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(54) **HOMOGENEOUS HARD SPEAKER RADIATING DIAPHRAGMS WITH DAMPING**

HOMOGENE HARTE LAUTSPRECHERMEMBRANEN MIT DÄMPFUNG

MEMBRANES RAYONNANTES DE HAUT-PARLEUR DURES HOMOGÈNES À AMORTISSEMENT

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(56) References cited:
WO-A1-2013/181484
WO-A1-2016/044361
US-A- 6 151 402
US-A1- 2010 009 154
US-A1- 2014 370 244
US-B1- 8 976 997

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a speaker, and more particularly to a speaker having a compressed skins-tensioned core diaphragm structure.

BACKGROUND OF THE INVENTION

[0002] A speaker is a device for converting an electrical audio signal into a corresponding sound. A variety of speakers have been developed and continue to be improved since the nineteenth century. Varying with different working principles, different structural and/or topologic modifications may be made. Moreover, different vibrating materials and mechanisms may be designed for different acoustic requirements. For example, US 6,151,402 A proposes a composite diaphragm particularly suitable for being bending wave speakers by using a low-density core formed of a material selected from a group consisting of polymethacrylimide foam, Balsa wood, and epoxy with a glass microspheres filler. In another example, WO 2016/044361 A1 discloses speaker assemblies and acoustic devices comprising a panel having a long side and a short side, at least one transducer configured to excite the panel at a plurality of excitation locations on the panel to generate a wave having a wave front substantially perpendicular to the long side and propagating toward the short side of the panel and, optionally, at least one attenuating component mounted to the panel. In addition to the above exemplified bending-mode-wave and distributed-mode loudspeakers, whose speaker radiating diaphragms work with bending waves, loudspeakers working in a pistonic mode substantially without bending are also popular in the field of speakers.

[0003] In general, an electrodynamic, direct-radiating speaker is mainly composed of a magnetic circuit assembly, a voice-coil partially or wholly inside the magnetic circuit assembly, and a sound-radiating diaphragm mechanically attached to the voice-coil; and in most cases, together with other supporting parts like the diaphragm surround, suspension, also referred to as the spider or the suspension, frame, etc. As a magnetic field resulting from the alternating current flowing through the coil interacts with a magnetic field from the magnetic-circuit assembly according to Fleming's rules, the voice-coil actuates the attached portion of the diaphragm, thus the portion of the diaphragm vibrates, and propagates such vibration to the rest of the diaphragm area not directly attached to the voice-coil. As a result, the sound radiates from the whole diaphragm area in a very complex manner due to the frequency-dependent and non-linearity in the sound-propagation, absorption (damping), and boundary reflection process. Therefore, the material, structure and configuration of the diaphragm significantly influences the sound quality of the speaker.

SUMMARY OF THE INVENTION

[0004] The present invention provides a speaker as defined in claim 1, the speaker having a diaphragm structure, which is based upon an amorphous compressed skins-tensioned core structure and can be implemented in various ways to achieve satisfactory sound quality. The compressed skins-tensioned core structure comprises:

- an upper surface layer;
- a lower surface layer;
- a core disposed between the upper surface layer and the lower surface layer;
- an upper transition layer continuous with the upper surface layer at a side, and continuous with the core at another side; and
- a lower transition layer continuous with the core at a side, and continuous with the lower surface layer at another side.

[0005] Preferred embodiments of the invention are defined in the dependent claims.

[0006] The diaphragm structure may be a composite diaphragm, comprising: a first facesheet; a second facesheet; and a low-density core disposed between the first facesheet and the second facesheet, wherein at least one of the first facesheet and the second facesheet is a compressed skins-tensioned core having the structure as described above.

[0007] Alternatively, the diaphragm structure may be a composite diaphragm, comprising: a first facesheet; a second facesheet; and a corrugated compressed skins-tensioned core disposed between the first facesheet and the second facesheet, wherein at least one of the first facesheet and the second facesheet is a compressed skins-tensioned core having the structure as described above. Preferably, the corrugated core includes a plurality of first supporting portions, a plurality of second supporting portions, and a plurality of connecting portions, wherein the first supporting portions are adhered to the first facesheet, the second supporting portions are adhered to the second facesheet, and each of the connecting portions connects one of the first supporting portions to one of the second supporting portions to isolate the first supporting portions from the second facesheet and/or isolate the second supporting portions from the first facesheet.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The invention will become more readily apparent to those ordinarily skilled in the art after reviewing the following detailed description and accompanying drawings, in which:

FIG. 1 is a cross-sectional view schematically illustrating an amorphous compressed skins-tensioned core of a speaker according to an embodiment of the present invention;

FIG. 2A is a schematic diagram illustrating a first configuration of a diaphragm structure of a speaker according to the present invention;

FIG. 2B is a schematic diagram illustrating a second configuration of a diaphragm structure of a speaker according to the present invention;

FIG. 2C is a cross-sectional view of the diaphragm structure as illustrated in FIG. 2A or 2B, which is taken along a line T-T';

FIG. 2D is a schematic diagram illustrating a third configuration of a diaphragm structure of a speaker according to the present invention;

FIG. 2E is a schematic diagram illustrating a fourth configuration of a diaphragm structure of a speaker according to the present invention;

FIG. 2F is a schematic diagram illustrating a fifth configuration of a diaphragm structure of a speaker according to the present invention;

FIG. 3A is a schematic diagram illustrating a sixth configuration of a diaphragm structure of a speaker according to the present invention;

FIG. 3B is a schematic a cross-sectional view of the diaphragm structure as illustrated in FIG. 3A, which is taken along a line T-T';

FIG. 4 is a schematic diagram illustrating a seventh configuration of a diaphragm structure of a speaker according to the present invention;

FIGS. 5A~5E are schematic side views and FIGS. 5F and 5G are schematic perspective views, each exemplifying a design of a diaphragm structure of a speaker according to the present invention;

FIG. 6A is a cross-sectional view schematically illustrating a diaphragm structure of a speaker according to another embodiment of the present invention;

FIG. 6B is a cross-sectional view schematically illustrating a diaphragm structure of a speaker according to a further embodiment of the present invention;

FIG. 7A is a schematic diagram illustrating an eighth configuration of a diaphragm structure of a speaker according to the present invention;

FIG. 7B is a schematic diagram illustrating a ninth configuration of a diaphragm structure of a speaker according to the present invention; and

FIG. 8 is a schematic diagram illustrating application of a diaphragm structure according to the present invention to a speaker.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0009] The present invention provides a variety of novel designs useful in the realization of diaphragms that have significant performance advantages over other types of diaphragms used in speakers.

[0010] As known, there is energy loss when sound travels from one medium to another medium with a different acoustic impedance, even if the densities of the two media are approximately the same. Carefully managed energy loss is advantageous in achieving good sound quality. Therefore, this concept of controlled energy loss, or damping to which it is often referred, may be advantageously applied in the design of the diaphragm structure of a speaker.

[0011] Please refer to FIG. 1, in which a cross-sectional view schematically illustrates an amorphous compressed skins-tensioned core structure that can serve as a diaphragm in its entity or as a component of the diaphragm of a speaker according to an embodiment of the present invention. In addition to tailor-making a diaphragm required by the present invention, some known materials or commercially available materials may be selected and further processed into a diaphragm applicable to the present invention. The glasses as described in US 2010/0009154 A1, US 2014/0370244 A1, US 8,976,997 B1, and WO 2013/181484 A1 are some of the examples. The amorphous compressed skins-tensioned core structure 400 includes an upper surface layer 410, an upper transition layer 420, a core 430, a lower transition layer 440 and a lower surface layer 450, and each layer comprises substantially the same hard homogeneous amorphous material with variations in internal stress resulting from the density distribution of guest ions in the upper surface layer 410, upper transition layer 420, lower transition layer 440, and lower surface layer 450, which vary by depth from the skin, as a result of chemical ion exchange occurring when the untreated piece of glass is immersed in a high temperature molten salt bath creating the compressive stress layer 410 and 450, and the corresponding transition layer 420 and 440, and compensating tension in the core 430, forming the amorphous compressed skins-tensioned core structure 400 used in the present invention. The stress distribution causes variation of acoustic impedance throughout the medium. The impedance variation throughout the medium results in losses of energy as sound travels through the medium, such energy loss, as long as being well controlled, results in optimize sound quality.

[0012] If the upper surface layer 410, the upper transition layer 420, the central layer 430, the lower transition layer 440 and the lower surface layer 450 are made of the same hard homogeneous amorphous material with different internal stress parameters, the stress distribution would make sound travel with different velocity-of-sound and/or acoustic-impedance through such a medium. Since the physical vibration properties of the diaphragm layers are differentiated so as to result in some energy loss, the energy loss, as long as being well controlled, would optimize sound quality.

[0013] According to an embodiment of the present invention, it is preferred that the upper surface layer 410 and the lower surface layer 450 have similar amounts of internal compressive stress, and the core 430 exhibits compensating internal tensile stress. As for the upper transition layer 420 between the upper surface layer 410 and the core 430, and the lower transition layer 440 between the lower surface layer 450 and the core 430, they do not have constant amount of stress throughout the layer, but instead, exhibit a stress gradient from the internal compressive stress to internal tensile stress of the core.

[0014] The upper transition layer 420 has maximal internal compressive stress at the region approaching the upper surface layer 410, which approximates the internal compressive stress of the upper surface layer 410, and has maximal internal tensile stress at the region approaching the core 430, which compensates the internal tensile stress of the core 430. Likewise, the lower transition layer 440 has maximal internal compressive stress at the region approaching the lower surface layer 450, which compensates the internal compressive stress of the lower surface layer 450, and has maximal internal tensile stress at the region approaching the core 430, which approximates the internal tensile stress of the core layer 430. It is to be noted that the amorphous compressed skins-tensioned core structure layers are defined with dash lines in FIG. 1 as they do not have clear boundaries. By way of repetitive experiments, the inventor found the graded compression-tension boundaries help enhance sound quality.

[0015] Furthermore, for providing better sound quality, the overall thickness of the amorphous compressed skins-tensioned core structure 400 is preferably ranged between 25μm and 850μm. Specifically, the thickness d_1 of the upper surface layer 410 plus the upper transition layer 420 or the lower surface layer 450 plus the lower transition layer 440 is preferably ranged between 1 μm and 40μm, and the thickness d_2 of the core 430 is preferably ranged between 20μm and 800μm.

[0016] Hereinafter, embodiments of the diaphragm structure included in the speaker according to the present invention will be illustrated in more detail with reference to drawings. The embodiments are given for example only rather than for confining the implementation and the scope of the invention, which is defined by the appended claims.

[0017] Please refer to FIG. 2A and FIG. 2B, in which two embodiments of diaphragm structure included in the speaker according to the present invention are schematically illustrated. In these embodiment, both the diaphragms have a wavy structure, wherein the diaphragm structure as shown in FIG. 2A fluctuates along only the X-axis, while the diaphragm structure as shown in FIG. 2B fluctuates along both the X-axis and the Y-axis. FIG. 2C schematically illustrates a cross-sectional view of the diaphragm structure as illustrated in FIG. 2A or 2B, which is taken along a line T-T'. The diaphragm 100a as illustrated in FIG. 2A and the diaphragm 100b as illustrated in FIG. 2B, for example, may be a continuous rectangular or any other suitably shaped sheet of substantially homogeneous amorphous material. Amplitude-reduction or wavelength-extension designs may be provided at edges of the diaphragms 100a and 100b, where the diaphragm may be coupled to a voice coil, or the edges are made flat in order to facilitate the coupling of the diaphragm to other elements of the speaker.

[0018] It is to be noted that the diaphragm 100a as illustrated in FIG. 2A and the diaphragm 100b as illustrated in FIG. 2B are exemplified, but not limited, to be rectangular. According to practical designs and requirements, the contours of the diaphragms 100a and 100b may be otherwise shaped. For example, it may be formed as an obround, a circle, an oval or ellipsoid, or any other suitable shape.

[0019] FIGS. 2D-2F exemplify a variety of circular diaphragms. The diaphragm 100c as illustrated in FIG. 2D has a circular outline, and fluctuates along both the X-axis and the Y-axis. The distribution of the shaded and blank blocks shown in FIG. 2D schematically indicate the topographic feature of the diaphragm. In this example, the X-axis and the Y-axis are orthogonal to each other. Alternatively, the X-axis and the Y-axis may have any suitable included angle therebetween. In further examples, the diaphragm may fluctuate in more than two directions. Likewise, amplitude-reduction or wavelength-extension designs may be provided at an edge or edges of the diaphragm 100c, where the diaphragm may be coupled to a voice coil, or the edge or edges are made flat in order to facilitate the coupling of the diaphragm to other elements of the speaker.

[0020] Please refer to FIG. 2E, in which a diaphragm 100d is schematically illustrated. The diaphragm 100d has a circular outline, and fluctuates around its central axis, e.g. along the circumferential T-T'-line direction. On the other hand, the diaphragm 100e as illustrated in FIG. 2F has a circular outline, and fluctuates along radial directions. In these examples, the diaphragms 100d and 100e are sheet-like shaped. Alternatively, the diaphragms 100d and 100e may be made stereoscopic. For example, the diaphragms 100d and 100e may be cone-shaped or dome-shaped.

[0021] Please refer to FIGS. 3A and 3B, in which an alternative configuration of diaphragm structure is schematically illustrated. In this embodiment, the diaphragm 200 differs from the diaphragm 100e as illustrated in FIG. 2F in that the diaphragm 200 has a central hole 29 at the area where the diaphragm is coupled to a voice-coil. Likewise, a central hole may also be provided in the diaphragm 100a, 100b, 100c or 100d to form an alternative diaphragm structure. The side view of a hollow diaphragm structure is schematically illustrated in FIG. 3B. FIG. 4 schematically illustrates a diaphragm structure 300 formed by creating a central hole 29 in the diaphragm 100d as illustrated in FIG. 2E, wherein the cross-sectional view taken along the T-T' line is like the cross-sectional view as shown in in FIG. 2C, and the cross-sectional view taken along the S-S' line is line the cross-sectional view as shown in in FIG. 3B. The presence of the central hole 29 makes the continuous wavy structure break at the area where the diaphragm is coupled to a voice-coil.

[0022] In the above embodiments and examples shown in the drawings, the diaphragms are rectangular or circular flat sheets with or without central holes. Alternatively, as mentioned above, the diaphragm may be formed as an obround, a circle, an oval or ellipsoid, polygon or any other suitable shape. FIGS. 5A-5E schematically exemplify the variations of the diaphragm structures in side views. In addition, the diaphragms may be cone-shaped, dome-shaped or tunnel-shaped, as exemplified by the schematic perspective views shown in FIGS. 5F and 5G.

[0023] In other embodiments, a diaphragm included in the speaker according to the present invention has a composite structure, as illustrated in FIGS. 6A and 6B. The diaphragm 60a as illustrated in FIG. 6A includes a first facesheet 600, a second facesheet 610 and a low-density core 620 between the first and second facesheets 600 and 610. In this embodiment, the first and second facesheets 600 and 610 can be implemented with one of the facesheets described above with reference to FIGS. 1-5. Alternatively, only one of the first and second facesheets is formed of a hard and substantially homogeneous amorphous material, and the other may be formed of, for example, aluminum foil, polymer film, carbon fiber, or any other suitable material conventionally used as a diaphragm material for a speaker.

[0024] The low-density core 620 may be made of a material whose density is lower than the first facesheet 600 and the second facesheet 610, e.g. polymethacrylimide foam (PMI form), Balsa wood, epoxy with a glass microspheres filler, etc., for reducing the overall weight of the composite diaphragm 60a. The first and second facesheets 600 and 610 are attached onto the low-density core 620 with an adhesive.

[0025] The diaphragm 60b as illustrated in FIG. 6B has a structure similar to the diaphragm 60a as illustrated in FIG. 6A. In other words, it also includes a first facesheet 600 and a second facesheet 610. Nevertheless, the diaphragm 60b includes a corrugated core 630 between the first and second facesheets 600 and 610 instead of a low-density core. As shown in FIG. 6B, the corrugated core 630 includes a plurality of first supporting portions 630a, a plurality of second supporting portions 630b, and a plurality of connecting portions 630c. The first supporting portions 630a are adhered to the first facesheet 600, the second supporting portions 630b are adhered to the second facesheet 610, and each of the connecting portions 630c connects one of the first supporting portions 630a to one of the second supporting portions 630b to isolate the first supporting portions 630a from the second facesheet 610 and/or isolate the second supporting portions 630b from the first facesheet 600. The corrugated core 630, for example, may be made of aluminum foil, a sheet of paper, polymer film, or any other suitable material.

[0026] FIG. 7A and FIG. 7B further exemplify configurations of diaphragm structures included in the speakers according to the present invention. In the embodiment illustrated in FIG. 7A, a diaphragm 70 includes a central flat region 700 and a set of bent regions 710 and 720 disposed at opposite sides of the central flat region 700. The diaphragm 70 may be a single diaphragm structure or a composite diaphragm structure as described above. Alternatively, the diaphragm 70 may further include another set of bent regions 730 and 740 disposed at other opposite sides of the central flat region 700. Since a thinned and lightened large-area diaphragm might suffer from warping, the bent regions 710, 720, 730 and/or 740 are provided for enhancing the stiffness of the structure so as to remedy the resulting problems. The contours of the diaphragms as shown are exemplified to be rectangular. Nevertheless, other polygons or other shapes may be adapted for implementation. Furthermore, the number, positions and configurations of the bent regions are not limited to the examples shown in the figures as long as the object of stiffness enhancement can be achieved.

[0027] FIG. 8 schematically illustrates a speaker 80 including a diaphragm structure described as above. In this example, the diaphragm 70 as illustrated in FIG. 7A, which has one pair of opposite bent regions 710 and 720 beside the flat region 700, is used for the speaker 80. Alternatively, the diaphragm 70 as illustrated in FIG. 7B, which has two pairs of opposite bent regions 710-740 beside the flat region 700, or any other suitable diaphragm shape, may also be used. As shown, the speaker 80 includes a back plate 800, a washer 810, a magnet 820, a frame 830, a surround 840, a voice coil 850, a top iron plate 860 and the diaphragm 70. The flat region 700 of the diaphragm 70 entirely covers the magnet 820, and optionally extensively covers a portion of the frame 830 continuous with the magnet 820. According to the invention, the diaphragm 70 is kept isolated, i.e. motionally and vibrationally decoupled, from stationary elements of the speaker such as the back plate 800, washer 810, magnet 820 and frame 830, and only in contact with the motional elements of the speaker 80 such as the surround 840 and voice coil 850. Moreover, it is preferred that the dimension of the bent regions 710 and 720 are consistent to that of the frame 830 and surround 840 in a manner that the bent regions 710 and 720 can be received in the space inherently constructed by these elements without increasing the overall thickness of the speaker.

[0028] In further embodiments, the diaphragms illustrated in FIGS. 1-6 may be used for the speaker in lieu of the diaphragm 70 or may constitute a portion of the diaphragm.

[0029] It is understood from the above embodiments, examples and descriptions that according to the present invention, at least a part of the diaphragm is made of hard and graded compression-tension boundary substantially homogeneous amorphous materials, such as silicon dioxide. Furthermore, new 3D variations and overall shapes are provided for achieving good sound quality.

[0030] In addition to the above-described embodiments, the configurations of a diaphragm structure of a speaker according to the present invention may be selected from a variety of combinations of the following features, e.g. surface, overall curvature, and overall "bird's-eye view" shape bird's-eye view" shape of the diaphragm structure may be, for example, rectangular (including square), round, obround, or oval (including elliptical).

Claims

1. A speaker (80) comprising:

stationary elements (800, 810, 820, 830), such as a back plate (800), a washer (810), a magnet (820) and a frame (830);
motional elements (840, 850), such as a surround (840) and a voice coil (850); and
a diaphragm structure (100a, 100b, 100c, 100d, 100e, 200, 300, 60a, 60b, 70) which includes a compressed skins-tensioned core structure (400), wherein the compressed skins-tensioned core structure (400) comprises:

an upper surface layer (410);
a lower surface layer (450);
a core (430) disposed between the upper surface layer (410) and the lower surface layer (450);
an upper transition layer (420) continuous with the upper surface layer (410) at a side, and continuous with the core (430) at another side; and
a lower transition layer (440) continuous with the core (430) at a side, and continuous with the lower surface layer (450) at another side;

wherein each of the upper surface layer (410), the lower surface layer (450), the core (430), the upper transition layer (420) and the lower transition layer (440) is formed of a substantially homogeneous amorphous material; and
wherein each of the upper surface layer (410) and the lower surface layer (450) exhibits an internal compressive stress, the core (430) exhibits an internal tensile stress, and each of the upper transition layer (420) and the lower transition layer (440) exhibits a stress gradient from the internal compressive stress to the internal tensile stress;
characterized in that
the diaphragm structure (100a, 100b, 100c, 100d, 100e, 200, 300, 60a, 60b, 70) is kept isolated from the stationary elements (800, 810, 820, 830) and only in contact with the motional elements (840, 850) of the speaker (80).

2. The speaker (80) according to claim 1, wherein the internal compressive stress of the upper surface layer (410) is substantially equal to the internal compressive stress of the lower surface layer (450).

3. The speaker (80) according to claim 1, wherein the upper transition layer (420) has a maximal internal compressive stress at an area approaching the upper surface layer (410), which is substantially equal to the internal compressive stress of the upper surface layer (410), and has a maximal internal tensile stress at an area approaching the core (430), which is substantially equal to the internal tensile stress of the core (430).

4. The speaker (80) according to claim 1, wherein the lower transition layer (440) has a maximal internal compressive stress at an area approaching the lower surface layer (450), which is substantially equal to the internal compressive stress of the lower surface layer (450), and has a maximal internal tensile stress at an area approaching the core (430), which is substantially equal to the internal tensile stress of the core (430).

5. The speaker (80) according to claim 1, wherein an overall thickness of the diaphragm structure (100a, 100b, 100c, 100d, 100e, 200, 300, 60a, 60b, 70) is ranged between 25μm and 850μm, and a thickness of the upper surface layer (410) plus the upper transition layer (420) or the lower surface layer (450) plus the lower transition layer (440) is preferably ranged between 1μm and 40μm, and a thickness of the core (430) is preferably ranged between 20μm and 800μm.

6. The speaker (80) according to claim 1, wherein the substantially homogeneous amorphous material includes silicon dioxide.

7. The speaker (80) according to claim 1, wherein the diaphragm structure (70) has a flat region (700) and at least two bent regions (710, 720) continuous with different sides of the flat region (700), and the bent regions (710, 720) is received in a space defined by the stationary elements (810, 830) of the speaker (80) without increasing the overall thickness of the speaker (80).

8. The speaker (80) according to claim 7, wherein the at least two bent regions include two bent regions (710, 720) respectively contiguous with two opposite sides of the flat region (700).

9. The speaker (80) according to claim 8, wherein the at least two bent regions include four bent regions (710, 720, 730, 740) respectively contiguous with two pairs of opposite sides of the flat region (700).

10. The speaker (80) according to claim 1, wherein the diaphragm structure (60a) is a composite diaphragm which comprises:

a first facesheet (600);
a second facesheet (610); and
a low-density core (620) disposed between the first facesheet (600) and the second facesheet (610),
wherein at least one of the first facesheet (600) and the second facesheet (610) is implemented with the compressed skins-tensioned core structure (400).

11. The speaker (80) according to claim 10, wherein the low-density core (620) is formed of a material whose density is lower than the first facesheet (600) and the second facesheet (610).

12. The speaker (80) according to claim 10, wherein the low-density core (620) is formed of a material selected from a group consisting of polymethacrylimide foam (PMI form), Balsa wood, and epoxy with a glass microspheres filler.

13. The speaker (80) according to claim 1, wherein the diaphragm structure (60b) is a composite diaphragm which comprises:

a first facesheet (600);
a second facesheet (610); and
a corrugated core (620) disposed between the first facesheet (600) and the second facesheet (610),
wherein at least one of the first facesheet (600) and the second facesheet (610) is implemented with the compressed skins-tensioned core structure (400).

14. The speaker (80) according to claim 13, wherein the corrugated core (630) includes a plurality of first supporting portions (630a), a plurality of second supporting portions (630b), and a plurality of connecting portions (630c), wherein the first supporting portions (630a) are adhered to the first facesheet (600), the second supporting portions (630b) are adhered to the second facesheet (610), and each of the connecting portions (630c) connects one of the first supporting portions (630a) to one of the second supporting portions (630b) to isolate the first supporting portions (630a) from the second facesheet (610) and/or isolate the second supporting portions (630b) from the first facesheet (600).

15. The speaker (80) according to claim 13, wherein the corrugated core (630) is made of an aluminum foil, a sheet of paper, or a polymer film.

Patentansprüche

1. Lautsprecher (80), umfassend:

stationäre Elemente (800, 810, 820, 830), wie beispielsweise eine Rückplatte (800), eine Unterlegscheibe (810), einen Magneten (820) und einen Rahmen (830);
bewegliche Elemente (840, 850), wie beispielsweise eine Einfassung (840) und eine Schwingspule (850); und
eine Membranstruktur (100a, 100b, 100c, 100d, 100e, 200, 300, 60a, 60b, 70), die eine mit zusammengedrückten Häuten gespannte Kernstruktur (400) umfasst, wobei die mit zusammengedrückten Häuten gespannte Kernstruktur (400) Folgendes umfasst:

eine obere Oberflächenschicht (410);
eine untere Oberflächenschicht (450);
einen Kern (430), der zwischen der oberen Oberflächenschicht (410) und der unteren Oberflächenschicht (450) angeordnet ist;
eine obere Übergangsschicht (420), die auf einer Seite an die obere Oberflächenschicht (410) anschließt und auf einer anderen Seite an den Kern (430) anschließt; und
eine untere Übergangsschicht (440), die auf einer Seite an den Kern (430) anschließt und auf einer anderen Seite an die untere Oberflächenschicht (450) anschließt;
wobei sowohl die obere Oberflächenschicht (410), die untere Oberflächenschicht (450), der Kern (430), die obere Übergangsschicht (420) als auch die untere Übergangsschicht (440) aus einem im Wesentlichen homogenen amorphen Material ausgebildet sind; und
wobei sowohl die obere Oberflächenschicht (410) als auch die untere Oberflächenschicht (450) eine Druckeigenspannung aufweisen, der Kern (430) eine Zugeigenspannung aufweist und sowohl die obere Übergangsschicht (420) als auch die untere Übergangsschicht (440) ein Spannungsgefälle von der Druckeigenspannung zu der Zugeigenspannung aufweisen;
dadurch gekennzeichnet, dass
die Membranstruktur (100a, 100b, 100c, 100d, 100e, 200, 300, 60a, 60b, 70) von den stationären Elementen (800, 810, 820, 830) isoliert und nur mit den beweglichen Elementen (840, 850) des Lautsprechers (80) in Kontakt gehalten wird.

2. Lautsprecher (80) nach Anspruch 1, wobei die Druckeigenspannung der oberen Oberflächenschicht (410) im Wesentlichen gleich der Druckeigenspannung der unteren Oberflächenschicht (450) ist.

3. Lautsprecher (80) nach Anspruch 1, wobei die obere Übergangsschicht (420) eine maximale Druckeigenspannung in einem der oberen Oberflächenschicht (410) angenäherten Bereich aufweist, die im Wesentlichen gleich der Druckeigenspannung der oberen Oberflächenschicht (410) ist, und eine maximale Zugeigenspannung in einem dem Kern (430) angenäherten Bereich aufweist, die im Wesentlichen gleich der Zugeigenspannung des Kerns (430) ist.

4. Lautsprecher (80) nach Anspruch 1, wobei die untere Übergangsschicht (440) eine maximale Druckeigenspannung in einem der unteren Oberflächenschicht (450) angenäherten Bereich aufweist, die im Wesentlichen gleich der Druckeigenspannung der unteren Oberflächenschicht (450) ist, und eine maximale Zugeigenspannung in einem dem Kern (430) angenäherten Bereich aufweist, die im Wesentlichen gleich der Zugeigenspannung des Kerns (430) ist.

5. Lautsprecher (80) nach Anspruch 1, wobei eine Gesamtdicke der Membranstruktur (100a, 100b, 100c, 100d, 100e, 200, 300, 60a, 60b, 70) in einem Bereich zwischen 25 μm und 850 μm liegt und eine Dicke der oberen Oberflächenschicht (410) plus der oberen Übergangsschicht (420) oder der unteren Oberflächenschicht (450) plus der unteren Übergangsschicht (440) bevorzugt in einem Bereich zwischen 1 μm und 40 μm liegt und eine Dicke des Kerns (430) bevorzugt in einem Bereich zwischen 20 μm und 800 μm liegt.

6. Lautsprecher (80) nach Anspruch 1, wobei das im Wesentlichen homogene amorphe Material Siliziumdioxid umfasst.

7. Lautsprecher (80) nach Anspruch 1, wobei die Membranstruktur (70) einen flachen Bereich (700) und mindestens zwei gebogene Bereiche (710, 720) aufweist, die an verschiedene Seiten des flachen Bereichs (700) anschließen, und die gebogenen Bereiche (710, 720) in einem Raum aufgenommen werden, der durch die stationären Elemente (810, 830) des Lautsprechers (80) definiert ist, ohne die Gesamtdicke des Lautsprechers (80) zu erhöhen.

8. Lautsprecher (80) nach Anspruch 7, wobei die mindestens zwei gebogenen Bereiche zwei gebogene Bereiche (710, 720) aufweisen, die jeweils an zwei gegenüberliegende Seiten des flachen Bereichs (700) anschließen.

9. Lautsprecher (80) nach Anspruch 8, wobei die mindestens zwei gebogenen Bereiche vier gebogene Bereiche (710, 720, 730, 740) aufweisen, die jeweils an zwei Paare von gegenüberliegenden Seiten des flachen Bereichs (700) anschließen.

10. Lautsprecher (80) nach Anspruch 1, wobei die Membranstruktur (60a) eine Verbundmembran ist, die Folgendes umfasst:

eine erste Außenlage (600);
eine zweite Außenlage (610); und
einen Kern (620) niedriger Dichte, der zwischen der ersten Außenlage (600) und der zweiten Außenlage (610) angeordnet ist,
wobei mindestens eine von der ersten Außenlage (600) und der zweiten Außenlage (610) mit der mit zusammengedrückten Häuten gespannten Kernstruktur (400) umgesetzt ist.

11. Lautsprecher (80) nach Anspruch 10, wobei der Kern (620) niedriger Dichte aus einem Material ausgebildet ist, dessen Dichte niedriger als die der ersten Außenlage (600) und der zweiten Außenlage (610) ist.

12. Lautsprecher (80) nach Anspruch 10, wobei der Kern (620) niedriger Dichte aus einem Material ausgebildet ist, das ausgewählt ist aus einer Gruppe, bestehend aus Polymethacrylimid-Schaumstoff (PMI-Schaumstoff), Balsaholz und Epoxid mit einem Füllstoff aus Glaskügelchen.

13. Lautsprecher (80) nach Anspruch 1, wobei die Membranstruktur (60b) eine Verbundmembran ist, die Folgendes umfasst:

eine erste Außenlage (600);
eine zweite Außenlage (610); und
einen Wellprofilkern (620), der zwischen der ersten Außenlage (600) und der zweiten Außenlage (610) angeordnet ist,
wobei mindestens eine von der ersten Außenlage (600) und der zweiten Außenlage (610) mit der mit zusammengedrückten Häuten gespannten Kernstruktur (400) umgesetzt ist.

14. Lautsprecher (80) nach Anspruch 13, wobei der Wellprofilkern (630) eine Vielzahl von ersten Stützabschnitten (630a), eine Vielzahl von zweiten Stützabschnitten (630b) und eine Vielzahl von Verbindungsabschnitten (630c) umfasst, wobei die ersten Stützabschnitte (630a) mit der ersten Außenlage (600) verklebt sind, die zweiten Stützabschnitte (630b) mit der zweiten Außenlage (600) verklebt sind und jeder der Verbindungsabschnitte (630c) einen der ersten Stützabschnitte (630a) mit einem der zweiten Stützabschnitte (630b) verbindet, um die ersten Stützabschnitte (630a) von der zweiten Außenlage (610) zu isolieren und/oder die zweiten

Stützabschnitte (630b) von der ersten Außenlage (600) zu isolieren.

15. Lautsprecher (80) nach Anspruch 13, wobei der Wellprofilkern (630) aus einer Aluminiumfolie, einem Blatt Papier oder einem Polymerfilm hergestellt ist.

Revendications

1. Haut-parleur (80) comprenant :

des éléments fixes (800, 810, 820, 830), tels qu'une plaque arrière (800), une rondelle (810), un aimant (820) et un châssis (830) ;
des éléments mobiles (840, 850), tels qu'une enceinte (840) et une bobine acoustique (850) ; et
une structure de membrane (100a, 100b, 100c, 100d, 100e, 200, 300, 60a, 60b, 70) qui comporte une structure d'âme à peau tendue comprimée (400), dans lequel la structure d'âme à peau tendue comprimée (400) comprend :

une couche de surface supérieure (410) ;
une couche de surface inférieure (450) ;
une âme (430) disposée entre la couche de surface supérieure (410) et la couche de surface inférieure (450) ;
une couche de transition supérieure (420) continue avec la couche de surface supérieure (410) au niveau d'un côté, et continue avec l'âme (430) au niveau d'un autre côté ; et
une couche de transition inférieure (440) continue avec l'âme (430) au niveau d'un côté, et continue avec la couche de surface inférieure (450) au niveau d'un autre côté ;
dans lequel chacune de la couche de surface supérieure (410), de la couche de surface inférieure (450), de l'âme (430), de la couche de transition supérieure (420) et de la couche de transition inférieure (440) est formée d'un matériau amorphe sensiblement homogène ; et
dans lequel chacune de la couche de surface supérieure (410) et de la couche de surface inférieure (450) présente une contrainte de compression interne, l'âme (430) présente une contrainte de traction interne, et chacune de la couche de transition supérieure (420) et de la couche de transition inférieure (440) présente un gradient de contrainte entre la contrainte de compression interne et la contrainte de traction interne ;
caractérisé en ce que
la structure de membrane (100a, 100b, 100c, 100d, 100e, 200, 300, 60a, 60b, 70) est maintenue isolée des éléments fixes (800, 810, 820, 830) et uniquement en contact avec les éléments mobiles (840, 850) du haut-parleur (80).

2. Haut-parleur (80) selon la revendication 1, dans lequel la contrainte de compression interne de la couche de surface supérieure (410) est sensiblement égale à la contrainte de compression interne de la couche de surface inférieure (450).

3. Haut-parleur (80) selon la revendication 1, dans lequel la couche de transition supérieure (420) a une contrainte de compression interne maximale au niveau d'une zone proche de la couche de surface supérieure (410), qui est sensiblement égale à la contrainte de compression interne de la couche de surface supérieure (410), et a une contrainte de traction interne maximale au niveau d'une zone proche de l'âme (430), qui est sensiblement égale à la contrainte de traction interne de l'âme (430).

4. Haut-parleur (80) selon la revendication 1, dans lequel la couche de transition inférieure (440) a une contrainte de compression interne maximale au niveau d'une zone proche de la couche de surface inférieure (450), qui est sensiblement égale à la contrainte de compression interne de la couche de surface inférieure (450), et a une contrainte de traction interne maximale au niveau d'une zone proche de l'âme (430), qui est sensiblement égale à la contrainte de traction interne de l'âme (430).

5. Haut-parleur (80) selon la revendication 1, dans lequel une épaisseur globale de la structure de membrane (100a, 100b, 100c, 100d, 100e, 200, 300, 60a, 60b, 70) est dans une plage entre 25 μm et 850 μm, et une épaisseur de la couche de surface supérieure (410) plus la couche de transition supérieure (420) ou de la couche de surface inférieure (450) plus la couche de transition inférieure (440) est de préférence dans une plage entre 1 μm et 40 μm, et une épaisseur de l'âme (430) est de préférence dans une plage entre 20 μm et 800 μm.

6. Haut-parleur (80) selon la revendication 1, dans lequel le matériau amorphe sensiblement homogène comporte du dioxyde de silicium.

7. Haut-parleur (80) selon la revendication 1, dans lequel la structure de membrane (70) a une région plate (700) et au moins deux régions fléchies (710, 720) continues avec des côtés différents de la région plate (700), et les régions fléchies (710, 720) sont reçues dans un espace défini par les éléments fixes (810, 830) du haut-parleur (80) sans augmentation de l'épaisseur globale du haut-parleur (80).

8. Haut-parleur (80) selon la revendication 7, dans lequel les au moins deux régions fléchies comportent deux régions fléchies (710, 720) respectivement contiguës à deux côtés opposés de la région plate (700).

9. Haut-parleur (80) selon la revendication 8, dans lequel les au moins deux régions fléchies comportent quatre régions fléchies (710, 720, 730, 740) respectivement contiguës à deux paires de côtés opposés de la région plate (700).

10. Haut-parleur (80) selon la revendication 1, dans lequel la structure de membrane (60a) est une membrane composite qui comprend :

une première feuille de revêtement (600) ;
une seconde feuille de revêtement (610) ; et
une âme basse densité (620) disposée entre la première feuille de revêtement (600) et la seconde feuille de revêtement (610),
dans lequel au moins l'une de la première feuille de revêtement (600) et de la seconde feuille de revêtement (610) est mise en œuvre avec la structure d'âme à peau tendue comprimée (400).

11. Haut-parleur (80) selon la revendication 10, dans lequel l'âme basse densité (620) est formée d'un matériau dont la densité est inférieure à la première feuille de revêtement (600) et à la seconde feuille de revêtement (610).

12. Haut-parleur (80) selon la revendication 10, dans lequel l'âme basse densité (620) est formée d'un matériau choisi dans un groupe constitué par la mousse de polyméthacrylimide (mousse PMI), le Balsa, et un époxy avec une charge à microsphères en verre.

13. Haut-parleur (80) selon la revendication 1, dans lequel la structure de membrane (60b) est une membrane composite qui comprend :

une première feuille de revêtement (600) ;
une seconde feuille de revêtement (610) ; et
une âme ondulée (620) disposée entre la première feuille de revêtement (600) et la seconde feuille de revêtement (610),
dans lequel au moins l'une de la première feuille de revêtement (600) et de la seconde feuille de revêtement (610) est mise en œuvre avec la structure d'âme à peau tendue comprimée (400).

14. Haut-parleur (80) selon la revendication 13, dans lequel l'âme ondulée (630) comporte une pluralité de premières portions de support (630a), une pluralité de secondes portions de support (630b), et une pluralité de portions de raccordement (630c), dans lequel les premières portions de support (630a) sont mises à adhérer à la première feuille de revêtement (600), les secondes portions de support (630b) sont mises à adhérer à la seconde feuille de revêtement (610), et chacune des portions de raccordement (630c) raccorde l'une des premières portions de support (630a) à l'une des secondes portions de support (630b) pour isoler les premières portions de support (630a) de la seconde feuille de revêtement (610) et/ou isoler les secondes portions de support (630b) de la première feuille de revêtement (600).

15. Haut-parleur (80) selon la revendication 13, dans lequel l'âme ondulée (630) est constituée d'une feuille d'aluminium, d'une feuille de papier, ou d'un film de polymère.

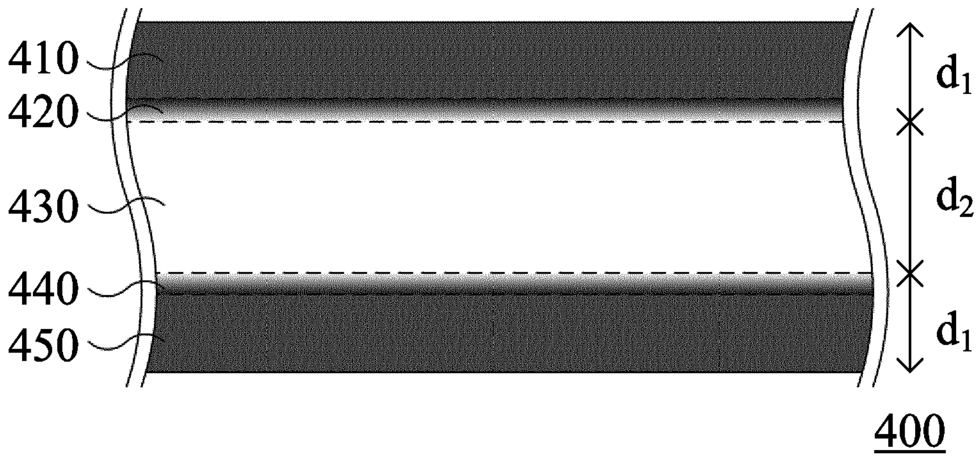

FIG. 1

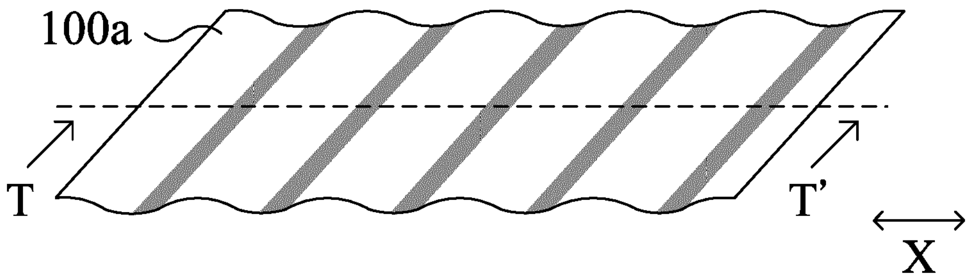

FIG. 2A

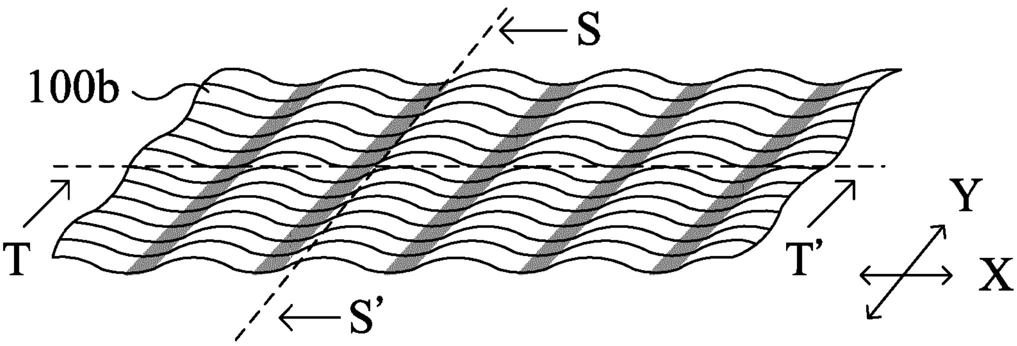

FIG. 2B

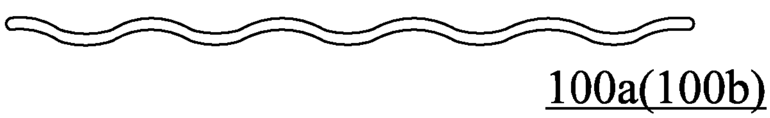

FIG. 2C

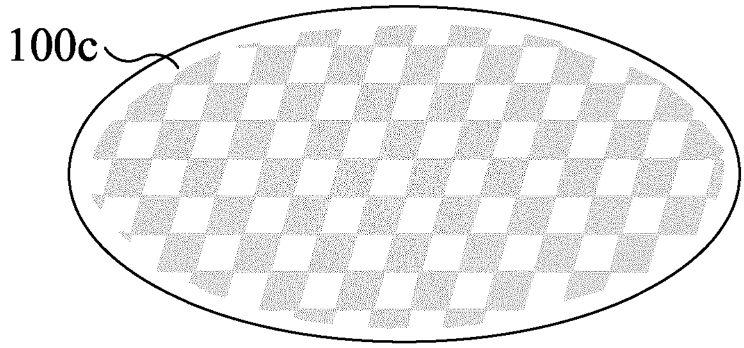

FIG. 2D

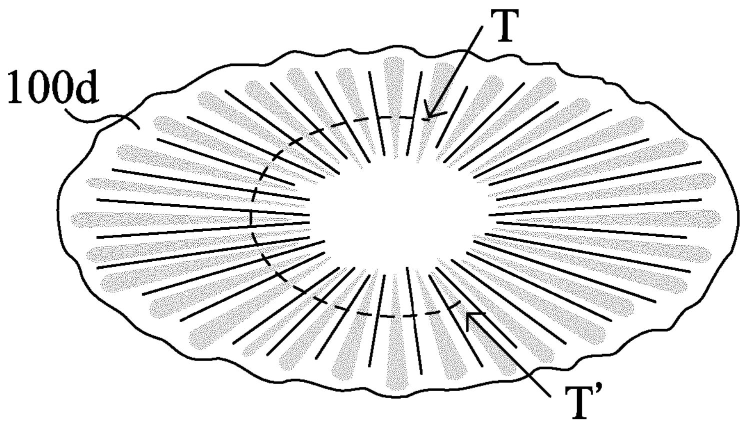

FIG. 2E

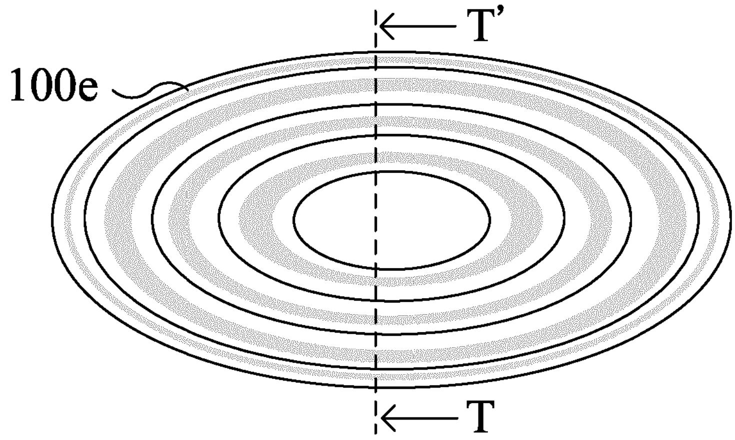

FIG. 2F

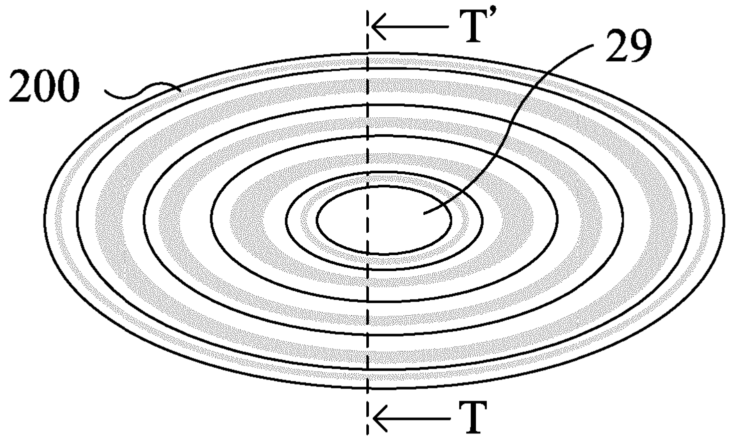

FIG. 3A

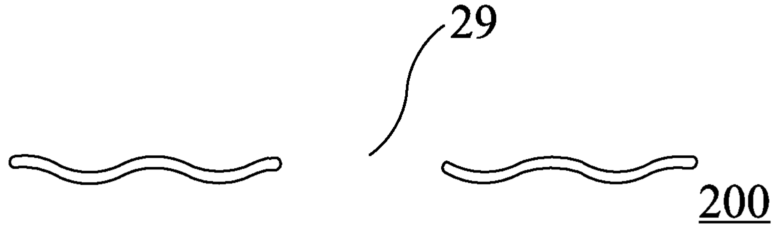

FIG. 3B

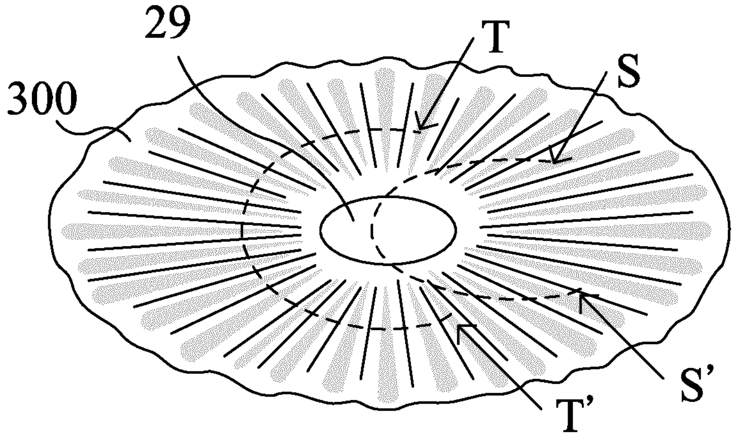

FIG. 4

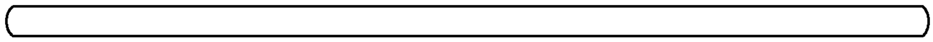

FIG. 5A

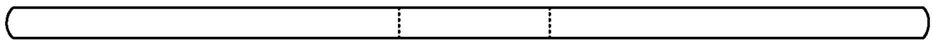

FIG. 5B

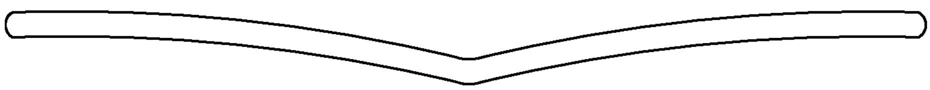

FIG. 5C

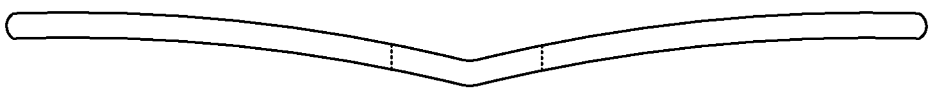

FIG. 5D

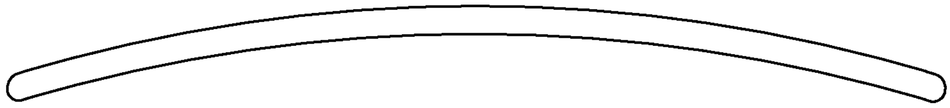

FIG. 5E

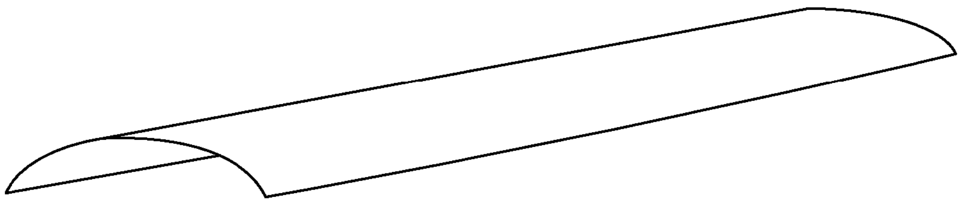

FIG. 5F

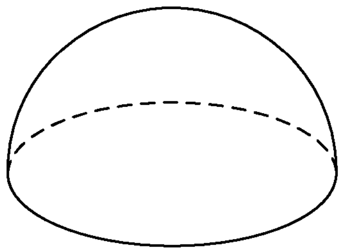

FIG. 5G

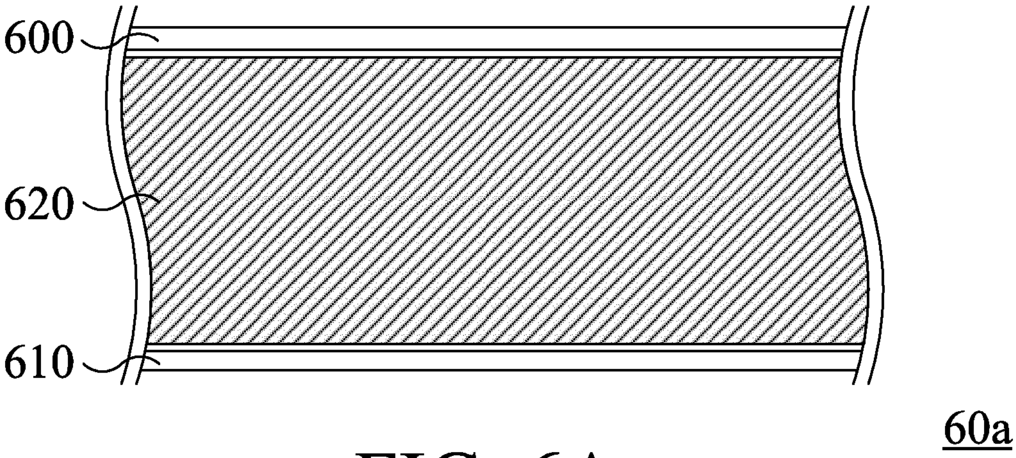

FIG. 6A

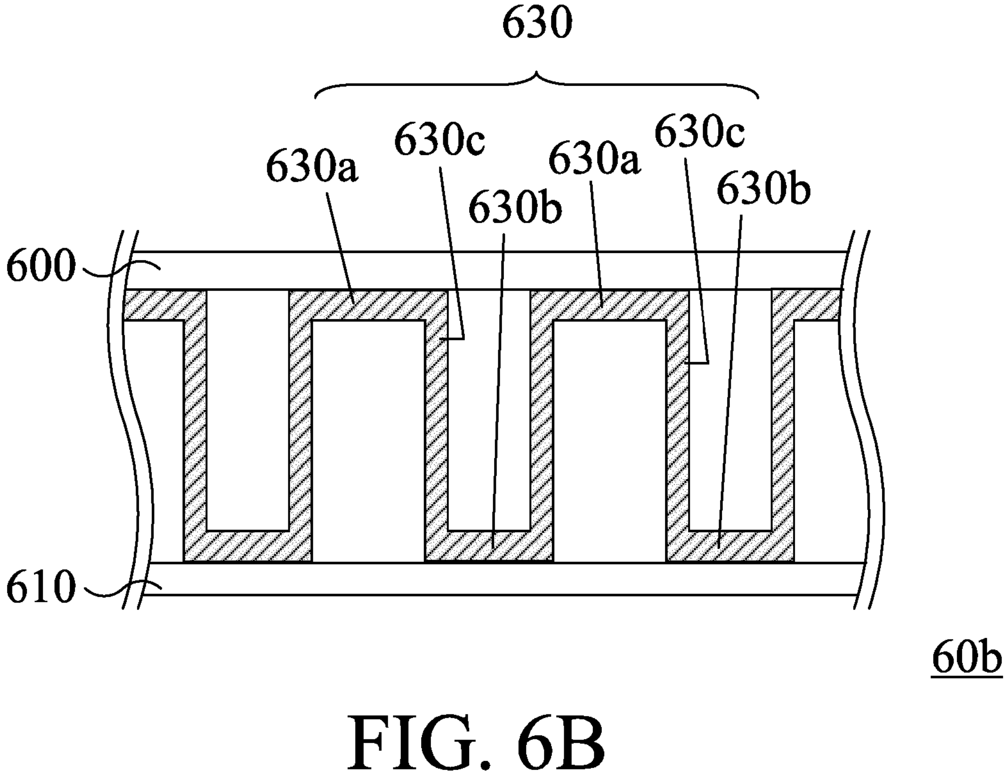

FIG. 6B

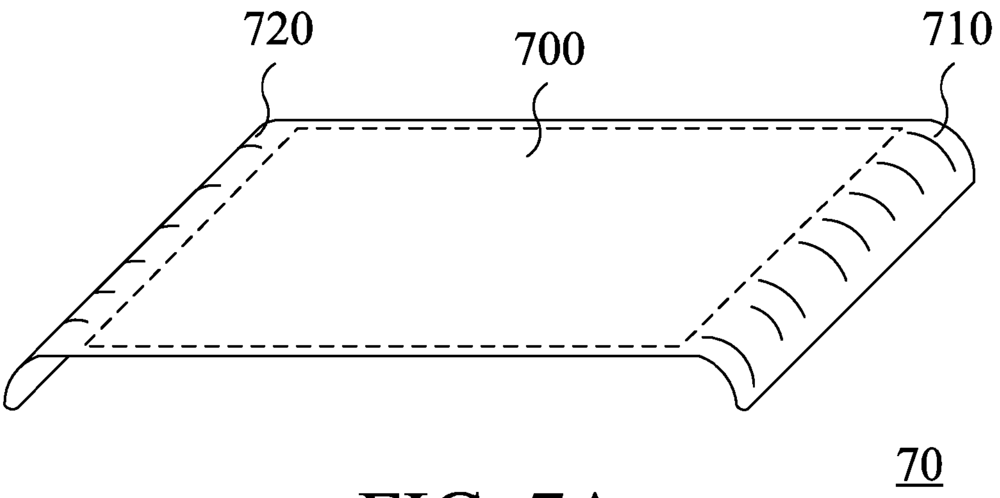

FIG. 7A

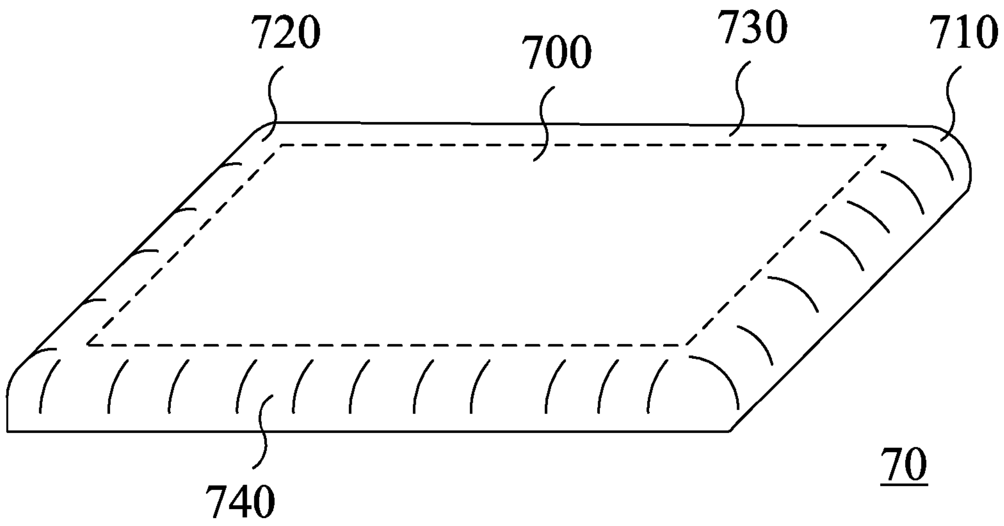

FIG. 7B

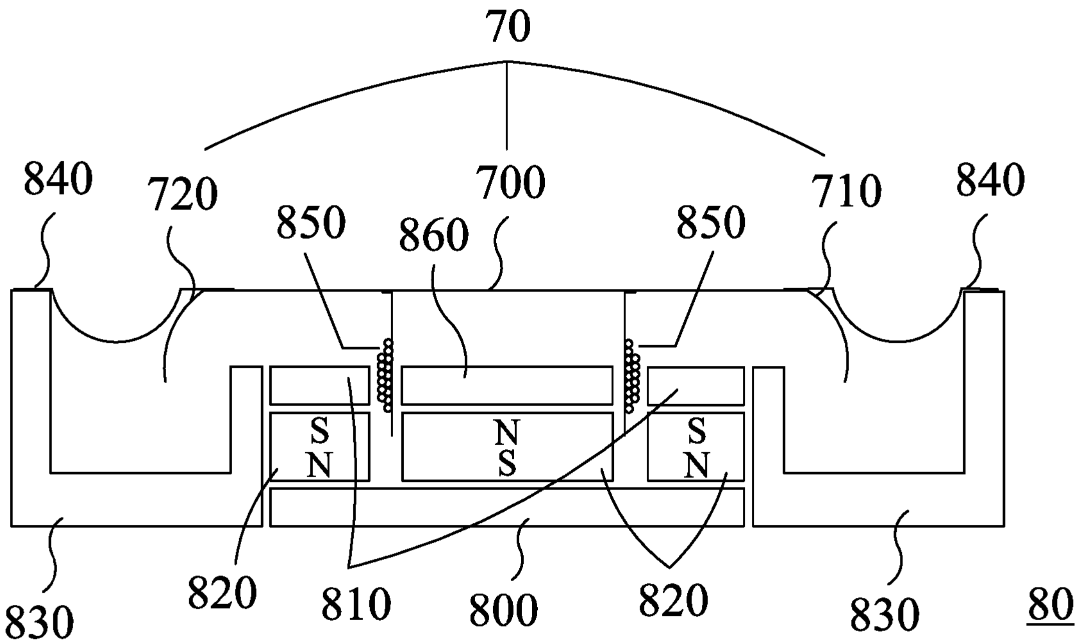
70
840
720
850
860
700
850
710
840
S
N
N
S
S
N
830
820
810
800
820
830
80

FIG. 8

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 6151402 A **[0002]**
- WO 2016044361 A1 **[0002]**
- US 20100009154 A1 **[0011]**
- US 20140370244 A1 **[0011]**
- US 8976997 B1 **[0011]**
- WO 2013181484 A1 **[0011]**