

HEADPHONE DRIVER

Technical Field

[0001] Various embodiments generally relate to a headphone driver.

5

Background

[0002] Conventional headphones mostly include a dynamic coil type speaker driver and are classified into closed-back headphone or open-back headphone. However, there are inadequacies in the sound qualities produced by these conventional headphones. For example, during gaming, the sound of footsteps produced by the conventional headphones is usually unclear. Further, the sound of gunshots, or the voice of gamers communicating, or the human voice can be unclear, or muffled, or soft in comparison with other sounds produced during gaming.

10

[0003] Accordingly, there is a need for an improved headphone driver which may improve the sound qualities of the headphones.

15

Summary

[0004] According to various embodiments, there is provided a headphone driver. The headphone driver includes an annular diaphragm having an inner circumferential edge and an outer circumferential edge. The headphone driver further includes an annular frame unit having an outer circular fringe portion and an inner cylindrical wall portion concentrically arranged with respect to a central axis of the annular frame unit. The inner cylindrical wall portion surrounds the central axis of the annular frame unit to define a hollow channel through the annular frame unit. The annular diaphragm is aligned coaxially to the annular frame unit with the inner circumferential edge of the annular diaphragm attached to the inner cylindrical wall portion of the annular frame unit and the outer circumferential edge of the annular diaphragm attached to the outer circular fringe portion of the annular frame unit so as to enclose an annular space therebetween. The headphone driver further includes a magnetic arrangement fitted to the annular frame unit to surround the inner cylindrical wall portion of the annular frame unit. The headphone driver further includes a voice coil disposed to a surface of the annular diaphragm that is directed towards the annular frame unit. The voice coil being in a concentric

20

25

30

configuration with the inner circumferential edge and the outer circumferential edge of the annular diaphragm. The voice coil coacts with the magnetic arrangement when a current is passed through the voice coil so as to vibrate the diaphragm.

5

Brief description of the drawings

[0005] In the drawings, like reference characters generally refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating the principles of the invention. In the following description, various embodiments are described with reference to the following drawings, in which:

10 FIG. 1A shows a schematic diagram of a cross-section of a headphone driver according to various embodiments;

 FIG. 1B shows a schematic diagram of a top view of the headphone driver of FIG. 1A according to various embodiments;

 FIG. 1C shows a schematic diagram of a cross-sectional exploded view of the
15 headphone driver of FIG. 1A according to various embodiments;

 FIG. 2A shows a cross-sectional view of a headphone driver according to various embodiments;

 FIG. 2B shows a top view of the headphone driver of FIG. 2A according to various embodiments;

20 FIG. 2C shows a bottom view of the headphone driver of FIG. 2A according to various embodiments;

 FIG. 2D shows an exploded view of the headphone driver of FIG. 2A according to various embodiments; and

 FIG. 3 shows a cross-section of a headphone having the headphone driver of FIG. 2A
25 according to various embodiments.

Detailed description

[0006] Embodiments described below in the context of the apparatus are analogously valid for the respective methods, and vice versa. Furthermore, it will be understood that the
30 embodiments described below may be combined, for example, a part of one embodiment may be combined with a part of another embodiment.

[0007] It should be understood that the terms “on”, “over”, “top”, “bottom”, “down”, “side”, “back”, “left”, “right”, “front”, “lateral”, “side”, “up”, “down” etc., when used in the following description are used for convenience and to aid understanding of relative positions or directions, and not intended to limit the orientation of any device, or structure or any part of any device or structure. In addition, the singular terms “a”, “an”, and “the” include plural references unless context clearly indicates otherwise. Similarly, the word “or” is intended to include “and” unless the context clearly indicates otherwise.

[0008] Various embodiments generally relate to a headphone driver. According to various embodiments, the headphone driver may improve the sound qualities of the headphone. According to various embodiments, the headphone driver may be a dynamic driver. According to various embodiments, the headphone driver may be configured to enhance the quality of sound in the middle frequency (or midrange) and/or the low-middle frequency (or low midrange), which are generally associated with the sound of footsteps and/or gunshots in gaming applications. According to various embodiments, the headphone driver may be configured to improve driver distortion caused by vibration. According to various embodiments, the headphone driver may be configured to reduce or minimize harmonic distortion. In various embodiments, the headphone driver may include a unique assembled structure and/or a unique magnetic driving arrangement to improve sensitivity and sound quality. For example, the unique assembled structure of the headphone driver may include a hollow channel extending through a center of the headphone driver, whereby the hollow channel may not be covered (or free of being covered) by the diaphragm. Further, the diaphragm may be of an annular shape. As another example, the unique magnetic driving arrangement may include the voice coil coacting with two concentric ring magnets, whereby an annular slot may be formed between the two concentric ring magnets such that the voice coil may be suspended therebetween.

[0009] FIG. 1A shows a schematic diagram of a cross-sectional view of a headphone driver 100 according to various embodiments. FIG. 1B shows a schematic diagram of a top view of the headphone driver 100 of FIG. 1A according to various embodiments. FIG. 1C shows a schematic diagram of a cross-sectional exploded view of the headphone driver 100 of FIG. 1A according to various embodiments.

[00010] According to various embodiments, the headphone driver 100 may include an annular diaphragm 110. The annular diaphragm 110 may include an inner circumferential edge 112 and an outer circumferential edge 114. The inner circumferential edge 112 may define a hole 113 in the annular diaphragm 110. Accordingly, the annular diaphragm 110 may be a

membrane or a sheet of material in a flat ring shape, wherein the inner circumferential edge 112 may define an inner circumference of the flat ring shape and the outer circumferential edge 114 may define an outer circumference of the flat ring shape. According to various embodiments, the inner circumferential edge 112 and the outer circumferential edge 114 may be two concentric circles with respect to a center of the annular diaphragm 110, wherein a radius of the inner circumferential edge 112 measured from the center of the annular diaphragm 112 may be smaller than a radius of the outer circumferential edge 114 measured from the center of the annular diaphragm 112.

[00011] According to various embodiments, the headphone driver 100 may include an annular frame unit 120 (e.g. a driver bracket or a driver frame). The annular frame unit 120 may serve as a frame or a base or a bracket or a structure which provides a physical form or body to the headphone driver 100. The annular frame unit 120 may be of a ring shape or a circular shape with a hollow center.

[00012] According to various embodiments, the annular frame unit 120 may include an inner cylindrical wall portion 122. The inner cylindrical wall portion 122 may surround a central axis 121 of the annular frame unit 120 to define a hollow channel 123 through the annular frame unit 120. Accordingly, the inner cylindrical wall portion 122 may be an innermost portion of the annular frame unit 120. Further, the inner cylindrical wall portion 122 may form an enclosure around the hollow channel 123. According to various embodiments, a longitudinal axis of the inner cylindrical wall portion 122 may coincide with the central axis 121 of the annular frame unit 120 such that the hollow channel 123 may extend through a centre of the annular frame unit 120. Accordingly, the hollow channel 123 may form the hollow centre of the annular frame unit 120. According to various embodiments, the annular frame unit 120 may include an outer circular fringe portion 124. The outer circular fringe portion 124 may be distal from the central axis 121 of the annular frame unit 120 in a radial direction while the inner cylindrical wall portion 122 may be proximal to the central axis 121 of the annular frame unit 120 along the radial direction. According to various embodiments, the outer circular fringe portion 124 and the inner cylindrical wall portion 122 may be concentrically arranged with respect to the central axis 121 of the annular frame unit 120. Accordingly, the central axis 121 of the annular frame unit 120 may be a common center for the outer circular fringe portion 124 and the inner cylindrical wall portion 122. Further, the outer circular fringe portion 124 may surround or encircle the inner cylindrical wall portion 122.

[00013] According to various embodiments, the annular diaphragm 110 and the annular frame unit 120 may be aligned, whereby the annular diaphragm 110 and the annular frame unit

120 may be assembled together with the hole 113 of the annular diaphragm 110 aligned with the hollow channel 123 of the annular frame unit 120. Further, according to various embodiments, the annular diaphragm 110 and the annular frame unit 120 may be coaxially aligned. Accordingly, the annular diaphragm 110 and the annular frame unit 120 may be assembled in a manner so as to have a common axis. Hence, the annular diaphragm 110 and the annular frame unit 120 may be assembled with the center of the annular diaphragm 110 coinciding with the central axis 121 of the annular frame unit 120.

[00014] According to various embodiments, when the annular diaphragm 110 and the annular frame unit 120 are assembled together, the alignment of the hole 113 of the annular diaphragm 110 and the hollow channel 123 of the annular frame unit 120 may maintain a through-hole in the headphone driver 100. Accordingly, the hollow channel 123 of the annular frame unit 120 may remain uncovered or unblock or clear or accessible. Hence, the annular diaphragm 110 may be free from covering or blocking (or may not cover or block) the hollow channel 123 of the annular frame unit 120. Thus, the headphone driver 100 formed by assembling the annular diaphragm 110 and the annular frame unit 120 may include the through-hole, whereby the through-hole may be a result of the alignment of the hole 113 of the annular diaphragm 110 and the hollow channel 123 of the annular frame unit 120.

[00015] According to various embodiments, the inner circumferential edge 112 of the annular diaphragm 110 may be attached to the inner cylindrical wall portion 122 of the annular frame unit 120. For example, the entire circumference of the inner circumferential edge 112 of the annular diaphragm 110 may conform with the entire rim and/or circumference of the inner cylindrical wall portion 122 of the annular frame unit 120. According to various embodiments, the inner circumferential edge 112 of the annular diaphragm 110 may form a continuous seal with the inner cylindrical wall portion 122 of the annular frame unit 120 such that there is no gap between the inner circumferential edge 112 of the annular diaphragm 110 and the inner cylindrical wall portion 122 of the annular frame unit 120 (or the attachment between the inner circumferential edge 112 of the annular diaphragm 110 and the inner cylindrical wall portion 122 of the annular frame unit 120 may be free or devoid of gaps).

[00016] According to various embodiments, the outer circumferential edge 114 of the annular diaphragm 110 may be attached to the outer circular fringe portion 124 of the annular frame unit 120. For example, the entire circumference of the outer circumferential edge 114 of the annular diaphragm 110 may conform with the entire rim and/or circumference of the outer circular fringe portion 124 of the annular frame unit 120. According to various embodiments, the outer circumferential edge 114 of the annular diaphragm 110 may form a continuous seal

with the outer circular fringe portion 124 of the annular frame unit 120 such that there is no gap between the outer circumferential edge 114 of the annual diaphragm 110 and the outer circular fringe portion 124 of the annular frame unit 120 (or the attachment between the outer circumferential edge 114 of the annual diaphragm 110 and the outer circular fringe portion 124 of the annular frame unit 120 may be free or devoid of gaps).

[00017] According to various embodiments, an annular space 102 may be enclosed between the annual diaphragm 110 and the annular frame unit 120. Accordingly, with the annual diaphragm 110 covering over the annular frame unit 120, the inner circumferential edge 112 of the annual diaphragm 110 being attached to the inner cylindrical wall portion 122 of the annular frame unit 120, and the outer circumferential edge 114 of the annular diaphragm 110 being attached to the outer circular fringe portion 124 of the annular frame unit 120, the annular space 102 may be defined between the annual diaphragm 110 and the annular frame unit 120.

[00018] According to various embodiments, the headphone driver 100 may include a magnetic arrangement 130. The magnetic arrangement 130 may be fitted to the annular frame unit 120. According to various embodiments, the magnetic arrangement 130 may surround the inner cylindrical wall portion 122 of the annular frame unit 120. According to various embodiments, the magnetic arrangement 130 may be disposed to encircle or form around the inner cylindrical wall portion 122 of the annular frame unit 120.

[00019] According to various embodiments, the headphone driver 100 may include a voice coil 140. The voice coil 140 may include a coil of wire. The coil of wire may function as an electro-magnetic actuator. According to various embodiments, the voice coil 140 may be disposed to a surface 116 of the annular diaphragm 110. The surface 116 of the annular diaphragm 110 may be directed towards (or facing) the annular frame unit 120. Accordingly, the surface 116 of the annular diaphragm 110 may be an underside surface of the annular diaphragm 110 directed inwards when the annular diaphragm 110 and the annular frame unit 120 are assembled together. Hence, the surface 116 of the annular diaphragm 110 may be an opposite surface of an exposed surface 118 of the annular diaphragm 110 when the annular diaphragm 110 and the annular frame unit 120 are assembled together.

[00020] According to various embodiments, the voice coil 140 may be disposed in a concentric configuration with the inner circumferential edge 112 of the annual diaphragm 110 and the outer circumferential edge 114 of the annual diaphragm 110. Accordingly, the inner circumferential edge 112 of the annular diaphragm 110, the outer circumferential edge 114 of the annual diaphragm 110 and the voice coil 140 may form concentric circles. Hence, a center of the voice coil 140 may coincide with the center of the annual diaphragm 110. Further, the

voice coil 140 may have a radius larger than the radius of the inner circumferential edge 112 of the annular diaphragm 110 and smaller than the radius of the outer circumferential edge 114 of the annular diaphragm 110. Thus, the voice coil 140 may surround the inner circumferential edge 112 of the annular diaphragm 110 while being within the outer circumferential edge 114 of the annular diaphragm 110.

[00021] According to various embodiments, when the annular diaphragm 110 is assembled to the annular frame unit 120, the voice coil 140 may be suspended by the annular diaphragm 110 relative to the magnetic arrangement 130 surrounding the inner cylindrical wall portion 122 of the annular frame unit 120. Accordingly, the voice coil 140 may be capable of coaxing with the magnetic arrangement 130 when a current is passed through the voice coil 140. In other words, the voice coil 140 may be suspended by the annular diaphragm 110 in an overhanging manner so as to be within a magnetic field of the magnetic arrangement 130 such that the magnetic arrangement 130 may have a magnetic influence over the voice coil 140. Hence, when the voice coil 140 is energized by passing a current through the voice coil 140, an interaction between the magnetic field generated by the voice coil 140 and the magnetic field of the magnetic arrangement 130 may exert a force on the annular diaphragm 110 to move the annular diaphragm 110. Rapid changes to the direction and magnitude of the current passing through the voice coil 140 may change the direction of movements of the annular diaphragm to cause the annular diaphragm to vibrate. Accordingly, the voice coil 140 may coact with the magnetic arrangement 130 when a current is passed through the voice coil 140 so as to vibrate the annular diaphragm 110.

[00022] According to various embodiments, when the annular diaphragm 110 is assembled to the annular frame unit 120 in a coaxial manner, the center of the voice coil 140 may coincide with the central axis 121 of the annular frame unit 120. Accordingly, the voice coil 140 may be suspended by the annular diaphragm 110 so as to be concentric with the inner cylindrical wall portion 122 of the annular frame unit 120. Hence, the voice coil 140 may in turn be suspended in a manner so as to be concentric with the magnetic arrangement 130.

[00023] According to various embodiments, the magnetic arrangement 130 may include a ring magnet (or at least one ring magnet, or one or more ring magnets). The ring magnet may be fitted to the annular frame unit 120 to surround the inner cylindrical wall portion 122 of the annular frame unit 120. Accordingly, the ring magnet may be fitted to the annular frame unit 120 in a manner such that the inner cylindrical wall portion 122 of the annular frame unit 120 may be extending through a center hole of the ring magnet. According to various embodiments, the voice coil 140 may be suspended by the annular diaphragm 110 relative to the ring magnet

so as to be capable of coacting with the magnetic arrangement 130 when a current is passed through the voice coil 140. According to various embodiments, the ring magnet may be coaxial with the annular frame unit 120. Accordingly, the ring magnet may be concentric with the inner cylindrical wall portion 122 of the annular frame unit 120, as well as the voice coil 140
5 suspended by the annular diaphragm 110. According to various embodiments, the ring magnet may be a permanent ring magnet.

[00024] According to various embodiments, the magnetic arrangement 130 may include a pair of ring magnets (or at least two ring magnets, or two or more ring magnets). The pair of ring magnets (or the at least two ring magnets, or the two or more ring magnets) may be
10 disposed in a concentric manner with respect to the inner cylindrical wall portion 122 of the annular frame unit 120. For example, the magnetic arrangement 130 may be fitted to the annular frame unit 120 in a manner such that the inner cylindrical wall portion 122 of the annular frame unit 120 may be extending through a center hole of an inner ring magnet of the pair of ring magnets (or the at least two ring magnets, or the two or more ring magnets), and
15 an outer ring magnet of the pair of ring magnets (or the at least two ring magnets, or the two or more ring magnets) may be surrounding the inner ring magnet of the pair of ring magnets (or the at least two ring magnets, or the two or more ring magnets). According to various embodiments, the magnetic arrangement 130 may include an annular slot formed between an inner ring magnet of the pair of ring magnets (or the at least two ring magnets, or the two or
20 more ring magnets) and an outer ring magnet of the pair of ring magnets (or the at least two ring magnets, or the two or more ring magnets). Accordingly, an inner diameter of the outer ring magnet may be larger than an outer diameter of the inner ring magnet such that there may be a gap between the outer ring magnet and the inner ring magnet when disposed in the concentric manner. Hence, the gap between the outer ring magnet and the inner ring magnet
25 may form the annular slot. According to various embodiments, the voice coil 140 may be suspended from the annular diaphragm 110 so as to be located between the inner ring magnet and the outer ring magnet. Accordingly, the voice coil 140 may be suspended relative to the inner ring magnet and the outer ring magnet so as to correspond with the annular slot of the magnetic arrangement 130. Further, the voice coil 140 may be capable of coacting with the
30 inner ring magnet and the outer ring magnet when a current is passed through the voice coil 140. According to various embodiments, each of the ring magnet may be a permanent ring magnet.

[00025] FIG. 2A shows a cross-sectional view of a headphone driver 200 according to various embodiments. FIG. 2B shows a top view of the headphone driver 200 of FIG. 2A

according to various embodiments. FIG. 2C shows a bottom view of the headphone driver 200 of FIG. 2A according to various embodiments. FIG. 2D shows an exploded view of the headphone driver 200 of FIG. 2A according to various embodiments. According to various embodiments, the headphone driver 200 of FIG. 2A to FIG. 2D includes all the features of the headphone driver 100 of FIG. 1A to FIG. 1C. Accordingly, all features, changes, modifications, and variations that are applicable to the headphone driver 100 of FIG. 1A to FIG. 1C may also be applicable to the headphone driver 200 of FIG. 2A to FIG. 2D. According to various embodiments, the headphone driver 200 may, similar to the headphone driver 100 of FIG. 1A to FIG. 1C, include the annular diaphragm 110 having the inner circumferential edge 112 and an outer circumferential edge 114; the annular frame unit 120 having the outer circular fringe portion 124 and the inner cylindrical wall portion 122, wherein the annular diaphragm 110 may be aligned coaxially to the annular frame unit 120 with the inner circumferential edge 112 of the annular diaphragm 110 attached to the inner cylindrical wall 122 of the annular frame unit 120 and the outer circumferential edge 114 of the annular diaphragm 110 attached to the outer circular fringe portion 124 of the annular frame unit 120; the magnetic arrangement 130 fitted to the annular frame unit 120 to surround the inner cylindrical wall portion 122 of the annular frame unit 120; and a voice coil 140 disposed to the surface of the annular diaphragm 110 that is directed towards the annular frame unit 120. According to various embodiments, the headphone driver 200 of FIG. 2A and FIG. 2B may further include the following additional features and/or limitations.

[00026] As shown in FIG. 2A and FIG. 2D, the magnetic arrangement 130 of the headphone driver 200 may include a pair of ring magnets 232, 234. The pair of ring magnets 232, 234 may be disposed in a concentric manner with respect to the inner cylindrical wall portion 122 of the annular frame unit 120. According to various embodiments, the pair of ring magnets 232, 234 may be fitted to the annular frame unit 120 with the inner cylindrical wall portion 122 of the annular frame unit 120 extending through a center hole of an inner ring magnet 232 of the pair of ring magnets 232, 234, and an outer ring magnet 234 of the pair of ring magnets 232, 234 may be surrounding the inner ring magnet 232 of the pair of ring magnets 232, 234. Accordingly, the inner cylindrical wall portion 122 of the annular frame unit 120 may form an innermost ring, the inner ring magnet 232 may form a ring around the inner cylindrical wall portion 122 of the annular frame unit 120, and the outer ring magnet 234 may form another ring around the inner ring magnet 232 such that the inner cylindrical wall portion 122, the inner ring magnet 232 and the outer ring magnet 234 form the concentric pattern. Further, a center (or geometric axis) of the inner ring magnet 232 and a center (or geometric axis) of the outer ring

magnet 234 may coincide with the central axis 121 of the annular frame unit 120 such that the inner cylindrical wall portion 122, the inner ring magnet 232 and the outer ring magnet 234 may share a common axis. According to various embodiments, an annular slot 236 may be formed between the inner ring magnet 232 of the pair of ring magnets 232, 234 and the outer ring magnet 234 of the pair of ring magnets 232, 234. Accordingly, an inner diameter of the outer ring magnet 234 may be larger than an outer diameter of the inner ring magnet 232 such that a gap between the outer ring magnet 234 and the inner ring magnet 232 may form the annular slot 236. Hence, the annular slot 236 may surround the inner ring magnet 232 and the outer ring magnet 234 may bound the annular slot 236. Further, the annular slot 236 may be defined between an outer wall surface 232b of the inner ring magnet 232 and an inner wall surface 234a of the outer ring magnet 234.

[00027] According to various embodiments, the voice coil 140 may be suspended from the annular diaphragm 110 so as to be located between the inner ring magnet 232 and the outer ring magnet 234. Accordingly, the voice coil 140 may be suspended relative to the inner ring magnet 232 and the outer ring magnet 234 so as to correspond with the annular slot 236. Further, the voice coil 140 may be capable of coacting with the inner ring magnet 232 and the outer ring magnet 234 when a current is passed through the voice coil 140. According to various embodiments, when the current is passed through the voice coil 140, the voice coil 140 may be moved into and out of the annular slot 236 (or may vary an amount of insertion into the annular slot 236) so as to vibrate the annular diaphragm 110. According to various embodiments, each of the inner ring magnet 232 and the outer ring magnet 234 may be a permanent ring magnet.

[00028] As shown, according to various embodiments, the inner cylindrical wall portion 122 of the annular frame unit 120 may have an inner wall surface 122a defining the hollow channel 123. Accordingly, the inner wall surface 122a of the inner cylindrical wall portion 122 of the annular frame unit 120 may bound the hollow channel 123. Hence, a diameter of the hollow channel 123 may be defined by the diameter of the inner wall surface 122a of the inner cylindrical wall portion 122 of the annular frame unit 120. Further, the inner cylindrical wall portion 122 of the annular frame unit 120 may have an outer wall surface 122b. Accordingly, a thickness of the inner cylindrical wall portion 122 of the annular frame unit 120 may be a difference in a radius of the outer wall surface 122b and a radius of the inner wall surface 122a respectively from the central axis 121 of the annular frame unit 120.

[00029] According to various embodiments, an inner wall surface 232a of the inner ring magnet 232 of the pair of ring magnets 232, 234 may abut the outer wall surface 122b of the inner cylindrical wall portion 122 of the annular frame unit 120. Accordingly, the inner wall

surface 232a of the inner ring magnet 232 may be in contact or in engagement with the outer wall surface 122b of the inner cylindrical wall portion 122 of the annular frame unit 120. For example, when the inner ring magnet 232 and the inner cylindrical wall portion 122 of the annular frame unit 120 are fitted together via clearance fit, such as location clearance fit, the inner wall surface 232a of the inner ring magnet 232 and the outer wall surface 122b of the inner cylindrical wall portion 122 of the annular frame unit 120 may be loosely abutting so as to be in contact or touching each other for ease of assembling and/or disassembling. As another example, when the inner ring magnet 232 and the inner cylindrical wall portion 122 of the annular frame unit 120 are fitted together via transition fit or interference fit, the inner wall surface 232a of the inner ring magnet 232 and the outer wall surface 122b of the inner cylindrical wall portion 122 of the annular frame unit 120 may be engaged with each other via friction.

[00030] According to various embodiments, the inner cylindrical wall portion 122 of the annular frame unit 120 may include a flange 122c protruding radially outward from the outer wall surface 122b of the inner cylindrical wall portion 122 of the annular frame unit 120. The flange 122c may be a circumferential rim or collar or ring protruding away from the outer wall surface 122b of the inner cylindrical wall portion 122 of the annular frame unit 120 with respect to the central axis 121 of the annular frame unit 120. According to various embodiments, with the inner ring magnet 232 and the inner cylindrical wall portion 122 of the annular frame unit 120 fitted together such that the inner wall surface 232a of the inner ring magnet 232 of the pair of ring magnets 232, 234 abuts the outer wall surface 122b of the inner cylindrical wall portion 122 of the annular frame unit 120, the flange 122c of the inner cylindrical wall portion 122 of the annular frame unit 120 may form an overhang extending from the inner cylindrical wall portion 122 and over the inner ring magnet 232.

[00031] According to various embodiments, the headphone driver 100 may further include an annular plate 250. The annular plate 250 may be sandwiched between the flange 122c of the inner cylindrical wall portion 122 of the annular frame unit 120 and an annular surface 232c of the inner ring magnet 232. The annular surface 232c of the inner ring magnet may be directed towards or facing the annular diaphragm 110. Accordingly, the annular plate 250 may be clamped between the flange 122c of the inner cylindrical wall portion 122 of the annular frame unit 120 and the annular surface 232c of the inner ring magnet 232.

[00032] According to various embodiments, the flange 122c of the inner cylindrical wall portion 122 of the annular frame unit 120 may serve as a stopper preventing the inner ring magnet 232 from slipping out of the inner cylindrical wall portion 122 of the annular frame

unit 120. According to various embodiments, the annular plate 250 may serve to prevent the inner ring magnet 232 from loosening and to maintain the inner ring magnet 232 in place, as well as prevent damage and to serve to protect the inner ring magnet 232 during assembling.

[00033] According to various embodiments, the annular frame unit 120 may include an annular receptacle portion 226. The annular receptacle portion 226 may serve to accommodate the pair of ring magnets 232, 234. Accordingly, the annular receptacle portion 226 may subdivide the annular space 102 between the annular diaphragm 110 and the annular frame unit 120 so as to define a region within the annular space 102 for receiving and accommodating the pair of ring magnets 232, 234. Hence, the annular receptacle portion 226 may delimit the region within the annular space 102 for receiving and accommodating the pair of ring magnets 232, 234. According to various embodiments, the pair of ring magnets 232, 234 may be disposed within the annular receptacle portion 226 of the annular frame unit 120.

[00034] According to various embodiments, the annular receptacle portion 226 of the annular frame unit 120 may be disposed concentrically between the inner cylindrical wall portion 122 of the annular frame unit 120 and the outer circular fringe portion 124 of the annular frame unit 120. Accordingly, the annular receptacle portion 226 may surround the inner cylindrical wall portion 122, and the outer circular fringe portion 124 may surround the annular receptacle portion 226. According to various embodiments, the pair of ring magnets 232, 234 may be disposed within the annular receptacle portion 226 in the concentric manner relative to the inner cylindrical wall portion 122. Further, the annular receptacle portion 226 may be dimensioned or configured to be capable of accommodating the pair of ring magnets 232, 234 arranged in the concentric manner along with the annular slot 236.

[00035] According to various embodiments, the annular receptacle portion 226 of the annular frame unit 120 may include an annular base 228. The annular base 228 of the annular receptacle portion 226 may surround the inner cylindrical wall portion 122 of the annular frame unit 120. Further, the annular base 228 may be immediately next to the inner cylindrical wall portion 122 of the annular frame unit 120. According to various embodiments, the annular base 228 of the annular receptacle portion 226 may include a circular wall 227. The circular wall 227 of the annular receptacle portion 226 may be extending upright from an outer circumference 228b of the annular base 228. Accordingly, the circular wall 227 of the annular receptacle portion 226 may define an outer boundary of the annular receptacle portion 226. Hence, the circular wall 227 of the annular receptacle portion 226 may serve to partition the annular space 102 between the annular diaphragm 110 and the annular frame unit 120. According to various embodiments, the inner cylindrical wall portion 112 of the annular frame unit 120 may extend

upright from an inner circumference 228a of the annular base 228. Accordingly, the inner cylindrical wall portion 112 of the annular frame unit 120 may define an inner boundary of the annular receptacle portion 226. Therefore, the circular wall 227 of the annular receptacle portion 226 and the inner cylindrical wall portion 112 may together define the region within
5 the annular space 102 for receiving and accommodating the pair of ring magnets 232, 234.

[00036] According to various embodiments, an outer wall surface 234b of the outer ring magnet 234 of the pair of ring magnets 232, 234 may abut an inner wall surface 227a of the circular wall 227 of the annular receptacle portion 226.

[00037] Accordingly, the outer wall surface 234b of the outer ring magnet 234 may be in
10 contact or in engagement with the inner wall surface 227a of the circular wall 227 of the annular receptacle portion 226 of the annular frame unit 120. For example, when the outer ring magnet 234 and the circular wall 227 of the annular receptacle portion 226 of the annular frame unit 120 are fitted together via clearance fit, such as location clearance fit, the outer wall surface 234b of the outer ring magnet 234 and the inner wall surface 227a of the circular wall 227 of
15 the annular receptacle portion 226 may be loosely abutting so as to be in contact or touching each other for ease of assembling and/or disassembling. As another example, when the outer ring magnet 234 and the circular wall 227 of the annular receptacle portion 226 of the annular frame unit 120 are fitted together via transition fit or interference fit, the outer wall surface 234b of the outer ring magnet 234 and the inner wall surface 227a of the circular wall 227 of
20 the annular receptacle portion 226 may be engaged with each other via friction.

[00038] According to various embodiments, the headphone driver 100 may include a retaining ring 260. The retaining ring 260 may be disposed on an annular surface 234c of the outer ring magnet 234. The annular surface 234c of the outer ring magnet 234 may be directed to the annular diaphragm 110. Accordingly, with the outer ring magnet 234 disposed within
25 the annular receptacle portion 226 of the annular frame unit 120, the retaining ring 260 may be disposed within the annular frame unit 120 and on the outer ring magnet 234. Hence, the outer ring magnet 234 may be between the annular base 228 the annular receptacle portion 226 of the annular frame unit 120 and the retaining ring 260.

[00039] According to various embodiments, a circumferential edge 262 of the retaining ring
30 260 may be in engagement with the inner wall surface 227a of the circular wall 227 of the annular receptacle portion 228 of the annular frame unit 120. According to various embodiments, the retaining ring 260 and the circular wall 227 of the annular receptacle portion 228 of the annular frame unit 120 may be fitted together via transition fit or interference fit. Accordingly, the circumferential edge 262 of the retaining ring 260 and the inner wall surface

227a of the circular wall 227 of the annular receptacle portion 228 of the annular frame unit 120 may be engaged with each other via friction.

[00040] According to various embodiments, with the retaining ring 260 in engagement with the circular wall 227 of the annular receptacle portion 226 of the annular frame unit 120, the retaining ring 260 may serve to clamp the outer ring magnet 234 between the annular base 228 of the annular receptacle portion 226 of the annular frame unit 120 and the retaining ring 260. Accordingly, the retaining ring 260 may keep the outer ring magnet 234 in place within the annular receptacle portion 226 of the annular frame unit 120.

[00041] Referring to FIG. 2A, according to various embodiments, the annular frame unit 120 of the headphone driver 200 may include a cylindrical tube 272, an annular receptacle 274, and an annular base frame 276. Accordingly, the annular frame unit 120 of the headphone driver 200 may be formed by integrally joining the cylindrical tube 272, the annular receptacle 274, and the annular base frame 276 together in a concentric manner. The cylindrical tube 272 may be at the center of the annular frame unit 120, the annular receptacle 274 may surround the cylindrical tube 272, and the annular base frame 276 may surround the annular receptacle 274. Hence, the cylindrical tube 272 may be inserted into the center of the annular receptacle 274, and the annular receptacle 274 may be inserted into the center of the annular base frame 276. According to various embodiments, the cylindrical tube 272, the annular receptacle 274, and the annular base frame 276 may be assembled together via transition fit or interference fit such that they may be integrally joined together. According to various embodiments, the cylindrical tube 272, the annular receptacle 274, and the annular base frame 276 may be joined together via adhesive or suitable bonding methods or suitable fastening methods such that they may be integrally joined together. According to various embodiments, the annular receptacle 274 and the annular base frame 276 may be overmolded or printed together. Subsequently, the cylindrical tube 272 may be assembled to the annular receptacle 274 and adhere thereto via adhesive or friction or binding. The cylindrical tube 272 may be assembled to the annular receptacle 274 after assembling the magnetic arrangement 130 and/or the voice coil 140.

[00042] According to various embodiments, the cylindrical tube 272 may serve as the inner cylindrical wall portion 122 of the annular frame unit 120. Accordingly, the cylindrical tube 272 may have the inner wall surface 122a defining the hollow channel 123, the outer wall surface 122b and the flange 122c protruding radially outward from the outer wall surface 122b. According to various embodiments, the annular receptacle 274 may serve as the annular receptacle portion 226 of the annular frame unit 120. Accordingly, the annular receptacle 274 may include the annular base 228 and the circular wall 227 extending upright from an outer

circumference 228b of the annular base 228, whereby the inner circumference 228a of the annular base 228 is abutting (or in engagement) with the outer wall surface 122b of the cylindrical tube 272. According to various embodiments, the annular base frame 276 may include the outer circular fringe portion 124 of the annular frame unit 120. Accordingly, a portion of the annular base frame 276 may serve as the outer circular fringe portion 124 of the annular frame unit 120. The portion of the annular base frame 276, serving as the outer circular fringe portion 124 of the annular frame unit 120, may be an outermost annular portion (or an annular border portion or annular edge portion) of the annular base frame 276.

[00043] While FIG. 2A shows an example of the annular frame unit 120 of the headphone driver 200 being formed by integrally joining three parts, namely the cylindrical tube 272, the annular receptacle 274, and the annular base frame 276, it is understood that the annular frame unit 120 of the headphone driver 200 being formed by integrally joining any number of parts, e.g. two or three or four or more parts. It is also understood that the annular frame unit 120 of the headphone driver 200 may be integrally molded or printed as a single unitary piece. Accordingly, in such an embodiment, the annular frame unit 120 may be a one-piece structure.

[00044] Referring back to FIG. 2A, according to various embodiments, the annular frame unit 120 of the headphone driver 200 may include an intermediate annular portion 280. The intermediate annular portion 280 may be disposed concentrically between the magnetic arrangement 130 and the outer circular fringe portion 124 of the annular frame unit 120. Accordingly, the intermediate annular portion 280 may be concentrically between the annular receptacle portion 226 of the annular frame unit 120 and the outer circular fringe portion 124 of the annular frame unit 120. Hence, the intermediate annular portion 280 of the annular frame unit 120 may surround the magnetic arrangement 130 and/or the annular receptacle portion 226, and the outer circular fringe portion 124 of the annular frame unit 120 may surround the intermediate annular portion 280. According to various embodiments, the intermediate annular portion 280 of the annular frame unit 120 may include holes and/or tunnel and/or tubes for sound tuning. According to various embodiments, when the annular frame unit 120 of the headphone driver 200 includes the annular base frame 276, the intermediate annular portion 280 may be part of the annular base frame 276. Accordingly, the annular base frame 276 may serve to provide the intermediate annular portion 280 and the outer circular fringe portion 124 of the annular frame unit 120.

[00045] According to various embodiments, the intermediate annular portion 280 of the annular frame unit 120 may include a first annular-disc-surface 282 and a second annular-disc-surface 284 arranged in a coaxial manner. According to various embodiments, each of the first

annular-disc-surface 282 and the second annular-disc-surface 284 may be a ring-shaped surface or area bounded by two concentric circles, i.e. an outer circle and an inner circle having a common centre point. According to various embodiments, a centre point of the first annular-disc-surface 282 and a centre point of the second annular-disc-surface 284 may lie on the central axis 121 of the annular frame unit 120.

[00046] According to various embodiments, the first annular-disc-surface 282 and the second annular-disc-surface 284 may be directed in a same axial direction along the central axis 121 of the annular frame unit 120. According to various embodiments, the first annular-disc-surface 282 and the second annular-disc-surface 284 may be facing in the same axial direction towards the annular diaphragm 110. Hence, the first annular-disc-surface 282 and the second annular-disc-surface 284 may be perpendicular to the central axis 121 of the annular frame unit 120 so as to face the annular diaphragm 110, whereby the first annular-disc-surface 282 and the second annular-disc-surface 284 may be parallel to each other.

[00047] According to various embodiments, the first annular-disc-surface 282 may have an outer radius equal or smaller than an inner radius of the second annular-disc-surface 284. Accordingly, a radius of an outer circumference of the first annular-disc-surface 282 may be equal or smaller than a radius of an inner circumference of the second annular-disc-surface 284. Hence, the second annular-disc-surface 284 may surround or encircle the first annular-disc-surface 282.

[00048] According to various embodiments, the second annular-disc-surface 284 may be offset from the first annular-disc-surface 282 in the axial direction (directed towards the annular diaphragm 110) along the central axis 121 of the annular frame unit 120 in a manner so as to form a radially-inward-step-down profile from the second annular-disc-surface 284 to the first annular-disc-surface 282. Accordingly, the centre point of the second annular-disc-surface 284 may be offset from the centre point of the first annular-disc-surface 282 in the axial direction along the central axis 121 of the annular frame unit 120 such that a disposition of the second annular-disc-surface 284 may be ahead of a disposition of the first annular-disc-surface 282 along the central axis 121 of the annular frame unit 120 in the axial direction (from the annular frame unit 120 towards the annular diaphragm 110). Hence, the first annular-disc-surface 282 may form a recess surface or a receding surface, with respect to the second annular-disc-surface 284, which retreats backward from the second annular-disc-surface 284 in a direction away from the annular diaphragm 110 along the central axis 121 of the annular frame unit 120. Thus, the second annular-disc-surface 284 and the first annular-disc-surface 282 may form a step-down profile in an inward radial direction towards the central axis 121 of the annular frame

unit 120 from an outer circumference of the second annular-disc-surface 284 to an inner circumference of the first annular-disc-surface 282.

[00049] According to various embodiments, the intermediate annular portion 280 of the annular frame unit 120 may include a first set of through-holes 286 distributed along the first annular-disc-surface 282. According to various embodiments, the first set of through-holes 286 may include two or more through-holes 286, or a plurality of through-holes 286. According to various embodiments, the first set of through-holes 286 may be lined and spaced along the first annular-disc-surface 282 in a circular arrangement or a circumferential direction at equal interval. Accordingly, the first set of through-holes 286 may be uniformly dispersed or scattered or ordered on the first annular-disc-surface 282 in a manner to follow the curvature of the first annular-disc-surface 282 so as to surround or encircle the central axis 121 of the annular frame unit 120. According to various embodiments, the first set of through-holes 286 may serve as tuning tubes or holes.

[00050] According to various embodiments, each through-hole 286 of the first set may have a hole-axis parallel to the central axis 121 of the annular frame unit 120. Accordingly, each through-hole 286 of the first set may extend through the intermediate annular portion 280 of the annular frame unit 120 from the first annular-disc-surface 282 in a manner so as to be parallel to the central axis 121 of the annular frame unit 120. Hence, each through-hole 286 of the first set may be a straight hole extending perpendicularly from the first annular-disc-surface 282 and through the intermediate annular portion 280 of the annular frame unit 120.

[00051] According to various embodiments, the intermediate annular portion 280 of the annular frame unit 120 may include a second set of through-holes 288 distributed along the second annular-disc-surface 284. According to various embodiments, the second set of through-holes 288 may include two or more through-holes 288, or a plurality of through-holes 288. According to various embodiments, the second set of through-holes 288 may be lined and spaced along the second annular-disc-surface 284 in a circular arrangement or a circumferential direction at equal interval. Accordingly, the second set of through-holes 288 may be uniformly dispersed or scattered or ordered on the second annular-disc-surface 284 in a manner to follow the curvature of the second annular-disc-surface 284 so as to surround or encircle the central axis 121 of the annular frame unit 120. According to various embodiments, the second set of through-holes 288 may serve as tuning tubes or holes.

[00052] According to various embodiments, each through-hole 288 of the second set may have a hole-axis parallel to the central axis 121 of the annular frame unit 120. Accordingly, each through-hole 288 of the second set may extend through the intermediate annular portion

280 of the annular frame unit 120 in a manner so as to be parallel to the central axis 121 of the annular frame unit 120. Hence, each through-hole 288 of the second set may be a straight hole extending perpendicularly from the second annular-disc-surface 284 and through the intermediate annular portion 280 of the annular frame unit 120.

5 [00053] According to various embodiments, each through-hole 286 of the first set of through-holes 286 may have a cross-sectional area smaller than that of the hollow channel 123 of the inner cylindrical wall portion 122. According to various embodiments, each through-hole 288 of the second set of through-holes 288 may have a cross-sectional area smaller than that of the hollow channel 123 of the inner cylindrical wall portion 122. Accordingly, a size or dimension
10 of each through-hole 286 of the first set of through-holes 286 and/or each through-hole 288 of the second set of through-holes 288 may be smaller than that of the hollow channel 123 of the inner cylindrical wall portion 122.

[00054] FIG. 3 shows a cross-section of a headphone 301 having the headphone driver 200 of FIG. 2A to FIG. 2D according to various embodiments. According to various embodiments,
15 the headphone 301 may include a headphone-shell-housing 303. According to various embodiments, the headphone 301 may further include the headphone driver 200 disposed to and/or in the headphone-shell-housing 303. According to various embodiments, the headphone 301 may further include an ear cushion 305 attached to the headphone-shell-housing 303. Accordingly, the headphone 301 with the headphone driver 200 of the various embodiments
20 may generate sound with better sound qualities.

[00055] Various embodiments have provided a headphone driver which may generate sound with better sound qualities for a headphone. Various embodiments have provided a headphone driver which may enhance the quality of sound. Various embodiments have provided a headphone driver which may improve driver distortion caused by vibration. Various
25 embodiments have provided a headphone driver with lower harmonic distortion as compared to conventional headphone driver. Various embodiments have provided a headphone driver which may produce brighter and clear sound. Various embodiments have also provided a headphone including the headphone driver according to various embodiments.

[00056] While the invention has been particularly shown and described with reference to
30 specific embodiments, it should be understood by those skilled in the art that various changes, modification, variation in form and detail may be made therein without departing from the scope of the invention as defined by the appended claims. The scope of the invention is thus indicated by the appended claims and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced.

Claims

1. A headphone driver, comprising:
 - an annular diaphragm having an inner circumferential edge and an outer circumferential edge;
 - an annular frame unit having an outer circular fringe portion and an inner cylindrical wall portion concentrically arranged with respect to a central axis of the annular frame unit, the inner cylindrical wall portion surrounding the central axis of the annular frame unit to define a hollow channel through the annular frame unit, wherein the annular diaphragm is aligned coaxially to the annular frame unit with the inner circumferential edge of the annular diaphragm attached to the inner cylindrical wall portion of the annular frame unit and the outer circumferential edge of the annular diaphragm attached to the outer circular fringe portion of the annular frame unit so as to enclose an annular space therebetween;
 - a magnetic arrangement fitted to the annular frame unit to surround the inner cylindrical wall portion of the annular frame unit; and
 - a voice coil disposed to a surface of the annular diaphragm that is directed towards the annular frame unit, the voice coil being in a concentric configuration with the inner circumferential edge and the outer circumferential edge of the annular diaphragm, wherein the voice coil coacts with the magnetic arrangement when a current is passed through the voice coil so as to vibrate the diaphragm.
2. The headphone driver as claimed in claim 1, wherein the magnetic arrangement comprises a ring magnet fitted to the annular frame unit to surround the inner cylindrical wall portion of the annular frame unit.
3. The headphone driver as claimed in claim 1, wherein the magnetic arrangement comprises a pair of ring magnets disposed in a concentric manner with respect to the inner cylindrical wall portion of the annular frame unit, wherein an annular slot is formed between an inner ring magnet of the pair of ring magnets and an outer ring magnet of the pair of ring magnets, wherein the voice coil is suspended from the annular diaphragm so as to be located between the inner ring magnet and the outer ring magnet.

4. The headphone driver as claimed in claim 3, wherein an inner wall surface of the inner ring magnet of the pair of ring magnets abuts an outer wall surface of the inner cylindrical wall portion of the annular frame unit.
5. The headphone driver as claimed in claim 4, wherein the inner cylindrical wall portion of the annular frame unit comprises a flange protruding radially outward from the outer wall surface of the inner cylindrical wall portion of the annular frame unit.
6. The headphone driver as claimed in claim 5, further comprising an annular plate sandwiched between the flange of the inner cylindrical wall portion of the annular frame unit and an annular surface of the inner ring magnet, the annular surface of the inner ring magnet being directed towards the annular diaphragm.
7. The headphone driver as claimed in any one of claims 4 to 6, wherein the annular frame unit comprises an annular receptacle portion to accommodate the pair of ring magnets, the annular receptacle portion being disposed concentrically between the inner cylindrical wall portion of the annular frame unit and the outer fringe portion of the annular frame unit, the annular receptacle portion comprising an annular base and a circular wall extending upright from an outer circumference of the annular base, wherein the inner cylindrical wall portion of the annular frame unit extends upright from an inner circumference of the annular base.
8. The headphone driver as claimed in claim 7, wherein an outer wall surface of the outer ring magnet of the pair of ring magnets abuts an inner wall surface of the circular wall of the annular receptacle portion.
9. The headphone driver as claimed in claim 8, further comprising a retaining ring disposed on an annular surface of the outer ring magnet, the annular surface of the outer ring magnet being directed to the annular diaphragm, wherein a circumferential edge of the retaining ring is in engagement with the inner wall surface of the circular wall of the annular receptacle portion.
10. The headphone driver as claimed in any one of claims 7 to 9, wherein the annular frame unit is formed by integrally joining a cylindrical tube, an annular receptacle, and an

annular base frame together in a concentric manner, whereby the cylindrical tube serves as the inner cylindrical wall portion of the annular frame unit, the annular receptacle serves as the annular receptacle portion, and the annular base frame comprises the outer fringe portion of the annular frame unit.

11. The headphone driver as claimed in any one of claims 7 to 9, wherein the annular frame unit is integrally molded or printed as a single unitary piece.

12. The headphone driver as claimed in any one of claims 1 to 11, wherein the annular frame unit comprises an intermediate annular portion, the intermediate annular portion being disposed concentrically between the magnetic arrangement and the outer circular fringe portion of the annular frame unit.

13. The headphone driver as claimed in claim 12, wherein the intermediate annular portion comprises

a first annular-disc-surface and a second annular-disc-surface arranged in a coaxial manner and directed in a direction along the central axis of the annular frame unit, the first annular-disc-surface having an outer radius equal or smaller than an inner radius of the second annular-disc-surface, the second annular-disc-surface being offset from the first annular-disc-surface in the direction along the central axis of the annular frame unit in a manner so as to form a radially-inward-step-down profile from the second annular-disc-surface to the first annular-disc-surface,

a first set of through-holes distributed along the first annular-disc-surface, each through-hole of the first set having a hole-axis parallel to the central axis of the annular frame unit, and

a second set of through-holes distributed along the second annular-disc-surface, each through-hole of the second set having a hole-axis parallel to the central axis of the annular frame unit.

14. The headphone driver as claimed in claim 13, wherein each through-hole of the first set of through-holes and/or each through-hole of the second set of through-holes may have a cross-sectional area smaller than that of the hollow channel of the inner cylindrical wall portion.