



(51) International Patent Classification:

G10K 11/16 (2006.01) G10K 11/175 (2006.01)
G10K 11/172 (2006.01) G10K 11/36 (2006.01)

(21) International Application Number:

PCT/US2016/062280

(22) International Filing Date:

16 November 2016 (16.11.2016)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

14/942,569 16 November 2015 (16.11.2015) US
15/353,332 16 November 2016 (16.11.2016) US

(71) Applicant: BONGIOVI ACOUSTICS LLC [US/US];
649 SW Whitmore Drive, Port St. Lucie, FL 34984 (US).

(72) Inventors: BONGIOVI, Anthony; 649 SW Whitmore
Drive, Port St. Lucie, FL 34984 (US). HAMELINK,
Lawrence, Robert; 3174 Rosco Drive, Hamilton, MI
49419 (US). SERVIS, Brian, K.; 1980 Tiffany Court,
Holland, MI 49424 (US). BIELSKI, John, Robert; 49682
Octavia Street, Chesterfield, MI 48947 (US).

(74) Agents: MATOS, Peter, A. et al.; Malloy & Malloy, P.L.,
Attorneys For Applicant, 2800 S.W. Third Avenue, Miami,
FL 33129 (US).

(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME,
MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,
OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,
SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM,
TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM,
ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,
TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,
DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,
LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,
SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,
GW, KM, ML, MR, NE, SN, TD, TG).

Published:

- with international search report (Art. 21(3))
- before the expiration of the time limit for amending the
claims and to be republished in the event of receipt of
amendments (Rule 48.2(h))

(54) Title: SYSTEMS AND METHODS FOR PROVIDING AN ENHANCED AUDIBLE ENVIRONMENT WITHIN AN AIR-
CRAFT CABIN

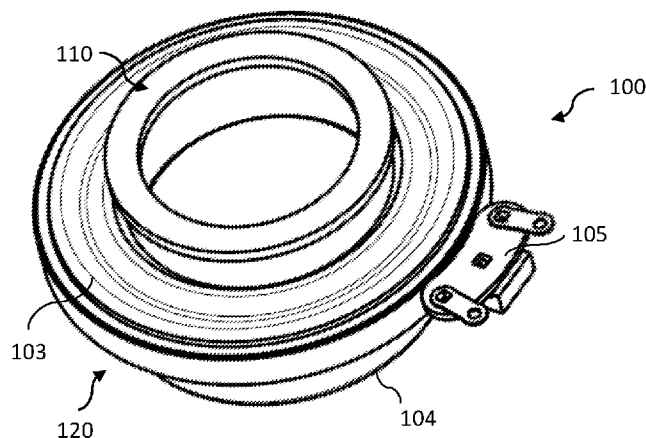


Figure 1

(57) Abstract: A system for providing an enhanced audible environment within an aircraft cabin includes at least one, but possibly, a plurality of transducers mounted symmetrically about a window of the aircraft cabin on a mounting flange of the window. The transducers are cooperatively disposed and configured to excite at least a viewing pane of said window so as to provide a desired audible environment within an aircraft cabin, without obstructing the view from the window.



SYSTEMS AND METHODS FOR PROVIDING AN ENHANCED AUDIBLE
ENVIRONMENT WITHIN AN AIRCRAFT CABIN

CLAIM OF PRIORITY

5 The present application is a continuation-in-part application of previously filed, now pending application having Serial No. 14/942,569, filed on November 16, 2015 incorporated herein by reference.

10 FIELD OF THE INVENTION

 The present invention provides for systems and methods associated with surface acoustic transducers optimally structured for an aircraft cabin and improving the audible environment within.

15

BACKGROUND OF THE INVENTION

 Where traditional loud speakers create sound by converting electric signals into mechanical motion in order to vibrate a diaphragm or cone, surface acoustic transducers
20 operate to produce sound without a cone. That is, a surface acoustic transducer operates by attachment to a surface, such as an existing panel or wall made of various materials, and directing vibrations directly onto the surface in order to create sound.

25 Surface acoustic transducers are generally known in the

art. For instance, a surface acoustic transducer might be created by merely removing the enclosure and cone from a traditional loud speaker or speaker driver, and attachment to an external vibrational surface in order to create sound.

5 However, although surface transducers have been known for some time, few have ever achieved commercial success due to the technical limitations of these transducers, and the resulting poor quality of sound by merely attaching the transducers to various surfaces.

10 Specifically, one limitation of surface acoustic transducers is due to the lack of a mechanical excursion, which causes an absence of highs and lows in sound frequency. For example, rather than achieving a rich bass sound, regular surface acoustic transducers have limited frequency response
15 resulting in a lower quality narrow band response as compared to traditional loudspeakers. Another issue with surface transducers is the effect of the attached bracket surface or external housing for mounting the surface transducers. That is, structurally, current surface mounted transducers do not
20 account for movement or variation to the vibrational surface which the surface transducer is attached to. For example, a person leaning against a wall or surface to which the surface transducer is attached to would have a drastic impact on the sound or sound quality being reproduced due to potential
25 deflection of the transducer onto adjacent surfaces behind the

application.

Therefore, there is a need in the industry for an improved surface acoustic transducer, as well as systems and methods for implementing same within an aircraft cabin, that
5 produces a better sound and overcomes the particular problems described above.

SUMMARY OF THE INVENTION

The present invention meets the existing needs described
10 above by providing for a structurally unique surface acoustic transducer and accompanying systems and methods. Specifically, the present invention provides for a surface acoustic transducer structured for producing high quality sound by vibrating an external surface. In a preferred
15 embodiment of the present invention, the surface acoustic transducer of the present invention is optimally structured for producing high quality sound within an aircraft cabin. Of course, the present transducer may also be further configured and utilized to vibrate other surfaces.

20 Accordingly, in initially broad terms, a surface acoustic transducer of the present invention comprises a primary assembly and a transducer housing structured to retain the primary assembly therein.

The primary assembly is structured to house a voice coil
25 assembly, include a voice coil former and a voice coil wire,

and optionally a coupler ring. The primary assembly may form a substantially cylindrical shape, with a portion of its proximal end protruding outwardly from the transducer housing. The magnet is disposed at a distal end of the primary
5 assembly. The coupler ring may be attached to a proximal end of the primary assembly. The primary body portion of the primary assembly may be formed from the voice coil former, having a voice coil wire wound in surrounding relations to at least a portion thereof.

10 The transducer housing may comprise a flange structure and a yoke structure, a spider, as well as a magnet, and top shunt plate attached and/or disposed therein. The flange structure forming a proximal portion of the transducer housing and the yoke structure forming a distal portion of the
15 transducer housing. The yoke may be coupled or movably attached to a distal end of the primary assembly. The top shunt plate may be juxtaposed to a distal end of the primary assembly, and between the magnet and the primary assembly. More specifically, a top shunt plate may be disposed
20 substantially within an interior of the voice coil former, and the voice coil wire may be wound external to the voice coil former at a portion thereof, such as to be disposed in a substantially overlying position relative to an external edge of the top shunt plate. The magnet may be attached and/or
25 disposed to a distal surface of the transducer housing, such

that a portion of the edge of the magnet is in overlying position relative to the voice coil wire of the voice coil assembly. The flange may be disposed in surrounding relations relative to an external surface of said voice coil assembly.

5 A terminal attachment may be attached to a portion of the flange, and structured and disposed to receive an electrical input. A spider may be coupled to the flange in juxtaposing surrounding relations with the primary assembly, and more particularly the voice coil assembly forming a portion
10 thereof. The spider may be disposed to mechanically dampen and/or at least partially impede the movement of the voice coil assembly as it is electrically excited from an electrical input signal.

An external housing or mounting bracket may further be
15 provided to at least partially enclose the transducer housing therein. The external housing may comprise a cylindrical retaining wall of a rigid composition, and an excursion cover disposed and/or affixed thereon for protecting the transducer yet at the same time allowing for the excursion of the primary
20 assembly therein.

Certain embodiments of the present invention also incorporate implementation of transducers within an aircraft cabin to improve the audible environment within. Accordingly, transducers may be applied to panels, bulkheads, walls, and/or
25 windows within the aircraft to facilitate transmission of

sounds, such as PA announcements, or, in particular
embodiments, active noise cancellation. Such embodiments may
be deployed in conjunction with microphones, receiver modules,
and processor modules, to produce appropriate signals for
5 driving the transducers so as to produce the desired audible
environment within the aircraft cabin.

These and other objects, features and advantages of the
present invention will become clearer when the drawings as
well as the detailed description are taken into consideration.

10

BRIEF DESCRIPTION OF THE DRAWINGS

For a fuller understanding of the nature of the present
invention, reference should be had to the following detailed
description taken in connection with the accompanying drawings
15 in which:

Figure 1 is a perspective external view of a surface
acoustic transducer in one embodiment of the present
invention.

Figure 2 is a bottom profile external view of the surface
20 acoustic transducer of Figure 1.

Figure 3A is a side profile external view of the surface
acoustic transducer of Figure 1

Figure 3B is a side profile partially cut away view of
the surface acoustic transducer of Figure 1.

25 Figure 4A is another side profile cut away view of the

surface acoustic transducer of Figure 1.

Figure 4B is an expanded view of a cross section of the surface acoustic transducer shown in Figure 4A.

Figure 5 is a profile view of a coupler ring forming part
5 of the surface acoustic transducer of the present invention.

Figure 6 is a profile view of the coupler ring of Figure 5 in connection with a voice coil assembly forming part of the surface acoustic transducer of the present invention.

Figure 7 is a profile view of a magnet forming part of
10 the surface acoustic transducer of the present invention.

Figure 8 is a profile view of a flange forming part of the surface acoustic transducer of the present invention.

Figure 9 is a profile view of a spider forming part of the surface acoustic transducer of the present invention.

15 Figure 10 is a profile view of a top shunt plate forming part of the surface acoustic transducer of the present invention.

Figure 11 is a profile view of a yoke forming part of the surface acoustic transducer of the present invention.

20 Figure 12 is a profile view of a surface acoustic transducer mounted within an external housing.

Figure 13A is a profile view of the external housing of Figure 12.

Figure 13B is a top down view of the external housing of
25 Figure 12.

Figure 13C is a side view of the external housing of Figure 12.

Figure 14 is a schematic view of an active noise cancellation system utilizing one or more of the surface
5 acoustic transducers of Figure 1 mounted along a periphery of an aircraft window panel via the external housing of Figure 12.

Figure 15 is a schematic view of another active noise cancellation system utilizing one or more of the surface
10 acoustic transducers of Figure 1 mounted along a periphery of an aircraft window area via the external housing of Figure 12.

Figure 16 is a schematic view of one or more surface acoustic transducers mounted along the periphery of an aircraft window panel in accordance with another embodiment of
15 the present invention.

Figure 17 is a schematic view of a system for enhancing the audible environment within an aircraft cabin utilizing one or more transducers mounted along a periphery of an aircraft window in accordance with one embodiment of the present
20 invention.

Like reference numerals refer to like parts throughout the several views of the drawings.

DETAILED DESCRIPTION OF THE EMBODIMENT

25 As illustrated by the accompanying drawings, the present

invention is directed to a surface acoustic transducer. In a preferred embodiment, the surface acoustic transducer of the present invention is optimally structured, as described below, for producing high quality sound within an aircraft cabin by vibrating its interior cabin walls, bulkheads, and/or windows. Of course, the present surface acoustic transducer may also be utilized to vibrate other surfaces. Specifically, the surface acoustic transducer of the present invention includes a transducer housing structured to at least partially enclose a primary assembly having a voice coil assembly and a magnet. In an embodiment, the transducer housing may further be mounted within an external housing or mounting bracket having a rigid retaining wall and an excursion cover. This excursion cover may be formed of a malleable helix structure such as to protect the surface acoustic transducer from external disturbance, yet at the same time allow for an excursion of the transducer via the excursion cover. This prevents or minimizes the distortion of sound when, for example, a person leans against a cabin wall that a surface acoustic transducer is attached to, or other surfaces or materials that are in close or contacting proximity to the surface acoustic transducer, all without sacrificing the sound range and quality of the transducer.

As schematically represented, Figures 1 and 2 illustrate a surface acoustic transducer 100 of the present invention.

10

Figure 1 provides a perspective view of the present transducer 100, and Figure 2 provides a bottom-up view of the present transducer 100. As shown initially, the transducer 100 may exteriorly comprise a transducer housing 120 and a primary
5 assembly 110 retained therein.

The primary assembly 110 may form a substantially cylindrical shape and may comprise and/or be formed at least partially from a voice coil assembly 117, with at least a portion of its proximal end protruding outwardly from the
10 transducer housing 120. The transducer housing 120 may comprise a flange 103 forming a proximal portion of the transducer housing 120, and a yoke 104 forming a distal portion of the transducer housing 120. Further, the distal end of the primary assembly 110 may terminate within the yoke
15 104.

The flange 103 may be coupled to a proximal end of said transducer housing 120, forming a portion thereof. Said flange 103 being disposed in surrounding relations to the primary assembly 110. The flange 103 may comprise a terminal
20 attachment 105 coupled to an end or edge of the flange as shown in the accompanying Figures. The terminal attachment 105 being structured with at least a positive and negative terminal portions for receiving power from a power source, and further relay the power to a voice coil assembly 117. In at
25 least one embodiment of the present invention, the transducer

11

housing 120, or more particularly the diameter of the flange 103 comprises a diameter of between 25 mm to 30 mm.

The yoke 104 may be coupled to a distal end of said transducer housing 120, forming another portion thereof. Said
5 yoke 104 may be coupled in at least partially surrounding relations relative to a distal portion of the primary assembly 110.

Drawing attention to Figures 3A and 3B, respective side profile and partial cutaway side profile views of the surface
10 acoustic transducer 100 are shown. As in Figure 3A, the primary assembly 110 may further comprise a coupler ring 101 attached to a proximal end thereof. The primary assembly 110 may comprise a voice coil assembly 117 disposed between the coupler ring 101 and the yoke 104.

15 Drawing attention to Figure 3B, a partial cutaway view of the surface acoustic transducer 100 further illustrates a spider 102 at least partially coupled to the flange 103, and structured to dampen the movement of the primary assembly 110 comprising the voice coil assembly 117. As such, the spider
20 102 may be coupled in surrounding relations to the primary assembly 110, or more specifically, a portion of the voice coil assembly 117. A magnet 111 providing a magnetic field may be coupled to a distal end of the transducer housing 120 and disposed in proximity to a distal end of the primary
25 assembly 110 and/or voice coil assembly 117, and the voice

12

coil wires 116 thereof, such as when the voice coil assembly 117 is in a resting state. A top shunt plate 112 may form circumferentially along a distal portion of the voice coil assembly 117, and disposed in juxtaposing relations to the magnet 111. In at least one embodiment, the top shunt plate 112 comprises a slanted edge configuration which facilitates the bleeding or absence of magnetic field at the corners of the top shunt plate 112. Such a configuration may also improve the shape of a "BL" curve representing force factor (magnetic field strength of the magnet multiplied by the length of the voice coil) relative to excursion distance.

Drawing attention to Figure 4A illustrating a cutaway view of the surface acoustic transducer 100, and more particularly Figure 4B illustrating an exploded view of the cross section C, the voice coil assembly 117 comprises a voice coil former 115 and voice coil wire 116. The voice coil former 115 may comprise a cylindrical shape and may form a part or a portion of the voice coil assembly 117. The voice coil wire 116 may be wound in surrounding relations to at least a portion of the voice coil former 115, as illustrated in Figure 4B, such that the voice coil wire 116 may be at least partially immersed within the magnetic field provided by the magnet 111.

In at least one embodiment of the present invention, a top shunt plate 112 may be disposed in substantially overlying

relations relative to the voice coil wire 116, while only a portion of the magnet 111 is disposed in overlying relations relative to the voice coil wire 116, when the voice coil assembly 117 is at a rest state. Further, the magnet 111 of the present invention is preferably mounted at a distance of approximately 0.33 mm away (or providing a gap of 0.33 mm) from the voice coil assembly 117, to ensure that the magnet 111 and voice coil assembly 117 do not collide. In other embodiments, the gap will be preferably between various ranges of 0.25 to 0.4 mm. When the voice coil assembly 117 is in an excited state, such as when electrically excited by an input electrical signal via the terminal attachment 105 from an external power source, the voice coil assembly 117 may move in accordance with the received signal. The spider 102 coupled to the flange 103 is in juxtaposing surrounding relations with the voice coil assembly 117, such as to abut the voice coil former 115 in order to at least partially impede and/or dampen its movement. In a preferred embodiment, the spider 102 is formed of a flexible material such as to allow for a large excursion range or movement of the voice coil assembly 117.

Drawing attention back to Figure 4A, and in at least one embodiment of the present invention, the transducer housing 120 is structured to house the primary assembly 110 including the voice coil assembly 117, and the magnet 111, such that the voice coil assembly 117 is disposed in movable relations

relative to the magnet 111. In other words, the voice coil assembly 117 is movably attached to the transducer housing 120 comprising the flange 103 and the yoke 104, such that it may move axially outwards from the transducer housing 120 along a path of excursion during various excited state(s), and return to rest in a position as illustrated in Figures 4A and 4B.

Moving further to Figures 12-13, other embodiments of the present invention further comprises an external housing 200 utilized for mounting the surface acoustic transducer 100 described above onto a surface or material, such as an interior cabin, bulkhead, and/or window panel of an aircraft. As indicated in Figure 12, the external housing 200 may at least partially enclose the surface acoustic transducer 100, in order to retain the transducer 100 therein and attach the same to a surface via at least one mounting bracket, such as mounting bracket(s) 203 and/or 203'. When mounted or installed therein, the transducer 100 maintains a center alignment with the external housing 200, and a center line screw 206 may be utilized to stabilize and affix the transducer 100 within the external housing 200, such that the screw may cooperatively enter a center aperture 205 of an excursion cover 201 forming on a proximal portion of the external housing 200, and reach distally down towards the yoke 104 attached to or forming the distal portion of the transducer housing 120, and therefore serving as a structural

securing mechanism.

It should also be appreciated that the housing 200 need not be mounted to the same surface as the transducer and, in fact, the housing 200 may be mounted to a surface that is
5 independent from the surface to which the transducer is mounted.

Drawing addition to additional details in Figures 13A-13C, the external housing 200 generally comprises a retaining wall 202, at least one mounting bracket 203 and/or 203', and
10 an excursion cover 201. The retaining wall 202 is preferably formed of a cylindrical shape and rigid composition such as to protect the interior thereof from external forces, such as when a person leans against a surface or interior cabin of an aircraft that the surface transducer 100 and external housing
15 200 are attached to. As such, the retaining wall 202 may further be attached to, or formed with, at least one mounting bracket 203 and/or 203', comprising at least one aperture on each bracket so as to secure the external housing 200 to a substantially flat surface by conventional means, such as
20 nails or screws, or adhesive. In one embodiment, the mounting brackets 203, 203' or alternatively, their respective apertures, may be optional as the external housing 200 may be secured to a surface via adhesives. In another embodiment, the mounting brackets 203, 203' or alternatively, their respective
25 apertures may allow mechanical reinforcement of bonding from

adhesive as adhesive flows into the aperture and onto the opposing surface creating a "mushroom shape when dry resulting in additional mechanical fastening strength.

The excursion cover 201 is formed on or attached to the
5 retaining wall 203 via a plurality of contact portions 207. In the embodiment illustrated in Figure 13B, the excursion cover 201 comprises a spiral or helix structure having three contact portions 207, such as to provide a degree of protection to the transducer 100 housed therein, yet at the
10 same time allow for the excursion of the transducer 100, and more specifically its primary assembly and/or voice coil assembly outwardly. In other words, the structural configuration, composition, contact portions, and/or combinations therefore, support the malleability of the
15 excursion cover 201, which may also move outwardly in response to the transducer 100 entering excited state(s), and therefore help support a richer and more vibrant sound rather than dampening it. Of course, in other embodiments, it should be understood that two or more contact portions 207, in addition
20 to various compositional and physical characteristics of the excursion cover 201, may be used, depending on the degree of malleability or rigidity required.

In one embodiment, the external housing 200 may be formed from injection molding as an injection molding resin including
25 but not limited to polypropylene, polyethylene, ABS,

polycarbonate, glass reinforced molding resin, injection molding resin with flame retardant. In other embodiments, the external housing 200 may be formed from steel stamping, and/or other appropriate materials known to those skilled in the art.

5 Drawing attention to back to Figures 5-11, each element of the transducer 100 of the present invention is further shown separately in perspective views.

Figure 5 illustrates a coupler ring 101 of the present invention. The material composition of the coupler ring 101
10 may comprise polycarbonate, plastic, and/or other appropriate materials or combinations thereof. The coupler ring 101 may be intended to be disposed against an external surface, such as an aircraft's interior cabin, in order to transfer the vibrations from the primary assembly for the production of
15 sound.

Figure 6 illustrates a voice coil assembly 117 comprising a voice coil former 115 attached to the coupler ring 101. The voice coil former 115 is preferably formed of aluminum, but may also utilize other appropriate materials. The voice coil
20 former 115 may comprise a thickness of approximately 0.05 mm in a preferred embodiment of the present invention. A voice coil wire 116 may be wound in surrounding relations relative to the voice coil former 115. In a preferred embodiment, the voice coil former 115 and wire 116 may comprise a diameter of
25 20-28 mm. In another embodiment, a single layer winding of

the voice coil wire may result in a diameter of 26.5 mm. In another embodiment, a two layer winding may result in a diameter of 26.8 mm. The voice coil wire 116 is preferably formed of copper, but may also utilize other appropriate materials. In at least one embodiment of the present invention, the surface acoustic transducer 100 comprises a voice coil having a wattage of between 20W to 30W. In a preferred embodiment, the voice coil will have a wattage of 25W.

Figure 7 illustrates a magnet 111 of the present invention for providing a magnetic field to the voice coil assembly 117 and voice coil wire 116 thereof. The magnet 111 may comprise a neodymium iron boron (NdFeB) N42H magnet in at least one embodiment. Of course, other grades of NdFeB ranging from N24 to N52 may be used in other various embodiments of the present invention. Various other materials may include Alnico (AlNiCo), Samarium Cobalt (SmCo), as well as other known and appropriate rare-earth magnet or permanent magnets may be utilized. In a preferred embodiment, the magnet comprises a substantially cylindrical and/or disc shape or profile.

Figure 8 illustrates a flange 103 of the present invention, and structured to retain a terminal attachment 105 for receiving electrical input from an external source. The material composition of the flange 103 may comprise a

polycarbonate or plastic compound and/or mixture.

Figure 9 illustrates a spider 102 of the present invention, and structured and cooperatively disposed to dampen or at least partially impede the movement of the voice coil assembly 117. The material composition of the spider 102 may comprise a resin dipped cloth or fabric. However, other flexible materials and/or coatings known to those skilled in the art may also be used in order to accomplish a desired mechanical compliance (or the inverse of stiffness). The preferred mechanical compliance of the spider 102 is 0.23 millimeters per Newton (mm/n), offering a greater excursion range (less damping) than other transducers known in the art. A range of between 0.2 mm/N to 0.3 mm/N may also be used in various other embodiments.

Figure 10 illustrates a top shunt plate 112 of the present invention, preferably coupled to the magnet 111 of the present invention. The material composition of the top shunt plate 112 may comprise a mild steel or low carbon steel such as EN1A, but may also comprise other appropriate metals known to those skilled in the art.

Figure 11 illustrates a yoke 104 of the present invention, forming a distal end of the transducer housing 120. As shown, the yoke may comprise a plurality of taps for the insertion of screws such as M4 screws or other screws for affixing and stabilizing the transducer housing 120. The yoke

104 may similarly comprise a mild steel or low carbon steel such as EN1A, but may also comprise other appropriate metals known to those skilled in the art.

Further embodiments of the present invention are directed
5 to systems and methods for using the surface acoustic transducer of the present invention, or like transducers, in order to enhance the audible environment within an aircraft cabin, such as by producing quality sound and/or for noise cancelling applications.

10 In at least one system embodiment of the present invention, a plurality of surface acoustic transducers, such as the transducer 100 described above, may be attached a panel or surface such as a window, a wall, or an interior cabin of a vehicle. Specifically, one embodiment may be directed to an
15 aircraft window panel having a plurality of surface acoustic transducers disposed thereon and hidden beneath the bulkhead or cabin wall within an aircraft.

At least one embodiment of the panel may be directed to noise cancelling operations for reducing the net vibration of
20 the window and/or various panels or surfaces in proximity thereof. As such, a plurality of surface transducers may be mounted to a surface of a window and/or window panel underneath a bulkhead or other non-visible area internal to an aircraft cabin, as external noise generally resonates loudest
25 at the windows. Ideally, the transducers are mounted along a

perimeter of the window, so as to avoid obstruction of the view, such as general illustrated in Figures 14 and 15 as systems 300 and 400 respectively. These Figures and systems are example embodiments of various configurations of transducer 100 placement via external housing 200, and are by no means limiting. In other words, any number of transducers 100 may be mounted via housing 200 on one or more external and/or internal structural window panels, dust covers, chromatic and/or electrochromatic panels, glass, or other transparent materials, as well as nontransparent bulkhead connections, that may act as points of entry of external sound such as engine noise into an interior cabin of an aircraft or other vehicle.

More specifically, and with reference to the embodiment depicted in Figures 16 and 17, a plurality of transducers 100 are disposed about a mounting flange 502 of an aircraft window 500. The aircraft window may contain both visible 506 and non-visible 506 portions, as well as a viewing pane 501 and mounting flange 502. The aforementioned elements of the window 500 may be integrally formed or assembled from sub-parts. Additionally, a variety of known transducers may be suitable for use in connection with the present embodiment, but that the surface acoustic transducer 100 of the present invention, and in certain embodiments, its housing 200, may be particularly suitable. The mounting flange 502 may be a

portion of the window 500 which is disposed behind a bulkhead 1000 of the aircraft and further assists with mounting the window 500 within the aircraft.

As such, the transducer(s) 100, when activated, are
5 operative to excite at least a portion of the window 500 surface, such as the mounting flange 502 and/or the viewing pane 501, such as by producing vibrations with the transducer(s) 100 and allowing vibrations to propagate through desired portions of the window 500. In a preferred embodiment,
10 more than one transducer 100 is mounted about the mounting flange 502 in symmetrical relation to the center of the window 500 and/or the viewing pane 501. As such, the transducers 100 may be disposed and configured to excite the window 500 to the effect of creating sound waves which, at least appear to,
15 emanate from the center of the window 500 and/or the viewing pane 501. More specifically, the output of the transducers, such as frequency and amplitude, as well as the precise location of mounting of the transducers, may be predetermined such that the excitations of each transducer 100 are additive
20 in nature, such as by in-phase coherence or constructive interference, and accomplish the aforementioned excitation of the viewing pane 501, converting the window 500 into an acoustic surface.

Accordingly, it will be appreciated that a given aircraft
25 window 500 may include a mounting flange 502 of a given

dimension that is suitable in size for both mounting the window 500 within the aircraft as well as mounting a transducer 100 upon the window 500, as indicated by the mounting flange minor length 505 on Figure 16. However, in
5 preferred embodiments, it may be necessary to increase the size of the mounting flange 502, either at discrete points or integrally, in order to accommodate an ideal mounting location of the transducer, which is indicated, by way of example, by the mounting flange major length 504, characterized by an
10 enlarged portion of the mounting flange 502 beyond what would merely be sufficient to mount the window 500 within the aircraft. It will also be appreciated that the depicted embodiment is but one example of a configuration of a window 500 including a mounting flange major length 504, and that
15 other configurations are envisioned by the present invention which may be suitable for differing aircraft windows and/or differing numbers of transducers to be utilized, e.g., along one side, multiple sides, top, and/or bottom of the mounting flange 502, as well as differing shapes and contours as
20 suitable.

In yet further embodiments, it may be preferable to mount a plurality of transducers 100 about a window 500 such that they are each equidistant from a common center point 1010. Alternatively, the output characteristics, such as amplitude
25 or frequency, of each transducer 100 may be modified to

account for varying mounting locations about a window 500.

In yet further embodiments, and with reference to Figure 17, it may be desirable to mount the transducer housings 200 in a non-visible portion of the window 500, relative to a passenger within the interior of the aircraft cabin. Accordingly, the housings 200 may be disposed so as to be obscured by a bulkhead 1000 of the aircraft, relative to a passenger within the aircraft cabin. Accordingly, the passenger may enjoy an undisturbed view through the visible portions 506 and/or viewing pane 501.

Moreover, the system of the present invention may be combined with a receiver module, such as a microphone 1020 disposed adjacent the window 500 (or other panel to be excited) and further disposed and configured to sense ambient noise 1040. A processor module 1030, may be disposed in communication with the microphone 1020 and structured to receive a signal corresponding to the ambient noise 1040. The signal processor 1030, being disposed in driving relation to the transducer(s) 100, may then generate a control signal or driving signal operative to activate or excite the transducer(s) 100 in a desired fashion. In one embodiment, the present invention may be utilized to accomplish active noise control (or noise-canceling) as described further below. It will be appreciated that the depicted embodiment comprises wired communication between the microphone 1020, processor

1030, and transducer 100, appropriate wireless communication may be utilized as well.

The panel may further comprise various components configured for active noise control (ANC) or noise
5 cancellation, such as to cause the plurality of transducers to emit an anti-noise signal in order to counter the noise source, and installed or disposed within an interior or non-visible portion of an aircraft cabin in proximity to the window panels whether by wired or wireless communication to
10 each of the transducers 100. For example, the panel may comprise a power source, a receiver module, a processing unit, and at least one transducer. The receiver module may be mounted within an interior or exterior of the panel, or may be mounted remotely and be communicably connected to the panel
15 and the processing unit. The receiver module may comprise a microphone 1020, and is configured to receive sound signals or noise signals to relay to the processing unit 1030. The processing unit is configured to receive the noise signals and produce an anti-noise signal, which may comprise a sound
20 signal with the same amplitude but with an inverted phase relative to the noise signal (or antiphase). This anti-noise signal is then transmitted to the at least one transducer to be reproduced at the panel, therefore canceling any noises received by the receiver module, such as external engine
25 noise.

Other embodiments of the present invention may be directed to methods for sound processing as directed to a surface acoustic transducer, such as transducer 100 described above. As discussed, one known limitation in the art is the inadequacy of bass frequencies of surface transducers,
5 primarily due to their mechanical limitations, i.e. the lack of adequate mechanical excursion. To overcome this limitation, and in order to provide a richer bass sound, a method of the present invention contemplates first selecting
10 the various points at which to limit the peak decibels of a sound signal. Next, the sound is processed at these points, such that the amplitude of the sound signal is reduced and its frequency proportionately enhanced. This, and other sound processing methodology may be accomplished pursuant to the
15 Applicant's digital signal processing methods as recited in U.S. Patent No. 8,160,274, which is hereby incorporated by reference in its entirety.

It should be understood that the above steps may be conducted exclusively or nonexclusively and in any order.
20 Further, the physical devices recited in the methods may comprise any apparatus and/or systems described within this document or known to those skilled in the art.

Since many modifications, variations and changes in detail can be made to the described preferred embodiment of
25 the invention, it is intended that all matters in the

foregoing description and shown in the accompanying drawings be interpreted as illustrative and not in a limiting sense. Thus, the scope of the invention should be determined by the appended claims and their legal equivalents.

5 Now that the invention has been described,

What is claimed is:

1. A system for providing an enhanced audible environment within an aircraft cabin comprising:

5 at least one transducer mounted on a non-visible portion of a window of the aircraft cabin; and,
 said at least one transducer further disposed in vibration transferring relation to at least one other portion of the window.

10 2. The system as recited in claim 1 wherein said at least one transducer is further mounted behind a bulkhead of the aircraft cabin relative to a passenger within the aircraft.

 3. The system as recited in claim 1 further comprising a microphone disposed in ambient sound receiving relation the window.

15 4. The system as recited in claim 3 further comprising a processing unit disposed in communication with said microphone and configured to produce a signal with inverted phase relative to said ambient sound.

20 5. The system as recited in claim 4 where said processing unit is disposed in driving relation to said at least one transducer and configured to transmit said inverted phase signal to said at least one transducer.

 6. A system for providing an enhanced audible environment within an aircraft cabin comprising:

25 a plurality of transducers mounted symmetrically about a

window of the aircraft cabin on a mounting flange of said window; and,

said plurality of transducers each further cooperatively disposed and configured to excite at least a viewing pane
5 of said window.

7. The system as recited in claim 6 wherein said mounting flange comprises a major length to accommodate said plurality of transducers.

8. The system as recited in claim 7 wherein said plurality
10 of transducers are further disposed to be obscured from view of a passenger within the aircraft cabin via placement of said plurality of transducers behind a bulkhead of the aircraft cabin.

9. The system as recited in claim 7 wherein said major
15 length of said mounting flange is longer than a minor length of said mounting flange.

10. The system as recited in claim 7 wherein said major length of said mounting flange is longer than a dimension sufficient for mounting said window within the aircraft cabin.

20 11. The system as recited in claim 6 wherein said plurality of transducers are each disposed equidistant from a center point.

12. The system as recited in claim 6 wherein an amplitude of output of each of said plurality of transducers is
25 predetermined to produce constructive interference of

excitations on said viewing pane.

13. The system as recited in claim 6 wherein each of said plurality of transducers is disposed within an external housing.

5 14. The system as recited in claim 13 wherein said external housing includes an excursion cover.

15. A method for providing an enhanced audible environment within an aircraft cabin, the aircraft cabin comprising windows with visible portions and non-visible portions, the

10 method comprising:

mounting at least one transducer on a non-visible portion of the window;

exciting said at least one transducer so as to transfer vibration to a visible portion of the window.

15 16. The method as recited in claim 15 further comprising mounting a plurality of transducers disposed on non-visible portions of the window.

17. The method as recited in claim 16 wherein said plurality of transducers are mounted symmetrically with respect to a
20 visible portion of the window.

18. The method as recited in claim 17 wherein said at least one transducer comprises a surface acoustic transducer disposed within an external housing, said external housing comprising an excursion cover.

25 19. The method as recited in claim 15 further comprising

sensing ambient sound with at least one microphone disposed adjacent the window.

20. The method as recited in claim 19 comprising generating a signal with an inverted phase relative to said ambient sound
5 and driving said at least one transducer with said inverted phase signal.

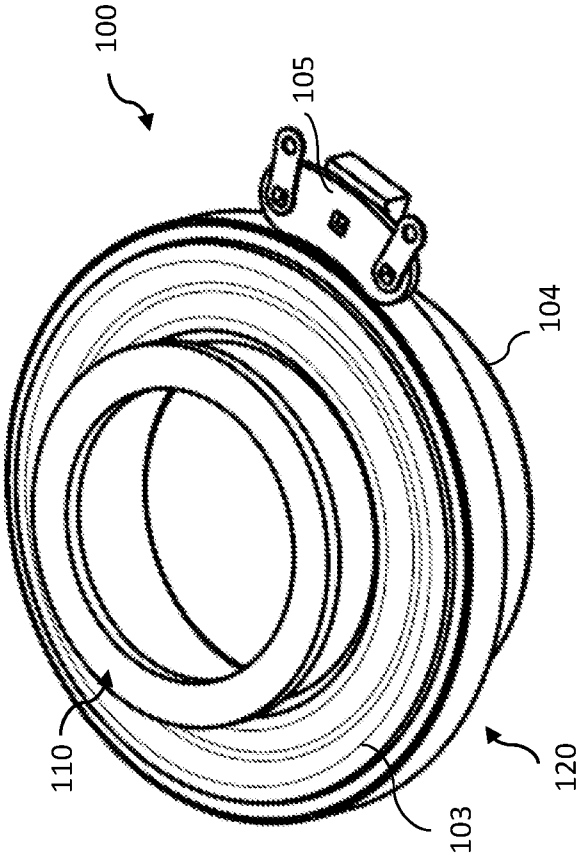


Figure 1

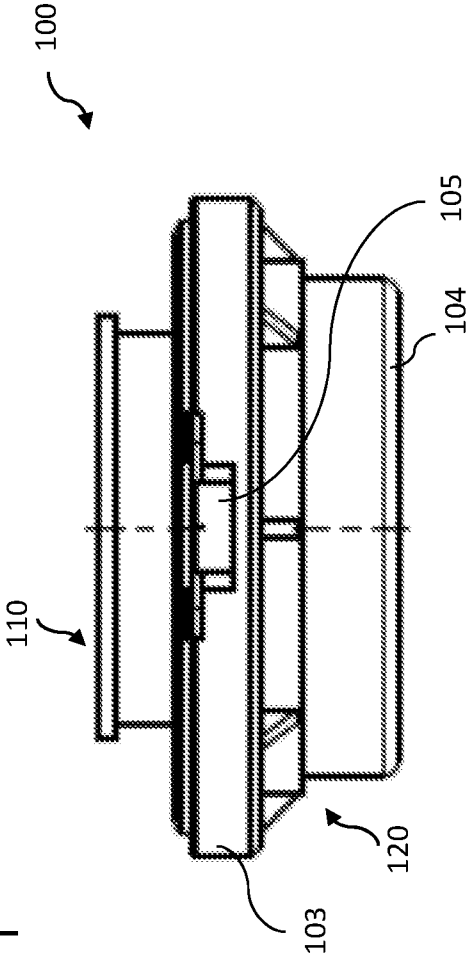


Figure 2

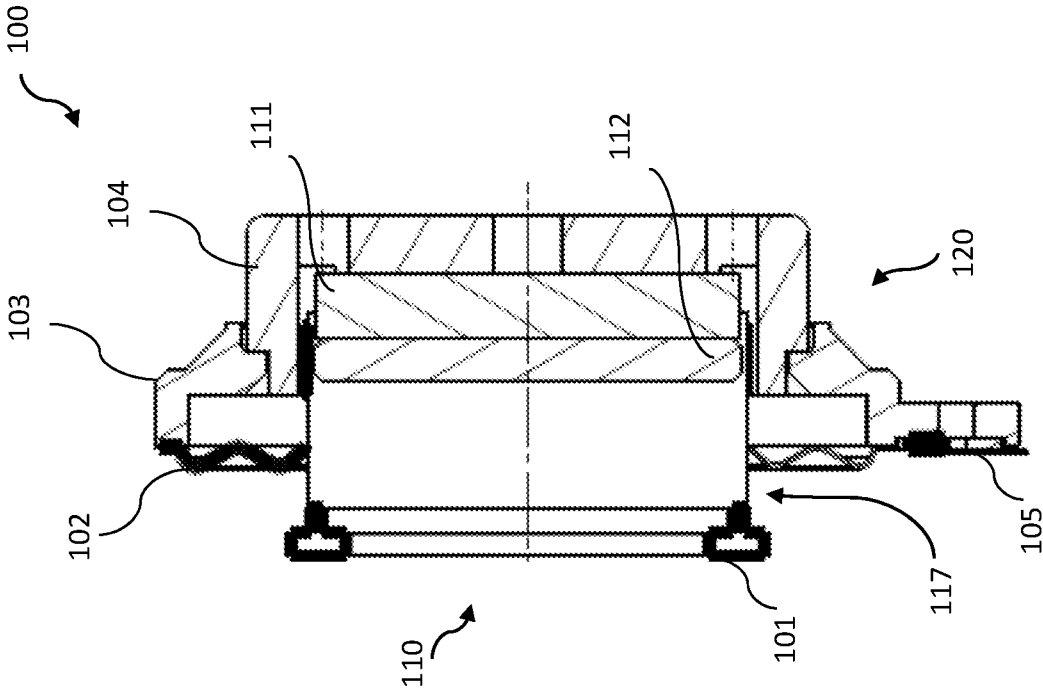


Figure 3B

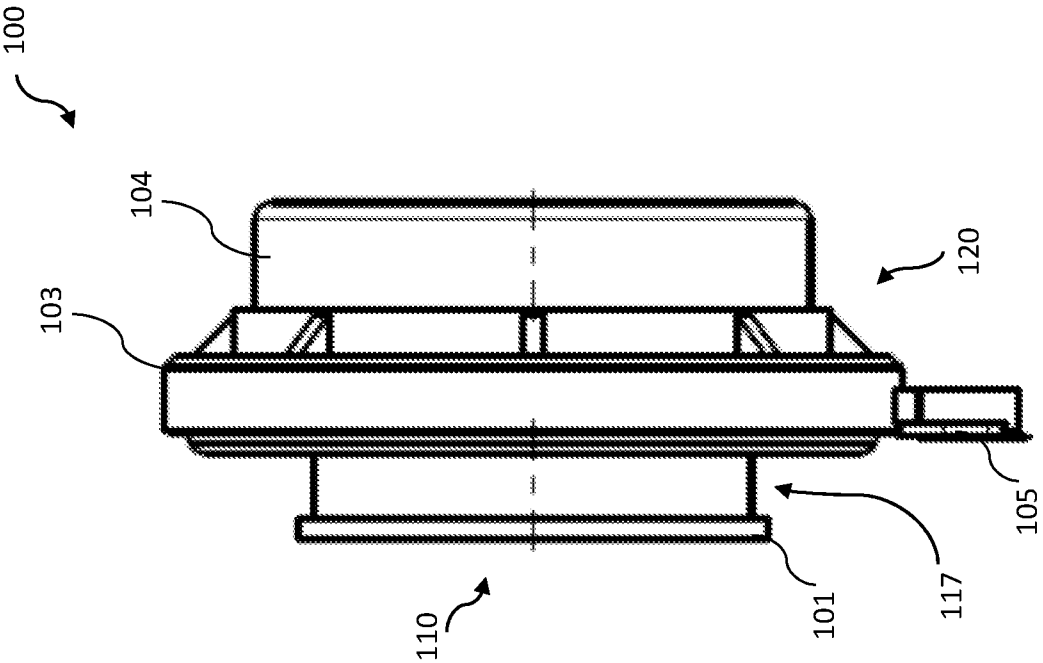


Figure 3A

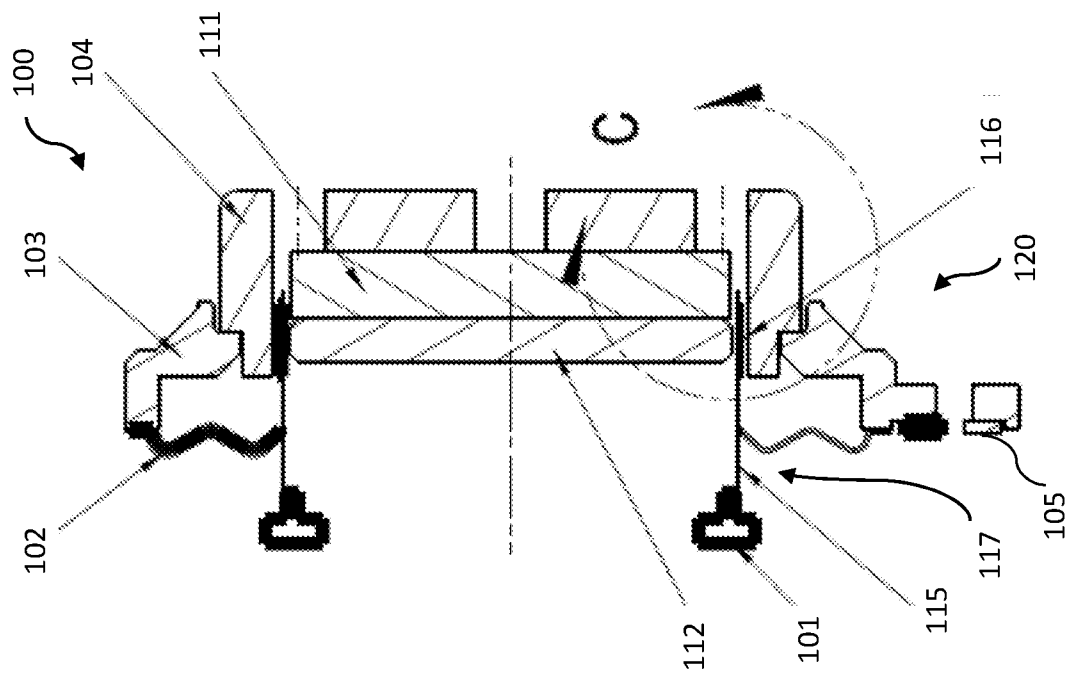


Figure 4A

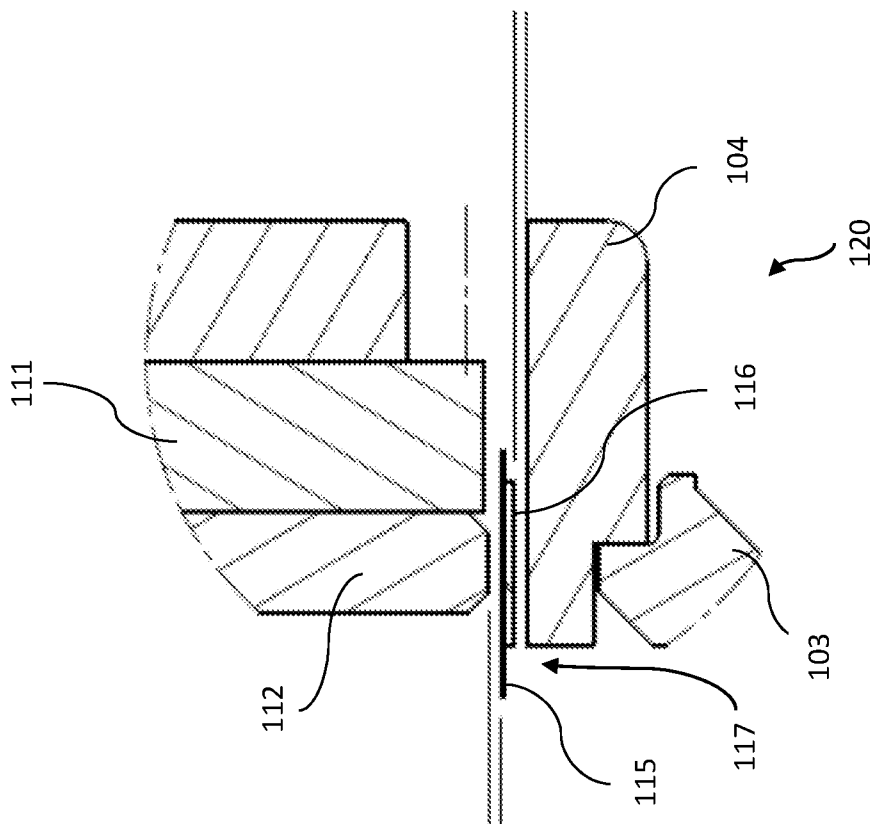


Figure 4B

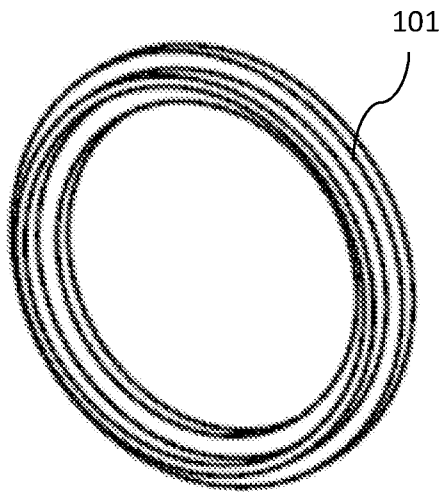


Figure 5

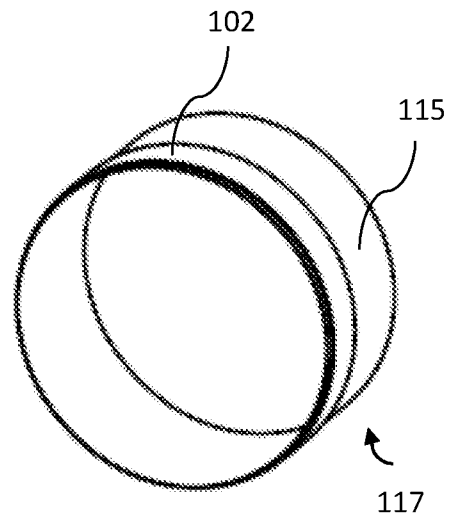


Figure 6

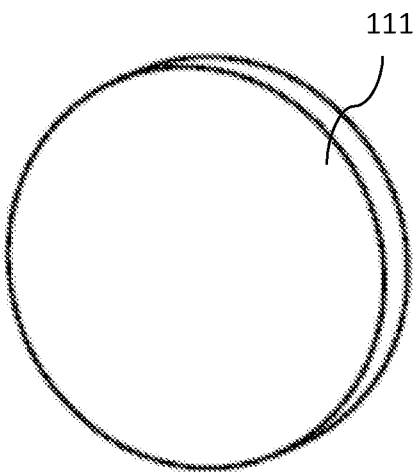


Figure 7

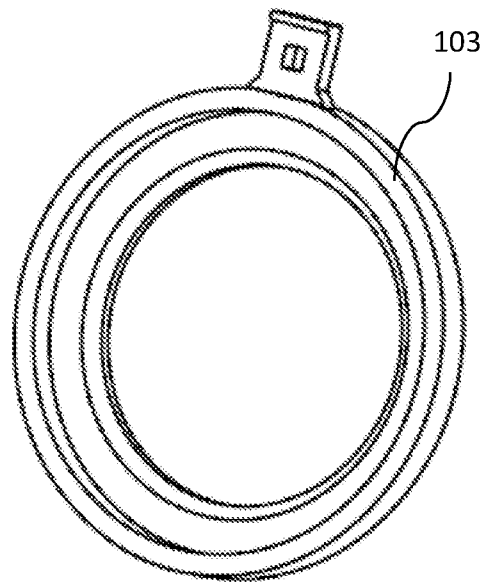


Figure 8

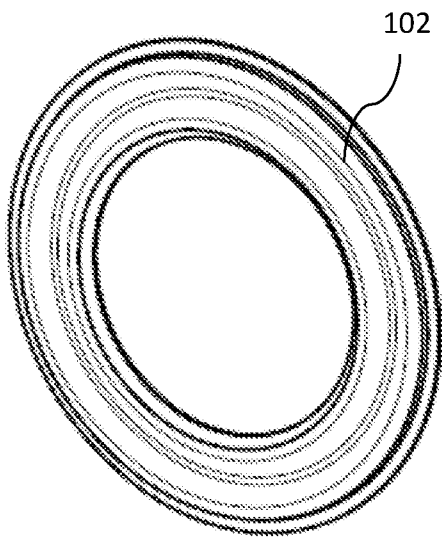


Figure 9

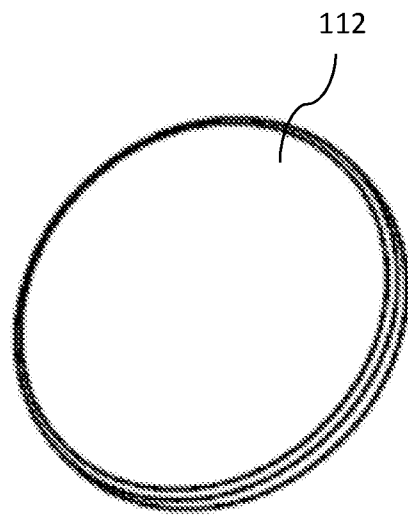


Figure 10

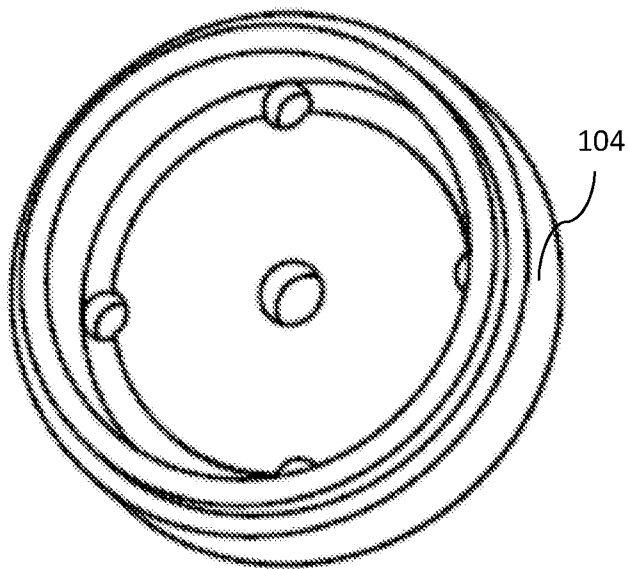


Figure 11

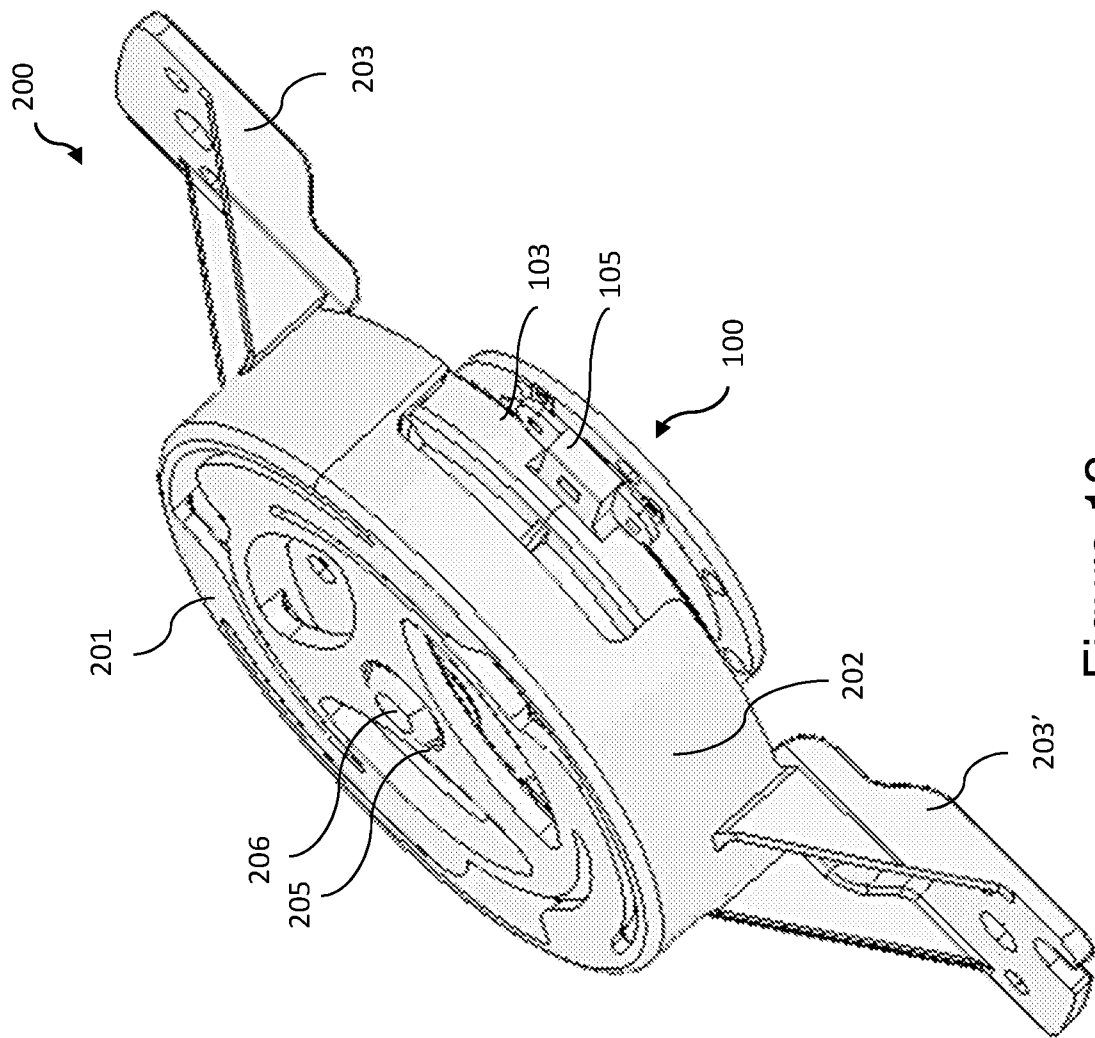


Figure 12

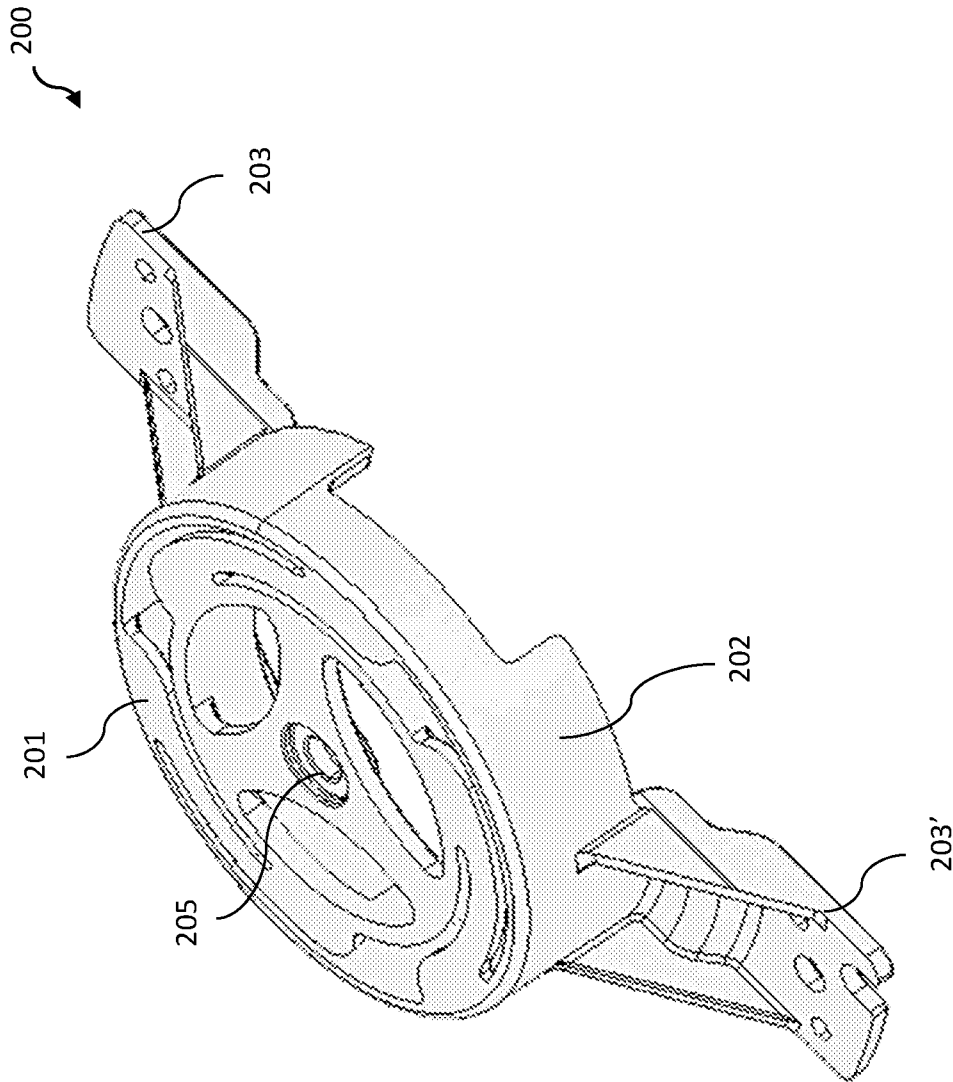


Figure 13A

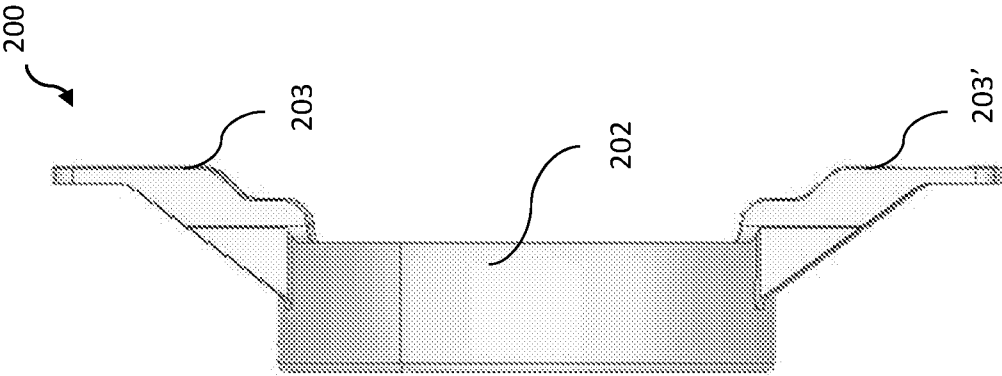


Figure 13C

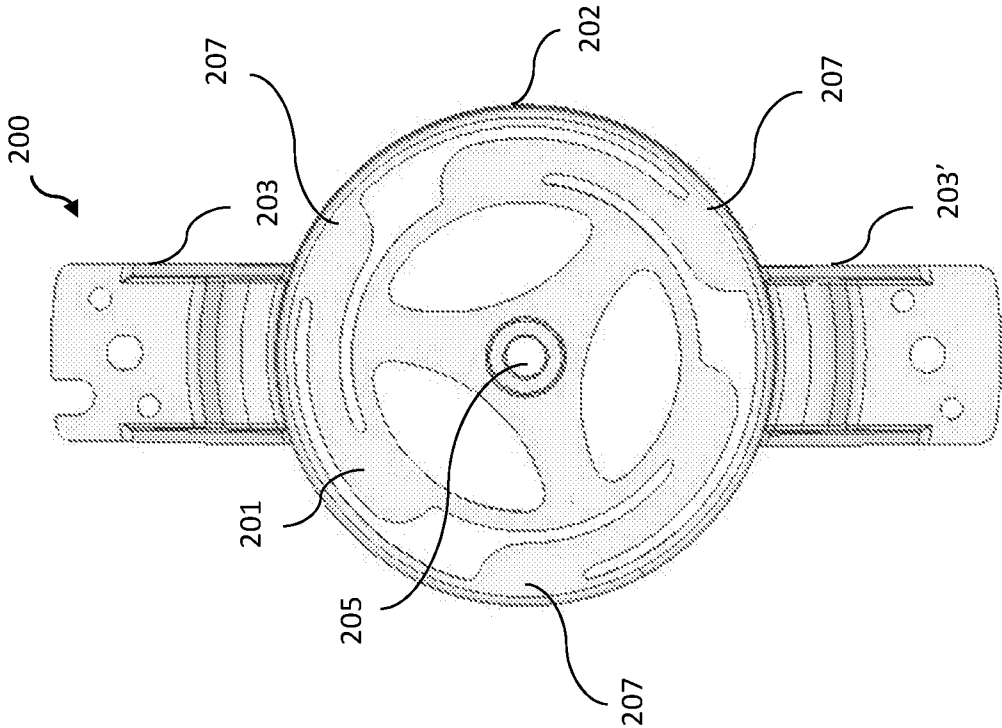


Figure 13B

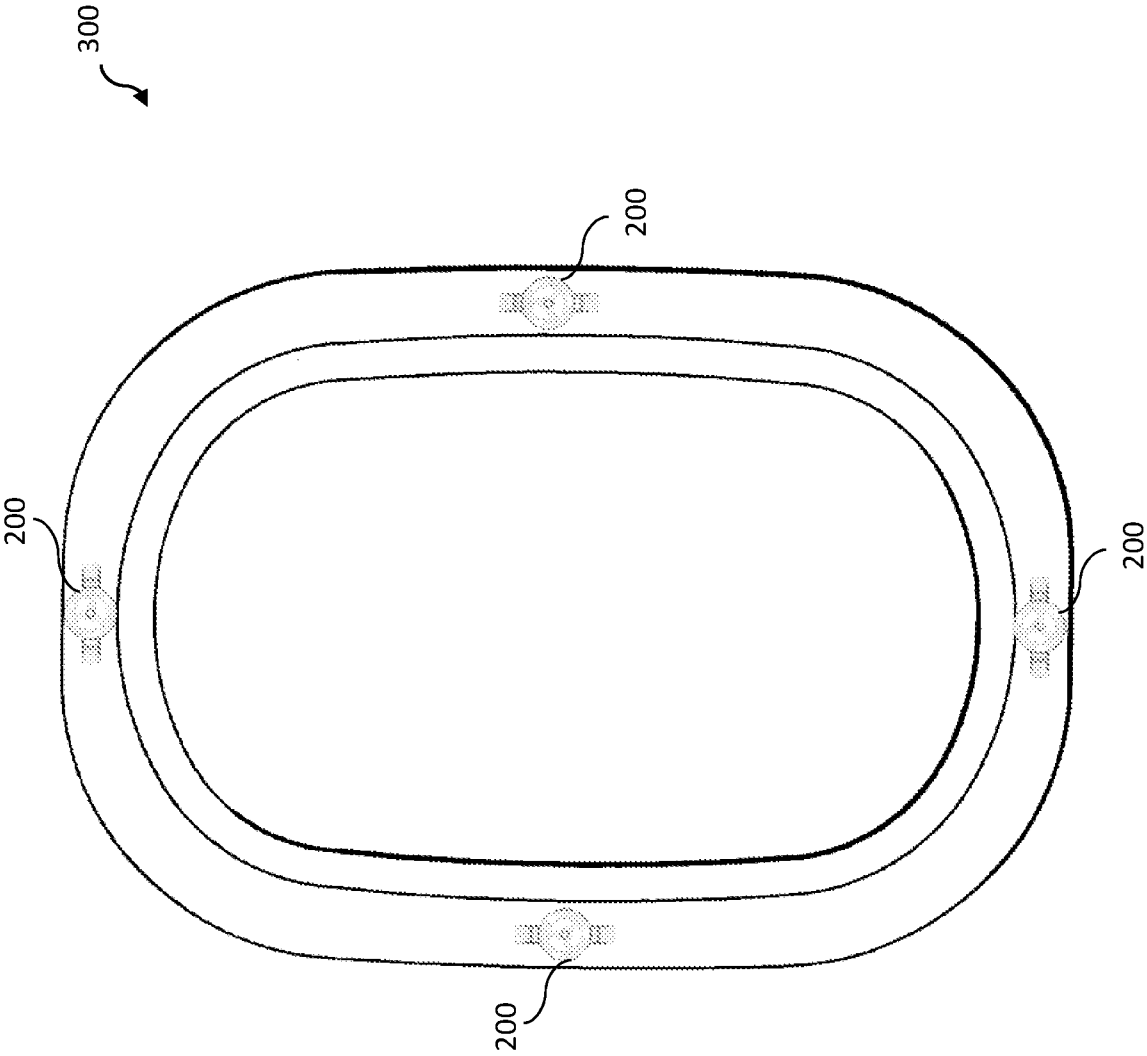


Figure 14

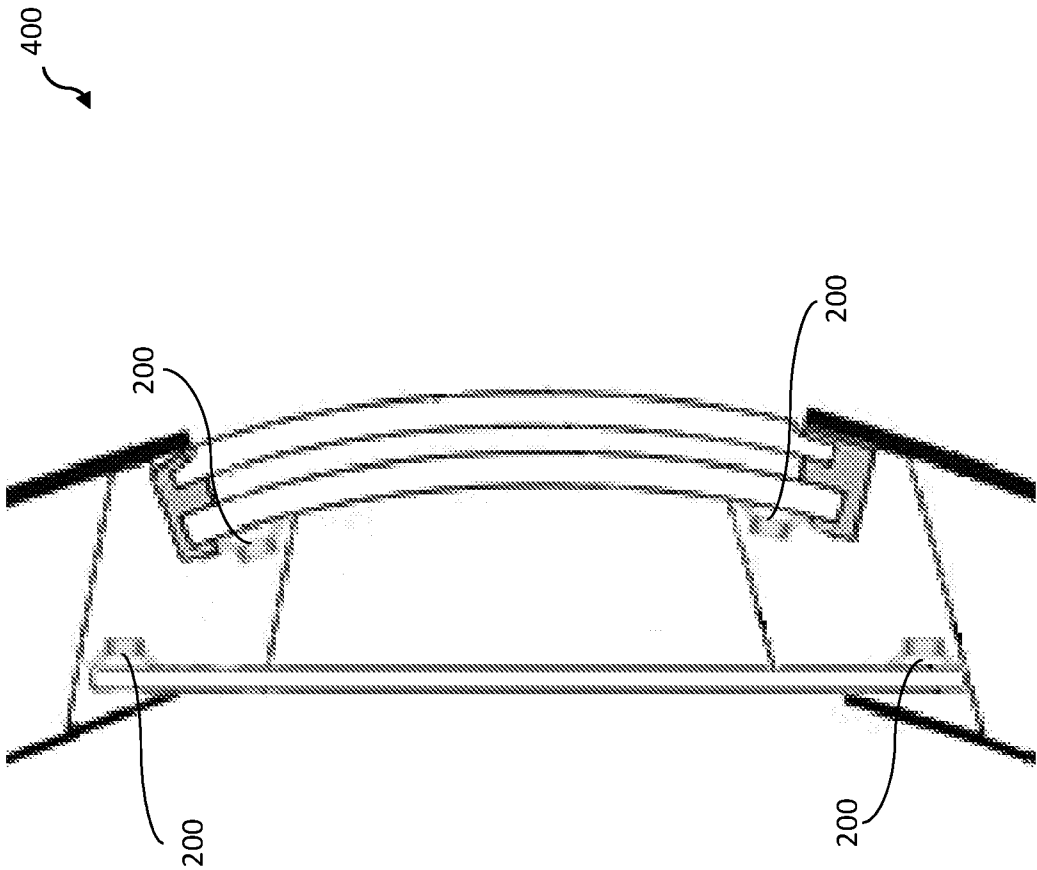


Figure 15

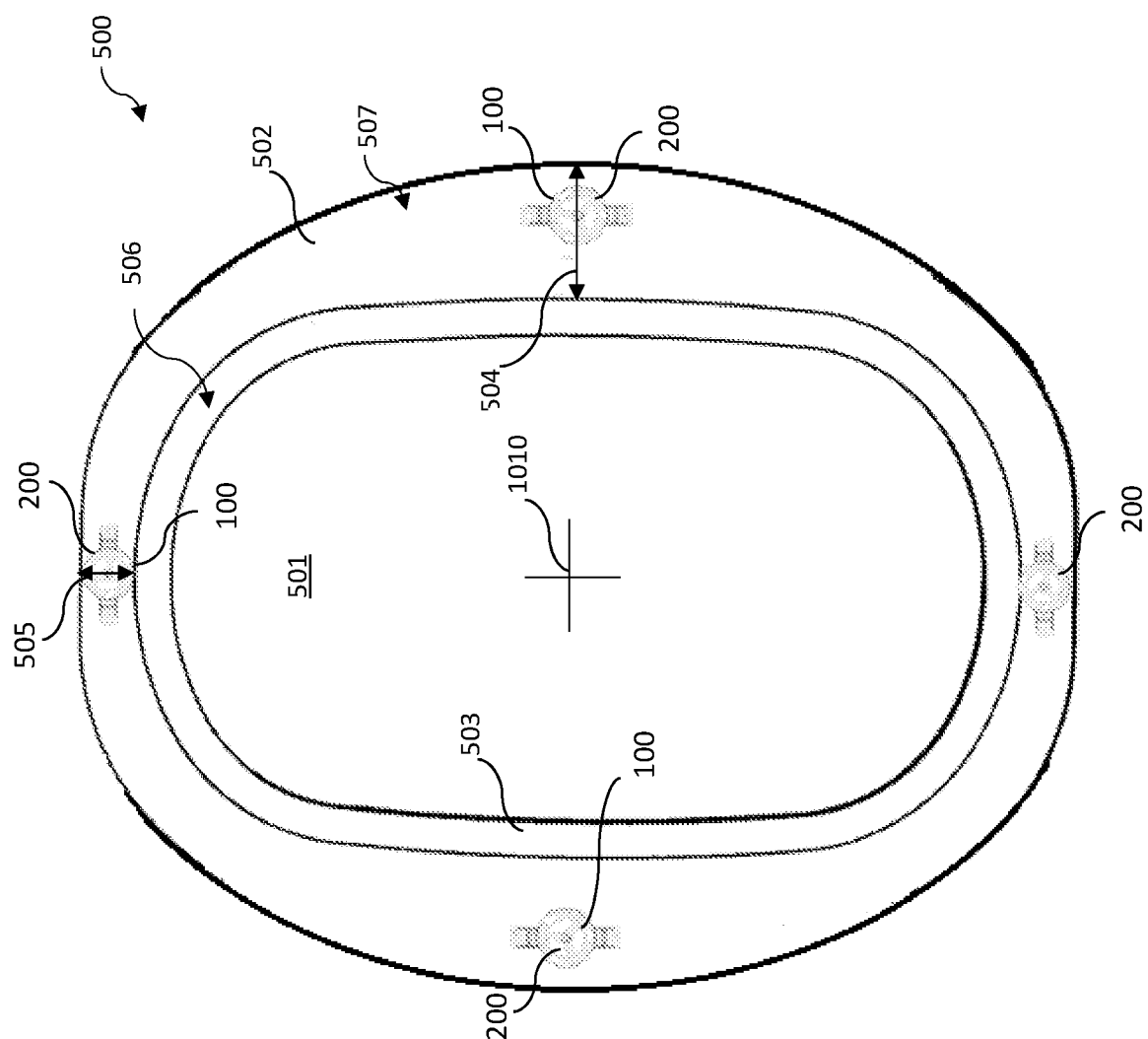


Figure 16

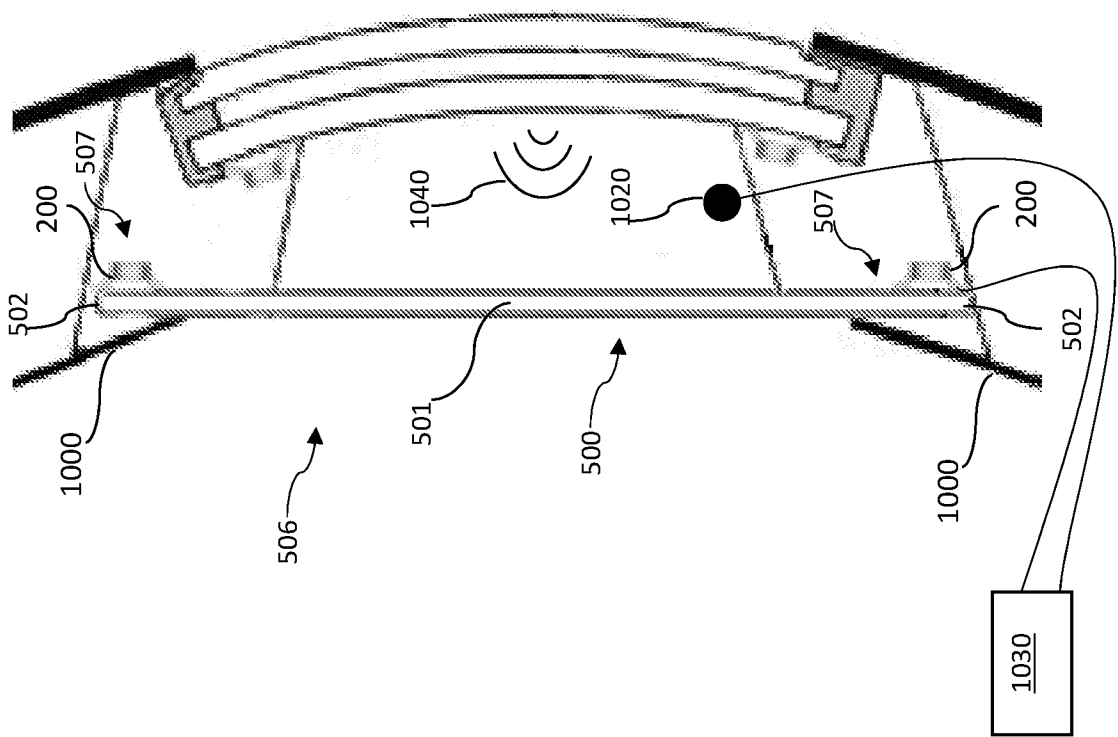


Figure 17

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 16/62280

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - G10K 11/16, 11/172, 11/175, 11/36 (2017.01)

CPC - G10K 11/172, 11/175, 11/36, 2210/1281

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)

CPC - G10K 11/172, 11/175, 11/36, 2210/1281

IPC(8) - G10K 11/16, 11/172, 11/175, 11/36 (2017.01)

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

CPC - G10K 11/16, 11/172, 11/175, 11/178, 11/1786, 11/1788, 11/18, 11/36, 2210/106, 2210/1281, 2210/1291, 2210/30, 2210/3214, 2210/511; H04R 1/00, 19/013, 19/02, 2410/05; B64C 1/00, 1/40; E06B 7/00; IPC(8) - G10K 11/16, 11/172, 11/175, 11/36 (2017.01)

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

Patbase; Google Web, Google Patent

Search terms used: Audible sound acoustic noise cancel aircraft airplane transducer speaker vibration actuator PZT detector sensor microphone window inverted phase adaptive reduction quality

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y --- A	US 2004/0103588 A1 (ALLAEI) 03 June 2004 (03.06.2004), Fig. 1; Fig. 3; para [0001]-[0003], [0007], [0022], [0024]-[0029], [0039], [0045]	15-17 ----- 1-10, 12-14, 18-20 ----- 11
Y --- A	US 6,343,127 B1 (BILLOUD) 29 January 2002 (29.01.2002), Fig. 1; Fig. 2; Fig. 10; col. 1, ln 7-10; col. 1, ln 29-55; col. 3, ln 11-14; col. 3, ln 32-37; col. 3, ln 45-48; col. 4, ln 5-11; col. 4, ln 14-17; col. 4, ln 20-29; col. 4, ln 41-44; col. 6, ln 6-10	1-10, 12-14, 18-20 ----- 11

☐ Further documents are listed in the continuation of Box C.

* 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

09 March 2017

Date of mailing of the international search report

06 APR 2017

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450

Facsimile No. 571-273-8300

Authorized officer:

Lee W. Young

PCT Helpdesk: 571-272-4300
PCT OSP: 571-272-7774