

(19)



(11)

EP 4 535 825 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
09.04.2025 Bulletin 2025/15

(51) International Patent Classification (IPC):
H04R 9/04 (2006.01) H04R 31/00 (2006.01)

(21) Application number: **24197342.9**

(52) Cooperative Patent Classification (CPC):
H04R 9/043; H04R 31/006; H04R 2499/13

(22) Date of filing: **29.08.2024**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL
NO PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

(72) Inventors:
• **CORSINI, Chiara**
20097 San Donato Milanese (MI) (IT)
• **VALDES, Silvio**
20097 San Donato Milanese (MI) (IT)

(74) Representative: **Rondano, Davide**
Società Italiana Brevetti S.p.A.
Via Carducci 8
20123 Milano (IT)

(30) Priority: **03.10.2023 IT 202300020403**

(71) Applicant: **Faital S.p.A.**
20097 San Donato Milanese (MI) (IT)

(54) LOUDSPEAKER WITH REDUCED HEIGHT

(57) The loudspeaker (10) comprises: a basket (14), a diaphragm (12) having a conical shape with an axis of symmetry (z), an electric coil (16), a magnetic circuit (18), a support member (20), which is connected to an inner edge of the diaphragm (12) and carries the electric coil (16), and first and second flexible suspension members (22, 24) connecting the assembly formed by the diaphragm (12), the electric coil (16) and the support member (20) to the basket (14), in such a manner that the electric coil (16) is constrained to move parallel to said axis of symmetry (z) through a cylindrical air gap (26) of the magnetic circuit (16). The first flexible suspension member (22) is connected at its inner edge to an upper, or wider, end (12a) of the diaphragm (12) and at its outer edge to an upper portion (14a) of the basket (14), while the second flexible suspension member (24) is connected at its inner edge to a mounting member (28), which is arranged around the support member (20) and is attached at its upper end to the diaphragm (12), and at its outer edge to a lower portion (14b) of the basket (14).

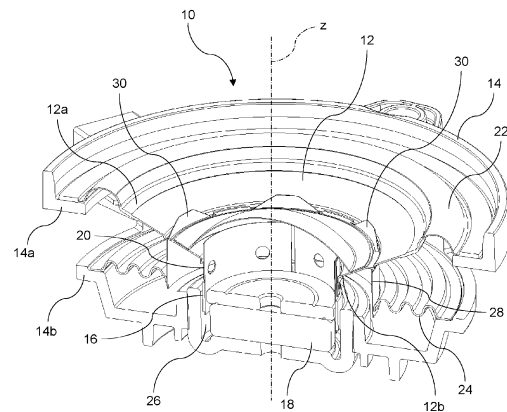


FIG. 1

EP 4 535 825 A1

Description

Technical field of the invention

[0001] The present invention generally relates to an electrodynamic loudspeaker (hereinafter simply referred to as loudspeaker), to be used in particular, although not exclusively, in passenger compartments of motor-vehicles.

State of the art

[0002] As it is known, a loudspeaker basically comprises a diaphragm (or cone) having a conical shape, a rigid basket (or frame), an electric coil (normally referred to as voice coil) and a magnetic circuit. The diaphragm is connected at its upper end (wider end) to an upper portion of the basket via a first flexible suspension member, typically called surround, and at its lower end (narrower end) to a voice coil support member supporting the voice coil. Furthermore, the voice coil support member is connected to a lower portion of the basket via a second flexible suspension member, typically called spider. The voice coil is constrained, by virtue of the connection of the diaphragm and of the support member with the basket via the above-mentioned first and second flexible suspension members, respectively, to move axially through a cylindrical air gap of the magnetic circuit. In a conventional loudspeaker, therefore, the diaphragm and the voice coil support member, with the voice coil attached thereto, form a suspended (or movable) part of the loudspeaker which is connected to the non-suspended (or stationary) part of the loudspeaker, namely to the basket, via the first and second flexible suspension members.

[0003] When an electrical current is applied to the voice coil, the interaction between the electric current in the voice coil and the magnetic field in the air gap generates a mechanical force that moves the voice coil axially through the air gap and, thus, the voice coil support member and the diaphragm attached thereto. Application of alternating electric current in the voice coil under control of an amplifier causes therefore the diaphragm to move back and forth, thereby reproducing sound.

[0004] Recently, sound systems in motor-vehicles have been changing their configuration in order to create 3D sound zones. An increasing number of loudspeakers are therefore placed in several positions within the passenger compartment of the vehicle, not only in the doors and dashboard, but also in the headrests and the roof. This requires more compact loudspeakers, in particular loudspeakers with reduced height (or depth), i.e. with a reduced size in the direction parallel to the sound waves propagation.

[0005] In order to reduce the overall height of the loudspeaker, WO2005/015950A1 teaches to provide the loudspeaker with a diaphragm having a reduced height, while including radial folds to assure acoustic

performance at mid to low frequency. However, this solution greatly reduces the space available for the magnetic circuit and therefore required the use of expensive magnet materials to reduce the volume of the magnetic circuit while keeping the same speaker efficiency.

[0006] US10820111 B2 discloses a loudspeaker which is made more compact by removal of the second flexible suspension member, i.e. the spider. According to this solution, therefore, the loudspeaker only has the first flexible suspension member, i.e. the surround, by means of which the diaphragm is connected at its wider end to the upper portion of the basket. However, this solution is only suitable for tweeter-type loudspeakers, as the absence of the second flexible suspension member limits the dynamic behaviour of the loudspeaker at mid to low frequency (e.g., less movement control at high excursions and more destructive rocking modes).

[0007] FR3024630A1 discloses a loudspeaker with a membrane comprising: a dome lying on a base surrounding the voice coil, a diaphragm extending radially from the base, and a plurality of folds on the diaphragm. The dome base allows to move the dome towards the peripheral edge of the membrane, to create a larger volume beneath the dome. At the same time, for a similar height of the diaphragm, this solution allows to reduce the height of the membrane. However, having a larger volume under the dome implies having a dome which is substantially flat, which limits the performance of the loudspeaker at high frequency, unless stiff and heavy materials are used. Moreover, the presence of folds on the diaphragm are necessary to guarantee proper dynamic behaviour of the membrane at low frequency.

[0008] Therefore, known compact loudspeakers either have a depth which does not fit the available space in the prescribed positions within the vehicle passenger compartments, or do not ensure the same acoustics on a broad frequency range at the same cost.

[0009] A loudspeaker having the features set forth in the preamble of independent claim 1 is known from US2007/121995A1.

Summary of the invention

[0010] It is an object of the present invention to provide a loudspeaker which combines reduced height (or depth) with good acoustic performances on a broad frequency range.

[0011] This and other objects are fully achieved according to the invention by virtue of a loudspeaker having the features set forth in independent claim 1.

[0012] Further advantageous features of the invention are defined in the dependent claims, whose subject-matter is intended to form an integral part of the following description.

[0013] In short, the invention is based on the idea of providing, in a loudspeaker having a suspended part which comprises a cone-shaped diaphragm and a voice coil support member and is connected to the basket via

first and second flexible suspension members, an annular mounting member which is arranged around the voice coil support member and is attached at its upper end to the diaphragm, and connecting the second flexible suspension member at its inner edge to the mounting member and at its outer edge to the basket. The second flexible suspension member is thus connected at its inner edge not to the voice coil support member, but to a mounting member which is arranged around the voice coil support member and has therefore a diameter larger than that of the voice coil support member.

[0014] This solution allows to reduce the height of the loudspeaker, while assuring good control of the movement of the voice coil at low frequencies and guaranteeing the same speaker efficiency. Moreover, this solution does not involve a reduction in the space available for the magnetic circuit and therefore does not involve an increase in the cost of the magnetic circuit.

[0015] Additionally, the mounting member has a crelated structure at its top, forming a plurality of protrusions configured to be inserted into corresponding slits provided in the diaphragm so as to ensure better positioning and connection of the mounting member and the diaphragm.

[0016] The mounting member may be attached to the diaphragm in various ways, for example by adhesion means such as glue.

[0017] According to an embodiment, the mounting member is made in one piece with the second flexible suspension member.

[0018] Further features and advantages of the invention will be evident to those skilled in the art from the following detailed description, given purely by way of non-limiting example.

Brief description of the drawings

[0019] In the following detailed description reference will be made to the appended drawings, where:

- Figure 1 is a perspective view of a loudspeaker according to an embodiment of the present invention, where the loudspeaker is cut through a plane passing through the axis of symmetry of the diaphragm;
- Figure 2 is an axial section view of the loudspeaker of Figure 1;
- Figures 3 to 5 are axial section views of loudspeakers according to further embodiments of the present invention; and
- Figure 6 shows a comparison between the loudspeaker of Figure 1 and a loudspeaker according to the prior art.

Detailed description

[0020] With reference first to Figure 1, a loudspeaker according to an embodiment of the present invention is generally indicated with 10 and basically comprises a diaphragm 12, a rigid basket 14, an electric coil 16 (commonly referred to as voice coil and therefore indicated hereinafter with this term), a magnetic circuit 18 and a voice coil support member 20.

[0021] The diaphragm 12 has a conical shape with an upper end (wider end) 12a and a lower end (narrower end) 12b. The axis of symmetry of the diaphragm 12, which is indicated z, defines the direction of propagation of the sound waves generated by the loudspeaker 10. In the drawings the loudspeaker 10 is always shown with the axis of symmetry z extending vertically, and terms such as "upper" or "lower" are used with reference to this particular orientation of the loudspeaker. However, the loudspeaker 10 may be used with any orientation, and therefore the axis of symmetry z may extend in any direction other than the vertical one, even in the horizontal direction.

[0022] The voice coil support member 20 is connected to the lower end 12b of the diaphragm 12 and supports the voice coil 16, so that the voice coil support member 20 and the voice coil 16 are movable as a single piece with respect to the magnetic circuit 18 and the basket 14.

[0023] The diaphragm 12, the voice coil 16 and the voice coil support member 20 form a suspended (or movable) part of the loudspeaker 10, while the basket 14 and the magnetic circuit 18 form a non-suspended (or stationary) part of the loudspeaker 10. The suspended part and the non-suspended part of the loudspeaker 10 are connected to each other via a first flexible suspension member 22 and a second flexible suspension member 24, which suspension members are configured in such a manner as to constrain the voice coil 16, carried by the voice coil support member 20, to move axially (i.e., parallel to the axis of symmetry z) through a cylindrical air gap 26 of the magnetic circuit 16. The first and second flexible suspension members 22 and 24 may be made of any suitable material, for example fabric, rubber or foam.

[0024] The first flexible suspension member 22 connects the upper end 12a of the diaphragm 12 with the basket 14, in particular with an upper portion 14a thereof.

[0025] As regards the second flexible suspension member 24, it is not connected at its inner edge to the voice coil support member 20, as it is the case with the prior art discussed in the introductory part of the present description, but to an annular mounting member 28 which is arranged around the voice coil support member 20 (and has, therefore, a diameter larger than that of the voice coil support member 20) and is attached at its upper end to the diaphragm 12. The second flexible suspension member 24 is thus connected at its inner edge to the mounting member 28, in particular to a lower end thereof, and at its outer edge to the basket 14, in particular to a lower portion 14b thereof.

[0026] The mounting member 28 may be made for example of aluminium or polymeric material, such as polyimide.

[0027] The mounting member 28 is made as a separate piece with respect to the diaphragm 12.

[0028] In the embodiment of Figures 1 and 2, the mounting member 28 is a separate piece not only with respect to the diaphragm 12, but also with respect to the second flexible suspension member 24. The mounting member 28 is thus attached both to the diaphragm 12 and to the second flexible suspension member 24 using suitable means, for example by gluing. Furthermore, the mounting member 28 has at its top a crenelated structure, thereby forming a plurality of protrusions 30, spaced apart from each other, configured to be inserted into corresponding slits 32 provided in the diaphragm 12 so as to ensure better positioning and connection of the mounting member 28 and the diaphragm 12.

[0029] With reference now to Figure 3, where parts and elements identical or corresponding to those of Figures 1 and 2 have been indicated with the same reference numerals, according to a further embodiment of the present invention the mounting member 28 has a plurality of inclined upper tabs 28a (better shown in the detail A), each of which is arranged between a respective pair of adjacent protrusions (not shown in Figure 3, but similar to the protrusions 30 of Figures 1 and 2) of the mounting member 28 and extends parallel to the diaphragm 12. This allows to enlarge the adhesion area between the mounting member 28 and the diaphragm 12 and thus strengthen the connection between these two components. The upper tabs 28a are shown in Figure 3 as extending outwards, i.e., as facing the upper or wider end 12a of the diaphragm 12, but might also be configured so as to extend inwards, i.e., facing the lower or narrower end 12b of the diaphragm 12.

[0030] Figure 4, where parts and elements identical or corresponding to those of Figures 1 to 3 have been indicated with the same reference numerals, shows another embodiment of the present invention, in which the mounting member 28 is formed in one piece with the second flexible suspension member 24. Also in this case, as in the embodiment of Figure 3, the mounting member 28 has a plurality of inclined upper tabs 28a, each interposed between a respective pair of adjacent protrusions (not shown in Figure 4, but similar to the protrusions 30 of Figures 1 and 2) of the mounting member 28. In this embodiment the inclined upper tabs 28a extend inwards, i.e., towards the lower or narrower end 12b of the diaphragm 12.

[0031] Additionally, Figure 5, where parts and elements identical or corresponding to those of Figures 1 to 4 have been indicated with the same reference numerals, shows another embodiment of the present invention, which is similar to the embodiment of Figure 4, in that the mounting member 28 is still formed in one piece with the second flexible suspension member 24 and has a plurality of inclined upper tabs 28a extending inwards, i.e.,

towards the lower or narrower end 12b of the diaphragm 12, and each interposed between a respective pair of adjacent protrusions (not shown in Figure 4, but similar to the protrusions 30 of Figures 1 and 2) of the mounting member 28. The difference between the embodiment of Figure 4 and the one of Figure 5 is that in this latter the mounting member 28 is attached with its inclined upper tabs 28a not only to the diaphragm 12 but also to the voice coil support member 20.

[0032] Finally, Figure 6 shows the loudspeaker 10 of Figures 1 and 2 compared to a loudspeaker 110 according to the prior art. In Figure 6 parts and elements of the loudspeaker 110 of the prior art identical or corresponding to those of the loudspeaker 10 of the invention are indicated with the same reference numerals, increased by 100. The two loudspeakers 10 and 110 have the same basket (and hence the same nominal diameter D), the same diaphragm, the same magnetic circuit, the same vertical distance d between the outer edge of the first flexible suspension member and the outer edge of the second flexible suspension member, as well as the same maximum travel t_{MAX} of the voice coil (which in the loudspeaker 10 corresponds to the vertical distance between the lower end 12b of the diaphragm 12 and the upper end of the magnetic circuit 18, while in the loudspeaker 110 corresponds to the vertical distance between the lower end of the second flexible suspension member 124 and the upper end of the magnetic circuit 118). It is clear from the comparison between the two loudspeakers 10 and 110 that the loudspeaker 10 (i.e., the loudspeaker of the invention) has a voice coil support member 20 with reduced height compared to the voice coil support member 120 of the loudspeaker 110 of the prior art. This allows to reduce the overall height of the loudspeaker (indicated with H for the loudspeaker of the prior art and with h for the loudspeaker of the invention), and hence to obtain a loudspeaker which is more compact in the axial direction (i.e., in the direction of propagation of the sound waves generated by the loudspeaker).

[0033] The present invention has been described herein with reference to preferred embodiments thereof. It is however clear that other embodiments may be envisaged, which share with the one disclosed herein the same inventive core, as defined by the appended claims.

Claims

1. Loudspeaker (10) comprising:

- a basket (14),
- a diaphragm (12) having a conical shape with an axis of symmetry (z),
- an electric coil (16),
- a magnetic circuit (18),
- a support member (20), which is connected to an inner edge of the diaphragm (12) and carries the electric coil (16),

- a mounting member (28) which is arranged around the support member (20) and is attached at an upper end thereof to the diaphragm (12), said mounting member (28) being a piece separate from the diaphragm (12), and 5

- first and second flexible suspension members (22, 24) connecting the assembly formed by the diaphragm (12), the electric coil (16) and the support member (20) to the basket (14), in such a manner that the electric coil (16) is constrained to move parallel to said axis of symmetry (z) through a cylindrical air gap (26) of the magnetic circuit (16), 10

wherein said first flexible suspension member (22) is connected at an inner edge thereof to an upper, or wider, end (12a) of the diaphragm (12) and at an outer edge thereof to an upper portion (14a) of the basket (14), and 15

wherein said second flexible suspension member (24) is connected at an inner edge thereof to the mounting member (28) and at an outer edge thereof to a lower portion (14b) of the basket (14), 20

characterized in that the mounting member (28) has a crenelated structure at its upper end, with a plurality of protrusions (30) inserted into corresponding slits (32) provided in the diaphragm (12). 25

2. Loudspeaker according to claim 1, wherein the mounting member (28) is attached to the diaphragm (12) by adhesion means, in particular glue. 30
3. Loudspeaker according to claim 1 or claim 2, wherein the mounting member (28) has a plurality of inclined upper tabs (28a), each of which is arranged between a corresponding pair of said protrusions (30) and extends parallel to the diaphragm (12) so as to enlarge an adhesion area between the mounting member (28) and the diaphragm (12). 35 40
4. Loudspeaker according to any one of the preceding claims, wherein the mounting member (28) is made in one piece with said second flexible suspension member (24). 45
5. Loudspeaker according to claim 4, wherein the mounting member (28) is also attached to the support member (20). 50

50

55

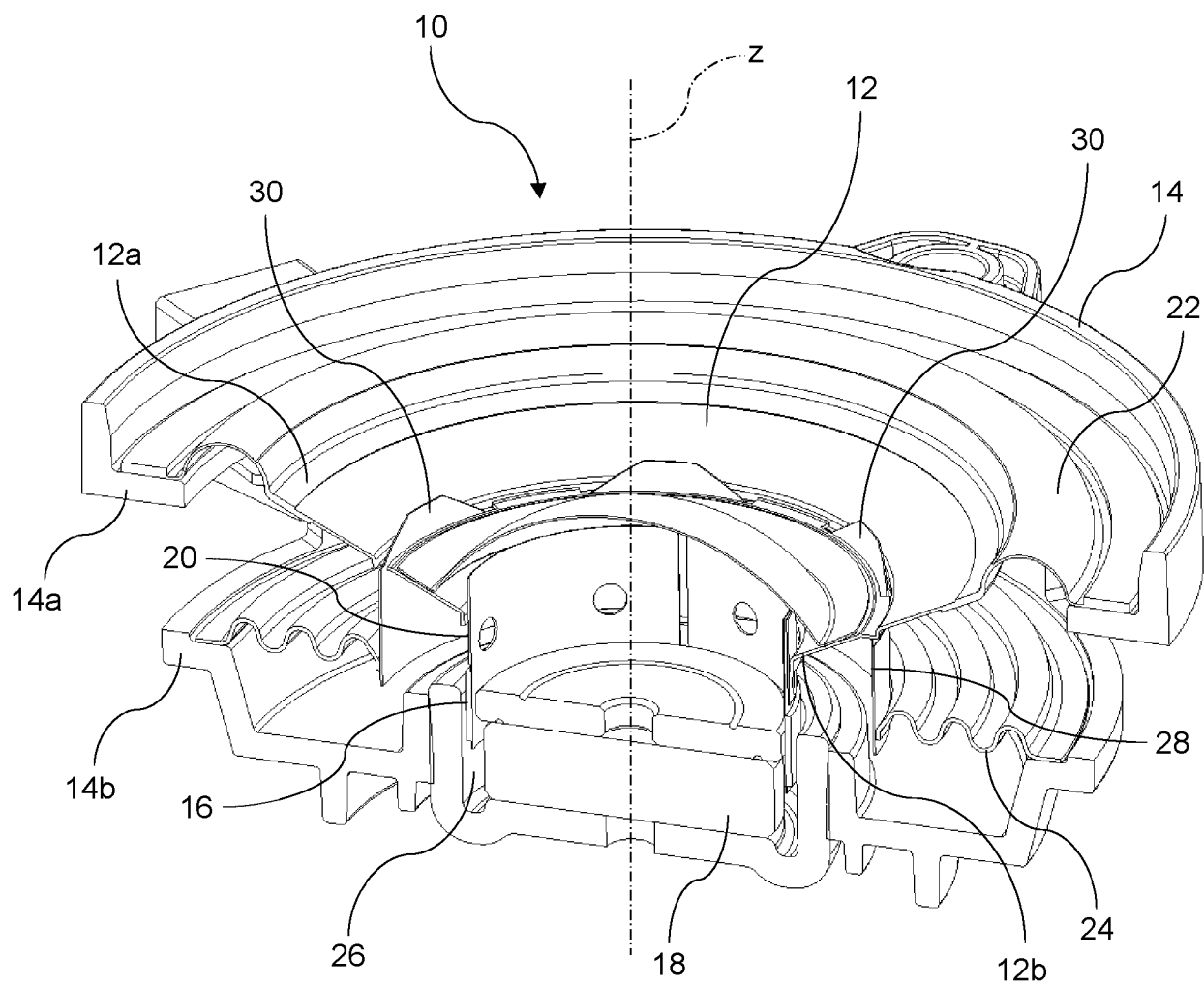
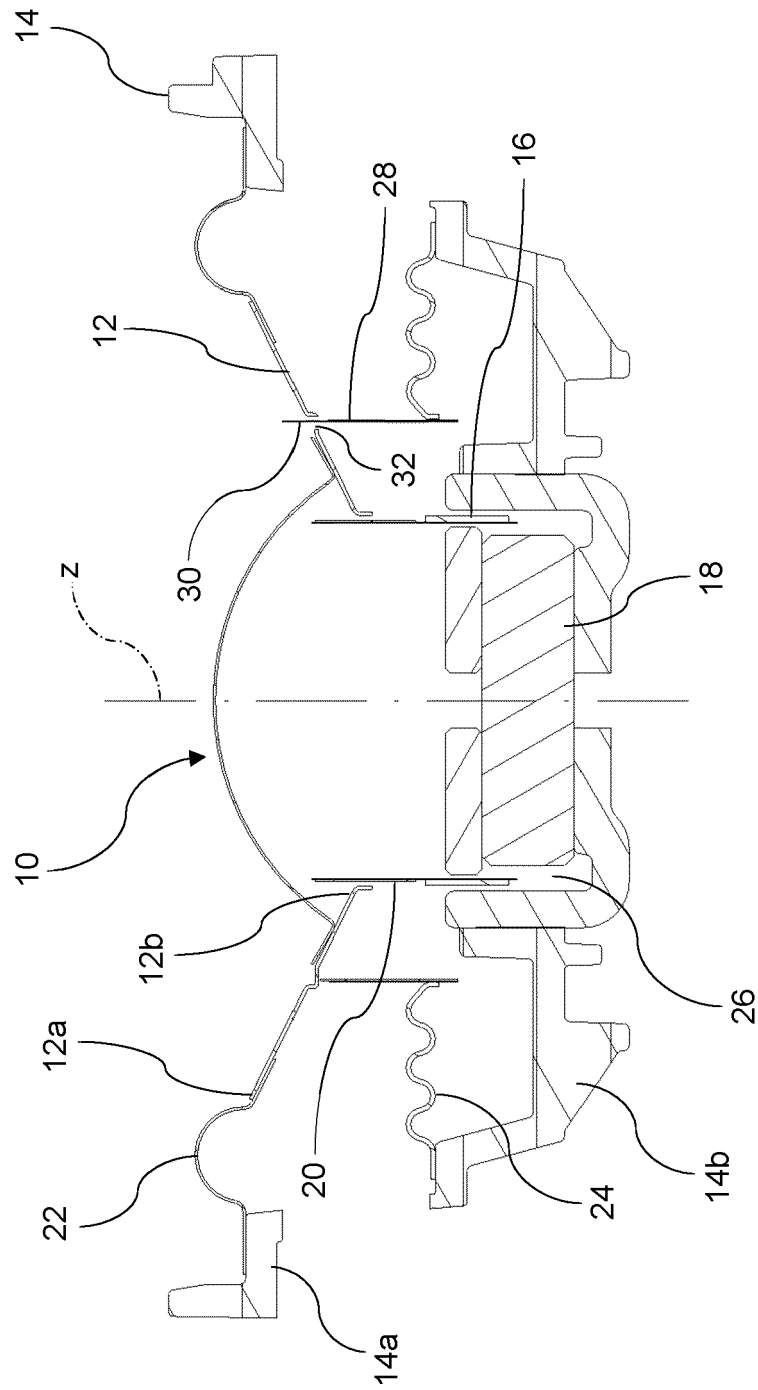


FIG.1



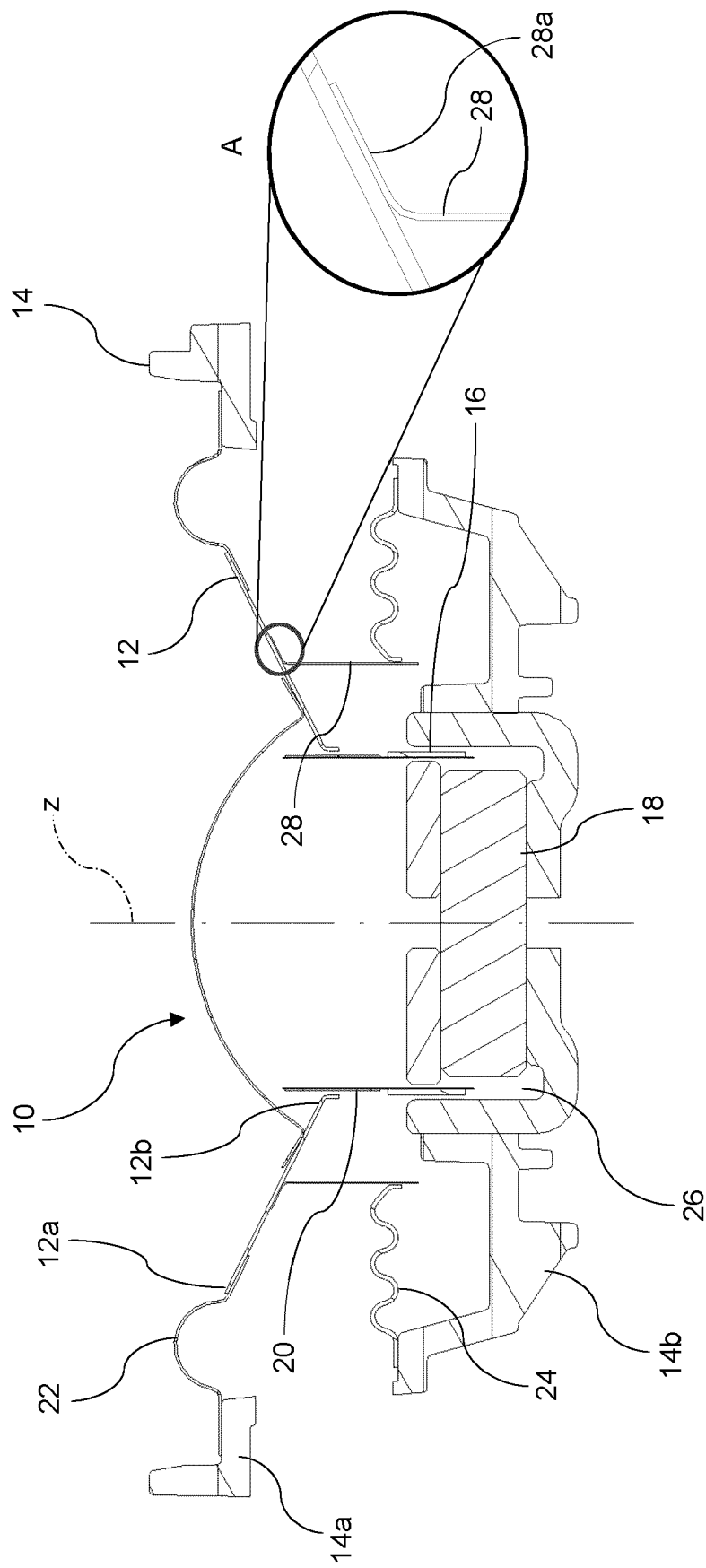


FIG.3

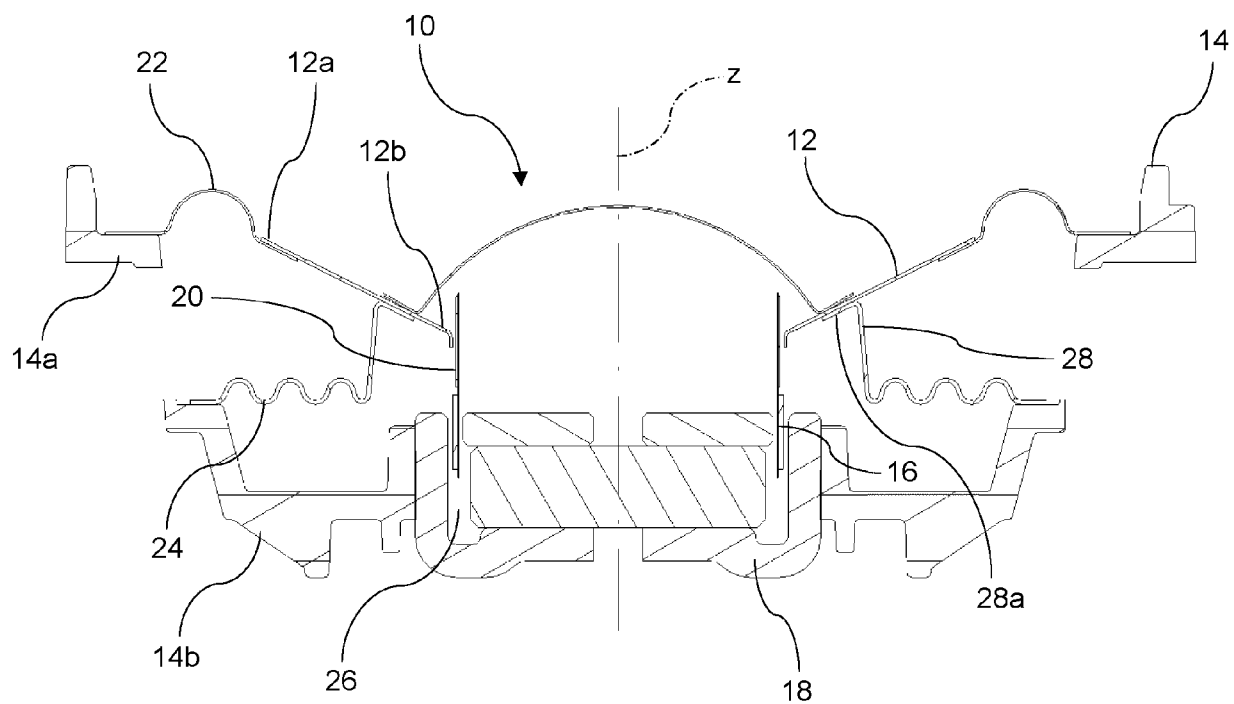


FIG.4

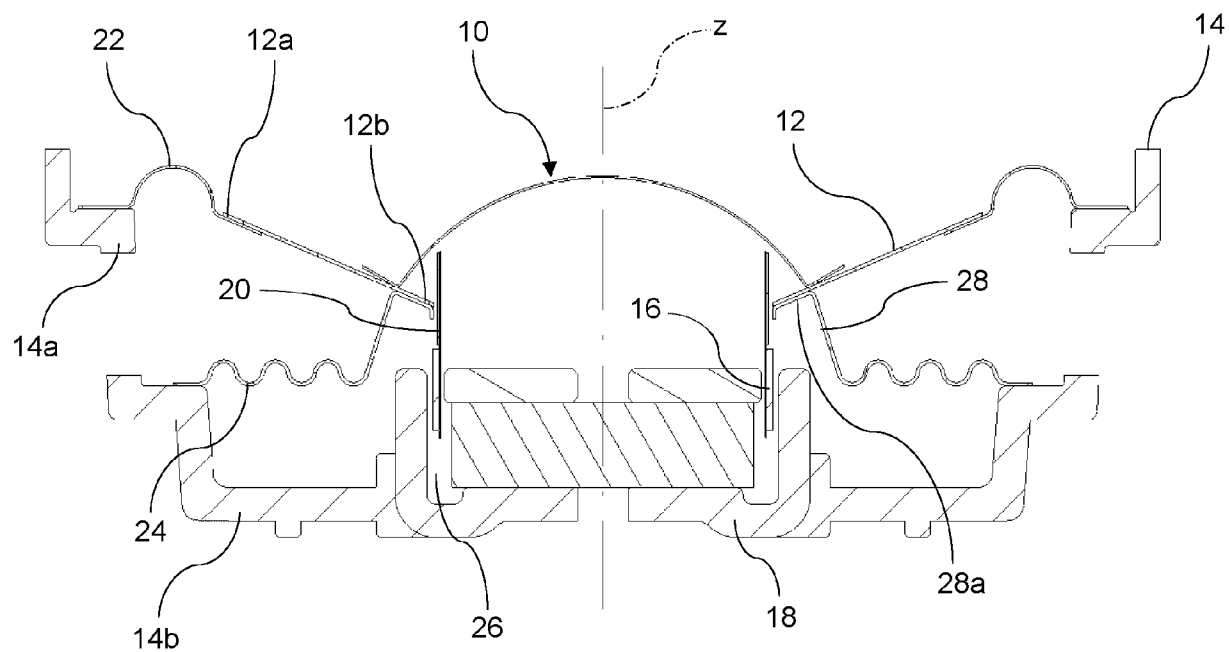


FIG.5

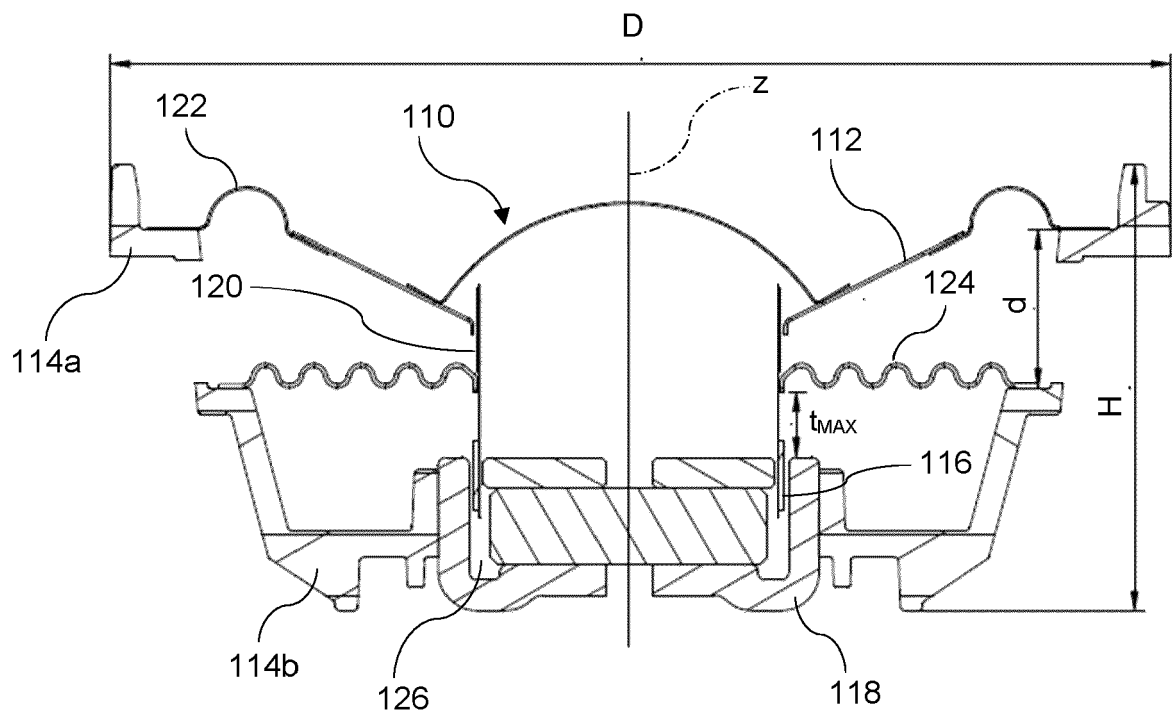
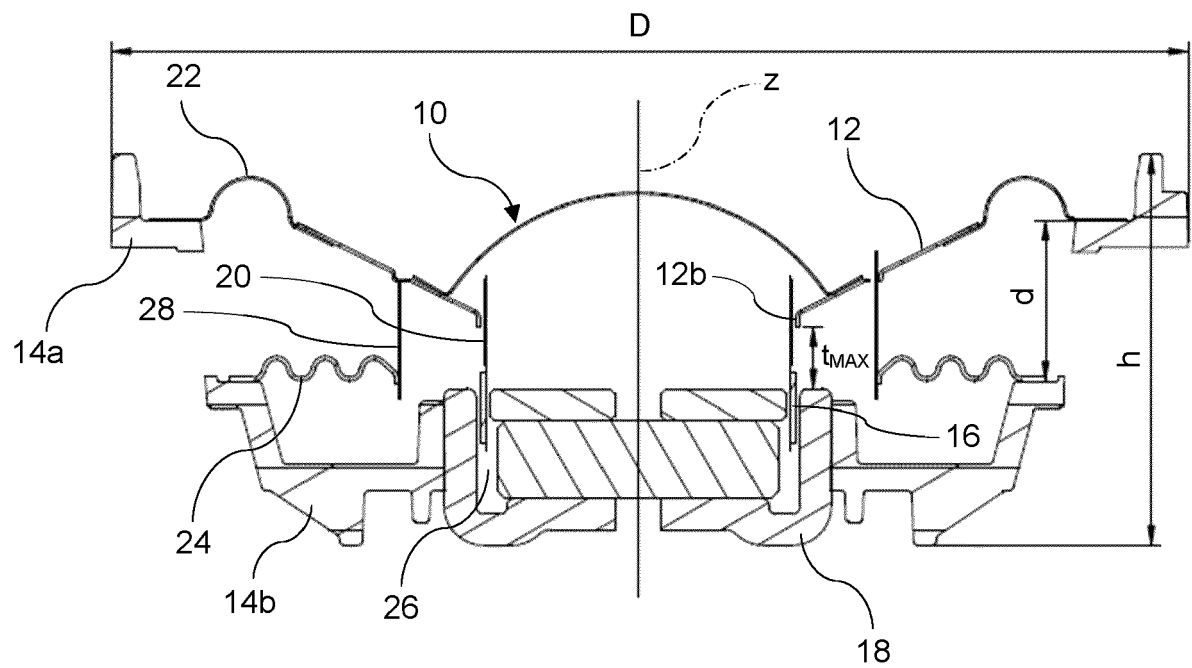


FIG.6



EUROPEAN SEARCH REPORT

Application Number

EP 24 19 7342

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2007/121995 A1 (FUNAHASHI OSAMU [JP] ET AL) 31 May 2007 (2007-05-31) * paragraphs [0012] - [0061]; figure 1 *	1-5	INV. H04R9/04 H04R31/00
A	EP 0 912 072 A1 (PRONI LUCIO [US]) 28 April 1999 (1999-04-28) * paragraphs [0028] - [0035]; figures 2,3 *	1-5	
A	US 2006/177091 A1 (FUNAHASHI OSAMU [JP]) 10 August 2006 (2006-08-10) * paragraphs [0002], [0027] - [0039]; figures 1-5 *	1-5	
A	FR 3 024 630 A1 (FOCAL JMLAB [FR]) 5 February 2016 (2016-02-05) * page 7, line 5 - page 8, line 26; figures 2,3 *	1-5	
			TECHNICAL FIELDS SEARCHED (IPC)
			H04R
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
Munich		31 January 2025	Righetti, Marco
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			
T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 24 19 7342

5

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
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

31-01-2025

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2007121995 A1	31-05-2007	CN 1930912 A	14-03-2007
		EP 1691571 A1	16-08-2006
		JP WO2006064725 A1	12-06-2008
		KR 20070047233 A	04-05-2007
		US 2007121995 A1	31-05-2007
		WO 2006064725 A1	22-06-2006

EP 0912072 A1	28-04-1999	DE 69733758 T2	30-03-2006
		EP 0912072 A1	28-04-1999

US 2006177091 A1	10-08-2006	CN 1765152 A	26-04-2006
		EP 1608203 A1	21-12-2005
		JP 2005252922 A	15-09-2005
		US 2006177091 A1	10-08-2006
		WO 2005086529 A1	15-09-2005

FR 3024630 A1	05-02-2016	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO 2005015950 A1 [0005]
- US 10820111 B2 [0006]
- FR 3024630 A1 [0007]
- US 2007121995 A1 [0009]