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Amended claims in accordance with Rule 137(2) EPC.

(54) **LOUDSPEAKER APPARATUS**

(57) Loudspeaker apparatus (10) for emitting high and low frequency sound waves, comprising: at least one membrane element (12) for generating sound waves, said membrane element (12) being adapted to simultaneously generate sound waves in a first frequency range and in a second frequency range; at least one voice coil/magnet assembly (14, 15) adapted for operatively engaging with the membrane element (12) such that the membrane element (12) is drivable by the voice coil/magnet assembly (14, 15) in the first frequency range to generate sound waves in the first frequency range; and at least one piezoelectric layer or element (17) being arranged at the membrane element (12) in such a way that the membrane element (12) is drivable by the piezoelectric layer or element (17) in the second frequency range in order to generate sound waves in the second frequency range.

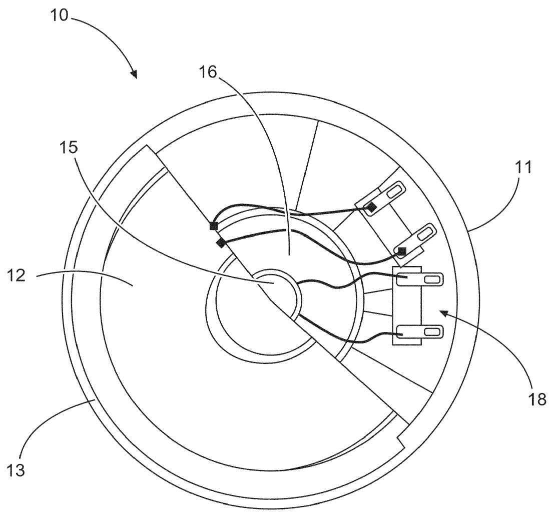

Fig. 1

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to loudspeaker apparatus for emitting high and low frequency sound waves, a vehicle door comprising such a loudspeaker apparatus, a use of a piezoelectric layer/element in such a loudspeaker apparatus and a vehicle comprising such a loudspeaker apparatus.

BACKGROUND ART

[0002] In the prior art, loudspeakers are known in a variety of different designs and for a wide range of different applications, wherein it is often the case that several loudspeakers, which emit sound waves in different frequency ranges, are used in one application. For example, in a typical car installation, it is known to use different loudspeakers, also called drivers, covering different or slightly overlapping frequency ranges. In such a typical example, a small driver for the high frequencies, e.g. over 3 kHz, which is called the tweeter, a midrange driver for midrange frequencies, e.g. between 200 Hz and 3 kHz, a woofer for low frequencies, e.g. between 50 Hz and 200 Hz, and a sub-woofer for very low frequencies, e.g. below 50 Hz, are used. One important objective in such a car installation is to mount the midrange driver and the tweeter as high as possible, targeting the height of a listener hears. Moreover, due to the wavelength difference between midrange frequencies and high frequencies, it is needed to keep the tweeter and the midrange loudspeakers fairly close to each other. If positioned too far apart, the phase relationship result may cause the midrange driver and the tweeter transducers to be perceived as two independent, and potentially delayed, audio sources.

SUMMARY

[0003] In view of this, it is found that a further need exists to provide a loudspeaker apparatus/system to prevent that in particular the midrange driver and the tweeter are perceived as two different audio sources.

[0004] In the view of the above, it is an object of the present invention to provide a loudspeaker apparatus/system to prevent that in particular a midrange driver and a tweeter are perceived as two different audio sources.

[0005] These and other objects, which become apparent upon reading the following description, are solved by the subject matter of the independent claims. The dependent claims refer to preferred embodiments of the invention.

[0006] According to a first aspect, a loudspeaker apparatus for emitting high and low frequency sound waves is provided, comprising: at least one membrane element for generating sound waves, said membrane element being adapted to simultaneously generate sound waves in a first frequency range and in a second frequency range; at least one voice coil/magnet assembly operatively engaged with the membrane element such that the membrane element is drivable by the voice coil/magnet assembly in the first frequency range to generate sound waves in the first frequency range; and at least one piezoelectric layer or element arranged at the membrane element in such a way that the membrane element is drivable by the piezoelectric layer or element in the second frequency range in order to generate sound waves in the second frequency range.

[0007] In other words, the present disclosure proposes to use one membrane/diaphragm element for generating sound waves in two frequency ranges. In a first frequency range, e.g. midrange frequencies, the membrane element can be moved by the at least one voice coil/magnet assembly back-and-forth and in a second frequency range, e.g. high frequencies, the surface of the membrane can be brought into movement/vibration by the at least one piezoelectric layer or element. This allows a superimposed movement of the membrane element, which can emit sound waves in two frequency ranges. In this context, it should be noted that the term membrane or diaphragm element is to be understood in a broad manner and includes any element capable of being moved back-and-forth by a voice coil/magnet assembly on the one hand and of being set in vibration by a piezoelectric element on the other. Furthermore, the present disclosure is also not limited to a specific first and second frequency range. Rather, a wide variety of frequency ranges can be made available in different configurations/implementations. Finally, also the term piezoelectric layer or element is to be understood broadly and includes designs with separate/adhered piezoelectric layers as well as designs where the piezoelectric layer is incorporated into the membrane element. In addition, this term also includes plane designs, as well as designs with individual/separate piezoelectric elements, as long as the piezoelectric layer/element is capable of causing the membrane element to vibrate in order to emit sound in the second frequency range.

[0008] In an example, the voice coil immerse in a magnet field may drive the membrane element back-and-forth enabling sound generation in the first frequency range. In addition, the membrane element may comprise a piezoelectric element that receives an electrical pulse, and then applies directional force to an opposing membrane surface, causing it to move in the desired direction. Thus, motion may be generated when the piezoelectric element moves against the membrane surface enabling sound generation in the second frequency range.

[0009] By means of such a loudspeaker apparatus, an exceptionally wide operating range can be provided. It may cover a range from 200 Hz up to 24 kHz, i.e. almost seven octaves. This extremely wide range may be achieved by the use of the two modes of sound generation, i.e. by means of a pistonic movement, where the membrane element or a driver cone moves back and forward like the piston in a car engine and by means of a modal radiation, where the vibrating piezoelectric material creates areas of excitation on the membrane surface. Thereby, a full-range sound reproduction in audio applications can be provided with a reduced number of loudspeakers needed, and widens the operational bandwidth of the loudspeaker, by virtue of a configuration that combines, in the same membrane element, the piston movement driven by a voice coil/magnet assembly and the induced vibration from a piezoelectric element.

[0010] Furthermore, the solution described in the present disclosure may enable sound from two excitation mechanisms to come from one sound source. This characteristic allows a synchronized summation of the sound sources than physically separated drivers. As well, the pattern of response is symmetric around the axis of the loudspeaker apparatus.

[0011] In an implementation, the first frequency range may be between 200 Hz and 3 kHz and the second frequency range is between 3 kHz and 24 kHz. In other words, in such an implementation the loudspeaker apparatus includes a midrange driver and a tweeter in one audio source.

[0012] In an implementation, the loudspeaker apparatus may further comprise at least one crossover circuit. In an example, the crossover frequency of the crossover circuit being at 3 kHz. As the different drivers work with different frequency ranges, individual audio channels or a crossover network of filters may be used to route the different frequency ranges to the appropriate driver.

[0013] In an alternative implementation, the loudspeaker apparatus may not comprise a crossover circuit, wherein both drives of the membrane element may be caused by the same audio signal. Such an implementation is possible since the piezoelectric membrane is resistant to overloads that would normally destroy most high frequency drivers. Due to their electrical properties, piezoelectric membranes are already a capacitive load and can be used without a crossover. Therefore, a loudspeaker apparatus with the piezoelectric membrane may be driven by individual audio channels or by only one audio channel with or without an existing passive crossover network.

[0014] In an implementation, the membrane element may be arranged conically. In an alternative implementation, the membrane element may be arranged as a flat plane. In this context, it should be noted that the present disclosure is not limited to a certain geometry of the membrane element as long as it can be operated/moved in the two modes mentioned.

[0015] In an implementation, the piezoelectric layer or element may be formed as a composite structure, comprising or is composed of: a top support layer; an electrode layer; a piezoelectric layer; an electrode layer; and a bottom carrier layer. In an implementation, the piezoelectric layer may be formed as a composite structure, comprising or may be composed of: at least one epoxy resin matrix and piezo-ceramic fibers embedded therein. In a further implementation, the piezoelectric layer or element may comprise piezo-ceramic fibers with two different angles of orientation, which may be arranged with an angle difference of 90° DEG to one another.

[0016] In an example, a piezoelectric ceramic may be adhered to an aluminum, paper, plastic or carbon fiber membrane element. However, lighter membrane elements with higher Young's modulus with good internal loss are desired. Notably, a lightweight and stiff membrane element may increase the efficiency of the mechanical moment conversion into sound. Good internal loss or damping creates a distributed breakup with smaller peaks in the frequency response and ultimately smoother and more natural sound without harshness.

[0017] The coverage area of the piezo ceramic material may vary from small piezo ceramic patches up to a full coverage layer of piezo ceramic adhered to the membrane element. Piezoelectric sound components comprise piezoelectric membranes to amplify the sound radiation. This is a structure in which a piezoelectric ceramic is adhered to a plate made of metal, brass, nickel-alloy or any other structural material substrate. A piezoelectric loudspeaker, also known as a piezo bender due to its mode of operation, and sometimes colloquially called a "piezo", buzzer, crystal loudspeaker or beep speaker, for instance, is a loudspeaker that uses the piezoelectric effect for generating sound. The initial mechanical motion is created by applying a voltage to a piezoelectric material, and this motion is typically converted into audible sound using membranes and resonators. Compared to other loudspeaker designs piezoelectric speakers are relatively easy to drive. For example, they can be connected directly to TTL (Transistor-Transistor Logic) outputs, although more complex drivers can give greater sound intensity. Typically, they operate well in the range of 1 to 5 kHz and up to 100 kHz in ultrasound applications. In an example, the membrane/diaphragm is provided of piezoelectric fiber composites receiving an electrical pulse thought etched interlinear electrodes, and then applies directional force to the opposing host composite material plies, causing it to move in the desired direction. In such an example, motion may be generated when the piezoelectric element moves against the host composite material, thus enabling sound generation.

[0018] In an example, the membrane element may also be made of Macro Fiber Composite (MFC). The MFC can also be applied, normally bonded, as a thin, surface-conformable sheet to various types of membrane elements, or embedded in a composite structure membrane element. The MFC may consist of rectangular piezo ceramic rods sandwiched between layers of adhesive, electrodes, and polyimide film. The electrodes are attached to the film in an interdigitated pattern, which transfers the applied voltage MFC-structure directly to and from the ribbon-shaped rods. Such an example enables in-plane poling, actuation, and sensing in a sealed and durable, ready-to-use package. The MFC can also be applied as a thin, surface-conformable sheet to various types of structures, or embedded in a composite structure.

[0019] In an implementation, the membrane element may be provided from carbon fibers (Kevlar). In a further implementation, the membrane element may be provided from a composite material comprising: at least one carbon fiber (Kevlar) layer and a damping layer. In a further implementation, the membrane element may be provided of a material having piezoelectric properties, for example, comprising nanotubes of boron nitride.

[0020] According to a further aspect, a vehicle door is provided, comprising at least one loudspeaker apparatus described above. In an example, the loudspeaker apparatus may be a combined midrange and tweeter loudspeaker. In a car installation, the large diaphragm and long excursion woofers, e.g. about 150 to 200 mm in diameter, are typically placed in lower areas, e.g. lower door corners, where there is more space for larger drivers. The size of the membrane for tweeters, e.g. about 20 mm diameter, and midrange drivers, e.g. about 80 to 100 mm diameter, allows higher mounting positions in a car installation, e.g. upper door corner, instrument panel, etc., targeting the height of the listener hears, to avoid obstructions and to better define the sound stage. As described in the present disclosure, an important issue in a car installation is to mount the midrange and twitters drivers as high as possible, targeting the height of the listener hears. Due to the wavelength difference between mid and high frequencies, every attempt should be made to keep the tweeter and the mid-range speakers fairly close to each other. If positioned too far apart, the phase relationship result may cause the mid-range and the tweeter transducers to be perceived as two independent, and potentially delayed, audio sources. In case of limited space or design constrains in a car installation, the most direct, but typically least acoustically effective approach is to use coaxial type speakers. Such coaxial speakers are usually 2- or 3-way loudspeakers in which the tweeter, or the tweeter and a midrange driver, are mounted in front of the woofer, partially obscuring it. The advantage of such a design is the ability to use a smaller area, hence their popularity in car audio. However, according to the present disclosure, there is no need for a tweeter in front of the woofer membrane, which may eliminate any obstruction of the membrane and prevents a phase-misalignment between high and low frequencies, further improving the acoustic performance of the loudspeaker apparatus.

[0021] A further aspect relates to a use of a piezoelectric layer or element and/or a membrane element comprising such a piezoelectric layer in a loudspeaker apparatus described above. According to a further aspect, a vehicle is provided, comprising at least one loudspeaker apparatus described above. In an example, the loudspeaker apparatus is a combined midrange and tweeter loudspeaker. However, the disclosed loudspeaker apparatus is not limited to a use in a door panel of a vehicle. In fact, potential applications range from automotive and aerospace industry to consumer electronic products.

BRIEF DESCRIPTION OF DRAWINGS

[0022] In the following, the disclosure is described exemplarily with reference to the enclosed figure, in which

Figure 1 is a schematic view of a loudspeaker apparatus according to an embodiment of the present disclosure;

Figure 2 is a schematic view of the loudspeaker apparatus shown in figure 1; and

Figure 3 is a schematic view of a vehicle door comprising a loudspeaker shown in figure 1.

[0023] Notably, the figures are merely schematic representations and serve only to illustrate an embodiment of the present disclosure. Identical or equivalent elements are in principle provided with the same reference signs.

DESCRIPTION OF EMBODIMENTS

[0024] Figures 1 and 2 show a schematic view of a loudspeaker apparatus 10 according to an embodiment of the present disclosure, wherein figure 1 shows a partially cut view of the loudspeaker apparatus 10. Figure 2 shows a cross-sectional view of the loudspeaker apparatus 10, although in order to make it easier to understand the function of the loudspeaker apparatus, several parts are not shown in Figure 2.

[0025] The shown embodiment of the loudspeaker apparatus 10 comprises a frame or basket 11, a membrane or diaphragm element 12 suspended by a surround gasket 13, a voice coil 14 which is arranged in a magnet field of magnet element 15. The loudspeaker apparatus 10 further comprises an elastic structure 16, also called Spider 16, for elastically supporting the movement of the voice coil 14 within the magnet field, e.g. between a center pole piece and a top plate of the magnet element 15. In the shown embodiment, the membrane element 12, e.g. provided by aluminum, paper, plastic or carbon fiber, comprises a piezoelectric ceramic layer 17, which is adhered to the membrane element 12. The shown embodiment of the loudspeaker apparatus 10 does not comprise a crossover circuit, both drives of the membrane element 10 are caused by the same audio signal 18. Such an implementation is possible since the piezoelectric layer/membrane 17 is resistant to overloads that would normally destroy most high frequency drivers. Due to their electrical properties, piezoelectric layers/membranes 17 are already a capacitive load and may be used without a crossover. Therefore, the loudspeaker apparatus 10 with the piezoelectric layer/membrane 17 may be driven by only one audio channel 18.

[0026] The voice coil 14 immerse in the magnet field of the magnet element 15 driving the membrane element 12 back-and-forth enabling sound generation in a first frequency range, e.g. between 200 Hz and 3 kHz. The back-and-forth movement for a sound generation in the first frequency range is indicated in figure 2 by the arrows 19.

[0027] In addition, the membrane element 12 with the piezoelectric layer/membrane 17 may receive an electrical pulse, and then applies directional force to the opposing surface of the membrane element 12, causing it to move in the desired direction. This movement for a sound generation in the second frequency range is indicated in figure 2 by the dotted line 20. Thus, motion is generated when the piezoelectric layer/membrane 17 moves against the membrane element 12 enabling sound generation in the second frequency range, e.g. between 3 kHz and 24 kHz. In other words, in the shown embodiment, the loudspeaker apparatus 10 includes a midrange driver and a tweeter in one audio source. However, the present disclosure is not limited to such an arrangement.

[0028] Figure 3 shows a vehicle door 100 comprising one loudspeaker apparatus 10 shown in figures 1 and 2. As can be taken from figure 3, the loudspeaker apparatus 10 can be mounted at a high position targeting the height of the listener hears. Moreover, in the shown embodiment, the loudspeaker apparatus is a combined midrange and tweeter loudspeaker. Thus, the midrange and tweeter frequencies are provided by one sound source and a listener does not perceive both as two different audio sources.

[0029] Other variations to the disclosed embodiment can be understood and effected by those skilled in the art in practicing the claimed subject matter, from the study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps and the indefinite article "a" or "an" does not exclude a plurality. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. Any reference signs in the claims should not be construed as limiting the scope of the claims.

LIST OF REFERENCE SIGNS

[0030]

10	loudspeaker apparatus
11	frame or basked
12	membrane or diaphragm element
13	surround gasket
14	voice coil
15	magnet element
16	elastic structure/ spider
17	piezoelectric membrane/piezoelectric ceramic layer
18	audio channel
19	arrow re back-and-forth movement of the membrane element
20	arrow re vibration of the membrane element
100	vehicle door

Claims

1. Loudspeaker apparatus (10) for emitting high and low frequency sound waves, comprising:

    at least one membrane element (12) for generating sound waves, said membrane element (12) being adapted to simultaneously generate sound waves in a first frequency range and in a second frequency range;
    at least one voice coil/magnet assembly (14, 15) adapted for operatively engaging with the membrane element (12) such that the membrane element (12) is drivable by the voice coil/magnet assembly (14, 15) in the first frequency range to generate sound waves in the first frequency range; and
    at least one piezoelectric layer or element (17) being arranged at the membrane element (12) in such a way that the membrane element (12) is drivable by the piezoelectric layer or element (17) in the second frequency range in order to generate sound waves in the second frequency range.

2. Loudspeaker apparatus (10) according to claim 1, the first frequency range being between 20 Hz and 3 kHz, and preferably between 200 Hz and 3 kHz, and the second frequency range being between 3 kHz and 24 kHz.

3. Loudspeaker apparatus (10) according to one of claims 1 or 2, the loudspeaker apparatus (10) further comprising at least one crossover circuit, the crossover frequency of the crossover circuit preferably being at 3 kHz.

4. Loudspeaker apparatus (10) according to one of claims 1 or 2, the loudspeaker apparatus (10) not comprising a crossover circuit, and both drives of the membrane element (12) being caused by the same audio signal (18).

5. Loudspeaker apparatus (10) according to any one of the preceding claims, the membrane element (12) being arranged conically.

6. Loudspeaker apparatus (10) according to any one of the claims 1 to 4, the membrane element (12) being arranged as a flat plane.

7. Loudspeaker apparatus (10) according to any one of the preceding claims, the piezoelectric layer or element (17) being formed as a composite structure,

comprising:

a top support layer;
an electrode layer;
a piezoelectric layer;
an electrode layer; and
a bottom carrier layer.

8. Loudspeaker apparatus (10) according to any one of the preceding claims, the piezoelectric layer or element (17) being formed as a composite structure, comprising:
at least one epoxy resin matrix and piezo-ceramic fibers embedded therein.

9. Loudspeaker apparatus (10) according to one of the claims 7 or 8, the piezoelectric layer or element (17) comprising piezo-ceramic fibers with two different angles of orientation, preferably arranged with an angle difference of 90° DEG to one another.

10. Loudspeaker apparatus (10) according to any one of the preceding claims, the membrane element (12) being provided from carbon fibers (Kevlar).

11. Loudspeaker apparatus (10) according to any one of the preceding claims, the membrane element (12) being provided from a composite material comprising: at least one carbon fiber (Kevlar) layer and a damping layer.

12. Loudspeaker apparatus (10) according to any one of the preceding claims, the membrane element (12) being provided of a material having piezoelectric properties, preferably comprising nanotubes of boron nitride.

13. Vehicle door (100) comprising at least one loudspeaker apparatus (10) according to any one of the claims 1 to 12, the loudspeaker apparatus (10) preferably being set up as a combined midrange and tweeter loudspeaker.

14. Use of a piezoelectric layer/element and/or a membrane element (12) comprising such a piezoelectric layer in a loudspeaker apparatus (10) according to any one of the claims 1 to 12.

15. Vehicle comprising at least one loudspeaker apparatus (10) according to any one of the claims 1 to 12, the loudspeaker apparatus (10) preferably being set up as a combined midrange and tweeter loudspeaker.

Amended claims in accordance with Rule 137(2) EPC.

1. Loudspeaker apparatus (10) for emitting high and low frequency sound waves, comprising:

at least one membrane element (12) for generating sound waves, said membrane element (12) being adapted to simultaneously generate sound waves in a first frequency range and in a second frequency range;
at least one voice coil/magnet assembly (14, 15) adapted for operatively engaging with the membrane element (12) such that the membrane element (12) is drivable by the voice coil/magnet assembly (14, 15) in the first frequency range to generate sound waves in the first frequency range; and
at least one piezoelectric layer or element (17) being arranged at the membrane element (12) in such a way that the membrane element (12) is drivable by the piezoelectric layer or element (17) in the second frequency range in order to generate sound waves in the second frequency range; and
the piezoelectric layer or element (17) being formed as a composite structure, comprising at least one epoxy resin matrix and piezo-ceramic fibers embedded therein.

2. Loudspeaker apparatus (10) according to claim 1, the first frequency range being between 20 Hz and 3 kHz, and preferably between 200 Hz and 3 kHz, and the second frequency range being between 3 kHz and 24 kHz.

3. Loudspeaker apparatus (10) according to one of claims 1 or 2, the loudspeaker apparatus (10) further comprising at least one crossover circuit, the crossover frequency of the crossover circuit preferably being at 3 kHz.

4. Loudspeaker apparatus (10) according to one of claims 1 or 2, the loudspeaker apparatus (10) not comprising a crossover circuit, and both drives of the membrane element (12) being caused by the same audio signal (18).

5. Loudspeaker apparatus (10) according to any one of the preceding claims, the membrane element (12) being arranged conically.

6. Loudspeaker apparatus (10) according to any one of the claims 1 to 4, the membrane element (12) being arranged as a flat plane.

7. Loudspeaker apparatus (10) according to any one of the preceding claims, the piezoelectric layer or element (17) being formed as a composite structure, comprising:

a top support layer;
an electrode layer;
a piezoelectric layer;

an electrode layer; and
a bottom carrier layer.

8. Loudspeaker apparatus (10) according to one of the claims 1 or 7, the piezoelectric layer or element (17) comprising piezo-ceramic fibers with two different angles of orientation, preferably arranged with an angle difference of 90° DEG to one another.

9. Loudspeaker apparatus (10) according to any one of the preceding claims, the membrane element (12) being provided from carbon fibers (Kevlar).

10. Loudspeaker apparatus (10) according to any one of the preceding claims, the membrane element (12) being provided from a composite material comprising: at least one carbon fiber (Kevlar) layer and a damping layer.

11. Loudspeaker apparatus (10) according to any one of the preceding claims, the membrane element (12) being provided of a material having piezoelectric properties, preferably comprising nanotubes of boron nitride.

12. Vehicle door (100) comprising at least one loudspeaker apparatus (10) according to any one of the claims 1 to 11, the loudspeaker apparatus (10) preferably being set up as a combined midrange and tweeter loudspeaker.

13. Use of a piezoelectric layer/element and/or a membrane element (12) comprising such a piezoelectric layer in a loudspeaker apparatus (10) according to any one of the claims 1 to 11.

14. Vehicle comprising at least one loudspeaker apparatus (10) according to any one of the claims 1 to 11, the loudspeaker apparatus (10) preferably being set up as a combined midrange and tweeter loudspeaker.

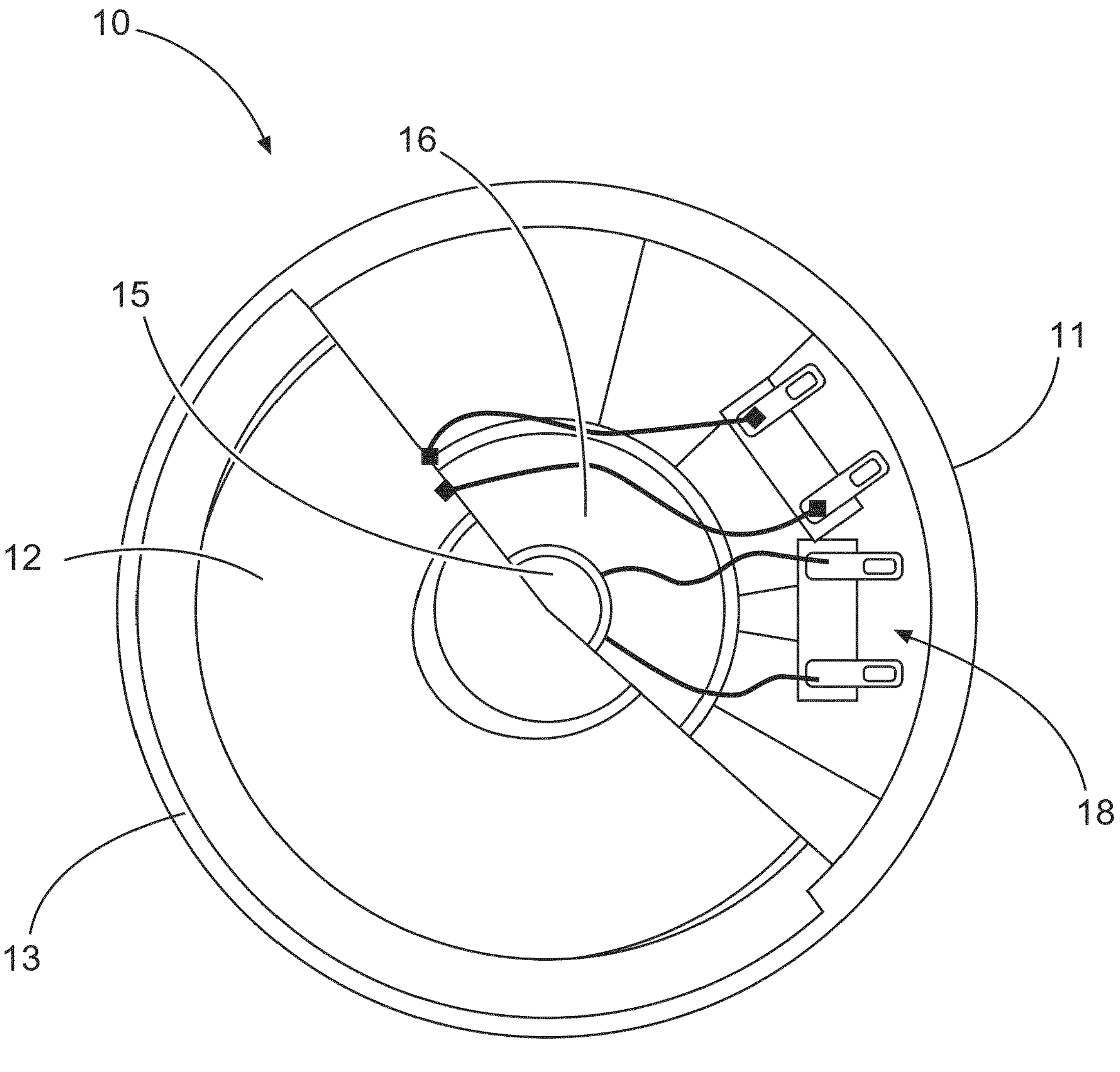

Fig. 1

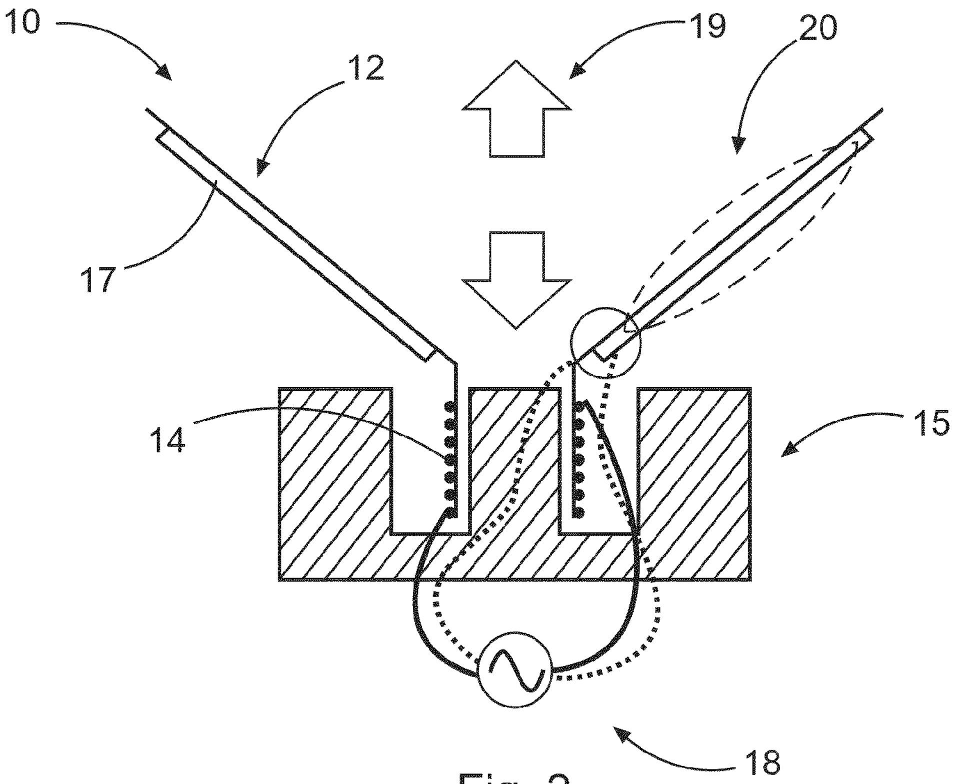

Fig. 2

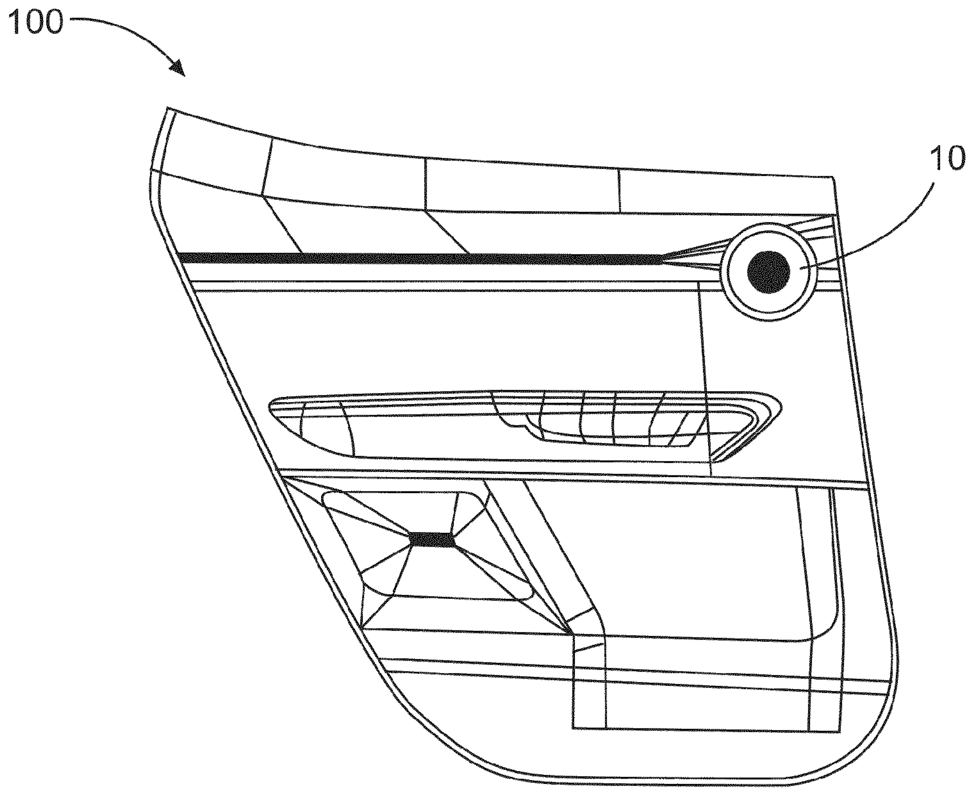

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 20 18 0066

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	JP S59 12699 A (MATSUSHITA ELECTRIC IND CO LTD) 23 January 1984 (1984-01-23) * the whole document * -----	1-15	INV. H04R17/00 H04R23/02 H04R3/12
X	JP S60 27300 A (FOSTER ELECTRIC CO LTD) 12 February 1985 (1985-02-12) * the whole document * -----	1-15	
X	EP 0 772 373 A2 (NOKIA TECHNOLOGY GMBH [DE]) 7 May 1997 (1997-05-07) * the whole document * -----	1-15	
X	CN 202 178 868 U (GUANGZHOU RUIFENG AUDIO TECHNOLOGY CO LTD) 28 March 2012 (2012-03-28) * the whole document * -----	1	
X	JP S63 279700 A (SHARP KK) 16 November 1988 (1988-11-16) * the whole document * -----	1-14	
X	JP S55 91299 A (SONY CORP) 10 July 1980 (1980-07-10) * the whole document * -----	1-15	TECHNICAL FIELDS SEARCHED (IPC) H04R

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	18 November 2020	Timms, Olegs

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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D : document cited in the application
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 20 18 0066

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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18-11-2020

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
JP S5912699	A	23-01-1984	NONE			
JP S6027300	A	12-02-1985	NONE			
EP 0772373	A2	07-05-1997	DE	19541197	A1	07-05-1997
			EP	0772373	A2	07-05-1997
			JP	H09215089	A	15-08-1997
CN 202178868	U	28-03-2012	NONE			
JP S63279700	A	16-11-1988	NONE			
JP S5591299	A	10-07-1980	NONE			

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