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## (54) Radiating unit for loudspeaker

(57) A radiating unit for a loudspeaker (10), comprises a diaphragm (15) and a surround suspension (17) adapted to be connected to a frame (12) of the loudspeaker (10), wherein said diaphragm (15) is made of composite material comprising at least one layer (15) of matrix material and reinforcing material.

The surround suspension (17) is an extension of at least one layer (15) of matrix material, the ratio by volume of the reinforcing material in said diaphragm (15) to the total amount of said composite material decreasing towards said surround suspension.

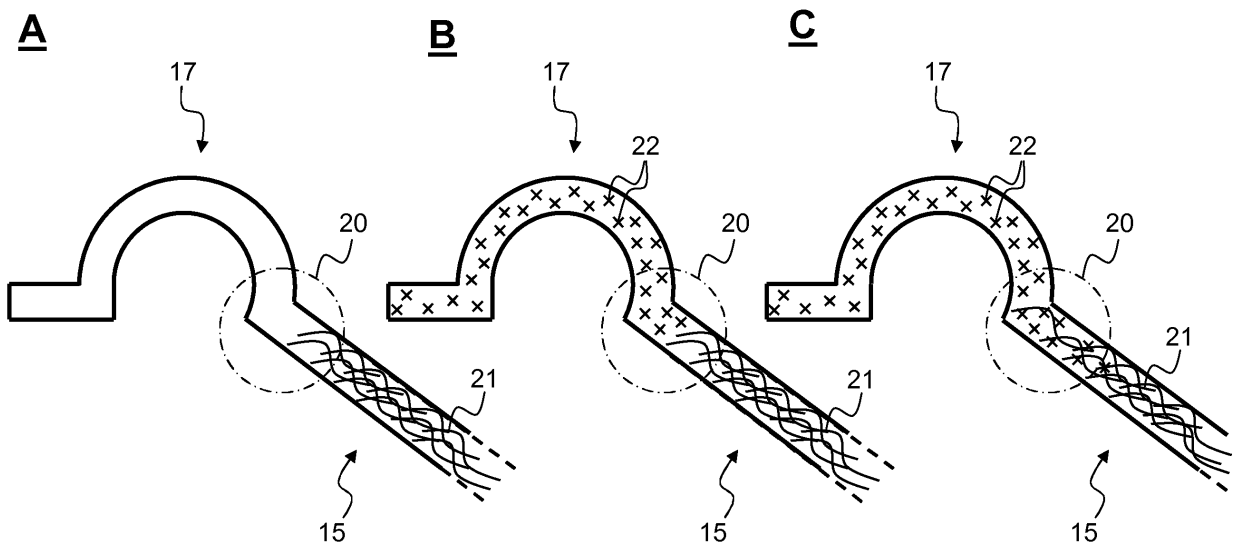


**Fig. 2**

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## Description

**[0001]** The present invention concerns a radiating unit for loudspeaker and a loudspeaker incorporating such a radiating unit.

**[0002]** In general terms, the present invention concerns the field of sound and audio, and more precisely loudspeakers producing sound by virtue of a sound reproduction element, for example by causing a diaphragm to vibrate.

**[0003]** In such a loudspeaker, a diaphragm is attached to a voice coil which moves back and forth due to a magnetic field created by an electric current in the voice coil. The diaphragm and the voice coil are mounted via flexible suspension in a rigid frame of the loudspeaker. Generally, the flexible suspension comprises a first element known as a spider connecting the voice coil to the frame and a surround suspension connecting the diaphragm to the frame, in the front face of the loudspeaker. Such surround suspension can be a roll of rubber or foam, or a ring of corrugated fabric attached to the outer circular edge of the diaphragm and to the frame of the loudspeaker.

**[0004]** The diaphragm and the surround suspension are the constituent elements of the radiating unit of the loudspeaker, and thus have a direct relation with the performance of the loudspeaker.

**[0005]** More precisely, the diaphragm plays a role in transforming the mechanical excitation movement of the voice coil into sound waves by modifying the air pressure while vibrating. The surround suspension guides the diaphragm along the central axis of the loudspeaker and damps the mechanical bending wave coming from the diaphragm.

**[0006]** Both of the diaphragm and the surround suspension should be light weight for best efficiency. However, the material used for the diaphragm should be stiff whereas the material used for the surround suspension should have high damping properties and should be soft and elastic.

**[0007]** Since the radiating unit is made of two separate parts, it is generally made of different constituent materials. Moreover, the diaphragm and the surround suspension have different geometries at their interface. Consequently, a mismatch of their impedance can occur.

**[0008]** The impedance in the diaphragm and in the surround suspension corresponds to the product of the mechanical bending wave velocity in the material by the density of the material. If the materials are different, the impedances are mismatched and for instance the mechanical waves coming from the excitation end of the diaphragm are reflected back to the diaphragm instead of being transmitted into the surround suspension to be damped. In the diaphragm, the reflected waves are mixed with the incident waves and may deteriorate the overall acoustic performance of the loudspeaker.

**[0009]** From the document FR 2 668 018, a loudspeaker is known comprising a diaphragm and a surround suspension made of materials chemically compatible, such as a polymer and an elastomer coming from the same material family. By a process of multi-injection, molecular bonds are created at the interface of the diaphragm and the surround suspension and the cross sections of the diaphragm and the surround suspension are identical at the interface. Due to the same geometry at the interface of the diaphragm and the surround suspension, the transmission of the mechanical bending waves at the interface is improved. However, the materials in the diaphragm and the surround suspension are different, leading to a mismatch of the impedances in the diaphragm and the surround suspension.

**[0010]** The aim of the present invention is to improve the radiating unit of a loudspeaker in order to damp the mechanical waves coming from the excitation means of the loudspeaker, and thus to improve the frequency response function of the loudspeaker.

**[0011]** For this purpose, the present invention concerns a radiating unit for a loudspeaker, comprising a diaphragm and a surround suspension adapted to be connected to a frame of the loudspeaker, wherein said diaphragm is made of composite material comprising reinforcing material and at least one layer of matrix material.

**[0012]** According to the invention, said surround suspension is an extension of at least one layer of matrix material, the ratio by volume of the reinforcing material in said diaphragm to the total amount of said composite material decreasing towards said surround suspension.

**[0013]** By virtue of the invention, the diaphragm and the surround suspension have common geometry at the interface and share the same matrix material.

**[0014]** Thus, the mismatch of the velocity of the mechanical waves in the diaphragm and the surround suspension is reduced and the damping of the radiating unit deformation modes (also known as "break-up modes") is improved. As a consequence, the frequencies of the break-up modes can be shifted higher in order to have a loudspeaker with wider bandwidth.

**[0015]** In one embodiment of the invention, the diaphragm is made of a layer of matrix material comprising said reinforcing material.

**[0016]** Thus, the diaphragm and the surround suspension are in one piece and made of the same matrix material which is mainly reinforced in the diaphragm, so that the diaphragm is stiffer than the surround suspension.

**[0017]** According to an advantageous characteristic of this embodiment, said ratio of reinforcing material gradually decreases over a transition zone linking said diaphragm and said surround suspension.

**[0018]** Thus, the evolution of the impedance from the diaphragm to the surround suspension is smoothed.

**[0019]** Alternatively, said ratio of reinforcing material decreases sharply in a transition zone linking said diaphragm and said surround suspension, so that the reinforcement is present only in the diaphragm.

**[0020]** In another embodiment of the invention, the diaphragm is a multilayer composite, said surround sus-

pension being an extension of at least one layer of said multilayer composite.

**[0021]** The continuity between the multilayer diaphragm and the single layer surround suspension is provided by a common layer chosen for its mechanical and damping properties.

**[0022]** According to an advantageous characteristic, said one layer is made of a layer of matrix material comprising said reinforcing material, said ratio by volume of the reinforcing material in said diaphragm to the total amount of said composite material decreasing towards said surround suspension.

**[0023]** According to one characteristic of the invention, the surround suspension is made of said matrix material without reinforcing material.

**[0024]** According to another characteristic of the invention, said surround suspension is made of a second composite material comprising said matrix material with a second reinforcing material.

**[0025]** The reinforcing material of the diaphragm and the surround suspension can be chosen independently, to satisfy the requirements of each of them.

**[0026]** Preferably, as explained above for the ratio of first reinforcing material in the diaphragm, the ratio by volume of the second reinforcing material to the total amount of said second composite material in said surround suspension gradually decreases over a transition zone linking said diaphragm and said surround suspension.

**[0027]** Consequently, the evolution of the impedance between the diaphragm and the surround suspension is smooth.

**[0028]** According to another characteristic of the invention, the ratio by volume of the second reinforcing material to the total amount of said second composite material in said surround suspension decreases sharply in a transition zone linking said diaphragm and said surround suspension.

**[0029]** In practice, the second reinforcing material is talc.

**[0030]** Talc presents good damping properties and thus improves the damping of the mechanical waves in the matrix material of the surround suspension.

**[0031]** In practice, the matrix material is made of polypropylene and the reinforcing material of said composite material of the diaphragm is chosen from carbon fibers, glass fibers and Kevlar fibers.

**[0032]** According to another aspect, the present invention also concerns a loudspeaker comprising a radiating unit according to the present invention.

**[0033]** The loudspeaker presents the same characteristics and advantages as those detailed above for the radiating unit.

**[0034]** Other particularities and advantages of the invention will also emerge from the following description.

**[0035]** In the accompanying drawings, given by way of non-limiting examples:

- Figure 1 is a view schematically illustrating a loudspeaker according to one embodiment of the invention;
- Figures 2A, 2B and 2C are partial sectional views of a radiating unit according to a first embodiment of the invention; and
- Figures 3A and 3B are partial sectional views of a radiating unit according to a second embodiment of the invention.

**[0036]** A loudspeaker implementing the general principle of the invention will be described first of all with reference to Figure 1.

**[0037]** A loudspeaker 10 with a radiating unit 11 is illustrated schematically in Figure 1.

**[0038]** As illustrated in Figure 1, the loudspeaker 10 comprises a radiating unit 11 housed into a rigid frame 12.

**[0039]** In this embodiment, the excitation means comprises a voice coil 13 adapted to move through an annular permanent magnet 14.

**[0040]** When an electrical signal is applied to the voice coil, a magnetic field is created by the electric current in the voice coil.

**[0041]** The voice coil 13 and the permanent magnet 14 interact, generating a mechanical force which causes the coil and so the attached radiating unit 11 to move back and forth and so reproduce sound under the control of the applied electrical signal coming from an amplifier.

**[0042]** In more detail, the radiating unit 11 mainly comprises a diaphragm 15.

**[0043]** As illustrated in Figure 1, the diaphragm 15 is usually manufactured with a cone or dome shaped profile.

**[0044]** In this embodiment, the diaphragm 15 is shaped as a cone with the top 15a of the cone attached to the voice coil 13.

**[0045]** The radiating unit 11 also comprises a suspension system 16, 17 adapted to keep the voice coil 13 and the diaphragm 15 centered in the gap of the permanent magnet 14.

**[0046]** Moreover, in order to protect the voice coil 13 and the magnetic system of the loudspeaker 10, a well-known dust cap 18 is provided at the top 15a of the diaphragm 15.

**[0047]** As well known by the one skilled in the art, the suspension system comprises a rear suspension called a spider 16 and a surround suspension 17 which surrounds an outer edge 15b of the diaphragm 15 at the front face 10a of the loudspeaker 10.

**[0048]** In this embodiment, the spider 16 is mounted inside the frame 12 of the loudspeaker 10 and is attached to the voice coil 13, close to the top 15a of the cone of the diaphragm 15.

**[0049]** The surround suspension 17 is adapted to be connected to the frame 12 of the loudspeaker, at the front face 10a of the loudspeaker 10.

**[0050]** Here, the surround suspension 17 extends between the frame 12 of the loudspeaker 10 and the outer

circular edge 15b of the diaphragm 15.

**[0051]** Thus, the surround suspension 17 is a ring attached to the outer circular edge 15b of the diaphragm 15.

**[0052]** In a cross section, the surround suspension 17 has a semi-circular profile with one flat edge 17a adapted to be attached to the frame 12 of the loudspeaker 10.

**[0053]** In the general principle of the invention, the surround suspension 17 is integral with the diaphragm 15.

**[0054]** The surround suspension 17 is an extension of the diaphragm 15, so that the outer circular edge 15b of the diaphragm 15 is made in one piece with the ring shape of the surround suspension 17.

**[0055]** In the present invention, the diaphragm 15 is made of composite material comprising at least a layer of matrix material and reinforcing material.

**[0056]** In the remainder of the description, a composite material encompasses a multilayer material with different layers of matrix material with or without reinforcements embedded therein, and a single layer material comprising a matrix material and a portion of reinforcements embedded therein.

**[0057]** The main principle of the present invention is to provide the surround suspension 17 as an extension of at least one layer comprising a matrix material of the diaphragm 15.

**[0058]** Since the diaphragm 15 is to be stiffer than the surround suspension 17, the reinforcing material provided for the diaphragm 15 decreases towards said surround suspension 17, that is the ratio by volume of the reinforcing material to the total amount of the composite material in the diagram decreases towards said surround suspension 17.

**[0059]** By using the same matrix material in both diaphragm 15 and surround suspension 17, the impedance in the diaphragm 15 and the surround suspension 17 can be matched.

**[0060]** Thus, the propagation of the mechanical waves from the diaphragm to the suspension means is improved, the mechanical waves being damped by the surround suspension 17 as required.

**[0061]** As a consequence the break-up modes can be damped by the surround suspension 17 as much as possible in the loudspeaker, and the frequency response function can be improved.

**[0062]** The bandwidth of the loudspeaker can thus be wider.

**[0063]** A first embodiment of the radiating unit 11 is now described with reference to Figures 2A, 2B and 2C.

**[0064]** In this first embodiment, the diaphragm 15 is made of one layer of matrix material comprising a portion of reinforcements embedded therein.

**[0065]** The composite material of the diaphragm 15 is here a single layer material with reinforcing material 21 embedded into the matrix material in order to reinforce it.

**[0066]** As known, the matrix materials surround and support the reinforcements by maintaining their relative positions.

**[0067]** The reinforcements impart their special mechanical and physical properties to enhance the matrix properties.

**[0068]** Generally, composite material uses a polymer matrix material.

**[0069]** As an example, matrix material can be made of polypropylene.

**[0070]** The reinforcements are often fibers but also can be ground minerals.

**[0071]** By way of example, the reinforcements of the matrix material of the diaphragm 15 are chosen from carbon fibers, glass fibers and Kevlar fibers.

**[0072]** The volumetric ratio of fibers in the matrix material of the diaphragm 15 depends on the target frequency range and sound power level. Determining the volumetric ratio of fibers is a process well known to persons skilled in the art.

**[0073]** In this first embodiment, the surround suspension 17 is an extension of the layer of matrix material of the diaphragm 15.

**[0074]** The volumetric ratio of reinforcements 21 embedded into the matrix material of the diaphragm 15 decreases towards the surround suspension 17.

**[0075]** As shown in the first arrangement of Figure 2A, the volumetric ratio of reinforcements 15 decreases sharply in a transition zone 20 linking the diaphragm 15 and the surround suspension 17.

**[0076]** In the arrangement illustrating in Figure 2A, the surround suspension 17 is made of a layer of the matrix material identical to the one used in the layer of the diaphragm 15.

**[0077]** Preferably, the thicknesses of the diaphragm 15 and of the surround suspension 17 are identical.

**[0078]** In this first arrangement, the surround suspension 17 is made of the matrix material without reinforcing material.

**[0079]** In this case the matrix material used in the composite material of the diaphragm should be adapted to be also used alone in the surround suspension 17.

**[0080]** For example, polypropylene is well adapted for a radiating unit used between 1200 Hz and 5000 Hz.

**[0081]** In the second arrangement illustrated in Figure 2B, the surround suspension 17 is made of a second composite material comprising the matrix material with a second reinforcing material 22.

**[0082]** Thus for the surround suspension 17, the damping properties of the matrix material can be enhanced by using appropriate reinforcements.

**[0083]** By way of example, the second reinforcing material 22 used in the matrix material of the surround suspension 17 is talc.

**[0084]** Talc material has high damping properties and is adapted to be used into the surround suspension 17.

**[0085]** The volumetric ratio of talc in the second composite material define its damping characteristics: the higher is the volumetric ratio, the higher is the damping property. Determining the volumetric ratio of talc is a process well known to persons skilled in the art.

**[0086]** In the second arrangement shown in Figure 2B,

the volumetric ratio of the second reinforcing material 22 in the second composite material of the surround suspension 17 decreases sharply in the transition zone 20 linking the diaphragm 12 and the surround suspension 17.

**[0087]** Thus, the composite materials used for each part of the radiating unit, that is for the diaphragm 15 and the surround suspension 17, have got their own properties due to the specific reinforcements used in the diaphragm 15 and the surround suspension 17.

**[0088]** In a third arrangement illustrated in Figure 2C, the volumetric ratio of the first reinforcing material21 to the composite material of the diaphragm 15 and the volumetric ratio of the second reinforcing material22 to the composite material of the surround suspension 17 gradually decrease over the transition zone 20 linking the diaphragm 15 and the surround suspension 17.

**[0089]** The transition zone 20 corresponds to the interface between the diaphragm 15 and the surround suspension 17, and more precisely, to the part constituting both the outer circular edge 15b of the diaphragm 15 and a circular edge of the ring of the surround suspension 17.

**[0090]** For example, the volumetric ratio of first reinforcing material21 in the diaphragm 15 and the volumetric ratio of second reinforcing material22 in the surround suspension 17 linearly decrease over a distance superior or equal to the thickness of the diaphragm 15.

**[0091]** Naturally, the present invention is not limited to the example arrangements described in Figures 2A, 2B and 2C.

**[0092]** In particular, the volumetric ratio of first reinforcing material21 in diaphragm 15 can gradually decrease over the transition zone 20 whereas the volumetric ratio of second reinforcing material22 of the surround suspension 17 can decrease sharply in the transition zone 20, and vice-versa.

**[0093]** A second embodiment of the present invention is now described in reference with Figures 3A and 3B.

**[0094]** In this second embodiment, the composite material used for the diaphragm 15 is a multilayer composite.

**[0095]** The multilayer composite is made of different layers of material stacked on each other.

**[0096]** Each layer can be made itself of one layer of composite material comprising matrix material and reinforcing material embedded therein, or made of one layer of a single material, such as a matrix material.

**[0097]** In this second embodiment, the surround suspension 17 is an extension of one layer of the multilayer composite of the diaphragm 15.

**[0098]** Generally speaking, said one layer of the multilayer composite used as an extension for the surround suspension 17 can be one layer of a matrix material without reinforcing material, such a matrix material being appropriate for the surround suspension 17, or can be one layer of a matrix material comprising a ratio of reinforcing material, said volumetric ratio of reinforcing material in the diagram decreasing towards the surround suspension.

**[0099]** A first arrangement of a radiating unit in a multilayer composite 30 is shown in Figure 3A.

**[0100]** In this first arrangement, the diaphragm 15 comprises, for example, four layers 31, 32, 33, 34 made of different or similar materials.

**[0101]** By way of example, the diaphragm 15 comprises a layer 33 made of an elastomer, and other layers 31, 32, 34 made of stiffer materials such as polypropylene or others.

**[0102]** In such a composite material 30, the layer 33 made of elastomer is reinforced by the other layers 31, 32, 34.

**[0103]** Since elastomer is an appropriate material for the surround suspension 17, an extension of the layer 33 of elastomer can be used for making the surround suspension 17.

**[0104]** Naturally, a layer made of a polypropylene could also be extended to be used for making the surround suspension if such a polypropylene is appropriate.

**[0105]** In this first arrangement, the surround suspension 17 is made of the elastomer without reinforcing material embedded therein.

**[0106]** Moreover, the volumetric ratio of reinforcing material, provided by the other layers 31, 32, 34 of the composite material 30, decreases towards the surround suspension 17. In this first arrangement, the other layers 31, 32, 34 sharply decrease in the transition zone 20 linking the diaphragm 15 and the surround suspension 17.

**[0107]** Naturally, the reinforcing material made of the other layers 31, 32, 34 could also gradually decreases over the transition zone 20.

**[0108]** By way of example, the thickness of the layers 31, 32, 34 other than the layer 33 which extends towards the surround suspension 17, could taper off in the transition zone 20.

**[0109]** Thus, the ratio by volume of the layers 31, 32, 33, 34 to the total amount of the composite material 30 comprising four layers 31, 32, 33, 34 decreases in the transition zone 20.

**[0110]** Preferably, the thickness of the layer 33 which extends to constitute the surround suspension 17 remains identical in the diaphragm 15 and in the surround suspension 17.

**[0111]** In a second arrangement shown in Figure 3B, the composite material 40 of the diaphragm 15 comprises for example three layers 41, 42, 43.

**[0112]** In this second arrangement, the surround suspension 17 is an extension of one layer 43 of the multilayer composite 40, said one layer 43 being made of a layer of matrix material comprising a reinforcing material 44.

**[0113]** By way of example, the diaphragm 15 is made of a sandwich composite.

**[0114]** Two layers 41, 43 called siding materials are stacked with an inner layer 42.

**[0115]** In this second arrangement, the inner layer 42 is lighter but thicker than the siding layers 41, 43. As

known in the composite material field, the inner layer 42 can be made of a honeycomb material.

**[0116]** The siding layers 41, 43 are stiffer and thinner and could be made of an elastomer material or a composite material comprising a matrix material with a reinforcing material 44 as disclosed in Figure 3B.

**[0117]** When the siding layer 43 is made of a matrix material comprising a reinforcing material 44, the surround suspension 17 is an extension of said siding layer 43 without the reinforcing material 44.

**[0118]** All the features disclosed previously in relation with the embodiment in Figures 2A, 2B and 2C can be applied to the side layer 43 made of matrix material comprising a reinforcing material 44, which extends to provide the surround suspension 17.

**[0119]** For example, the multilayer composite 40 comprises an inner layer 42 made of a honeycomb material such as NOMEX® and two siding layers 41, 43 made of a composite material. This composite material can be made of a thermoplastic polymer matrix material reinforced with carbon fibers. The volumetric ratio of carbon fibers in the matrix material can be equal to 45% about.

**[0120]** In this embodiment, the surround suspension 17 is an extension of the outer siding layer 43, in the front face of a loudspeaker comprising such a radiating unit.

**[0121]** Such a feature avoids any diffraction problems in the transition zone between the diaphragm 15 and the surround suspension 17, which would be caused by an excessive thickness of an outer siding layer in this transition zone.

**[0122]** A variety of molding methods can be performed to manufacture the radiating unit according to the present invention. Preferably, a process of injection is used.

**[0123]** Naturally the present invention is not limited to the example embodiments described above.

**[0124]** In particular, the shape of the diaphragm and the surround suspension can be modified.

**[0125]** Moreover, the excitation means of the diaphragm could be different.

**[0126]** Finally, when the diaphragm is a multilayer composite, the surround suspension can be an extension of several layers of said multilayer composite, said several layers comprising the same matrix material or different matrix materials.

## Claims

1. Radiating unit for a loudspeaker (10), comprising a diaphragm (15) and a surround suspension (17) adapted to be connected to a frame (12) of the loudspeaker (10), wherein said diaphragm (15) is made of composite material comprising reinforcing material (21, 31, 32, 34, 44) and at least one layer (15, 33, 43) of matrix material, **characterized in that** said surround suspension (17) is an extension of at least one layer (15, 33, 43) of matrix material, the ratio by volume of the reinforcing material (21, 31, 32, 34, 44) in said diaphragm (15) to the total amount of said composite material decreasing towards said surround suspension (17).

2. Radiating unit according to claim 1, **characterized in that** said diaphragm (15) is made of a layer (15) of matrix material comprising said reinforcing material (21).

3. Radiating unit according to claim 2, **characterized in that** said ratio gradually decreases over a transition zone (20) linking said diaphragm (15) and said surround suspension (17).

4. Radiating unit according to claim 2, **characterized in that** said ratio decreases sharply in a transition zone (20) linking said diaphragm (15) and said surround suspension (17).

5. Radiating unit according to claim 1, **characterized in that** said diaphragm (15) is a multilayer composite (30, 40), said surround suspension (17) being an extension of at least one layer (33, 43) of said multilayer composite (30, 40).

6. Radiating unit according to claim 5, **characterized in that** said at least one layer (43) is made of a layer of matrix material comprising said reinforcing material (44), said ratio by volume of the reinforcing material (44) in said diaphragm (15) to the total amount of said composite material decreasing towards said surround suspension (17).

7. Radiating unit according to one of claims 1 to 6, **characterized in that** said surround suspension (17) is made of said matrix material without reinforcing material.

8. Radiating unit according to one of claims 1 to 6, **characterized in that** said surround suspension (17) is made of a second composite material comprising said matrix material with a second reinforcing material (22).

9. Radiating unit according to claim 8, **characterized in that** the ratio by volume of the second reinforcing material (22) to the total amount of said second composite material in said surround suspension (17) gradually decreases over a transition zone linking said diaphragm (15) and said surround suspension (17).

10. Radiating unit according to claim 8, **characterized in that** the ratio by volume of the second reinforcing material (22) to the total amount of said second composite material in said surround suspension (17) sharply decreases in a transition zone (20) linking said diaphragm (15) and said surround suspension

(17).

**11.** Radiating unit according to one of claims 8 to 10, **characterized in that** said second reinforcing material (22) is talc.

**12.** Radiating unit according to one of claims 2 to 4, **characterized in that** said reinforcing material (21, 44) of said composite material of said diaphragm (15) is chosen from carbon fibers, glass fibers and Kevlar fibers.

**13.** Radiating unit according to one of claims 1 to 12, **characterized in that** said matrix material is made of polypropylene.

**14.** Loudspeaker, **characterized in that** it comprises a radiating unit (11) according to one of claims 1 to 13.

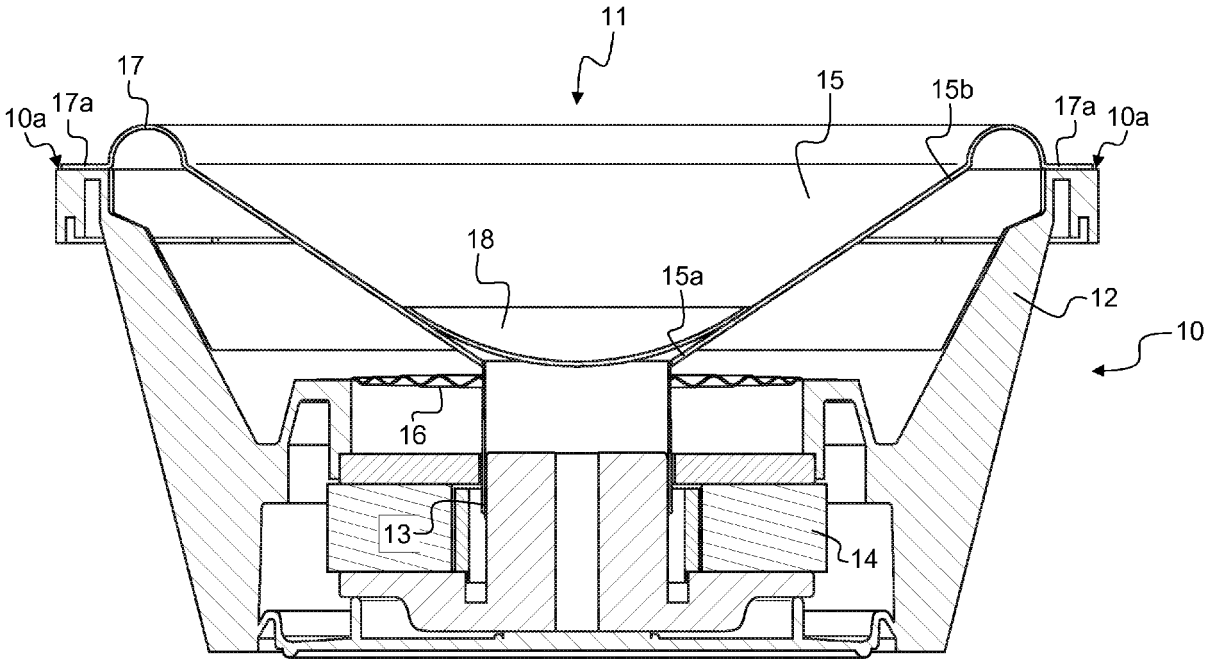


Fig. 1

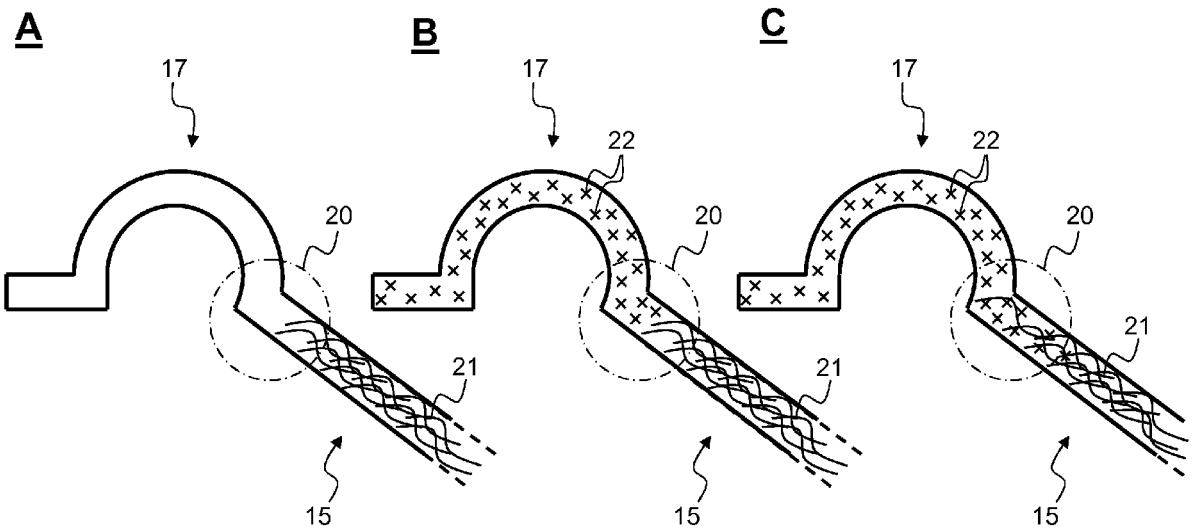


Fig. 2

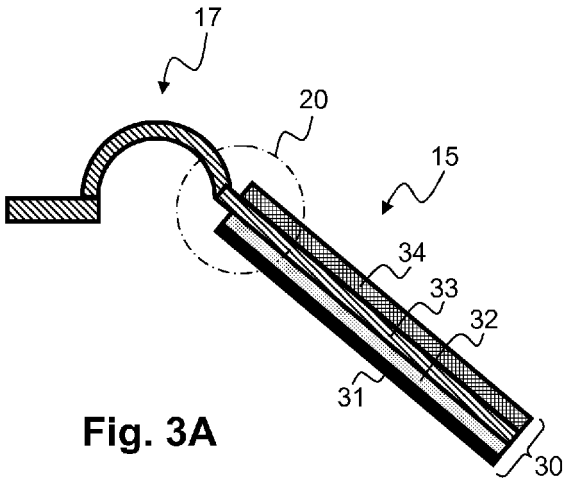


Fig. 3A

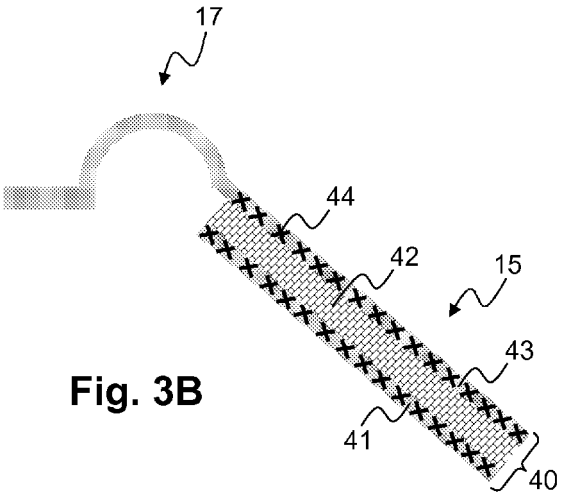


Fig. 3B

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# EUROPEAN SEARCH REPORT

Application Number
EP 09 30 5610

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|---|---|
| X | GB 2 094 701 A (MATSUSHITA ELECTRIC IND CO LTD) 22 September 1982 (1982-09-22)<br>* figure 3 *<br>* page 1, line 55 - line 86 *<br>* page 2, line 14 - line 35 *<br>* page 2, line 58 - line 97 *<br>* page 2, line 118 - line 122 *<br>* claims 8,10 * | 1-14 | INV.<br>H04R7/20 |
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| A | WO 2007/093903 A (BANG & OLUFSEN ICEPOWER AS [DK]; NIELSEN KARSTEN [DK]; HANSEN LARS BRA) 23 August 2007 (2007-08-23)<br>* figure 20 *<br>* page 11, line 24 - page 12, line 4 *<br>* page 16, line 24 - line 35 * | 1-14 | TECHNICAL FIELDS SEARCHED (IPC)<br>H04R |
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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 |
|---|---|---|
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CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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## ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 09 30 5610

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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09-10-2009

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