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(54) **LOUDSPEAKER AND EARPHONE**

(57) The present invention relates to a loudspeaker and an earphone. The loudspeaker comprises: a magnetic circuit assembly; a voice coil assembly; and a first diaphragm and a second diaphragm spaced apart from each other in a vibration direction. The voice coil assembly comprises a first voice coil connected to the first diaphragm and a second voice coil connected to the second diaphragm; and the first voice coil and the second voice coil respectively drive the first diaphragm and the second diaphragm to vibrate synchronously in opposite directions. The magnetic circuit assembly comprises a magnetically conductive cover and an internal magnet; the magnetically conductive cover has a side wall and a bottom wall; the side wall comprises a corrugated structure; the corrugated structure has an inner side wall and an outer side wall spaced apart from each other, and an extension portion connecting the inner side wall and the outer side wall; the bottom wall is connected to the inner side wall; a first magnetic gap is formed between the inner side wall and the internal magnet; a second magnetic gap is formed between the inner side wall and the outer side wall; the first voice coil is at least partially located in the first magnetic gap; and the second voice coil is at least partially located in the second magnetic gap. The first diaphragm and the

second diaphragm vibrate synchronously in opposite directions, thereby effectively improving the output capability of the loudspeaker, and thus satisfying the use effect of specific scenarios.

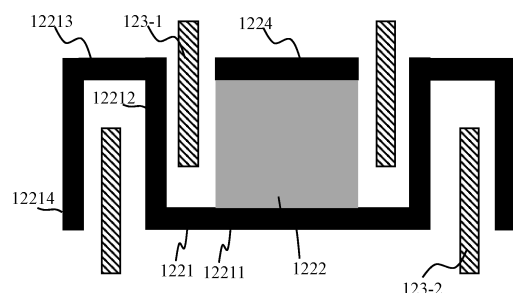


FIG. 19A

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Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to Chinese Patent Application No. 202410966001.5, filed on July 17, 2024, the contents of which are hereby incorporated by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to the field of acoustic technology, and in particular to a speaker and an earphone.

BACKGROUND

[0003] As the demand of people for life quality increases, consumers have higher requirements for earphones. In addition to stable output performance, the earphone is also required to shield environmental noise for normal listening in noisy or even high-noise environments. Consequently, the noise reduction performance of the earphone greatly affects the comfort of use for a user.

[0004] Therefore, it is necessary to provide a speaker and an earphone to improve the noise reduction effect of an acoustic device.

SUMMARY

[0005] One or more embodiments of the present disclosure provide a speaker, comprising: a magnetic circuit assembly; a voice coil assembly, at least a portion of the voice coil assembly being located within a magnetic gap of the magnetic circuit assembly; a first diaphragm and a second diaphragm, the first diaphragm and the second diaphragm being spaced apart in a vibration direction; wherein the voice coil assembly includes a first voice coil and a second voice coil arranged along the vibration direction, the first diaphragm is connected to the first voice coil, and the second diaphragm is connected to the second voice coil; the first voice coil and the second voice coil are configured to respectively drive the first diaphragm and the second diaphragm to vibrate synchronously in opposite directions; wherein the magnetic circuit assembly includes a magnetic shield and an inner magnet, the magnetic shield includes a side wall and a bottom wall, the side wall includes a folded structure, the folded structure includes an inner side wall and an outer side wall spaced apart in a direction perpendicular to the vibration direction, and an extension portion connecting the inner side wall and the outer side wall, the bottom wall is connected to the inner side wall, a first magnetic gap is formed between the inner side wall and the inner magnet, a second magnetic gap is formed between the inner side wall and the outer side wall, at least a portion

of the first voice coil is located within the first magnetic gap, and at least a portion of the second voice coil is located within the second magnetic gap.

[0006] One or more embodiments of the present disclosure also provide an earphone, comprising the speaker as described above, the earphone further comprising: a first housing, the speaker being arranged within the first housing; the first diaphragm of the speaker and an inner wall of the first housing form a first acoustic cavity, the second diaphragm of the speaker and another inner wall of the first housing form a second acoustic cavity, and a third acoustic cavity is formed between the first diaphragm and the second diaphragm; wherein the speaker further includes a frame, the frame is located between the first diaphragm and the second diaphragm in the vibration direction; an opening is provided on the frame, and the opening is in acoustic communication with the third acoustic cavity.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The present disclosure will be further illustrated by way of exemplary embodiments, which will be described in detail with reference to the accompanying drawings. These embodiments are not limiting, and in these embodiments, like numerals denote like structures, wherein:

FIG. 1 is a schematic diagram illustrating an exemplary physiological structure of an ear according to some embodiments of the present disclosure;

FIG. 2 is a schematic diagram illustrating a wearing state of an earphone when worn on an ear according to some embodiments of the present disclosure;

FIG. 3 is a block diagram illustrating a sound generating portion according to some embodiments of the present disclosure;

FIG. 4 is a schematic diagram illustrating an internal structure of a sound generating portion according to some embodiments of the present disclosure;

FIG. 5 is a schematic diagram illustrating frequency response curves output by a first sound outlet hole and a second sound outlet hole of an earphone shown in FIG. 4;

FIG. 6 is a schematic diagram illustrating another exemplary structure of a speaker according to some embodiments of the present disclosure;

FIG. 7 is a schematic diagram illustrating an internal structure of the speaker shown in FIG. 6;

FIG. 8 is a schematic diagram illustrating frequency response curves of an earphone corresponding to different pressure relief holes according to some embodiments of the present disclosure;

FIG. 9 is a schematic diagram illustrating another structure of an earphone according to some embo-

diments of the present disclosure;

FIGS. 10A-10D are schematic diagrams illustrating distributions of a first pressure relief hole and a second pressure relief hole with different dimensions according to some embodiments of the present disclosure;

FIGS. 11A-11D are schematic diagrams illustrating frequency response curves of earphones corresponding to FIGS. 10A-10D;

FIG. 12 is a schematic diagram illustrating a structure of a first housing according to some embodiments of the present disclosure;

FIGS. 13A-13B are schematic diagrams illustrating different relative positions of a first pressure relief hole and a second pressure relief hole according to some embodiments of the present disclosure;

FIG. 14 is a schematic diagram illustrating a first pressure relief hole and a second pressure relief hole with different dimensions according to some embodiments of the present disclosure;

FIGS. 15A-15B are schematic diagrams illustrating pressure relief holes with different shapes according to some embodiments of the present disclosure;

FIGS. 16A-16B are schematic diagrams illustrating different counts of pressure relief holes according to some embodiments of the present disclosure;

FIGS. 17A-17F are schematic diagrams illustrating pressure relief holes with non-single concentrated openings in different distributions according to some embodiments of the present disclosure;

FIG. 18 is a schematic diagram illustrating a relative position between a first sound outlet hole and a tuning hole according to some embodiments of the present disclosure;

FIGS. 19A-19G are schematic diagrams illustrating different exemplary structures of a speaker according to some embodiments of the present disclosure;

FIG. 20 is a schematic diagram illustrating another structure of a speaker according to some embodiments of the present disclosure;

FIG. 21A is a schematic diagram illustrating a structure of a frame according to some embodiments of the present disclosure;

FIG. 21B is a schematic diagram illustrating a position of a frame and an outer magnet according to some embodiments of the present disclosure;

FIG. 22 is a schematic diagram illustrating another structure of a cross section of a sound generating assembly according to some embodiments of the present disclosure; and

FIG. 23 is a structural exploded diagram illustrating a speaker according to some embodiments of the present disclosure.

DETAILED DESCRIPTION

[0008] In order to more clearly describe technical solutions of the embodiments of the present disclosure, a brief introduction to drawings to be used in a description of the embodiments will be provided below. It is apparent that the drawings in the following descriptions are merely some examples or embodiments of the present disclosure, and a person of ordinary skill in the art may apply the present disclosure to other similar scenarios based on the drawings without inventive effort. Unless otherwise apparent from the context or stated otherwise, the same reference numerals in the drawings represent the same structures or operations.

[0009] It should be understood that the words 'system', 'device', 'unit', and/or 'module' as used herein are a manner configured to distinguish between different components, elements, parts, portions, or assemblies of different levels. However, if other words may achieve the same purpose, the words may be replaced by other expressions.

[0010] As shown in the present disclosure and claims, unless the context clearly indicates otherwise, words such as 'a', 'an', and/or 'the' are not specifically limited to the singular, but may also include the plural. Generally speaking, terms 'comprising' and 'including' merely suggest inclusion of explicitly identified steps and elements, and these steps and elements do not constitute an exclusive list, and a manner or a device may also include other steps or elements.

[0011] Flowcharts are used in the present disclosure to illustrate operations performed by a system according to embodiments of the present disclosure. It should be understood that the preceding or subsequent operations are not necessarily performed in the exact order. Instead, the steps may be processed in reverse order or simultaneously. Meanwhile, other operations may also be added to these processes, or one or more steps may be removed from these processes.

[0012] FIG. 1 is a schematic diagram illustrating an exemplary physiological structure of an ear according to some embodiments of the present disclosure. Referring to FIG. 1, the ear includes physiological parts such as an external auditory canal 11, a concha cavity 12, a cavum concha 13, a triangular fossa 14, an antihelix 15, a scapha 16, a helix 17, an earlobe 18, a crus of helix 19, or the like. Although the external auditory canal 11 has a certain depth and extends to an eardrum of the ear, in the absence of specific instructions, the external auditory canal 11 may be understood as an opening away from the eardrum (that is, an earhole or an ear canal opening). Further, the physiological parts such as the concha cavity 12, the cavum concha 13, and the triangular fossa 14 have a certain volume and depth in a three-dimensional space, and the concha cavity 12 is in direct communication with the external auditory canal 11, that is, it may be simply regarded that the aforementioned ear canal opening is located

at a bottom of the concha cavity 12.

[0013] Since the physiological parts such as the external auditory canal 11, the concha cavity 12, the cavum concha 13, and the triangular fossa 14 have a certain depth and volume in a three-dimensional space, regarding an earphone provided in some embodiments of the present disclosure, stable wearing of the earphone may be achieved with the aid of one or more physiological parts of the ear.

[0014] Exemplarily, with the aid of other physiological parts of the ear except the external auditory canal 11 (e.g., the cavum concha 13, the triangular fossa 14, the antihelix 15, the scapha 16, the helix 17, or the like, or a combination thereof), the wearing of the earphone is achieved. For example, in a wearing state, an overall structure or a partial structure of the earphone may be in contact with an upper portion of the external auditory canal 11 (e.g., one or more physiological parts such as the cavum concha 13, the triangular fossa 14, the antihelix 15, the scapha 16, the helix 17, the crus of helix 19, or the like). Alternatively, in the wearing state, an overall structure or a partial structure of the earphone may be located within a first region P1 enclosed by dashed lines in FIG. 1 and at least including the cavum concha 13 and the triangular fossa 14, or may be located within a second region P2 enclosed by dashed lines in FIG. 1 and at least including the concha cavity 12. In addition, the overall structure or the partial structure of the earphone may be located at a front side of the crus of helix 19 (that is, within a third region P3 enclosed by dashed lines in FIG. 1).

[0015] By virtue of other physiological parts of the ear, except the external auditory canal 11, the wearing of the earphone and transmission of sound are achieved, which not only may free the external auditory canal and reduce an impact of the earphone on ear health of a user, but also may effectively improve user experience of the earphone. For example, when the user wears the earphone on a road, the earphone will not block the external auditory canal 11. In this way, the user may both receive a sound from the earphone and receive ambient sounds (e.g., horn sounds, bicycle bell sounds, surrounding human voices, traffic command sounds, or the like), thereby being capable of effectively reducing the occurrence of traffic accidents.

[0016] Since different users may have individual differences, resulting in dimension differences, such as different shapes, sizes, or the like, in the ear. To facilitate description and understanding and to reduce or even eliminate individual differences of different users, unless otherwise specified, the present disclosure primarily describes structures of earphones in different embodiments and their wearing manners on an ear model with standard shape and dimensions, by taking the ear model as a reference. For example, a simulator including a head and its (left and right) ears (e.g., GRAS 45BC KEMAR) may be prepared based on the ANSI:S3.36, S3.25, and IEC:60318-7 standards, as a

reference for wearing the earphone, thereby presenting scenarios where most users normally wear earphones.

[0017] The descriptions in the present disclosure such as 'user wearing', 'in a wearing state', and 'under a wearing state' refer to the earphone described in the present disclosure being worn on an ear of the aforementioned simulator. Of course, considering that different users have individual differences, the structures, shapes, sizes, thicknesses, or the like of one or more ear parts may be differentially designed according to ears of different shapes and dimensions. These differentiated designs may be manifested as characteristic parameters of one or more parts of the earphone having values in different ranges, so as to adapt to different ears.

[0018] It should be noted that, in fields such as medicine, anatomy, or the like, three basic sections, namely a sagittal plane, a coronal plane, and a horizontal plane, and three basic axes, namely a sagittal axis, a coronal axis, and a vertical axis, may be defined for a human body. The sagittal plane refers to a section made along an anterior-posterior direction of the body and perpendicular to the ground, which divides the human body into left and right parts. The coronal plane refers to a section made along a left-right direction of the body and perpendicular to the ground, which divides the human body into anterior and posterior parts. The horizontal plane refers to a section made along a superior-inferior direction of the body and parallel to the ground, which divides the human body into upper and lower parts. Correspondingly, the sagittal axis refers to an axis along the anterior-posterior direction of the body and perpendicular to the coronal plane. The coronal axis refers to an axis along the left-right direction of the body and perpendicular to the sagittal plane. The vertical axis refers to an axis along the superior-inferior direction of the body and perpendicular to the horizontal plane.

[0019] Further, the 'front side of the ear' described in the present disclosure is a concept relative to the 'rear side of the ear', where the former refers to a side of the ear away from the head, and the latter refers to a side of the ear facing the head. Both are for the user's ear. When the ear of the aforementioned simulator is observed along a direction where the coronal axis of the human body is located, a schematic diagram of a front side contour of the ear shown in FIG. 1 may be obtained.

[0020] It should be noted that the above description regarding the ear is merely for the purpose of illustration and is not intended to limit the scope of the present disclosure. For those skilled in the art, various changes and modifications may be made according to the description of the present disclosure (e.g., a partial structure of the earphone may cover a portion or all of the external auditory canal 11). These changes and modifications still fall within the protection scope of the present disclosure.

[0021] With continuous improvement of people's living demands, consumers' demands for earphones are also increasing. In addition to needing to have stable output performance, earphones also need to be capable of blocking ambient noise in a noisy or even high-noise environment to perform normal listening. For in-ear earphones, a sound outlet hole is located within the user's external auditory canal, and the user's listening is louder. Meanwhile, a portion of ambient noise will be blocked outside the ear canal opening. At this time, it is only necessary to utilize the noise reduction sound generated by the earphone to perform active noise reduction on the ambient noise transmitted into the ear canal. For open-ear earphones that are not inserted into the external auditory canal, given that a sound generating portion of the open-ear earphone has a certain distance from the external auditory canal and is unable to form a closed sound transmission channel with the external auditory canal, more ambient noise will be transmitted into the external auditory canal, which will have a more significant impact on the user's listening experience. In addition, since there is an open-type structure and a certain distance between the sound outlet hole of the open-ear earphone and the user's ear canal opening, it may also cause the sound output by the earphone to leak to the surrounding environment, resulting in obvious sound leakage. To improve the user experience of open-ear earphones, e.g., to improve active noise reduction effect, sound output effect, sound leakage reduction effect, or the like, it is necessary to allow the earphone to provide higher-intensity output and have lower distortion while taking into account miniaturization and lightweighting, and at the same time make amplitude frequency response and phase frequency response of the earphone more stable and have smaller fluctuations, and enable the earphone to have a relatively flat output within a relatively wide frequency band range, to provide higher sound output and/or meet the demands for better noise reduction effects.

[0022] The present disclosure provides an earphone that, in the context of open-ear earphones, improves sound generation efficiency and enables the earphone to have a relatively flat output over a wider frequency range, thereby enhancing the sound output effect and/or the active noise reduction effect.

[0023] FIG. 2 is a schematic diagram illustrating a wearing state of an earphone when worn on an ear according to some embodiments of the present disclosure. FIG. 3 is a block diagram illustrating a sound generating portion according to some embodiments of the present disclosure.

[0024] Referring to FIG. 2 and FIG. 3, in some embodiments of the present disclosure, an open-ear earphone (hereinafter referred to as the earphone) is provided, which includes a sound generating portion 100 and an ear hook. The ear hook is configured to place the sound generating portion 100 at a position in a vicinity of the ear, but not blocking the external auditory

canal 11. It should be pointed out that, since different users have individual differences, when the earphone is worn by different users, the sound generating portion 100 may partially cover the external auditory canal 11, but the external auditory canal 11 is still not blocked. Detailed descriptions will be provided below.

[0025] The sound generating portion 100 includes a first housing 110, a sound generating assembly, a microphone assembly 140, or the like. The sound generating assembly is arranged within the first housing 110. The sound generating assembly may include a speaker 120. The speaker 120 can convert an electrical signal into a corresponding mechanical vibration, thereby generating a sound output (e.g., a noise reduction sound, an audio played by the earphone, or the like). Exemplarily, the sound generated by the speaker 120 may include the noise reduction sound. The noise reduction sound output to the exterior of the first housing 110 may have the same amplitude and opposite phase as ambient noise in the vicinity of the external auditory canal 11, to eliminate the ambient noise in the vicinity of the external auditory canal 11, thereby achieving active noise reduction. The sound generated by the speaker 120 may also include a call sound, a played audio, a notification sound, or the like. After these sounds are output to the exterior of the first housing 110, they may be directed to the external auditory canal 11 to ensure the user's listening effect.

[0026] In some embodiments, the sound generating assembly further includes a limiting assembly 130. The limiting assembly 130 is configured to position and limit the speaker 120 within the interior of the first housing 110. On the one hand, by fixing the speaker 120 within the interior of the first housing 110 with the limiting assembly 130, it may ensure that the sound generated by the speaker 120 is stably output to the exterior of the first housing 110 through an acoustic hole arranged on the first housing 110. On the other hand, by limiting the speaker 120 with the limiting assembly 130, it may avoid the speaker 120 shaking relative to the first housing 110 during vibration, thereby ensuring sound output performance of the sound generating portion 100.

[0027] The microphone assembly 140 may be configured to collect sound signals (e.g., a user's voice, ambient sound, or the like). Exemplarily, based on the ambient noise collected by the microphone assembly 140, an output of the speaker 120 may be adjusted to cause the sound output by the speaker 120 to include a sound signal that cancels out the ambient noise, thereby achieving active noise reduction by the earphone on the ambient noise.

[0028] In some embodiments, the ear hook may include an ear hook housing and a battery assembly, a circuit board assembly, or the like, disposed inside the ear hook housing. Structures such as the battery assembly, the speaker 120, and the microphone assembly are electrically connected to the circuit board assembly. The circuit board assembly may be understood

as a collection of a main control board or a main board of the earphone and related components. The circuit board assembly plays a regulatory and management role for all or a portion of functional components in the earphone. For example, the circuit board assembly is configured to perform conversion processing on electrical signals in the earphone to support the realization of various functions of the earphone (e.g., supporting the earphone to realize power on/off, playback content switching, volume increase/decrease, or the like)

[0029] Referring to FIG. 2, in some embodiments, the ear hook may be divided into two portions along its length direction, namely a battery portion 200 and an adapter 300. The adapter portion 300 is connected between the battery portion 200 and the sound generating portion 100. In the wearing state, a portion of the battery portion 200 (e.g., a portion occupied by the battery assembly and the circuit board assembly) is hooked between an auricle and the head. Another portion of the battery portion 200 extends towards a side of the auricle away from the head and is connected to the adapter portion 300, thereby positioning the sound generating portion 100 near the external auditory canal 11 without blocking the external auditory canal 11, so that the earphone functions as an open-ear earphone. Further, the battery assembly, the circuit board assembly, or the like, may be arranged in the battery portion 200. The adapter portion 300 may be provided with one or more earphone buttons and with components such as a transfer board, which are configured to electrically connect the circuit board assembly with the speaker 120 and the microphone assembly 140. In some embodiments, the battery assembly, the circuit board assembly, or the like, may be arranged at an end of the battery portion 200 away from the adapter portion 300, to balance the center of the earphone and improve the wearing comfort of the earphone.

[0030] In some embodiments, to improve stability of the earphone in the wearing state, the earphone may adopt any one or any combination of the following manners. First, at least a portion of the ear hook is configured as a conforming structure (e.g., an arc-shaped barb-like shape) that conforms to at least one of the rear side of the ear and the head, to increase the contact area between the ear hook and the ear or the head, thereby increasing the resistance of the earphone detaching from the ear. Second, at least a portion of the ear hook is configured as an elastic structure, thereby causing the ear hook to have a certain elastic deformation amount in the wearing state, to increase a pressure of the ear hook on the ear or the head, thereby increasing the resistance of the earphone detaching from the ear. Third, at least a portion of the ear hook is configured to abut against the head in the wearing state, thereby causing the ear hook to form a reaction force for pressing the ear, to cause the sound generating portion 100 to be pressed against the front side of the ear, thereby increasing the resis-

tance of the earphone detaching from the ear. Fourth, the sound generating portion 100 and the ear hook are configured to respectively clamp physiological parts such as a region where the helix 17 is located and a region where the concha cavity 12 is located, from the front and rear sides of the ear in the wearing state, thereby increasing the resistance of the earphone detaching from the ear. Fifth, the sound generating portion 100 is configured to at least partially extend into physiological parts such as the concha cavity 12, the cavum concha 13, the triangular fossa 14, and the scapha 16 in the wearing state, thereby increasing the resistance of the earphone detaching from the ear.

[0031] In some embodiments, the earphone may be combined with products such as glasses, headsets, head-mounted display devices, augmented reality (AR)/virtual reality (VR) helmets, or the like. For example, the ear hook may be omitted or retained, and the sound generating portion 100 is worn in a vicinity of a user's ear by manners such as suspension, clamping, or the like.

[0032] FIG. 4 is a schematic diagram illustrating an internal structure of a sound generating portion according to some embodiments of the present disclosure.

[0033] Referring to FIG. 2, the sound generating portion 100 may have a long axis direction and a short axis direction that are perpendicular to a thickness direction and orthogonal to each other. The long axis direction may be defined as a direction having a maximum extension dimension in a shape of a two-dimensional projection plane of the sound generating portion 100 (e.g., a projection of the sound generating portion 100 on a plane where its outer side surface is located or on the sagittal plane). For example, when the projection shape is a rectangle or an approximately rectangular shape, the long axis direction is the length direction of the rectangle or the approximately rectangular shape. The short axis direction may be defined as a direction perpendicular to the long axis direction in the shape of the projection of the sound generating portion 100 on the sagittal plane. For example, when the projection shape is a rectangle or an approximately rectangular shape, the short axis direction is the width direction of the rectangle or the approximately rectangular shape. The thickness direction may be defined as a direction perpendicular to the two-dimensional projection plane. For example, the thickness direction may be consistent with a direction of the coronal axis, both pointing to the left and right sides of the body. In some embodiments, the thickness direction may also be defined as a direction in which a housing approaches or moves away from the ear in the wearing state. In some embodiments, when the sound generating portion 100 is in an inclined state in the wearing state, the long axis direction and the short axis direction may still be parallel or approximately parallel to the sagittal plane. The long axis direction may have a certain angle with a direction of the sagittal axis, that is, the long axis direction is

accordingly inclined. The short axis direction may have a certain angle with a direction of the vertical axis, that is, the short axis direction is accordingly inclined. In some embodiments, a whole or partial structure of the housing of the sound generating portion 100 may extend into the concha cavity 12, that is to say, a projection of the housing of the sound generating portion 100 on the sagittal plane may have an overlapping portion with a projection of the concha cavity 12 on the sagittal plane. In some embodiments, the long axis direction and the short axis direction of the speaker 120 are consistent with the long axis direction and the short axis direction of the sound generating portion 100.

[0034] Referring to FIG. 2 and FIG. 4, in some embodiments, the first housing 110 of the sound generating portion 100 may include a plurality of different side walls, such as an inner side surface 110a, an outer side surface 110b, an upper side surface 110c, a lower side surface 110d, a front side surface 110e, or the like. The inner side surface 110a is a side surface of the first housing 110 that faces the ear (e.g., the external auditory canal 11) in the thickness direction in the wearing state; the outer side surface 110b is a side surface of the first housing 110 that is away from the ear (e.g., the external auditory canal 11) in the thickness direction in the wearing state; the upper side surface 110c is a side surface of the first housing 110 that is close to the user's vertex in the short axis direction in the wearing state; the lower side surface 110d is a side surface of the first housing 110 that is away from the user's vertex in the short axis direction in the wearing state; and the front side surface 110e is a side surface of the first housing 110 that faces a rear of the ear in the long axis direction in the wearing state. It may be understood that these different side surfaces of the housing may cooperatively form an accommodating cavity of the sound generating portion 100, and the sound generating assembly (e.g., the speaker 120, or the like) is accommodated within the accommodating cavity.

[0035] In order to effectively enhance the active noise reduction effect of the earphone in an open application scenario, the earphone may be designed to have a relatively flat output in a relatively wide frequency band range. In some embodiments, a frequency response curve of the sound output by the earphone to an exterior of the first housing 110 has a first resonance peak and a second resonance peak, wherein a peak resonance frequency of the first resonance peak is less than a peak resonance frequency of the second resonance peak. In some embodiments, the first resonance peak and the second resonance peak refer to two adjacent and continuous resonance peaks on the frequency response curve, and a flat region is present on the frequency response curve between these two resonance peaks. In the frequency band range corresponding to the flat region between the first resonance peak and the second resonance peak, the earphone has a better active noise reduction effect. Designing the first

resonance peak and the second resonance peak may affect a frequency range of the active noise reduction of the earphone. Designing the flat region (e.g., the flatness, the curve height of the flat region, or the like) may affect the effect of the active noise reduction. For example, the flatness of the flat region may reflect the stability of the sound output by the earphone. The more stable the output of the earphone is, the more convenient it is to perform active noise reduction, and the better the active noise reduction effect is. For example, the curve height of the flat region may reflect a magnitude of the sound that the earphone can output. The larger the sound that the earphone can output, the larger noise for which the earphone can perform noise reduction, and the better the active noise reduction effect is.

[0036] In order to design the first resonance peak, the second resonance peak, and the flat region between them, referring to FIG. 4, in some embodiments, the speaker 120 may include a magnetic circuit assembly 122, a voice coil assembly 123, a first diaphragm 121-1, and a second diaphragm 121-2. The voice coil assembly 123 drives the first diaphragm 121-1 and the second diaphragm 121-2 to vibrate synchronously in opposite directions. At least a portion of the voice coil assembly 123 is located within the magnetic gap of the magnetic circuit assembly 122. The first diaphragm 121-1 and the second diaphragm 121-2 are spaced apart in the vibration direction. The voice coil assembly 123 includes a first voice coil 123-1 and a second voice coil 123-2 arranged along the vibration direction. The first diaphragm 121-1 is connected to the first voice coil 123-1, and the second diaphragm 121-2 is connected to the second voice coil 123-2. The first voice coil 123-1 and the second voice coil 123-2 are configured to respectively drive the first diaphragm 121-1 and the second diaphragm 121-2 to vibrate synchronously in opposite directions. In this case, the first voice coil 123-1 and the second voice coil 123-2 are not directly connected, and relative movement may occur between them, thereby facilitating driving the first diaphragm 121-1 and the second diaphragm 121-2 to vibrate synchronously in opposite directions.

[0037] The first diaphragm 121-1 and an inner wall of the first housing 110 are spaced apart and arranged opposite to each other in the vibration direction (that is, the thickness direction), thereby forming a first acoustic cavity 111-1. The second diaphragm 121-2 and another inner wall of the first housing 110 are spaced apart and arranged opposite to each other in the vibration direction, thereby forming a second acoustic cavity 111-2. A third acoustic cavity 111-3 is formed between the first diaphragm 121-1 and the second diaphragm 121-2. The third acoustic cavity 111-3 serves as a common cavity between the first diaphragm 121-1 and the second diaphragm 121-2. The first housing 110 is penetrably provided with a first acoustic hole that is in acoustic communication with the speaker 120 through the first acoustic cavity 111-1. The first housing 110 is penetra-

bly provided with a second acoustic hole that is in acoustic communication with the speaker 120 through the second acoustic cavity 111-2. The first housing 110 is penetrably provided with a third acoustic hole that is in acoustic communication with the speaker 120 through the third acoustic cavity 111-3.

[0038] A connection configuration of the first acoustic cavity 111-1 and the first acoustic hole may be approximately equivalent to a first Helmholtz resonance cavity model. A connection configuration of the second acoustic cavity 111-2 and the second acoustic hole may be approximately equivalent to a second Helmholtz resonance cavity model. A connection configuration of the third acoustic cavity 111-3 and the third acoustic hole may be approximately equivalent to a third Helmholtz resonance cavity model. The first acoustic hole, the second acoustic hole, and the third acoustic hole serve as neck openings of their respective corresponding Helmholtz resonance cavity models. When the speaker 120 vibrates and outputs a sound, the first acoustic hole outputs a first sound, the second acoustic hole outputs a second sound, and the third acoustic hole outputs a third sound. The superposition of the first sound, the second sound, and the third sound is the sound output by the earphone.

[0039] The first resonance peak is related to the flexibility of the first diaphragm 121-1 and the second diaphragm 121-2 in the vibration direction. The second resonance peak is related to the first acoustic cavity 111-1, the second acoustic cavity 111-2, and the third acoustic cavity 111-3. The flat region is related to the vibration of the first diaphragm 121-1 and the second diaphragm 121-2. Specifically, the flexibility of the first diaphragm 121-1 and the second diaphragm 121-2 in the vibration direction corresponds to an elastic coefficient K of their vibration along the vibration direction. When a load remains unchanged, the smaller the K value is, the lower the frequency of the first resonance peak is. The magnitude of the second resonance peak corresponds to a resonance frequency corresponding to the first Helmholtz resonance cavity model (the second Helmholtz resonance cavity model), which depends on a configuration of the first acoustic cavity 111-1 (the second acoustic cavity 111-2) and the first acoustic hole (the second acoustic hole). The flatness of the flat region is related to vibration consistency of both the first diaphragm 121-1 and the second diaphragm 121-2. The curve height of the flat region is related to driving force of the first diaphragm 121-1 and the second diaphragm 121-2. In some embodiments, in order to improve the sound output effect and/or the active noise reduction effect of the earphone in a wider frequency band, the resonance frequency of the first resonance peak and the resonance frequency of the second resonance peak may be designed to increase a width of the flat region of the frequency response curve of the sound output by the earphone. For example, the first diaphragm 121-1 and the second dia-

phragm 121-2 may be designed (e.g., material, structure, or the like), thereby lowering the resonance frequency of the first resonance peak. For example, the first acoustic cavity 111-1 and the second acoustic cavity 111-2 may be designed, thereby increasing the resonance frequency of the second resonance peak. In some embodiments, the first sound and the second sound may have a phase opposite to that of the third sound, thereby cooperatively cancelling the third sound and improving anti-leakage performance of the earphone. By designing the first acoustic cavity 111-1 and the second acoustic cavity 111-2, the high-frequency resonance frequencies of the first sound and the second sound are improved, thereby enabling the earphone to have a flat output in a relatively wide frequency band range. Meanwhile, the third acoustic cavity 111-3 may also be designed to improve the high-frequency resonance of the third sound, thereby enabling the first sound and the second sound to have an opposite phase to the third sound in a relatively wide frequency band range, and thereby enabling the earphone to have a better anti-leakage effect in the relatively wide frequency band range. In some embodiments, by designing the third acoustic cavity 111-3, the vibration capability of the first diaphragm 121-1 and the second diaphragm 121-2 may also be improved, thereby improving the output of the earphone and the user's listening effect.

[0040] In some embodiments, for the speaker 120 in which the first diaphragm 121-1 and the second diaphragm 121-2 vibrate synchronously in opposite directions, in order to enable the frequency response curve of the sound output by the speaker 120 to have a relatively flat region in a wider frequency band range, the resonance frequency of the second resonance peak may be increased by designing a count, a shape, a dimension, a position, or the like, of one or more acoustic structures (e.g., sound outlet holes, acoustic cavities) of the sound generating portion 100, thereby optimizing the frequency response curve of the sound output by the earphone (such as the first sound outlet hole 112-1), thereby supporting the earphone to perform active noise reduction in a relatively wide frequency band range and improving the sound output effect of the earphone. Meanwhile, a design of an acoustic structure corresponding to the third acoustic cavity 111-3 may also improve vibration capability of the first diaphragm 121-1 and the second diaphragm 121-2, thereby improving output performance of the earphone and the user's listening effect.

[0041] In some embodiments, as shown in FIG. 4, the first acoustic hole that is in acoustic communication with the first acoustic cavity 111-1 is a first sound outlet hole 112-1. The second acoustic hole that is in acoustic communication with the second acoustic cavity 111-2 is a second sound outlet hole 112-2. The third acoustic hole that is in acoustic communication with the third acoustic cavity 111-3 is a pressure relief hole 113. In

some embodiments, the first sound outlet hole 112-1 and the second sound outlet hole 112-2 are both set to face the user's external auditory canal (e.g., the inner side surface of the first housing 110 shown in FIG. 4). The sound generated by the first diaphragm 121-1 is output through the first sound outlet hole 112-1 and guided to the user's external auditory canal. The sound generated by the second diaphragm 121-2 is output through the second sound outlet hole 112-2 and guided to the user's external auditory canal, thereby increasing the output of the earphone. When applied to an open-ear earphone, since the user's external auditory canal receives larger ambient noise, improving the output performance of the earphone helps the earphone perform active noise reduction for the larger ambient noise. The pressure relief hole 113 is set further away from the user's external auditory canal (e.g., the outer side surface of the first housing 110 shown in FIG. 4) compared to the first sound outlet hole 112-1 and the second sound outlet hole 112-2. The pressure relief hole 113 may be configured to guide the sound generated by the speaker 120 out of the first housing 110 to interfere and cancel with the sound leaked through the first sound outlet hole 112-1 and the second sound outlet hole 112-2 in the far field, thereby reducing sound leakage of the earphone.

[0042] FIG. 5 is a schematic diagram illustrating frequency response curves output by the first sound outlet hole and the second sound outlet hole of the earphone shown in FIG. 4. The curve L_{161} is a frequency response curve output at the first sound outlet hole 112-1, which may be measured by a test microphone spaced 2 mm from the first sound outlet hole 112-1 when only the first diaphragm 121-1 is driven. The curve L_{162} is a frequency response curve output at the second sound outlet hole 112-2, which may be measured by a test microphone spaced 2 mm from the second sound outlet hole 112-2 when only the second diaphragm 121-2 is driven. As shown in FIG. 5, the curve L_{161} and curve L_{162} are close, and a difference in an output sound pressure level corresponding to a same frequency is within 1 dB, that is, the output sound pressure levels of the first diaphragm 121-1 and the second diaphragm 121-2 are close, the vibration consistency of the first diaphragm 121-1 and the second diaphragm 121-2 is higher, a distortion degree of the earphone output is lower, and the active noise reduction effect of the earphone is better.

[0043] FIG. 6 is a schematic diagram illustrating another exemplary structure of a speaker according to some embodiments of the present disclosure; and FIG. 7 is a schematic diagram illustrating an internal structure of the speaker shown in FIG. 6. In some embodiments, as shown in FIGS. 6 and 7, the first acoustic hole that is in acoustic communication with the first acoustic cavity 111-1 is a first pressure relief hole 113-1, the second acoustic hole that is in acoustic communication with the second acoustic cavity 111-2 is a

second pressure relief hole 113-2, and the third acoustic hole that is in acoustic communication with the third acoustic cavity 111-3 is a sound outlet hole 112. The sound outlet hole 112 is arranged towards the user's external auditory canal. For example, as shown in FIGS. 6 and 7, the sound outlet hole 112 may be arranged on the inner side surface of the first housing 110. The first pressure relief hole 113-1 and the second pressure relief hole 113-2 are arranged further away from the user's external auditory canal compared to the sound outlet hole 112. For example, the first pressure relief hole 113-1 may be arranged on the upper side surface of the first housing 110, and the second pressure relief hole 113-2 may be arranged on the lower side surface of the first housing 110, as shown in FIGS. 6 and 7. The sounds generated by the first diaphragm 121-1 and the second diaphragm 121-2 are output through the sound outlet hole 112 and guided to the user's external auditory canal, thereby increasing the output of the earphone. When applied to the open-ear earphone, since the ambient noise received by the user's external auditory canal is relatively high, improving the output performance of the earphone facilitates the earphone to perform the active noise cancellation on the relatively high ambient noise.

[0044] In some embodiments, to reduce the difficulty of air exchange between the third acoustic cavity 111-3 and the outside, the sound outlet hole 112 may adopt an L-shaped structure. The L-shaped structure includes a short side portion located on the front side surface of the first housing 110 parallel to the short axis direction, and a long side portion located on the inner side surface of the first housing 110 parallel to the long axis direction, as shown in FIG. 6.

[0045] FIG. 8 is a schematic diagram illustrating frequency response curves of an earphone corresponding to different pressure relief holes according to some embodiments of the present disclosure; and FIG. 9 is a schematic diagram illustrating another structure of an earphone according to some embodiments of the present disclosure.

[0046] In some embodiments, in the wearing state, the front side surface of the first housing 110 as shown in FIG. 9 may abut against the user's auricle. At this time, the front side surface of the first housing 110 may not output sound. In some embodiments, the sound outlet hole 112 is located on the inner side surface of the first housing 110. A gap is provided between the front side surface of the first housing 110 and the speaker 120, and the gap serves as a sound guide channel. The sound guide channel is configured to: guide the sound generated by the speaker 120 on the front side surface to the sound outlet hole 112 for output. That is, compared to FIGS. 6 and 7, in the earphone shown in FIG. 9, the sound generated by the speaker 120 on the short side portion of the sound outlet hole 112 is guided through the sound guide channel to the long side portion of the sound outlet hole 112 for

output. For example, in FIG. 9, the sound outlet hole 112 may only include the long side portion. The sound output by the speaker 120 on the short side portion of the sound outlet hole 112 may be guided to the long side portion of the sound outlet hole 112 for output through the sound guide channel formed by the gap between the first housing 110 and the speaker 120. In some embodiments, the speaker 120 outputs the sound through an opening 1251 on a short side portion of a frame 125. The opening 1251 of the short side portion of the frame 125 may be in acoustic communication with a sound guide channel (e.g., a sound guide tube), thereby guiding the sound to the long side portion of the sound outlet hole 112 for output.

[0047] In FIG. 8, a curve L_{191} is the frequency response curve of the earphone shown in FIG. 4, a curve L_{192} is the frequency response curve at the first pressure relief hole 113-1 when the earphone shown in FIG. 7 separately drives the first diaphragm 121-1, a curve L_{193} is the frequency response curve at the second pressure relief hole 113-2 when the earphone shown in FIG. 7 separately drives the second diaphragm 121-2, and a curve L_{194} is the frequency response curve of the earphone shown in FIG. 9. As shown in FIG. 8, the curve L_{192} is close to and substantially coincides with the curve L_{193} , indicating that the vibration consistency of the first diaphragm 121-1 and the second diaphragm 121-2 of the earphone shown in FIG. 7 is relatively high.

[0048] In a flat section (e.g., 200Hz-4kHz as shown in FIG. 8), at the same frequency, the output sound pressure level corresponding to the curve L_{191} is approximately 4 dB higher than the output sound pressure level corresponding to the curve L_{192} , indicating that the output of the earphone shown in FIG. 4 is approximately 4 dB higher than the output of the earphone shown in FIG. 7. In some embodiments, this may be due to a relatively long length of the sound outlet hole 112 arranged on the earphone shown in FIG. 7, thereby causing unfocused sound output.

[0049] In the flat section (e.g., 200Hz-4kHz as shown in FIG. 8), at the same frequency, the output sound pressure level corresponding to the curve L_{194} is approximately 3 dB higher than the output sound pressure level corresponding to the curve L_{192} , indicating that guiding the sound output from the front side surface of the first housing 110 to the sound outlet hole 112 on the inner side surface (as shown in FIG. 9) via the sound guide channel may make the sound output from the sound outlet hole 112 more focused, thereby improving the output directivity of the earphone.

[0050] In some embodiments, the width of the sound guide channel may also affect the output of the earphone, thereby further affecting the active noise cancellation effect of the earphone on relatively high ambient noise in an open-type wearing manner. Illustratively, when the sound output by the speaker 120 on the short side portion of the sound outlet hole 112 is

guided to the long side portion of the sound outlet hole 112 for output through the sound guide channel formed by the gap between the first housing 110 and the speaker 120, the gap between the first housing 110 and the speaker 120 serves as the sound guide channel, and the width of the gap between the short side portion of the first housing 110 and the short side portion of the speaker 120 is the width of the sound guide channel. If the width of the sound guide channel is too small, it may increase the difficulty of sound transmission, reduce the sound transmitted to the long side portion of the sound outlet hole 112, and affect the output sound pressure level of the earphone. If the width of the sound guide channel is too large, it may lead to an excessively large dimension of the first housing 110 or an excessively small volume of the third acoustic cavity 111-3 of the speaker 120, thereby causing an excessively high resonance frequency of the third acoustic cavity 111-3. In some embodiments, to ensure the output sound pressure level of the earphone and make the resonance frequency of the third acoustic cavity 111-3 appropriate, so that the earphone has a relatively flat and stable output within a relatively wide frequency band range, the width of the sound guide channel may be 0.5 mm-2 mm. In some embodiments, to enable the earphone to have a relatively large output sound pressure level, the width of the sound guide channel may be 1 mm-1.5 mm. In some embodiments, the width of the sound guide channel may be 1.3 mm, to make the resonance frequency of the third acoustic cavity 111-3 around 5.5kHz, thereby enabling the earphone to have a relatively flat and stable output within the wide frequency band range.

[0051] In some embodiments, the microphone assembly 140 may include a noise cancellation microphone. The noise cancellation microphone may include a first microphone. The first microphone may be arranged on the first housing 110 at a position close to the user's external auditory canal to collect the ambient noise near the user's external auditory canal. Further, the first microphone is arranged in a region near the acoustic null of the earphone to reduce the interference of the output of the earphone with the first microphone, thereby improving the accuracy of the first microphone in collecting the ambient noise near the user's external auditory canal. In some embodiments, the noise cancellation microphone may also include a second microphone. The second microphone may be arranged near the sound outlet hole 112 to collect a sound signal output from the sound outlet hole 112, including a noise cancellation signal, thereby monitoring the effect of active noise cancellation. The first microphone may also be regarded as a feedforward microphone, configured to generate a primary noise signal based on the ambient noise collected by the first microphone, to perform the active noise cancellation. The second microphone may also be regarded as a feedback microphone, configured to generate a secondary noise signal based on

the sound collected by the second microphone, and configured to generate the noise cancellation signal based on the primary noise signal and the secondary noise signal, to improve the active noise cancellation effect.

[0052] In some embodiments, when the first pressure relief hole 113-1 and the second pressure relief hole 113-2 are respectively arranged on the upper side surface and the lower side surface of the first housing 110 of the earphone, and when the first pressure relief hole 113-1 and the second pressure relief hole 113-2 are arranged facing each other or staggered, a region of the acoustic null where sound cancellation occurs does not change significantly. In a length direction gradually away from the front side surface (i.e., the left-right direction in FIGS. 10A-10D), when the first pressure relief hole 113-1 and the second pressure relief hole 113-2 are arranged at different positions, the region of the acoustic null where sound cancellation occurs does not change significantly. In summary, the first microphone may be arranged near an intersection region of a right side surface and the front side surface of the first housing 110, thereby arranging the first microphone in a region near the acoustic null of the first housing 110 close to the user's external auditory canal.

[0053] In some embodiments, the microphone assembly 140 may also include a call microphone, and the call microphone may be configured to collect the user's speech sound. The call microphone may include a third microphone and a fourth microphone. The third microphone is arranged on the first housing 110 in a region close to the user's mouth (e.g., near an intersection region of the front side surface and the outer side surface), and a line connecting the fourth microphone and the third microphone points to the user's mouth. In some embodiments, the fourth microphone may be arranged in a region near the acoustic null of the earphone, to reduce the sound collected by the fourth microphone from the sound outlet hole 112 and the pressure relief hole 113, thereby minimizing an echo during a call. In some embodiments, the third microphone and the first microphone may be the same microphone. In this case, the first microphone may serve as both the call microphone and the noise cancellation microphone. The first microphone and the fourth microphone may cooperate to perform the active noise cancellation during a user's call, and the second microphone may improve the effect of active noise cancellation.

[0054] In some embodiments, by designing the first pressure relief hole 113-1 and the second pressure relief hole 113-2, the output of the earphone may also be adjusted, thereby further adjusting the active noise cancellation effect of the earphone on relatively high ambient noise in an open-type wearing manner.

[0055] FIGS. 10A-10D are schematic diagrams illustrating distributions of a first pressure relief hole and a second pressure relief hole with different dimensions according to some embodiments of the present disclo-

sure; and FIGS. 11A-11D are schematic diagrams illustrating frequency response curves of earphones corresponding to FIGS. 10A-10D. The dimensions of the first pressure relief hole 113-1 and the second pressure relief hole 113-2 shown in FIG. 10A are both relatively small. The dimension of the first pressure relief hole 113-1 shown in FIG. 10B is relatively small, and the dimension of the second pressure relief hole 113-2 is relatively large. The dimension of the first pressure relief hole 113-1 shown in FIG. 10C is relatively large, and the dimension of the second pressure relief hole 113-2 is relatively small. The dimensions of the first pressure relief hole 113-1 and the second pressure relief hole 113-2 shown in FIG. 10D are both relatively large. In FIGS. 11A-11D, a curve L_{231} represents the frequency response curve at the pressure relief hole, and a curve L_{232} represents the frequency response curve at the sound outlet hole. The output sound pressure level at the pressure relief hole may be measured by a test microphone arranged at an equivalent pressure relief hole of both the first pressure relief hole 113-1 and the second pressure relief hole 113-2. A center of the equivalent pressure relief hole may be located at a midpoint of a line connecting a center of the first pressure relief hole 113-1 and a center of the second pressure relief hole 113-2.

[0056] Referring to FIGS. 10A-11D, as the total opening area of the first pressure relief hole 113-1 and the second pressure relief hole 113-2 increases, a peak width of the curve L_{231} at high frequencies (e.g., 6kHz-10kHz) increases, and the curve L_{232} exhibits peak-to-valley fluctuations at high frequencies (e.g., 6kHz-10kHz). Further, when the dimensions of the first pressure relief hole 113-1 and the second pressure relief hole 113-2 are different, the curve L_{231} exhibits a plurality of peaks at high frequencies (e.g., 6kHz-10kHz), and the high-frequency vibration characteristics are richer.

[0057] In some embodiments, the first pressure relief hole 113-1 and the second pressure relief hole 113-2 may be staggered in the vibration direction (i.e., an up-down direction in FIGS. 10A-10D) and have different dimensions, to improve the high-frequency vibration characteristics of the earphone, improve output performance of the earphone, thereby further improving the active noise cancellation effect of the earphone on relatively high ambient noise in the open-type wearing manner.

[0058] In some embodiments, the earphone may further include an equalization (EQ). The EQ may be configured to adjust the proportion of different frequencies in the sound output by the earphone. To improve the high-frequency output of the earphone, in some embodiments, by adjusting the EQ, a proportion of high-frequency components in the sound output by the earphone may be increased, thereby compensating for a lack of the high-frequency output, improving the output performance of the earphone, and further enhan-

cing the active noise reduction effect of the earphone on the relatively large ambient noise under an open wearing state.

[0059] In some embodiments, to improve a high-frequency output of the earphone, and further enhance the active noise reduction effect of the earphone on the relatively large ambient noise under the open wearing state, the earphone may also be provided with a high-frequency unit. The speaker 120 may serve as a low-frequency unit, being at least responsible for the output of middle and low frequencies (e.g., frequency bands below 6 kHz); and the high-frequency unit may be primarily responsible for the output of high-frequency bands (e.g., 6 kHz-10 kHz). By using the high-frequency unit, the high-frequency lack of the earphone may be compensated, thereby improving the output performance of the earphone.

[0060] In some embodiments, a working frequency band of the high-frequency unit may be greater than 7 kHz, which means that the frequency of a signal input to the high-frequency unit may be greater than 7 kHz, thereby reducing an intersection of working frequencies of the high-frequency unit and the speaker 120, allowing the earphone to have a relatively flat frequency response curve in a relatively wide frequency range in middle and low frequency bands (e.g., 200 Hz-6 kHz), improving the output performance of the earphone, and further enhancing the active noise reduction effect of the earphone on the relatively large ambient noise under the open wearing state.

[0061] Referring to the curve L_{231} in FIG. 11A to FIG. 11D, in some embodiments, at high frequencies, the sound output by the pressure relief hole may generate resonance, interfering with signal acquisition of the second microphone, and affecting the active noise reduction effect of the earphone.

[0062] In some embodiments, the acoustic resistance of the pressure relief hole (e.g., the first pressure relief hole 113-1, the second pressure relief hole 113-2, or the like) may be increased, thereby reducing the sound leakage of the pressure relief hole, and especially reducing an influence on the second microphone near the high-frequency resonance frequency. In some embodiments, an acoustic resistance mesh may be arranged in the pressure relief hole (e.g., the first pressure relief hole 113-1, the second pressure relief hole 113-2, or the like), to increase the acoustic resistance of the pressure relief hole.

[0063] FIG. 12 is a schematic diagram illustrating a structure of a first housing according to some embodiments of the present disclosure. Referring to FIG. 12, in some embodiments, when the first pressure relief hole 113-1 and the second pressure relief hole 113-2 are respectively arranged on the upper side surface 110c and the lower side surface 110d of the first housing 110, by designing the first Helmholtz resonance cavity model and the second Helmholtz resonance cavity model (e.g., the count, the shape, the dimension, the

position, or the like, of the sound outlet hole and the acoustic cavity), the resonance frequency of the second resonance peak may be increased, allowing the frequency response curve of the sound output by the speaker 120 to have a relatively flat region in a relatively wide frequency band range, optimizing the frequency response curve of the sound output by the earphone (specifically, by the sound outlet hole 112), thereby supporting the earphone to perform active noise reduction in the relatively wide frequency band range, and improving the sound output effect of the earphone.

[0064] As the dimension of the pressure relief hole (e.g., the first pressure relief hole 113-1, the second pressure relief hole 113-2, or the like) gradually decreases, the resonance peak of the sound generating portion 100 at high frequencies (e.g., above 4.5 kHz) gradually shifts forward. To increase the resonance frequency of the second resonance peak at high frequencies of the earphone, and to allow the earphone to have a flat output in the relatively wide frequency band range, the dimension of the pressure relief hole should not be too small. Based on this, in some embodiments, the first pressure relief hole 113-1 and the second pressure relief hole 113-2 may adopt a single-hole structure, and a ratio of a dimension of the first pressure relief hole 113-1 and/or the second pressure relief hole 113-2 to a corresponding dimension of the first housing 110 may be not less than 0.3. For example, in the case where the lengths of the first housing 110 and the pressure relief hole in the long axis direction are greater than the widths thereof in the short axis direction, respectively, the ratio of the long side dimension of the pressure relief hole to the long side dimension of the first housing 110 may be not less than 0.3; for example, the ratio of the length of the first pressure relief hole 113-1 in the long axis direction to the length of the inner side wall in the long axis direction may be not less than 0.3, and the ratio of the length of the first pressure relief hole 113-1 in the long axis direction to the length of the outer side wall in the long axis direction may be not less than 0.3. In the case where an outline shape of the sound generating portion 100 is a circularly symmetric geometric shape (e.g., circular, or the like), a ratio of the radius of the pressure relief hole to the radius of the corresponding side wall of the first housing 110 may be not less than 0.3. In this manner, the resonance frequency of the corresponding acoustic cavity may be made larger, ensuring that the second resonance peak of the sound output through the pressure relief hole moves to the high-frequency band, and finally allowing the earphone to have a relatively flat output in a relatively wide frequency band range, thereby enhancing the active noise reduction effect of the earphone on the relatively large ambient noise in the open-fit scenario.

[0065] FIGS. 13A-13B are schematic diagrams illustrating different relative positions of a first pressure relief hole and a second pressure relief hole according to

some embodiments of the present disclosure. In FIG. 13A, the first pressure relief hole 113-1 and the second pressure relief hole 113-2 are arranged opposite to each other, and both are located at a central position of a corresponding surface. In FIG. 13B, the first pressure relief hole 113-1 and the second pressure relief hole 113-2 are arranged eccentrically in the length direction.

[0066] In some embodiments, a staggered arrangement of the first pressure relief hole 113-1 and the second pressure relief hole 113-2 may cause the second resonance frequency of the earphone to shift forward, thereby causing the flat region of the earphone to narrow. To ensure that the second resonance peak of the sound output through the pressure relief hole moves to the high-frequency band, and finally allow the earphone to have the relatively flat output in the relatively wide frequency band range, thereby enhancing the active noise reduction effect of the earphone on the relatively large ambient noise in the open-fit scenario, the first pressure relief hole 113-1 and the second pressure relief hole 113-2 may adopt the single-hole structure, and the first pressure relief hole 113-1 and the second pressure relief hole 113-2 may be arranged opposite to each other, as shown in FIG. 13A. That is, on a reference plane perpendicular to the vibration direction, a centroid of a projection of the second pressure relief hole 113-2 and a centroid of a projection of the first pressure relief hole 113-1 are coincident or approximately coincident.

[0067] Due to process limitations during an actual manufacturing process, and component design or appearance design requirements of the earphone, the dimensions of the first pressure relief hole 113-1 and the second pressure relief hole 113-2 may be different, which may affect the output of the earphone, and further affect a near-field listening effect of the earphone and the active noise reduction effect of the earphone on the relatively large ambient noise in the open-fit scenario.

[0068] FIG. 14 is a schematic diagram illustrating a first pressure relief hole and a second pressure relief hole with different dimensions according to some embodiments of the present disclosure.

[0069] In some embodiments, when the dimensions of the first pressure relief hole 113-1 and the second pressure relief hole 113-2 are different, this may cause the second resonance frequency of the earphone to shift forward, thereby causing the flat region of the earphone to narrow. To ensure that the second resonance peak of the sound output through the pressure relief hole moves to the high-frequency band, and finally allow the earphone to have the relatively flat output in the relatively wide frequency band range, thereby enhancing the active noise reduction effect of the earphone on the relatively large ambient noise in the open-fit scenario, in some embodiments, the dimensions of the first pressure relief hole 113-1 and the second pressure re-

lief hole 113-2 may be set to be the same (as shown in FIG. 13A), thereby facilitating ensuring that the sound generating portion 100 has a flat frequency response curve and a phase curve with small changes in the relatively wide frequency band range, and strengthening the effect of the earphone in performing active noise reduction in the relatively wide frequency band range.

[0070] FIGS. 15A-15B are schematic diagrams illustrating pressure relief holes with different shapes according to some embodiments of the present disclosure. In FIG. 15A, the pressure relief hole is a single concentrated opening, and in FIG. 15B, the pressure relief hole is a single non-concentrated opening (e.g., an annular opening).

[0071] In some embodiments, compared with the pressure relief hole in the form of a single concentrated opening as shown in FIG. 15A, adopting the pressure relief hole in the form of the single non-concentrated opening as shown in FIG. 15B may allow the peak resonance frequency of the second resonance peak of the sound output by the pressure relief hole to be in the relatively high-frequency band, thereby being more conducive to the earphone having a relatively flat acoustic output in the relatively wide frequency band range, and improving the active noise reduction effect of the earphone. To ensure that the second resonance peak of the sound output through the pressure relief hole moves to a high-frequency band, and finally allow the earphone to have the relatively flat output in the relatively wide frequency band range, thereby enhancing the active noise reduction effect of the earphone on the relatively large ambient noise in an open-fit scenario, in some embodiments, the first pressure relief hole 113-1 and/or the second pressure relief hole 113-2 may adopt the form of the single non-concentrated opening as shown in FIG. 15B.

[0072] FIGS. 16A-16B are schematic diagrams illustrating different counts of pressure relief holes according to some embodiments of the present disclosure.

[0073] In some embodiments, when the total opening area of the pressure relief holes is constant, the smaller the dimension of a single pressure relief hole is, and the larger the count of the pressure relief holes is, the more the second resonance peak of the corresponding output sound shifts towards the high-frequency band. In some embodiments, the pressure relief hole (e.g., the first pressure relief hole 113-1) may have holes distributed as non-single concentrated openings as shown in FIG. 16A and FIG. 16B, that is, the pressure relief hole is a multi-hole structure composed of a plurality of micro-holes arranged in an array. This may not only shift the high-frequency peak of the speaker 120 to a higher position, but also significantly increase an effective area of the sound output and ensure the active noise reduction effect, while also satisfying appearance design requirements of the sound generating portion 100 or the earphone.

[0074] When the total area of the pressure relief holes is constant, if the dimension of a single pressure relief hole is too small, although the total count of the pressure relief holes may be increased, thereby increasing the resonance peak at high frequencies, it may also increase the acoustic resistance of the pressure relief hole, and further affect the output sound pressure level of the earphone, when the pressure relief hole (e.g., the first pressure relief hole 113-1) adopts the multi-hole structure in the form of non-single concentrated openings as shown in FIG. 16A and FIG. 16B, that is, when the pressure relief hole is a multi-hole structure composed of a plurality of micro-holes arranged in an array, a diameter of a single micro-hole may be not less than 0.2 mm.

[0075] FIGS. 17A-17F are schematic diagrams illustrating pressure relief holes with non-single concentrated openings in different distributions according to some embodiments of the present disclosure. FIG. 17A illustrates the pressure relief holes with non-single concentrated openings distributed on one side of a side wall of the first housing 110 in the long axis direction, and a corresponding opening ratio is 0.15; FIG. 17B illustrates the pressure relief holes with non-single concentrated openings annularly distributed on one side of the side wall of the first housing 110 in the long axis direction, and the corresponding opening ratio is 0.15; FIG. 17C illustrates the pressure relief holes with non-single concentrated openings annularly distributed on an entire surface of the side wall of the first housing 110, and the corresponding opening ratio is 0.15; FIG. 17D illustrates the pressure relief holes with non-single concentrated openings annularly distributed on one side of the side wall of the first housing 110 in the long axis direction, and a sound tuning hole 113-3 is provided on another side of the side wall in the long axis direction, wherein an opening ratio corresponding to the pressure relief holes is 0.15, and an opening ratio corresponding to the sound tuning hole 113-3 is 0.0375; FIG. 17E illustrates the pressure relief holes with non-single concentrated openings distributed in a central region of the side wall of the first housing 110, and the corresponding opening ratio is 0.15; and FIG. 17F illustrates the pressure relief holes with non-single concentrated openings distributed on the entire surface of the side wall of the first housing 110, and the corresponding opening ratio is 0.30. In this case, the first pressure relief hole 113-1 and the second pressure relief hole 113-2 may be aligned, or may be staggered. The opening ratio is calculated as a ratio of an opening area of the pressure relief hole to an area of a corresponding side wall of the first housing 110 (e.g., an area ratio of the first pressure relief hole 113-1 to the inner wall).

[0076] In some embodiments, a lower opening ratio of the pressure relief hole, indicating a smaller total area of the pressure relief hole, may cause the reso-

nance frequency of the second resonance peak of the sound output by the pressure relief hole to be smaller, thereby causing the flat region of the earphone to become narrower and affecting the active noise cancellation effect of the earphone. When the pressure relief hole is a porous structure composed of a plurality of micro-holes arranged in an array (that is, when the pressure relief hole adopts a non-single concentrated opening structure), in order to enable the earphone to have a relatively flat output in a relatively wide frequency band range, the opening ratio of the pressure relief hole may be not less than 0.1. It may also be understood that, on a reference plane perpendicular to the thickness direction (the vibration direction), an area proportion of the projection of the first pressure relief hole 113-1 or the second pressure relief hole 113-2 in the projection of a corresponding side wall of the first housing 110 (e.g., the upper side wall or the lower side wall) is not less than 10%.

[0077] Due to limitations of factors such as an opening dimension of the first pressure relief hole 113-1 and a covering area relative to the first acoustic cavity 111-1 in the wearing state, a portion of the sound generated by the speaker 120 (specifically, such as the first diaphragm 121-1) within the first acoustic cavity 111-1 may be blocked by a side wall of the first housing 110 (e.g., a portion of the upper side wall where the first pressure relief hole 113-1 is not formed) and cannot be directly output through the first pressure relief hole 113-1, thereby causing a standing wave to be formed within the first acoustic cavity 111-1, which may cause the peak resonance frequency of the second resonance peak to shift forward (that is, to move toward a low frequency band), thereby affecting the active noise cancellation effect of the earphone in a relatively wide frequency band range.

[0078] Therefore, referring to FIG. 17D and FIG. 18, in some embodiments, the inner side wall of the first housing 110 may be further provided with the sound tuning hole 113-3, wherein the sound tuning hole 113-3 is in acoustic communication with the first acoustic cavity 111-1; based on an acoustic communication relationship of the first pressure relief hole 113-1 and the sound tuning hole 113-3 with the first acoustic cavity 111-1, the peak resonance frequency of the second resonance peak of the sound output through the first pressure relief hole 113-1 to outside the first housing 110 may be adjusted by means of the sound tuning hole 113-3 (e.g., the peak resonance frequency of the second resonance peak is not less than 1 kHz). In this case, the first pressure relief hole 113-1 may be a single-hole structure (e.g., a single concentrated opening structure), or may also be a porous structure (that is, a non-single concentrated opening structure).

[0079] Specifically, most of the sound generated by the speaker 120 within the first acoustic cavity 111-1 is output through the first pressure relief hole 113-1, while a small portion of the sound may be output through the

sound tuning hole 113-3, thereby avoiding a standing wave from being formed within the first acoustic cavity 111-1 as much as possible, allowing the peak resonance frequency of the second resonance peak of the frequency response curve of the sound output by the first pressure relief hole 113-1 to move as much as possible toward a high frequency band, thereby realizing an adjustment of the peak resonance frequency of the resonance peak, and finally enabling the earphone to have a relatively flat output in a relatively wide frequency band range, which facilitates active noise cancellation by the earphone in a relatively wide frequency band range; at the same time, this also facilitates an enhancement of the sound pressure level of the sound output by the first pressure relief hole 113-1, and ensures the user's listening effect.

[0080] FIG. 18 is a schematic diagram illustrating a relative position between a first sound outlet hole and a tuning hole according to some embodiments of the present disclosure.

[0081] Considering differences in relative positions between the sound tuning hole 113-3 and the first pressure relief hole 113-1, the output of the speaker 120 or a position of the peak resonance frequency of a resonance peak may be affected. Referring to FIG. 18, taking the first pressure relief hole 113-1 and the sound tuning hole 113-3 both adopting porous structures as an example, L1-X is defined as a minimum distance between any two holes, L2-X is defined as a minimum distance from the boundary of the first acoustic cavity 111-1 to any hole, and LM is defined as the minimum distance between any two holes or the minimum distance from the boundary of the first acoustic cavity 111-1 to any hole. It should be noted that the minimum distance referred to herein refers to a distance between contour edges of any hole, or a distance from a contour edge of any hole to a boundary of an acoustic cavity.

[0082] In some embodiments, with the increase of the LM, the corresponding high-frequency peak shifts forward accordingly, causing the flat region of the earphone to become narrower and affecting the active noise cancellation effect of the earphone. At the same time, the increase of the LM means that the opening area of the pressure relief hole is correspondingly reduced, thereby causing the sound pressure level of the output sound to decrease. In order to enable the earphone to have a relatively flat output in a relatively wide frequency band range and at the same time ensure the output sound pressure level of the earphone, in some embodiments, the minimum distance between any two holes or the minimum distance from the boundary of the first acoustic cavity 111-1 to any hole may be set to be not greater than 14 mm. It may also be understood that the minimum distance between the first pressure relief hole 113-1 and the sound tuning hole 113-3 is not greater than 14 mm, the minimum distance from the boundary of the first acoustic cavity 111-1 to the first pressure relief hole 113-1 is not greater than 14 mm,

and the minimum distance from the boundary of the first acoustic cavity 111-1 to the sound tuning hole 113-3 is not greater than 14 mm. It may also be understood that, when the first pressure relief hole 113-1 and/or the sound tuning hole 113-3 are porous structures composed of a plurality of micro-holes arranged in an array, the minimum distance between any two adjacent micro-holes is not greater than 14 mm.

[0083] Thus, the sound output by the first pressure relief hole 113-1 may have a relatively flat phase curve at least in a frequency band range before 1 kHz, thereby ensuring the earphone to have a relatively flat output in a relatively wide frequency band range, which facilitates active noise cancellation by the earphone in a relatively wide frequency band range. In addition, as described in the foregoing embodiments, an aperture of each of the micro-holes may be set to be not less than 0.2 mm.

[0084] In some embodiments, on a reference plane perpendicular to the thickness direction, a total projection area of the first pressure relief hole 113-1 on the reference plane is defined as S1, a total projection area of the sound tuning hole 113-3 on the reference plane is defined as S2, and a ratio of the total projection area S1 of the sound tuning hole 113-3 to the total projection area S1 of the first pressure relief hole 113-1 is defined as SS.

[0085] With a gradual increase of the SS, a corresponding high-frequency peak gradually shifts backward, and a sound pressure level of the output sound gradually decreases; the increase of the SS means that the opening area of the sound tuning hole 113-3 increases, which may effectively achieve a pressure relief effect, thereby causing the high-frequency peak to shift backward, but at the same time, due to the increase in the opening area of the sound tuning hole 113-3, the sound leaked through the sound tuning hole 113-3 also increases, thereby causing the sound pressure level of the sound output through the first pressure relief hole 113-1 to decrease.

[0086] In some embodiments, in order to enable the earphone to have a relatively flat output in a relatively wide frequency band range and at the same time ensure the output sound pressure level of the earphone, a ratio of the total area of the sound tuning hole 113-3 to the total area of the first pressure relief hole 113-1 may be set to be less than 23%. By setting the ratio of the total area of the sound tuning hole 113-3 to the total area of the first pressure relief hole 113-1 to be less than 23%, problems such as an opening of the sound tuning hole 113-3 being too large or an area proportion being too large, which causes excessive sound leakage and consequently reduces the sound pressure level or volume of the first pressure relief hole 113-1, may be effectively avoided.

[0087] In some embodiments, referring to FIG. 18, in the wearing state, the sound tuning hole 113-3 is located at a position farther from the external auditory

canal 11 compared to the first pressure relief hole 113-1. In an open-type application scenario, since the user's external auditory canal 11 receives larger ambient noise, improving an output performance of the earphone is conducive to active noise cancellation by the earphone against larger ambient noise. Therefore, by setting the sound tuning hole 113-3 at a position farther from the external auditory canal 11 compared to the first pressure relief hole 113-1, destructive interference in a near field between the sound output through the sound tuning hole 113-3 and the sound output through the first pressure relief hole 113-1 may be avoided as much as possible, and the user's listening effect may be ensured.

[0088] In some embodiments, on a reference plane perpendicular to the thickness direction, a length of a projection of the first acoustic cavity 111-1 in the long axis direction is not less than a width thereof in the short axis direction. For example, a projection shape of the first acoustic cavity 111-1 may be a rectangle with a length greater than a width. As another example, the projection shape of the first acoustic cavity 111-1 may be a square or a circle with a length equal to a width. The projection of the first acoustic cavity 111-1 on the reference plane (e.g., a region shown by a dashed box in FIG. 18) is divided into a first region and a second region (e.g., two regions separated by a dashed arrow in FIG. 18) along the length direction, wherein a ratio of a length of the first region in the long axis direction to the length of the projection of the first acoustic cavity in the long axis direction may be set to be less than 40% (e.g., 38.3%). The projection of the sound tuning hole 113-3 on the reference plane is located within the first region, and the projection of the first pressure relief hole 113-1 on the reference plane is located within the second region.

[0089] Thus, by setting the sound tuning hole 113-3 and the first pressure relief hole 113-1 in different regions corresponding to the first acoustic cavity 111-1 on a corresponding side surface of the first housing 110 (e.g., the upper side surface), it may not only ensure that in the wearing state, the sound tuning hole 113-3 is located farther from the external auditory canal compared to the first pressure relief hole 113-1; but also may distinguish between the sound tuning hole 113-3 and the first pressure relief hole 113-1 when the sound tuning hole 113-3 adopts micro-holes in an array or a large-area concentrated opening, and is relatively close to the first pressure relief hole 113-1. For example, in the length direction or a diameter direction of the first acoustic cavity 111-1, holes located within a region accounting for 38.3% from the boundary of the first acoustic cavity 111-1 may be regarded as the sound tuning hole 113-3.

[0090] It should be noted that the dashed box in FIG. 18 represents a projection boundary of the first acoustic cavity 111-1 on the reference plane; the dashed arrow in FIG. 18 represents an approximate boundary be-

tween the first region and the second region in the projection shape of the first acoustic cavity 111-1. The region located on the left side of the dashed arrow represents the first region, and the region located on the right side of the dashed arrow represents the second region.

[0091] In some embodiments, by designing the magnetic circuit assembly 122 of the speaker 120, the driving force of the voice coil assembly 123 may be improved, thereby optimizing the output of the earphone.

[0092] FIGS. 19A-19G are schematic diagrams illustrating different exemplary structures of a speaker according to some embodiments of the present disclosure.

[0093] Referring to FIG. 19A, in some embodiments, the first diaphragm 121-1 is connected to the first voice coil 123-1, the second diaphragm 121-2 is connected to the second voice coil 123-2, and the first voice coil 123-1 and the second voice coil 123-2 respectively drive the first diaphragm 121-1 and the second diaphragm 121-2 to vibrate synchronously in a same direction. The first diaphragm 121-1 and the second diaphragm 121-2 are not directly connected, and the first voice coil 123-1 and the second voice coil 123-2 are not directly connected. The first voice coil 123-1 individually drives the first diaphragm 121-1 to vibrate, the second voice coil 123-2 individually drives the second diaphragm 121-2 to vibrate, and the first diaphragm 121-1 and the second diaphragm 121-2 vibrate synchronously in opposite directions. Through the above settings, an internal structure of the speaker 120 may be simplified, and manufacturing difficulty may be reduced.

[0094] In some embodiments, in order to improve the output sound of the earphone, improve a listening effect of the earphone, and improve the active noise cancellation effect of the earphone for larger ambient noise, the magnetic circuit assembly 122 may be designed to enhance a magnetic field strength thereof and improve a driving force of the voice coil assembly 123.

[0095] Referring to FIG. 19A, in some embodiments, the magnetic circuit assembly 122 includes a magnetic shield 1221 and an inner magnet 1222. The inner magnet 1222 is arranged within the magnetic shield 1221, and a first magnetic guide plate 1224 is provided on a side of the inner magnet 1222 away from the magnetic shield 1221. The magnetic shield 1221 may include a bottom wall 12211 and a side wall. The side wall may be a folded structure. The folded structure has an opening facing a bottom of the magnetic shield 1221. The folded structure includes an inner side wall 12212 and an outer side wall 12214 spaced apart in a direction perpendicular to the vibration direction, and an extension portion 12213 connecting the inner side wall 12212 and the outer side wall 12214. The bottom wall 12211 is arranged at an end of the inner side wall 12212 close to the opening, and the inner magnet

1222 is arranged on the bottom wall 12211. The end of the inner side wall 12212 away from the opening and the end of the outer side wall 12214 away from the opening are connected through the extension portion 12213. A first magnetic gap is formed between the inner side wall 12212 of the magnetic shield 1221 and the inner magnet 1222, wherein at least a portion of the first voice coil 123-1 is located within the first magnetic gap. A second magnetic gap is formed between the inner side wall 12212 of the magnetic shield 1221 and the outer side wall 12214, wherein at least a portion of the second voice coil 123-2 is located within the second magnetic gap.

[0096] Since the second voice coil 123-2 is relatively far from the inner magnet 1222, the magnetic field strength near the second voice coil 123-2 is relatively small, and the second voice coil 123-2 may have a problem of insufficient driving force. In order to improve the driving force of the second voice coil 123-2, thereby improving the driving force of the speaker 120, improving the output of the speaker 120, and improving the active noise cancellation effect of the earphone for larger ambient noise, the magnetic circuit assembly 122 may be designed.

[0097] Referring to FIG. 19B, in some embodiments, an outer magnet 1223 may be arranged at the outer side wall 12214 of the magnetic shield 1221 (that is, the outer side wall 12214 may include the outer magnet 1223), to increase the magnetic field strength near the second voice coil 123-2, thereby improving the driving force of the second voice coil 123-2, improving the driving force of the speaker 120, improving the output of the speaker 120, and improving the active noise cancellation effect of the earphone for larger ambient noise. In this case, the first magnetic gap is formed between the inner magnet 1222 and the inner side wall 12212, and the second magnetic gap is formed between the outer magnet 1223 and the inner side wall 12212. In some embodiments, a magnetization direction of the outer magnet 1223 and a magnetization direction of the inner magnet 1222 may be the same or opposite. For example, an N-pole of the inner magnet 1222 may be located at an upper end, and the N-pole of the outer magnet 1223 may be located at the upper end (as shown in FIG. 19A). As another example, the N-pole of the inner magnet 1222 may be located at the upper end, and the N-pole of the outer magnet 1223 may be located at a lower end (as shown in FIG. 19G).

[0098] In some embodiments, when the magnetization directions of the inner magnet 1222 and the outer magnet 1223 are the same (e.g., the N-poles are both located at the upper end shown in FIG. 19B), the inner side wall 12212 of the magnetic shield 1221 is subjected to a combined action of the inner magnet 1222 and the outer magnet 1223, thereby causing a magnetic saturation phenomenon to occur in the inner side wall 12212, which limits an improvement in the magnetic field strength at positions of the first voice coil

123-1 and the second voice coil 123-2, affecting the driving force of the first voice coil 123-1 and the second voice coil 123-2, and affecting the active noise cancellation effect of the earphone. In some embodiments, as shown in FIG. 19C, the dimension of the inner side wall 12212 may be increased to avoid magnetic saturation from occurring in the inner side wall 12212 as much as possible, thereby improving the magnetic field strength at positions of the first voice coil 123-1 and the second voice coil 123-2, thereby improving the driving force of the speaker 120, improving the output of the speaker 120, and improving the active noise cancellation effect of the earphone for larger ambient noise.

[0099] Referring to FIGS. 19B and 19C, in some embodiments, in order to avoid the dimension of the magnetic circuit assembly 122 from being too large, the dimension of the inner magnet 1222 may be reduced to increase the dimension of the inner side wall 12212, while keeping the dimension of the magnetic circuit assembly 122 unchanged (that is, the dimension of the magnetic shield 1221 being unchanged). In some embodiments, in the short axis direction or the long axis direction, a ratio of the thickness of the inner side wall 12212 to the dimension of the magnetic shield 1221 may be 0.05 to 0.16. In some embodiments, in order to further improve the driving force of the speaker 120, in the short axis direction or the long axis direction, a ratio of the thickness of the inner side wall 12212 to the dimension of the magnetic shield 1221 may be 0.06 to 0.15. In some embodiments, in a case of keeping the dimension of the magnetic circuit assembly 122 unchanged (that is, a width of the magnetic shield 1221 being unchanged), the thickness of the inner side wall 12212 and the dimension of the inner magnet 1222 are negatively correlated. Exemplarily, in the short axis direction or the long axis direction, when the dimension of the magnetic shield 1221 is 16 mm, the thickness of the inner side wall 12212 may be 0.8 mm to 2.5 mm. When the dimension of the inner magnet 1222 is greater than 4.7 mm, the thickness of the inner side wall 12212 may be 2 mm to 2.5 mm. When the dimension of the inner magnet 1222 is greater than 5.7 mm, the thickness of the inner side wall 12212 may be 1.5 mm to 2.5 mm. When the dimension of the inner magnet 1222 is greater than 6.7 mm, the thickness of the inner side wall 12212 may be 1.25 mm to 2.5 mm. When a radius of the inner magnet 1222 is greater than 7.7 mm, the thickness of the inner side wall 12212 may be 1.1 mm to 2.5 mm. When the dimension of the inner magnet 1222 is greater than 8.7 mm, the thickness of the inner side wall 12212 may be 1 mm to 2 mm. When the radius of the inner magnet 1222 is greater than 9.7 mm, the thickness of the inner side wall 12212 may be 0.8 mm to 1.6 mm. When the radius of the inner magnet 1222 is greater than 10.7 mm, the thickness of the inner side wall 12212 may be 0.8 mm to 1.3 mm.

[0100] It should be noted that the aforementioned ratio of the dimension of the inner side wall 12212 to the

dimension of the magnetic shield 1221 refers to the ratio of the thickness of the inner side wall 12212 in the long axis direction to the dimension of the magnetic shield 1221 in the long axis direction, or the ratio of the thickness of the inner side wall 12212 in the short axis direction to the dimension of the magnetic shield 1221 in the short axis direction. When the magnetic shield 1221 is a 'II'-shaped structure and only includes a side wall in the long axis direction or the short axis direction, the aforementioned ratio of the thickness of the inner side wall 12212 to the dimension of the magnetic shield 1221 refers to the ratio of the thickness of the inner side wall 12212 in a corresponding direction to the dimension of the magnetic shield 1221 in the corresponding direction.

[0101] In some embodiments, as shown in FIG. 19D, the outer magnet 1223 may also be arranged on the inner side wall 12212 (i.e., the inner side wall 12212 may include the outer magnet 1223), to avoid magnetic field saturation of the inner side wall 12212 and to ensure the magnetic field strength at positions of the first voice coil 123-1 and the second voice coil 123-2, thereby improving the driving force of the speaker 120, improving the output of the speaker 120, and improving the active noise cancellation effect of the earphone against a relatively large ambient noise. In this case, the first magnetic gap is formed between the inner magnet 1222 and the outer magnet 1223, and the second magnetic gap is formed between the outer magnet 1223 and the outer side wall 12214. In some embodiments, the magnetization direction of the outer magnet 1223 may be the same as or opposite to the magnetization direction of the inner magnet 1222.

[0102] In some embodiments, as shown in FIG. 19E, to further improve the magnetic field strength at positions of the first voice coil 123-1 and the second voice coil 123-2, thereby improving the driving force of the speaker 120, improving the output of the speaker 120, and improving the active noise cancellation effect of the earphone against a relatively large ambient noise, the inner side wall 12212 of the magnetic shield 1221 may be provided with a first outer magnet 1223-1, and the outer side wall 12214 of the magnetic shield 1221 may be provided with a second outer magnet 1223-2. That is, the inner side wall 12212 may include the first outer magnet 1223-1, and the outer side wall 12214 may include the second outer magnet 1223-2. In this case, the first magnetic gap is formed between the inner magnet 1222 and the first outer magnet 1223-1, and the second magnetic gap is formed between the first outer magnet 1223-1 and the second outer magnet 1223-2. In some embodiments, the magnetization directions of the inner magnet 1222, the first outer magnet 1223-1, and the second outer magnet 1223-2 may be the same as or opposite to each other. For example, the magnetization direction of the inner magnet 1222 may be the same as that of the first outer magnet 1223-1, and the magnetization direction of the inner

magnet 1222 may be the same as that of the second outer magnet 1223-2. As another example, the magnetization direction of the inner magnet 1222 may be the same as that of the first outer magnet 1223-1, and the magnetization direction of the inner magnet 1222 may be opposite to that of the second outer magnet 1223-2. As yet another example, the magnetization direction of the inner magnet 1222 may be opposite to that of the first outer magnet 1223-1, and the magnetization direction of the inner magnet 1222 may be the same as that of the second outer magnet 1223-2. For a further example, the magnetization direction of the inner magnet 1222 may be opposite to that of the first outer magnet 1223-1, and the magnetization direction of the inner magnet 1222 may be opposite to that of the second outer magnet 1223-2.

[0103] Referring to FIG. 19F, when the outer magnet 1223 is arranged on the outer side wall 12214 of the magnetic shield 1221 (i.e., the outer side wall 12214 includes the outer magnet 1223), and the magnetization direction of the inner magnet 1222 is opposite to that of the outer magnet 1223 (e.g., the N-pole of the inner magnet 1222 may be located at the upper end, and the N-pole of the outer magnet 1223 may be located at the lower end), the inner side wall 12212 of the magnetic shield 1221 may exhibit a magnetic field null point, and the inner side wall 12212 is not configured to guide magnetism. In this case, the inner side wall 12212 of the magnetic shield 1221 mainly functions as connection and support. To reduce the mass and dimension of the speaker 120, the thickness of the inner side wall 12212 of the magnetic shield 1221 may be less than or equal to 0.4 mm. In some embodiments, as shown in FIG. 19G, to further reduce the mass and dimension of the speaker 120, the thickness of the inner side wall 12212 of the magnetic shield 1221 may also be designed to be 0, meaning that the structure of the inner side wall 12212 is omitted.

[0104] In some embodiments, to reduce the mass and dimension of the speaker 120, the inner side wall 12212 may be hollowed out.

[0105] Since the outer magnet 1223 and the inner magnet 1222 need to be installed and connected, the annular side wall of the magnetic shield 1221 needs to retain at least a portion of the inner side wall 12212, to connect the outer side wall 12214 with the bottom wall 12211 of the magnetic shield 1221. For example, the outer side wall 12214 on the long side of the magnetic shield 1221 may be connected with the bottom wall 12211 of the magnetic shield 1221 via the inner side wall 12212, and the short side of the magnetic shield 1221 may not be provided with the inner side wall 12212. The long side of the magnetic shield 1221 refers to a side parallel to the long axis direction, and the short side of the magnetic shield 1221 refers to a side parallel to the short axis direction.

[0106] To improve vibration consistency of the first diaphragm 121-1 and the second diaphragm 121-2,

and to reduce distortion of the earphone output, thereby improving the output effect of the speaker 120 and improving active noise cancellation effect of the earphone against a relatively large ambient noise in the open-type wearing manner, the driving force of the first voice coil 123-1 and the second voice coil 123-2 may be approximate or the same. In some embodiments, by designing dimensions of the inner magnet 1222 and the outer magnet 1223, the magnetic field strength near the first voice coil 123-1 and the second voice coil 123-2 may be similar, thereby improving vibration consistency of the first diaphragm 121-1 and the second diaphragm 121-2, reducing distortion of the earphone output, and improving the active noise cancellation effect of the earphone.

[0107] FIG. 20 is a schematic diagram illustrating another structure of a speaker according to some embodiments of the present disclosure.

[0108] Referring to FIG. 20, a ratio of the dimension W_{im} of the inner magnet 1222 to the dimension W_{om} of the outer magnet 1223 is defined as W_{im}/W_{om} . The dimension refers to a dimension parameter of a related component in a direction perpendicular to the vibration direction. For example, the thickness of the outer magnet 1223 refers to a distance between an outer surface and an inner surface of the outer magnet 1223, and the dimension of the inner magnet 1222 refers to a dimension of a cross section of the inner magnet 1222. In some embodiments, when the ratio of the dimension of the inner magnet 1222 to the thickness of the outer magnet 1223 is too small, the dimension of the inner magnet 1222 is too small, which may result in a weak magnetic field strength of the magnetic circuit assembly 122 and insufficient driving force of the voice coil assembly 123, thereby affecting the output of the speaker 120. When the ratio of the dimension of the inner magnet 1222 to the thickness of the outer magnet 1223 is too large, the dimension of the inner magnet 1222 is too large, which may cause the dimension of the speaker 120 to be too large, affecting wearing of the earphone and reducing user experience.

[0109] By designing the dimension ratio of the outer magnet 1223 and the inner magnet 1222, electromagnetic conversion efficiency of the speaker 120 may be ensured, thereby improving the driving force of the voice coil assembly 123, improving the output of the speaker 120, and improving the active noise cancellation effect of the earphone against a relatively large ambient noise, while preventing earphone dimension from being too large. For example, a ratio of the dimension of the inner magnet 1222 in the long axis direction to the thickness of the outer magnet 1223 in the long axis direction may be between 1.7 and 33; and a ratio of the dimension of the inner magnet 1222 in the short axis direction to the thickness of the outer magnet 1223 in the short axis direction may be between 1.7 and 33.

[0110] In some embodiments, in the long axis direction, the ratio of the dimension of the inner magnet

1222 to the thickness of the outer magnet 1223 may be 1.7 to 6.7; and in the short axis direction, the ratio of the dimension of the inner magnet 1222 to the thickness of the outer magnet 1223 may be 1.7 to 2.7. By means of the above range design, the force factor (BL) value of the speaker 120 may be significantly improved, thereby enhancing sound output performance of the speaker 120, and improving the active noise cancellation effect of the earphone against a relatively large ambient noise.

[0111] For example, when the contour shape of the speaker 120 is circular, a ratio of the dimension of the inner magnet 1222 in a radial direction (i.e., equivalent to the long axis direction or the short axis direction) to the thickness of the outer magnet 1223 in the radial direction is between 1.7 and 33.

[0112] It should be noted that the thickness of the outer magnet 1223 refers to a distance between the outer surface and the inner surface of the outer magnet 1223.

[0113] When the volume of the outer magnet 1223 is too small relative to the volume of the inner magnet 1222, a driving force of the second voice coil 123-2 which is close to the outer magnet 1223 and far from the inner magnet 1222 is small, and a driving force of the first voice coil 123-1 which is far from the outer magnet 1223 and close to the inner magnet 1222 is large, thereby causing a large driving force difference between the first voice coil 123-1 and the second voice coil 123-2. Similarly, when the volume of the outer magnet 1223 is too large relative to the volume of the inner magnet 1222, the driving force of the second voice coil 123-2 which is close to the outer magnet 1223 and far from the inner magnet 1222 is large, and the driving force of the first voice coil 123-1 which is far from the outer magnet 1223 and close to the inner magnet 1222 is small, thereby causing a large driving force difference between the first voice coil 123-1 and the second voice coil 123-2. That is, when the volume of the outer magnet 1223 differs too much from the volume of the inner magnet 1222, it will cause a large driving force difference between the first voice coil 123-1 and the second voice coil 123-2, and affect the active noise cancellation effect of the earphone. In some embodiments, to improve vibration consistency of the first diaphragm 121-1 and the second diaphragm 121-2, to reduce distortion of the earphone output, and to improve the active noise cancellation effect of the earphone, a ratio of the volume of the outer magnet 1223 to the volume of the inner magnet 1222 may be 0.3 to 3. In some embodiments, to further improve vibration consistency of the first diaphragm 121-1 and the second diaphragm 121-2, to reduce distortion of the earphone output, and to improve the active noise cancellation effect of the earphone, the ratio of the volume of the outer magnet 1223 to the volume of the inner magnet 1222 may be 0.5 to 1.5.

[0114] In some embodiments, with an increase in the

thickness of the magnetic shield 1221 or the first magnetic plate 1224 (i.e., a ratio of a dimension of the magnet to the thickness of the magnetic shield 1221 decreases), the BL value of the speaker 120 gradually increases. However, when the thickness of the magnetic shield 1221 or the first magnetic plate 1224 increases to a certain value, excessively increasing the thickness of the magnetic shield 1221 or the first magnetic plate 1224 may cause magnetic field lines to disperse, which cannot be effectively concentrated near the voice coil assembly 123, thereby reducing the magnetic field near the voice coil assembly 123. When the thickness of the magnetic shield 1221 or the first magnetic plate 1224 decreases (i.e., the ratio of the dimension of the magnet to the thickness of the magnetic shield 1221 increases), it may cause a decrease in a magnetic saturation amount of the magnetic shield 1221 or the first magnetic plate 1224, and a reduction in magnetism guiding capability, thereby reducing the magnetic field strength passing through the voice coil assembly 123.

[0115] To improve electromagnetic conversion efficiency of the speaker 120, to improve the output sound pressure level of the speaker 120, and to improve the active noise cancellation performance of the earphone against a relatively large ambient noise, in some embodiments, a ratio of the dimension of the inner magnet 1222 to the thickness of the magnetic shield 1221 (e.g., the bottom wall 12211) or the first magnetic plate 1224 may be between 1 and 4, and a ratio of the thickness of the outer magnet 1223 to the thickness of the magnetic shield 1221 (e.g., the inner side wall 12212) may be between 1 and 4.

[0116] In some embodiments, the first voice coil 123-1 and the second voice coil 123-2 may adopt a non-equal diameter structure. For example, on a reference plane perpendicular to the vibration direction, a gap may exist between an orthographic projection of the first voice coil 123-1 and an orthographic projection of the second voice coil 123-2 in both the long axis direction and the short axis direction, and the orthographic projection of the first voice coil 123-1 may be located in an inner circle or an outer circle of the orthographic projection of the second voice coil 123-2. That is, an annular orthographic projection of the first voice coil 123-1 is located in the inner ring or the outer ring of an annular orthographic projection of the second voice coil 123-2, thereby forming the gap between the first voice coil 123-1 and the second voice coil 123-2, which serves as an avoidance channel 123-3 allowing the magnetic circuit assembly 122 (e.g., the side wall of the magnetic shield 1221) to pass through the voice coil assembly 123.

[0117] In some embodiments, when the contour shape of the speaker 120 is non-circular, e.g., rectangular, elliptical, or the like, in this case, side walls of the first voice coil 123-1 and the second voice coil 123-2 parallel to the long axis direction may be defined as

long side walls, and side walls parallel to the short axis direction may be defined as short side walls. The dimension of the short side wall of the first voice coil 123-1 is smaller than the dimension of the short side wall of the second voice coil 123-2, and the dimension of the long side wall of the first voice coil 123-1 is smaller than the dimension of the long side wall of the second voice coil 123-2. Alternatively, the dimension of the short side wall of the first voice coil 123-1 is larger than the dimension of the short side wall of the second voice coil 123-2, and the dimension of the long side wall of the first voice coil 123-1 is larger than the dimension of the long side wall of the second voice coil 123-2.

[0118] In some embodiments, when the contour shape of the sound generating portion 100 or the speaker 120 is substantially circular, in this case, the orthographic projection of the first voice coil 123-1 on the reference plane is a first annular ring, the orthographic projection of the second voice coil 123-2 on the reference plane is a second annular ring, and the first annular ring and the second annular ring have different diameters, and the first voice coil 123-1 and the second voice coil 123-2 are completely staggered, thereby forming the avoidance channel 123-3.

[0119] By setting the first voice coil 123-1 and the second voice coil 123-2 with the above dimensions, the avoidance channel 123-3 formed between the first voice coil 123-1 and the second voice coil 123-2 can be utilized to provide an avoidance space for the magnetic circuit assembly 122 (e.g., the side wall of the magnetic shield 1221), which is equivalent to placing the voice coil assembly 123 within the same magnetic gap of the magnetic circuit assembly 122. This not only can enhance the structural robustness of the magnetic circuit assembly 122 itself, provide support for rapid combined assembly of the speaker 120, and facilitate reduction of assembly difficulty and cost, but also avoids contact between the voice coil assembly 123 and the magnetic circuit assembly 122 during movement, which might affect sound output. Meanwhile, by adopting the above dimension setting, it can also avoid reserving the gap between the first voice coil 123-1 and the second voice coil 123-2 in the vibration direction for the magnetic circuit assembly 122 to pass through, thereby reducing the dimension of the speaker 120 in the vibration direction.

[0120] It should be noted that, when the magnetic shield 1221 is of a 'IT'-shaped structure and is only provided with the side wall parallel to the long axis direction (or, only provided with the side wall parallel to the short axis direction), the first voice coil 123-1 and the second voice coil 123-2 may accordingly have dimension differences only in short side walls (or, only in long side walls), to form the corresponding avoidance channel 123-3.

[0121] FIG. 21A is a schematic diagram illustrating a structure of a frame according to some embodiments of the present disclosure; and FIG. 21B is a schematic

diagram illustrating a position of a frame and an outer magnet according to some embodiments of the present disclosure.

[0122] Referring to FIG. 4, FIG. 21A, and FIG. 21B, in some embodiments, the speaker 120 may further include the frame 125. The frame 125 is located between the first diaphragm 121-1 and the second diaphragm 121-2 in the vibration direction. The frame 125 may provide an installation and fixing platform for various components of the speaker 120. The speaker 120 may be connected to the first housing 110 via the frame 125.

[0123] Since the first diaphragm 121-1 and the second diaphragm 121-2 may simultaneously compress air within the third acoustic cavity 111-3, to reduce vibration resistance of the first diaphragm 121-1 and the second diaphragm 121-2 and to enhance gas exchange efficiency between the third acoustic cavity 111-3 and the outside, the opening 1251 may be provided on the frame 125. The opening 1251 is in acoustic communication with the third acoustic cavity 111-3, and the opening 1251 is in acoustic communication with the third acoustic hole.

[0124] In some embodiments, by designing the third acoustic cavity 111-3, the resonance frequency of the third acoustic cavity 111-3 may be increased, thereby increasing the peak resonance frequency of the second resonance peak, allowing the earphone to have a relatively stable sound output in a relatively large frequency range, providing support for active noise reduction of the earphone in a wider frequency range, and simultaneously improving the output effect of the earphone. In addition, designing the third acoustic cavity 111-3 may also enable a high-frequency resonance frequency of the third sound generated by the third acoustic cavity 111-3 to be increased, thereby allowing the third sound to have a phase opposite to phases of the first sound and the second sound in a relatively wide frequency range, enabling the third sound to cancel out the first sound and the second sound in the relatively wide frequency range, and providing the earphone with a better sound leakage reduction effect in a wider frequency range.

[0125] In some embodiments, the resonance frequency of the third acoustic cavity 111-3 may be greater than 4.5 kHz, to allow the peak resonance frequency of the second resonance peak to be increased, thereby allowing the earphone to have a relatively stable sound output in a relatively large frequency range, providing support for active noise reduction of the earphone in a wider frequency range, and simultaneously improving the output effect of the earphone. In some embodiments, to further enable the earphone to have a relatively stable sound output in a larger frequency range, the resonance frequency of the third acoustic cavity 111-3 may be greater than 5 kHz. In some embodiments, to further enable the earphone to have a relatively stable sound output in a larger frequency range,

the resonance frequency of the third acoustic cavity 111-3 may be greater than 6 kHz.

[0126] Since the third acoustic hole is in acoustic communication with the third acoustic cavity 111-3 via the opening 1251, an area of the opening 1251 may also affect the third Helmholtz resonance cavity model. In some embodiments, to enable the resonance frequency of the third acoustic cavity 111-3 to be greater than 6 kHz, a plurality of openings 1251 may be provided on the frame 125, to increase a total area of the openings 1251.

[0127] In some embodiments, the outer magnet 1223 may include a plurality of separated sub-magnets, and as shown in FIG. 21B, the plurality of separated sub-magnets are in a separated structure. The plurality of sub-magnets of the outer magnet 1223 are arranged on an inner wall of the frame 125, and the frame 125 cooperates with the magnetic shield 1221 to fix the outer magnet 1223. The frame 125 may fix the outer magnet 1223, thereby preventing the outer magnet 1223 from falling off.

[0128] In some embodiments, to reduce manufacturing difficulty, a position of the opening 1251 on the frame 125 may be staggered with respect to a position of the outer magnet 1223. Meanwhile, the staggered arrangement of the opening 1251 and the outer magnet 1223 may also prevent the opening 1251 from being blocked by the outer magnet 1223, allowing the opening 1251 to have a larger usable area, thereby increasing the resonance frequency of the third acoustic cavity 111-3, improving the second resonance frequency of the sound output by the speaker 120, enabling the earphone to have a flat output in a relatively wide frequency range, while ensuring gas circulation between the third acoustic cavity 111-3 and the outside, reducing the difficulty of gas exchange between the third acoustic cavity 111-3 and the outside, reducing the difficulty of the volume change of the third acoustic cavity 111-3, reducing the difficulty of synchronous and opposite relative vibration of the first diaphragm 121-1 and the second diaphragm 121-2, and improving the output of the earphone.

[0129] In some embodiments, the opening 1251 may include a first opening 12511 arranged near a corner of the frame 125, as shown in FIG. 21A and FIG. 21B. In some embodiments, all the four corners of the frame 125 may be provided with the first opening 12511, to allow the opening 1251 to have a larger area, thereby increasing the resonance frequency of the third acoustic cavity 111-3, enabling the earphone to have a flat output in a relatively wide frequency range, simultaneously reducing the difficulty of gas exchange between the third acoustic cavity 111-3 and the outside, reducing the difficulty of synchronous and opposite relative vibration of the first diaphragm 121-1 and the second diaphragm 121-2, and improving the output of the earphone.

[0130] In some embodiments, the opening 1251 may

further include a second opening 12512. In the vibration direction, the dimension of the outer magnet 1223 is smaller than the dimension of the frame 125. In the vibration direction, the frame 125 includes a staggered portion (e.g., a region near upper and lower ends of the frame 125) staggered with respect to the outer magnet 1223, and the second opening 12512 is arranged on the staggered portion. The arrangement of the second opening 12512 may further increase the total area of the opening 1251, while ensuring that the opening 1251 is staggered with respect to the outer magnet 1223.

[0131] In some embodiments, on a plane where the port of the third acoustic hole (e.g., the pressure relief hole 113 shown in FIG. 4 or the sound outlet hole 112 shown in FIG. 6 and FIG. 7) is located, an orthographic projection of the opening 1251 at least partially overlaps the orthographic projection of the third acoustic hole, to allow the opening 1251 to be at least partially directly opposite to the third acoustic hole, thereby allowing the third acoustic cavity 111-3 to be in direct communication with the outside via the opening 1251 and the third acoustic hole, reducing obstacles between the third acoustic cavity 111-3 and an external environment, to reduce the difficulty of gas exchange between the third acoustic cavity 111-3 and the outside, reducing the difficulty of synchronous and opposite relative vibration of the first diaphragm 121-1 and the second diaphragm 121-2, and improving the output of the earphone. The plane where the port of the third acoustic hole is located may refer to a plane where an outer port of the third acoustic hole is located, or a plane where an inner port of the third acoustic hole is located. For example, when the third acoustic hole is the pressure relief hole 113 arranged on the inner side surface of the first housing 110 as shown in FIG. 4, or the sound outlet hole 112 arranged on the first housing 110 as shown in FIG. 7, the plane where the end surface of the third acoustic hole is located may refer to an outer surface or an inner surface of the inner side surface of the first housing 110. As another example, when the third acoustic hole is the L-shaped sound outlet hole 112 shown in FIG. 6, on the plane where the port of the long side portion of the L-shaped structure is located (the outer surface or the inner surface of the inner side surface), an orthographic projection of the opening 1251 on a long side of the frame 125 parallel to the long axis direction at least partially overlaps an orthographic projection of the long side portion of the L-shaped structure; and on the plane where the port of the short side portion of the L-shaped structure is located (the outer surface or the inner surface of the front side surface), an orthographic projection of the opening 1251 on a short side of the frame 125 parallel to the short axis direction at least partially overlaps an orthographic projection of the short side portion of the L-shaped structure.

[0132] In some embodiments, on the plane where the

port of the third acoustic hole is located, an orthographic projection of the first opening 12511 at least partially overlaps an orthographic projection of the third acoustic hole. In some embodiments, on the plane where the port of the third acoustic hole is located, an orthographic projection of the second opening 12512 at least partially overlaps the orthographic projection of the third acoustic hole. In some embodiments, on the plane where the port of the third acoustic hole is located, orthographic projections of both the first opening 12511 and the second opening 12512 at least partially overlap the orthographic projection of the third acoustic hole. The third acoustic hole may be the pressure relief hole 113 or the sound outlet hole 112 that is only arranged on the inner side surface as shown in FIG. 4 or FIG. 7, or may be the sound outlet hole 112 of the L-shaped structure as shown in FIG. 6. Through the above arrangement, the total area of the opening 1251 may be further increased, while ensuring that the opening 1251 is staggered with respect to the outer magnet 1223. In some embodiments, the orthographic projection of the opening 1251 in the long axis direction at least partially overlaps the orthographic projection of the third acoustic hole in the long axis direction, to allow the opening 1251 to be at least partially directly opposite to the third acoustic hole, to reduce the difficulty of gas exchange between the third acoustic cavity 111-3 and the outside, and improve the output of the earphone.

[0133] FIG. 22 is a schematic diagram illustrating another structure of a cross section of a sound generating assembly according to some embodiments of the present disclosure; and FIG. 23 is a structural exploded diagram illustrating a speaker according to some embodiments of the present disclosure.

[0134] In some embodiments, referring to FIG. 22 to FIG. 23, an end of the outer magnet 1223 away from the extension portion 12213 may be provided with a second magnetic conductive plate 1225. The magnetic circuit assembly 122 may further include a bracket assembly. The bracket assembly may include a first bracket 122-4 and a second bracket 122-5. The first bracket 122-4 is annularly connected to an outer periphery of the second magnetic conductive plate 1225, the second bracket 122-5 is annularly connected to an outer periphery of the extension portion 12213, and the first bracket 122-4 and the second magnetic conductive plate 1225, and the second bracket 122-5 and the extension portion 12213 may be connected in forms such as injection molding, adhesive bonding, bolting, or snap-fitting. An outer periphery of the first diaphragm 121-1 is fixed to the first bracket 122-4 (e.g., by adhesive bonding), and an outer periphery of the second diaphragm 121-2 is fixed to the second bracket 122-5 (e.g., by adhesive bonding).

[0135] On one hand, by the cooperation of the first bracket 122-4, the second bracket 122-5, and the second magnetic conductive plate 1225, a cone frame in

some existing speakers or the aforementioned frame 125 may be replaced, allowing the outer magnet 1223 to have a larger volume and dimension, enhancing magnetic flux, and thereby increasing a driving force of the voice coil assembly 123; meanwhile, also enabling the speaker 120 to have a more compact structure, reducing assembly difficulty, and improving assembly effect.

[0136] On the other hand, by the cooperation of the first bracket 122-4 and the second bracket 122-5, and the magnetic shield 1221 and the diaphragms, the internal space of the speaker 120 may be enclosed to form a relatively closed cavity (i.e., the common cavity 111-3), and the first bracket 122-4 and the second bracket 122-5 may be used as structural connection carriers between the speaker 120 and the first housing 110, or between the speaker 120 and the limiting assembly 130, so as to firmly restrict the speaker 120 within the first housing 110, and form the first acoustic cavity 111-1 and the second acoustic cavity 111-2 that are relatively independent of the common cavity 111-3.

[0137] In some embodiments, referring to FIG. 23, the first bracket 122-4 has a first receiving groove enclosed around the second magnetic conductive plate 1225, and the second bracket 122-5 has a second receiving groove enclosed around the extension portion 12213. An outer periphery of the second magnetic conductive plate 1225 is inserted into the first receiving groove, and an outer periphery of the extension portion 12213 is inserted into the second receiving groove. Merely by way of example, the first bracket 122-4 may be integrally formed with the second magnetic conductive plate 1225 by injection molding, overmolding, or the like, and the first bracket 122-4 covers the outer periphery of the second magnetic conductive plate 1225, at this time, the first receiving groove is equivalent to being naturally formed on the first bracket 122-4.

[0138] Based on the provided receiving grooves, a structural connection area between the brackets and the corresponding magnetic conductive plates may be effectively increased, thereby allowing the brackets to be firmly integrated with the corresponding magnetic conductive plates (e.g., the brackets and the corresponding magnetic conductive plates are integrally injection molded), which is beneficial for reducing a count of components of the speaker 120 and lowering assembly difficulty of the speaker 120.

[0139] In some embodiments, referring to FIG. 23, the first bracket 122-4, the second magnetic conductive plate 1225, and the first diaphragm 121-1 cooperatively form a first chamber 120a within the speaker 120, and the second bracket 122-5, the extension portion 12213, and the second diaphragm 121-2 cooperatively form a second chamber 120b within the speaker 120. It may be understood that the first chamber 120a and the second chamber 120b are equivalent to a portion of the common cavity 111-3, and both are located on two sides of the magnetic circuit assembly in the vibration

direction.

[0140] At this point, referring to FIG. 23, the first bracket 122-4 and the second bracket 122-5 are respectively provided with a positioning structure 120c and a through-hole structure 120d. For ease of differentiation and description, the positioning structure 120c and the through-hole structure 120d arranged on the first bracket 122-4 are respectively defined as a first positioning structure and a first through-hole structure, and the positioning structure 120c and the through-hole structure 120d arranged on the second bracket 122-5 are respectively defined as a second positioning structure and a second through-hole structure.

[0141] The first positioning structure is located within the first chamber 120a, and is mainly configured to position and restrict a wire of the first voice coil 123-1 on the first bracket 122-4 within the first chamber 120a. The first through-hole structure is arranged through a side wall of the first bracket 122-4 (e.g., the side wall in the short axis direction), to allow the wire of the first voice coil 123-1 to be drawn out from an interior of the speaker 120, and thereby connected to a circuit board arranged at a periphery of the speaker 120 (the circuit board may implement electrical connection between the speaker 120 and the microphone assembly and the circuit board assembly of the earphone). Based on the same principle, the second positioning structure is located within the second chamber 120b, and is mainly configured to position and restrict a wire of the second voice coil 123-2 on the second bracket 122-5 within the second chamber 120b, and the second through-hole structure is arranged through a side wall of the second bracket 122-5, to allow the wire of the second voice coil 123-2 to be connected to the circuit board after being drawn out from the interior of the speaker 120.

[0142] As a result, by the cooperation between the corresponding chambers, brackets, positioning structures 120c, and through-hole structures 120d, the compactness of the overall structure of the speaker 120 may be effectively enhanced, and restrictions on the voice coil wires may be formed, to prevent the wires from interfering with vibration of the diaphragms. In a specific implementation, the positioning structure 120c may be a mechanical structure such as a snap-fit buckle arranged on the corresponding bracket, or the like, or may be a structure formed by adhesive fixing the voice coil wires.

[0143] In some embodiments, referring to FIG. 23, the first bracket 122-4 and the second bracket 122-5 are arranged separately in the vibration direction, thereby forming a receiving gap distributed around the outer magnet 1223 between the two. The circuit board may be received and fixed within the receiving gap, for example, being attached and fixed on an outer peripheral surface of the first outer magnet 122-11. As a result, the overall volume and the dimension of the speaker 120 may be effectively reduced, thereby further enhancing the structural compactness of the

speaker 120.

[0144] In some embodiments, referring to FIG. 23, one or both of the first bracket 122-4 and the second bracket 122-5 may be provided with a pressure balance channel 120e. The pressure balance channel 120e may be arranged through the corresponding bracket along a direction perpendicular to the vibration direction (e.g., the long axis direction, the short axis direction, or the like). In some embodiments, since the bracket assembly replaces the frame 125, an arrangement of the pressure balance channel 120e on the bracket assembly may be the same as an arrangement of the opening 1251 on the frame 125, and the third acoustic cavity 111-3 is in acoustic communication with the sound outlet hole 112 on the first housing 110 via the pressure balance channel 120e. For example, the pressure balance channel 120e may also be staggered with respect to the outer magnet 1223, or the like.

[0145] In some embodiments, the pressure balance channel 120e may be covered by a gauze, a waterproof and breathable membrane, or the like, to improve waterproof performance of the speaker 120.

[0146] The basic concepts have been described above, and it is apparent to those skilled in the art that the detailed disclosure described above is merely by way of example and does not constitute a limitation on the present disclosure. Although not explicitly stated herein, those skilled in the art may make various modifications, improvements, and revisions to the present disclosure. Such modifications, improvements, and revisions are contemplated in the present disclosure, and thus still fall within the spirit and scope of the exemplary embodiments of the present disclosure.

[0147] In addition, the present disclosure employs specific terms to describe the embodiments of the present disclosure. For example, 'an embodiment', 'one embodiment', and/or 'some embodiments' mean that a particular feature, structure, or characteristic is related to at least one embodiment of the present disclosure. Therefore, it should be emphasized and noted that 'one embodiment' or 'an embodiment' or 'an alternative embodiment' mentioned two or more times in different locations in the present disclosure do not necessarily refer to the same embodiment. Furthermore, certain features, structures, or characteristics in one or more embodiments of the present disclosure may be appropriately combined.

[0148] Similarly, it should be noted that, in order to simplify the description of the present disclosure and thereby facilitate an understanding of one or more embodiments of the present disclosure, in the preceding descriptions of the embodiments of the present disclosure, a plurality of features may sometimes be grouped into an embodiment, a figure, or descriptions thereof. However, such a disclosure approach does not imply that the subject matter of the present disclosure requires more features than those mentioned in the claims. In fact, the features of an embodiment are few-

er than all the features of a single embodiment described in the above disclosure.

[0149] In some embodiments, numerical values describing quantities of components and attributes are used, and it should be understood that such numerical values used in the descriptions of the embodiments are modified by the modifier 'approximately' in some examples. Unless otherwise specified, 'approximately' indicates that the numerical values allow for a $\pm 20\%$ variation. Accordingly, in some embodiments, the numerical parameters used in the present disclosure and the claims are all approximate values, and the approximate values may vary according to required characteristics of individual embodiments. In some embodiments, the numerical parameters should take into account the specified significant figures and be expressed using a general method of rounding. While the numerical ranges and parameters used in some embodiments of the present disclosure to confirm their scope of applicability are approximate values, in specific embodiments, such numerical values are set to be as precise as possible to the extent practicable.

[0150] Finally, it should be understood that the described embodiments in the present disclosure are merely illustrative of the principles of the embodiments of the present disclosure. Other variations may also fall within the scope of the present disclosure. Therefore, by way of example and not limitation, alternative configurations of the embodiments of the present disclosure may be considered to be consistent with the teachings of the present disclosure. Accordingly, the embodiments of the present disclosure are not limited to the embodiments explicitly introduced and described in the present disclosure.

Claims

1. A speaker, comprising:

a magnetic circuit assembly;
a voice coil assembly, at least a portion of the voice coil assembly being located within a magnetic gap of the magnetic circuit assembly;
a first diaphragm and a second diaphragm, the first diaphragm and the second diaphragm being spaced apart in a vibration direction;
wherein the voice coil assembly includes a first voice coil and a second voice coil arranged along the vibration direction, the first diaphragm is connected to the first voice coil, and the second diaphragm is connected to the second voice coil;
the first voice coil and the second voice coil are configured to respectively drive the first diaphragm and the second diaphragm to vibrate synchronously in opposite directions;
wherein the magnetic circuit assembly in-

- cludes a magnetic shield and an inner magnet, the magnetic shield includes a side wall and a bottom wall, the side wall includes a folded structure, the folded structure includes an inner side wall and an outer side wall spaced apart in a direction perpendicular to the vibration direction, and an extension portion connecting the inner side wall and the outer side wall, the bottom wall is connected to the inner side wall, a first magnetic gap is formed between the inner side wall and the inner magnet, a second magnetic gap is formed between the inner side wall and the outer side wall, at least a portion of the first voice coil is located within the first magnetic gap, and at least a portion of the second voice coil is located within the second magnetic gap.
2. The speaker of claim 1, wherein the outer side wall includes an outer magnet, the first magnetic gap is formed between the inner magnet and the inner side wall, and the second magnetic gap is formed between the outer magnet and the inner side wall.
 3. The speaker of claim 2, wherein a magnetization direction of the inner magnet is the same as a magnetization direction of the outer magnet, the speaker includes a long axis direction and a short axis direction, and in the short axis direction or in the long axis direction, a ratio of a thickness of the inner side wall to a dimension of the magnetic shield is 0.05-0.16.
 4. The speaker of claim 2, wherein a magnetization direction of the inner magnet is opposite to a magnetization direction of the outer magnet, and a thickness of the inner side wall is less than or equal to 0.4 mm.
 5. The speaker of claim 4, wherein the inner side wall is hollowed out.
 6. The speaker of claim 1, wherein the inner side wall includes an outer magnet, the first magnetic gap is formed between the inner magnet and the outer magnet, and the second magnetic gap is formed between the outer magnet and the outer side wall.
 7. The speaker of claim 1, wherein the inner side wall includes a first outer magnet, the outer side wall includes a second outer magnet, the first magnetic gap is formed between the inner magnet and the first outer magnet, and the second magnetic gap is formed between the first outer magnet and the second outer magnet.
 8. The speaker of any one of claims 1-6, wherein the speaker includes a long axis direction and a short axis direction, and in the short axis direction or in the long axis direction, a ratio of a dimension of the inner magnet to a thickness of the outer magnet is between 1.7 and 33.
 9. The speaker of claim 8, wherein in the long axis direction, a ratio of a dimension of the inner magnet to a thickness of the outer magnet is 1.7-6.7; and in the short axis direction, a ratio of a dimension of the inner magnet to a thickness of the outer magnet is 1.7-2.7.
 10. An earphone, comprising the speaker of any one of claims 1-9, the earphone further comprising:
 - a first housing, the speaker being arranged within the first housing;
 - the first diaphragm of the speaker and an inner wall of the first housing form a first acoustic cavity, the second diaphragm of the speaker and another inner wall of the first housing form a second acoustic cavity, and a third acoustic cavity is formed between the first diaphragm and the second diaphragm;
 - wherein the speaker further includes a frame, the frame is located between the first diaphragm and the second diaphragm in the vibration direction; an opening is provided on the frame, and the opening is in acoustic communication with the third acoustic cavity.
 11. The earphone of claim 10, wherein the magnetic circuit assembly includes an outer magnet, the outer magnet includes a plurality of separated sub-magnets, the plurality of sub-magnets of the outer magnet are each arranged on an inner wall of the frame, and the opening is staggered with respect to the sub-magnets of the outer magnet.
 12. The earphone of claim 10, wherein in a wearing state, the first housing includes an inner side surface facing an external auditory canal and an outer side surface opposite to the inner side surface and away from the external auditory canal, the first housing is provided with a first sound outlet hole communicating with the first acoustic cavity, a second sound outlet hole communicating with the second acoustic cavity, and a pressure relief hole communicating with the third acoustic cavity; wherein the first sound outlet hole and the second sound outlet hole are located on the inner side surface of the first housing, and the pressure relief hole is located on the outer side surface of the first housing.
 13. The earphone of claim 10, wherein in a wearing state, the first housing includes an inner side surface facing an external auditory canal, an outer

side surface opposite to the inner side surface and away from the external auditory canal, an upper side surface facing the user's vertex, and a lower side surface opposite to the upper side surface and facing the user's skull base, the first housing is provided with a first pressure relief hole communicating with the first acoustic cavity, a second pressure relief hole communicating with the second acoustic cavity, and a sound outlet hole communicating with the third acoustic cavity; wherein the sound outlet hole is arranged on the inner side surface of the first housing, and the first pressure relief hole and the second pressure relief hole are both arranged on the outer side surface of the first housing.

14. The earphone of claim 10, wherein in a wearing state, the first housing includes an inner side surface facing an external auditory canal, an outer side surface opposite to the inner side surface and away from the external auditory canal, an upper side surface facing a user's vertex, and a lower side surface opposite to the upper side surface and facing the user's skull base, the first housing is provided with a first pressure relief hole communicating with the first acoustic cavity, a second pressure relief hole communicating with the second acoustic cavity, and a sound outlet hole communicating with the third acoustic cavity; wherein the sound outlet hole is arranged on the inner side surface of the first housing, and the first pressure relief hole and the second pressure relief hole are respectively arranged on the upper side surface and the lower side surface of the first housing.
15. The earphone of claim 14, wherein in the wearing state, the first housing further includes a front side surface facing a rear of a user's ear, the sound outlet hole is in an L-shaped structure, and the L-shaped structure includes a short side portion located on the front side surface of the first housing and a long side portion located on the inner side surface of the first housing.
16. The earphone of any one of claims 13-15, wherein the opening on the frame is in acoustic communication with the sound outlet hole, and on a plane where a port of the sound outlet hole is located, an orthographic projection of the opening at least partially overlaps an orthographic projection of the sound outlet hole.
17. The earphone of claim 15, wherein a gap is provided between the front side surface of the first housing and the speaker, the gap serves as a sound guide channel, and the sound guide channel is configured to: guide a sound generated by the

speaker on the front side surface to the sound outlet hole for output; wherein in the long axis direction, a dimension of the sound guide channel is 0.5 mm-2 mm.

18. The earphone of claim 13, wherein the first pressure relief hole and the second pressure relief hole are staggered in the vibration direction.
19. The earphone of claim 13, wherein a dimension of the first pressure relief hole is different from a dimension of the second pressure relief hole.
20. The earphone of claim 13 or 14, wherein the earphone further comprises a microphone assembly, the microphone assembly includes a third microphone and a fourth microphone, the first microphone is arranged at an intersection region of the outer side surface and the front side surface of the first housing, and in a wearing state, a line connecting the fourth microphone and the third microphone points to a user's mouth.

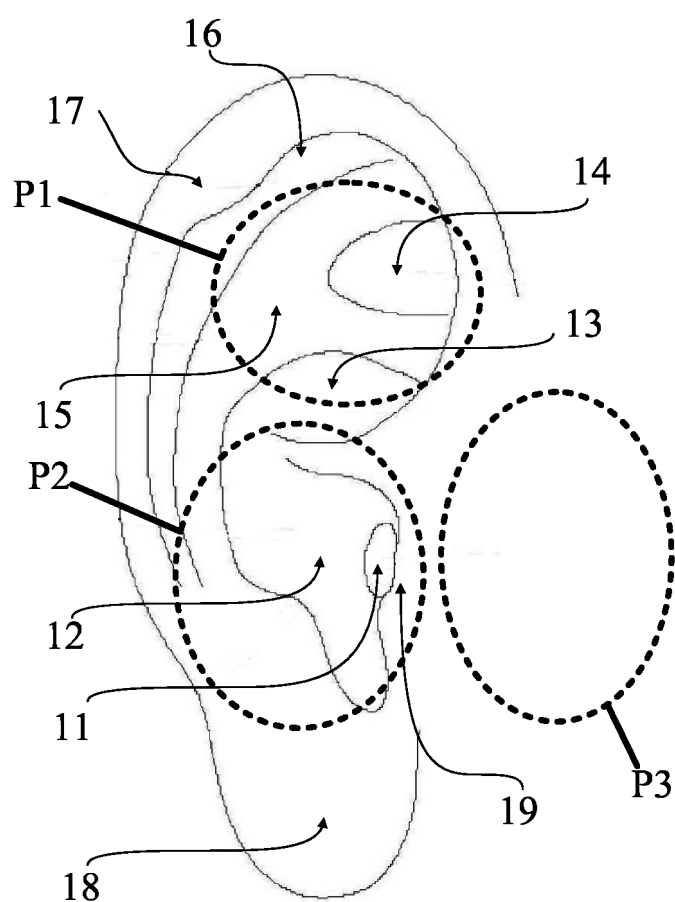


FIG. 1

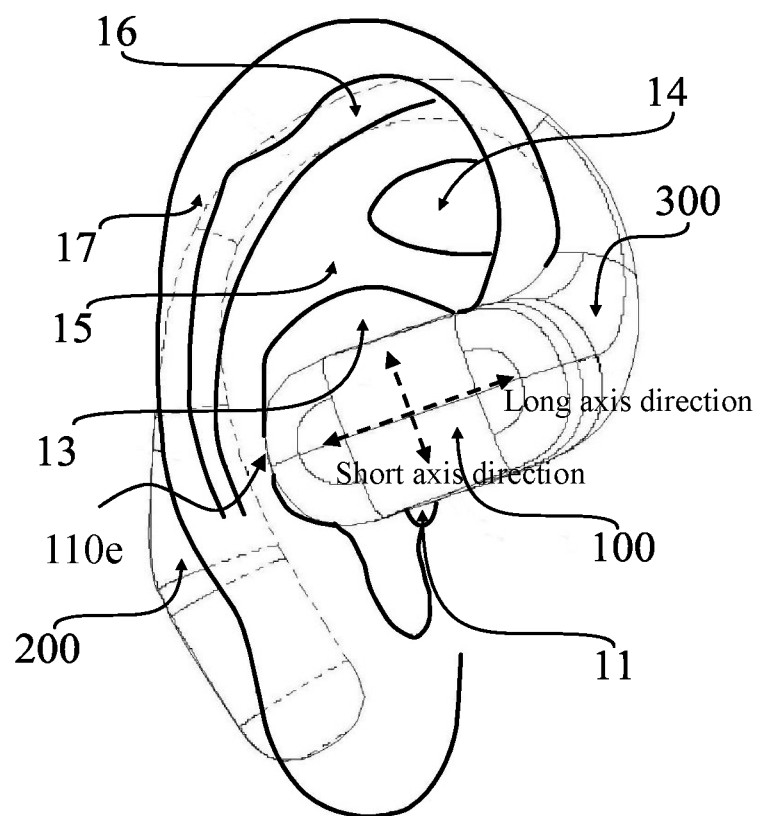


FIG. 2

100

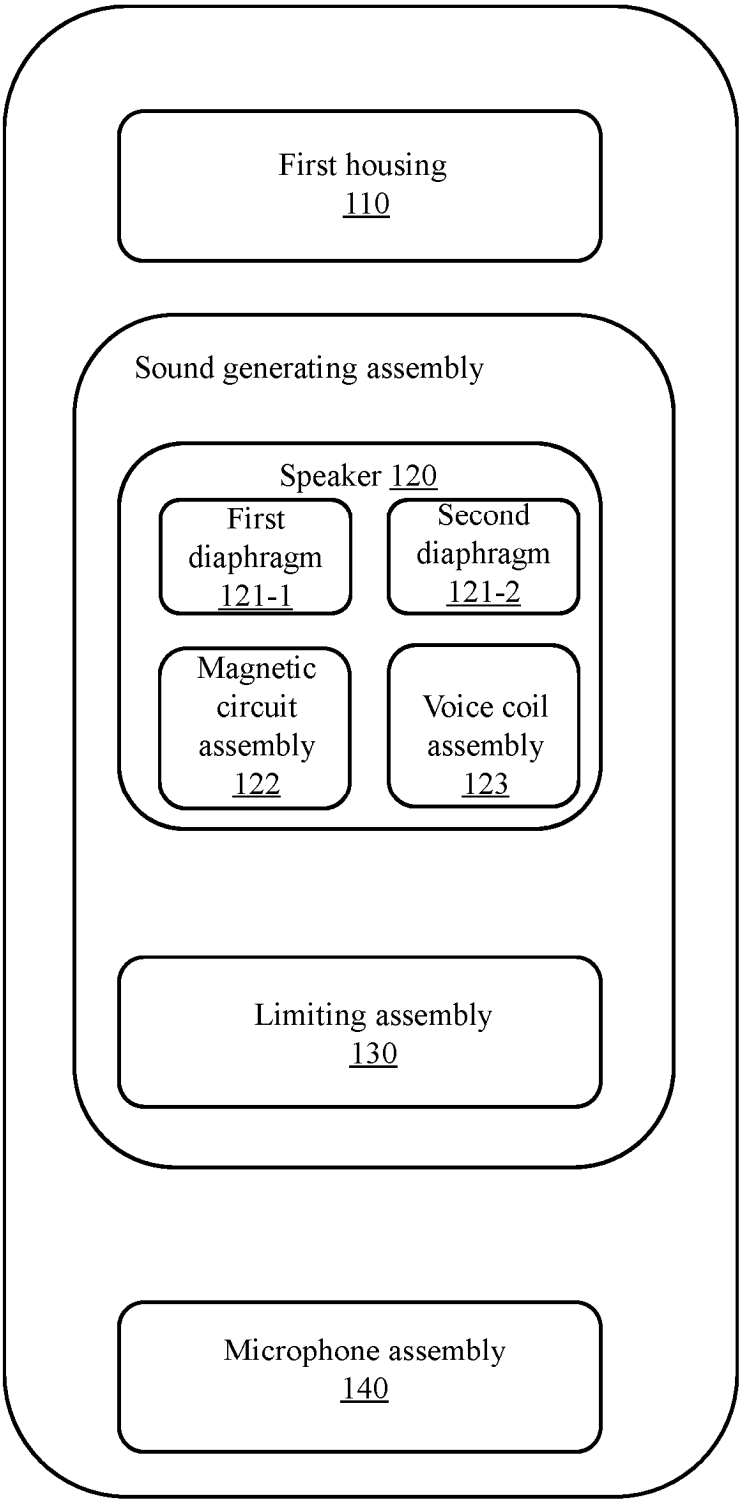


FIG. 3

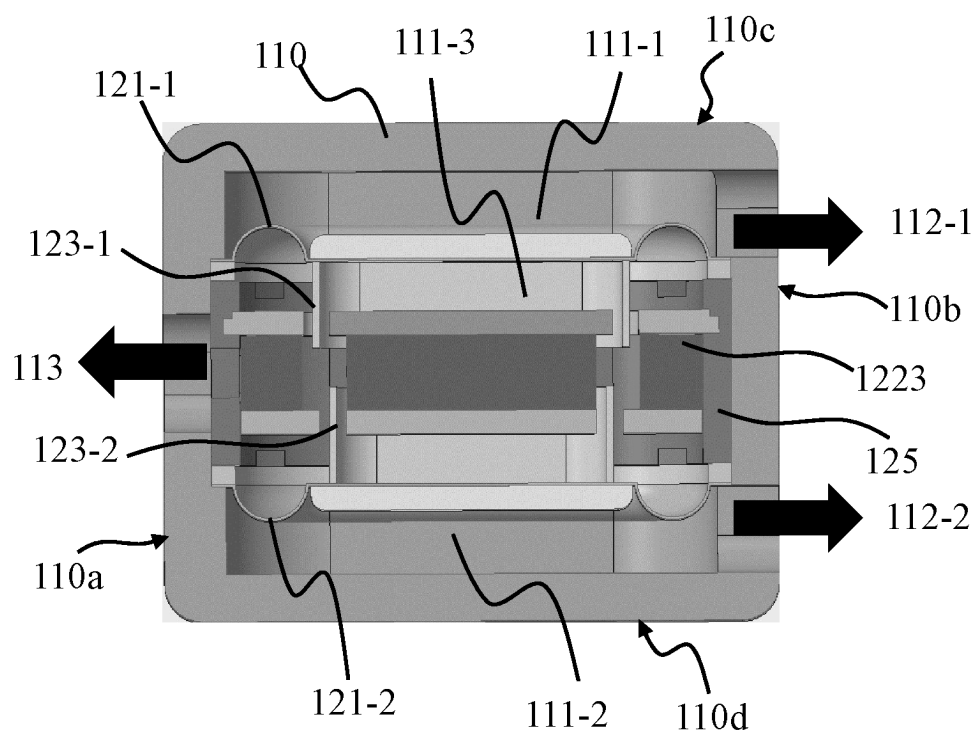


FIG. 4

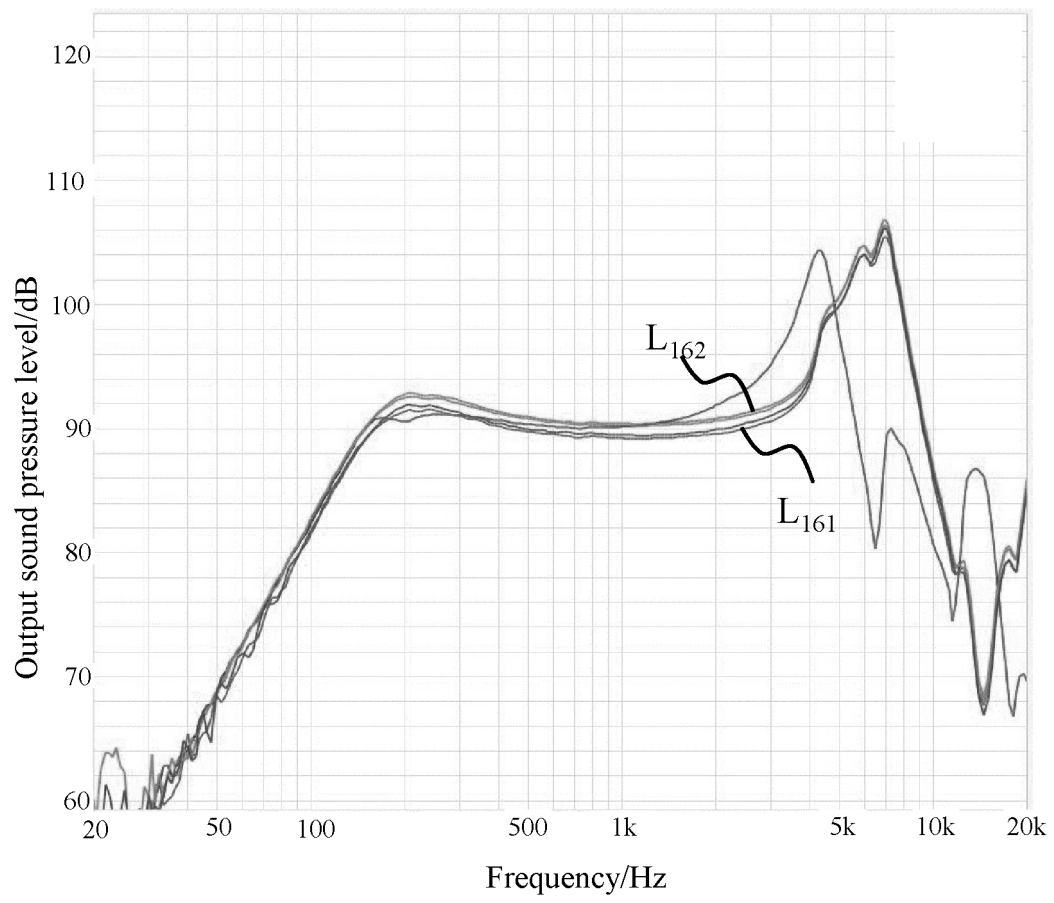


FIG. 5

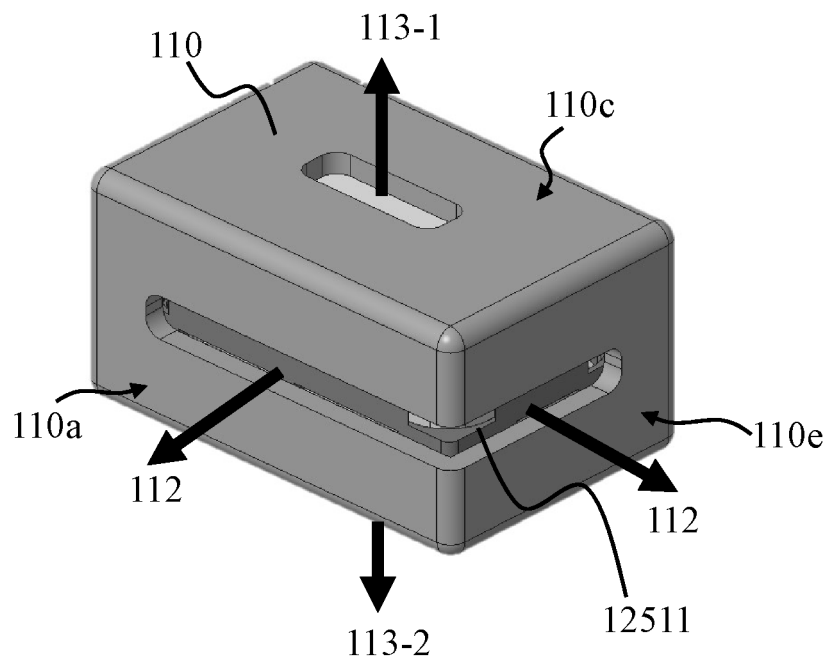


FIG. 6

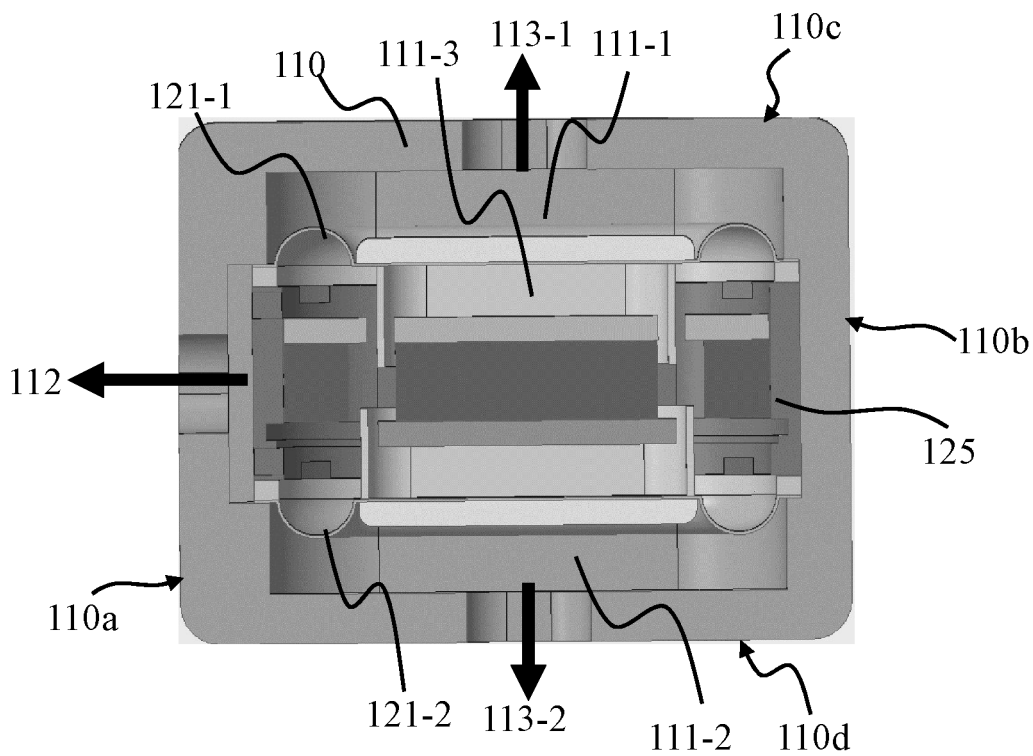


FIG. 7

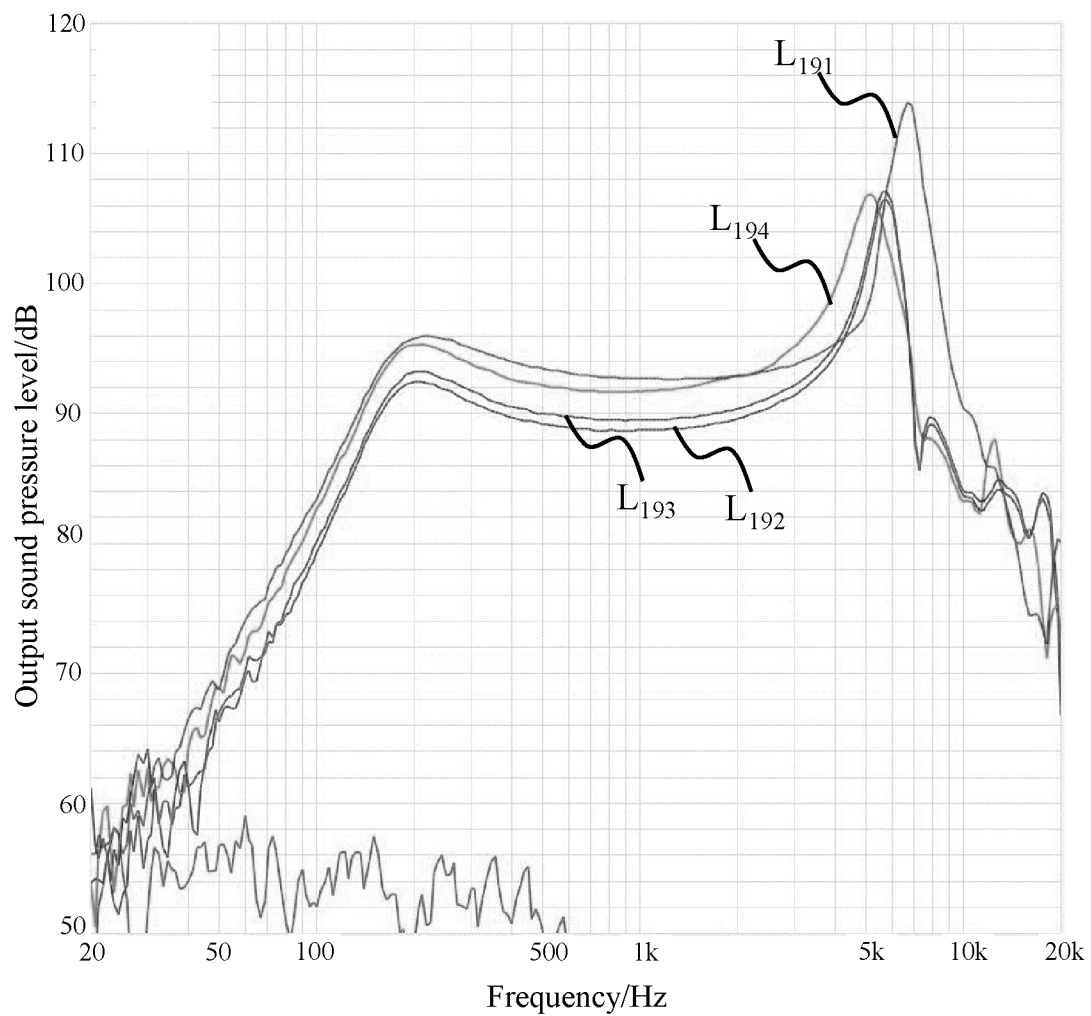


FIG. 8

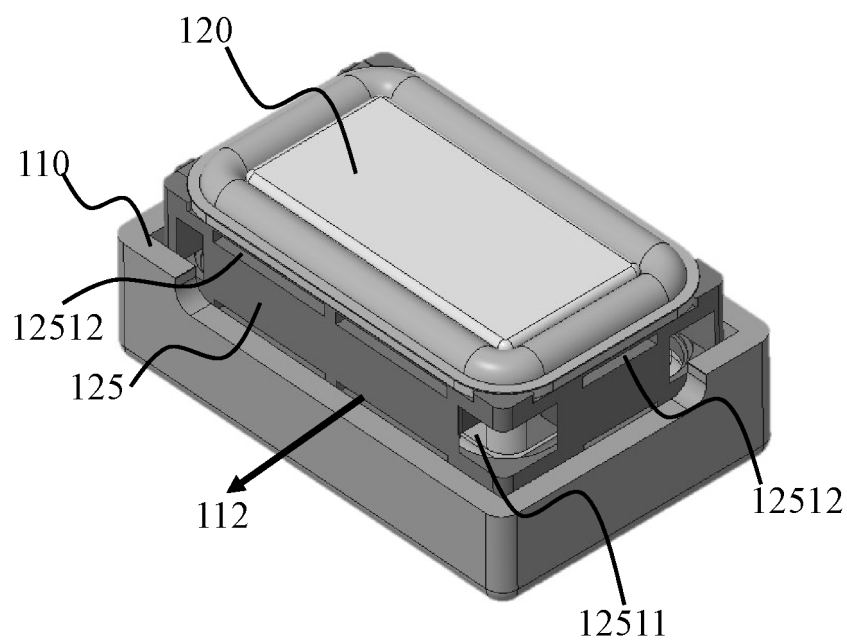


FIG. 9

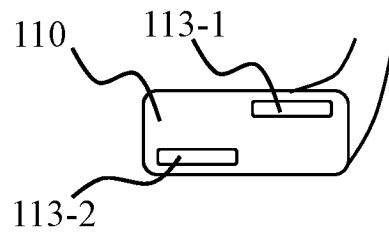


FIG. 10A

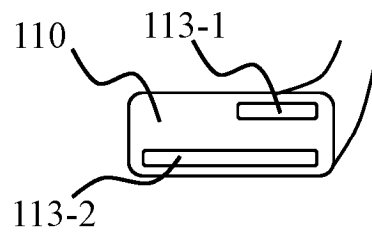


FIG. 10B

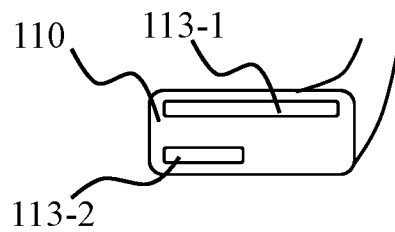


FIG. 10C

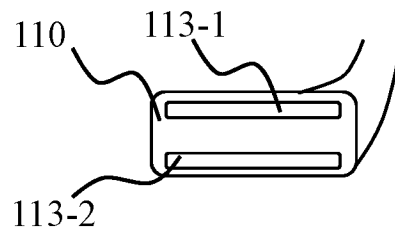


FIG. 10D

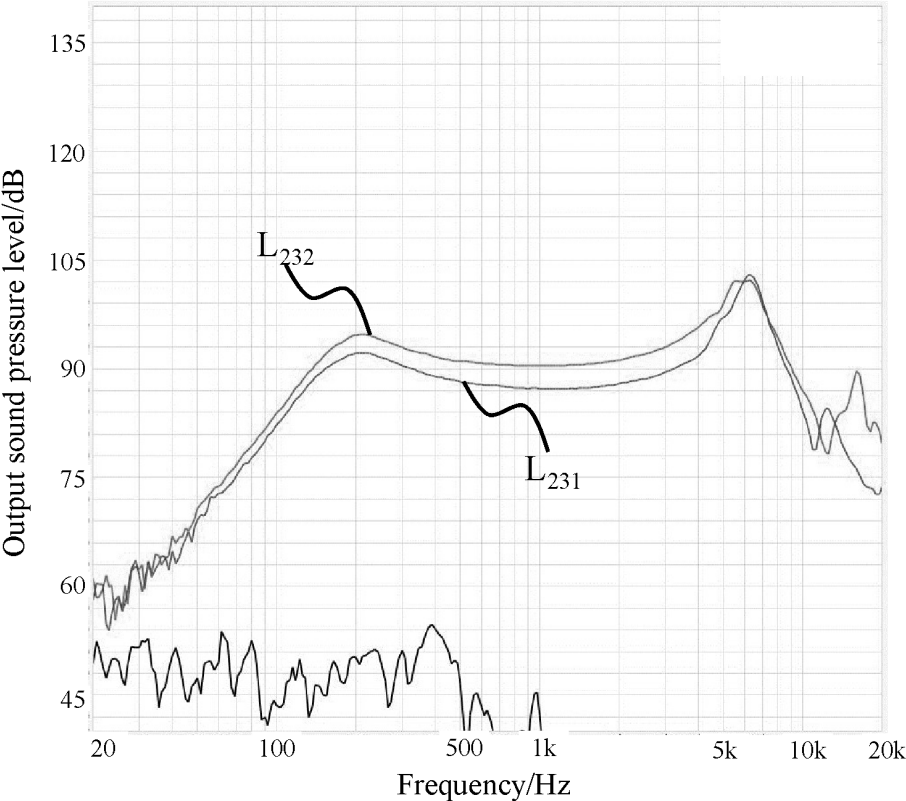


FIG. 11A

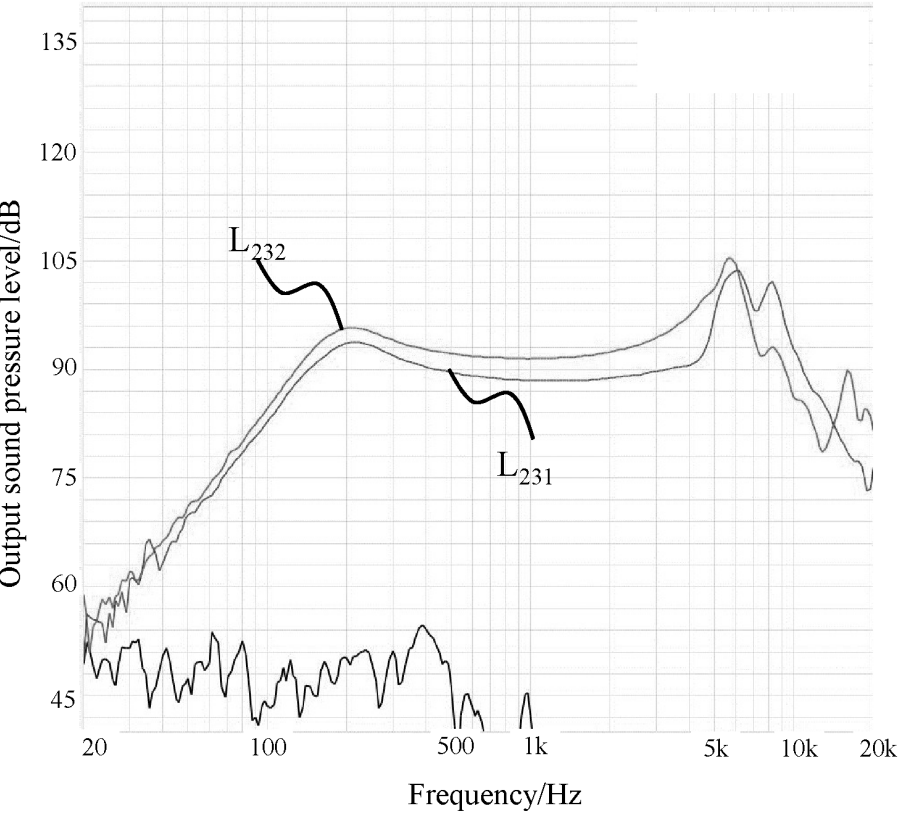


FIG. 11B

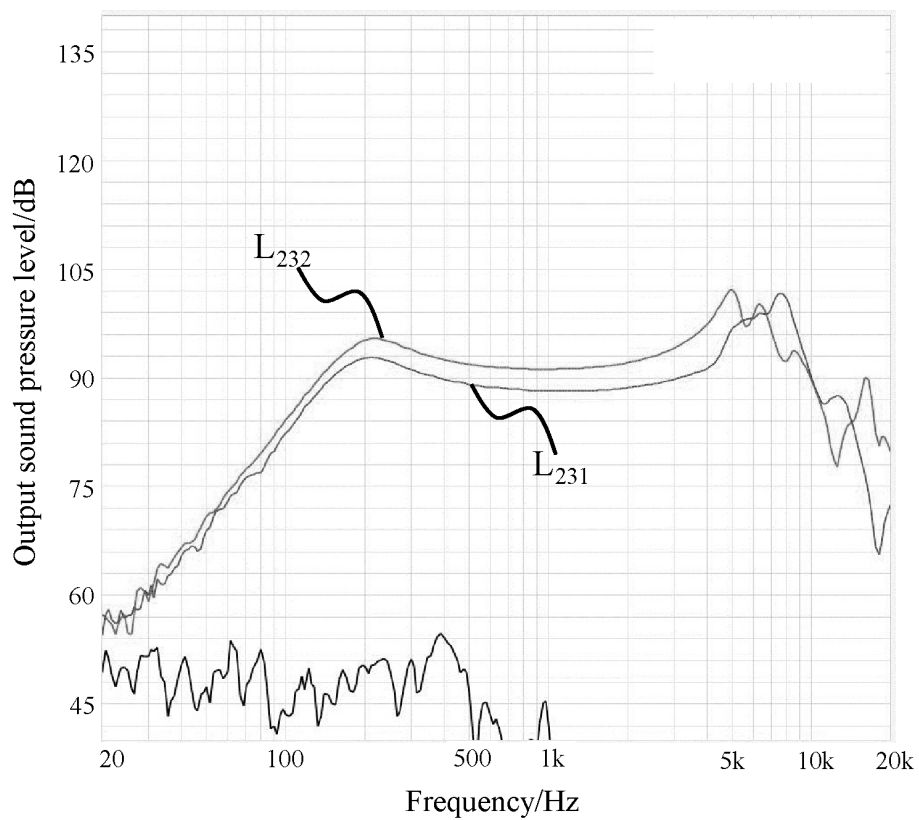


FIG. 11C

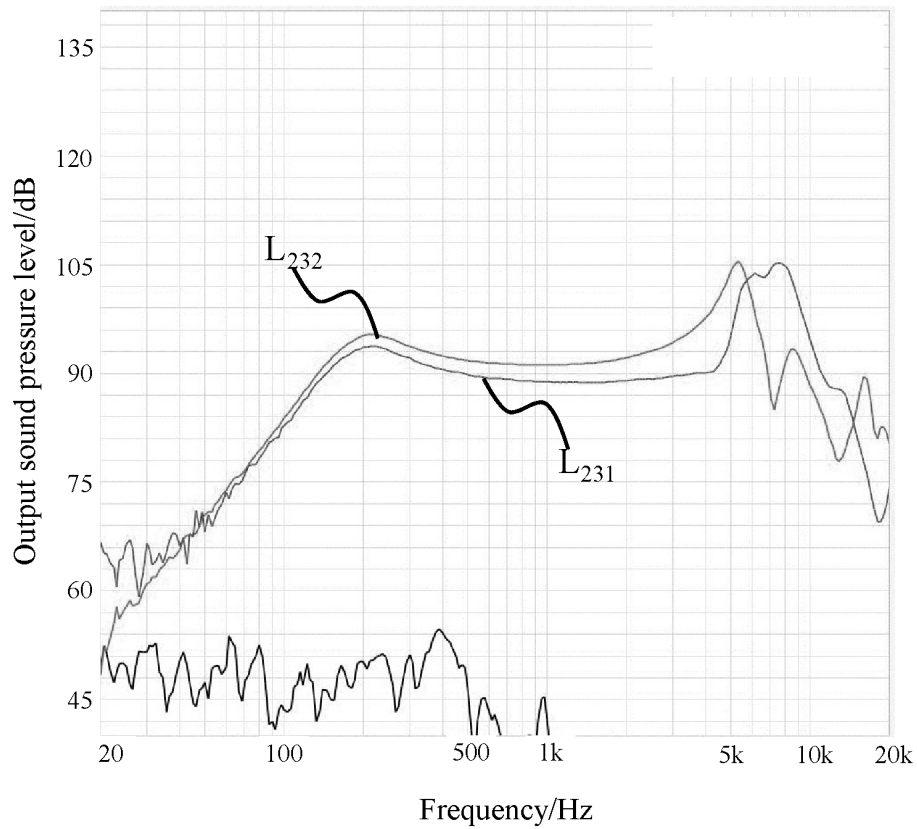


FIG. 11D

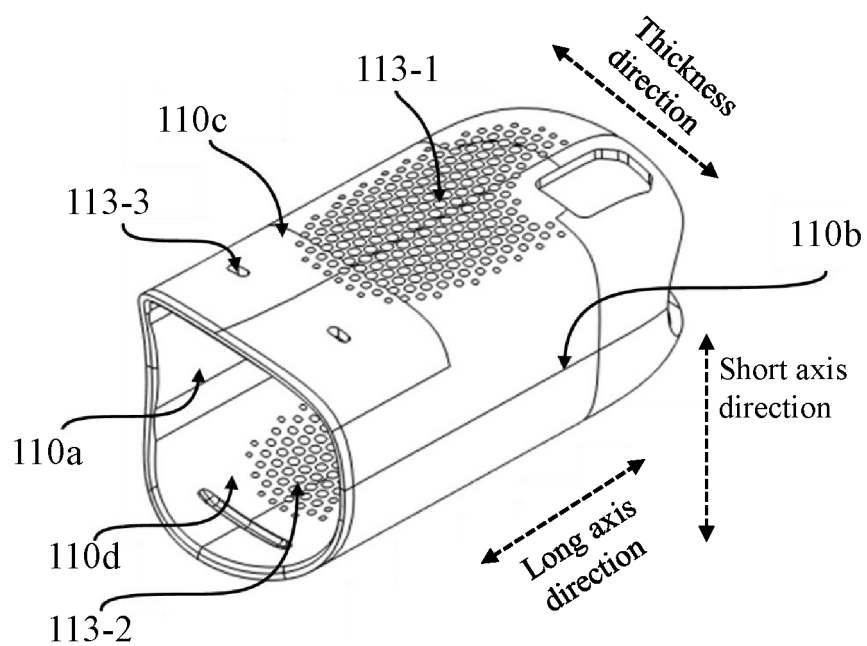


FIG. 12

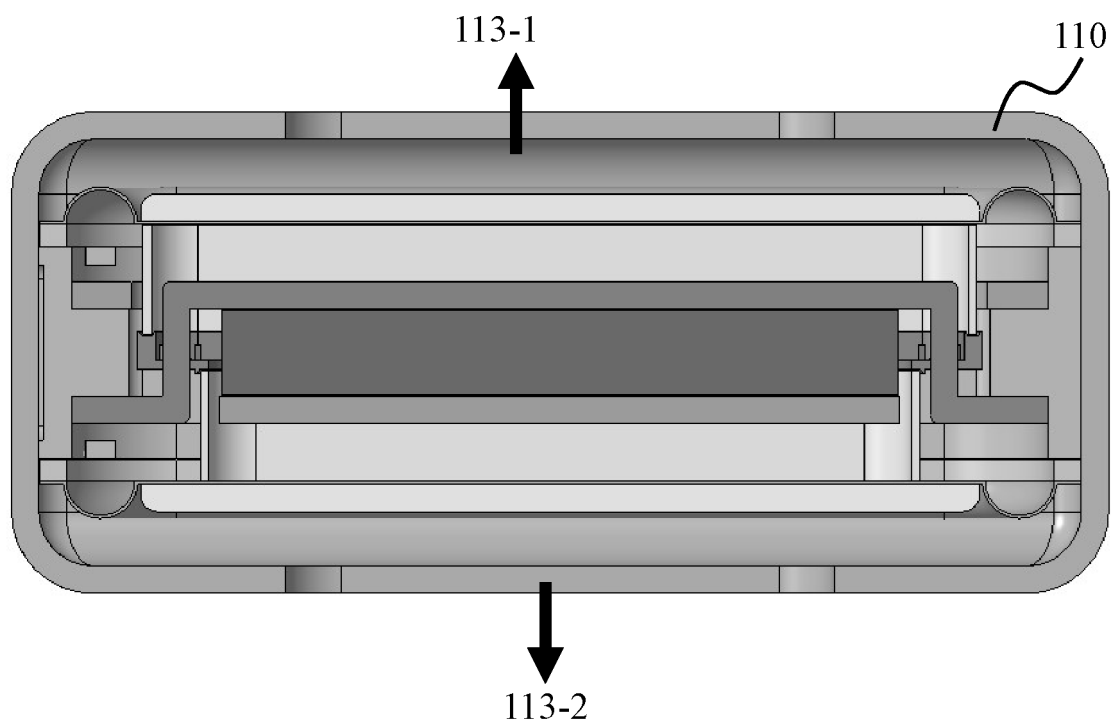


FIG. 13A

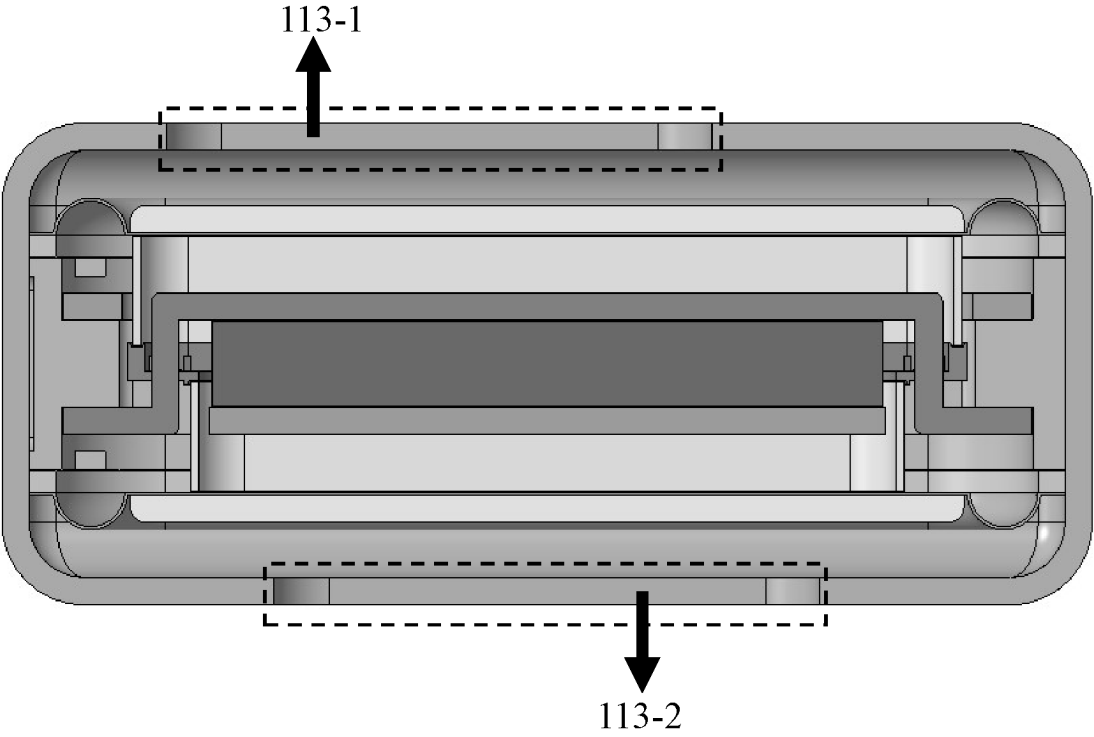


FIG. 13B

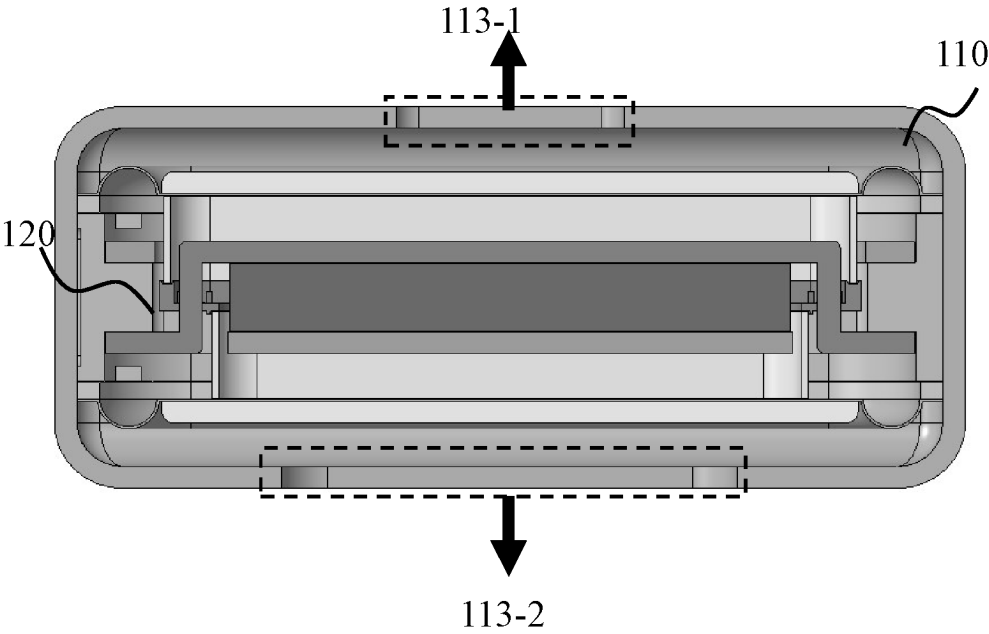


FIG. 14

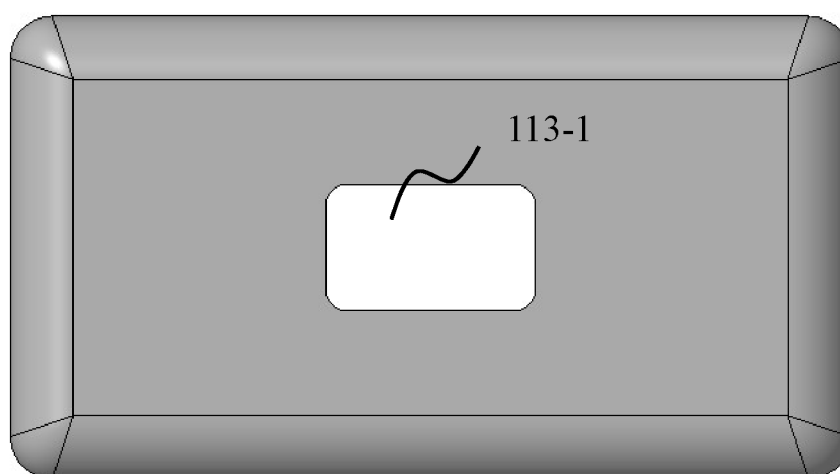


FIG. 15A

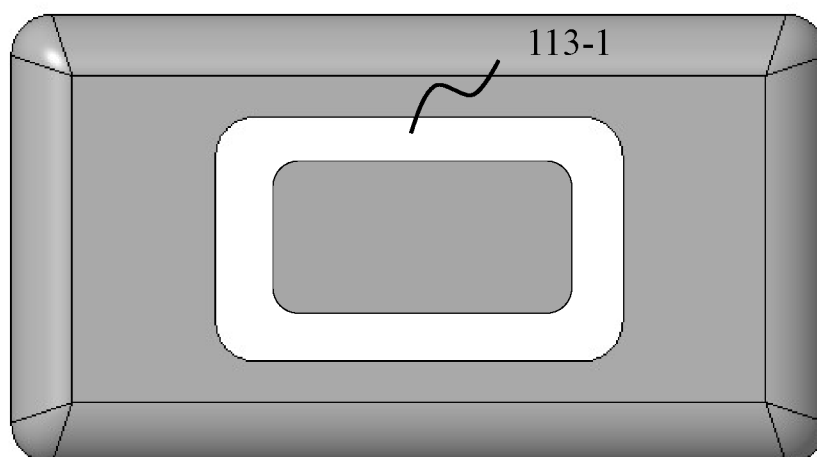


FIG. 15B

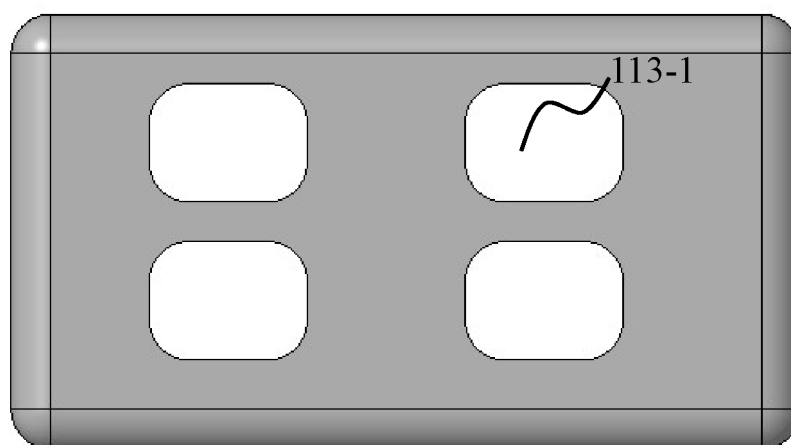


FIG. 16A

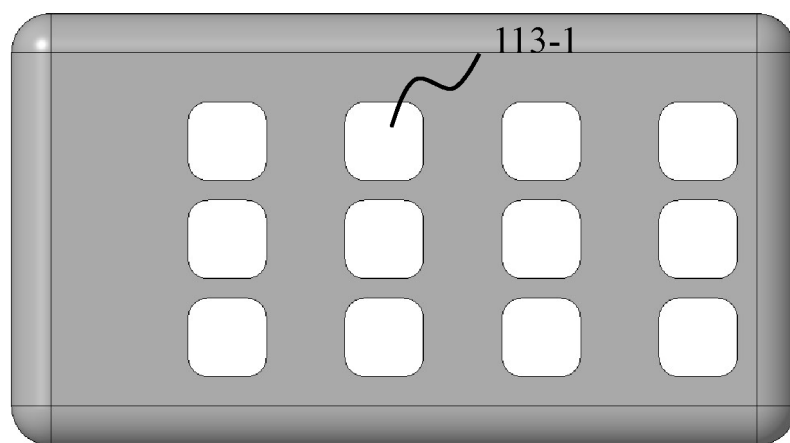


FIG. 16B

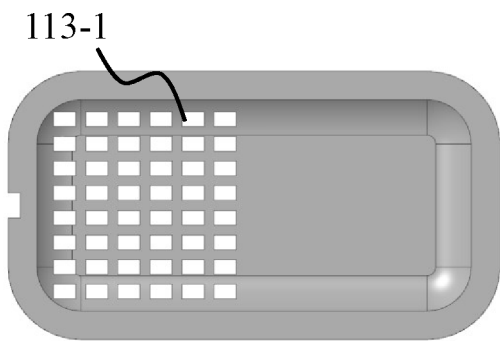


FIG. 17A

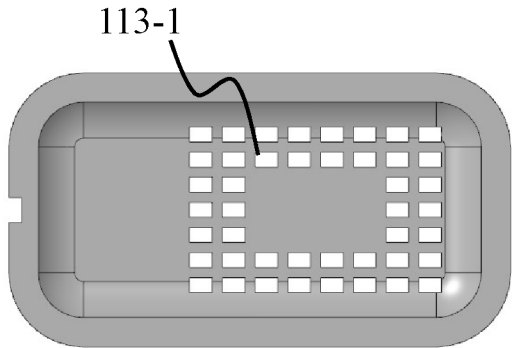


FIG. 17B

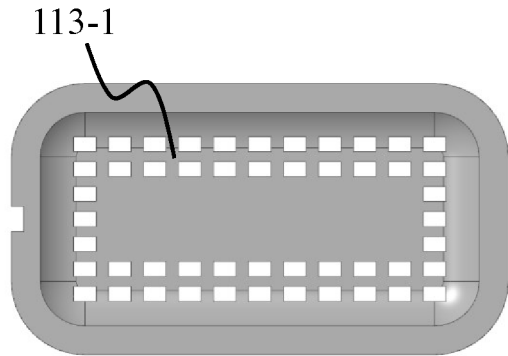


FIG. 17C

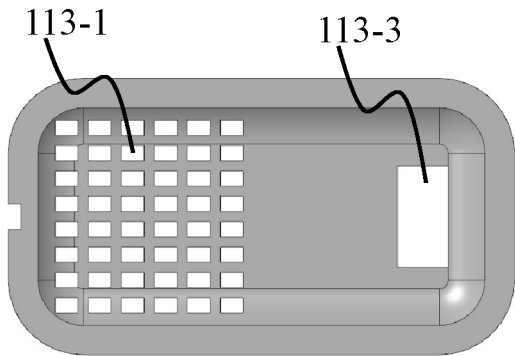


FIG. 17D

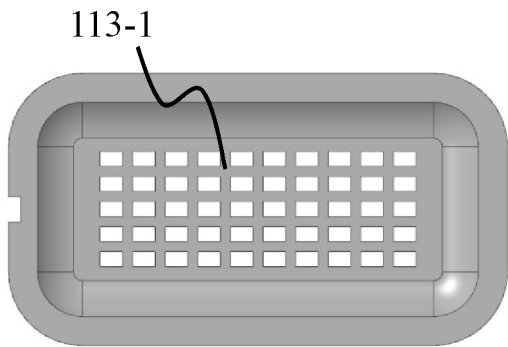


FIG. 17E

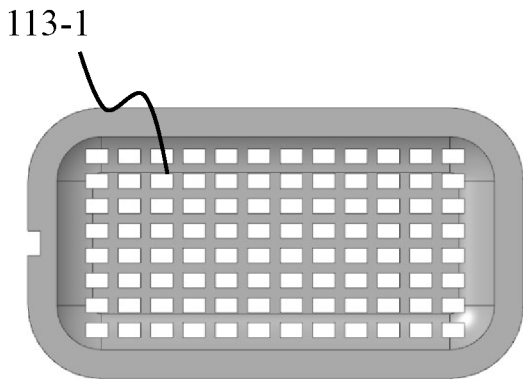


FIG. 17F

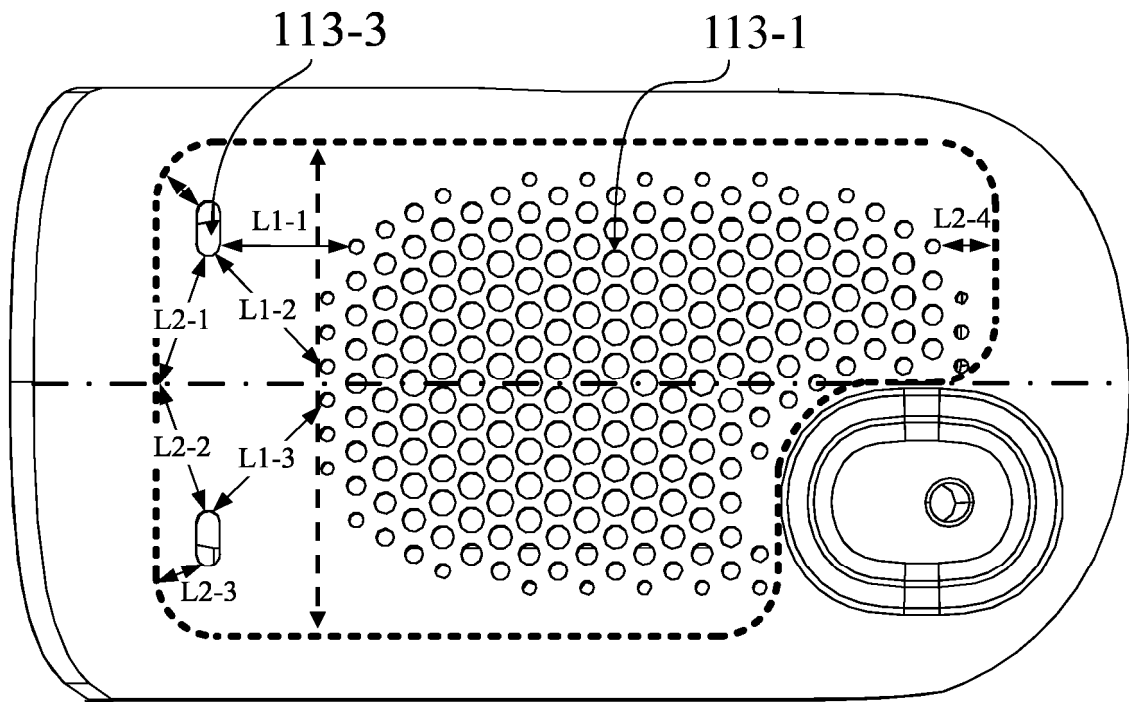


FIG. 18

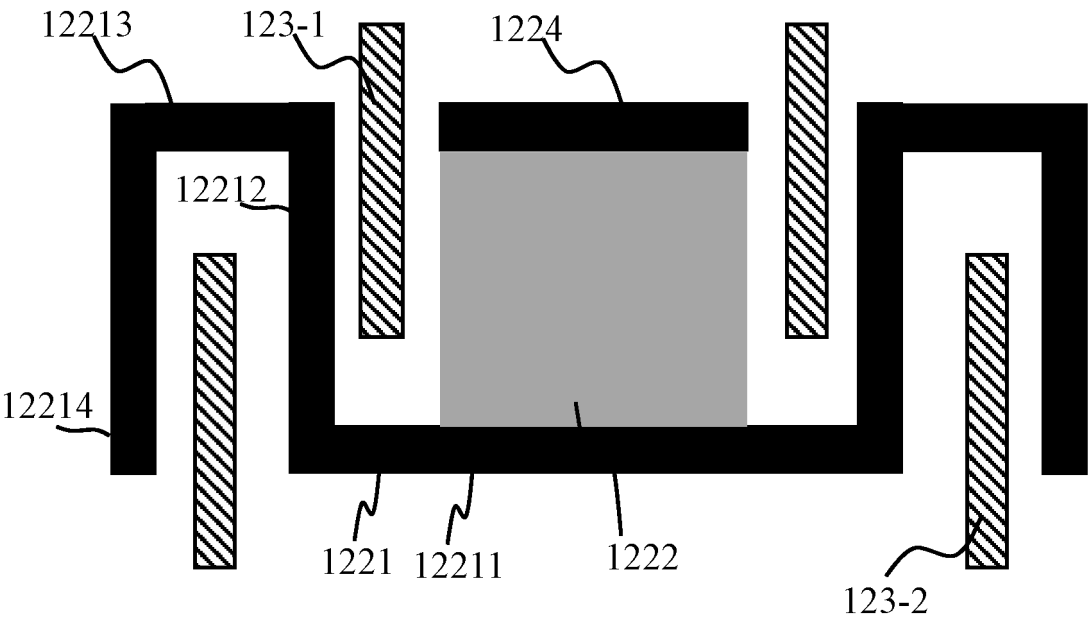


FIG. 19A

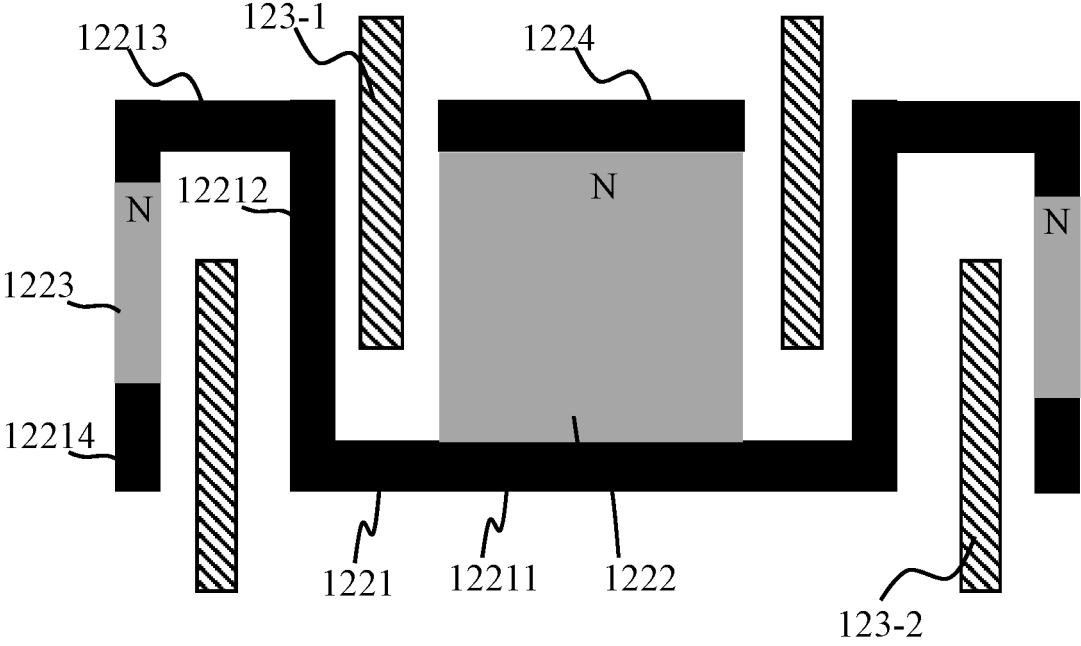


FIG. 19B

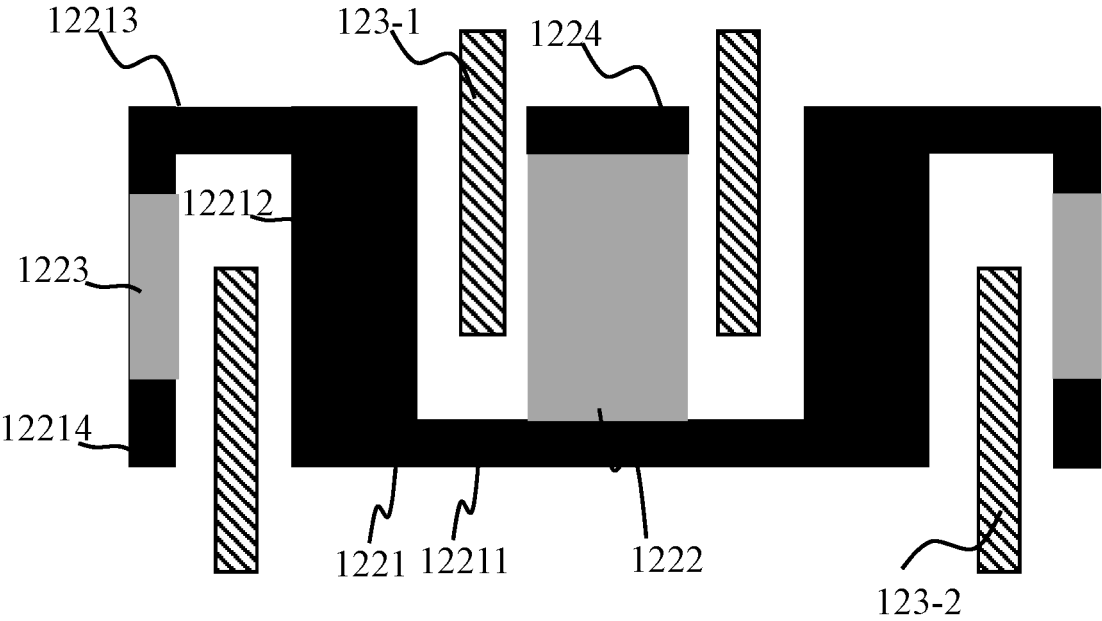


FIG. 19C

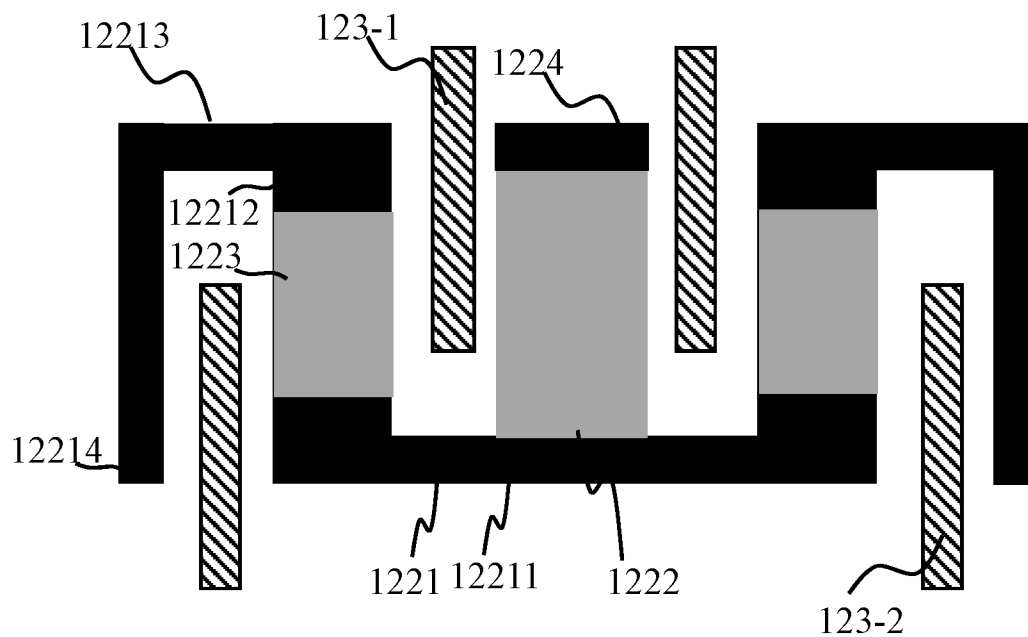


FIG. 19D

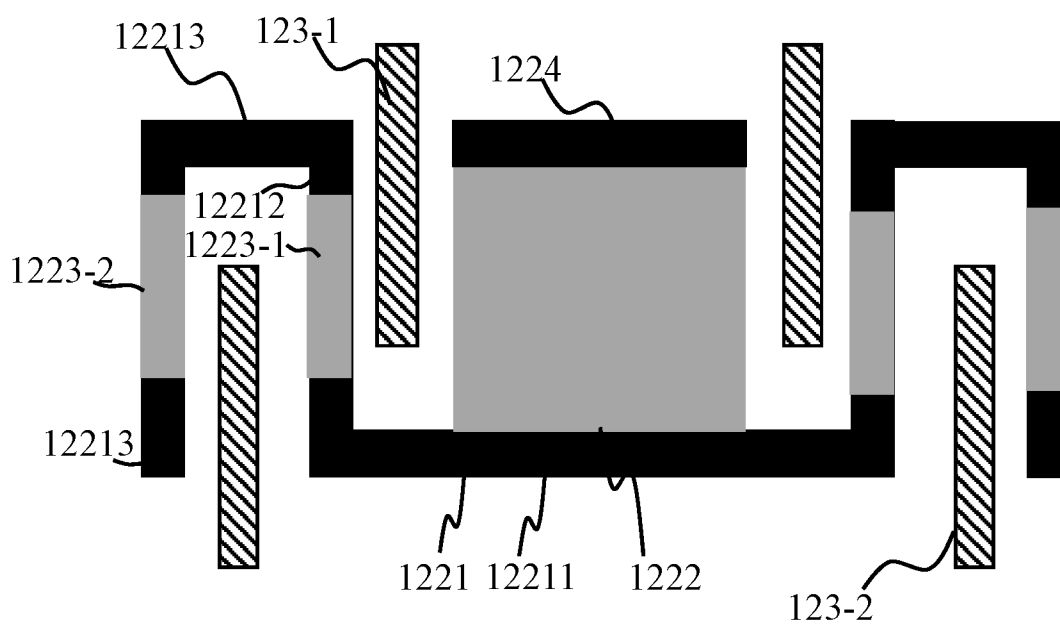


FIG. 19E

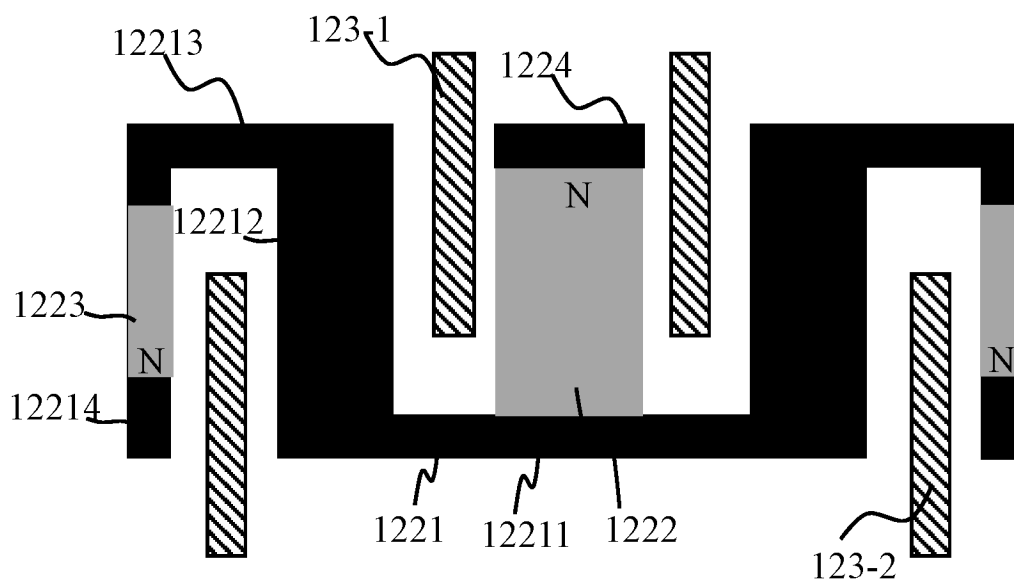


FIG. 19F

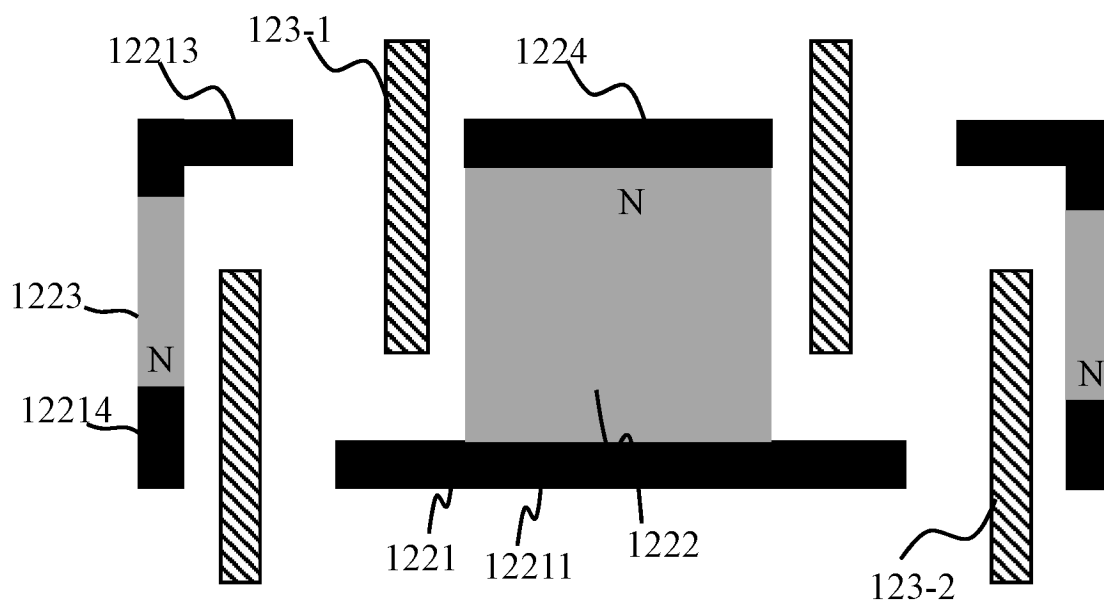


FIG. 19G

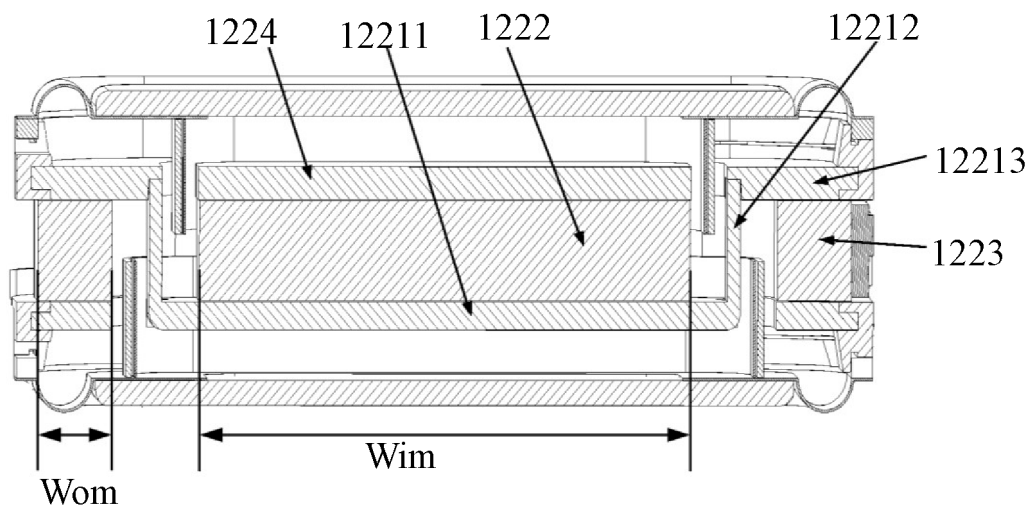


FIG. 20

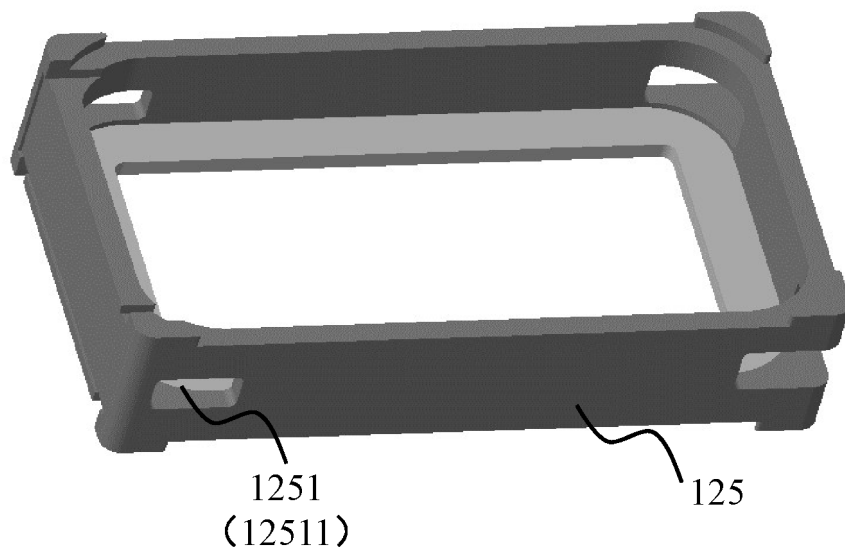


FIG. 21A

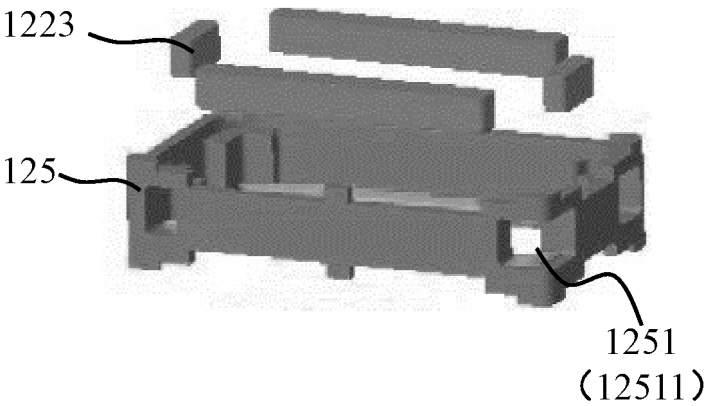


FIG. 21B

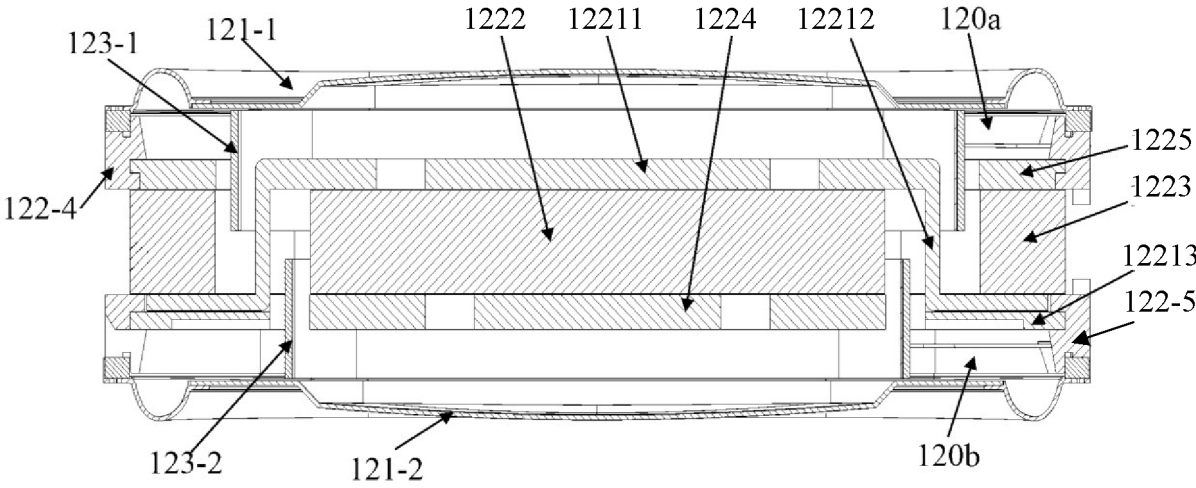


FIG. 22

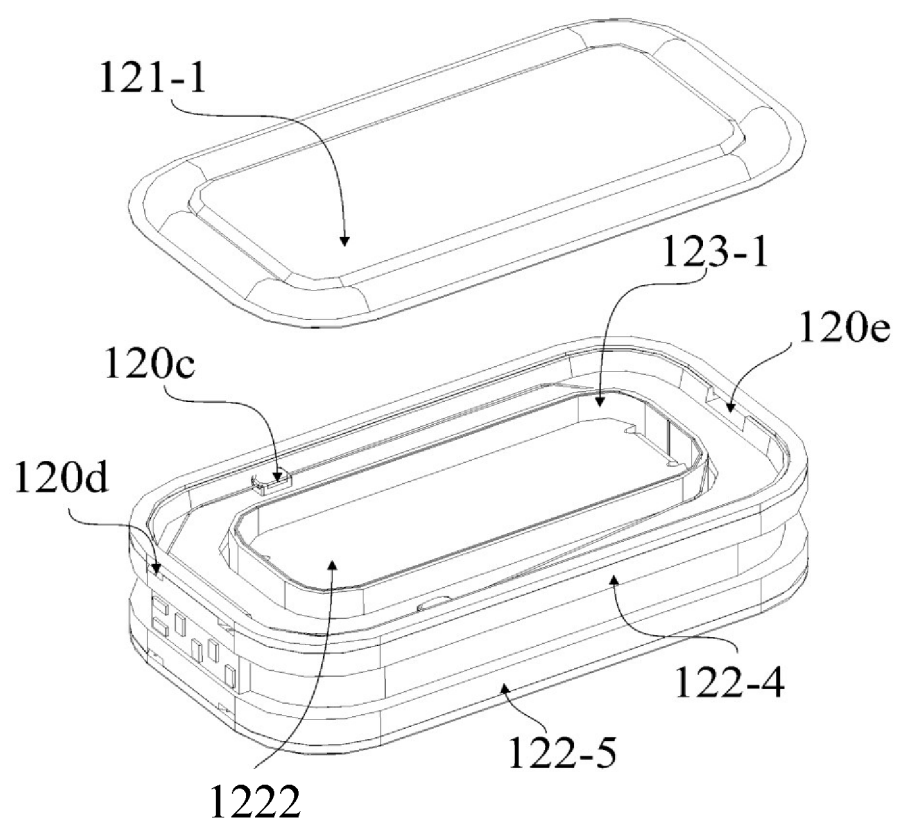


FIG. 23

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2025/109116

A. CLASSIFICATION OF SUBJECT MATTER

H04R9/02(2006.01)i; H04R9/06(2006.01)i; H04R1/02(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC:H04R9/-; H04R1/-

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

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

CNABS, CNTXT, ENTXTC, 百度, BAIDU: 喇叭, 扬声器, 耳机, 发声装置, 第一振膜, 第二振膜, 相反, 反向, 泄压孔; VEN, ENTXT: speaker?, loudspeaker?, earphone?, earpiece?, diaphragm, membrane, film, second, reverse

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 109936803 B (HUAWEI DEVICE CO., LTD.) 12 January 2021 (2021-01-12) description, paragraphs [0028]-[0036] and [0042], and figure 4	1-9
Y	CN 109936803 B (HUAWEI DEVICE CO., LTD.) 12 January 2021 (2021-01-12) description, paragraphs [0028]-[0036] and [0042], and figure 4	10-20
Y	CN 220711647 U (SHENZHEN VOXTECH CO., LTD.) 02 April 2024 (2024-04-02) description, paragraph [0199]	10-20
A	CN 114449420 A (GOERTEK TECHNOLOGY CO., LTD.) 06 May 2022 (2022-05-06) entire document	1-20
A	US 10609465 B1 (BOSE CORP.) 31 March 2020 (2020-03-31) entire document	1-20

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

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"A" document defining the general state of the art which is not considered to be of particular relevance	"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
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"E" earlier application or patent but published on or after the international filing date	"&" document member of the same patent family
"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	

Date of the actual completion of the international search

2025.10.04

Date of mailing of the international search report

05 October 2025

Name and mailing address of the ISA/CN

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Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2025/109116

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		EP 3920553 A4	23 March 2022
		US 2022174409 A1	02 June 2022
		US 11997464 B2	28 May 2024
		WO 2020173395 A1	03 September 2020
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		EP 4462808 A1	13 November 2024
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		JP 2025506280 A	07 March 2025
CN 114449420 A	06 May 2022	None	
US 10609465 B1	31 March 2020	US 2020145745 A1	07 May 2020
		US 11095966 B2	17 August 2021
		EP 3861764 A1	11 August 2021
		EP 3861764 B1	04 June 2025
		US 2020112783 A1	09 April 2020
		WO 2020072943 A1	09 April 2020
		US 2021377639 A1	02 December 2021
		US 11589149 B2	21 February 2023

Form PCT/ISA/210 (patent family annex) (July 2022)

REFERENCES CITED IN THE DESCRIPTION

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