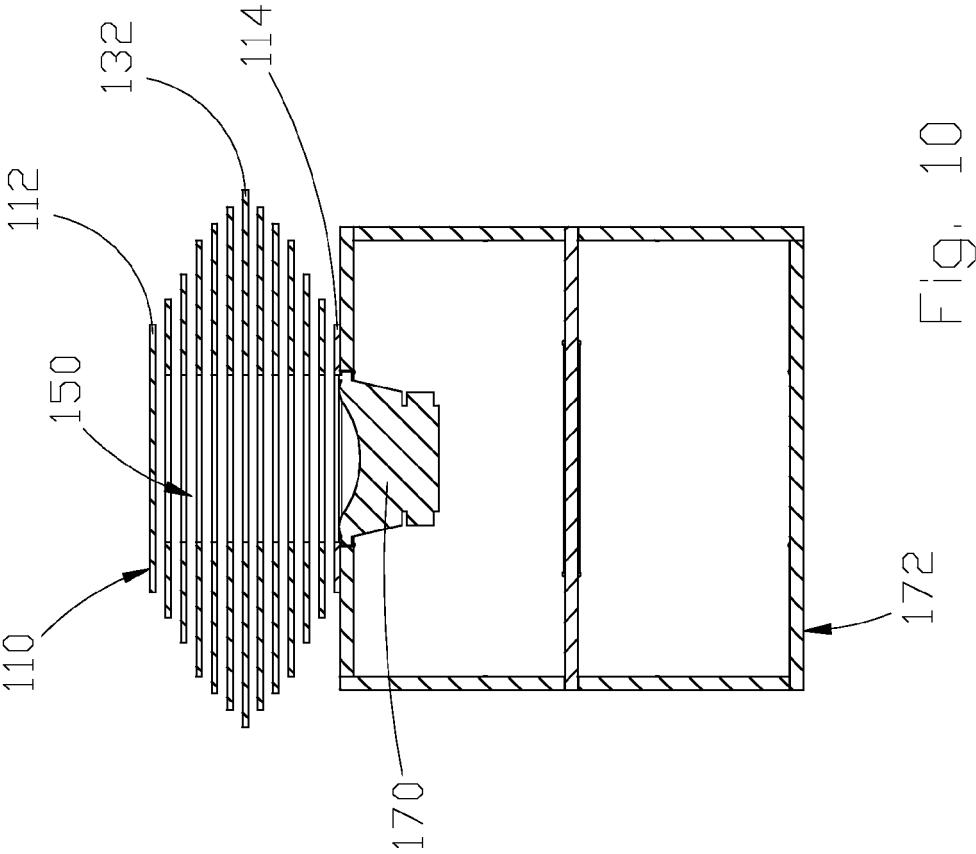
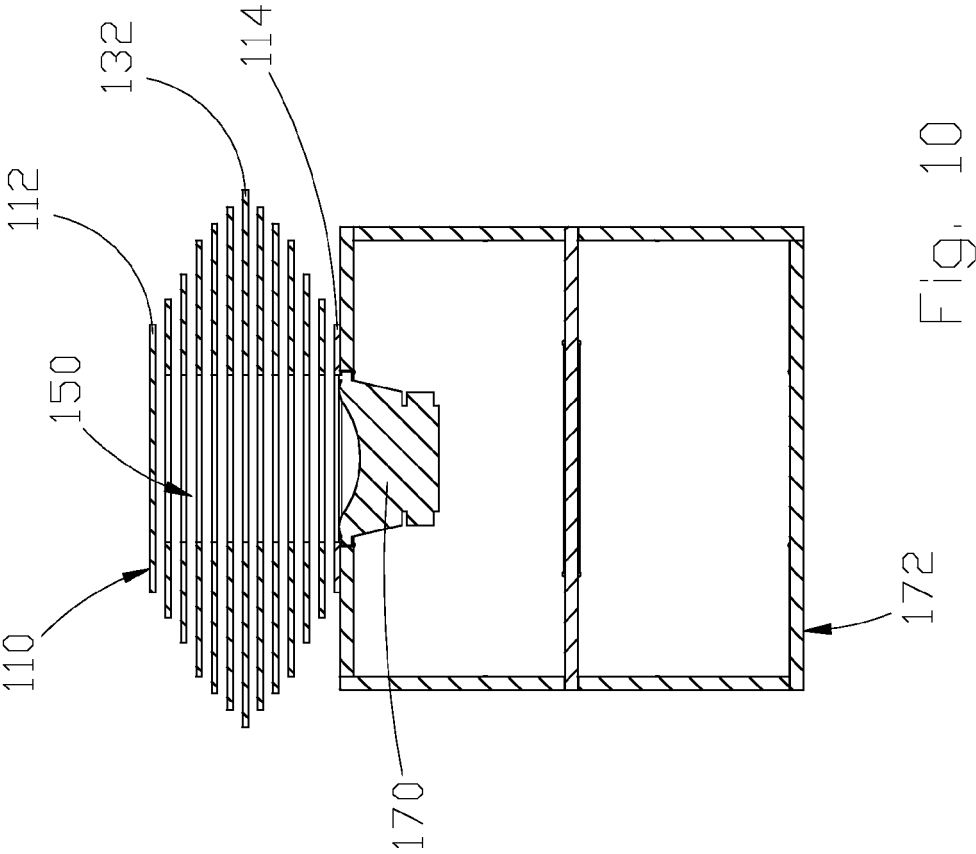


Fig. 5a





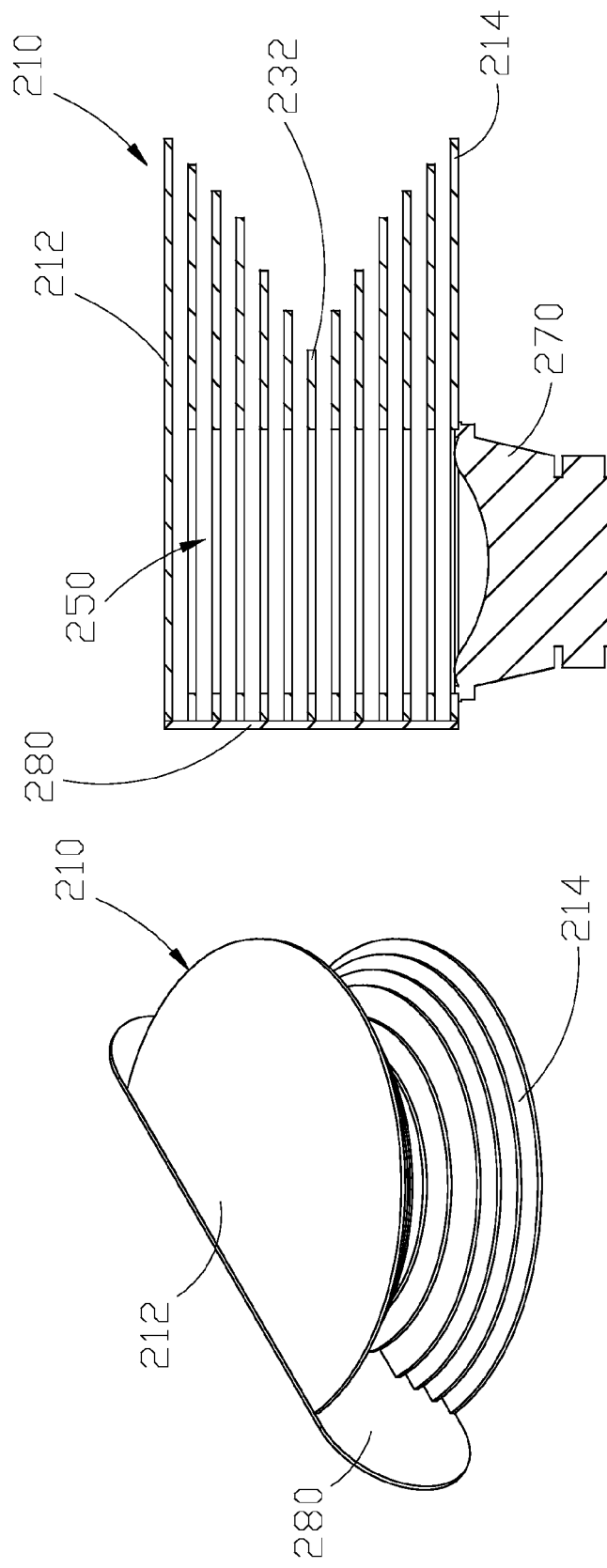
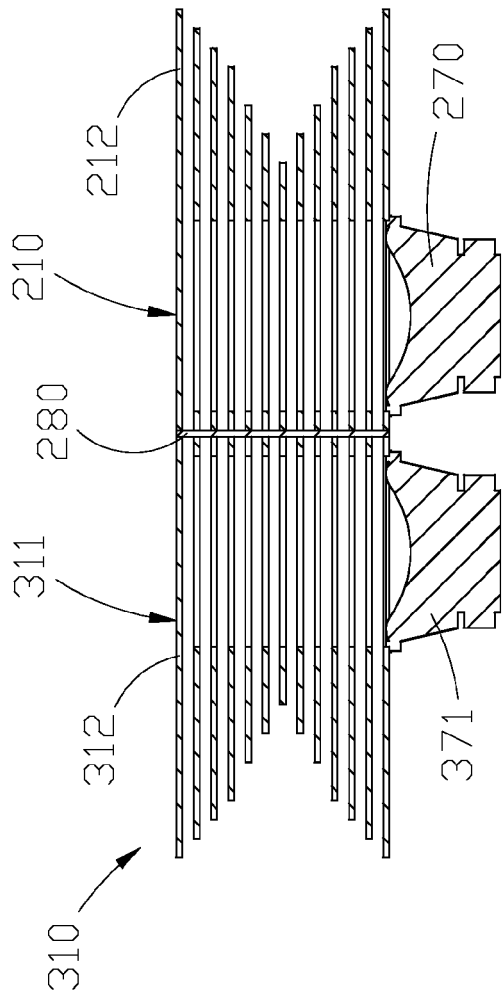
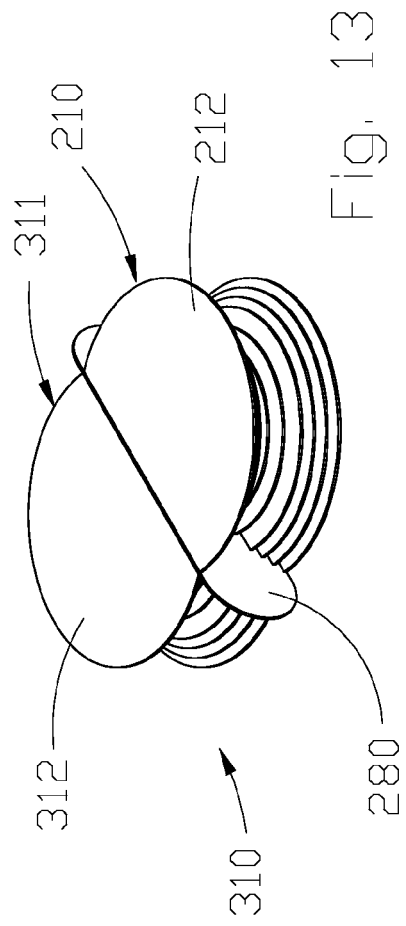


Fig. 12

Fig. 11



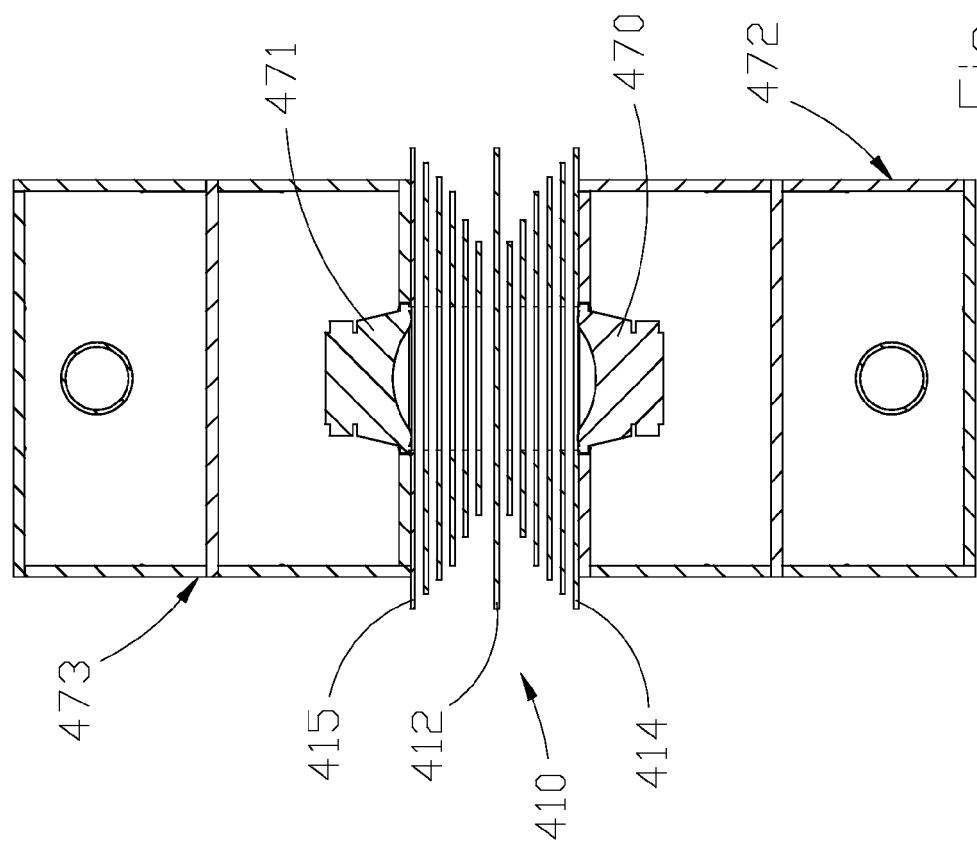


Fig. 15

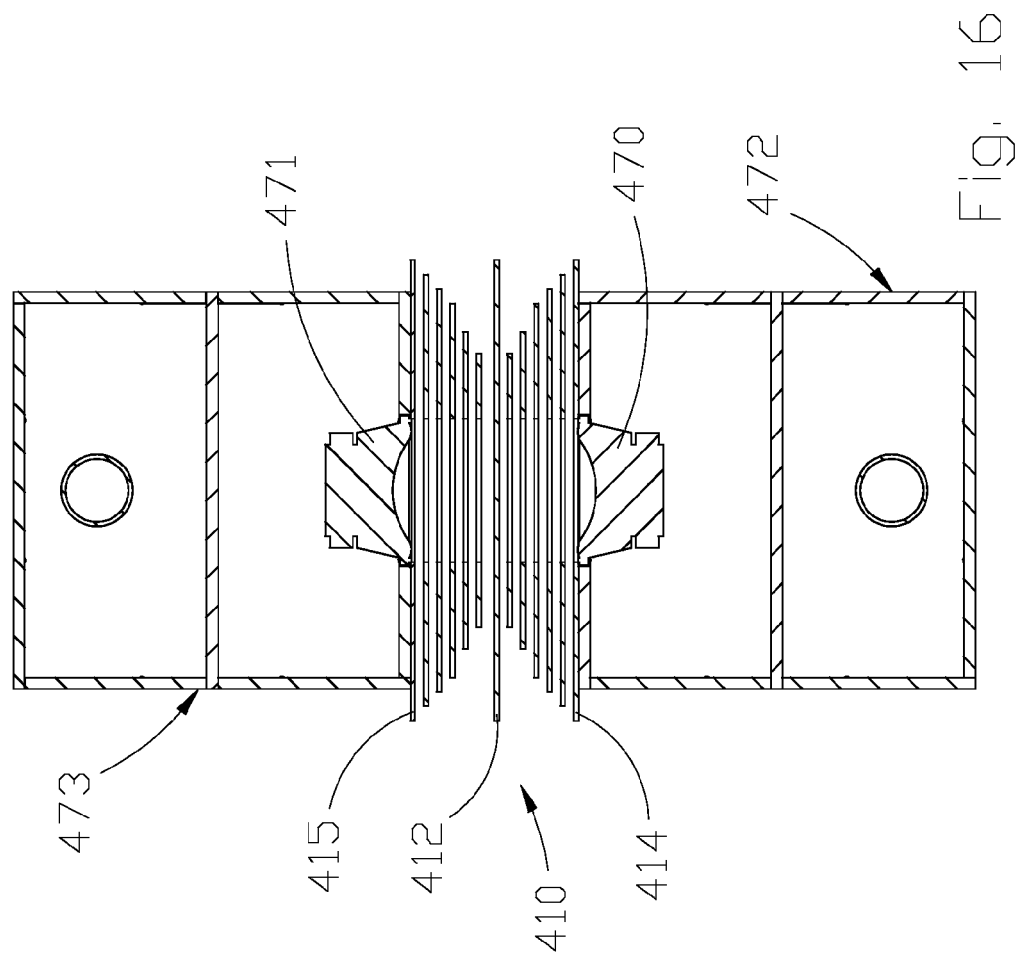


Fig. 16

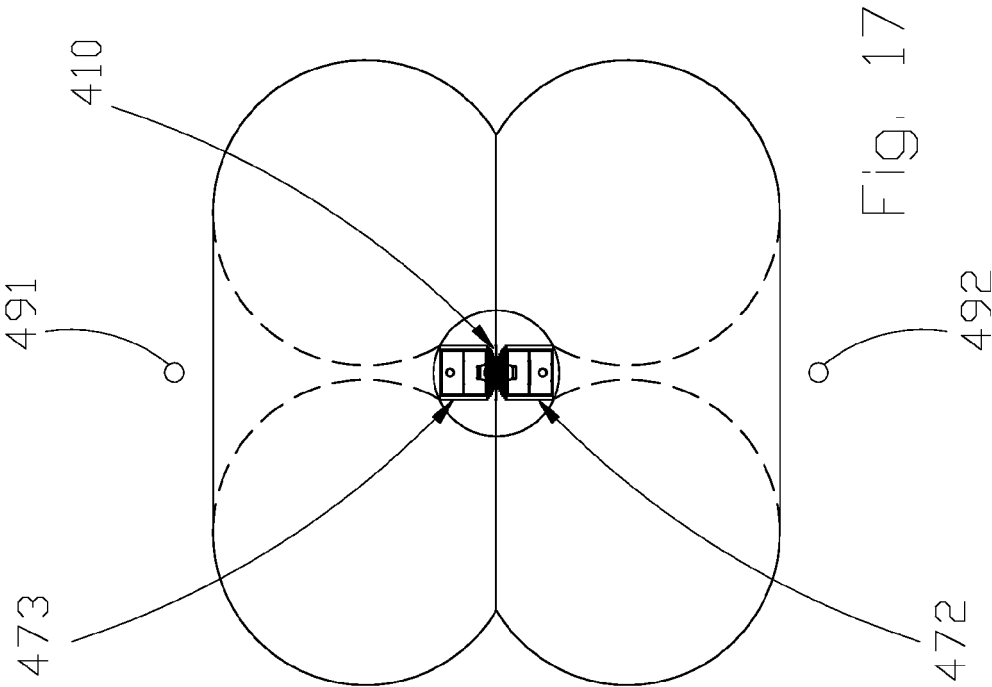


Fig. 17

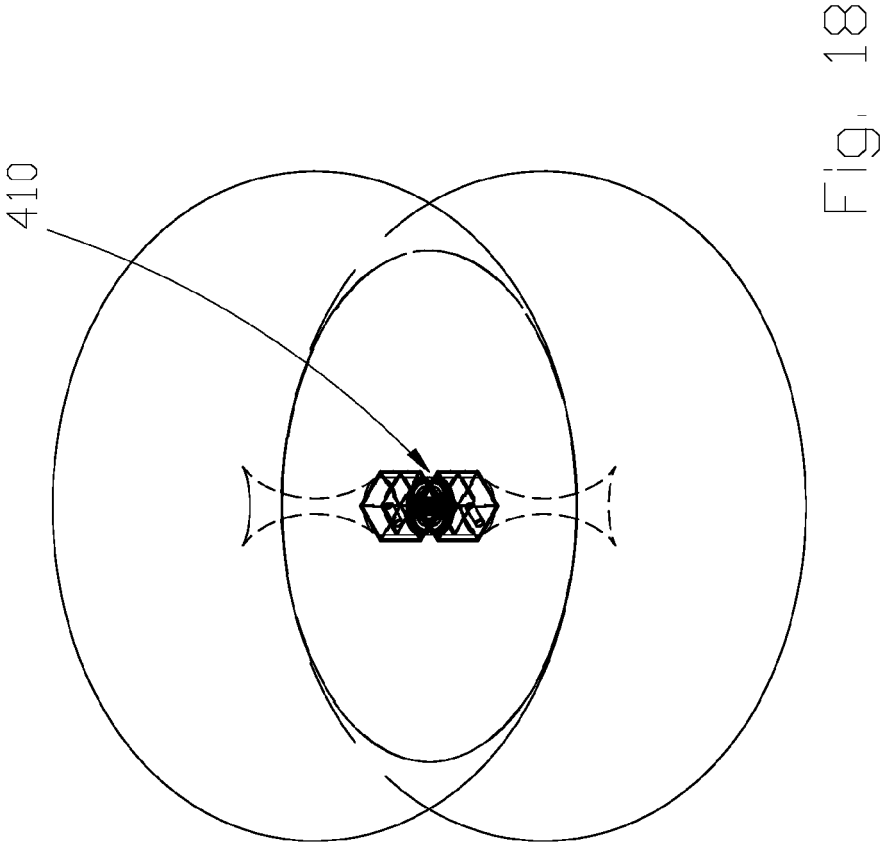


Fig. 18

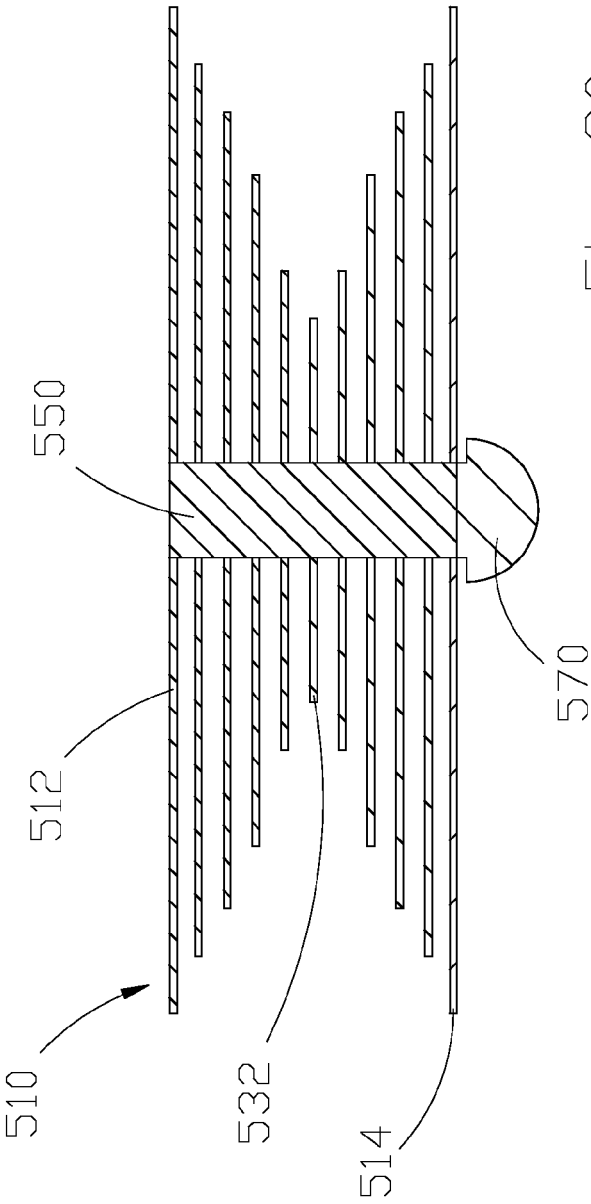


Fig. 20

