



- (51) International Patent Classification:
G02B 27/01 (2006.01) *H04R 1/28* (2006.01)
- (21) International Application Number:
PCT/US2017/068817
- (22) International Filing Date:
28 December 2017 (28.12.2017)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
62/467,135 05 March 2017 (05.03.2017) US
15/680,086 17 August 2017 (17.08.2017) US
- (71) Applicant: **OCULUS VR, LLC** [US/US]; 1601 Willow Road, Menlo Park, CA 94025 (US).
- (72) Inventors: **BRISTOL, Peter, Wesley**; c/o Oculus VR, LLC, 1601 Willow Road, Menlo Park, CA 94025 (US).
DALLMEYER, Scott, Andrew; Oculus VR, LLC, 1601

Willow Road, Menlo Park, CA 94025 (US). **MORRIS, Quintin**; Oculus VR, LLC, 1601 Willow Road, Menlo Park, CA 94025 (US). **DEVOE, Matthew, James**; Oculus VR, LLC, 1601 Willow Road, Menlo Park, CA 94025 (US). **TAO, David**; Oculus VR, LLC, 1601 Willow Road, Menlo Park, CA 94025 (US).

(74) Agent: **HULSE, Robert, A.** et al.; Fenwick & West LLP, 801 California Street, Mountain View, CA 94041 (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, JO, JP, KE, KG, KH, 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,

(54) Title: STRAP ARM HEAD-MOUNTED DISPLAY WITH INTEGRATED AUDIO PORT

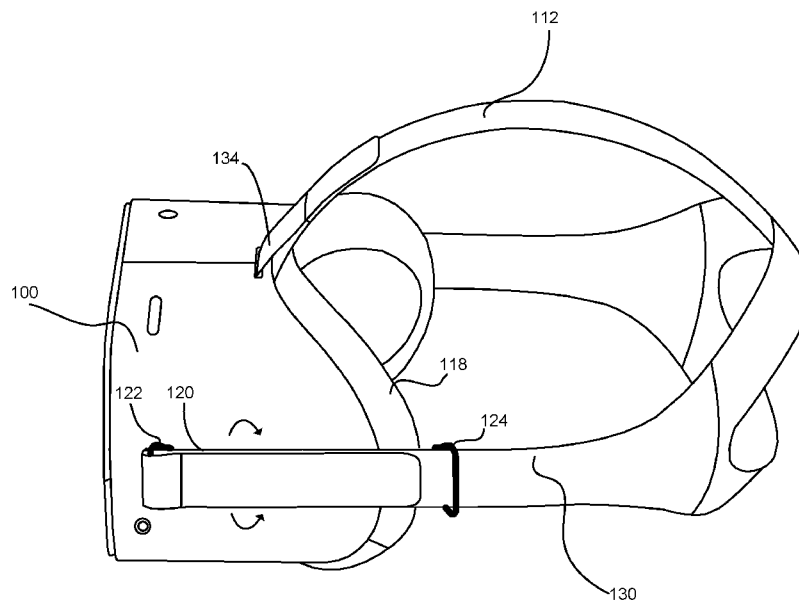


FIG. 1

(57) Abstract: A head-mounted display (HMD) includes a strap arm that transmits audio. The HMD includes a front rigid body and a strap arm. The strap arm includes a body portion defining a boss having an aperture that rotatably connects the strap arm to the front rigid body. The body portion defines an audio passage to transmit sound and an audio port to output the sound. The audio passage is defined along the body portion between the aperture of the boss and the audio port. A speaker is positioned, such as within the aperture, to emit the sound through the audio passage and to the audio port. The strap arm can further include a back volume unit that enhances the sound transmitted through the audio passage.



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))

STRAP ARM OF HEAD-MOUNTED DISPLAY WITH INTEGRATED AUDIO PORT**BACKGROUND**Field of the Disclosure

[0001] The present disclosure generally relates to a strap system for a head-mounted display, and specifically to a strap system with integrated audio ports for transmitting sound.

Description of the Related Arts

[0002] Head-mounted displays (HMDs) have wide applications in various fields, including engineering design, medical surgery practice, military simulated practice, and video gaming. For example, a user wears an HMD while playing video games so that the user can have a more interactive experience in a virtual environment. As opposed to other types of display devices, an HMD is worn directly over a user's head. The HMD may directly interface with a user's face while exerting pressure onto the user's head due to its weight. Hence, a strap system is used in the HMD to secure the HMD securely to the user's head in a comfortable manner.

[0003] Audio systems for HMDs are also subject to constraints often not encountered in other devices. Ear buds or ear phones of HMDs impose inconvenience because of lines to transmit signals to the ear buds or ear phones. Moreover, when the HMDs are used by multiple users, sharing of ear buds or ear phones may cause hygiene issues.

SUMMARY

[0004] Embodiments relate to a head-mounted display (HMD) including a strap arm that transmits audio. The HMD includes a front rigid body, and the strap arm attached to a strap that secures the front rigid body to a user's head. The strap arm includes a body portion and a speaker. The body portion defines a boss at a side of the body portion. The boss includes an aperture, and rotatably connects the strap arm to the front rigid body. The body portion further defines an audio passage to transmit sound and an audio port to output the sound. The audio passage being is along the body portion between the aperture of the boss and the audio port. The speaker is positioned, such as within the aperture, to emit the sound through the audio passage and to the audio port.

[0005] In some embodiments, the strap arm further includes a back volume unit. The back volume unit includes an enclosure portion and a cylindrical column. The cylindrical column is inserted through the aperture of the boss. The cylindrical column defines a second aperture. The speaker is positioned within the second aperture with a back side of the speaker facing an interior surface of the enclosure portion to define a back volume between the interior surface and the back side of the speaker for enhancing the sound emitted by the speaker. At least a portion of the sound from the speaker is transmitted from the back volume through the audio passage.

[0006] Some embodiments include a strap arm for a head-mounted display (HMD). The strap arm includes a body portion and a speaker. The body portion defines a boss at a side of the body portion, the boss having an aperture, and the boss rotatably connecting the strap arm to a front rigid body of the HMD. The body portion further defines an audio passage to transmit sound and an audio port to output the sound. The audio passage is defined along the body portion between the aperture of the boss and the audio port. The speaker is positioned, such as within the aperture, to emit the sound through the audio passage and to the audio port.

[0007] Some embodiments include an HMD including a housing and a strap arm. The strap arm is attached to a strap that secures the housing to a user's head. The strap arm includes a body portion defining a boss at a side of the body portion. The boss has an aperture, and the boss rotatably connects the strap arm to the housing. The body portion further defines an audio passage to transmit sound from the aperture and an audio port to output the sound. The audio passage is defined along the body portion between the aperture of the boss and the audio port.

[0008] Embodiments according to the invention are in particular disclosed in the attached claims directed to a head-mounted display (HMD) and a strap arm for a HMD, wherein any feature mentioned in one claim category, e.g. HMD, can be claimed in another claim category, e.g. system, method, storage medium, and computer program product as well. The dependencies or references back in the attached claims are chosen for formal reasons only. However any subject matter resulting from a deliberate reference back to any previous claims (in particular multiple dependencies) can be claimed as well, so that any combination of claims and the features thereof is disclosed and can be claimed regardless of the dependencies chosen in the attached claims. The subject-matter which can be claimed comprises not only the combinations of features as set out in the attached claims but also any other combination of features in the claims, wherein each feature mentioned in the claims can be combined with

any other feature or combination of other features in the claims. Furthermore, any of the embodiments and features described or depicted herein can be claimed in a separate claim and/or in any combination with any embodiment or feature described or depicted herein or with any of the features of the attached claims.

[0009] In an embodiment according to the invention, a head-mounted display (HMD) may comprise:

a front rigid body;

a strap arm attached to a strap that secures the front rigid body to a user's head, the strap arm including:

a body portion defining a boss at a side of the body portion, the boss having an aperture, the boss rotatably connecting the strap arm to the front rigid body, the body portion further defining an audio passage to transmit sound and an audio port to output the sound, the audio passage being defined along the body portion between the aperture of the boss and the audio port; and

a speaker positioned to emit the sound through the audio passage and to the audio port.

[0010] The strap arm further may include a back volume unit including:

an enclosure portion; and

a cylindrical column inserted through the aperture of the boss, the cylindrical column defining a second aperture, the speaker being positioned within the second aperture with a back side of the speaker facing an interior surface of the enclosure portion to define a back volume between the interior surface and the back side of the speaker for enhancing the sound emitted from the speaker, at least a portion of the sound from the speaker being transmitted from the back volume through the audio passage.

[0011] The speaker may be positioned within the aperture of the boss of the body portion and the front side of the speaker may face toward the audio passage.

[0012] The boss may extend through a second aperture of the front rigid body to rotatably connect the strap arm to the front rigid body; and the enclosure portion may be positioned on a first side of the second aperture within the front rigid body and the body portion of the strap arm may be positioned on a second side of the second aperture exterior to the front rigid body.

[0013] The strap arm may include: a rear loop at one end of the body portion, and a front loop at the other end of the body portion, the rear loop and the front loop receiving the strap.

[0014] The body portion may include a support surface facing the strap inserted through the front loop and the rear loop.

[0015] The audio port may be formed on the side of the body portion including the boss and at a location closer to the rear loop than the front loop.

[0016] The body portion may include: a base portion; and a cover portion secured to the base portion, the audio passage being defined between the base portion and the cover portion.

[0017] The body portion may define: a second audio passage; and a center rib separating the audio passage and the second audio passage.

[0018] The front rigid body may define a second aperture to receive a center bridge of the strap.

[0019] In an embodiment according to the invention, a strap arm for a head-mounted display (HMD) may comprise:

a body portion defining a boss at a side of the body portion, the boss having an aperture, the boss rotatably connecting the strap arm to a front rigid body of the HMD, the body portion further defining an audio passage to transmit sound and an audio port to output the sound, the audio passage being defined along the body portion between the aperture of the boss and the audio port; and

a speaker positioned to emit the sound through the audio passage and to the audio port.

[0020] In an embodiment according to the invention, a strap arm may comprise a back volume unit including: an enclosure portion; and a cylindrical column inserted through the aperture of the boss, the cylindrical column may define a second aperture, the speaker may be positioned within the second aperture with a back side of the speaker facing an interior surface of the enclosure portion to define a back volume between the interior surface and the back side of the speaker for enhancing the emitted from by the speaker, at least a portion of the sound from the speaker may be transmitted from the back volume through the audio passage.

[0021] The speaker may be positioned within the aperture of the boss of the body portion and the front side of the speaker may face toward the audio passage.

[0022] The boss may extend through a second aperture of the front rigid body to rotatably connect the strap arm to the front rigid body; the enclosure portion may be positioned on a first side of the second aperture within the front rigid body and the body portion of the strap arm may be positioned on a second side of the second aperture exterior to the front rigid body.

[0023] In an embodiment according to the invention, a strap arm may include: a rear loop at one end of the body portion; and a front loop at the other end of the body portion, the rear loop and the front loop receiving the strap.

[0024] The body portion may include a support surface facing the strap inserted through the front loop and the rear loop.

[0025] The audio port may be formed on the side of the body portion including the boss and at a location closer to the rear loop than the front loop.

[0026] The body portion may include: a base portion; and a cover portion secured to the base portion, the audio passage may be defined between the base portion and the cover portion.

[0027] The body portion may define: a second audio passage; and a center rib separating the audio passage and the second audio passage.

[0028] In an embodiment according to the invention, a head-mounted display (HMD) may comprise:

a housing; and

a strap arm attached to a strap that secures the housing to a user's head, the strap arm may include a body portion defining a boss at a side of the body portion, the boss may have an aperture, the boss may rotatably connect the strap arm to the housing, the body portion further may define an audio passage to transmit sound from the aperture and an audio port to output the sound, the audio passage may be defined along the body portion between the aperture of the boss and the audio port.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] The teachings of the embodiments can be readily understood by considering the following detailed description in conjunction with the accompanying drawings.

[0030] Figure (FIG.) 1 is an example perspective view of a HMD attached with a strap system, in accordance with an embodiment.

[0031] FIGs. 2 through 4 are perspective views of a strap arm of a HMD, in accordance with an embodiment.

[0032] FIG. 5A is front view of a base portion of the strap arm, in accordance with an embodiment.

[0033] FIG. 5B is a perspective view of the base portion of the strap arm, in accordance with an embodiment.

[0034] FIG. 6 is an exploded perspective view of the strap arm, in accordance with an embodiment.

[0035] FIG. 7 is a cross-sectional view of the strap arm, in accordance with an embodiment.

[0036] The figures depict various embodiments for purposes of illustration only.

DETAILED DESCRIPTION

[0037] In the following description of embodiments, numerous specific details are set forth in order to provide more thorough understanding. However, note that the embodiments may be practiced without one or more of these specific details. In other instances, well-known features have not been described in detail to avoid unnecessarily complicating the description.

[0038] Embodiments are described herein with reference to the figures where like reference numbers indicate identical or functionally similar elements. Also in the figures, the left most digits of each reference number corresponds to the figure in which the reference number is first used.

[0039] Embodiments relate to a strap system with a strap arm that incorporates audio passages and an audio port for delivering sound generated by a HMD to a user's ear. The strap arm has a cylindrical boss that couples the strap arm to a back volume unit of the HMD in a rotatable manner. The strap arm has loops for fastening head straps and is formed with audio passages that deliver sound generated from a speaker in the back volume unit. The strap arm performs the function of securing the head straps and transmitting sound generated from the HMD to the user's ear.

[0040] FIG. 1 is an example perspective view of a HMD attached with a strap system, in accordance with an embodiment. The HMD includes, among other components, a front rigid body 100 (or “body 100”) and a facial interface 118 attached to the body 100. The body 100 includes various components such as a display panel, optical elements and circuits (not shown). The facial interface 118 is made of a material softer than the body 100 and comes into contact with a user’s face when the HMD is worn by the user. In some embodiments, the HMD includes a different type of housing than the body 100.

[0041] The body 100 is attached with a strap 130 at both sides (i.e., the left side and the right side). As shown in FIG. 1, the left portion of the strap 130 (or “left strap 130”) is fixed to a front loop 122 and a rear loop 124 of a left strap arm 120. The left strap arm 120 is fixed in a rotatable manner to the body 100 in directions as shown by arrows. In order to fix the strap 130 to the strap arm 120, the left strap 130 is first inserted through loops 124, then through loop 122, and then folded back onto itself as shown in FIG. 1. The overlapping of the left strap 130 can be adjusted to control the length of the left strap 130. The back side of the left strap 130 and the front side of the left strap 130 has Velcro attached, and hence, the end of the strap 130 is securely fixed once the user presses the back side of the left strap 130 onto the front side of the left strap 130. Other types of adjustable mechanical attachment between a strap and strap arm may also be used, such as a buckle attachment. By controlling the length of the left and right straps as well as the tilting angle of the HMD, the user can comfortably wear the HMD.

[0042] The right portion of the strap 130 (or “right strap”) is attached to the right side of the HMD using a right strap arm (not shown) in the same way.

[0043] An aperture 134 is formed in the body 100 to receive an end of a center bridge 112 of the strap 130. The end of the center bridge 112 is inserted below an edge of the body 100 and extends through the aperture 134. The end of the center bridge 112 extending from the aperture 134 folds back onto another portion of the center bridge 112 and overlaps with the other portion of the center bridge 112 to secure the center bridge 112 to the body 100. The center bridge 112 may include Velcro (or some other type of attachment) on the upper surface and lower surface of the center bridge 112 so that the end portion of the center bridge 112 is secured onto the other portion of the center bridge 112 when pressed against the other portion of the center bridge 112. The user may adjust the length of the center bridge 112 by detaching the end portion of the center bridge 112 from the other portion of the center bridge 112 and changing the location of the center bridge 112 where the end portion of the center

bridge 112 is attached. By adjusting the length of the center bridge 112, the user can adjust the orientation of the strap arm 120 with respect to the body 100 to direct sound through the strap arm 120 to the user's ear.

[0044] FIGS. 2 through 4 are perspective views of the strap arm 120 of a HMD, in accordance with an embodiment. The strap arm 120 has a body portion 232 defined between the front loop 122 and the rear loop 124, a back volume unit 210, and a speaker 612. The speaker 612 is positioned within the body portion 232 and/or back volume unit 210, as shown in FIGS. 6 and 7. The body portion 232 includes a support surface 240 that supports a portion of the strap 130 inserted through the loops 122, 124 and the portion of the strap 130 folded backwards from loop 122. The support surface 240 functions as surface onto which the folded back portion of the strap 130 and the portion of the strap 130 extending between the loops 122, 124 can be pressed by the user to secure the folded back portion onto the portion of the strap 130 between the loops 122, 124.

[0045] The back volume unit 210 includes an enclosure portion 614 and a cylindrical column 616 that protrudes from the enclosure portion 614 (e.g., as shown in FIG. 6). The enclosure portion 614 that provides a cavity from which the sound generated from a speaker 612 can be reverberated towards audio passages 512A, 512B (e.g., as shown in FIG. 5A) of the strap arm 120. The back volume unit 210 enhances the quality and/or volume of the sound provided to the user via the audio port 412. In some embodiments, the enclosure portion 614 has a cylindrical shape defining a diameter that is larger than a diameter defined by the cylindrical column.

[0046] The strap arm 120 includes a cylindrical boss 310 that is received in an aperture formed at a side of the body 100 of the HMD. The strap arm 120 can rotate relative to the body 100 about the center of the boss 310. The cylindrical boss 310 of the strap arm 120 defines an aperture 516 that holds the cylindrical column 616 of the back volume unit 210.

[0047] The speaker 612 is positioned to emit sound through the audio passages 512A, 512B and to the audio port 412. In some embodiments, the speaker 612 is inserted into the cylindrical column 616, as shown in FIG. 7. In particular, the speaker 612 is positioned within an aperture 618 defined by the cylindrical column 616 of the back volume unit 210, with the cylindrical column 616 being positioned within the aperture 516 defined by the boss 310. The speaker 612 is positioned within the aperture 618 with a back side of the speaker 612 facing an interior surface of the enclosure portion 614 to define a back volume between

the interior surface and the back side of the speaker 612 for enhancing the sound emitted from the speaker. At least a portion of the sound from the speaker 612 is transmitted from the back volume through the audio passages 512A, 512B, and output at the audio port 412. The front side of the speaker 612 faces a volume within the strap arm 120 defined by the audio passages 512A and 512B.

[0048] The cylindrical boss 310 extends through an aperture of the body 100 to attach the strap arm 120 to the body 100. The enclosure portion 614 of the back volume unit 210 is positioned on a first side of the aperture of the body 100 within the body 100, and the body portion 232 of the strap arm 120 (including audio passages 512A, 512B and the audio port 412) is positioned on a second side of the aperture of the body 100 exterior to the body 100.

[0049] The body portion 232 of the strap arm 120 may include a base portion 620 and a cover portion 630. FIG. 5A is a front view of the base portion 620 of the strap arm 120. The base portion 620 includes loops 122, 124 and has a body portion 232 with the audio passages 512A, 512B that extend along the body portion 232 from the aperture 516 of the boss 310 to the audio port 412. The audio passages 512A, 512B are separated by a center rib 522. In some embodiments, the audio passages 512A, 512B are defined by recesses within the base portion 620 separated by a protrusion defining the center rib 522. When the base portion 620 and the cover portion 630 are joined, the recesses within the base portion 620 between the center rib 522 results in the audio passages 512A, 512B being defined between the base portion 620 and the cover portion 630.

[0050] The sound generated by the speaker 612 travels through the audio passages 512A, 512B to the audio port 412. Furthermore, some or all of the sound generated by speaker 612 may be enhanced by the back volume unit 210, and then directed by the trap arm 120 through the audio passages 512A, 512B to the audio port 412. The audio port 412 is placed and oriented so that that the sound from the audio port 412 is forwarded or directed toward a user's ear when the user wears the HMD. The body portion 232 of the base portion 620 is covered by the cover portion 630, as shown in FIG. 6.

[0051] FIG. 5B is a perspective view of the base portion 620 of the strap arm 120, in accordance with an embodiment. The audio port 412 and the boss 310 are formed on the same side of the body portion 232 to direct sound toward the user's ear. When the HMD is worn by the user, the audio port 412 can be positioned close to the user's ear. The audio port 412 is a carved out section of the strap arm 120 that is connected to the audio passages 512A,

512B to transmit the sound in a backward direction (e.g., from the perspective of the user) to the user's ear.

[0052] FIG. 6 is an exploded perspective view of the strap arm 120, in accordance with an embodiment. The speaker 612 is inserted into the cylindrical column 616, as discussed above. Signal lines (not shown) of the speaker 612 may extend from an audio circuit in the HMD via the back volume unit 210 or through a gap between the cylindrical column 616 and the boss 310. In some embodiments, the back volume unit 210 is formed from two separate clamshell portions that are joined to form a sealed cavity for the back volume. The signal lines (e.g., wires) extend between the interface of the joined portions, with the interface and wires forming a seal to maintain the sealed cavity for the back volume.

[0053] The cylindrical column 616 of the back volume unit 210 is inserted into the aperture 516 of the boss 310 with the speaker 612 mounted in the aperture 618 of the cylindrical column 616. The cover portion 630 is placed onto the base portion 620 to enclose the audio passages 512A, 512B to transmit the sound to generated by the speaker 612 to the audio port 412.

[0054] FIG. 7 is a cross-sectional view of the strap arm 120 in an assembled state, in accordance with an embodiment. The speaker 612 is mounted in the cylindrical column 616 and has its front side facing towards the audio passages 512A, 512B. As shown in FIG. 7, a front side (or membrane) of the speaker 612 is generally aligned in parallel to a rear interior surface portion of the back volume unit 210 and the body portion 232.

[0055] In various embodiments, the speaker 612 can be positioned in different locations of the strap arm 120. For example, the speaker 612 can be attached to the cylindrical column 616 of the back volume unit 210 as shown in FIG. 7. In yet another example, the speaker 612 is positioned within the enclosure portion 614 of the back volume unit 210. Here, the size of the speaker 612 can be larger than the aperture 516 defined by the boss 310. These embodiments allows the body portion 232 of the strap arm to be separated from the body 100 of the HMD without removing the speaker 612, and thus the body portion 232 of the strap arm 120 is more readily detachable (e.g., for replacement).

[0056] In other embodiments, the speaker 612 is attached to body portion 232 of the strap arm 120 exterior to the body 100. For example, the speaker 612 may be attached to the cylindrical boss 310 of the body portion 232 of the strap arm 120. In another example, the speaker 612 is attached to the cover portion 630 instead of the base portion 620. Whether the

speaker 612 is attached to the base portion 620 or cover portion 630, the speaker 612 may be positioned in various locations such as within the aperture 516, or away from the aperture 516 and closer to the audio port 412.

[0057] The foregoing description of the embodiments has been presented for the purpose of illustration; it is not intended to be exhaustive or to limit the embodiments to the precise forms disclosed. Persons skilled in the relevant art can appreciate that many modifications and variations are possible in light of the above disclosure.

[0058] Finally, the language used in the specification has been principally selected for readability and instructional purposes, and it may not have been selected to delineate or circumscribe the inventive subject matter. It is therefore intended that the scope be limited not by this detailed description, but rather by any claims that issue on an application based hereon. Accordingly, the disclosure of the embodiments is intended to be illustrative, but not limiting, of the scope, which is set forth in the following claims.

CLAIMS

What is claimed is:

1. A head-mounted display (HMD), comprising:
a front rigid body;
a strap arm attached to a strap that secures the front rigid body to a user's head, the strap arm including:
a body portion defining a boss at a side of the body portion, the boss having an aperture, the boss rotatably connecting the strap arm to the front rigid body, the body portion further defining an audio passage to transmit sound and an audio port to output the sound, the audio passage being defined along the body portion between the aperture of the boss and the audio port; and
a speaker positioned to emit the sound through the audio passage and to the audio port.
2. The HMD of claim 1, wherein the strap arm further includes a back volume unit including:
an enclosure portion; and
a cylindrical column inserted through the aperture of the boss, the cylindrical column defining a second aperture, the speaker being positioned within the second aperture with a back side of the speaker facing an interior surface of the enclosure portion to define a back volume between the interior surface and the back side of the speaker for enhancing the sound emitted from the speaker, at least a portion of the sound from the speaker being transmitted from the back volume through the audio passage.
3. The HMD of claim 2, wherein the speaker is positioned within the aperture of the boss of the body portion and the front side of the speaker faces toward the audio passage.
4. The HMD of claim 2, wherein:

the boss extends through a second aperture of the front rigid body to rotatably connect the strap arm to the front rigid body; and
the enclosure portion is positioned on a first side of the second aperture within the front rigid body and the body portion of the strap arm is positioned on a second side of the second aperture exterior to the front rigid body.

5. The HMD of claim 1, wherein the strap arm further includes:
a rear loop at one end of the body portion, and
a front loop at the other end of the body portion, the rear loop and the front loop receiving the strap.

6. The HMD of claim 5, wherein the body portion includes a support surface facing the strap inserted through the front loop and the rear loop.

7. The HMD of claim 5, wherein the audio port is formed on the side of the body portion including the boss and at a location closer to the rear loop than the front loop.

8. The HMD of claim 1, wherein the body portion includes:
a base portion; and
a cover portion secured to the base portion, the audio passage being defined between the base portion and the cover portion.

9. The HMD of claim 1, wherein the body portion further defines:
a second audio passage; and
a center rib separating the audio passage and the second audio passage.

10. The HMD of claim 1, wherein the front rigid body defines a second aperture to receive a center bridge of the strap.

11. A strap arm for a head-mounted display (HMD), comprising:
a body portion defining a boss at a side of the body portion, the boss having an aperture, the boss rotatably connecting the strap arm to a front rigid

body of the HMD, the body portion further defining an audio passage to transmit sound and an audio port to output the sound, the audio passage being defined along the body portion between the aperture of the boss and the audio port; and
a speaker positioned to emit the sound through the audio passage and to the audio port.

12. The strap arm of claim 11, further comprising a back volume unit including:
an enclosure portion; and

a cylindrical column inserted through the aperture of the boss, the cylindrical column defining a second aperture, the speaker being positioned within the second aperture with a back side of the speaker facing an interior surface of the enclosure portion to define a back volume between the interior surface and the back side of the speaker for enhancing the emitted from by the speaker, at least a portion of the sound from the speaker being transmitted from the back volume through the audio passage.

13. The strap arm of claim 12, wherein the speaker is positioned within the aperture of the boss of the body portion and the front side of the speaker faces toward the audio passage.

14. The strap arm of claim 12, wherein:
the boss extends through a second aperture of the front rigid body to rotatably connect the strap arm to the front rigid body;
the enclosure portion is positioned on a first side of the second aperture within the front rigid body and the body portion of the strap arm is positioned on a second side of the second aperture exterior to the front rigid body.

15. The strap arm of claim 11, further including:
a rear loop at one end of the body portion; and
a front loop at the other end of the body portion, the rear loop and the front loop receiving the strap.

16. The strap arm of claim 15, wherein the body portion includes a support surface facing the strap inserted through the front loop and the rear loop.

17. The strap arm of claim 15, wherein the audio port is formed on the side of the body portion including the boss and at a location closer to the rear loop than the front loop.

18. The strap arm of claim 11, wherein the body portion includes:
a base portion; and
a cover portion secured to the base portion, the audio passage being defined between the base portion and the cover portion.

19. The strap arm of claim 11, wherein the body portion further defines:
a second audio passage; and
a center rib separating the audio passage and the second audio passage.

20. A head-mounted display (HMD), comprising:
a housing; and
a strap arm attached to a strap that secures the housing to a user's head, the strap arm including a body portion defining a boss at a side of the body portion, the boss having an aperture, the boss rotatably connecting the strap arm to the housing, the body portion further defining an audio passage to transmit sound from the aperture and an audio port to output the sound, the audio passage being defined along the body portion between the aperture of the boss and the audio port.

21. A head-mounted display (HMD), comprising:
a front rigid body;
a strap arm attached to a strap that secures the front rigid body to a user's head, the strap arm including:
a body portion defining a boss at a side of the body portion, the boss having an aperture, the boss rotatably connecting the strap arm to the front rigid body, the body portion further defining an audio passage to transmit sound and an audio port to output the sound, the audio passage being

defined along the body portion between the aperture of the boss and the audio port; and
a speaker positioned to emit the sound through the audio passage and to the audio port.

22. The HMD of claim 21, wherein the strap arm further includes a back volume unit including:

an enclosure portion; and
a cylindrical column inserted through the aperture of the boss, the cylindrical column defining a second aperture, the speaker being positioned within the second aperture with a back side of the speaker facing an interior surface of the enclosure portion to define a back volume between the interior surface and the back side of the speaker for enhancing the sound emitted from the speaker, at least a portion of the sound from the speaker being transmitted from the back volume through the audio passage.

23. The HMD of claim 21 or 22, wherein the speaker is positioned within the aperture of the boss of the body portion and the front side of the speaker faces toward the audio passage.

24. The HMD of any of claims 21 to 23, wherein:
the boss extends through a second aperture of the front rigid body to rotatably connect the strap arm to the front rigid body; and
the enclosure portion is positioned on a first side of the second aperture within the front rigid body and the body portion of the strap arm is positioned on a second side of the second aperture exterior to the front rigid body.

25. The HMD of any of claims 21 to 24, wherein the strap arm further includes:
a rear loop at one end of the body portion, and
a front loop at the other end of the body portion, the rear loop and the front loop receiving the strap;
optionally, wherein the body portion includes a support surface facing the strap inserted through the front loop and the rear loop; and/or

optionally, wherein the audio port is formed on the side of the body portion including the boss and at a location closer to the rear loop than the front loop.

26. The HMD of any of claims 21 to 25, wherein the body portion includes:
a base portion; and
a cover portion secured to the base portion, the audio passage being defined between the base portion and the cover portion.

27. The HMD of any of claims 21 to 26, wherein the body portion further defines:
a second audio passage; and
a center rib separating the audio passage and the second audio passage.

28. The HMD of any of claims 21 to 27, wherein the front rigid body defines a second aperture to receive a center bridge of the strap.

29. A strap arm for a head-mounted display (HMD), comprising:
a body portion defining a boss at a side of the body portion, the boss having an aperture, the boss rotatably connecting the strap arm to a front rigid body of the HMD, the body portion further defining an audio passage to transmit sound and an audio port to output the sound, the audio passage being defined along the body portion between the aperture of the boss and the audio port; and
a speaker positioned to emit the sound through the audio passage and to the audio port.

30. The strap arm of claim 29, further comprising a back volume unit including:
an enclosure portion; and
a cylindrical column inserted through the aperture of the boss, the cylindrical column defining a second aperture, the speaker being positioned within the second aperture with a back side of the speaker facing an interior surface of the enclosure portion to define a back volume between the interior surface and the back side of the speaker for enhancing the emitted from by the speaker, at

least a portion of the sound from the speaker being transmitted from the back volume through the audio passage;

optionally, wherein the speaker is positioned within the aperture of the boss of the body portion and the front side of the speaker faces toward the audio passage; and/or

optionally, wherein:

the boss extends through a second aperture of the front rigid body to rotatably connect the strap arm to the front rigid body;

the enclosure portion is positioned on a first side of the second aperture within the front rigid body and the body portion of the strap arm is positioned on a second side of the second aperture exterior to the front rigid body.

31. The strap arm of claim 29 or 30, further including:

a rear loop at one end of the body portion; and

a front loop at the other end of the body portion, the rear loop and the front loop receiving the strap;

optionally, wherein the body portion includes a support surface facing the strap inserted through the front loop and the rear loop; and/or

optionally, wherein the audio port is formed on the side of the body portion including the boss and at a location closer to the rear loop than the front loop.

32. The strap arm of any of claims 29 to 31, wherein the body portion includes:

a base portion; and

a cover portion secured to the base portion, the audio passage being defined between the base portion and the cover portion.

33. The strap arm of any of claims 29 to 32, wherein the body portion further defines:

a second audio passage; and

a center rib separating the audio passage and the second audio passage.

34. A head-mounted display (HMD), in particular according to any of claims 21 to 28, comprising:

a housing; and

a strap arm attached to a strap that secures the housing to a user's head, the strap arm including a body portion defining a boss at a side of the body portion, the boss having an aperture, the boss rotatably connecting the strap arm to the housing, the body portion further defining an audio passage to transmit sound from the aperture and an audio port to output the sound, the audio passage being defined along the body portion between the aperture of the boss and the audio port.

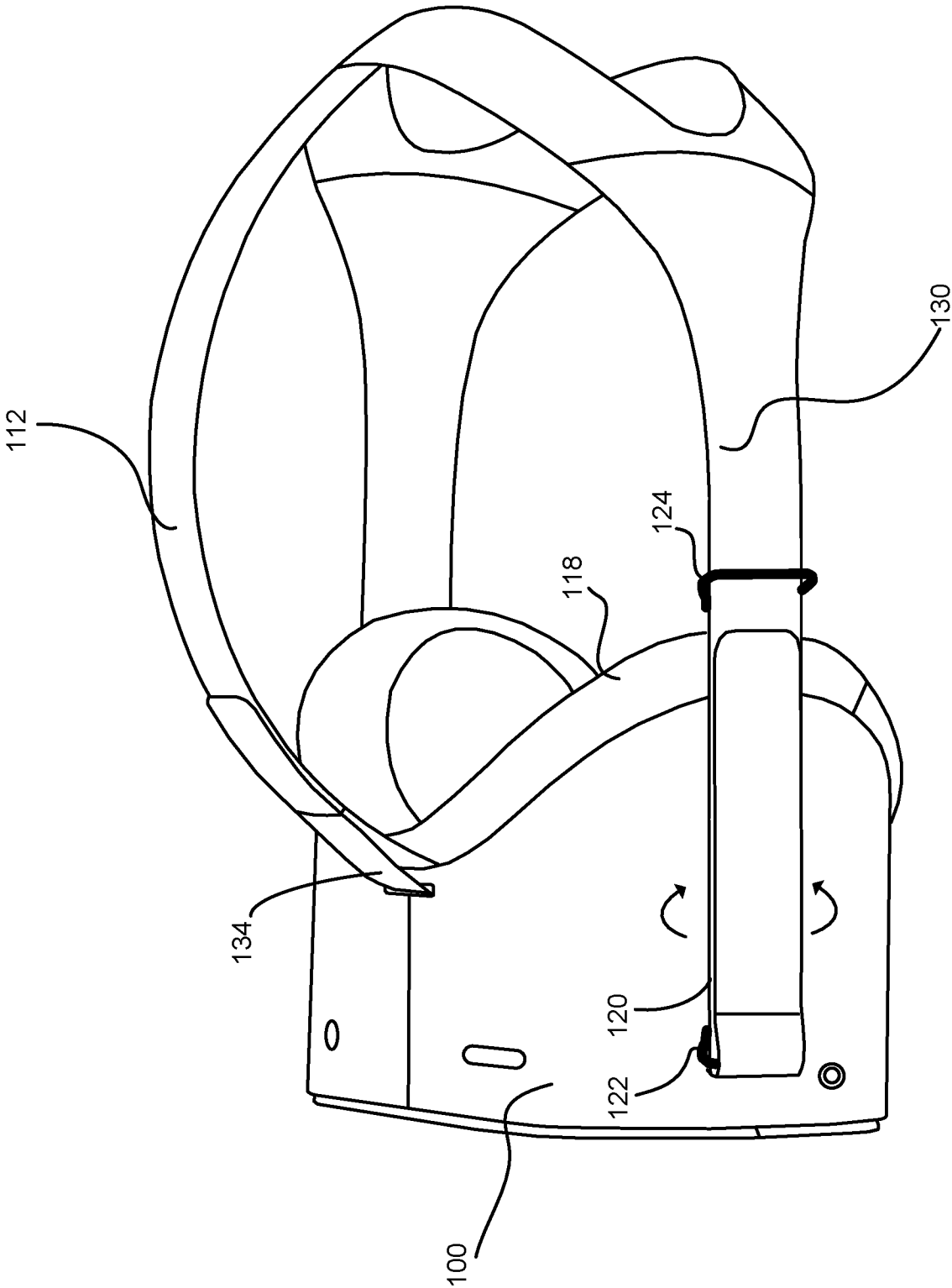


FIG. 1

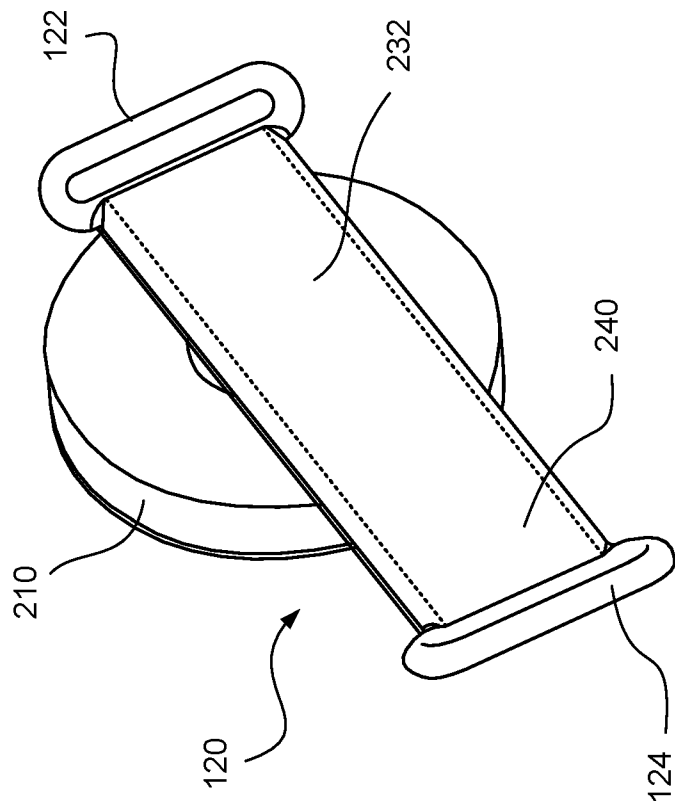


FIG. 2

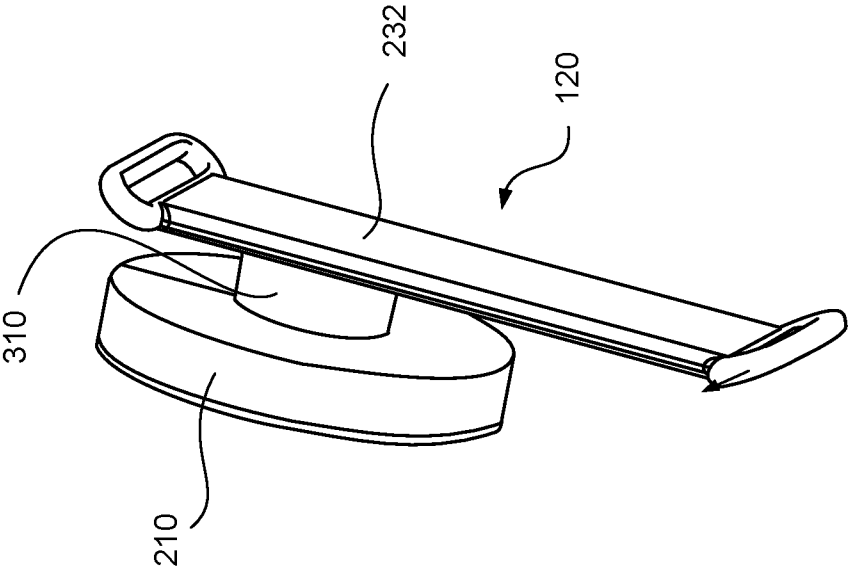


FIG. 3

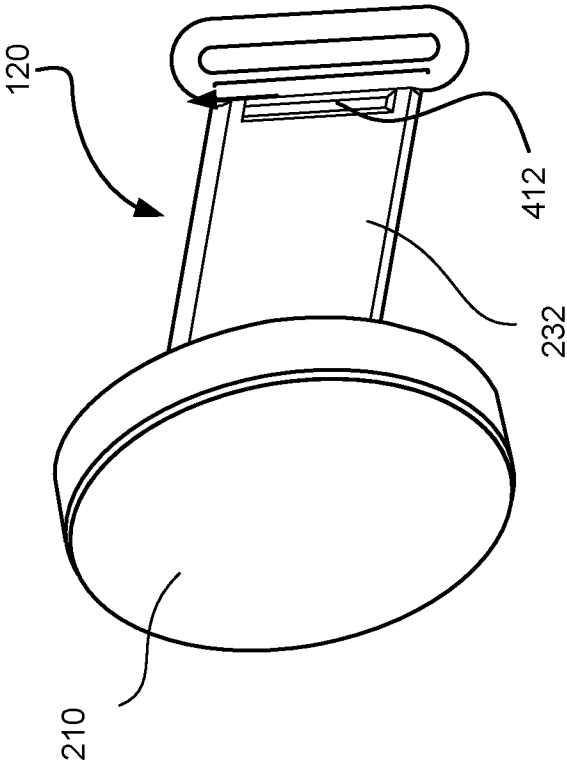
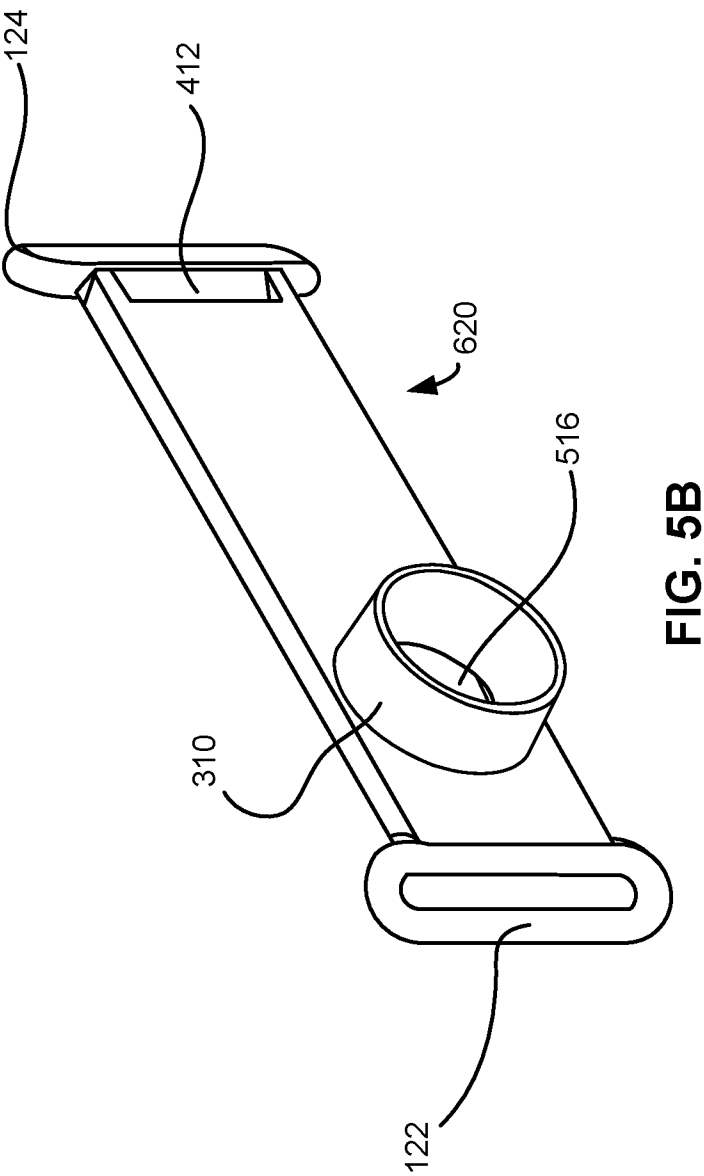
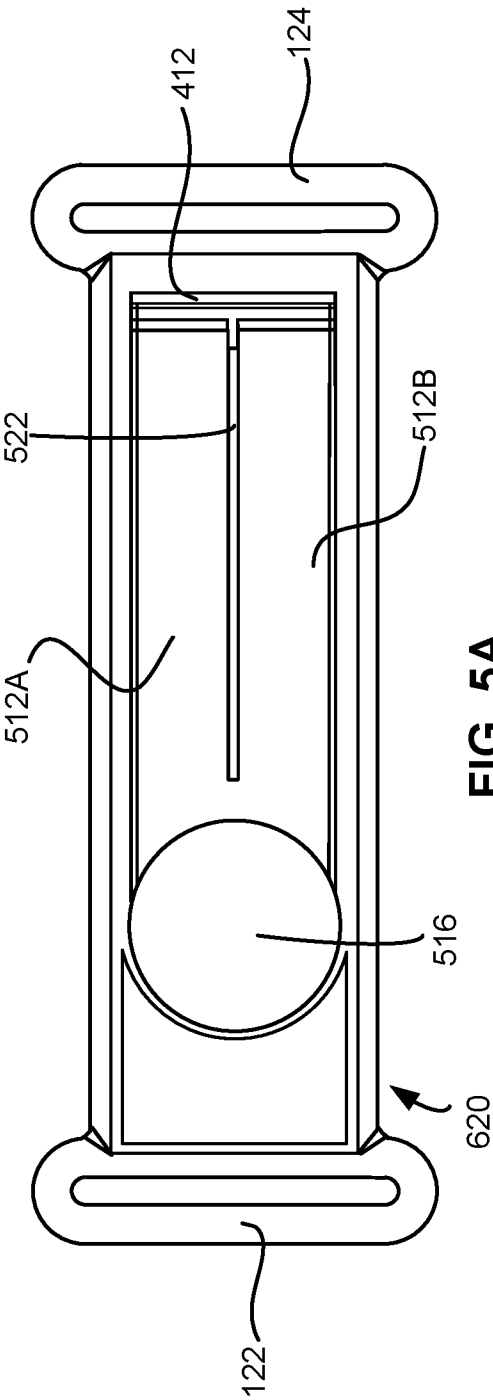


FIG. 4



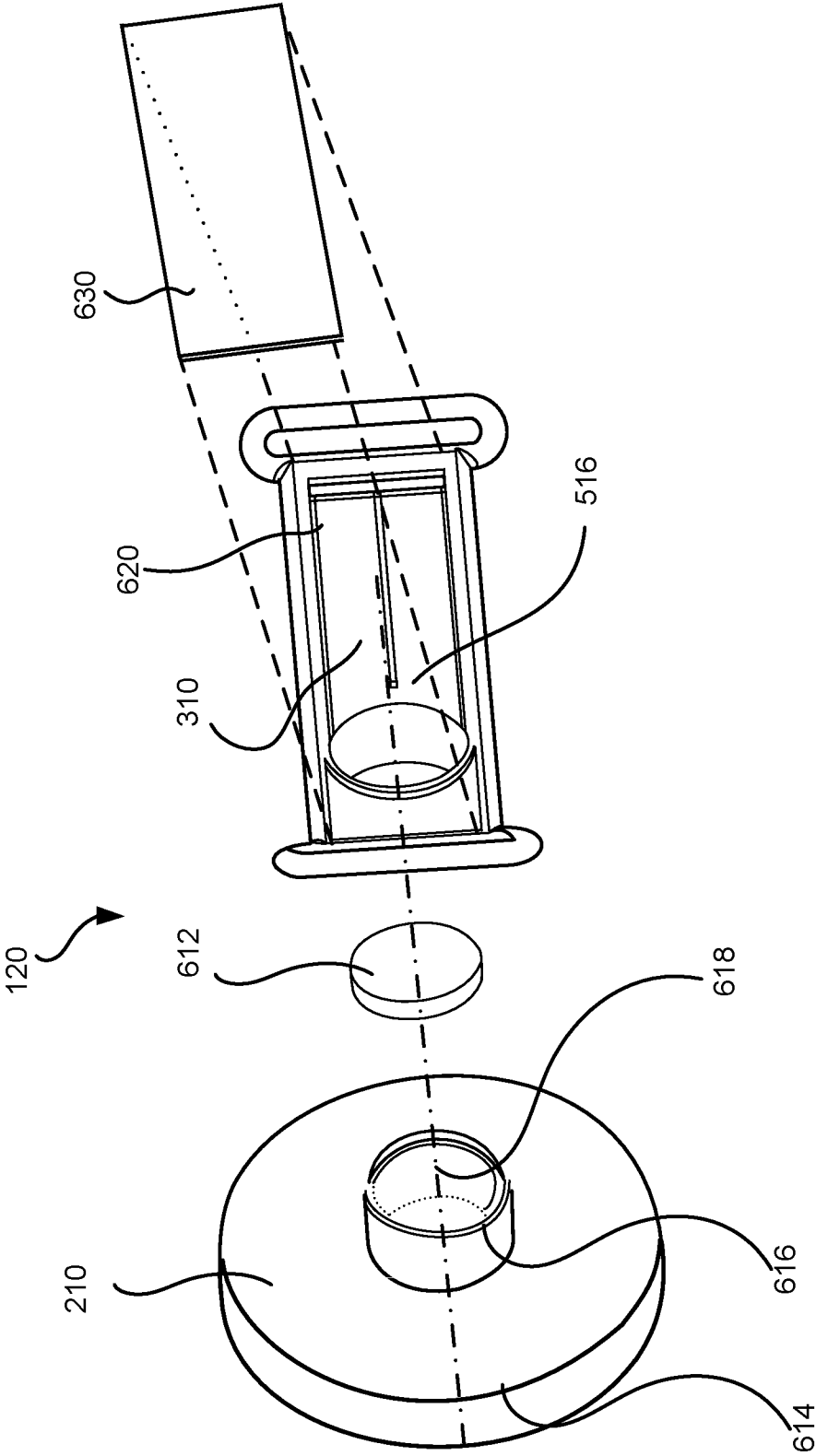


FIG. 6

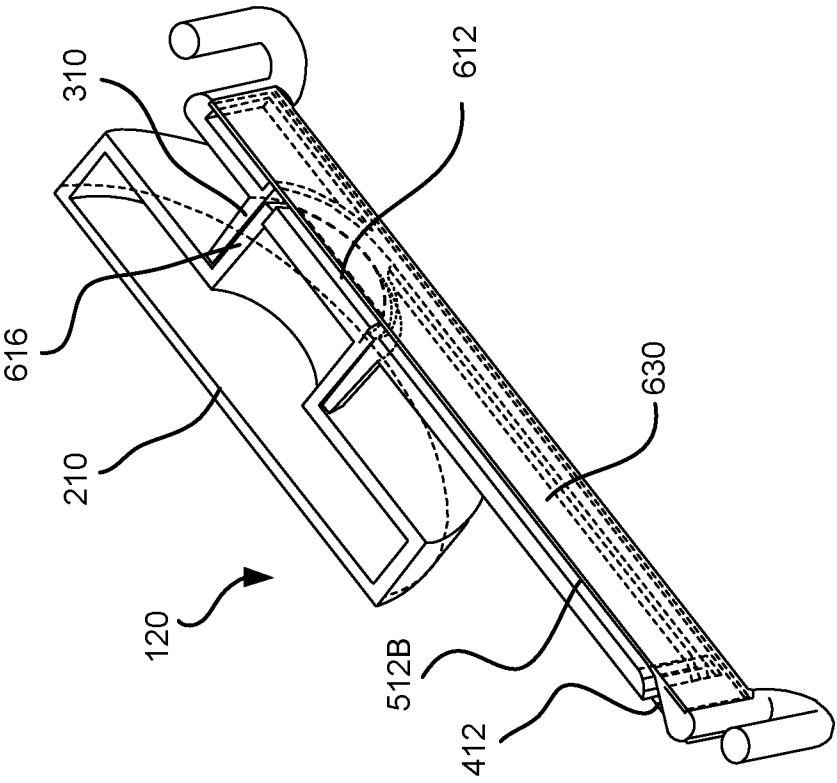


FIG. 7

A. CLASSIFICATION OF SUBJECT MATTER**G02B 27/01(2006.01)i, H04R 1/28(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)

G02B 27/01; G02C 5/02; G02C 1/00; G02C 11/00; H04R 1/10; H04R 1/28

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & keywords: hmd, speaker, audio, strap

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 204925511 U (LUO CHUANGXIN) 30 December 2015 See paragraphs [0025], [0037]–[0040] and figures 1–6.	1–23, 29–31
Y	US 2007–0030442 A1 (THOMAS A. HOWELL et al.) 08 February 2007 See paragraphs [0056]–[0059] and figures 2–4.	1–23, 29–31
Y	US 2016–0103339 A1 (BENJAMIN L. WHITE et al.) 14 April 2016 See paragraph [0024] and figure 1.	5–7, 15–17, 31
A	US 2014–0268016 A1 (KOPIN CORPORATION) 18 September 2014 See claims 1–9 and figures 2–7.	1–23, 29–31
A	US 2016–0249124 A1 (OCULUS VR, LLC.) 25 August 2016 See claims 1–7 and figures 6A–6C.	1–23, 29–31



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

23 April 2018 (23.04.2018)

Date of mailing of the international search report

23 April 2018 (23.04.2018)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

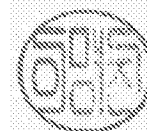
189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

Facsimile No. +82-42-481-8578

Authorized officer

LEE, Myung Jin

Telephone No. +82-42-481-8474



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/068817

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 24-28, 32-34
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of any additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2017/068817

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CN 204925511 U	30/12/2015	None	
US 2007-0030442 A1	08/02/2007	CN 101046557 A	03/10/2007
		CN 101297191 A	29/10/2008
		CN 1700059 A	23/11/2005
		CN 2859575 Y	17/01/2007
		US 2005-0078274 A1	14/04/2005
		US 2005-0124324 A1	09/06/2005
		US 2005-0230596 A1	20/10/2005
		US 2005-0248717 A1	10/11/2005
		US 2005-0248718 A1	10/11/2005
		US 2005-0248719 A1	10/11/2005
		US 2005-0264752 A1	01/12/2005
		US 2006-0001827 A1	05/01/2006
		US 2006-0003803 A1	05/01/2006
		US 2006-0023158 A1	02/02/2006
		US 2006-0259565 A1	16/11/2006
		US 2006-0276210 A1	07/12/2006
		US 2007-0046887 A1	01/03/2007
		US 2007-0109491 A1	17/05/2007
		US 2007-0186330 A1	16/08/2007
		US 2007-0279584 A1	06/12/2007
		US 2008-0068559 A1	20/03/2008
		US 2008-0151179 A1	26/06/2008
		US 2008-0218684 A1	11/09/2008
		US 2008-0278678 A1	13/11/2008
		US 2009-0059159 A1	05/03/2009
		US 2009-0141233 A1	04/06/2009
		US 2009-0147215 A1	11/06/2009
		US 2009-0296044 A1	03/12/2009
		US 2010-0205272 A1	12/08/2010
		US 2010-0309426 A1	09/12/2010
		US 2011-0102734 A1	05/05/2011
		US 2011-0187990 A1	04/08/2011
		US 2012-0050668 A1	01/03/2012
		US 2012-0133885 A1	31/05/2012
		US 2013-0201440 A1	08/08/2013
		US 2013-0308089 A1	21/11/2013
		US 2014-0242956 A1	28/08/2014
		US 2014-0256293 A1	11/09/2014
		US 2014-0268008 A1	18/09/2014
		US 2014-0361185 A1	11/12/2014
		US 2015-0085245 A1	26/03/2015
		US 2015-0253590 A1	10/09/2015
		US 2016-0044474 A1	11/02/2016
		US 2016-0246075 A9	25/08/2016
		US 2017-0074721 A1	16/03/2017
		US 2017-0090219 A1	30/03/2017
		US 2017-0131575 A1	11/05/2017

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2017/068817

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		US 2017-0146829 A1	25/05/2017
		US 2017-0201872 A1	13/07/2017
		US 7116976 B2	03/10/2006
		US 7192136 B2	20/03/2007
		US 7255437 B2	14/08/2007
		US 7376434 B2	20/05/2008
		US 7380936 B2	03/06/2008
		US 7401918 B2	22/07/2008
		US 7438410 B1	21/10/2008
		US 7481531 B2	27/01/2009
		US 7500746 B1	10/03/2009
		US 7500747 B2	10/03/2009
		US 7543934 B2	09/06/2009
		US 7581833 B2	01/09/2009
		US 7621634 B2	24/11/2009
		US 7677723 B2	16/03/2010
		US 7729688 B2	01/06/2010
		US 7760898 B2	20/07/2010
		US 7771046 B2	10/08/2010
		US 7792552 B2	07/09/2010
		US 7806525 B2	05/10/2010
		US 7890128 B1	15/02/2011
		US 7922321 B2	12/04/2011
		US 8109629 B2	07/02/2012
		US 8112104 B1	07/02/2012
		US 8280419 B1	02/10/2012
		US 8337013 B2	25/12/2012
		US 8430507 B2	30/04/2013
		US 8434863 B2	07/05/2013
		US 8465151 B2	18/06/2013
		US 8500271 B2	06/08/2013
		US 8737978 B1	27/05/2014
		US 8744407 B2	03/06/2014
		US 8770742 B2	08/07/2014
		US 8905542 B2	09/12/2014
		US 9033493 B2	19/05/2015
		US 9204268 B2	01/12/2015
		US 9488520 B2	08/11/2016
		US 9547184 B2	17/01/2017
		US 9690121 B2	27/06/2017
		US 9736664 B2	15/08/2017
		WO 2006-135614 A2	21/12/2006
		WO 2006-135614 A3	22/03/2007
		WO 2006-135614 A8	10/07/2008
		WO 2006-135614 A9	11/12/2008
US 2016-0103339 A1	14/04/2016	WO 2014-204512 A1	24/12/2014
US 2014-0268016 A1	18/09/2014	CN 105229737 A	06/01/2016
		EP 2973556 A1	20/01/2016

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2017/068817

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		JP 2016-516343 A	02/06/2016
		TW 201508375 A	01/03/2015
		TW 201508376 A	01/03/2015
		TW 201510990 A	16/03/2015
		TW 201523064 A	16/06/2015
		US 2014-0270244 A1	18/09/2014
		US 2014-0270316 A1	18/09/2014
		US 2014-0278383 A1	18/09/2014
		US 2014-0278384 A1	18/09/2014
		US 2014-0278385 A1	18/09/2014
		US 2014-0301558 A1	09/10/2014
		US 2016-0112817 A1	21/04/2016
		US 2016-0140949 A1	19/05/2016
		US 2016-0189729 A1	30/06/2016
		US 9257952 B2	09/02/2016
		US 9312826 B2	12/04/2016
		US 9633670 B2	25/04/2017
		US 9753311 B2	05/09/2017
		US 9792927 B2	17/10/2017
		US 9810925 B2	07/11/2017
		WO 2014-158426 A1	02/10/2014
		WO 2014-160329 A1	02/10/2014
		WO 2014-160435 A1	02/10/2014
		WO 2014-160443 A1	02/10/2014
		WO 2014-163794 A2	09/10/2014
		WO 2014-163794 A3	11/06/2015
		WO 2014-163796 A1	09/10/2014
		WO 2014-163797 A1	09/10/2014
US 2016-0249124 A1	25/08/2016	US 2017-0230740 A1	10/08/2017
		US 9635450 B2	25/04/2017