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(54) **A RECEIVER AND A METHOD OF MANUFACTURING A RECEIVER**

(57) A receiver (10) comprising a coil (24), a magnet assembly (26) forming a magnet gap (27) and a membrane (28), the coil (24), magnet assembly (26) and membrane (28) provided in a housing (20) comprising a sound output opening (22) and defining an inner volume, wherein the membrane (28) divides the inner volume into a front chamber (12) and a back chamber (14), the front and back chambers (12, 14) being at least partly defined by opposite sides of the membrane (28), wherein the coil (24) has a first portion provided in the front chamber (12) and a second portion provided in the back chamber (14).

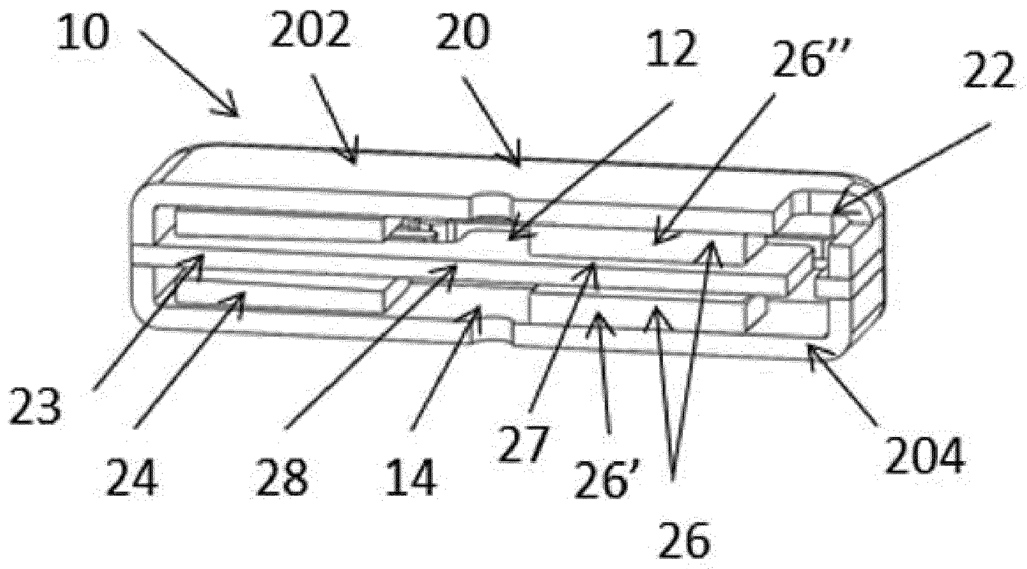

Fig. 1

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Description

[0001] The present invention relates to a receiver, for generating sound, and in particular a flat or small receiver, which is often called a miniaturised loudspeaker. The receiver comprises a coil, a magnet assembly forming a magnet gap and a membrane. The coil, magnet assembly and membrane are provided in a housing comprising a sound output opening and defining an inner volume, wherein the membrane divides the inner volume into a front chamber, also called front volume, and a back chamber, also called back volume, the front and back chambers being at least partly defined by opposite sides of the membrane.

[0002] Such receivers, are usually provided for generating sound for hearables, such as hearing aids or personal hearing devices, such as ear phones or the like, and are desired small, with a height of less than 2 mm, yet efficient.

[0003] Such receivers are disclosed in e.g. CN 2080 1599. The receiver disclosed in this document has a front chamber and a back chamber. In the back chamber the electromagnetic drive mechanism, comprising a coil and vibrating plate, is located. When the receiver is in operation, the coil in the electromagnetic drive mechanism is energised to become an electromagnet. As the signal changes, the magnetic field generated by the electromagnet will also change. The first magnet and the second magnet drive the vibrating plate and the vibrating frame connected to the vibrating plate, generating up and down movements. This in turn drives the sound membrane to drive air in the front and back chambers to generate sound. Another receiver is disclosed in EP 1962 550. In this publication a receiver is shown, wherein the front chamber is equipped with a magnet and the back chamber is equipped with another magnet and a coil. The armature extends through the coil and the magnet gap and the diaphragm extends through the magnet gap only. In both disclosures the receiver comprises a diaphragm and an armature requiring the receiver to be relatively thick. Both a diaphragm and armature are needed to produce a decent sound output.

[0004] It is an object of the invention to provide a receiver that can be made with less components and is smaller in size than the prior art receivers. Further it is an object to provide a receiver with an increased output intensity per unit volume. Another object is to provide a receiver having less vibration noise and distortion.

[0005] The current invention solves these problems of the prior art in a first aspect by providing a receiver wherein the coil has a first portion provided in the front chamber and a second portion provided in the back chamber. By effectively assembling the coil in both front chamber and back chamber a more compact receiver is made that needs less parts, is symmetrical and produces less noise. The armature function and diaphragm are combined in this invention to a single membrane that also forms the separation between front and back chambers.

[0006] In the present context, a receiver is an element configured to convert an electrical signal into sound. In the present receiver, an electrical signal fed to the coil brings about movement of the membrane to generate sound. Preferably, the receiver is a miniature receiver, where the housing has a length of no more than 10 mm, preferably no more than 8 mm, preferably no more than 6 mm or no more than 5 mm. In one situation, the receiver housing may have a volume of no more than 100 mm^3, preferably no more than 70 mm^3, preferably no more than 50 mm^3, preferably no more than 30 mm^3, preferably no more than 20 mm^3.

[0007] The coil may be formed by one or more windings of one or more electrical conductors. Multiple coils may be provided if desired.

[0008] The magnet assembly forms a magnet gap. Often, magnets are provided in a yoke or other structure, such as the housing itself, facilitating a closing or guiding of the magnetic fields to whichever elements form the magnet gap. The magnet gap is a gap in which the magnetic field lines are present and inside which an element may be present, such as the membrane or an armature, which may then be forced in a direction parallel with the magnetic field lines in the magnet gap. Multiple magnet gaps may be provided if desired. The guiding or closing structure may be metallic structures guiding the magnetic field lines without causing too much loss of the field lines outside of the magnet gap. Multiple magnets may be provided. In one embodiment, the magnet gap is generated between two magnets.

[0009] The housing comprises a sound output opening. A sound output opening preferably has a size or cross section large enough to support transport of sound in the audible range, such as 20-20,000 Hz, preferably 30-10,000 Hz. It may be preferred that the housing has only one sound output opening and that no other openings are present which cater for sound outputting. It may be desired to provide a vent in the housing, which vent allows air passage into the housing, such as into the second chamber, without allowing too much sound to pass through it. A vent may have a cross section so small that sound with frequencies above 10 Hz, such as above 5 Hz are substantially attenuated.

[0010] The housing has an inner volume. The housing may be formed by two or more parts which fit together to close the volume and define the sound output. The membrane divides the inner volume into two chambers. Each chamber is defined partly by an inner surface of the housing and partly by a side or side portion of the membrane. The two chambers are defined, respectively, of opposing sides or side portions of the membrane.

[0011] The membrane preferably is relatively stiff, so that a force generated at one portion of the membrane is transferred to other portions of the membrane. The membrane may be a plane element or an element with e.g. corrugation or ridges, which may be provided to increase a stiffness of the membrane in one or more directions, often in the longitudinal direction thereof.

[0012] Useful materials for the membrane may be any material, such as aluminium, copper, cobalt, iron, nickel, steel, titanium, or alloys thereof, such as Nickel-Iron 50-50, Nickel-Iron 80-20, brass, or metal matrix composite materials. Also, reinforced composites may be used, such as an aluminium matrix with ceramic particles therein. A very high stiffness is preferred. The membrane is desired relatively thin, such as in the interval of 10 to 100 μm, preferably in the interval of 10-50 μm.

[0013] The housing may comprise additional elements, such as electrically conducting portions allowing electrical signals to be guided from the outside of the housing to inside the housing. Such portions may, at the outside, be connected to by conductors guiding the signals to the receiver and, on the inside, to the coil.

[0014] When the coil has a first portion provided in the front chamber and a second portion provided in the back chamber, the receiver may be made more compact that in the prior art set-ups where the coil is located only in the back chamber, so that the overall height of the receiver according to the invention may be lower as the armature and diaphragm functions are combined into a single membrane. A reduction in size will give room for other components, such as more receivers, in the same space. The inner volume may have a height corresponding to that of the coil or only slightly more, such as up to only 10 % more, preferably up to only 5 % more. A reduced size may increase the sound output intensity per unit of volume of the receiver.

[0015] The first and second portions may be portions on either side of a plane or element extending through the coil, such as through one, two, three or all windings thereof. Preferably, the coil has a central or symmetry axis, the plane comprising this axis. Preferably, all complete windings of the coil may form part of both the first and the second portions.

[0016] In a preferred embodiment the coil forms a coil tunnel and the magnet assembly forms a magnet gap, the membrane extending through the coil tunnel and the magnet gap. In this situation, the coil tunnel and magnet gap may be positioned within a predetermined plane, so that the membrane may be plane or at least substantially plane and still extend through both the magnet gap and the coil tunnel. In this situation, the membrane has the function of not only the standard diaphragm (sound generation) but also that of an armature. When extending through the coil tunnel and the magnet gap, a field is generated in the membrane by the coil, which magnetises the membrane (or armature in the prior art) that extends into the magnet gap, which results in a force generated to the membrane. This force will move the membrane and thus create sound. This has the advantage that less components are needed. In addition, also a drive pin is not needed and thus multiple steps in the manufacturing process are also not needed.

[0017] The membrane divides the housing volume into the two chambers, and when it extends through the coil tunnel, a portion of the coil naturally is in one chamber and another portion is in another chamber. Another advantage thereof is that a symmetrical design may be obtained, which reduces distortion in the sound output and therefore a clearer sound is produced which is beneficial to the user of the hearing aid or the like.

[0018] When the membrane extends through the coil, the receiver preferably comprises a resilient layer or seal between the membrane and an inner surface of the coil. In this manner, the membrane is also able to move relative to the coil while ensuring airtight operation. The division of the inner volume into the front and back chambers preferably is air tight in the manner that when the membrane moves, an increased pressure will be experienced in one chamber and a reduced pressure in the other. So, it is desired that air is not allowed to travel from one chamber to the other, as this would counteract the pressure difference generation and thus the sound generation. Therefore, this receiver preferably comprises a resilient material between the membrane, or a stiffer portion thereof, and the inner surface of the housing. Preferably, a frame may be provided around the membrane, so that the resilient seal may be provided between the membrane and the frame. The frame may then be used for connecting the membrane to the housing, such as at a periphery or inner surface of the housing. This allows the membrane to move relative to the housing while ensuring airtight operation. So, the airtight operation acts to increase the intensity of the sound output.

[0019] The choice of material for the resilient seal may be made based on a number of parameters, such as the movement to be covered, the forces applied and the like. The same material may be used between the membrane and the housing as between the membrane and the coil. Alternatively, different materials may be used. Typically, plastic materials, like polymers or the like, are used.

[0020] The resilient seal is configured to prevent air from moving between the membrane portions while allowing the membrane to vibrate or move independently of the housing. In order for the resilient seal not to transfer too much of one membrane's movement to the housing, the resilient seal may be selected with a sufficiently large bendability or stretchability. The function of the resilient seal is to mimic that of standard sealing elements for sealing between a membrane and a housing or frame of the membrane. Thus, the same types of elements, shapes, functions and materials may be used.

[0021] The resilient seal preferably offers a minimum resistance to the membrane movement. Thus, the resilient material preferably has a compliance (quantified in m/N which is the inverse of stiffness, N/m) which is higher, preferably much higher, than the compliance of the membrane. Preferably, the compliance of the resilient seal is at least one order of magnitude higher than that of the membrane. A mechanical compliance that has been found suitable is in the interval of 0.1-0.0001 m/N, preferably in the interval of 0.08-0.0008 m/N, preferably 0.07-0.001 m/N, preferably 0.05 m/N - 0.005 m/N.

[0022] Alternatively or in addition, preferably the resilient material is as stretchable as possible. When the stretchability of the resilient material increases, the distortion caused by the resilient material drops.

[0023] Preferably, the resilient seal is made of a polymer material, such as PU or PET. Usually, PU can be stretched 50% before breaking. Naturally, the thickness and other parameters of the resilient material may influence the operation thereof. The density, for example, may be altered by providing the material as a foam, such as a closed foam, which then will often be less dense and thus more resilient (stretchable, bendable and the like) than if provided as a solid material.

[0024] Ideally, the resilient material has an infinite compliance (and hence zero stiffness), and the material of the membrane and/or oblong elements has an infinite stiffness (and hence zero compliance). However, a stiffer material may be used in order to apply damping to the movements of the portions of the membrane. In one example, the resilient material is PU with a thickness of 0.001-0.1 mm, preferably 0.01-0.05 mm, preferably around 0.015 mm or PET with a thickness of 0.001-0.05 mm, preferably 0.002-0.01 mm, preferably 0.004-0.005 mm.

[0025] Another type of material useful as a resilient material is a gel. Gels combine high damping properties with low stiffness and thus may reduce the peak at resonance frequency to make the resonance frequency peak less sharp and thus alter the corresponding sound to be more pleasant. Reducing the resonance frequency peak will spread the acoustic energy in the "surrounding" frequency range. Thus, the resonance frequencies obtained with the oblong elements may be further manipulated by selecting the resilient material, such as a gel with desired parameters.

[0026] Also, the use of a gel may reduce the number of steps in the process of adding the sealing material to the membrane. Using a sheet/foil shaped resilient material may require the stretching of the foil and gluing the stretched foil to the membrane and, potentially, also making a rib therein. Gels and their use in transducers such as receivers may be seen in the Applicants co-pending application EP 3342 749, which is hereby incorporated by reference in its entirety.

[0027] The resilient seal may be provided between the membrane and the housing, frame and/or coil. Thus, the gel may be used in one or both of these positions and a sheet of a resilient material, such as PU or PET may be used in one or more of these positions. In addition, at the hinge portion, a slit may be provided which may again be covered by a gel or a sheet. Any combination may be used. The gel may be applied in a non-cured state and then cured to become less viscous or more rigid or stiff. The degree of curing and the resulting properties may be adapted to the desired properties of the gel.

[0028] A further alternative material for the resilient material is a resin or a mineral filler.

[0029] The resilient material may be provided as a sheet-like element covering only a space between the membrane and the frame/housing/coil or as a sheet covering all of the membrane. The latter is an easier manner of obtaining a membrane, even though the membrane becomes slightly heavier and the manufacturing may comprise additional steps.

[0030] In a preferred embodiment, the receiver further comprises one or more elements attached to an inner surface of the coil and a resilient seal between the membrane and the one or more elements. The elements are preferably oblongly shaped. In this manner, the resilient material may not be connected to or attached directly to the coil but to the elements. This may facilitate attachment of the resilient material or seal.

[0031] Preferably, the membrane is rotatable (such as by torsion) around a deflecting portion or an axis which often is at or close to a side wall of the housing. The membrane, such as the deflecting portion, may be attached to this side wall or to e.g. a frame attached to the housing. The deflecting portion may be a portion with a lower resilience, such as a weakened, thinner, more narrow portion or the like, so that the rotation of the membrane takes place at or primarily around this portion. The deflecting portion may be well defined, such as having a small extent along a longitudinal direction of the membrane, or less well defined, so that rotation may take place around a longer portion along the longitudinal direction of the membrane. The deflecting portion acts to both attach the membrane in relation to the housing and facilitate the relative movement between the membrane and the housing. With the rotation around the deflecting portion, the movement of the membrane is a rotation and not e.g. a piston movement where all portions of the membrane move the same distance in relation to the housing.

[0032] Preferably the membrane is rotatable in relation to a deflecting portion, the one or more elements being connected to the deflecting portion. The elements may be attached to the deflecting portion or may be unitary with the deflecting portion. 6 The membrane preferably is rotatable also in relation to the elements, so that the elements do not to any large degree prevent rotation of the membrane. The connection of the elements to the deflecting portion assists in both ensuring an airtight separation between the housing chambers and in attaching or fixing the coil to the membrane. Then, it is possible to attach the coil to the elements, as the relative movement is created between the elements and the membrane. In this manner, the attachment need not be resilient but may be fixed, such as by gluing.

[0033] Preferably, the deflecting portion is provided at the coil, such as at a portion of the coil extending away from a main portion of the membrane. In this manner, the movement of the membrane and the coil is limited, as the portion of the relative movement is farther from the coil.

[0034] Another aspect of the invention relates to a method of manufacturing a receiver, the method comprising:

- providing a first housing portion also comprising a sound output opening,
- providing a first magnet,
- providing a second housing portion, where, when the first and second housing portions are attached to each other, the second magnet is positioned so as to generate a magnet gap,
- providing a membrane assembly comprising a membrane and a coil, the membrane having a first membrane portion extending inside the coil, the first membrane portion configured to rotate in relation to the coil, wherein the method further comprising
- assembling the receiver by providing the membrane assembly in a volume defined between the first and second housing portions so as to divide the space into a front and a back chamber, a first portion of the coil being provided in the front chamber and a second portion of the coil being provided in the back chamber.

[0035] The aspects of the invention may be combined and interchanged, as may embodiments and situations thereof.

[0036] In this manner, the number of elements to be handled and the number of steps is reduced compared to assembly of the state of the art receivers. Pre-assembling the membrane and coil, for example, simplifies the method considerably, making an easier and quicker manufacturing process possible at lower cost. The magnet may be provided in one of the first and the second housing portions before assembly, so as to reduce the number of sub-assemblies to handle.

[0037] If the housing itself is not sufficient to generate a return path for the magnetic field generated by the magnet, a yoke member or the like may be provided for this purpose. This yoke member may be divided into portions each attached to one of the housing portions prior to the assembling step. Alternatively, the yoke member or portions may be a separate subassembly. One of the housing portions or both housing portions may additionally comprise, as mentioned above, electrically conducting portions configured to transfer an electrical signal from outside of the housing to the coil. The housing portions, when assembled, define the inner volume. Preferably, one or both housing portions are concavely shaped.

[0038] The step of providing the first housing portion may thus, comprise shaping a material into the first housing portion and the generation of the sound opening. Alternatively, this step may also comprise attaching the magnet and optionally yoke member(s) to the first housing portion. The step of forming the second housing portion may also comprise a step of shaping a material to the desired shape. Preferably, the first and second portions are shaped such that, when assembled, the inner volume has no other sound outputs than that of the first housing portion.

[0039] The step of providing the membrane assembly may comprise the step of providing the coil, such as shaping it from one or more conductors. The membrane has a first membrane portion extending inside the coil. Thus, the step may comprise providing the first membrane portion inside the coil. This step may also comprise directly or indirectly attaching the coil to the membrane, so that the membrane assembly can be handled as a unit. The assembly step may comprise positioning the membrane assembly in relation to one of the housing portions and subsequently positioning the other housing portion in relation there to.

[0040] The membrane assembly divides the inner volume of the housing into the two chambers. In a preferred embodiment, the step of providing the membrane assembly comprises providing a membrane assembly comprising a frame, the membrane being rotatable in relation to the frame, a resilient material being provided between the membrane and the frame. In that situation, the frame may be attached to the housing during the assembly step. Otherwise, airtight operation could be obtained by providing the resilient material between the membrane and the housing.

[0041] The attachment of the frame to the housing may be a gluing/welding/soldering thereof to the housing, a press-fitting thereof to the housing or the providing of the frame between the housing portions so as to fix the frame between the housing portions during assembly.

[0042] As mentioned, a yoke member may be provided for closing the field lines of the magnet(s), if it e.g. is not desired to have the field travel in the material of the housing. This yoke member may comprise a portion of the frame, so that the field lines pass from a yoke portion above the membrane to a yoke portion below the membrane through a portion of the frame, which usually will be close to the housing and may extend slightly into the housing volume and away from the walls.

[0043] The coil may be a free-standing object or it may be provided on a bobbin. Alternatively, the coil may be wound directly on the desired portion of the membrane so that it may not require glue or the like for attaching it to the membrane. Further, a bobbin may be attached to the membrane, where after the coil may be wound on the bobbin.

[0044] In a preferred embodiment, the step of providing the membrane assembly comprises also the step of providing the resilient seal between an inner surface of the coil and the first membrane portion. In this manner, the membrane may move relative to the coil during airtight operation. Alternatively, the membrane may fit the inside of the coils so well that a material is not required to provide a sufficient sealing between the membrane and the coil. Ultimately, the membrane may be fixed to the coil so as to not be movable in relation to the coil at least in the coil tunnel. In this situation, the membrane portions outside of the coil will be movable so as to generate sound. The deflecting portion may be a part of the membrane or a separate element therefrom. The membrane may be attached to the deflecting portion, such as via a resilient material.

[0045] In a preferred embodiment, the step of providing the membrane assembly comprises attaching the coil in relation to the membrane. In that manner, a more easy to handle unit is achieved. In this embodiment, the fastening step may comprise fastening the coil to the one or more elements of the membrane. Preferably, the fastening step comprises fastening the coil to one or more elements of the membrane, the membrane assembly comprising a deflecting portion, the membrane being rotatable in relation to the deflecting portion and the one or more elements being attached to the deflecting portion. As mentioned above, the elements may have been separate from the deflecting portion or the deflecting portion and the one or more elements may be provided as a unitary unit.

[0046] In a preferred embodiment, the step of providing the first housing portion comprises providing the first housing portion comprising the first magnet and the step of providing the second housing portion comprises providing the second housing portion comprising a second magnet. In this manner, also the magnets form part of pre-assembled sub-assemblies so that the assembly of the overall receiver may be made generally from the two housing portions and the membrane assembly.

[0047] In the following, preferred embodiments will be described with reference to the drawing, wherein:

- Figure 1 illustrates a cross-section of a receiver according to the invention,
- Figure 2 illustrates a membrane element and frame for use in the receiver of figure 1,
- Figure 3 illustrates a coil attached to the membrane,
- Figure 4 illustrates a resilient seal,
- Figure 5 illustrates the membrane assembly connected to the lower housing portion,
- Figure 6 illustrates an exploded view of the receiver of figure 1,
- Figure 7 illustrates an alternative membrane shape,
- Figure 8 illustrates a preferred embodiment,
- Figure 9 illustrates the coil, coil bobbin, magnets and yoke members in cross section,
- Figure 10 illustrates yet another preferred embodiment of a receiver,
- Figure 11 illustrates a further preferred embodiment of a receiver, and
- Figure 12 illustrates the yoke members, coil, magnet and membrane of the receiver in figure 11.

[0048] In figure 1, a receiver 10 is illustrated in a cross section. The receiver 10 comprises a housing 20, formed by a first housing portion 202 and a second housing portion 204, and having a sound output opening 22. In the housing 20, a coil 24 is provided. Also, a magnet assembly 26 is provided, formed by magnets 26', 26" generating a magnet gap 27 in which a membrane 28 is provided having the combined function of an armature for generating a magnetic field and a diaphragm for displacing air and producing sound output. The membrane 28 is configured to carry an electromagnetic field generated therein by a current fed to the coil 24. As the membrane 28, supporting this field, is provided in the magnet gap 27, the membrane 28 is forced in a direction along the field lines of the magnetic field. Thus, the current is converted into movement of the membrane 28, thus causing sound to be generated in the housing 20. The membrane 28 divides an inner space of the housing 20 into a front chamber 12 and a back chamber 14, where the sound output opening 22 is an opening in the front chamber 12 to the surroundings of the receiver 10.

[0049] Figure 2 shows that one or more elements 288 may be provided for guiding magnetic fields outside of the magnets 26', 26" and the magnet gap 27. In another configuration these elements may also be the housing 20 itself.

[0050] Figure 3 shows the assembly 25 of the membrane 28 and coil 24. The membrane 28 also has a membrane portion 283 extending through a coil tunnel 23 of the coil 24. Preferably a resilient seal 30 - see figure 4, such as a thin polymer layer, is provided between the membrane 28 and the inner surface of the housing 20 or the frame 284 surrounding the membrane 28 and connected to or connectable to the housing 20. This sealing covers an opening 294 between the membrane 28 and the frame 284. In this manner, air cannot move around the edges of the membrane 28 from the front chamber 12 to the back chamber 14.

[0051] A sealing is also provided between the membrane 28 and an inner surface of the coil 24 or between the coil 24 and extending portions 288 extending inside the coil 24 and which are connected to, such as in an air sealing manner, the inner surface of the coil 24. That sealing then may cover an opening 292. Now, the membrane portion 282 is capable of rotating vis-à-vis the frame 284 provided around it as well as in relation to a bending or deflecting portion 286 at the end of this membrane assembly 25.

[0052] The resilient seal 30 allows the membrane 28 to move up and down while preventing air flow from the front chamber 12 to the back chamber 14. This air flow would reduce the efficiency of the receiver 10. The resilient sealing material is provided as a resilient seal 30 covering the complete surface of the membrane 28, such as also on the membrane 28 itself and optionally also on the frame 284. This sealing and the membrane 28 divides an inner volume of the housing 20 into the front chamber 12 and the back chamber 14. Alternatively, a pressure equalising opening may be provided, through which air may flow at a rate so low that the opening does not support sound with a frequency above 30 Hz, preferably above 10 Hz, preferably above 5 Hz.

[0053] As it is desired that also the portion 283 of the membrane 28 positioned within the coil 24 is movable, the sealing therein is resilient. The extended portions 288 allow fastening of the membrane 28 to the coil 24 while allowing the membrane portion 283 to move inside the coil 24. It is seen that the membrane 28 may be paddle shaped with a wider portion 282 where the magnets 26', 26" are located and a more narrow portion 283 inside the coil 24. In this manner, the total width of the wider portion 282 of the paddle, added twice the width of the opening 294, may correspond to an outer width of the coil 24. Then, a very efficient use of the space is seen, especially at low frequencies. Clearly, the portions the farthest from the bending portion or hinge portion 286 are the most efficient, so that efficiency lost by the narrowed portion 283 of the membrane 28 is very small.

[0054] The assembly of the present receiver 10 is relatively simple. Three sub-assemblies may be provided: a first housing portion 202 with the sound output opening 22 and with a first magnet 26', a second housing portion 204 with a second magnet 26", and a membrane assembly 25 comprising a membrane 28, the frame 284, the resilient seal 30 and the coil 24. The only other step needed is to connect the coil 24 to conducting elements 288 of the membrane 28 and to then close the first and second housing portions 202, 204 around the membrane assembly 25 so that the membrane assembly 25 divides an inner space of the housing 20 into the front chamber 12 and back chamber 14.

[0055] In figure 4, a resilient seal 30 is illustrated having a half-roll shaped portion 34 configured to cover the opening 294 to allow the membrane portion 282 to move while retaining air tightness. This resilient seal 30 may be attached to the membrane 28 so as to be attached to the membrane portion 282 and the frame 284. The resilient seal 30 may be severed or cut along the broken lines at the openings 290 to allow the coil 24 to be attached. A half-roll portion may also be provided for covering the opening 292, but as the relative movement between the elements 288 and the membrane portion 283 may be rather low, the natural resilience of the resilient seal 30 may suffice.

[0056] In figures 5 and 6, the membrane assembly 25 is seen with the coil 24, the membrane 28 and the resilient seal 30 provided on top of the second housing portion 204. The position of the magnet assembly 26 is also illustrated. The coil 24 may be attached to the elements 288 and optionally additionally to the frame 284. Then, the assembly is more rugged and easier to handle.

[0057] In figure 7, another membrane 28 shape is illustrated which has a narrower portion 283, a wider portion 282, openings 290, 292 and 294, and a hinge portion 286. In this configuration the frame 284 is attached to the membrane 28 and additionally has two upwardly bent portions which may add to a stiffness of the assembly, not the least before mounting in the housing 20. It is also seen that the whole assembly forms one piece even before adding the resilient seal 30 illustrated in the lower illustration of figure 7.

[0058] In figure 8, a preferred embodiment of a receiver 10 is shown in which, in addition to the elements 288 described above, the coil 24 is provided on a coil bobbin 241. The advantage of a coil bobbin 241 is that it makes the coil 24 easier to handle. The coil bobbin 241 may be attached to the membrane 28 before or after the coil 24 has been wound on it. In addition to the coil bobbin 241, this embodiment also has a magnet yoke member 261 which acts to transport the magnetic field in a more efficient manner without requiring the field to travel through the material of the housing 20. It may be desired to not have the field mainly travel through the material of the housing 20, such as if restrictions exist as to the fields emitted by the receiver 10.

[0059] The coil 24, coil bobbin 241, magnets 26', 26" and yoke member 261 are illustrated also in figure 9. The coil bobbin 241 may be made as a single or monolithic element, whereas it may be desired to provide the yoke member 261 as two individual elements, as they will be provided on either side of the membrane 28 but may be in contact with each other outside of the membrane 28, such as via the frame 284. Thus, the frame 284 may form part of the yoke member 261 or the path which the magnetic field lines take outside of the magnet gap 27. It is noted that the yoke member 261, in addition to the magnet(s) 26', 26", may be attached to the respective first or second housing portion 202, 204, to still stay within the desired, low number of sub-assemblies.

[0060] In figure 10, a further preferred embodiment of a receiver 10 is illustrated which has the configuration of figure 8 but in which the membrane 28 is attached to the housing 20 in a different manner. In figure 8, as in figure 1, the membrane 28 is attached to the housing 20 by the frame 284 being provided between the first and second housing portions 202, 204. In this embodiment an inner ledge 21 is formed on which the membrane 28 or frame 284 may lie or be attached to. The ledge 21 may be provided by slightly bending the upper portions of the second housing portion 204 inwardly, or these portions may be made slightly thicker so that the ledge 21 is formed. Alternatively, an element may be attached to the first and/or second housing portion 202, 204 of the housing 20 to form a ledge 21 to which the membrane 28 and/or frame 284 may be attached. Naturally, the membrane 28 and/or frame 284 may also simply be glued or attached in other manners to the first housing portion 202 and/or second housing portion 204.

[0061] In figure 11, a further preferred embodiment of a receiver 10 is illustrated which, compared to figure 1, has a magnet yoke structure 262 which also differs from that of figure 10. The yoke structure 262 is illustrated together with the membrane 28 / frame 284, the magnet assembly 26 and the coil 24 in figure 12 from different angles. In figure 11, it is seen that the yoke structure 262 now also extends to the membrane portion 283 at the other end of the coil 24. The illustrated yoke structure 262 also extends around the magnets 26', 26" and the membrane portion 282. The return path along the yoke structure 262 and through the membrane 28 at the hinge portion 286, or even farther from the coil 24 if desired, may suffice to provide a sufficient path for the magnetic field lines. The yoke structure 262 may be provided in two parts which may each be connected to a housing portion 202, 204, so as to be handled in unison with the housing portion 202, 204 and a magnet 26', 26".

[0062] Clearly, a receiver 10 of this reduced size may be used in combination with other receivers, such as other receivers of the present design, so that a potent combination of multiple receivers may be provided which nevertheless has a limited size. Assemblies with multiple receivers may be provided which have reduced vibration or particular dimensions or cross sections.

[0063] Although the invention has been discussed in the foregoing with reference to exemplary embodiments of the invention, the invention is not restricted to these particular embodiments which can be varied in many ways without departing from the invention. The discussed exemplary embodiments shall therefore not be used to construe the appended claims strictly in accordance therewith. On the contrary, the embodiments are merely intended to explain the wording of the appended claims, without intent to limit the claims to these exemplary embodiments. The scope of protection of the invention shall therefore be construed in accordance with the appended claims only, wherein a possible ambiguity in the wording of the claims shall be resolved using these exemplary embodiments.

Claims

1. A receiver (10) comprising a coil (24), a magnet assembly (26) forming a magnet gap (27) and a membrane (28), the coil (24), magnet assembly (26) and membrane (28) provided in a housing (20) comprising a sound output opening (22) and defining an inner volume, wherein the membrane (28) divides the inner volume into a front chamber (12) and a back chamber (14), the front and back chambers (12, 14) being at least partly defined by opposite sides of the membrane (28), **characterised in that** the coil (24) has a first portion provided in the front chamber (12) and a second portion provided in the back chamber (14).

2. A receiver (10) according to claim 1, **characterised in that** the coil (24) forms a coil tunnel (23) and the magnet assembly (26) forms a magnet gap (27), the membrane (28) extending through the coil tunnel (23) and the magnet gap (27).

3. A receiver (10) according to any of the preceding claims, **characterised in that** the receiver (10) further comprising a resilient seal (30) between the membrane (28) and an inner surface of the coil (24).

4. A receiver (10) according to claim 1 or 2, **characterised in that** the receiver (10) further comprising one or more elements (288) attached to an inner surface of the coil (24) and a resilient seal (30) between the membrane (28) and the one or more elements (288).

5. A receiver (10) according to claim 4, **characterised in that** the membrane (28) is rotatable in relation to a deflecting portion (286), the one or more elements (288) being connected to the deflecting portion (286).

6. A receiver (10) according to claim 5, **characterised in that** the membrane (28) is rotatable also in relation to the one or more elements (288).

7. A receiver (10) according to any of the preceding claims, **characterised in that** the receiver further comprising a frame (284) and a resilient seal (30) provided between the membrane (28) and the frame (284).

8. A method of manufacturing a receiver (10), the method comprising:

- providing a first housing portion (202) also comprising a sound output opening (22),
- providing a first magnet (26'),
- providing a second housing portion (204), where, when the first and second housing portions (202, 204) are attached to each other, the second magnet (26") is positioned so as to generate a magnet gap (27),
- providing a membrane assembly (25) comprising a membrane (28) and a coil (24), the membrane (28) having a first membrane portion (283) extending inside the coil (24), the first membrane portion (283) configured to rotate in relation to the coil (24),

characterised in that the method further comprising

- assembling the receiver (10) by providing the membrane assembly (25) in a volume defined between the first and second housing portions (202, 204) so as to divide the space into a front and a back chamber (14), a first portion of the coil (24) being provided in the front chamber (12) and a second portion of the coil (24) being provided in the back chamber (14).

9. A method according to claim 8, **characterised in that** the step of providing the membrane assembly (25) comprises providing a membrane assembly comprising a frame (284), the membrane (28) being rotatable in relation to the frame (284), a resilient seal (30) being provided between the membrane (28) and the frame (284).

10. A method according to claim 8 or 9, **characterised in that** the method further comprising the step of providing the resilient seal (30) between an inner surface of the coil (24) and a first membrane portion (283).

11. A method according to any of claims 8-10, **charac-**

terised in that the step of providing the membrane assembly (25) comprises attaching the coil (24) in relation to the membrane (28).

12. A method according to claim 11, **characterised in that** the method further comprising fastening the coil (24) to the one or more elements (288) of the membrane (28), the membrane assembly (25) comprising a deflecting portion (286), the membrane (28) being rotatable in relation to the deflecting portion (286) and the one or more elements (288) being attached to the deflecting portion (286).

13. A method according to any of claims 8-12, **characterised in that** the step of providing the first housing portion (202) comprises providing the first housing portion (202) comprising the first magnet (26') and the step of providing the second housing portion (204) comprises providing the second housing portion (204) comprising a second magnet (26").

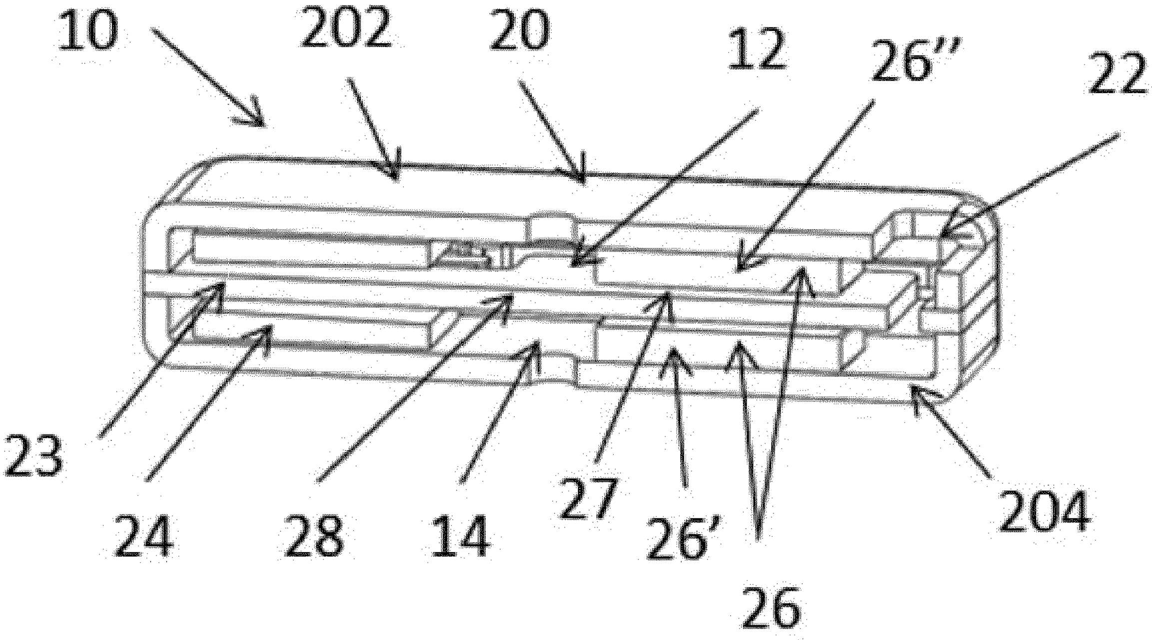

Fig. 1

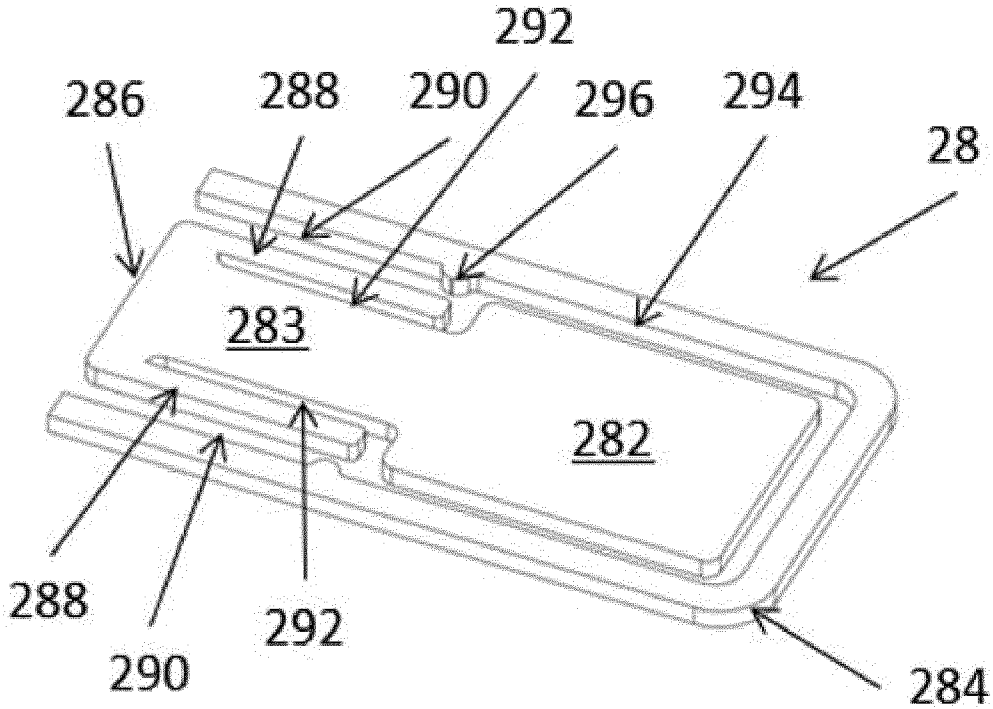

Fig. 2

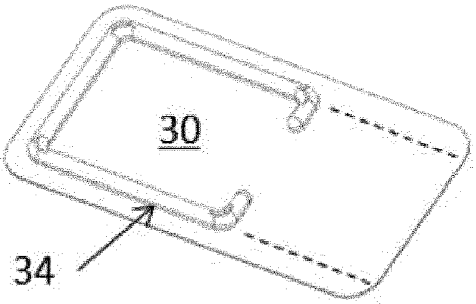

Fig. 4

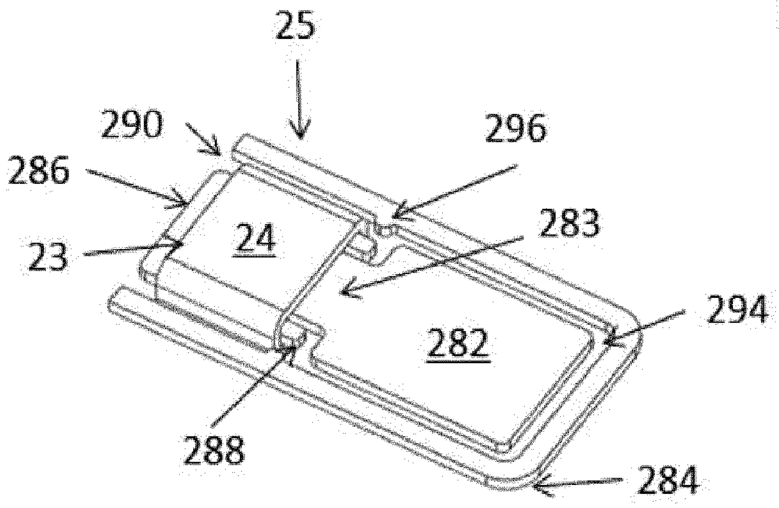

Fig. 3

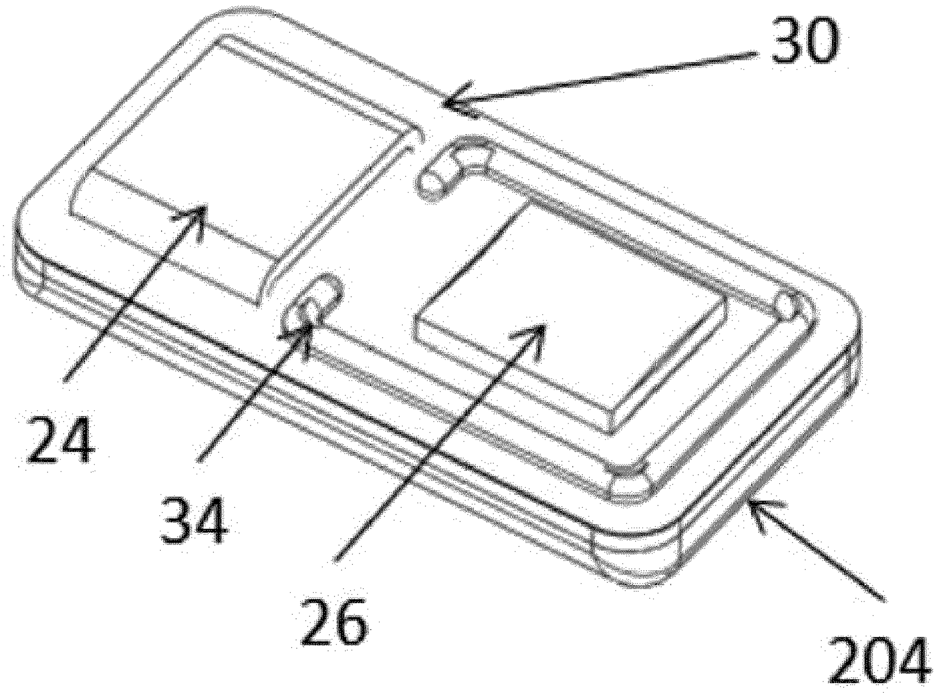

Fig.5

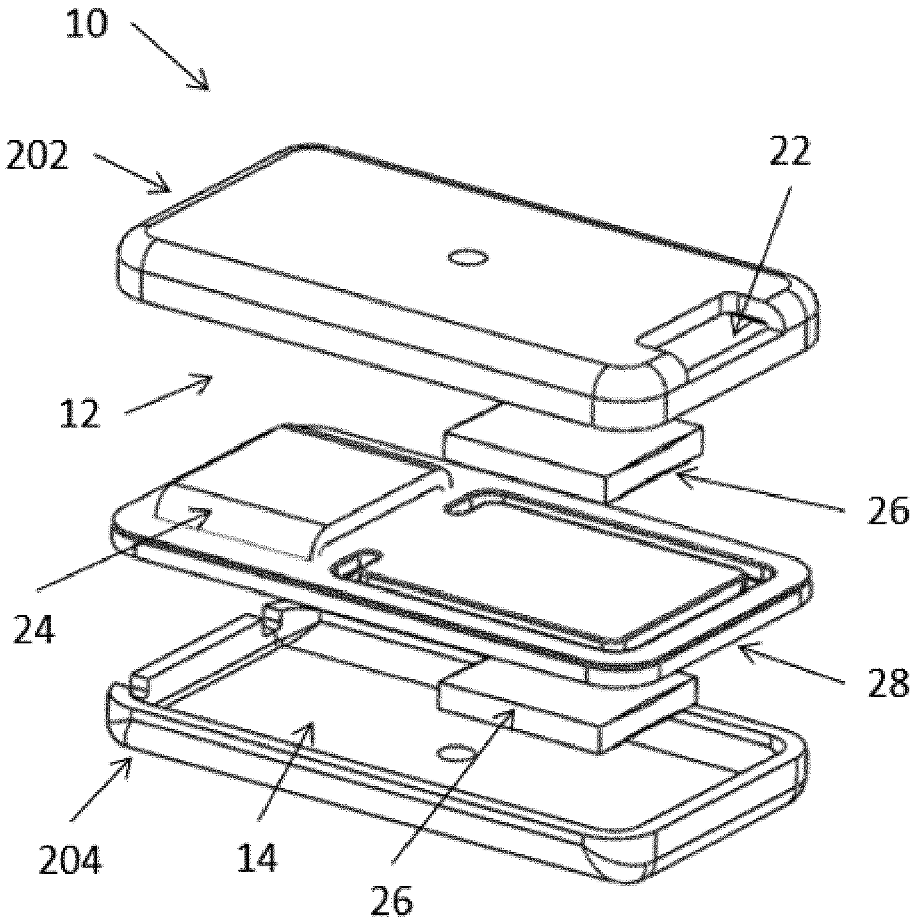

Fig. 6

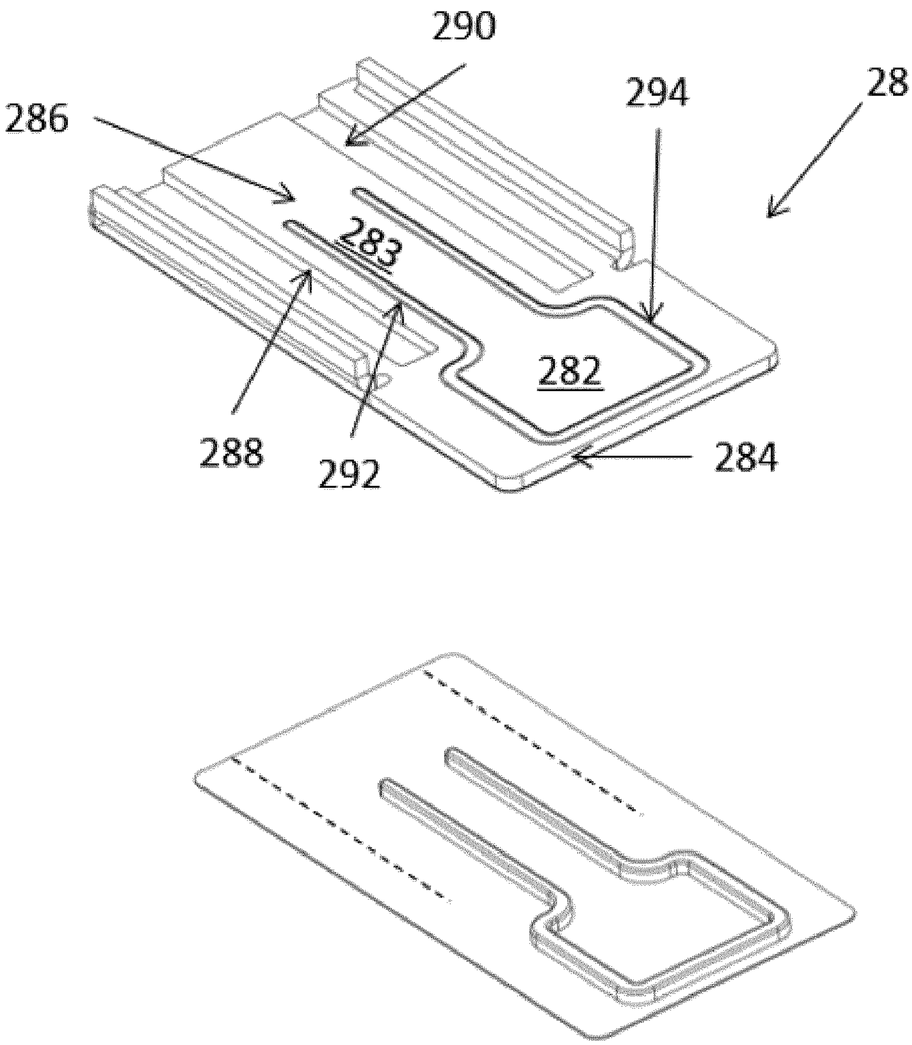

Fig.7

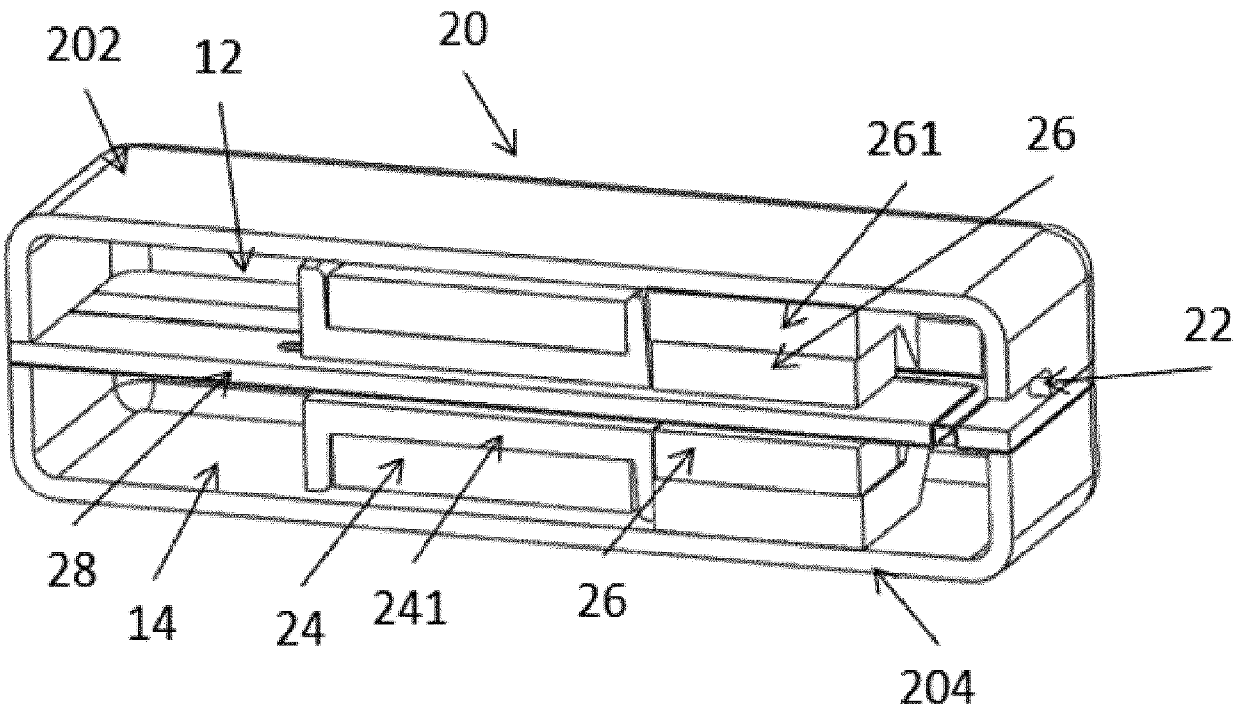

Fig. 8

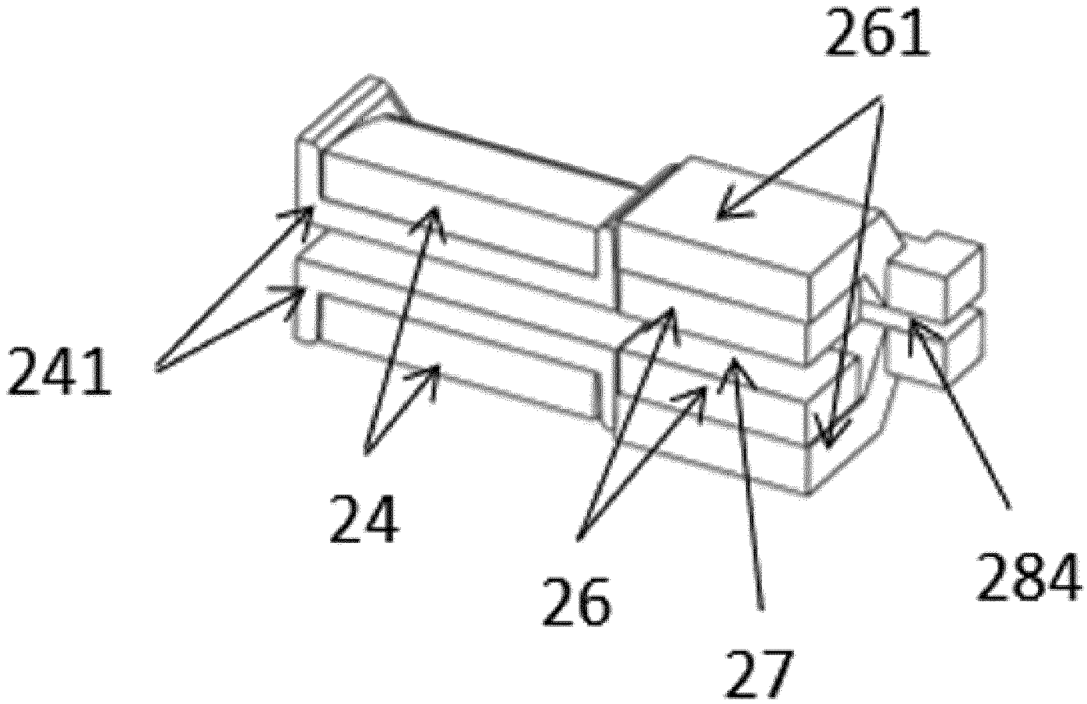

Fig. 9

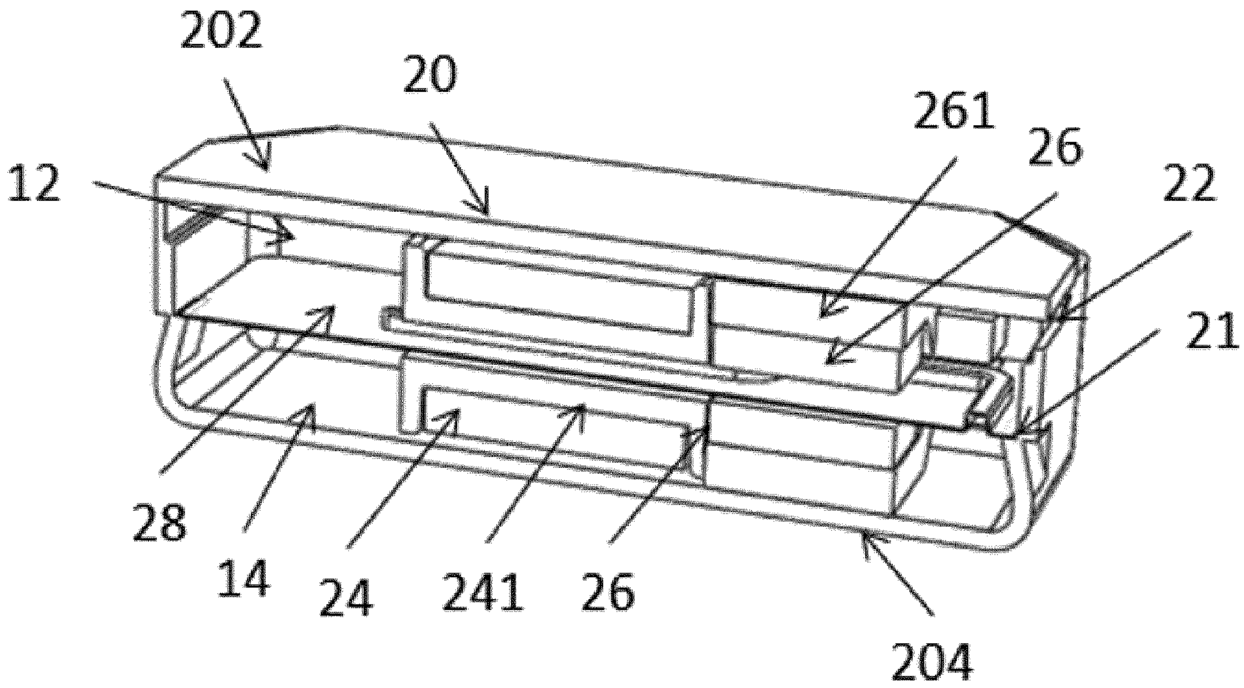

Fig. 10

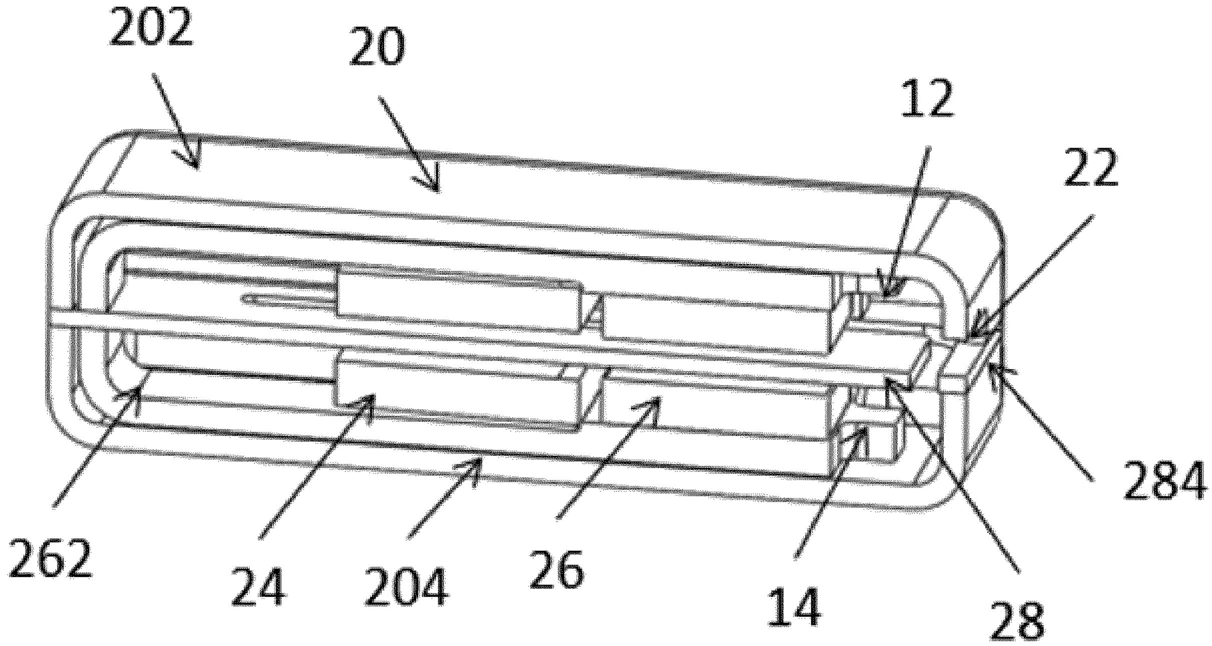

Fig. 11

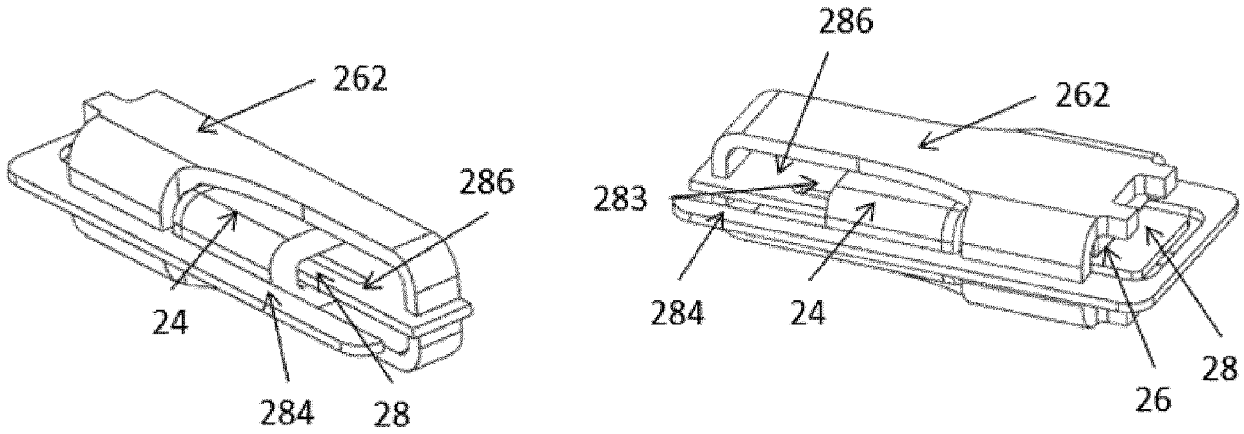

Fig. 12

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EUROPEAN SEARCH REPORT

Application Number
EP 20 18 1213

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	EP 3 648 472 A1 (SUZHOU YICHUAN ACOUSTIC TECH CO LTD [CN]) 6 May 2020 (2020-05-06) * the whole document * -----	1-13	INV. H04R11/02 H04R31/00
			TECHNICAL FIELDS SEARCHED (IPC)
			H04R

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
The Hague	17 November 2020	Fachado Romano, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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17-11-2020

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

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- EP 3342749 A **[0026]**