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(54) **WAVE-SHAPED SUSPENSION EDGE STRUCTURE AND VIBRATION UNIT**

(57) The invention discloses a wave-shaped suspension edge structure. The wave-shaped suspension edge structure includes an elastic suspension edge. The elastic suspension edge is provided around a vibration element and extended between the vibration element and a supporting frame, and the elastic suspension edge further includes a plurality of wave-shaped retaining sections. The wave-shaped retaining sections forms a wave-shaped structure along a circumferential direction around the vibration element so as to ensure a movement direction of the vibration element is kept an axial direction, thereby preventing the vibration element from shaking and deviating. The wave-shaped suspension edge structure is suitable for manufacturing a loudspeaker or a passive vibration plate.

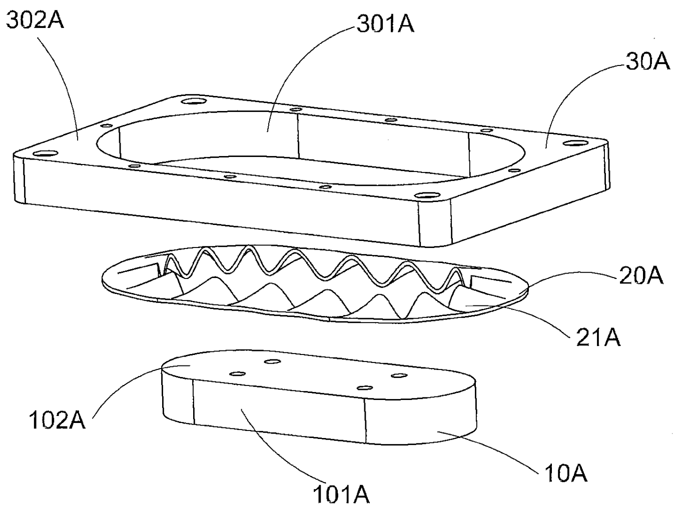

FIG. 7

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Description

NOTICE OF COPYRIGHT

CROSS REFERENCE OF RELATED APPLICATION

[0002] This is a non-provisional application that claims priority to international application number PCT/CN2015/070682, international filing date Jan 14, 2015, which claims priority to first Chinese application number 201410019799.9, filing data Jan 16, 2014, second Chinese application number 201410328141.6, filing data Oct 7, 2014, the entire contents of each of which are expressly incorporated herein by reference.

BACKGROUND OF THE PRESENT INVENTION

FIELD OF INVENTION

[0003] The present invention relates to an acoustic device, and more particularly to a wave-shaped suspension edge structure of a vibration unit of a loudspeaker.

DESCRIPTION OF RELATED ARTS

[0004] A conventional acoustic device, such as a speaker, generally comprises a speaker frame, a vibration diaphragm supported by the speaker frame, a voice coil coupled at the vibration diaphragm, and a magnetic coil unit magnetically inducing with voice coil in order to drive the vibration diaphragm to vibrate for sound reproduction. In particular, the vibration diaphragm is mounted at an opening of the speaker frame, wherein when the voice coil is magnetically induced to reciprocatingly move, the vibration diaphragm is driven to vibrate correspondingly. However, the vibration direction of the vibration diaphragm is uncontrollable, such that the vibration diaphragm cannot reproduce good sound quality. In order to achieve better sound quality, the vibration diaphragm should only be reciprocatingly moved along one direction with even amplitude. For example, when the vibration diaphragm is placed horizontally, the vibration diaphragm should only be reciprocatingly moved in a vertical (up-and-down) direction while the upward displacement of the vibration diaphragm should be the same as the downward displacement of the vibration diaphragm.

[0005] In other words, the conventional vibration diaphragm cannot move only along an axial direction, while the conventional vibration diaphragm will produce offset and shaking movement along the axial direction and will results in sounds which are not pure. As shown in Fig. 1, a vibration unit of a typical conventional speaker is illustrated, the vibration unit can be used as a vibration system of a speaker to connect with the voice coil in response to the input of the audio signals, or the vibration unit can be used as a passive vibration unit to be driven by other speaker systems due to air pressure changes to reproduce an auxiliary sound. As shown in the drawings, a vibration unit of a typical and conventional speaker comprises an intermediate vibration block 1, a suspension 2 around the vibration block 1 and an outer frame 3. The suspension 2 is arch-shaped and is coaxial with the vibration block 1. However, for the conventional vibration unit during a vibration period, the suspension 2 cannot retains the vibration directions of the vibration block 1 in the axial direction. Because when the vibration block 1 deviates from the axial direction, the suspension 2 cannot apply a responding pulling force to prevent the deviating movement of the vibration block 1, while an eccentric force of the vibration block 1 does not decrease until being transferred to the connection of the suspension 2 and the outer frame 3. In other words, the suspension 2 cannot effectively prevent the vibration block 1 from deviating.

[0006] As shown in Fig. 2 and Fig. 3 of the drawings, a conventional solution is illustrated. A plurality of reinforcing ribs 4 is provided between the suspension 2 and the outer frame 3. The reinforcing ribs 4 provide a retaining effect so as to prevent the vibration block 1 deviating from the axial direction. In other words, when the vibration block 1 is about to deviate, the eccentric force will be transferred to these reinforcing ribs 4 so as to be offset. However, as shown in Fig. 3, it is can be seen in a cross-section of the vibration unit that these reinforcing ribs 4 contact with the vibration block 1 and the outer frame 3 line-to-line, so that when the vibration block 1 moves along the axial direction, a pull force in the axial direction will be affected by these reinforcing ribs 4. In other words, although the reinforcing ribs 4 has a certain effect on preventing deviating movement, the vibration block 1 has a displacement along the axial direction which decreases the stroke of the vibration unit, so that the whole stroke of the vibration unit is affected and the sound quality especially the bass sound quality is poor.

[0007] In addition, in order to obtain a better sound quality especially the bass quality, the stroke of the vibration unit or the vibration diaphragm need to be as large as possible, and the solutions in the traditional audio devices usually are making a vibration unit or a vibration diaphragm with large size, as a result the conventional acoustic devices are not small enough. While many small sized devices with audio arrangement such as flat-panel TVs, mobile phones and laptops need to be flat and thin, so that the small sized devices can maintain compact product designs and unique shapes. The acoustic arrangement with a big size is not suitable for these small sized products.

SUMMARY OF THE PRESENT INVENTION

[0008] An advantage of the present invention is to provide a wave-shaped suspension edge structure of a vibration unit, wherein the vibration unit comprises a vibration element, a supporting frame and an elastic suspension edge provided around the vibration element, the elastic suspension edge forms a wave shape along a circumferential direction of the center axis of the vibration unit, thereby effectively preventing the vibration element from shaking and deviating along the central axis direction.

[0009] Another advantage of the present invention is to provide a wave-shaped suspension edge structure of a vibration unit, the elastic suspension edge comprises a plurality of retaining ribs extending between the vibration element and the supporting frame, so that an undulating structure is formed between the vibration element and the supporting frame so as to retain and prevent deviation.

[0010] Another advantage of the present invention is to provide a wave-shaped suspension edge structure of a vibration unit, each of the retaining ribs is coupled to the supporting frame in a point-to-point connection and the cross section of each retaining rib is triangular-shaped so as to be firmly connected and to effectively prevent shaking and deviating of the vibration unit, and the axial displacement of the vibrating element will not be affected to ensure the sound quality reproduced by the vibration element.

[0011] Another advantage of the present invention is to provide a wave-shaped suspension edge structure of a vibration unit, the elastic suspension edge comprises a plurality of wave-shaped retaining sections formed around the vibration element, the plurality of wave-shaped retaining sections form a wave shape along the circumferential direction, so that the plurality of wave-shaped retaining sections retain the vibration element from radial deviation.

[0012] Another advantage of the present invention is to provide a wave-shaped suspension edge structure of a vibration unit, in the conventional vibration unit, the radial cross section of the suspension is arch-shaped or wave-shaped, while the vibration unit of the present invention forms a wave-shaped shape along the circumferential direction of the central axis of the vibration element, thereby when the vibration element deviates from the center axis and moves along a radial direction, the wave-shaped structure formed by the wave-shaped retaining sections around can effectively prevent the radial deviation, so that the vibration element is retained in the axial direction.

[0013] Another advantage of the present invention is to provide a wave-shaped suspension edge structure of a vibration unit, a wave-shaped suspension of a conventional vibration unit has a waveform extending along the circumferential direction of the vibrating element and the suspension of the conventional vibration unit cannot offset the eccentric force, while the elastic suspension edge of the present invention the can effectively provide an offset role to prevent the deviation of the vibrating element.

[0014] Another advantage of the present invention is to provide a wave-shaped suspension edge structure of a vibration unit, a plurality of spaced grooves arranged annularly is formed around the vibration element, so that the elastic suspension edge forms a series of concave-convex structures around the vibration element, and the concave-convex structures can form a wave shape so as to prevent a further radial displacement of the vibration element.

[0015] Another advantage of the present invention is to provide a wave-shaped suspension edge structure of a vibration unit, the elastic suspension edge can be bonded with the supporting frame and the vibration element by glue, or during a forming process of the elastic suspension edge, the elastic material can be simultaneously coated on the vibrating element, so that the production method is easy and has a low cost.

[0016] Another advantage of the present invention is to provide a wave-shaped suspension edge structure of a vibration unit, the vibration unit can be used to make speakers or a passive vibration plate providing an auxiliary sound effect, and can also improve the sound quality especially the bass quality.

[0017] Another advantage of the present invention is to provide a wave-shaped suspension edge structure of a vibration unit, the vibration unit has a small size and volume and can reach to a larger stroke, so that the vibration unit of the present invention can be applied to compact digital products such as flat-panel TVs, mobile phones, laptops and so on.

[0018] Additional advantages and features of the invention will become apparent from the description which follows, and may be realized by means of the instrumentalities and combinations particular point out in the appended claims.

[0019] According to the present invention, the foregoing and other objects and advantages are attained by a wave-shaped suspension edge structure, which is provided between a vibration element and a supporting frame, wherein the wave-shaped suspension edge structure comprises an elastic suspension edge provided around the vibration element and extended between the vibration element and the supporting frame, wherein the elastic suspension edge structure comprises a plurality of wave-shaped retaining sections forming a wave-shaped structure around the vibration element along a circumferential direction so as to restrict a movement direction of the vibration element to an axial direction and to prevent the vibration element from shaking and deviating.

[0020] In one embodiment, a groove is formed between two adjacent wave-shaped retaining sections so as to form the wave-shaped structure, wherein the shape of the wave-shaped structure is selected from the group consisting of sinusoidal waveform, sinusoidal waveform, triangular waveform and saw-tooth waveform.

[0021] In one embodiment, each of the wave-shaped retaining sections perpendicularly extends from an outer peripheral surface of the vibration element to an interior peripheral surface of the supporting frame.

[0022] In one embodiment, each of the wave-shaped retaining sections is slantedly extended from an outer peripheral surface of the vibration element to an interior peripheral surface of the supporting frame.

[0023] In one embodiment, each of the wave-shaped retaining sections which is connected to the vibration element has a sinusoidal waveform shaped inner edge.

[0024] In one embodiment, an inner edge of each of the wave-shaped retaining sections which is connected to the vibration element has a shape selected from the group consisting of sinusoidal waveform, sinusoidal waveform, triangular waveform and saw-tooth waveform.

[0025] In one embodiment, each of the wave-shaped retaining sections which is connected to the supporting frame has an outer edge which is arc-shaped along a circumferential direction.

[0026] In one embodiment, each of the wave-shaped retaining sections which is connected to the supporting frame has an outer edge which is sinusoidal-waveform-shaped.

[0027] In one embodiment, each of the wave-shaped retaining sections which is connected to the supporting frame has an outer edge which is arc-shaped along a circumferential direction.

[0028] In one embodiment, each of the wave-shaped retaining sections which is connected to the supporting frame has an outer edge which has a shape selected from the group consisting of sinusoidal waveform, sinusoidal waveform, triangular waveform and saw-tooth waveform.

[0029] In one embodiment, each vibration element connection end of each wave-shaped retaining section, which is connected with the supporting frame, comprises two portions forming one angle therebetween.

[0030] In one embodiment, each supporting frame connection end of each wave-shaped retaining section comprises two portions forming one angle therebetween.

[0031] In one embodiment, supporting frame connection ends of each wave-shaped retaining sections are connected to each other to form a ring-shaped outer edge coaxial with the vibration element.

[0032] In one embodiment, the angle formed between the two portions of the vibration element connection ends is selected from the group consisting of an acute angle, a right angle and an obtuse angle.

[0033] In one embodiment, wave crests of the wave-shaped retaining sections have lower height than a level surface of an outer surface of the vibration element.

[0034] In one embodiment, wave crests of the wave-shaped retaining sections have higher height than a level surface of an outer surface of the vibration element.

[0035] In one embodiment, the plurality of wave-shaped retaining sections is arranged symmetrically relative to a center of the vibration element.

[0036] In one embodiment, the vibration element has a shape which is selected from the group consisting of circular, oval, rectangle, and polygon.

[0037] In one embodiment, the vibration element is circular-shaped and each wave-shaped retaining sections are arranged along a radial direction of the vibration element so as to form a radial configuration of the wave-shaped retaining sections.

[0038] In one embodiment, the number of the wave-shaped retaining sections is 2-200 and the ripple amplitude of each wave-shaped retaining sections is 1-500mm.

[0039] In one embodiment, the area of the vibration element is 0.005-0.2m^2.

[0040] In one embodiment, the vibration element comprises a vibration weighted element and a coating layer coated on the vibration weighted element, and is made of same material with the elastic suspension edge.

[0041] In one embodiment, the elastic suspension edge is bonded with the supporting frame and the vibration element.

[0042] In one embodiment, the vibration unit is connected to a voice coil coupling with a magnetic coil system so as to form a loudspeaker.

[0043] In one embodiment, the vibration unit is a passive vibrating plate sharing a vibration cavity with at least one main vibration speaker, wherein the main vibration speaker makes response to input of audio signals to vibrate to produce sounds and the vibration unit is driven to vibrate to produce an auxiliary sound by the air pressure changes within the vibration cavity.

[0044] In one embodiment, the main vibration speaker and the vibration unit are arranged side by side.

[0045] In one embodiment, the main vibration speaker and the vibration unit are coaxial arranged back-to-back.

[0046] According to another aspect of the present invention, the present invention also provides a wave-shaped suspension edge structure, which is provided between a vibration element and a supporting frame, wherein the wave-shaped suspension edge structure comprises an elastic suspension edge provided around the vibration element and extended between the vibration element and the supporting frame, wherein the elastic suspension edge structure comprises a plurality sets of connecting ribs, wherein each sets of the connecting ribs comprise at least one top connecting rib extending from a top side of an outer peripheral surface of the vibration element to an interior peripheral surface of the supporting frame and at least one bottom connecting rib adjacent to the top connecting rib and extending from a bottom side of the outer peripheral surface to the interior peripheral surface of the supporting frame, wherein an arc-shaped connecting section is formed between the top connecting rib and the bottom connecting rib so as to form the wave-shaped structure around the vibration element.

[0047] In one embodiment, a groove is formed between each wave-shaped retaining sections so as to form the wave-shaped structure, wherein the shape of the wave-shaped structure is selected from the group consisting of sinusoidal waveform, sinusoidal waveform, triangular waveform and saw-tooth waveform.

[0048] In one embodiment, each connecting ribs and the connecting sections are made of different elastic materials.

[0049] In one embodiment, each connecting ribs and the connecting sections are made of same elastic materials.

[0050] In one embodiment, an angle is formed between two adjacent arc-shaped connecting sections.

[0051] In one embodiment, each sets of connecting ribs comprise one top connecting rib and one bottom connecting rib, wherein a cross section of an inner edge of the elastic suspension edge connected to the vibration element is sinusoidal waveform shaped.

[0052] In one embodiment, each sets of connecting ribs comprise two top connecting ribs and two bottom connecting ribs, wherein the two bottom connecting ribs are respectively positioned on two sides of the top connecting ribs and a cross section of an inner edge of the elastic suspension edge connected to the vibration element has a shape which is selected from the group consisting of sinusoidal waveform, sinusoidal waveform, triangular waveform and saw-tooth waveform.

[0053] In one embodiment, each top connecting ribs are extended from the outer peripheral surface of the vibration element to the interior peripheral surface of the supporting frame vertically or aslant.

[0054] In one embodiment, each bottom connecting ribs are extended from the outer peripheral surface of the vibration element to the interior peripheral surface of the supporting frame vertically or aslant.

[0055] In one embodiment, supporting frame connection ends of each elastic suspension edge connected with the interior peripheral surface of the supporting frame form a ring-shaped outer edge coaxial with the vibration element.

[0056] In one embodiment, the vibration element has a shape which is selected from the group consisting of circular, oval, rectangle, and polygon.

[0057] In one embodiment, the vibration element is circular-shaped and each connecting ribs are arranged along a radial direction of the vibration element.

[0058] In one embodiment, the vibration element comprises a vibration weighted element and a coating layer coated on the vibration weighted element and be made of same material with the elastic suspension edge.

[0059] In one embodiment, the elastic suspension edge is bonded with the supporting frame and the vibration element.

[0060] In one embodiment, the vibration unit is connected to a voice coil coupling with a magnetic coil system so as to form a loudspeaker.

[0061] In one embodiment, the vibration unit is a passive vibrating plate sharing a vibration cavity with at least one main vibration speaker, wherein the main vibration speaker makes response to input of audio signals to vibrate to produce sounds and the vibration unit is driven to vibrate to produce an auxiliary sound by the air pressure changes within the vibration cavity.

[0062] In one embodiment, the main vibration speaker and the vibration unit are arranged side by side.

[0063] In one embodiment, the main vibration speaker and the vibration unit are coaxial arranged back-to-back.

[0064] According to another aspect of the present invention, the present invention also provides a wave-shaped suspension edge structure, which is provided between a vibration element and a supporting frame, wherein the wave-shaped suspension edge structure comprises an elastic suspension edge, wherein the elastic suspension edge is provided around the vibration element and extended between the vibration element and the supporting frame and the elastic suspension edge forms a plurality of spaced grooves around the vibration element, wherein the grooves are arranged along a circumferential shape and the elastic suspension edge forms a wave-shaped structure around the vibration element along a circumferential direction and restricts a movement direction of the vibration element to an axial direction.

[0065] In one embodiment, the plurality of grooves is radially arranged.

[0066] In one embodiment, the plurality of grooves is arranged symmetrically relative to a center of the vibration element.

[0067] In one embodiment, the elastic suspension edge comprises a plurality of arc-shaped connecting sections and each two adjacent arc-shaped connecting sections form the grooves and each two adjacent grooves are respectively positioned on two opposite sides of the elastic suspension edge.

[0068] In one embodiment, the number of grooves is 2-200.

[0069] In one embodiment, an outer edge of the elastic suspension edge is ring-shaped and the elastic suspension edge is coaxial with the vibration element.

[0070] In one embodiment, the shape of an outer edge of the elastic suspension edge is selected from the group consisting of ring sinusoidal waveform, ring sinusoidal waveform, ring triangular waveform and ring saw-tooth waveform.

[0071] In one embodiment, the shape of an inner edge of the elastic suspension edge is selected from the group consisting of ring sinusoidal waveform, ring sinusoidal waveform, ring triangular waveform and ring saw-tooth waveform.

[0072] In one embodiment, the vibration unit is connected to a voice coil coupling with a magnetic coil system so as to form a loudspeaker.

[0073] In one embodiment, the vibration unit is a passive vibrating plate sharing a vibration cavity with at least one main vibration speaker, wherein the main vibration speaker makes response to input of audio signals to vibrate to produce sounds and the vibration unit is driven to vibrate to produce an auxiliary sound by the air pressure changes within the vibration cavity.

[0074] In one embodiment, the main vibration speaker and the vibration unit are arranged side by side.

[0075] In one embodiment, the main vibration speaker and the vibration unit are coaxial arranged back-to-back.

[0076] The present invention further provides a vibration unit which comprises a vibration element, an elastic suspension edge, and a supporting frame, wherein the elastic suspension edge is provided between the vibration element and the supporting frame, wherein the elastic suspension edge comprises a plurality of wave-shaped retaining sections forming a wave-shaped structure around the vibration element along a circumferential direction so as to ensure a movement direction of the vibration element is kept along an axial direction and prevent the vibration element to shake and deviate

[0077] Still further objects and advantages will become apparent from a consideration of the ensuing description and drawings.

[0078] These and other objectives, features, and advantages of the present invention will become apparent from the following detailed description, the accompanying drawings, and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0079]

FIG. 1 is a schematic view of a vibration unit of a conventional speaker.

FIG. 2A is a schematic view of an improved vibration unit of a conventional speaker.

FIG. 2B is a schematic cross section view of the FIG. 2A along an A-A line.

FIG. 3 is a perspective view of a vibration unit according to a first preferred embodiment of the present invention.

FIG. 4 is an exploded perspective view of the vibration unit according to above first preferred embodiment of the present invention.

FIG. 5A is a section view of the FIG. 3 along a B-B line.

FIG. 5B is a section view of the FIG. 3 along a C-C line.

FIG. 6 is a perspective view of a vibration unit with a wave-shaped suspension edge according to a second preferred embodiment of the present invention.

FIG. 7 is an exploded perspective view of the vibration unit according to above second preferred embodiment of the present invention.

FIG. 8 is a partially enlarged schematic view of the FIG. 6 at a position of D.

FIG. 9 is a section view of the FIG. 6 along a E-E line.

FIG. 10A is a perspective view of the vibration unit applied to a loudspeaker according to the above second preferred embodiment of the present invention.

FIG. 10B is an exploded perspective view of the vibration unit applied to the loudspeaker according to above second preferred embodiment of the present invention.

FIG. 11A is a perspective view of the vibration unit applied to a passive vibration plate according to the above second preferred embodiment of the present invention.

FIG. 11B is an exploded perspective view of the vibration unit applied to the passive vibration plate according to above second preferred embodiment of the present invention.

FIG. 12 is a perspective view of a vibration unit according to an alternative mode of the second preferred embodiment of the present invention.

FIG. 13 is an exploded perspective view of the vibration unit according to the alternative mode of above second preferred embodiment of the present invention.

FIG. 14 is a partially enlarged schematic view of the FIG. 12 at a position of F.

FIG. 15 is a section view of the FIG. 12 along a F-F line.

FIG. 16 is a perspective view of a vibration unit with a wave-shaped suspension edge according to a third preferred embodiment of the present invention.

FIG. 17 is an exploded perspective view of the vibration unit according to above third preferred embodiment of the present invention.

FIG. 18 is a partially enlarged schematic view of the FIG. 16 at a position of H.

FIG. 19 is a section view of the FIG. 16 along a I-I line.

FIG. 20 is a perspective view of a vibration unit according to an alternative mode of the third preferred embodiment of the present invention.

FIG. 21 is an exploded perspective view of the vibration unit according to the alternative mode of above third preferred embodiment of the present invention.

FIG. 22 is a partially enlarged schematic view of the FIG. 20 at a position of I.

FIG. 23 is a section view of the FIG. 20 along a K-K line.

FIG. 24 is a perspective view of a vibration unit with a wave-shaped suspension edge according to a fourth preferred embodiment of the present invention.

FIG. 25 is an exploded perspective view of the vibration unit according to above fourth preferred embodiment of the present invention.

FIG. 26 is a partially enlarged schematic view of the FIG. 24 at a position of L.

FIG. 27 is a section view of the FIG. 24 along a M-M line.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0080] The following description is disclosed to enable any person skilled in the art to make and use the present invention. Preferred embodiments are provided in the following description only as examples and modifications will be apparent to those skilled in the art. The general principles defined in the following description would be applied to other embodiments, alternatives, modifications, equivalents, and applications without departing from the spirit and scope of the present invention.

[0081] Referring to Fig. 3 to Fig. 5B of the drawings, a vibration unit 100 according to a first preferred embodiment of the present invention is illustrated, wherein the vibration unit 100 comprises a vibration element 10 in the middle, and a suspension structure around the vibration element 10. The suspension structure comprises an elastic suspension edge 20 and a supporting frame 30 positioned around the elastic suspension edge 20. In other words, the elastic suspension edge 20 is made of an elastic material and extends between the vibration element 10 and the supporting frame 30 to confine the vibration of the vibration element 10. The shape of the vibration element 10 can be implied as circular, oval, square or other polygonal shape, in this preferred embodiment, the vibration element 10 is elliptical. The elastic suspension edge 20 correspondingly forms a substantially elliptical shape around the vibration element 10. The supporting frame 30 can have a variety of shapes, the present invention is not intended to be limiting in this aspect.

[0082] In this preferred embodiment, the vibration unit 100 further comprises a plurality of retaining ribs 40 extending between the vibration element 10 and the supporting frame 30, so that an undulating structure is formed between the vibration element 10 and the supporting frame 30. The retaining ribs 40 is adapted for providing a confining effect to prevent the vibration element 10 deviating from the center axis of displacement. More specifically, when the vibration element 10 is about to deviate from the center axis to cause an deviation, the corresponding retaining ribs 40 produces an offset biasing force to counteract an eccentric force which causes a displacement of the vibration element 10. It is worth mentioning that the retaining ribs 40 can extend along a direction which is perpendicular to an outer circumferential surface of the corresponding vibration element 10 and an inner circumferential surface of the corresponding supporting frame 30. As shown in Fig. 3, the retaining ribs 40 can be provided along a radial direction of the vibration element 10 or be provided aslant. This arrangement can produce a corresponding tensile force along these directions so as to effectively prevent the vibration element 10 producing offset along these directions.

[0083] It is worth mentioning that the retaining ribs 40 can be uniformly arranged around the 10 and is symmetrically arranged with respect to the center of the vibration element 10. For example, as shown in Fig.3, the retaining ribs 40 comprises a left retaining rib 401 and a right retaining rib 402. When the vibration unit 100 is positioned vertically and operated normally, the vibration element 10 moves up and down along an axial direction. When the vibration element 10 is about to deviate to the left, the right retaining rib 402 immediately exerts a reverse tensile force along a right direction on the vibration element 10 so as to prevent the vibration element 10 from further deviating to the left. On the contrary, when the vibration element 10 is about to deviate to the right, the left retaining rib 401 immediately exerts a reverse tensile force along a left direction on the vibration element 10 so as to prevent the vibration element 10 from further deviating to the right. Thus, the elastic suspension edge 20 and the retaining ribs 40 can effectively confine the vibration direction of the vibration element 10 between the upward and downward direction of the axial directions.

[0084] The elastic suspension edge 20 can have a structure as shown in Fig. 1, wherein the elastic suspension edge 20 is provided coaxially with the vibration element 10 and has a wave-shaped or arched cross section along a radial direction of the vibration element 10 as shown in Fig.5B so as to form a ring embossing along a central axis of the vibration element 10. It is worth mentioning that each of the retaining ribs 40 is protruded from the elastic suspension edge 20 to form the undulating structure in a circumferential direction of the vibration element 10. In other words, the "wave-shaped" of the present invention is not strictly similar to a wave formed by water, but is a drape structure or is similar to a corrugated paper structure formed around the vibration element 10.

[0085] As shown in Fig. 3, the plurality of retaining ribs 40 substantially divides the elastic suspension edge 20 to a plurality of suspension edge portion 201. The number of the retaining ribs 40 is not intended to be limiting, and can be adjusted according to different needs. In the embodiment of the present invention in the Fig. 3, eight retaining ribs 40 divide the elastic suspension edge 20 into eight suspension edge portion 201. Each of the retaining ribs 40 is made of elastic materials and can be made of same or different elastic materials with the elastic suspension edge 20. When the retaining ribs 40 and the elastic suspension edge 20 are made of the same elastic materials, the plurality of retaining ribs 40 and the elastic suspension edge 20 can be molded in one piece. In other words, a mould is injected with a predetermined elastic material in one molding step, so that a combination with the plurality of retaining ribs 40 and the elastic suspension edge 20 is made. It is worth mentioning that the in the molding process, the predetermined elastic material can be coated with the vibration element 10 so as to form a elastic coating layer 12. In other words, the vibration element 10 comprises an internal vibration weighted element 11 and the external elastic coating layer 12. It is worth mentioning that the elastic suspension edge 20 and the retaining ribs 40 can be bonded with the supporting frame 30 and the vibration element 10 using a conventional method by glue.

[0086] As shown in Fig. 5B, it is worth mentioning that the arched structure of the elastic suspension edge 20 can form a ring-shaped groove 202. Each of the retaining ribs 40 can be disposed on two sides of the elastic suspension edge 20 and bulges outwardly, or can be disposed on one side of the vibration element 10. In this preferred embodiment, each of the retaining ribs 40 and the ring-shaped groove 202 are positioned on two sides of the elastic suspension edge 20. In other words, each of the retaining ribs 40 is not extended into the ring-shaped groove 202 and is extended on one side of the vibration element 10, as shown in Fig. 5B, each of the retaining ribs 40 protrudes from the upper side of the vibration element 10. While a groove 203 is formed between two adjacent retaining ribs 40, so that the elastic suspension edge 20 and the retaining ribs 40 from a undulating structure around the vibration element 10.

[0087] As shown in Fig. 3 and Fig. 5A, the shape of the cross section of each of the retaining ribs 40 can be triangle, trapezoidal, rhombus and so on, so that not only each of the retaining ribs 40 is firmly located and connected with each other, but also does not hinder an axial motion of the vibration element 10. More specifically, in the embodiment of the present invention as shown in Fig.3 and Fig. 5A, each of the retaining ribs 40 is sheet-shaped and has a triangular cross section. The retaining ribs 40 can be connected with the vibration element 10 by one base of the triangle and is connected with the supporting frame 30 by one vertex of the triangle, or the retaining ribs 40 can be connected with the supporting frame 30 by one base of the triangle and is connected with the vibration element 10 by one vertex of the triangle.

[0088] Preferably, each of the retaining ribs 40 comprises a vibration element connecting end 41 and a supporting frame connecting end 42. The vibration element connecting end 41 and a outer peripheral surface 101 of the vibration element 10 are line-to-line connected, in other words, the base of the triangle of the retaining ribs 40 and the outer peripheral surface 101 of the vibration element 10 are connected to contact. The supporting frame connecting end 42 and an interior peripheral surface 301 of the supporting frame 30 are point-to-point connected, in other words, the vertex of the triangle of the retaining ribs 40 and the interior peripheral surface 301 of the supporting frame 30 are connected to contact. It is worth mentioning that the shape of the triangle which is the cross section of the retaining ribs 40 can be any triangle shape, such as right-angled triangle, isosceles triangle, regular triangle and so on. It is worth mentioning that each side of these triangles can be straight line and curved line. As shown in Fig. 5A, the connected portion of each of the retaining ribs 40 and the elastic suspension edge 20 can be connected to form an arc shape.

[0089] It is worth mentioning that this design makes the connection strength of the 40 and the vibration element 10 bigger than the connection strength of the retaining ribs 40 and the supporting frame 30, so that at the same time the vibration element 10 is prevented from shifting, the pushing force which pushes the vibration element 10 to move axially is not quickly transferred to the supporting frame 30, while the stroke which is the axial displacement of the vibration element 10 is not greatly affected. In other words, the pulling force which is applied to the retaining ribs 40 by the supporting frame 30 and which pulls the vibration element 10 back to its initial position is not quickly transmitted to the vibration element 10, while the vibration element 10 is pulled to reach the maximum axial displacement as far as possible. In other words, it cannot make that when the retaining ribs 40 just begins the axial displacement from the middle initial position, the retaining ribs 40 shortens the axial displacement due to the affect of a restoring force immediately applied by the supporting frame 30.

[0090] In other words, as shown in Fig. 2A and Fig. 2B, the reinforcing ribs 4 and the vibration block 1 are connected line-to-line and have substantially rectangular cross-sections, in this way two ends of the reinforcing ribs 4 have a same connection structure with the vibration block 1 and with the outer frame 3, so that two ends of the reinforcing ribs 4 have a same connection strength. Thus, the pulling force which the outer frame 3 and the reinforcing ribs 4 pull back the vibration block 1 can apply to the vibration block 1 in real time, and the axial displacement of the vibration block 1 is influenced. In other words, although the reinforcing ribs 4 has an affect on reducing the shifting of the vibration block 1, at the same time the stroke of the vibration block 1 has a serious negative impact. In the present invention, one end of each of the retaining ribs 40 is connected to the supporting frame 30 point-to-point, while other end thereof is connected to the vibration element 10 line-to-line, which not only prevents the vibration element 10 from swaying and shifting, but also not affect the axis displacement of the vibration element 10.

[0091] Referring to Fig. 6 to Fig. 11B, a vibration unit 100A according to a second preferred embodiment of the present invention is illustrated, wherein the vibration unit 100A comprises a vibration element 10A and a wave-shaped suspension structure around the vibration element 10A. The wary suspension structure comprises an elastic suspension edge 20A and a supporting frame 30A. The elastic suspension edge 20A extends between the vibration element 10A and the supporting frame 30A. In this embodiment, the elastic suspension edge 20A forms a wave-shaped structure around the vibration element 10A along a circumferential direction thereof.

[0092] Specifically, the elastic suspension edge 20A comprises a plurality of wave-shaped retaining sections 21A disposed along the circumferential direction, so that the plurality of wave-shaped retaining sections 21A form the wave-shaped structure around the vibration element 10A. While the suspension 2 in Fig.1 only forms an arched or wave-shaped structure in a radial direction of the vibration block 1, so that the shifting of the vibration element 10A is not effectively prevented.

[0093] The plurality of wave-shaped retaining sections 21A of the present invention is for providing a retaining effect, so as to prevent a displacement of the vibration element 10A deviating from a center X-axial. More specifically, when the vibration element 10A is about to deviate from the center X-axial to deviate in a certain direction, the corresponding wave-shaped retaining sections 21A applies a pulling force in an opposite direction to offset a deviation force which results in a deviation of the vibration element 10A. It is worth mentioning that these wave-shaped retaining sections 21A can be arranged evenly around the vibration element 10A and be arranged symmetrically relative to a center of the vibration element 10A.

[0094] For example, as shown in Fig. 6, each of the wave-shaped retaining sections 21A comprises a left wave-shaped retaining section 21A and a right wave-shaped retaining section 21A. When the vibration unit 100A is positioned vertically and operated normally, the vibration element 10A moves up and down along a X-axis. When the vibration element 10A is about to deviate to left along a Y-axial as shown in Fig. 6, the vibration element 10A will be applied by a reversed pulling force to the right by the right wave-shaped retaining sections 21A so as to prevent the vibration element 10A from further deviating to the left. Otherwise, when the vibration element 10A is about to deviate to right along the Y-axial as shown in Fig. 6, the vibration element 10A will be immediately applied by a reversed pulling force to the left by the left wave-shaped retaining sections 21A so as to prevent the vibration element 10A from further deviating to the right. Thus, the elastic suspension edge 20A is able to effectively limit a vibration direction of the vibration element 10A along an upward and downward direction of the X-axial.

[0095] Each of the wave-shaped retaining sections 21A comprises a vibration element connection end 211A and a supporting frame connection end 212A. As shown in Fig. 8, a cross section along a circumferential direction of the vibration element connection end 211A is wave-shaped and the vibration element connection end 211A is connected to an outer peripheral surface 101A of the vibration element 10A. The supporting frame connection end 212A is an outer edge, which is connected to an interior peripheral surface 301A of the supporting frame 30A. More specifically, to be described in more detail, as shown in Fig. 8, in this preferred embodiment, the vibration element connection end 211A has two lower connection sites 2111A, 2112A and an upper connection site 2113A. The lines connecting the two lower connection site 2111A, 2112A and the upper connection site 2113A can form a triangle. Three connecting sites 2121A, 2122A and 2123A are respectively extended from the two lower connection site 2111A, 2112A and the upper connection site 2113A to the interior peripheral surface 301A of the supporting frame 30A. The three connecting sites 2121A, 2122A and 2123A are formed in the supporting frame connection end 212A and lines connecting the three connecting sites 2121A, 2122A and 2123A are along the interior peripheral surface 301 and are arc-shaped. In other words, in this embodiment, the wave-shaped retaining sections 21A has an inner edge and an outer edge, and the inner edge connecting to the outer peripheral surface 101A of the vibration element 10A is wave-shaped or arch-shaped, the outer edge connecting to the interior peripheral surface 301A of the supporting frame 30A extends along the interior peripheral surface 301A of the supporting frame 30A and is arc-shaped and is positioned in a same level surface perpendicular to the center X-axis of the vibration element 10A.

[0096] In other words, the vibration element connection end 211A of each of the wave-shaped retaining sections 21A is divided into two portions, an angle is formed between the two portions. The formed angle can be acute, right or obtuse angle.

[0097] This wave-shaped structure of the present invention can prevent the vibration element 10A from skewing, and the pushing force which pushes the vibration element 10A to move axially will not quickly transferred to the supporting frame 30A, while the stroke of the vibration element 10A which is an axial displacement will not be greatly affected. In other words, a tensile force which the supporting frame 30A applies to the wave-shaped retaining sections 21A and which pulls the vibration element 10A back to its initial position will not be quickly transmitted to the vibration element 10A, so that the vibration element 10A reaches a maximum axial displacement to the greatest extent.

[0098] It is worth mentioning that, in this preferred embodiment, the joint strength of the wave-shaped retaining sections 21A and the vibration element 10A is bigger than the joint strength of the wave-shaped retaining sections 21A and the supporting frame 30A. In other words, a connection structure of the inner edge of the wave-shaped retaining sections 21A and the vibration element 10A is triangular-shaped and is more stable, so that the joint strength of the wave-shaped retaining sections 21A and the vibration element 10A is stronger than the joint strength of the outer edge of the wave-shaped retaining sections 21A and the supporting frame 30A. One skilled in the art shall understand that the connection type can be reversed. In other words, the outer edge of the wave-shaped retaining sections 21A and the supporting frame 30A have a triangular-shaped connection structure, while the outer edge of the wave-shaped retaining sections 21A and the vibration element 10A have an arc-shaped connection in a same level surface rather than an undulating-shaped connection.

[0099] In addition, a groove 203A is formed between the two adjacent wave-shaped retaining sections 21A, so that a series of the groove 203A which are arranged spaced apart are formed along a circumferential direction of the vibration element 10A and the wave-shaped structure is formed.

[0100] It is worth mentioning that the wave-shaped retaining sections 21A in the preferred embodiment of the present invention can be molded in one piece by using a mould injected with the predetermined elastic material in a molding step. It is worth mentioning that the in the molding process, the predetermined elastic material can be coated on the vibration element 10A so as to form an elastic coating layer 12A. In other words, as shown in Fig. 9, the vibration element 10A comprises an internal vibration weighted element 11A and the external elastic coating layer 12A. It is worth mentioning that the elastic suspension edge 20A can also be bonded with the supporting frame 30A and the vibration element 10A using a conventional method by glue.

[0101] Referring to Fig. 12 to Fig. 15 of the drawings, an alternative mode according to the preferred embodiment of the present invention is illustrated. The structure configuration in the alternative mode is similar to the structure configuration in the preferred embodiment except the formed wave height of the wave-shaped retaining sections 21A. As shown in Fig. 9, the wave crest of each of the wave-shaped retaining sections 21A can be lower than an outer surface 102A of the vibration element 10A and can be lower than an outer surface 302A of the supporting frame 30A. However, as shown in Fig. 15, the wave crest of each of the wave-shaped retaining sections 21A' can be higher than the outer surface 102A of the vibration element 10A and can be higher than the outer surface 302A of the supporting frame 30A.

[0102] It is worth mentioning that according to the embodiment, the resonant frequency of the vibration unit 100A is 5-200Hz, and the elastic suspension edge 20A can be made of any thermoset rubber or thermoplastic elastomer material. The elastic suspension edge 20A also has a predetermined rigidity. For example, the shore hardness of the elastic suspension edge 20A preferably is about 5-85A. The ripple amplitude of each of the wave-shaped retaining sections 21A is 1-500mm and the ripple number of each of the wave-shaped retaining sections 21A is 2-100. Preferably, the area size of the vibration element 10A is 0.005-0.2m^2. It is worth mentioning that these detailed numerical values are only examples and are not intended to be limiting, and can be adjusted according to needs in practical use. It is worth mentioning that these detailed numerical values are suitable for the vibration units obtained in other embodiments of the present invention.

[0103] As shown in Fig. 10A and Fig. 10B, the vibration unit 100A according to the preferred embodiment of the present invention can be used as a vibration system of a speaker 1000A. The vibration element 10A of the vibration unit 100A is connected with a voice coil 110A. The voice coil 110A has an electromagnetic induction with a magnetic coil system 120A, so that when the speaker 1000A is input with the audio signal, the voice coil 110A is magnetically induced to reciprocating move in the magnetic field of the magnetic coil system 120A, so that the vibration element 10A is driven to vibrate to produce sound. The elastic suspension edge 20A of the present invention retains the movement of the vibration element 10A in the axial direction by the wave-shaped structure, so that the reproduced sound is purer.

[0104] As shown in Fig. 11A and Fig. 11B, the vibration unit 100A according to the preferred embodiment of the present invention can be used as a passive vibrating plate of a speaker 1000A'. Specifically, the speaker 1000A' comprises a main vibration speaker 1100A' and the vibration unit 100A. The main vibration speaker 1100A' vibrates to produce sounds in response to the input of the audio signal. The vibration unit 100A and the main vibration speaker 1100A' share a vibration cavity 1200A'. When the main vibration speaker 1100A' vibrates, the vibration unit 100A is also driven to vibrate to produce an auxiliary sound effect by means of the air pressure changes within the vibration cavity 1200A', so that the sound quality is improved, and especially the bass quality is strengthened.

[0105] The main vibration speaker 1100A can be a conventional speaker structure and it can also be a horn or speaker made by the vibration unit 100A of the present invention. The speaker 1000A' comprises one or more main vibration speakers 1100A' and one or more vibration units 100A. and the main vibration speakers 1100A' and the vibration units 100A are arranged side by side or coaxial arranged back-to-back as shown in Fig. 11 A.

[0106] It is worth mentioning that the speaker 1000A and the passive vibrating plate of the speaker 1000A both use the vibration unit 100A according to the preferred embodiment of the present invention. The vibration unit according to other embodiment can be applied to make the speaker 1000A and the passive vibrating plate of the speaker 1000A'.

[0107] Referring to Fig. 16 to Fig. 19 of the drawings, a vibration unit 100B according to a third preferred embodiment of the present invention is illustrated, wherein the vibration unit 100B comprises a vibration element 10B and a wave-shaped suspension structure around the vibration element 10B. The wary suspension structure comprises an elastic suspension edge elastic suspension edge 20B and a supporting frame 30B. The elastic suspension edge 20B is extended between the vibration element 10B and the supporting frame 30B. In this embodiment, the elastic suspension edge 20B forms a wave-shaped structure around the vibration element 10B along a circumferential direction thereof.

[0108] Specifically, the elastic suspension edge 20B comprises a plurality of wave-shaped retaining sections 21B disposed along the circumferential direction, so that the plurality of wave-shaped retaining sections 21B form the wave-shaped structure around the vibration element 10B. The 100B according to the third embodiment and the vibration unit 100A according to the second preferred embodiment have a similar structure except that two ends of each of the wave-shaped retaining sections 21B which are a vibration element connection end 211B and a 212B have the same structure. In other words, an inner edge and an outer edge of the wave-shaped retaining sections 21B are wave-shaped or arch-shaped. As shown in Fig. 18, an upper vertex and two lower bottom points are connected to form a triangle.

[0109] It is worth mentioning that, in the third preferred embodiment, the vibration element 10B is circular. The plurality of wave-shaped retaining sections 21B is disposed along a radial direction of the vibration element 10B so as to form a plurality of radial wave-shaped retaining sections 21B. In other words, the wave-shaped retaining sections 21B can be radially and coaxially arranged. The plurality of wave-shaped retaining sections 21B retains the position of the vibration element 10B in the radial direction to prevent the vibration element 10B deviates along a certain radial direction, so that the vibration element 10B only move along the axial direction.

[0110] Referring to Fig. 20 to Fig. 23 of the drawings, a vibration unit 100C in an alternative mode according to the third preferred embodiment of the present invention is illustrated, wherein the vibration unit 100C comprises a vibration element 10C and a wave-shaped suspension structure around the vibration element 10C. The wavy suspension structure comprises an elastic suspension edge 20C and a supporting frame 30C. The elastic suspension edge 20C is extended between the vibration element 10C and the supporting frame 30C. In this embodiment, the elastic suspension edge 20C forms a wave-shaped structure around the vibration element 10C along a circumferential direction thereof.

[0111] Specifically, the elastic suspension edge 20C comprises multiple sets of connecting ribs 22C. Each set of the connecting ribs 22C comprise at least one top connecting rib 221C and at least one bottom connecting rib 222C adjacent to the top connecting rib 221C. The elastic suspension edge 20C further comprises a connecting section 23C respectively extended between the adjacent connecting ribs 22C (221C, 222C).

[0112] In the preferred embodiment of the present invention, the top connecting rib 221C is extended from the top side of an outer peripheral surface 101C of the vibration element 10C to an interior peripheral surface 301C of the supporting frame 30C. The bottom connecting rib 222C is extended from the bottom side of the outer peripheral surface 101C to the interior peripheral surface 301C of the supporting frame 30C. The arc-shaped connecting section 23C is formed between the top connecting rib 221C and the bottom connecting rib 222C.

[0113] The connecting ribs 22C alternatively extends from the top side and the bottom side of the vibration element 10C to the supporting frame 30C, so that the elastic suspension edge 20C forms the wave-shaped structure around the vibration element 10C. Similarly, the plurality of grooves 203C is also formed around the vibration element 10C.

[0114] The connecting ribs 22C and the connecting section 23C can be made of different or same elastic materials. When the connecting ribs 22C and the connecting section 23C are made of the same elastic materials, the elastic suspension edge 20C is made by injecting an elastic material into a mould such that the connecting ribs 22C and the connecting section 23C are integrally formed, so that a similar structure to the vibration unit 100B in the above second preferred embodiment is obtained.

[0115] The vibration element 10C in the preferred embodiment of the present invention can be circular, so that these connecting ribs 22C are disposed along a radial direction of the vibration element 10C, so that the plurality of radial connecting ribs 22C are formed to prevent the vibration element 10C from skewing to the radial direction.

[0116] Referring to Fig. 24 to Fig. 27, a vibration unit 100D according to a fourth preferred embodiment of the present invention is illustrated, wherein the vibration unit 100D comprises a vibration element 10A and a wave-shaped suspension structure around the vibration element 10D. The wavy suspension structure comprises an elastic suspension edge 20D and a supporting frame 30D. The elastic suspension edge 20D is extended between the vibration element 10D and the supporting frame 30D. In this embodiment, the elastic suspension edge 20D forms a wave-shaped structure around the vibration element 10D along a circumferential direction thereof.

[0117] The vibration unit 100D according to the embodiment and the wave-shaped structure according to the second preferred embodiment have a similar structure, and the vibration unit 100D comprises a plurality of wave-shaped retaining sections 21D. each of the wave-shaped retaining sections 21D has a vibration element connection end 211D and a supporting frame connection end 212D. An outer edge which is the vibration element connection end 211D and which is connected to an outer peripheral surface 101D of the vibration element 10D does not form a sharp corner, and a rectangular will be obtained if connecting each vertexes. In other words, different with the waveforms in above three embodiments which are formed as sinusoidal waveform, the waveform in this preferred embodiment is about square wave. It is expected that each above vertexes can be connected to form a trapezoid. These structures all form a groove 203D around the vibration element 10D, so that a series of concave-shaped structure forms an undulating wave-shaped structure.

[0118] It is worth mentioning that the vibration unit 100D in this embodiment of the present invention is obtained by a transform of the vibration unit 100C in the third embodiment. In other words, in the multiple sets of the connecting ribs 22C of the elastic suspension edge 20C of the vibration unit 100C, when each set of the connecting ribs 22 comprises two adjacent top connecting rib 221C and two bottom connecting ribs 222C adjacent to the two top connecting ribs 221C, the vibration unit 100D in the embodiment of the present invention is obtained.

[0119] It is worth mentioning that, similarly, two ends of the elastic suspension edge 20D which are respectively connected to the vibration element 10D and the supporting frame 30D have a same or different connection configuration. As shown in Fig. 26, the vibration element connection end 211D which is an inner edge of the wave-shaped retaining sections 21D and which is connected to the outer peripheral surface 101D of the vibration element 10D can be a poly-line comprising different line segments, while the supporting frame connection end 212D which is an outer edge of the wave-shaped retaining sections 21D and which is connected to the interior peripheral surface 301D of the supporting frame 30D only forms one line, so that the connecting strength of the elastic suspension edge 20D and the vibration element 10D is bigger than the connecting strength of the elastic suspension edge 20D and the supporting frame 30D.

[0120] One skilled in the art will understand that the embodiment of the present invention as shown in the drawings and described above is exemplary only and not intended to be limiting.

[0121] It will thus be seen that the objects of the present invention have been fully and effectively accomplished. The embodiments have been shown and described for the purposes of illustrating the functional and structural principles of the present invention and is subject to change without departure from such principles. Therefore, this invention includes all modifications encompassed within the spirit and scope of the following claims.

Claims

1. A wave-shaped suspension edge structure, which is provided between a vibration element and a supporting frame, wherein said wave-shaped suspension edge structure comprises an elastic suspension edge provided around said vibration element and extended between said vibration element and said supporting frame, wherein said elastic suspension edge structure comprises a plurality of wave-shaped retaining sections forming a wave-shaped structure around said vibration element along a circumferential direction so as to ensure a movement direction of said vibration element is kept along an axial direction and to prevent said vibration element from shaking and deviating.

2. The wave-shaped suspension edge structure, as recited in claim 1, wherein a groove is formed between two adjacent wave-shaped retaining sections so as to form said wave-shaped structure, wherein the shape of said wave-shaped structure is selected from the group consisting of sinusoidal waveform, sinusoidal waveform, triangular waveform and saw-tooth waveform.

3. The wave-shaped suspension edge structure, as recited in claim 1, wherein each of said wave-shaped retaining sections is perpendicularly extended from an outer peripheral surface of said vibration element to an interior peripheral surface of said supporting frame.

4. The wave-shaped suspension edge structure, as recited in claim 1, wherein each of said wave-shaped retaining sections is extended aslantfrom an outer peripheral surface of said vibration element to an interior peripheral surface of said supporting frame.

5. The wave-shaped suspension edge structure, as recited in claim 1, wherein each of said wave-shaped retaining sections which is connected to said vibration element has a sinusoidal waveform shaped inner edge.

6. The wave-shaped suspension edge structure, as recited in claim 1, wherein an inner edge of each of said wave-shaped retaining sections which is connected to said vibration element has a shape selected from the group consisting of sinusoidal waveform, sinusoidal waveform, triangular waveform and saw-tooth waveform.

7. The wave-shaped suspension edge structure, as recited in claim 5, wherein each of said wave-shaped retaining sections which is connected to said supporting frame has an outer edge which is arc-shaped along a circumferential direction.

8. The wave-shaped suspension edge structure, as recited in claim 5, wherein each of said wave-shaped retaining sections which is connected to said supporting frame has an outer edge which is sinusoidal-waveform-shaped.

9. The wave-shaped suspension edge structure, as recited in claim 6, wherein each of said wave-shaped retaining sections which is connected to said supporting frame has an outer edge which is arc-shaped along a circumferential direction.

10. The wave-shaped suspension edge structure, as recited in claim 6, wherein each of said wave-shaped retaining sections which is connected to said supporting frame has an outer edge which has a shape selected from the group consisting of sinusoidal waveform, sinusoidal waveform, triangular waveform and sawtooth waveform.

11. The wave-shaped suspension edge structure, as recited in claim 1, wherein each vibration element connection end of each of said wave-shaped retaining sections, which is connected with said supporting frame, comprises two portions forming one angle therebetween.

12. The wave-shaped suspension edge structure, as recited in claim 11, wherein each supporting frame connection end of each of said wave-shaped retaining sections comprises two portions forming one angle therebetween.

13. The wave-shaped suspension edge structure, as recited in claim 11, wherein supporting frame connection end of said wave-shaped retaining sections, which are connected with said supporting frame, are connected to each other to form a ring-shaped outer edge coaxial with said vibration element.

14. The wave-shaped suspension edge structure, as recited in claim 11, wherein said angle formed between two said portions of said vibration element connection ends is selected from the group consisting of an acute angle, a right angle and an obtuse angle.

15. The wave-shaped suspension edge structure, as recited in claim 1, wherein wave crests of said wave-shaped retaining sections have lower height than a level surface of an outer surface of said vibration element.

16. The wave-shaped suspension edge structure, as recited in claim 1, wherein wave crests of a part of or all of said wave-shaped retaining sections have higher height than a level surface of an outer surface of said vibration element.

17. The wave-shaped suspension edge structure, as recited in any one of claims 1-16, wherein said plurality of wave-shaped retaining sections is arranged symmetrically relative to a center of said vibration element.

18. The wave-shaped suspension edge structure, as recited in any one of claims 1-16, wherein said vibration element has a shape which is selected from the group consisting of circular, oval, rectangle, and polygon.

19. The wave-shaped suspension edge structure, as recited in any one of claims 1-16, wherein said vibration element is circular-shaped and each wave-shaped retaining sections are arranged along a radial direction of said vibration element so as to form a radial configuration of said plurality of wave-shaped retaining sections.

20. The wave-shaped suspension edge structure, as recited in any one of claims 1-16, wherein the number of said wave-shaped retaining sections is 2-200 and the ripple amplitude of each wave-shaped retaining sections is 1-500mm.

21. The wave-shaped suspension edge structure, as recited in any one of claims 1-16, wherein the area size of said vibration element is 0.005-0.2m^2.

22. The wave-shaped suspension edge structure, as recited in any one of claims 1-16, wherein said vibration element comprises a vibration weighted element and a coating layer coated on said vibration weighted element, wherein said coating layer is made of same material with said elastic suspension edge.

23. The wave-shaped suspension edge structure, as recited in any one of claims 1-16, wherein said elastic suspension edge is bonded with said supporting frame and said vibration element.

24. The wave-shaped suspension edge structure, as recited in any one of claims 1-16, wherein said vibration unit is connected to a voice coil coupling with a magnetic coil system so as to form a loudspeaker.

25. The wave-shaped suspension edge structure, as recited in any one of claims 1-16, wherein said vibration unit is a passive vibrating plate sharing a vibration cavity with at least one main vibration speaker, wherein said main vibration speaker vibrates to produce sounds in response to an input of audio signals, wherein said vibration unit is driven to vibrate to produce an auxiliary sound by means of the air pressure changes within said vibration cavity.

26. The wave-shaped suspension edge structure, as recited in claim 22, wherein said main vibration speaker and said vibration unit are arranged side by side.

27. The wave-shaped suspension edge structure, as recited in claim 22, wherein said main vibration speaker and said vibration unit are coaxial arranged back-to-back.

28. A wave-shaped suspension edge structure, which is provided between a vibration element and a supporting frame, wherein said wave-shaped suspension edge structure comprises an elastic suspension edge provided around said vibration element and extended between said vibration element and said supporting frame, wherein said elastic suspension edge structure comprises a plurality sets of connecting ribs, wherein each sets of said connecting ribs comprise at least one top connecting rib extending from a top side of an outer peripheral surface of said vibration element to an interior peripheral surface of said supporting frame and at least one bottom connecting rib adjacent to said top connecting rib and extending from a bottom side of said outer peripheral surface to said interior peripheral surface of said supporting frame, wherein an arc-shaped connecting section is formed between said top connecting rib and said bottom connecting rib so as to form said wave-shaped structure around said vibration element.

29. The wave-shaped suspension edge structure, as recited in claim 28, wherein a groove is formed between each wave-shaped retaining sections so as to form said wave-shaped structure, wherein the shape of said wave-shaped structure is selected from the group consisting of sinusoidal waveform, sinusoidal waveform, triangular waveform and sawtooth waveform.

30. The wave-shaped suspension edge structure, as recited in claim 28, wherein each connecting ribs and said connecting sections are made of different elastic materials.

31. The wave-shaped suspension edge structure, as recited in claim 28, wherein each connecting ribs and said connecting sections are made of same elastic materials.

32. The wave-shaped suspension edge structure, as recited in claim 28, wherein an angle is formed between two adjacent arc-shaped connecting sections.

33. The wave-shaped suspension edge structure, as recited in claim 28, wherein each sets of connecting ribs comprise one top connecting rib and one bottom connecting rib, wherein a cross section of an inner edge of said elastic suspension edge connected to said vibration element is sinusoidal waveform shaped.

34. The wave-shaped suspension edge structure, as recited in claim 28, wherein each sets of connecting ribs comprise two top connecting ribs and two bottom connecting ribs, wherein two said bottom connecting ribs are respectively positioned on two sides of said top connecting ribs and a cross section of an inner edge of said elastic suspension edge connected to said vibration element has a shape which is selected from the group consisting of sinusoidal waveform, sinusoidal waveform, triangular waveform and sawtooth waveform.

35. The wave-shaped suspension edge structure, as recited in claim 28, wherein each top connecting ribs are extended from said outer peripheral surface of said vibration element to said interior peripheral surface of said supporting frame vertically or aslant.

36. The wave-shaped suspension edge structure, as recited in claim 28, wherein each bottom connecting ribs are extended from said outer peripheral surface of said vibration element to said interior peripheral surface of said supporting frame vertically or aslant.

37. The wave-shaped suspension edge structure, as recited in claim 28, wherein supporting frame connection ends of each elastic suspension edge connected with said interior peripheral surface of said supporting frame form a ring-shaped outer edge coaxial with said vibration element.

38. The wave-shaped suspension edge structure, as recited in any claims 28-37, wherein said vibration element has a shape which is selected from the group consisting of circular, oval, rectangle, and polygon.

39. The wave-shaped suspension edge structure, as recited in any claims 28-37, wherein said vibration element is circular-shaped and each connecting ribs are arranged along a radial direction of said vibration element.

40. The wave-shaped suspension edge structure, as recited in any claims 28-37, wherein said vibration element comprises a vibration weighted element and a coating layer coated on said vibration weighted element and be made of same material with said elastic suspension edge.

41. The wave-shaped suspension edge structure, as recited in any claims 28-37, wherein said elastic suspension edge is bonded with said supporting frame and said vibration element.

42. The wave-shaped suspension edge structure, as recited in any claims 28-37, wherein said vibration unit is connected to a voice coil coupling with a magnetic coil system so as to form a loudspeaker.

43. The wave-shaped suspension edge structure, as recited in any claims 28-37, wherein said vibration unit is a passive vibrating plate sharing a vibration cavity with at least one main vibration speaker, wherein said main vibration speaker makes response to input of audio signals to vibrate to produce sounds and said vibration unit is driven to vibrate to produce an auxiliary sound by the air pressure changes within said vibration cavity.

44. The wave-shaped suspension edge structure, as recited in claim 43, wherein said main vibration speaker and said vibration unit are arranged side by side.

45. The wave-shaped suspension edge structure, as recited in claim 43, wherein said main vibration speaker and said vibration unit are coaxial arranged back-to-back.

46. A vibration unit, comprising a wave-shpaed suspension edge structure as recited in one of claims 1-16 and 28-37, wherein said vibration unit further comprises a vibration element, an elastic suspension edge with a plurality of wave-shaped retaining sections, and a supporting frame, wherein said elastic suspension edge is provided between said vibration element and said supporting frame, so as to ensure a movement direction of said vibration element is kept along an axial direction and prevent said vibration element to shake and deviate.

47. The vibration unit, as recited in claim 46, wherein said vibration unit is a passive vibrating plate sharing a vibration cavity with at least one main vibration speaker, wherein said main vibration speaker vibrate to produce sounds in response to an input of audio signals, wherein said vibration unit is driven to vibrate to produce an auxiliary sound by means of an air pressure changes within said vibration cavity.

48. The vibration unit, as recited in claim 47, wherein said main vibration speaker and said vibration unit are arranged side by side or coaxially arranged back-to-back.

49. The vibration unit, as recited in claim 46, wherein said vibration element has a shape which is selected from the group consisting of circular, oval, rectangle, and polygon.

50. The vibration unit, as recited in claim 46, wherein said vibration element is circular-shaped, wherein each of the wave-shaped retaining sections is radially arranged with respect to said vibration unit, so as to form a plurality radial wave-shpaed retaining sections.

51. The vibration unit, as recited in claim 46, wherein the number of said wave-shaped retaining sections is 2-200 and the ripple amplitude of each wave-shaped retaining sections is 1-500mm, wherein the area size of said vibration element is 0.005-0.2m^2.

52. The vibration unit, as recited in claim 46, wherein said vibration element comprises a vibration weighted element and a coating layer coated on the vibration weighted element, wherein said coating layer is made of same material with said elastic suspension edge.

53. The vibration unit, as recited in claim 46, wherein said elastic suspension, said supporting frame and said vibration element are adhered with each other.

54. The vibration unit, as recited in claim 46, wherein said vibration unit is connected to a voice coil which couples with a magnetic coil system so as to form a loudspeaker.

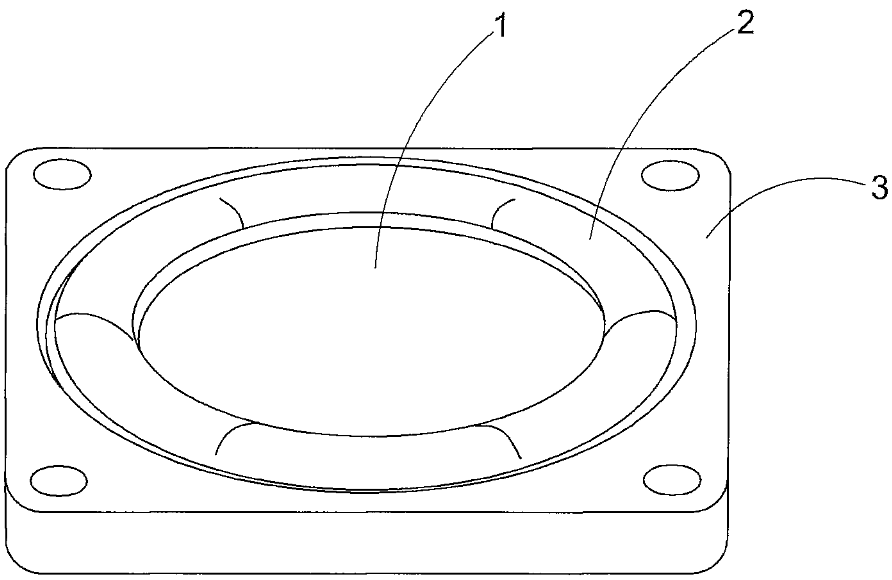


FIG. 1

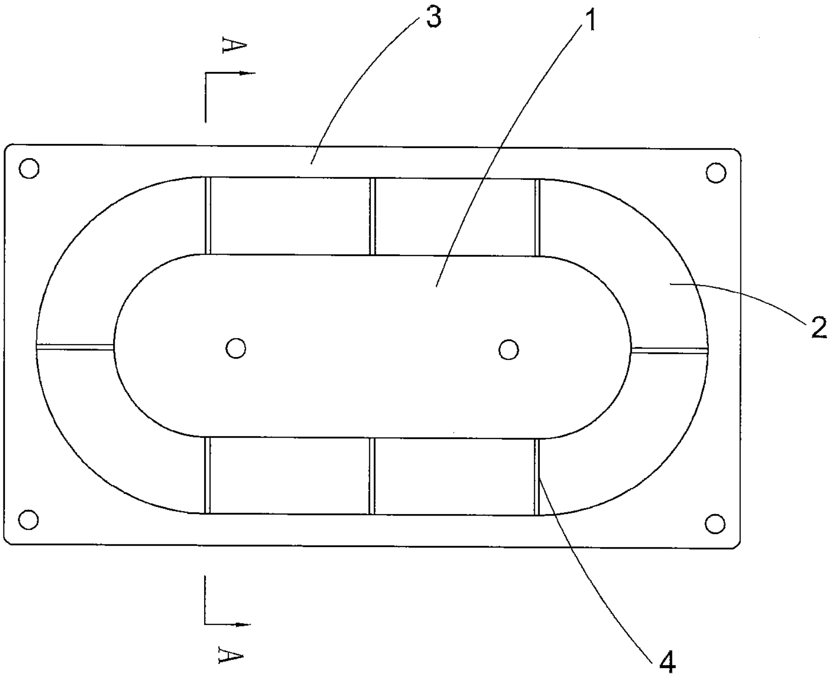


FIG. 2A

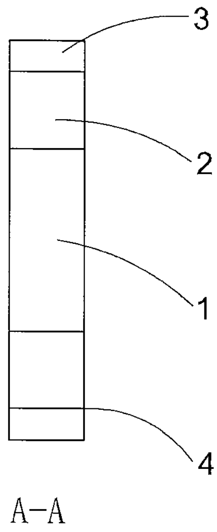


FIG. 2B

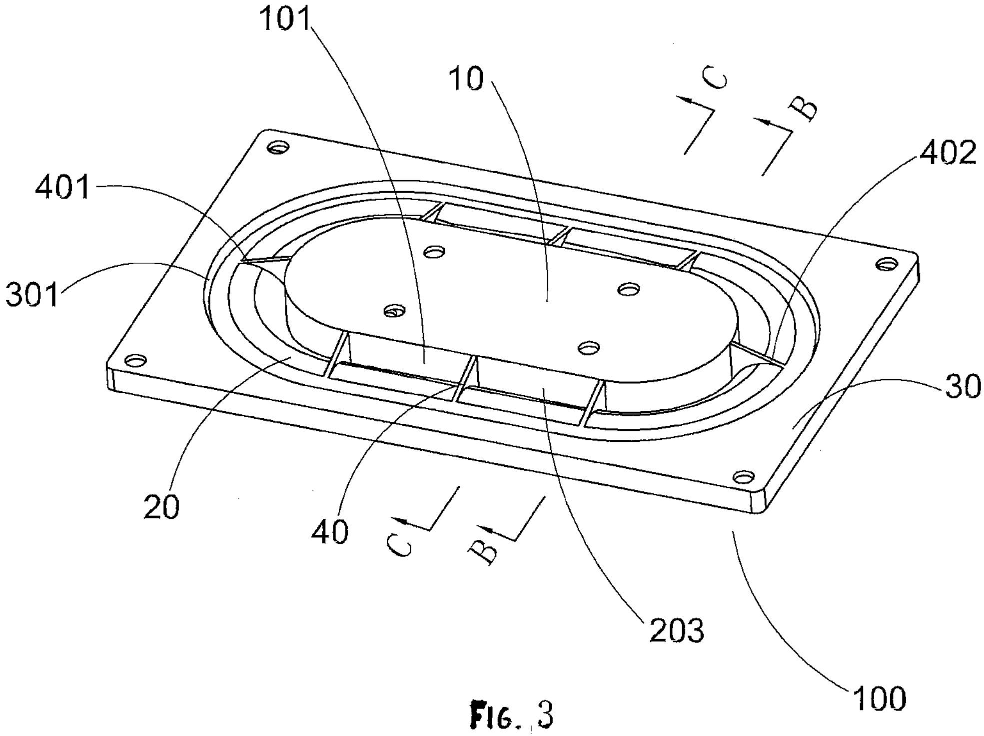


FIG. 3

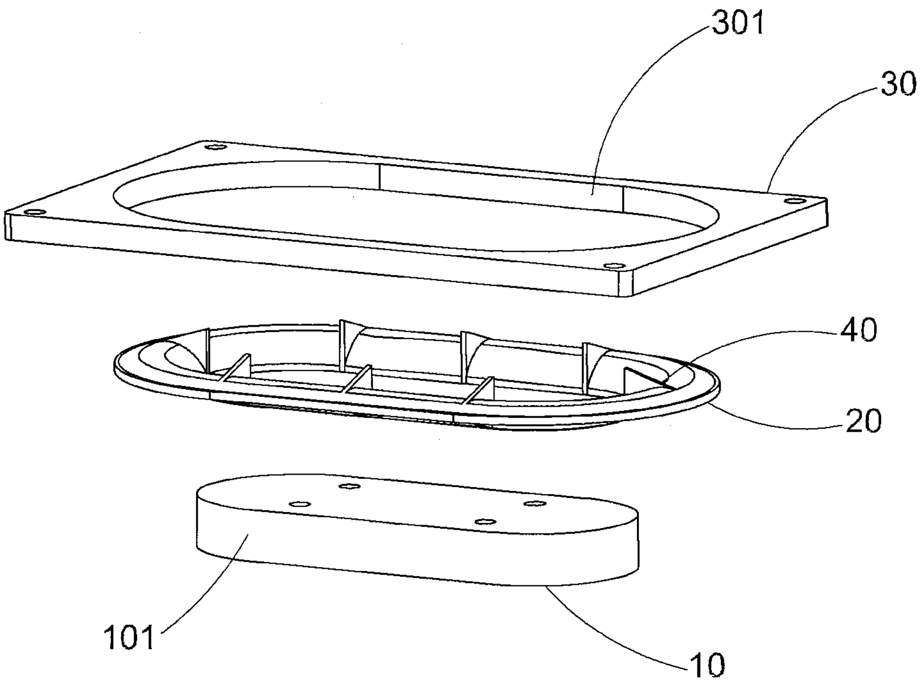
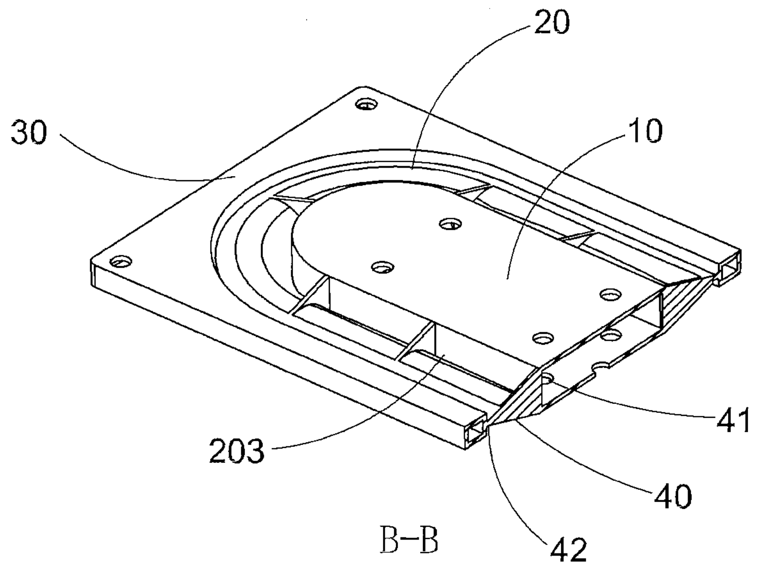
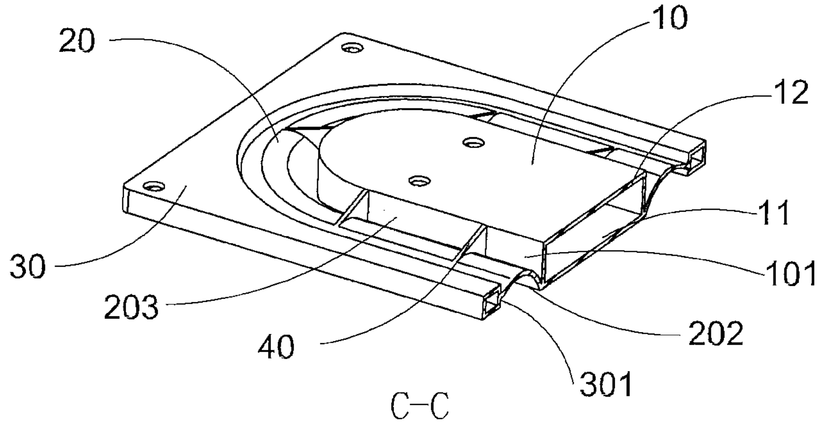


FIG. 4



B-B

FIG. 5A



C-C

FIG. 5B

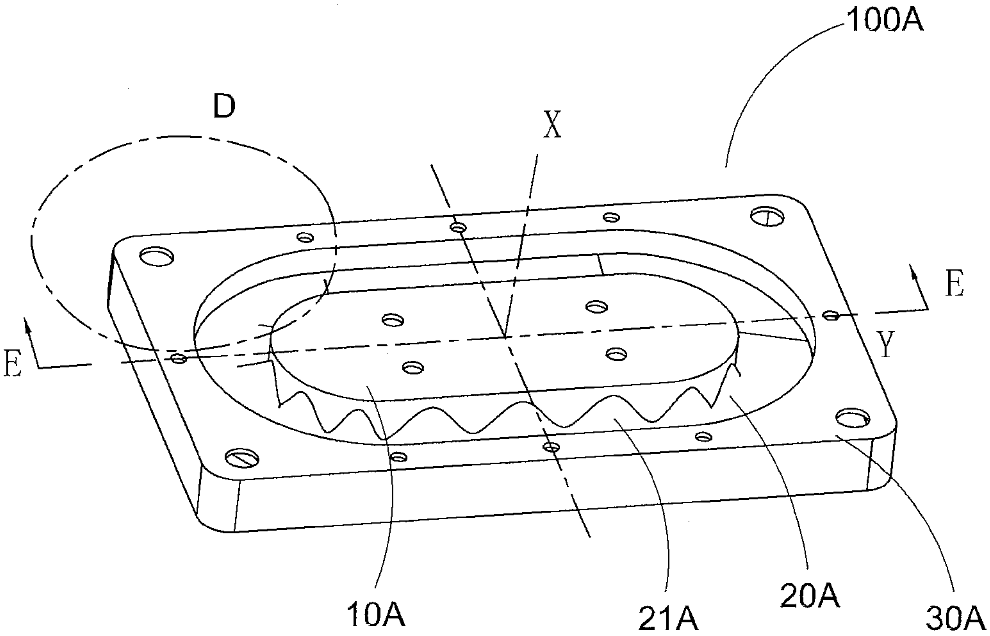


FIG. 6

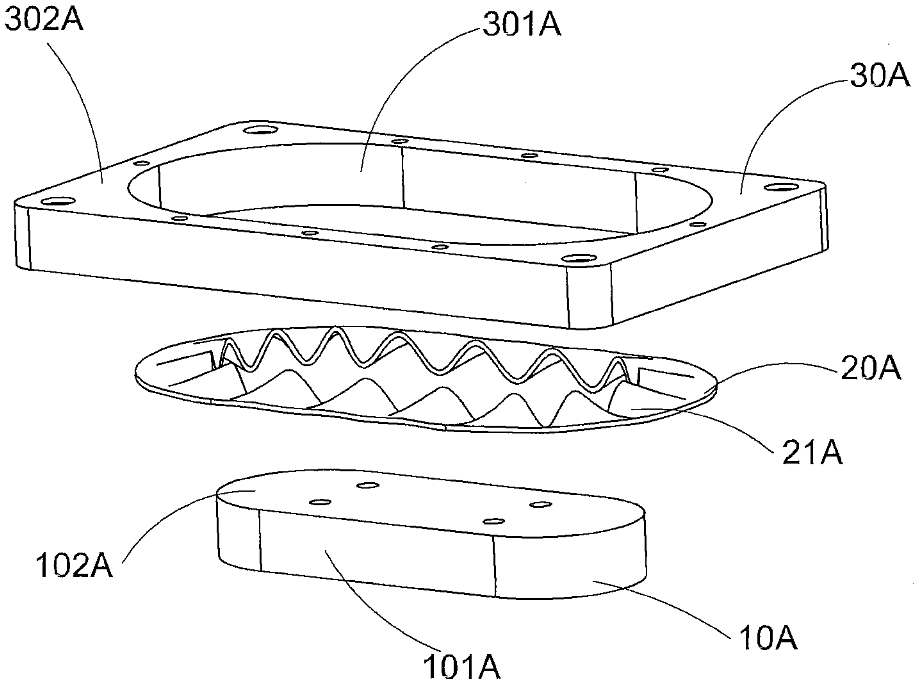
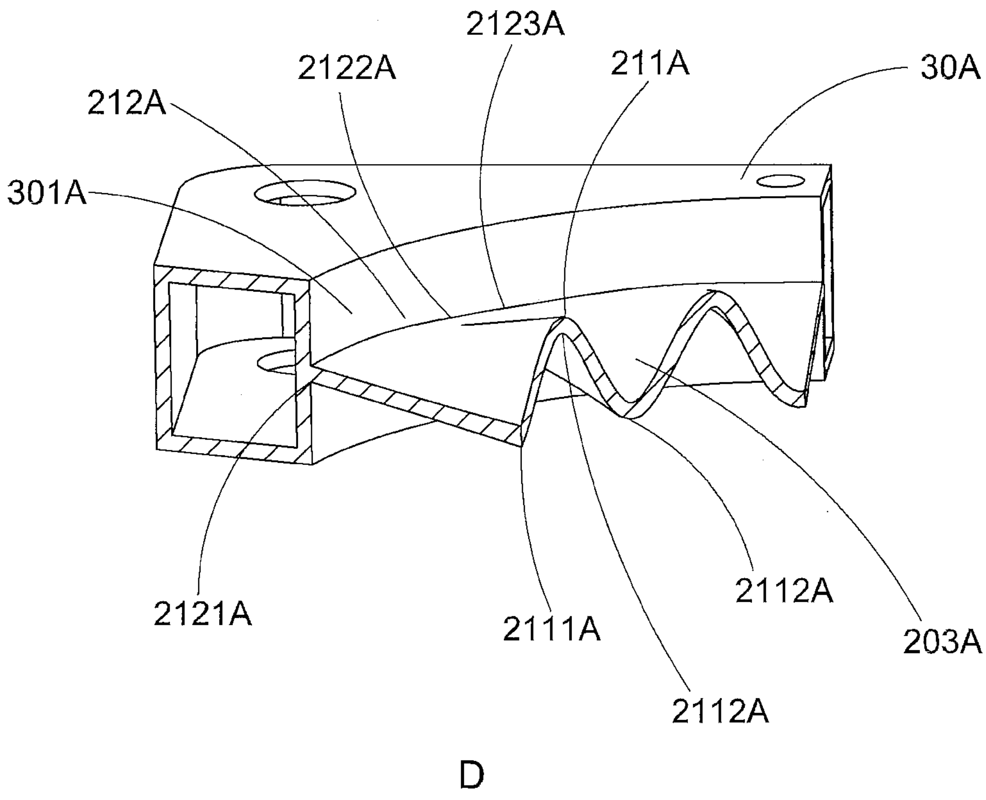


FIG. 7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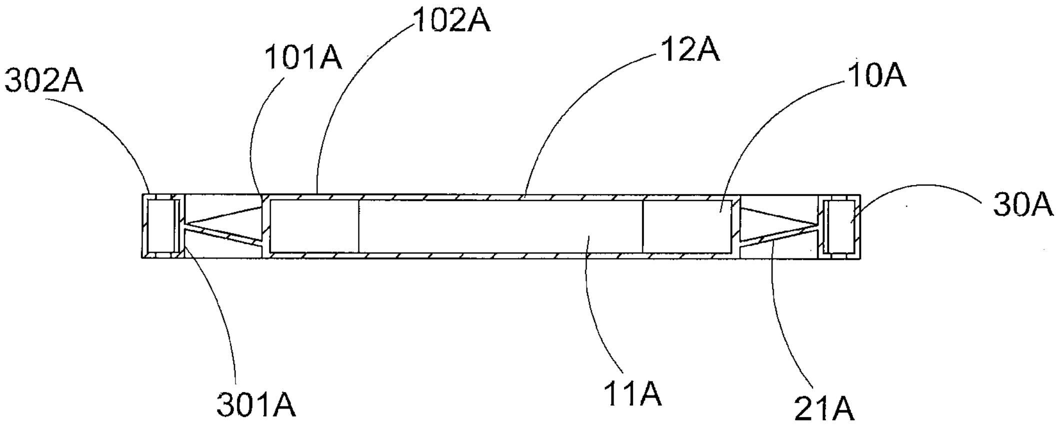
D

FIG. 8



E-E

FIG. 9

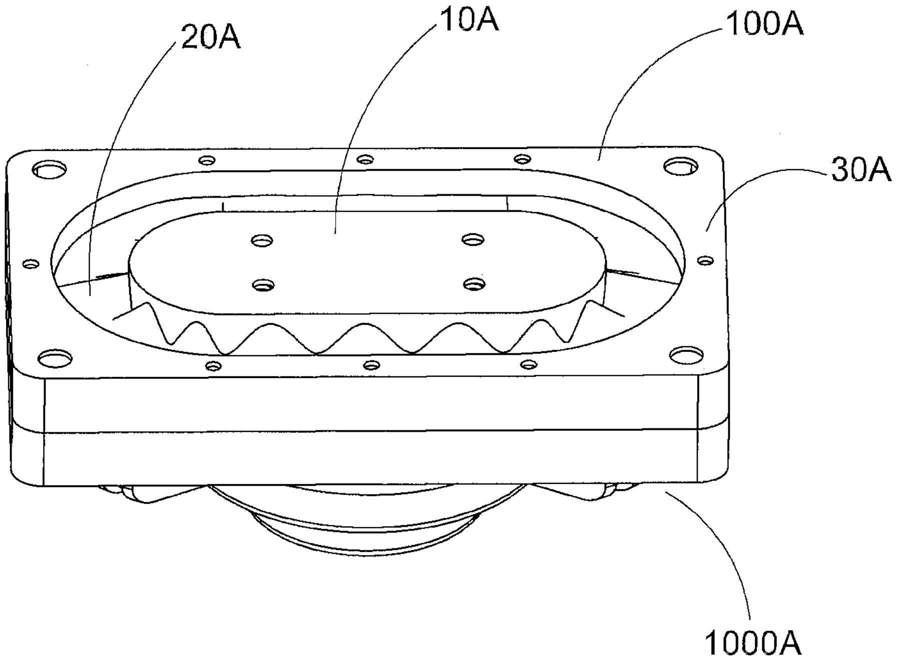


FIG. 10A

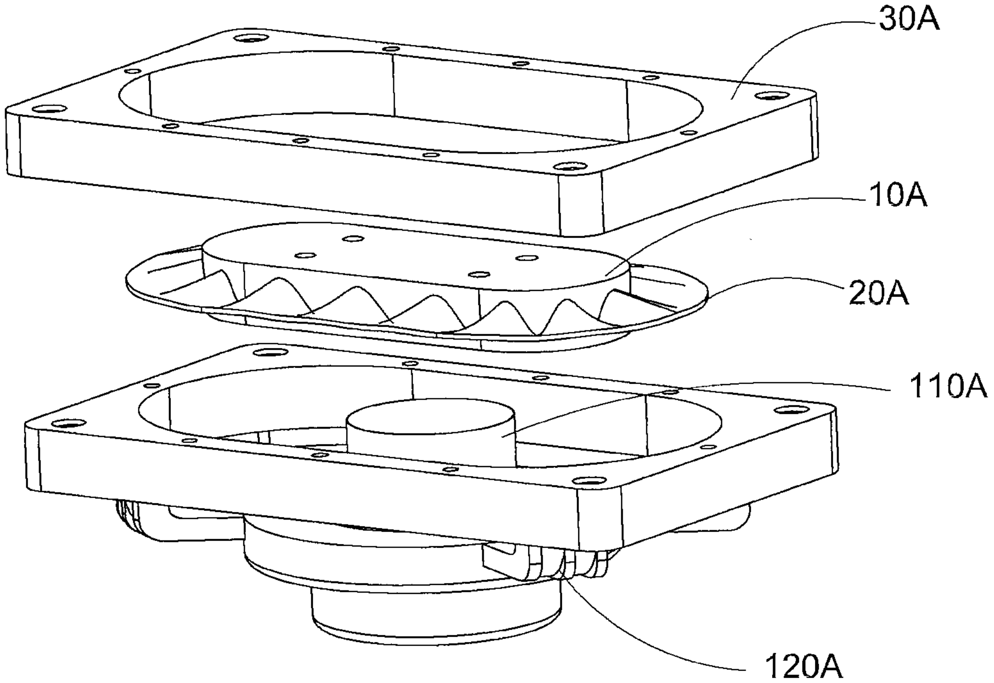


FIG. 10B

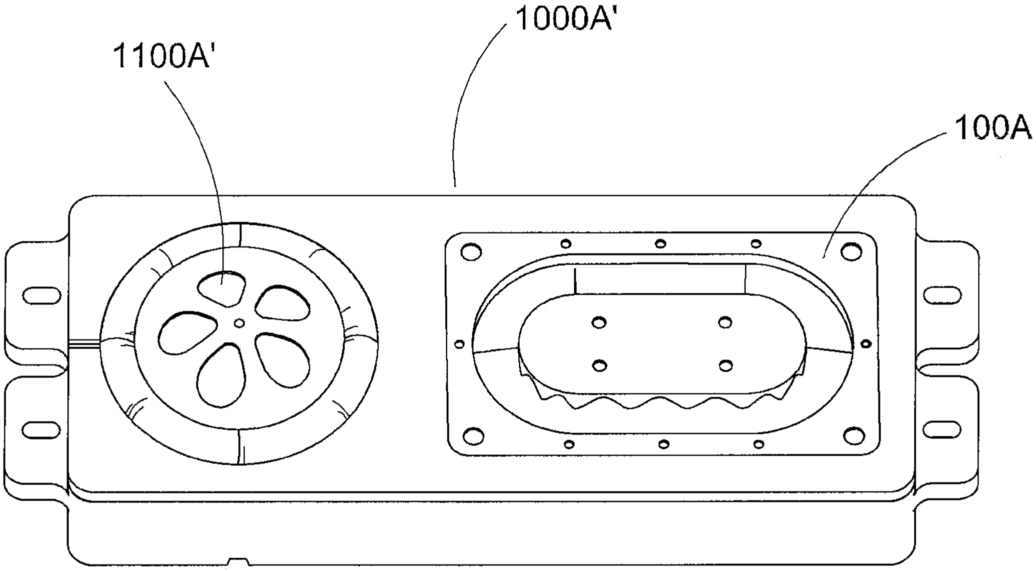


FIG. 11A

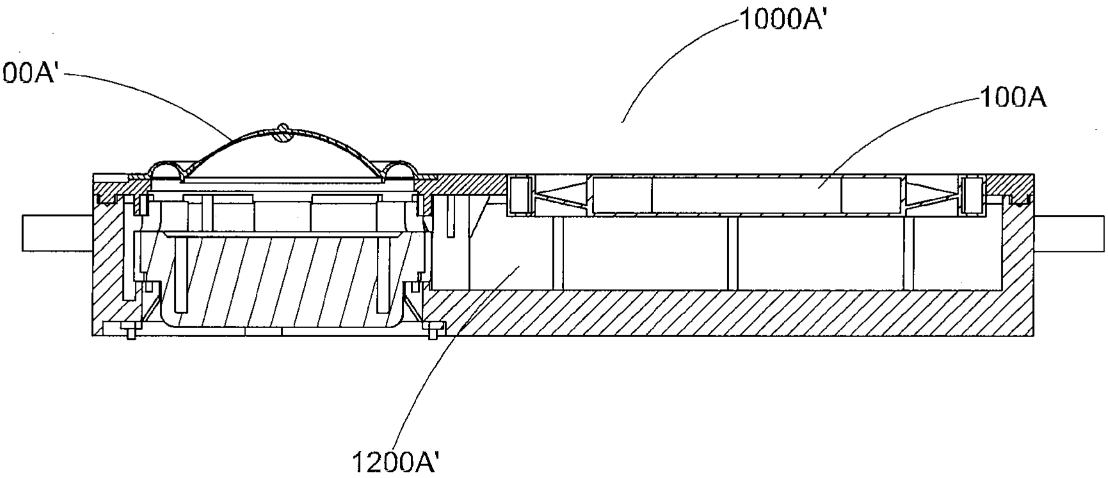


FIG. 11B

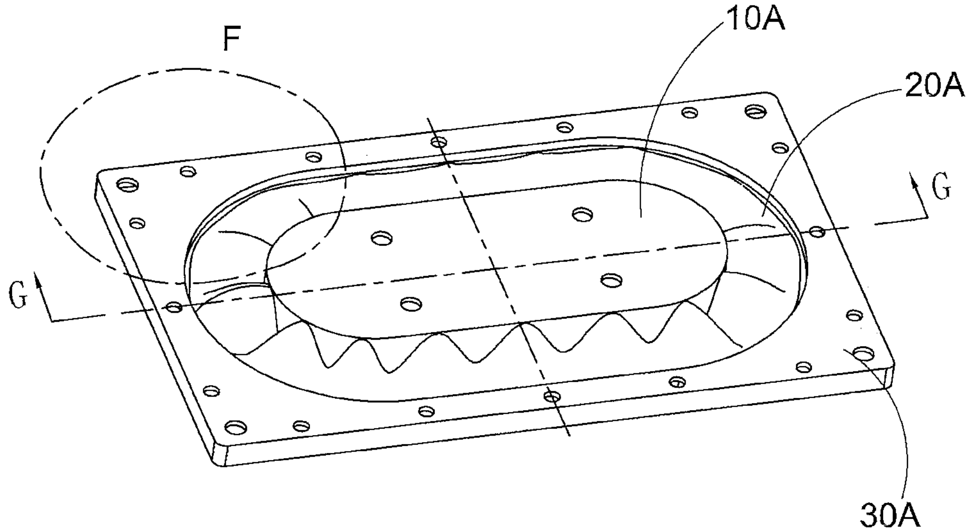


FIG. 12

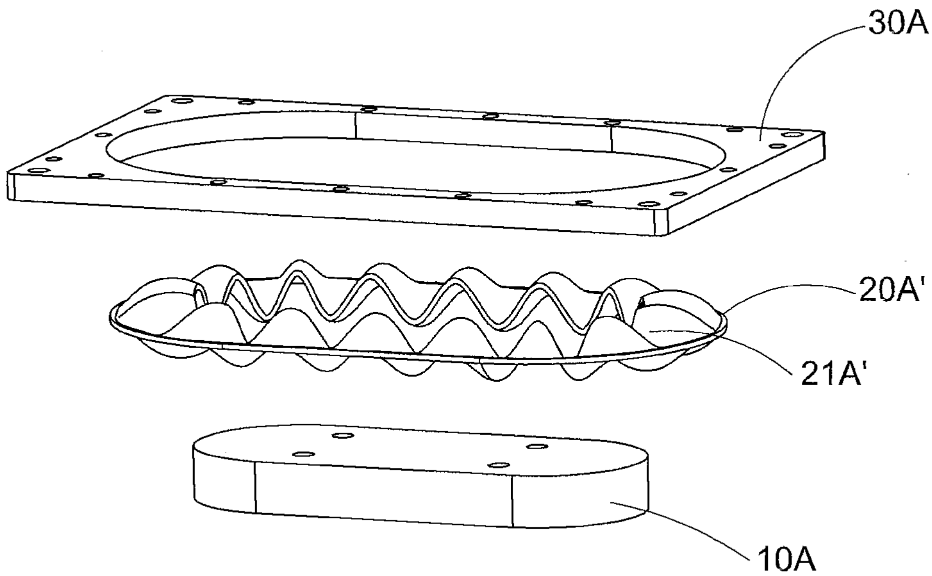


FIG. 13

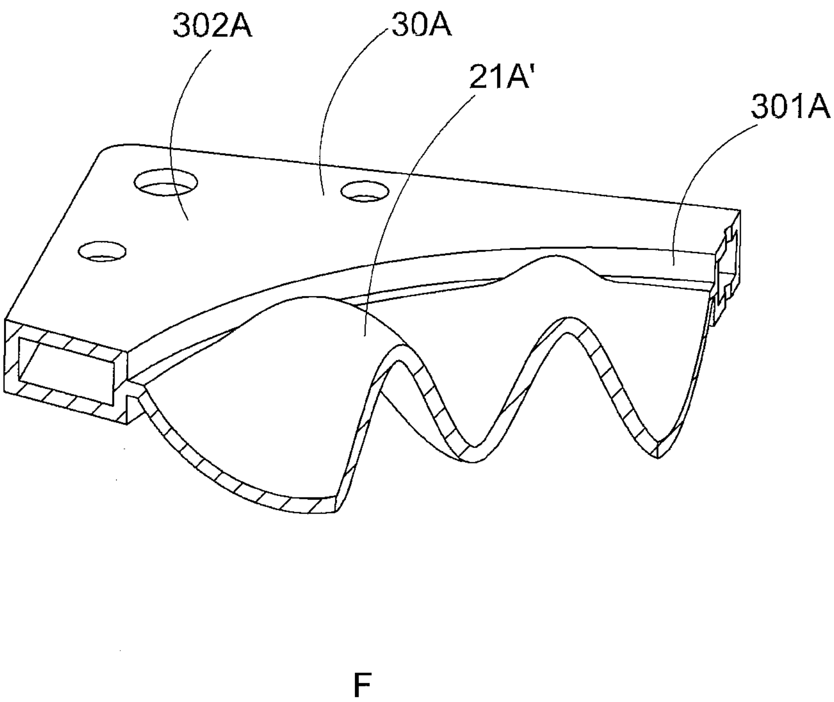
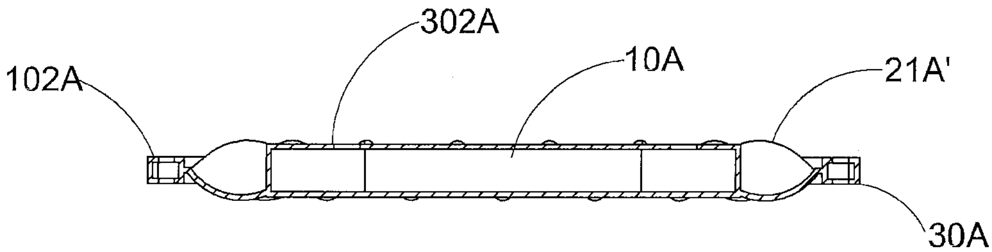


FIG. 14



G-G

FIG. 15

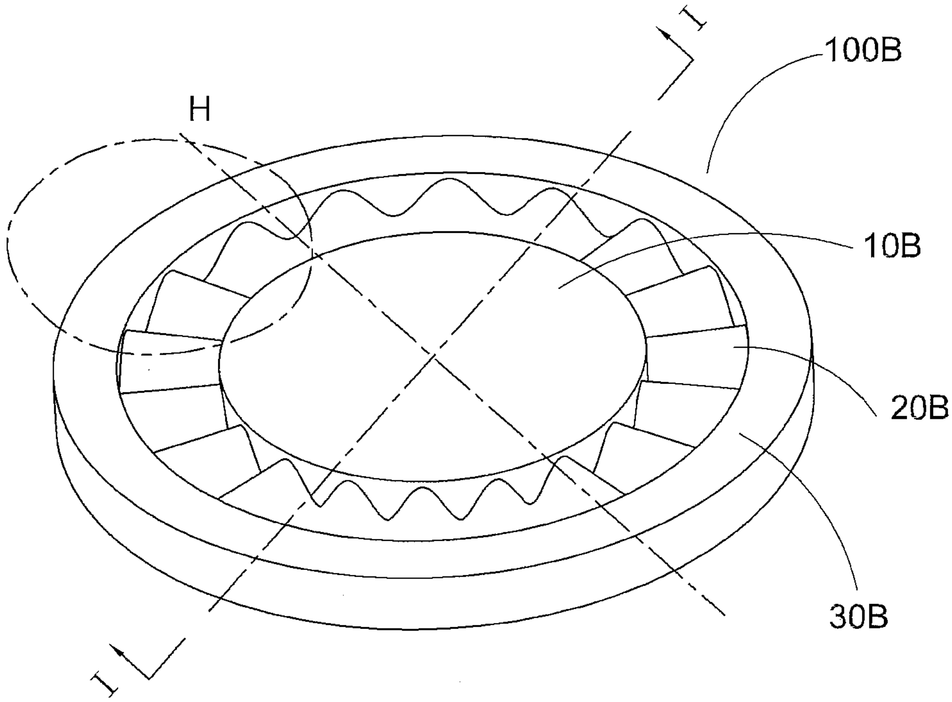


FIG. 16

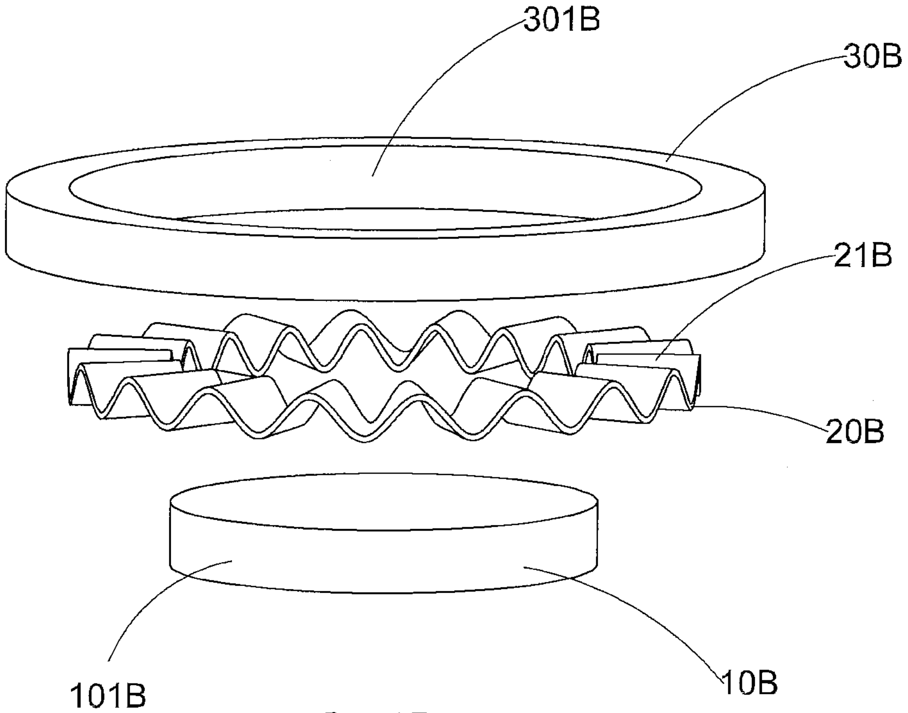


FIG. 17

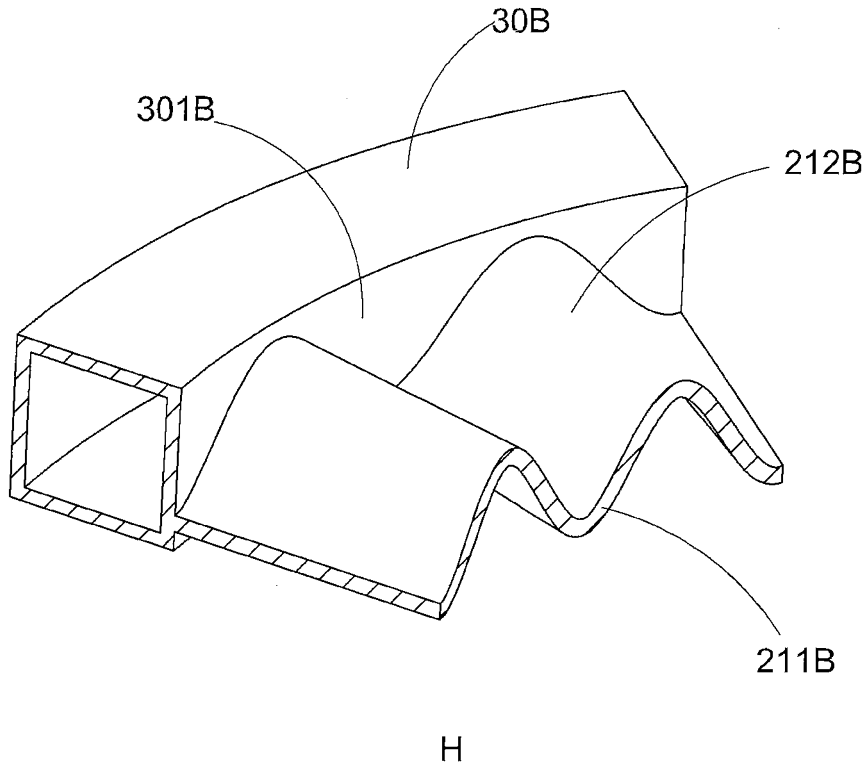
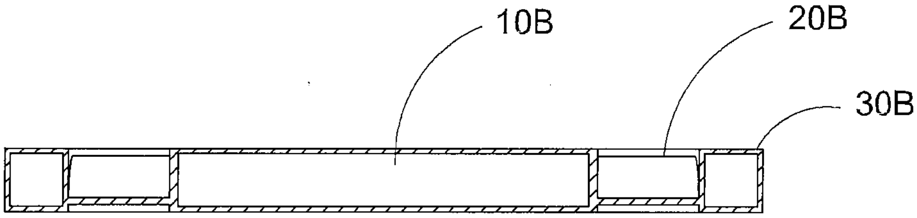


FIG. 18



I-I

FIG. 19

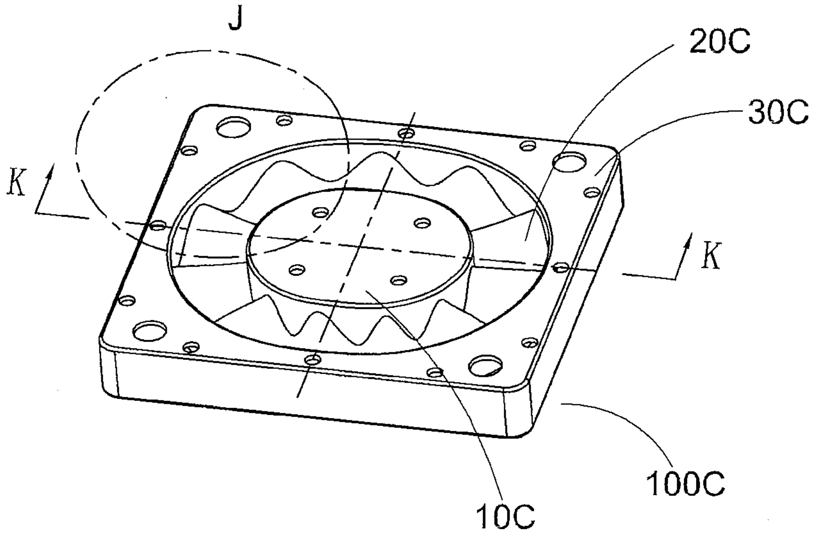


FIG. 20

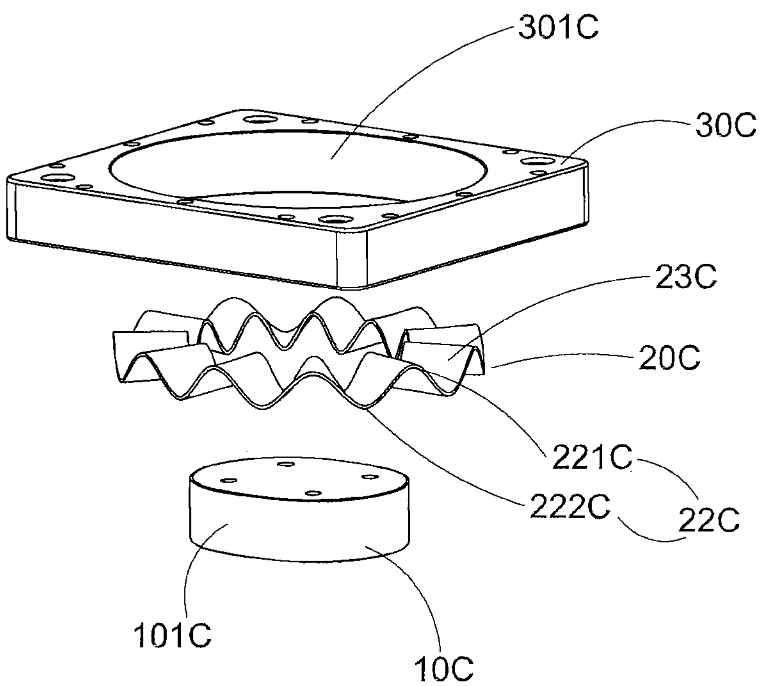


FIG. 21

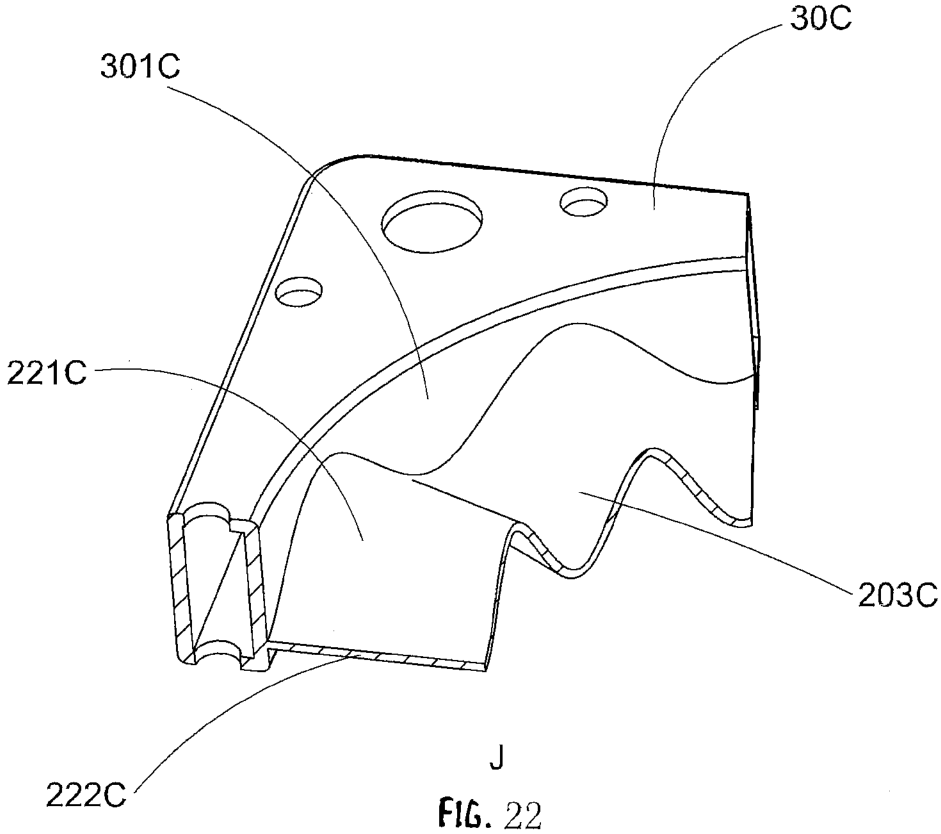
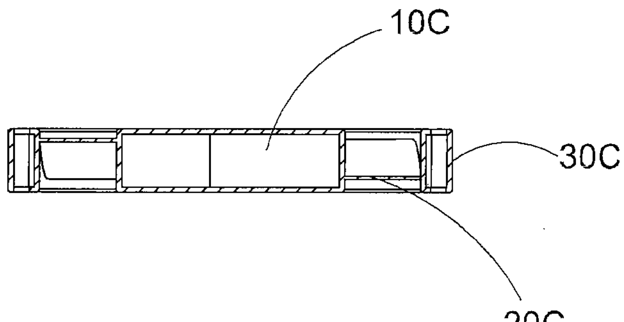


FIG. 22



K-K
FIG. 23

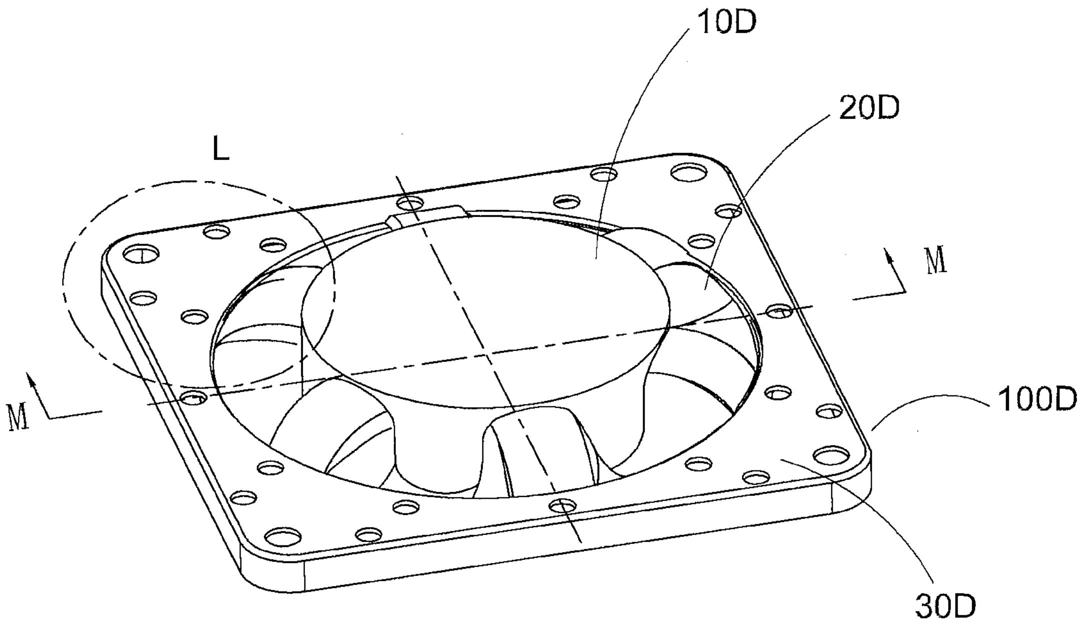


FIG. 24

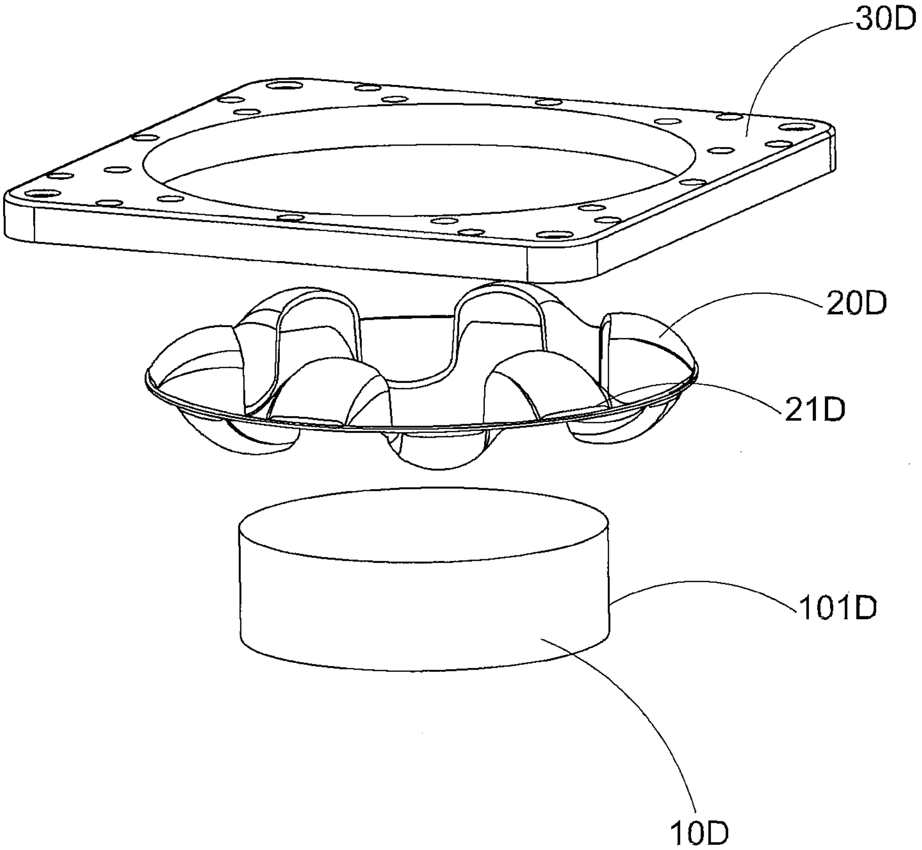


FIG. 25

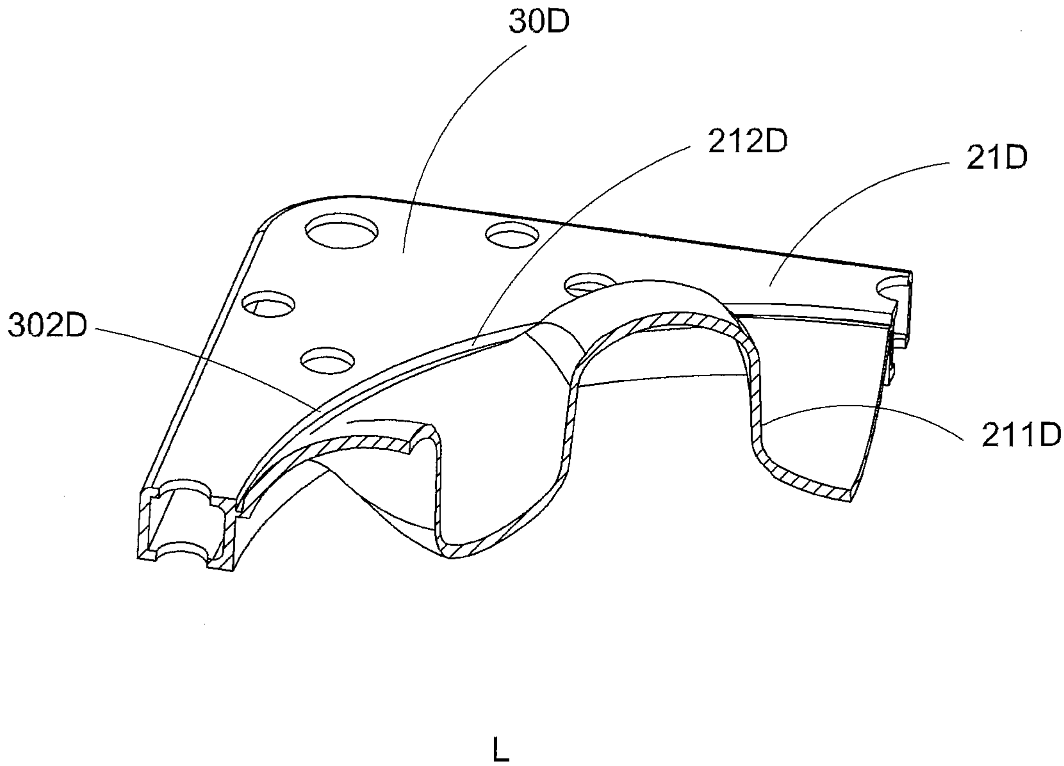
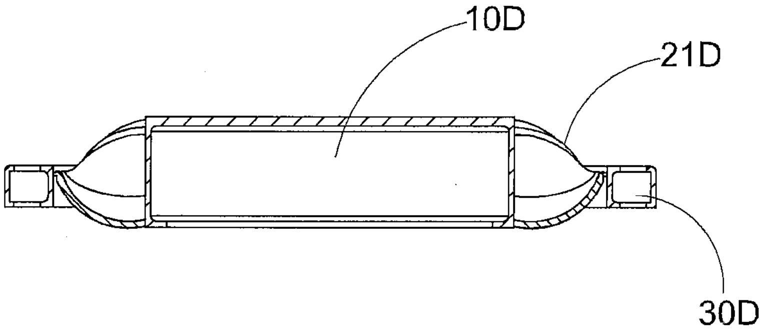


FIG. 26



M-M

FIG. 27

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2015/070682

A. CLASSIFICATION OF SUBJECT MATTER

H04R 9/06 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04R H05K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS; CNTXT; CNKI; VEN; DWPI: frame, vibrat+, member, element, component, wave, bellow, shape, edge, support+, connect+, circle, round, rib, surface

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009086416 A1 (SONY CORP.) 02 April 2009 (02.04.2009) description, pages 212-222	1
X	CN 102984631 A (NINGBO SHENGYA ELECTRONIC CO., LTD.) 20 March 2013 (20.03.2013) description, pages 60-70	1
A	CN 202135035 U (IEA ELECTRO ACOUSTIC CO., LTD,) 01 February 2012 (01.02.2012) the whole document	1-54

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 March 2015	22 April 2015

Name and mailing address of the ISA
State Intellectual Property Office of the P. R. China
No. 6, Xitucheng Road, Jimenqiao
Haidian District, Beijing 100088, China
Facsimile No. (86-10) 62019451

Authorized officer
WU, Zhibiao
Telephone No. (86-10) 62411320

Form PCT/ISA /210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2015/070682

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
US 2009086412 A1	02 April 2009	US 8325477 B2	04 December 2012
		WO 2006114934 A1	02 November 2006
		JP 2006320887 A	30 November 2006
		JP 5088526 B2	05 December 2012
		KR 20080007438 A	21 January 2008
		TWI 328735 B	11 August 2010
		US 2012140414 A1	07 June 2012
		CN 101171896 A	30 April 2008
		JP 2006320892 A	30 November 2006
		JP 4910464 B2	04 April 2012
		TW 200710637 A	16 March 2007
CN 102984631 A	20 March 2013	WO 2014075611 A1	22 May 2014
CN 202135035 U	01 February 2012	None	

Form PCT/ISA /210 (patent family annex) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- CN 2015070682 W **[0002]**
- CN 201410019799 **[0002]**
- CN 201410328141 **[0002]**