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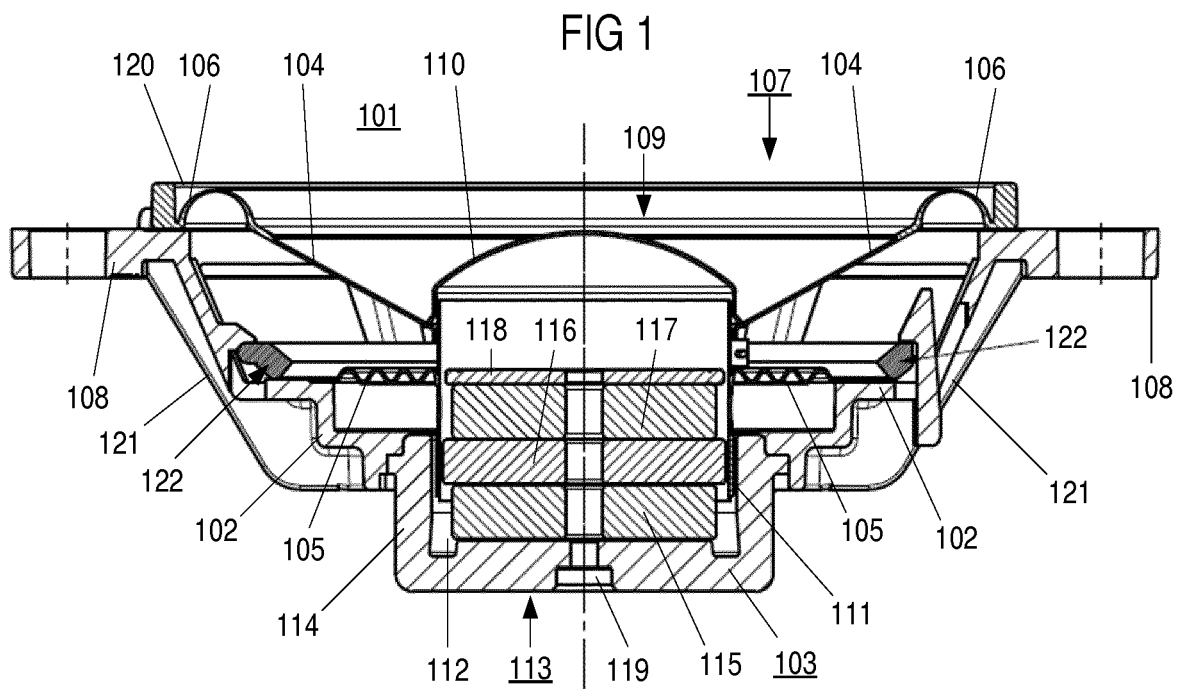
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(54) **LOUDSPEAKER ASSEMBLY WITH LIGHTING**

(57) A loudspeaker assembly (101, 301, 501) includes a diaphragm (104, 304, 504) having a front side, a rear side and a circumferential edge between the front side and the rear side, and a frame (102, 302, 502) disposed at the rear side and at the edge of the diaphragm, and configured to support the diaphragm. The assembly

further includes a light source (201, 401, 601) configured to generate light, and a light guide (122, 320, 512) attached to the frame and optically coupled to the light source, the light guide configured to guide the light from the light source to the frame and to illuminate a vicinity of the light guide.



Description

BACKGROUND

1. Technical Field

[0001] The disclosure relates to a loudspeaker assembly with lighting.

2. Related Art

[0002] For a variety of reasons, a lighting device may be integrated into a loudspeaker assembly. One such reason may be that there is simply not enough space to arrange the loudspeaker assembly and the lighting device side by side. Another reason may be to create ornamental effects. Still another reason may be to link acoustic information to visual information. Accordingly, there are various fields where loudspeaker assemblies with integrated lighting devices are applied such as acoustic and visual emergency warning applications, automotive applications and home entertainment applications. However, integrating a lighting device into a loudspeaker assembly may cause some difficulties including thermal and mechanical issues.

SUMMARY

[0003] A loudspeaker assembly includes a diaphragm having a front side, a rear side and a circumferential edge between the front side and the rear side, and a frame disposed at the rear side and at the edge of the diaphragm and which is configured to support the diaphragm. The assembly further includes a light source configured to generate light, and a light guide attached to the frame and optically coupled to the light source, the light guide being configured to guide the light from the light source to the frame and to illuminate a vicinity of the light guide.

[0004] Other systems, methods, features and advantages will be, or will become, apparent to one with skill in the art upon examination of the following detailed description and appended figures. It is intended that all such additional systems, features and advantages be included within this description, be within the scope of the invention, and be protected by the following claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The system may be better understood with reference to the following drawings and description. The components in the figures are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention. Moreover, in the figures, like referenced numerals designate corresponding parts throughout the different views.

Figure 1 is a schematic cross-sectional view illustrating an electrodynamic loudspeaker assembly

with a translucent membrane and a lighting assembly radiating light at a rear side of the membrane.

Figure 2 is a schematic isometric view illustrating a light guide and a light source applicable in the assembly shown in Figure 1.

Figure 3 is a schematic cross-sectional view illustrating a midrange loudspeaker assembly with a translucent membrane and a lighting assembly radiating light at a rear side of the membrane.

Figure 4 is a schematic isometric view illustrating a light guide and a light source applicable in the assembly shown in Figure 3.

Figure 5 is a schematic cross-sectional view illustrating a tweeter assembly with a light-reflective membrane and a lighting assembly radiating light at a front side of the membrane.

Figure 6 is a schematic isometric view illustrating a light guide and a light source applicable in the assembly shown in Figure 5.

[0006] The Figures describe concepts in the context of one or more structural components. The various components shown in the figures can be implemented in any appropriate manner. In some examples, the various components may reflect the use of corresponding components in an actual implementation. Certain components may be broken apart into plural sub-components and certain components can be implemented in an order that differs from that which is illustrated herein.

DETAILED DESCRIPTION

[0007] Referring to Figure 1, an exemplary loudspeaker assembly 101 includes a rigid basket 102 as a basic frame structure to which a magnet system 103 is fixedly mounted and to which, as a diaphragm, a membrane 104 is movably attached via a resilient spider 105 and a resilient surrounding 106 to allow for an inward and outward movement of the membrane 104 relative to the basket 102. At a front end 107 of the loudspeaker assembly 101, a mounting ring 108 that includes holes and that defines a front aperture 109 forms an adhered (not shown) or integral part (shown) of the rigid basket 102 to allow the loudspeaker assembly 101 to be mounted to a carrier (not shown) such as an enclosure or baffle. The membrane 104 is rigidly connected to a dust cap 110 at one end of a voice coil 111 which dips with its other end into an air-gap 112 of the magnet system 103. The magnet system 103 is attached to the basket 102 at a rear side 113 of the loudspeaker assembly 101 and includes a U-shaped pole piece 114, i.e., a pole piece with a U-shaped cross-section, which encompasses an alternating arrangement of two discoidal permanent magnets 115, 116

and two discoidal pole pieces 117, 118. The discoidal permanent magnets 115, 116 and the soft-magnetic discoidal pole pieces 117, 118 have central holes that form together with a central hole in the U-shaped pole piece 103 a venting channel 119. The loudspeaker assembly 101 may include a grill 120 at the front end 107 and a cover 121 at the rear end 113 of the loudspeaker assembly 101.

[0008] The loudspeaker assembly 101 further includes a light guide 122 which, in the present example, is wound to form a ring and is attached to the basket 102 on the rear side (i.e., the side facing the rear end 113) of the membrane 104 in a position adjacent to the position where the spider 105 is attached to the basket 102 between the basket 102, the membrane 104 and the spider 105, i.e., the light guide 122 is disposed "behind" the membrane 104 from a front-end perspective. The membrane 104 is translucent so that light emitted by the light guide 122 is visible from the front end 107. The translucent character of the membrane 104 may be diffuse, clear or of any nuance in between and may be white or have any desired color. The light guide can be produced of different kinds of materials and in various arrangements. In one example, the light guide 122 may be diffuse, clear or of any nuance in between and may be white or have any desired color. In another example, a diffuser may be placed in front of the light guide to obtain more diffused illumination. The light guide 122 may be screwed on, welded, clamped, molded, adhered with adhesive or attached in any other suitable way to the basket 102.

[0009] In Figure 2, the light guide 122, when connected to a light source 201 via an optical connector 202, is shown. For example, the light guide 122 may be any suitable type that allows guiding the light in a main direction 203 along the light guide 122 and reflecting (or diffusing, distracting, diverting etc.) parts of the light 204 in at least one other direction, e.g., perpendicular to the (curved) main direction 203 of the light guide 122. In this example, prisms 205 are included in the light guide 122 which couple out light in a controlled way along the main direction, so that the light direction and intensity can be adapted to specific applications, i.e., to illuminate a field of interest 206 such as the (center of the) membrane 104. The light guide 122 is wound into a ring form starting at a certain distance from the optical connector 202 as shown.

[0010] For example, the light guide 122 may (or may not) be covered by a transparent layer of polytetrafluoroethylene, polyurethane, polyvinylchloride, polyester, a blend of two or more of these materials, or any other suitable cladding. The polyurethane material may be based on any suitable isocyanate, e.g. diisocyanate, and polyol combination. The polyol may for example be a polyester, polycaprolactone, or polycarbonate. For example, polyether polyurethane can provide a side-emissive light guide having both a bright output and good transmissive quality. The material may also include any suitable additives, including for example additives for ultraviolet (UV) protection or micro prisms for directing the

light. An exemplary light guide may be formed from an unclad solid length of extruded thermoplastic polyurethane material of polyether composition with UV protection and may include other additives. The (straight) light guide 122 may have any suitable cross-section such as circular, oval, odd-shaped, triangular, rectangular etc.

[0011] The lighting module 201 may include any suitable illuminant such as one or more single-color or multi-color (RGB) light emitting diodes (LED), fluorescent lamps, lasers, light-emissive polymeric materials and other suitable illuminants. The light source 201 may be cooled with cooling fins, Peltier elements and other suitable cooling systems and may be watertight or waterproof, e.g., for automotive applications. The lighting module 201 is connected via power supply lines (not shown) to a power source (not shown).

[0012] Another exemplary loudspeaker assembly 301 is shown in Figure 3 and includes a rigid basket 302 as a basic frame structure to which a magnet system 303 is fixedly mounted and to which a membrane 304 is movably attached via a resilient spider 305 and a resilient suspension 306 to allow an inward and outward movement of the membrane 304 relative to the basket 302. At a front end 307 of the loudspeaker assembly 301, a mounting ring 308 that includes threaded holes and that defines a front aperture 309 forms an adhered (shown) or integral part (not shown) of the rigid basket 302 to allow the loudspeaker assembly 301 to be mounted to a carrier (not shown) such as an enclosure or baffle. The membrane 304 is rigidly connected to a dust cap 310 at one end of a voice coil 311 which dips with its other end into an air-gap 312 of the magnet system 303. The magnet system 303 is attached to the basket 302 at a rear side 313 of the loudspeaker assembly 301 and includes an L-shaped pole piece 314, i.e., a pole piece with a double-L-shaped cross-section, which encompasses an arrangement of a discoidal permanent magnet 315 between a discoidal pole pieces 316 and the L-shaped pole piece 314. The discoidal permanent magnet 315 and the soft-magnetic discoidal pole piece 316 have central holes that form an opening with which the L-shaped pole piece 314 engages, thereby forming the air-gap 312 between the L-shaped pole piece 314 on one side and the discoidal permanent magnet 315 and the soft-magnetic discoidal pole piece 316 on the other side of the air-gap 312. The L-shaped pole piece 314 includes a central hole which serves as a venting channel 317. The loudspeaker assembly 301 may include a grill 318 with an edge profile 319 at the front end 307 of the loudspeaker assembly 301.

[0013] The loudspeaker assembly 301 further includes a light guide 320 which, in the present example, is wound to form a ring and is disposed between the mounting ring 308 and the edge profile 319 on the front side (i.e., the side facing the front end 307) of the basket 302 in a position adjacent to the position where the suspension 306 is attached to the basket 302, i.e., is disposed "in front of" the membrane 304 from a front-end perspective. The

membrane 304 is reflective so that light emitted by the light guide 320 is shadowed by the edge profile 319, but is visible from the front end 307 via the reflective membrane 304. The reflective character of the membrane 304 may be diffuse or mirroring and may be clear, white or have any desired color. Similarly, the light guide 320 may be reflective (diffuse, clear or of any nuance in between) and may be white or have any desired color. The light guide can be produced in different kinds of materials and in various arrangements. In one example, a diffuser is placed in front of the light guide to obtain more diffused illumination. The light guide 320 may be screwed on, welded, clamped, molded, adhered with adhesive or attached in any other suitable way to the basket 302.

[0014] In Figure 4, the light guide 320, when connected to a light source 401 via an optical connector 402, is shown. For example, the light guide 320 may be any suitable type that allows for guiding the light in a main direction 403 along the light guide 320 and reflecting, diffusing, distract, divert etc. parts of the light 404 in at least one other direction, e.g., perpendicular to the main direction 403 of the light guide 320, along the light guide 320. In this example, prisms 405 are included in the light guide 320 which couple out light in a controlled way along the main direction, so that the light direction and intensity can be adapted to specific applications, i.e., to illuminate a field of interest 406 such as the (center of the) membrane 304. The light guide 320, starting from the optical connector 402 is wound into a ring form as shown. The light guide 320 and the lighting module 401 may be designed similar to the light guide 122 and the lighting module 201 described above in connection with Figure 2. The lighting module 401 is connectable to a power source (not shown) via an electrical connector 407.

[0015] Still another exemplary loudspeaker assembly 501 is shown in Figure 5 and includes a rigid basket 502 as a basic frame structure to which a motor system 503 is fixedly mounted and to which a dome shaped membrane 504 is movably attached via a resilient suspension 505 to allow for an inward and outward movement of the membrane 504 relative to the basket 502. At a rear end 506 of the loudspeaker assembly 501, a mounting ring 507 that includes holes and that defines a rear aperture 508 forms an adhered (not shown) or integral part (shown) of the rigid basket 502 to allow the loudspeaker assembly 501 to be mounted to a carrier (not shown) such as an enclosure or baffle. The membrane 504 is driven by the motor system 503 which may include a voice coil, an air-gap, pole pieces and magnets. The motor system 503 is attached to the basket 502 at a rear side 506 of the loudspeaker assembly 501. The loudspeaker assembly 501 may include at a front end 509 of the loudspeaker assembly 501 a grill 510 having an edge profile 511. The edge profile 511 may be made from a material that diffuses light and/or may be designed to diffuse light.

[0016] The loudspeaker assembly 501 further includes a light guide 512 which, in the present example, is wound

to form a ring and is disposed between the basket 502 and the edge profile 511 on the front side (i.e., the side facing the front end 509) of the basket 502 in a position adjacent to the position where the suspension 505 is attached to the basket 502, i.e., is disposed "in front of" the membrane 504 from a front-end perspective. The membrane 504 may be reflective so that light emitted by the light guide 512 is diffused by the edge profile 519 and, thus, is visible from the front end directly and via the reflective membrane 504. The reflective character of the membrane 504 may be diffuse or mirroring and may be clear, white or have any desired color. Similarly, the light guide 512 may be diffuse, clear or of any nuance in between and may be white or have any desired color. The light guide can be produced of different kinds of materials and in various arrangements. In one example, a diffuser is placed in front of the light guide to obtain more diffused illumination. The light guide 512 may be screwed on, welded, clamped, molded, adhered with adhesive or attached in any other suitable way to the basket 502.

[0017] In Figure 6, the light guide 512, when connected to a light source 601 via an optical connector 602, is shown. For example, the light guide 512 may be of any suitable type that allows guiding the light in a main direction 603 along the light guide 512 and reflecting, diffusing, distracting, diverting etc. parts of the light 604 in at least one other direction, e.g., perpendicular to the main direction 603 of the light guide 512. In this example, prisms 605 are included in the light guide 122 which couple out light in a controlled way along the main direction, so that the light direction and intensity can be adapted to specific applications, i.e., to illuminate a field of interest 606 such as the (center of the) membrane 504. The light guide 512, starting from the optical connector 602 is wound into a ring form as shown. The light guide 512 and the lighting module 601 may be designed similar to the light guide 122 and the lighting module 201 described above in connection with Figure 2.

[0018] The translucent membranes may be made from any material that fulfills, on the one hand, all acoustic requirements that allow an optimum sound experience but, on the other hand, are also translucent such as diffusing, transparent or clear. Such materials may be, for example, aromatic polyamides, para-aramids, or polycarbonate. Reflective membranes may be based on common membrane material and include a reflective surface coating with highly reflective material (e.g., mirror coating) or diffusing coating (e.g., white paint).

[0019] Figure 1 depicts a common electro-dynamic loudspeaker (e.g., midrange loudspeaker) with back light illumination, i.e., the light is radiated at the rear side of the translucent membrane. Figure 3 depicts a midrange speaker with a colored (e.g., yellow) para-amide membrane which is illuminated with light from in front of the membrane. Figure 5 depicts a tweeter with front light illumination in the form of two luminous rings and in connection with a light-reflective double dome membrane. The assemblies described above allow applications in

harsher environments such as automotive environments. The assemblies are very compact as a slim light guide is used at the loudspeaker and the corresponding light source can be placed where more space is available. The light source may be designed to control the color of the emitted light. The light source can be replaced easily since it is separate from the loudspeaker. Less light sources are, in most applications even only one light source is utilized which makes the lighting system more efficient and reduces the necessity for cooling at the loudspeaker. A light guide may be molded using materials such as poly-methyl methacrylate or polycarbonate which is useful, e.g., in automotive applications.

[0020] To couple out light from the light guide (optical fiber, fiber optics etc.), the design of the light guide may be adapted by, e.g., integrating an adequate number of prisms into the light guide, each of which of an adequate size so that a desired light pattern around the light guide is achieved. In the present examples, the light guide is focused on the speaker membrane but can be adapted easily to other points of interest. The light guide may include a light diffusing outer shell. Alternatively or additionally, a separate diffuser may be used to diffuse the light from the light guide if desired. Notwithstanding that only one ring is utilized in the examples described above, a multiplicity of rings may be employed in connection with a single source (e.g., a single light guide wound to a coil and connected to a single source) or a multiplicity of sources (e.g., one ring-shaped light guide per source), in order to further intensify the illumination, to create multiple concentric illumination effects etc.

[0021] The loudspeaker assemblies described above are suitable for applications in harsh environments such as automotive applications. Harsh environments include at least one of a wide (ambient and/or operating) temperature range, moisture, dust and mechanical stress such as vibrations. Possible mounting locations in a vehicle such as an automobile are e.g., a pillar, dashboard, door, center console, roof liner or any other location in a field of view of a vehicle occupant. For example, the temperature range complying with automotive standards is commonly of between -40° C and 125° C. The loudspeaker assemblies are able to provide not only acoustic information such as speech, music or warning sounds, but also corresponding optical information by controlling, e.g., the intensity, pattern and/or color of the light emitted by the assembly.

[0022] The description of embodiments has been presented for purposes of illustration and description. Suitable modifications and variations to the embodiments may be performed in light of the above description or may be acquired from practicing the methods. For example, unless otherwise noted, one or more of the described methods may be performed by a suitable device and/or combination of devices. The described methods and associated actions may also be performed in various orders in addition to the order described in this application, in parallel, and/or simultaneously.

[0023] The described systems are exemplary in nature, and may include additional elements and/or omit elements. As used in this application, an element or step recited in the singular and proceeded with the word "a" or "an" should be understood as not excluding plural of said elements or steps, unless such exclusion is stated. Furthermore, references to "one embodiment" or "one example" of the present disclosure are not intended to be interpreted as excluding the existence of additional embodiments that also incorporate the recited features.

[0024] While various embodiments of the invention have been described, it will be apparent to those of ordinary skilled in the art that many more embodiments and implementations are possible within the scope of the invention. In particular, the skilled person will recognize the interchangeability of various features from different embodiments. Although these techniques and systems have been disclosed in the context of certain embodiments and examples, it will be understood that these techniques and systems may be extended beyond the specifically disclosed embodiments to other embodiments and/or uses and obvious modifications thereof.

Claims

1. A loudspeaker assembly comprising:

a diaphragm having a front side, a rear side and a circumferential edge between the front side and the rear side,
a frame disposed at the rear side and at the edge of the diaphragm, and configured to support the diaphragm,
a light source configured to generate light, and
a light guide attached to the frame and optically coupled to the light source, the light guide configured to guide the light from the light source to the frame and to illuminate a vicinity of the light guide.

2. The assembly of claim 1, wherein the light guide is attached to the frame by clamping, molding or adhering with adhesive.

3. The assembly of claim 1 or 2, wherein the light guide is attached to the frame adjacent to the edge of the diaphragm.

4. The assembly of claim 3, wherein the diaphragm has a light reflective surface on the front side.

5. The assembly of claim 1 or 2, wherein the light guide is attached to the frame adjacent to the rear side of the diaphragm.

6. The assembly of claim 5, wherein the diaphragm is translucent.

7. The assembly of any of claims 1 to 6, wherein the light guide includes at least one of light redirecting elements and light diffusing elements.
8. The assembly of any of claims 1 to 7, wherein the light guide is wound to one or more rings. 5
9. The assembly of any of claims 1 to 8, wherein the light guide is coupled to the light source via an optical connector. 10
10. The assembly of any of claims 1 to 9, wherein the light guide is molded.
11. The assembly of any of claims 1 to 10, wherein the light guide is detachable from the light source. 15
12. The assembly of any of claims 1 to 11, wherein the light source is configured to provide light with a color that is controllable. 20
13. The assembly of any of claims 1 to 12, wherein the light source is disposed distant from the frame and the diaphragm. 25
14. The assembly of any of claims 1 to 12, wherein the light source comprising a cooling arrangement.
15. The assembly of any of claims 1 to 14, further comprising a diffusing element attached to the light guide. 30

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FIG 1

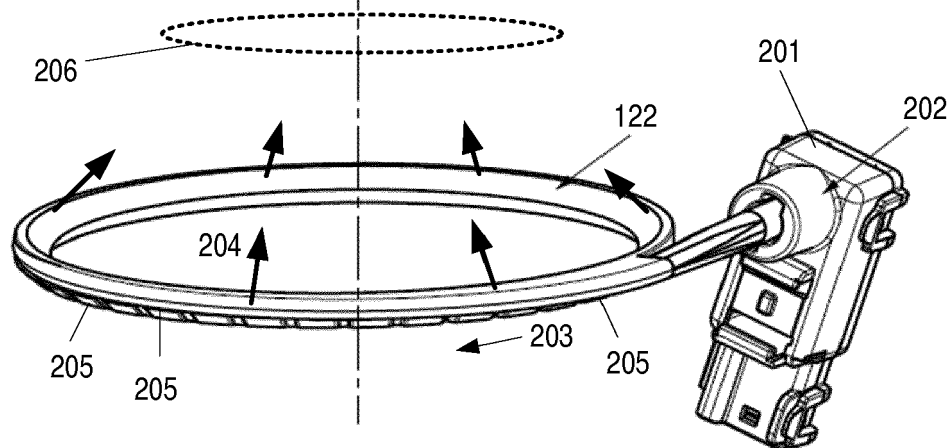
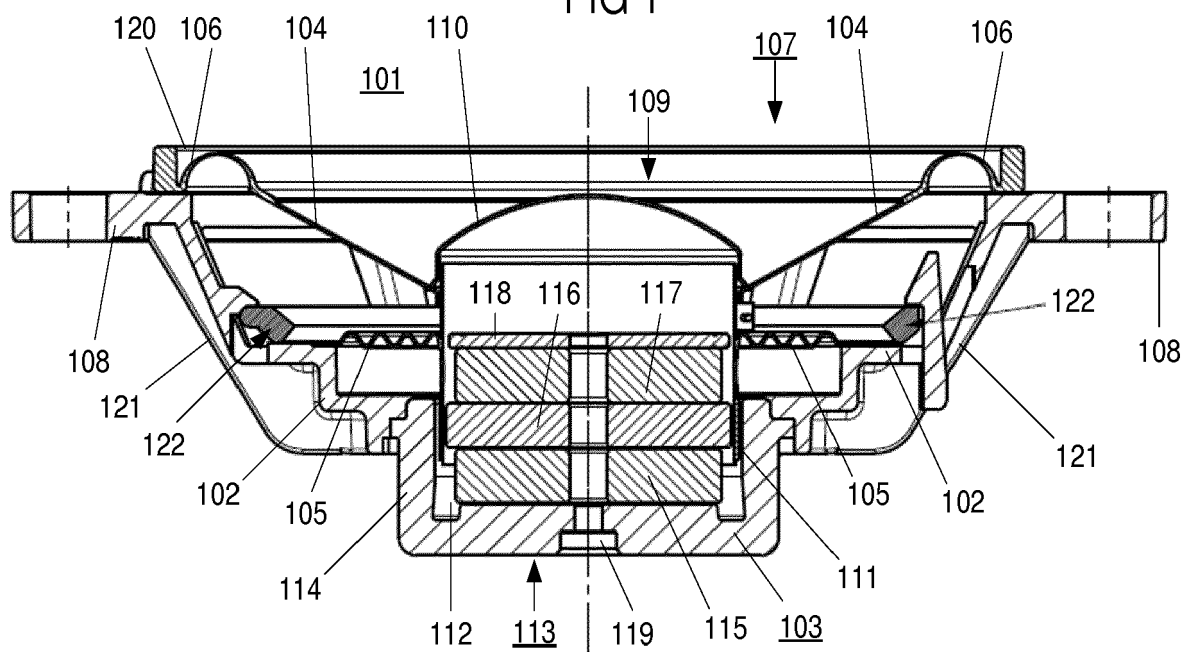


FIG 2

FIG 3

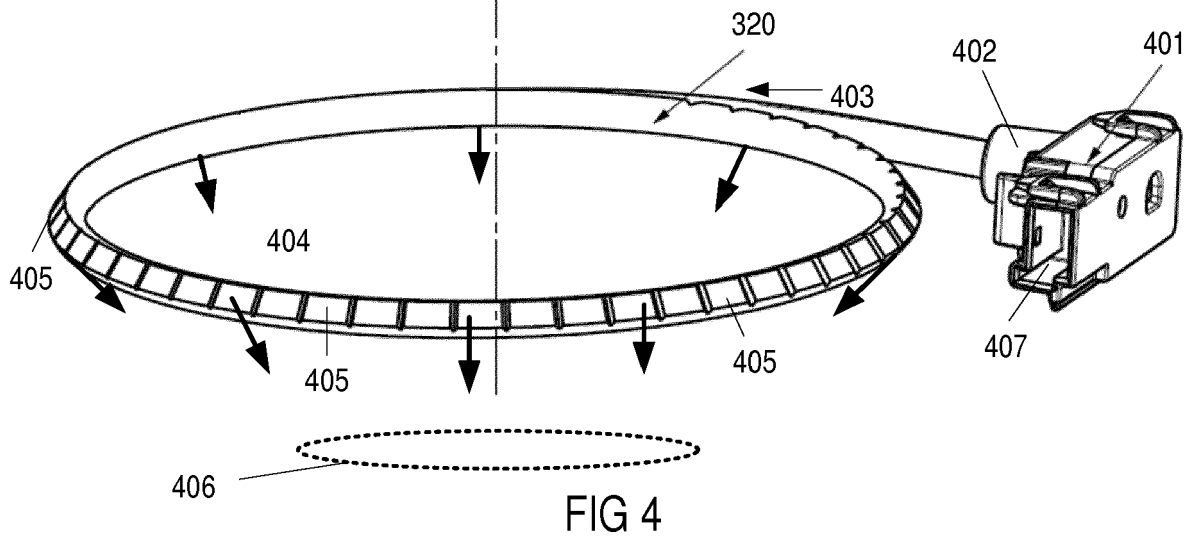
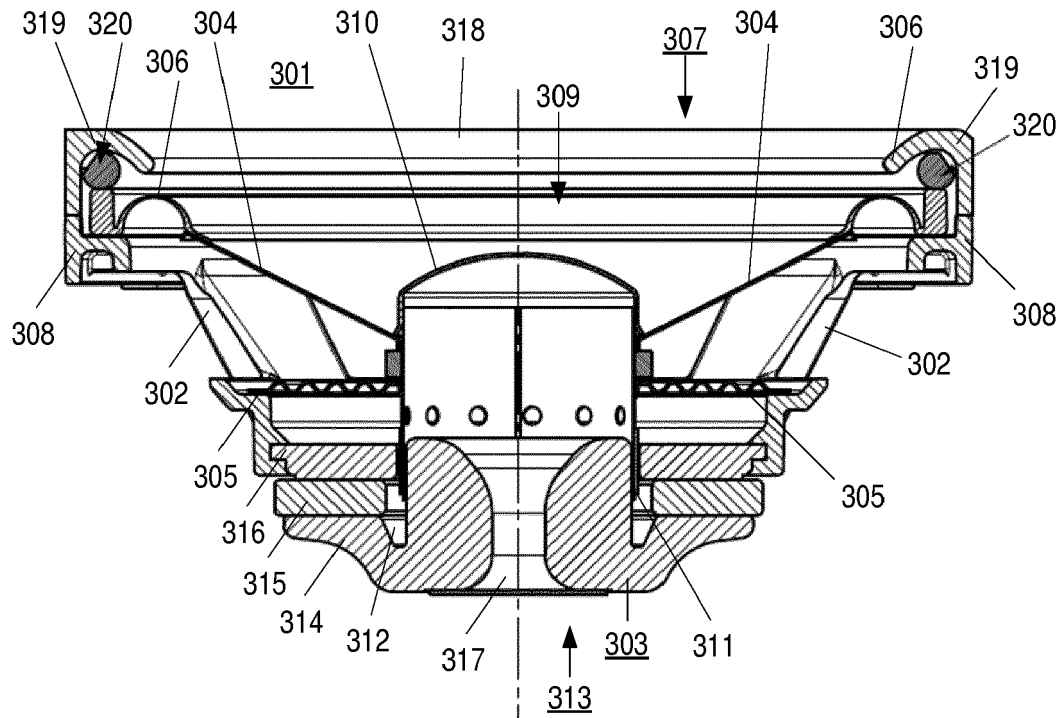


FIG 4

FIG 5

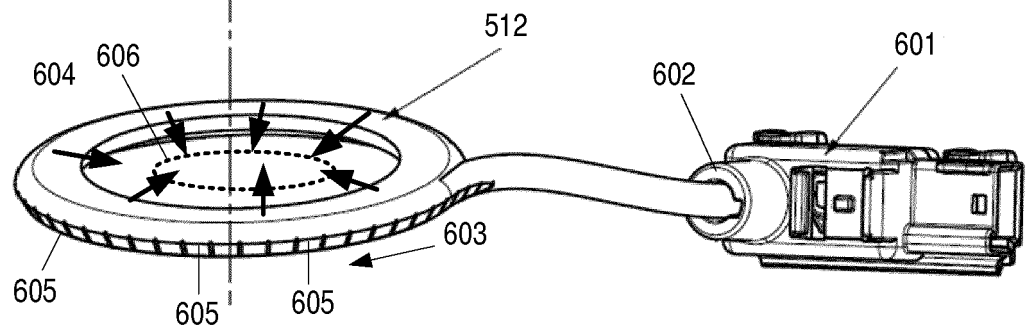
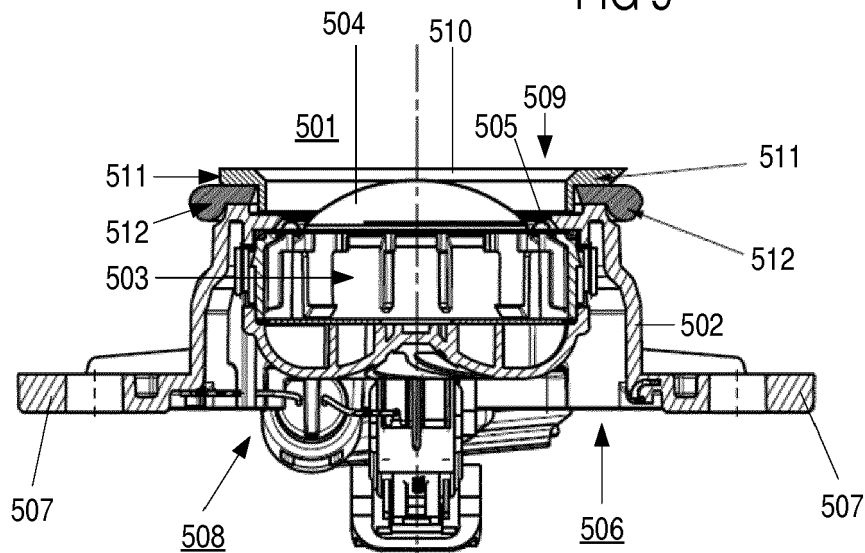


FIG 6



EUROPEAN SEARCH REPORT

Application Number
EP 18 20 8469

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The present search report has been drawn up for all claims			
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 18 20 8469

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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