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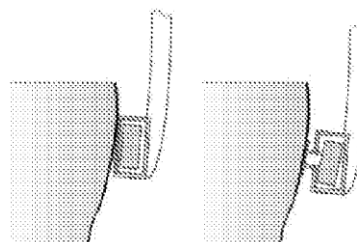
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[54] Title of invention

Bone conduction speaker

[57] Abstract

The present invention discloses a bone conduction speaker, comprising a housing, an energy conversion device, and a first vibration transmitting plate; the energy conversion device is disposed inside the housing; the energy conversion device of the first vibration transmitting plate is suspended and connected to the housing via the first vibration transmitting plate; the panel is connected to the energy conversion device and vibrates under the driving of the energy conversion device. The panel protrudes from the housing, and the first vibration transmitting plate can cause the panel to tilt at a certain angle relative to the housing when it is in contact with the user. The present invention can improve the sound quality of bone conduction speakers.



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1. A bone conduction speaker, characterized in that, it comprises:
a housing;
an energy conversion device disposed inside the housing;
a first vibration transmitting plate, via which the energy conversion device is suspended and connected to the housing;
a panel connected to the energy conversion device and vibrating under the driving of the energy conversion device, wherein the panel protrudes from the housing, and the first vibration transmitting plate can cause the panel to tilt at a certain angle relative to the housing when in contact with the user.
2. The bone conduction speaker according to claim 1, characterized in that the inclination angle of the panel does not exceed 5°.
3. The bone conduction speaker according to claim 1, characterized in that the first vibration transmitting plate can cause the bone conduction speaker to generate a resonance peak within the audible range of the human ear, and the energy conversion device comprises at least one vibrating plate and a second vibration transmitting plate, and the energy conversion device can generate at least two resonance peaks.
4. The bone conduction speaker according to claim 1, characterized in that the bone conduction speaker further comprises a vibration transmitting layer, wherein the vibration transmitting layer is wrapped around the outer side of the panel and comprises a first contact surface area and a second contact surface area, wherein the first contact surface area is not in contact with the panel, and the second contact surface area is in contact with the panel and higher than the first contact surface area to form a stepped structure, and when the vibration transmitting layer is in direct or indirect contact with the user, the clamping force on the first contact surface area is less than that on the second contact surface area.
5. The bone conduction speaker according to claim 4, characterized in that the first contact surface area is not in contact with the user.
6. The bone conduction speaker according to claim 4, characterized in that one or more small holes are provided on the first contact surface area.
7. The bone conduction speaker according to claim 5, characterized in that the bone conduction speaker further comprises a housing, the small hole guides the sound waves formed by the vibration of the air inside the housing to the outside of the housing, and offsets the sound leakage waves formed by the vibration of the housing pushing the air outside the housing.
8. The bone conduction speaker according to claim 1, characterized in that the vibration transmitting layer is bonded to the panel with adhesive, and the small hole is disposed in the non-bonded area between the vibration transmitting layer and the panel.
9. The bone conduction speaker according to claim 4, characterized in that the vibration transmitting layer is bonded to the panel with adhesive, the tensile strength of the adhesive is not less than 1 Mpa, the elongation at break of the adhesive is 100%-500%, the shear strength of the adhesive is not less than 2 Mpa, the Shore hardness of the adhesive is 25-30, the thickness of the vibration transmitting layer is 0.3-5 mm, the tensile strength of the vibration transmitting layer is 3.0 Mpa-13 Mpa, the Shore hardness of the vibration transmitting layer is 10-80, and the elongation at break of the vibration transmitting layer is 160-700%.
10. The bone conduction speaker according to claim 4, characterized in that the vibration transmitting layer is bonded to the panel with adhesive, the tensile strength of the adhesive is not less than 2 Mpa, the elongation at break of the adhesive is 200%-400%, the shear strength of the adhesive is not less than 3 Mpa, the Shore hardness of the adhesive is 30-50, the thickness of the vibration transmitting layer is 0.5-3 mm, the tensile strength of the vibration transmitting layer is 8.7 Mpa-12 Mpa, the Shore hardness of the vibration transmitting layer is 20-60, and the elongation at break of the vibration transmitting layer is 300-900%.

Bone conduction speaker**Field of the invention**

[0001] The present invention relates to the field of bone conduction technology, particularly to a bone conduction speaker.

Background of the invention

[0002] In general, people can hear sound because air transmits vibrations via the external auditory canal to the eardrum, and the vibrations formed via the eardrum drive the auditory nerves of people, thereby perceiving the vibrations of sound. During operation, bone conduction speakers can typically transmit sound to the auditory nerves of people via their skin, subcutaneous tissues, and bones, allowing them to hear sound.

Contents of the invention

[0003] A bone conduction speaker comprising a housing, an energy conversion device, and a first vibration transmitting plate; the energy conversion device is disposed inside the housing; the energy conversion device of the first vibration transmitting plate is suspended and connected to the housing via the first vibration transmitting plate; the panel is connected to the energy conversion device and vibrates under the driving of the energy conversion device. The panel protrudes from the housing, and the first vibration transmitting plate can cause the panel to tilt at a certain angle relative to the housing when it is in contact with the user. The present invention can improve the sound quality of bone conduction speakers.

Description of figures

[0004] Figure 1 shows the process by which a bone conduction speaker induces auditory perception in the human ear.

[0005] Figure 2-A is an external view of the vibration generating portion of the bone conduction speaker provided in an embodiment of the present invention.

[0006] Figure 2-B is a structural diagram of the vibration generating portion of the bone conduction speaker provided in an embodiment of the present invention.

[0007] Figure 2-C is a structural diagram of the vibration generating portion of the bone conduction speaker provided in an embodiment of the present invention.

[0008] Figure 3-A shows the equivalent vibration model of the vibration generating portion of the bone conduction speaker in an embodiment of the present invention.

[0009] Figure 3-B shows the vibration response curve of the bone conduction speaker applicable to an embodiment of the present invention.

[0010] Figure 4 is a schematic diagram of the sound vibration transmitting system of the bone conduction speaker in an embodiment of the present invention.

[0011] Figures 5-A and 5-B are respectively a top view and a side view of the bone conduction speaker panel bonding method in an embodiment of the present invention.

[0012] Figure 6 is a structural diagram of the vibration generating portion of the bone conduction speaker in an embodiment of the present invention.

[0013] Figure 7 shows the vibration response curve of the bone conduction speaker applicable to an embodiment of the present invention.

[0014] Figure 8 shows the vibration response curve of the bone conduction speaker applicable to an embodiment of the present invention.

[0015] Figure 9 is a structural diagram of the vibration generating portion of the bone conduction speaker in an embodiment of the present invention.

[0016] Figure 10 shows the frequency response curve of the bone conduction speaker in an embodiment of the present invention.

[0017] Figure 11 shows an equivalent model of the vibration generation and transmission system of the bone conduction speaker in an embodiment of the present invention.

[0018] Figure 12 is a structural diagram of the bone conduction speaker provided in an embodiment of the present invention.

[0019] Figures 13-A and 13-B show the vibration response curves of the bone conduction speaker applicable to an embodiment of the present invention.

[0020] Figures 14-A and 14-B show a method for measuring the clamping force of the bone conduction speaker provided in an embodiment of the present invention.

[0021] Figure 14-C shows the vibration response curve of the bone conduction speaker applicable to an embodiment of the present invention.

[0022] Figure 15 shows a method of adjusting the clamping force in an embodiment of the present invention.

[0023] Figure 16-A is a schematic diagram of the contact surface of the bone conduction speaker vibration unit in an embodiment of the present invention.

[0024] Figure 16-B shows the vibration response curve of the bone conduction speaker applicable to an embodiment of the present invention.

[0025] Figure 17 is a schematic diagram of the contact surface of the bone conduction speaker vibration unit in an embodiment of the present invention.

[0026] Figures 18-A and 18-B are the structural diagrams of the bone conduction speaker and its composite vibration device provided in an embodiment of the present invention.

[0027] Figure 19 shows the frequency response curve of the bone conduction speaker applicable to an embodiment of the present invention.

[0028] Figure 20 is the structural diagram of the bone conduction speaker and its composite vibration device provided in an embodiment of the present invention.

[0029] Figure 21-A is an equivalent model diagram of the vibration generating portion of the bone conduction speaker in an embodiment of the present invention.

[0030] Figure 21-B shows the vibration response curve of the bone conduction speaker applicable in a specific embodiment.

[0031] Figure 21-C shows the vibration response curve of the bone conduction speaker applicable in a specific embodiment.

[0032] Figure 22-A is the structural diagram of the vibration generating portion of the bone conduction speaker in a specific embodiment.

[0033] Figure 22-B shows the vibration response curve of the vibration generating portion of the bone conduction speaker in a specific embodiment.

[0034] Figure 22-C shows the sound leakage curve of the bone conduction speaker in a specific embodiment.

[0035] Figure 23 is the structural diagram of the vibration generating portion of the bone conduction speaker in a specific embodiment.

[0036] Figure 24-A shows an application scenario of the bone conduction speaker in a specific embodiment.

[0037] Figure 24-B shows the vibration response curve of the vibration generating portion of the bone conduction speaker in a specific embodiment.

[0038] Figure 25 is the structural diagram of the vibration generating portion of the bone conduction speaker in a specific embodiment.

[0039] Figure 26 is the schematic diagram of the panel structure of the bone conduction speaker in a specific embodiment.

[0040] Figure 27 shows the gradient structure on the outer side of the contact surface of the bone conduction speaker in a specific embodiment.

[0041] Figures 28-A and 28-B show the vibration response curves in specific embodiments.

[0042] Figure 29 shows the gradient structure on the inner side of the contact surface of the bone conduction speaker in a specific embodiment.

[0043] Figure 30 is the structural diagram of the vibration generating portion of the bone conduction speaker in a specific embodiment.

Specific embodiments

[0044] To more clearly illustrate the technical solution of the embodiments of the present invention, a brief introduction will be given to the figures required for the description of the embodiments. It is obvious that the figures described below are only some embodiments of the present invention but do not limit the scope of application of the present invention. For general technical personnel in this field, the present invention can be applied to other similar scenarios based on these figures without creative work.

[0045] As shown in this description and the claims, unless the context clearly indicates an exception, words such as "a", "an", "one", and/or "this" do not specifically refer to the singular, but may also include the plural. Generally speaking, the terms "including", "comprising" and "containing" only indicate the steps and elements that have been clearly identified, and these steps and elements do not constitute an exclusive list, and methods or devices may also include/contain other steps or elements. The term "based on" means "based on at least in part". The term "one embodiment" means "at least one embodiment"; the term "another embodiment" means "at least one further embodiment". The relevant definitions of other terms will be provided in the following description.

[0046] In the following, without loss of generality, when describing the bone conduction related technology in the present invention, the description of "bone conduction speaker" or "bone conduction earphone" will be used. This description is only one form of bone conduction application. For general technical personnel in this field, "speaker" or "earphone" can also be replaced by other similar words, such as "player", "hearing aid", etc. In fact, various implementation methods in the present invention can be easily applied to other non-speaker hearing devices. For example, for those skilled in the art, after understanding the basic principles of bone conduction speakers, they may make various modifications and changes in form and detail to the specific methods and steps of implementing bone conduction speakers without deviating from the principles. Specifically, they may add

environmental sound pickup and processing functions to bone conduction speakers to enable them to function as hearing aids. For example, devices such as microphone can pick up sound in the user/wearer's surrounding environment, and under certain algorithms, process the sound (or generate electrical signals) and transmit them to the bone conduction speaker portion. That is, the bone conduction speaker can be modified to add the function of picking up environmental sound, and after certain signal processing, the sound can be transmitted to the user/wearer via the bone conduction speaker portion, thereby achieving the function of a bone conduction hearing aid. As an example, the algorithms mentioned here can include one or more combinations such as noise cancellation, auto gain control, acoustic feedback suppression, wide dynamic range compression, active environment recognition, active noise reduction, directional processing, tinnitus processing, multi-channel wide dynamic range compression, active howling suppression, volume control, etc.

[0047] Bone conduction speakers transmit sound via bones to the hearing system, thereby producing auditory perception. Figure 1 shows the process of auditory perception generated by a bone conduction speaker, which mainly includes the following steps: in step 101, the bone conduction speaker acquires or generates a signal containing sound information; in step 102, the bone conduction speaker generates vibration based on the signal; in step 103, the vibration is transmitted to the sensing terminal 104 via the transmission system. In a work scenario, a bone conduction speaker picks up or generates signals containing sound information, converts the sound information into sound vibrations via an energy conversion device, and transmits the sound to the sensory organs via a transmission system, ultimately resulting in hearing the sound. Without loss of generality, the subjects of the hearing system, sensory organs, etc. described above can be humans or animals with hearing systems. It shall be noted that the following description of human use of bone conduction speakers does not constitute a limitation on the usage scenarios of bone conduction speakers, but similar descriptions can also be applied to other animals.

[0048] The above description of the general process of bone conduction speakers is only a specific example and shall not be considered as the only feasible implementation solution. Obviously, for those skilled in the art, after understanding the basic principles of bone conduction speakers, they may make various modifications and changes in form and detail to the specific methods and steps of implementing bone conduction speakers without deviating from the principles. However, these modifications and changes are still within the scope described above. For example, between acquiring a signal containing sound information in step 101 and generating vibration in step 102, an additional signal correction or enhancement step can be added, which can enhance or modify the signal acquired in step 101 according to specific algorithms or parameters. Furthermore, an additional vibration strengthening or correction step can be added between the vibration generation step 102 and the vibration transmitting step 103. This step can utilize the sound signal of 101 or enhance or correct the vibration generated in 102 based on environmental parameters. Similarly, the vibration enhancement or correction step can be completed between steps 103 and 104, such as noise reduction, acoustic feedback suppression, wide dynamic range compression, auto gain control, active environment recognition, active noise reduction, directional processing, tinnitus processing, multi-channel wide dynamic range compression, active howling suppression, volume control, or any other similar operation, or any combination of the above. These modifications and changes are still within the scope of protection of the claims of the present invention. The methods and steps described here can be implemented in any suitable sequence or simultaneously under appropriate circumstances. Furthermore, individual steps can be removed from any method without deviating from the spirit and scope of the subject matter described herein. The various aspects of any of the examples described above can be combined with the various aspects of any of the other examples described to form further examples without losing the desired effect.

[0049] Specifically, in step 101, the bone conduction speaker can acquire or generate signals containing sound information in different ways. Sound information can refer to video and audio files in specific data formats, or it can generally refer to data or files that can be carried and ultimately converted into sound with specific means. The signal containing sound information can come from the storage unit of the bone conduction speaker itself, or from information generation, storage, or transmission systems outside of the bone conduction speaker. The sound signals discussed here are not limited to electrical signals, but can also include other forms beyond electrical signals such as optical signals, magnetic signals, mechanical signals, etc. In principle, as long as the signal contains sound information that the speaker can use to generate vibration, it can be processed as a sound signal. The sound signal is not limited to one signal source but can come from multiple signal sources. These multiple signal sources can be related or unrelated to each other. The transmission or generation of sound signals can be wired or wireless, real-time or delayed. For example, bone conduction speakers can receive electrical signals containing sound information via wired or wireless means,

or directly acquire data from storage media to generate sound signals; components with sound collection function can be added to bone conduction hearing aids to pick up sounds in the environment, convert mechanical vibrations into electrical signals, and obtain electrical signals that meet specific requirements via amplifier processing. Among them, wired connections include but are not limited to the use of metal cables, optical cables, or mixed metal and optical cables, such as coaxial cables, communication cables, flexible cables, spiral cables, non-metallic sheathed cables, metal sheathed cables, multi-core cables, twisted pair cables, ribbon cables, shielded cables, telecommunications cables, two-stranded cables, parallel two-core wires, and twisted pair wires.

[0050] The examples described above are for illustrative purposes only. The medium of wired connection can also be in other types, such as the transmission carriers for other electrical or optical signals. Wireless connections include but are not limited to wireless communication, free space optics communication, acoustic communication, and electromagnetic induction. Wireless communications include but are not limited to the IEEE802.11 series standards, IEEE802.15 series standards (such as Bluetooth technology and ZigBee technology), first-generation mobile communication technology, second-generation mobile communication technology (such as FDMA, TDMA, SDMA, CDMA, and SSMA), general packet radio service technology, third-generation mobile communication technology (such as CDMA2000, WCDMA, TD-SCDMA, and WiMAX), fourth-generation mobile communication technology (such as TD-LTE and FDD-LTE), satellite communication (such as GPS technology), near field communication (NFC), and other technologies operating in the ISM frequency band (such as 2.4 GHz); Free space optics communications include but are not limited to visible light, infrared signals, etc.; Acoustic communications include but are not limited to sound waves, ultrasonic signals, etc.; Electromagnetic inductions include but are not limited to near-field communication technology. The examples described above are for illustrative purposes only. The medium of wireless connection can also be in other types, such as Z-wave technology, other paid civilian radio frequency bands, and military radio frequency bands. For example, as some application scenarios of this technology, bone conduction speakers can acquire signals containing sound information from other devices via Bluetooth technology, or directly acquire data from the built-in storage unit of the bone conduction speaker to generate sound signals.

[0051] The storage devices/units referred to here include storage devices on storage systems such as Direct Attached Storage, Network Attached Storage, and Storage Area Network. Storage devices include but are not limited to common types of storage devices such as solid-state storage devices (solid-state drives, solid-state hybrid drives, etc.), mechanical hard drives, USB flash drives, memory sticks, storage cards (such as CF, SD, etc.), other drives (such as CD, DVD, HD DVD, Blu-ray, etc.), random access memory (RAM), and read-only memory (ROM). Among them, RAM includes but is not limited to: decade counter, selector, delay line memory, Williams transistor, dynamic random access memory (DRAM), static random access memory (SRAM), thyristor random access memory (T-RAM), and zero capacitance random access memory (Z-RAM), etc.; ROM includes but is not limited to: magnetic bubble memory, magnetic button line memory, thin film memory, magnetic plated line memory, magnetic core memory, magnetic drum memory, optical disc drive, hard disk, magnetic tape, early NVRAM (non-volatile random access memory), phase change memory, reluctance random access memory, ferroelectric random access memory, non-volatile SRAM, flash memory, electronic erasable rewritable read-only memory, erasable programmable read-only memory, programmable read-only memory, shielded stack read memory, floating gate random access memory, nanorandom access memory, racetrack memory, variable resistance memory, and programmable metallization units. The storage devices/units mentioned above are examples, and the storage devices/units that can be used are not limited to these.

[0052] In 102, a bone conduction speaker can convert signals containing sound information into vibrations and generate sound. The generation of vibration is accompanied by the conversion of energy, and bone conduction speakers can use specific energy conversion devices to convert signals into mechanical vibrations. The process of conversion may involve the coexistence and conversion of multiple types of energy. For example, electrical signals can be directly converted into mechanical vibrations and produce sound via an energy conversion device. For example, sound information is contained in optical signals, and a specific energy conversion device can achieve the process of converting optical signals into vibration signals. Other types of energy that can coexist and be converted during the operation of the energy conversion device include thermal energy, magnetic field energy, etc. The energy conversion methods of the energy conversion device include but are not limited to dynamic coil, electrostatic, piezoelectric, dynamic iron, pneumatic, electromagnetic, etc. The frequency response range and sound quality of bone conduction speakers are affected by different energy conversion

methods and the performance of various physical components in the energy conversion device. For example, in a dynamic coil energy conversion device, the wound cylindrical coil is connected to the vibrating plate, and the coil driven by the signal current drives the vibrating plate to vibrate and produce sound in the magnetic field. The extension and contraction of the vibrating plate material, the deformation, size, shape, and fixing method of wrinkles, as well as the magnetic density of the permanent magnet, all have a significant impact on the final sound quality of the bone conduction speaker. For example, the vibrating plate can have a mirror symmetric structure, a center symmetric structure, or an asymmetric structure; intermittent hole shaped structures can be disposed on the vibrating plate to generate greater displacement, thereby enabling the bone conduction speaker to achieve higher sensitivity and improve the output power of vibration and sound; for example, the vibrating plate has a circular ring structure, and multiple support rods converging towards the center are disposed inside the circular ring, and the quantity of support rods can be two or more.

[0053] Obviously, for those skilled in the art, after understanding the basic principles of how energy conversion methods and specific devices can affect the sound quality of bone conduction speakers, they may make appropriate choices, combinations, corrections, or changes to the above-mentioned influencing factors without deviating from the principles, so as to obtain ideal sound quality. For example, using high-density permanent magnets, more ideal vibrating plate materials, and designs can achieve better sound quality.

[0054] The term "sound quality" used here can be understood as reflecting the quality of sound, referring to the fidelity of audio after processing, transmission, and other processes. Sound quality is mainly described by three elements: loudness, pitch, and timbre. Loudness is the subjective perception of sound intensity by the human ear, which is proportional to the logarithm of sound intensity. The higher the sound intensity, the louder it sounds. Moreover, it is related to the frequency and waveform of the sound. Pitch, also known as high tone, refers to the subjective perception of the human ear regarding the frequency of sound vibration. The pitch mainly depends on the fundamental frequency of the sound, the higher the fundamental frequency, the higher the pitch, and it is also related to the intensity of the sound. Timbre refers to the subjective perception of sound characteristics by the human ear. The timbre mainly depends on the spectral structure of the sound, as well as factors such as loudness, duration, establishment process, and decay process of the sound. The spectral structure of sound is described by the fundamental frequency, number of harmonics, distribution of harmonics, amplitude, and phase relationship. Different spectral structures result in different timbres. Even if the fundamental frequency and loudness are the same, if the harmonic structure is different, the timbre will also be different.

[0055] There are many methods for implementing the vibration of a bone conduction speaker. Figures 2-A and 2-B are structural diagrams of the vibration generating portion of the bone conduction speaker in a specific embodiment, including a housing 210, a panel 220, an energy conversion device 230, and a connection member 240.

[0056] The vibration of the panel 220 is transmitted to the auditory nerve via tissues and bones, allowing people to hear sound. The panel 220 can be in direct contact with human skin, or it can be in contact with the skin via a vibration transmitting layer composed of specific materials (which will be described in detail below). The specific materials mentioned here can be selected from low-density materials, such as plastics (such as but not limited to high molecular weight polyethylene, blow molded nylon, engineering plastics, etc.), rubber, and other single or composite materials that can achieve the same performance. The rubbers are, for example, but not limited to general-purpose rubber and specialty rubber. General purpose rubbers include but are not limited to natural rubber, isoprene rubber, styrene butadiene rubber, cis-polybutadiene, chloroprene rubber, etc. Special rubbers include but are not limited to nitrile rubber, silicone rubber, fluororubber, polysulfide rubber, polyurethane rubber, chlorohydrin rubber, acrylic rubber, epoxy propane rubber, etc. Among them, styrene butadiene rubbers include but are not limited to lotion polymerized styrene butadiene rubber and solution polymerized styrene butadiene rubber. Composite materials include, for example but are not limited to glass fiber, carbon fiber, boron fiber, graphite fiber, fiber, graphene fiber, silicon carbide fiber, aramid fiber and other reinforced materials. They can also be composite of other organic and/or inorganic materials, such as glass fiber reinforced unsaturated polyester, epoxy resin, or various types of glassfiber composed of phenolic resin matrix. Other materials that can be used to make vibration transmitting layers include combinations of one or more of silicone, Poly Urethane, and Poly Carbonate. The energy conversion device 230 is an assembly that converts electrical signals into mechanical vibrations based on a certain principle. The panel 220 is connected to the energy conversion device 230 and vibrates under the drive of the energy conversion device 230. The connection member 240 connects the panel 220 and the housing 210, used to position the energy conversion device 230 within the housing. When the energy conversion device 230 transmits vibration to the panel 220, the vibration will also be transmitted to the housing via the connection member 240, causing the housing 210 to vibrate and correspondingly changing the vibration mode of the panel 220, thereby affecting the vibration transmitted from the panel 220 to the human skin.

[0057] It shall be noted that the method of fixing the energy conversion device and the panel in the housing is not limited to the connection method described in figure 2-B. Obviously, for those skilled in the art, whether to use the connection member 240, or to use the connection member 240 made of different materials, adjust the energy conversion device 230, or connect the panel 220 to the housing 210, will all exhibit different mechanical impedance characteristics, produce different vibration transmission effects, thereby affecting the overall vibration efficiency of the vibration system and producing different sound quality.

[0058] For example, if connection members are not used, the panel can be directly attached to the housing, or connected to the housing by clamping or welding. If connection members are used, connection members with moderate elastic force have a shock-absorbing effect during the transmission of vibration, which can reduce the vibration energy transmitted to the housing and effectively suppress the bone conduction speaker from leaking sound to the outside caused by housing vibration. It can also help avoid the occurrence of abnormal sound caused by possible abnormal resonance, achieving the effect of improving sound quality. The connecting pieces located at different positions inside/on the housing will also have varying degrees of impact on the transmission efficiency of vibration. Preferably, the connection members can keep the energy conversion device in different status such as a suspended or supported status.

[0059] Figure 2-B shows an example of a connection method, where the connection member 240 can be connected to the top of the housing 210. Figure 2-C shows an example of another connection method, wherein the panel 220 extends from the opening of the housing 210, and the panel 220 is connected to the energy conversion device 230 via the connecting portion 250, and connected to the housing 210 via the connection member 240.

[0060] In other embodiments, the energy conversion device can also be fixed inside the housing in other connection methods. For example, the energy conversion device can be fixed on the bottom surface of the housing via connection members, or the bottom of the energy conversion device (the side where the energy conversion device is connected to the panel is the top, and the opposite side is the bottom) can be suspended and fixed inside the housing with springs. The top of the energy conversion device can also be connected to the housing, or the energy conversion device and the housing can be connected with multiple connection members located at different positions, or any combination of the above connection methods.

[0061] In some specific embodiments, the connection member has a certain degree of elasticity. The elasticity of the connection member is determined by various factors such as the material, thickness, and structure of the connection member. The materials of the connection member can be, such as but not limited to steel (such as but not limited to stainless steel, carbon steel, etc.), lightweight alloys (such as but not limited to aluminum alloy, beryllium copper, magnesium alloy, titanium alloy, etc.), plastics (such as but not limited to high molecular weight polyethylene, blow molded nylon, engineering plastics, etc.), as well as other single or composite materials that can achieve the same performance. Composite materials can be, for example but not limited to reinforced materials such as glass fiber, carbon fiber, boron fiber, graphite fiber, graphene fiber, silicon carbide fiber, or aramid fiber. The materials that are used to make the connection member can also be composites of other organic and/or inorganic materials, such as glass fiber reinforced unsaturated polyester, epoxy resin, or various types of glassfiber composed of phenolic resin matrix. The thickness of the connection member is not less than 0.005 mm, preferably, the thickness is between 0.005 mm-3 mm, more preferably, the thickness is between 0.01 mm-2 mm, even more preferably, the thickness is between 0.01 mm-1 mm, and further preferably, the thickness is between 0.02 mm-0.5 mm.

[0062] The structure of the connection member can be disposed as a ring, preferably including at least one ring, preferably including at least two rings, which can be concentric rings or non-concentric rings. The rings are connected by at least two support rods, which radiate from the outer ring to the center of the inner ring. Furthermore, it is preferred to include at least one elliptical ring, and further preferred to include at least two elliptical rings. Different elliptical rings have different curvature radii, and the rings are connected by support rods. Furthermore, it is preferred to include at least one square ring. The connection member structure can also be designed as a sheet, preferably with a hollow pattern on the sheet. More preferably, the area of the hollow pattern is not less than the area of the non-hollow portion of the connection member. It is worth noting that the materials, thicknesses, and structures of the connection members described above can be combined in any way to form different connection members. For example, circular connection members can have different thickness distributions. Preferably, the thickness of the support rod is equal to the thickness of the circular ring, further preferably, the thickness of the support rod is greater than the thickness of the circular ring, and further preferably, the thickness of the inner ring is greater than that of the outer ring.

[0063] General technical personnel in this field can determine the material, position, and connection method of the connection member according to different practical applications, or modify, improve, or combine the properties of the different connection members mentioned above, but these modifications and improvements

are still within the scope described above. For example, the connection members described above may not be necessary. The panel can be directly mounted on the housing or bonded to the housing with adhesive. It shall be noted that the shape, size, proportion, etc. of the vibration generating portion of the bone conduction speaker in practical applications are not limited to those described in figure 2A, figure 2B, or figure 2C. When considering other factors that may affect the sound quality of the bone conduction speaker, such as the degree of sound leakage, the generated harmonics, and the wearing method, those skilled in the art can make certain changes based on the content described in the figure.

[0064] Careful design of and adjustment to the energy conversion device and panel can solve many issues that bone conduction speakers often face. For example, bone conduction speakers are prone to sound leakage. The sound leakage referred to here refers to the sound transmitted to the surrounding environment by the vibration of the bone conduction speaker during its operation. In addition to the wearer of the speaker, other people in the environment can also hear the sound emitted from the speaker. There are many reasons for the occurrence of sound leakage, including the vibration of the energy conversion device and panel transmitted to the housing via the connection member, causing the housing to vibrate, or the vibration of the energy conversion device causing air vibration inside the housing, which is transmitted to the housing and causes the housing to vibrate, resulting in sound leakage. As shown in figure 3-A, an equivalent vibration model of the vibration generating portion of a bone conduction speaker comprises a fixed end 301, a housing 311, and a panel 321. The fixed end 301 and the housing 311 are connected by an elastic body 331 and a damper 332, while the housing 311 and the panel 321 are connected by an elastic body 341. The fixed end 301 can be a point or area of relatively fixed position during the vibration process of the bone conduction speaker (which will be described in detail below). The elastic body 331 and damper 332 are determined by the connection method between the earphone holder/strap and the housing, and the influencing factors include the rigidity, shape, and composition materials of the earphone holder/strap, as well as the material properties of the connection portion between the earphone holder/strap and the housing. The earphone holder/strap mentioned here provides pressure for the bone conduction speaker to come into contact with the user. The elastic body 341 is determined by the connection method between the panel 321 (or the system composed of the panel and the energy conversion device) and the housing 311, and the influencing factors include the above-mentioned connection member 240. The vibration equation can be expressed as:

$$[0065] \quad m\ddot{x}_2 + R\dot{x}_2 - k_1(x_1 - x_2) + k_2x_2 = 0 \quad (1)$$

[0066] Among them, m is the mass of the housing 311, x_1 is the displacement of the panel 321, x_2 is the displacement of the housing 311, R is the vibration damping, k_1 is the rigidity coefficient of the elastic body 341, and k_2 is the rigidity coefficient of the elastic body 331. In the case of stable vibration (without considering transient response), the ratio of the housing vibration to the panel vibration x_2/x_1 can be derived:

$$\frac{x_2}{x_1} = \frac{1}{1 + \frac{k_2 - m\omega^2}{k_1} - j\frac{R\omega}{k_1}} \quad (2)$$

[0067]

[0068] The ratio of the housing vibration to the panel vibration x_2/x_1 mentioned here can reflect the magnitude of sound leakage of the bone conduction speaker. Generally speaking, the higher the value of x_2/x_1 , the higher the vibration of the housing compared to the effective vibration transmitted to the hearing system, and at the same volume, the higher the sound leakage; the lower the value of x_2/x_1 , the lower the vibration of the housing compared to the effective vibration transmitted to the hearing system, and the lower the sound leakage at the same volume. From this, it can be known that factors affecting the amplitude of sound leakage of bone conduction speaker include the connection method between the panel 321 (or the system composed of the panel and the energy conversion device) and the housing 311 (the rigidity coefficient k_1 of the elastic body 341), the earphone holder/strap and housing system (k_2 , R , m), etc. In one embodiment, the rigidity coefficient k_1 , the housing mass m , and the damping R of the elastic body 331 are related to the shape of the speaker and the wearing method. After determining k_1 , m , and R , the relationship between x_2/x_1 and the rigidity coefficient k_1 of the elastic body 341 is shown in figure 3-B. From the figure, it can be known that different rigidity coefficients k_1 will affect the ratio of the amplitude of the housing vibration to the amplitude of the panel vibration, i.e. x_2/x_1 . When the frequency f is greater than 200 Hz, the vibration of the housing is smaller than that of the panel ($x_2/x_1 < 1$), and as the frequency increases, the vibration of the housing gradually decreases. Specifically, as shown in figure 3-B, for different values of k_1 (with rigidity coefficients disposed from left to right as 5 times, 10 times, 20 times, 40 times, 80 times, and 160 times of k_2), when the frequency is greater than 400 Hz, the housing vibration is already less than 1/10 of the panel vibration ($x_2/x_1 < 0.1$). In specific embodiments, reducing the value of rigidity coefficient k_1 (for example, using connection member 240 with a lower rigidity coefficient) can effectively reduce the vibration of the housing, thereby reducing sound leakage.

[0069] In specific embodiments, using connection members made of specific materials and connection methods can reduce sound leakage. For example, using elastic connection members to connect the panel, energy conversion device, and housing can reduce the vibration amplitude of the housing under higher vibrations of the panel, thereby reducing sound leakage. There are many materials that can be used to make connection members, including but not limited to stainless steel, beryllium copper, plastic (such as polycarbonate), etc. The shape of the connection member can be disposed in many ways. For example, the connection member can be a circular ring with at least two support rods converging towards the center. The thickness of the circular ring is not less than 0.005 mm, preferably between 0.005 mm-3 mm, more preferably between 0.01 mm-2 mm, even more preferably between 0.01 mm-1 mm, and even more preferably between 0.02 mm-0.5 mm. In another embodiment, the connection member can be a circular ring piece, which can be further provided with multiple intermittent ring holes, forming intermittent intervals between each ring hole. For example, a certain number of sound holes that meet certain conditions can be made on the housing or the panel (or on the vibration transmitting layer outside the panel, which will be described in detail below). During the vibration process of the energy conversion device, the sound waves inside the housing can be guided and propagated to the outside of the housing, and interact with the sound leakage waves formed by the vibration of the housing, achieving the effect of suppressing the sound leakage of the bone conduction speaker. For example, a housing made of sound absorbing materials can be selected, or sound absorbing materials can be used on at least a portion of the housing. Sound absorbing materials can be used on one or more inner/outer surfaces of the housing, or on a portion of an inner/outer surface of the housing. Sound absorbing materials refer to materials that can absorb incident sound energy by one or more mechanisms such as their physical properties (such as but not limited to porosity), thin film effects, and resonance effects. In particular, sound absorbing materials can be porous materials or materials with porous structure, including but not limited to organic fiber materials (such as but not limited to natural plant fibers, organic synthetic fibers, etc.), inorganic fiber materials (such as but not limited to glass wool, slag wool, aluminum silicate wool, rock wool, etc.), metal sound absorbing materials (such as but not limited to metal fiber sound absorbing boards, foam metal materials, etc.), rubber sound absorbing materials, foam plastic sound absorbing materials (such as but not limited to polyurethane foam, PVC foam, polyacrylate polystyrene foam, phenolic resin foam, etc.), etc.; they can also be a flexible material that absorbs sound via resonance, including but not limited to closed cell foam plastic; membrane materials, including but not limited to plastic film, cloth, canvas, lacquer cloth, or synthetic leather; board like materials, including but not limited to hard fiberboard, gypsum board, plastic board, metal board), or perforated board (such as those made by punching holes in the board like material). Sound absorbing materials can be one or a combination of multiple types, or they can be composite materials. The sound absorbing material can be disposed on the housing, or separately on the vibration transmitting layer vibrating the housing or on the housing.

[0070] The housing, vibration transmitting layer, and panel attached to the vibration transmitting layer together constitute the vibration unit of the bone conduction speaker. The energy conversion device is located in the vibration unit and transmits vibration to the vibration unit via connections with the panel and housing. Preferably, at least 1% of the vibration unit is made of sound absorbing material, more preferably, at least 5% of the vibration unit is made of sound absorbing material, and further preferably, at least 10% of the vibration unit is made of sound absorbing material. Preferably, at least 5% of the housing is made of sound absorbing material, more preferably, at least 10% of the housing is made of sound absorbing material, further preferably, at least 40% of the housing is made of sound absorbing material, and even further preferably, at least 80% of the housing is made of sound absorbing material. In further embodiments, a compensation circuit can be introduced to actively control the sound leakage based on its properties, generating a reverse signal with the opposite phase to the sound leakage, thereby suppressing the sound leakage. It shall be noted that the methods described above for changing the sound quality of bone conduction speakers can be selected or combined to obtain various implementation schemes, which are still within the scope of protection of the present invention.

[0071] The above description of the structure of the bone conduction speaker that generates vibration is only a specific example and shall not be considered as the only feasible implementation solution. Obviously, for those skilled in the art, after understanding the basic principle, they may make various modifications and changes to the specific structure and connection method of implementing vibration without deviating from the principle, but these modifications and changes are still within the scope described above. For example, the connection portion 250 in figures 2-B and 2-C can be a portion of the panel 220, bonded to the energy conversion device 230 with adhesive; it can also be a portion of the energy conversion device 230 (such as the protruding portion on the vibrating plate), bonded to the panel 220 with adhesive; it can also be an independent assembly that is

bonded to both the panel 220 and the energy conversion device 230 with adhesive. Of course, the connection method between the connection portion 250 and the panel 220 or the energy conversion device 230 is not limited to bonding. The other connection methods known to those skilled in the art are also applicable to the present invention, such as clamping or welding. Preferably, the panel 220 and the housing 210 can be directly bonded with adhesive. More preferably, they can be connected by components similar to the elastic member 240. Further preferably, they can be connected to the housing 210 by adding a vibration transmitting layer (which will be described in detail below) on the outside of the panel 220. It shall be noted that the connection portion 250 is a schematic diagram describing the connection between different components. Those skilled in the art can use components with similar functions and different shapes to replace it, and these substitutions and changes are still within the scope of protection described above.

[0072] In step 103, the sound is transmitted to the hearing system via the transmission system. The transmission system can directly transmit sound vibrations to the hearing system via a medium, or it can include processing the sound before transmitting it to the hearing system.

[0073] Figure 4 is a specific embodiment of a sound transmission system, in which the bone conduction speaker 401 is in contact with the ear, cheek, or forehead during operation, transmitting sound vibrations to the skin 402, passing through subcutaneous tissue 403 and bone 404 to the cochlea 405, and ultimately transmitted to the brain by the cochlear auditory nerve. The sound quality perceived by the human body is influenced by the transmission medium and other factors that affect the physical properties of the transmission medium. For example, the density and thickness of skin and subcutaneous tissues, the shape and density of bones, and other human tissues via which vibrations may be transmitted can all affect the final sound quality. Furthermore, in the process of vibration transmission, the portion of the bone conduction speaker in contact with the human body and the vibration transmission efficiency of human tissues will also affect the final sound effect.

[0074] For example, the panel of a bone conduction speaker transmits vibrations via human tissues to the human hearing system. Changing the material, contact area, shape, and/or size of the panel, as well as the interaction force between the panel and the skin, can affect the transmission efficiency of sound via the medium, thereby affecting the sound quality. For example, under the same driving force, the vibrations transmitted by panels of different sizes have different distributions on the fitting surface of the wearer, resulting in differences in volume and sound quality. Preferably, the area of the panel is not less than 0.15 cm^2 , more preferably, the area is not less than 0.5 cm^2 , and further preferably, the area is not less than 2 cm^2 . For example, the panel vibrates due to the drive of the energy conversion device, and the bonding point between the panel and the energy conversion device is at the center of the panel vibration. Preferably, the mass distribution of the panel around the vibration center is even (i.e., the vibration center is the physical center of the panel), and more preferably, the mass distribution of the panel around the vibration is uneven (i.e., the vibration center deviates from the physical center of the panel). For example, a vibrating plate can be connected to multiple panels. The shapes and materials of multiple panels can be the same or different from each other. Multiple panels can be connected or not connected. Multiple panels transmit sound and vibration in multiple ways. The vibration transmitting modes between different paths are different from each other, and the positions of vibration transmitted to the panels are also different. The vibration signals between different panels can complement each other to generate a relatively flat frequency response. For example, dividing a large vibrating plate into two or more smaller vibrating plates can effectively improve the uneven vibration caused by panel deformation at high frequencies, making the frequency response more ideal.

[0075] It is worth noting that the physical properties of the panel, such as mass, size, shape, rigidity, vibration damping, etc., can all affect the efficiency of panel vibration. Those skilled in the art can choose panels made of appropriate materials according to actual needs, or use different molds to inject panels into different shapes. Preferably, the shape of the panel can be disposed as rectangular, circular, or elliptical. More preferably, the shape of the panel can be obtained by cutting the edges of the rectangular, circular, or elliptical shape (such as but not limited to an elliptical shape obtained by symmetrically cutting the circular shape, etc.). Further preferably, the panel can be disposed as hollow. The panel materials referred to here include but are not limited to acrylonitrile butadiene styrene (ABS), polystyrene (PS), high impact polystyrene (HIPS), polypropylene (PP), polyethylene terephthalate (PET), polyester (PES), polycarbonate

(PC), polyamides (PA), polyvinyl chloride (PVC), polyurethane (PU), polyvinylidene chloride, polyethylene (PE), polymethyl methacrylate (PMMA), polyetheretherketone (PEEK), phenolics (PF), Urea-formaldehyde (UF), melamine formaldehyde (MF), as well as some metals, alloys (such as aluminum alloys, chromium molybdenum steel, scandium alloys, magnesium alloys, titanium alloys, magnesium lithium alloys, nickel alloys, etc.) or composite materials. The relevant parameters include the relative density, tensile strength, elastic modulus, Rockwell hardness, etc. of the material. Preferably, the relative density of the panel material is 1.02-1.50, more preferably, the relative density is 1.14-1.45, and further preferably, the relative density is 1.15-1.20. The tensile strength of the panel is not less than 30 MPa, more preferably, the tensile strength is 33 MPa-52 MPa, and further preferably, the tensile strength is not less than 60 MPa. The elastic modulus of the panel material can range from 1.0 GPa to 5.0 GPa, more preferably, the elastic modulus ranges from 1.4 GPa to 3.0 GPa, and further preferably, the elastic modulus ranges from 1.8 GPa to 2.5 GPa. Similarly, the hardness (Rockwell hardness) of the panel material can be 60-150, more preferably, the hardness can be 80-120, and further preferably, the hardness can be 90-100. Specifically, considering both the panel material and tensile strength, the relative density can be 1.02-1.1, the tensile strength can be 33 MPa-52 MPa, and more preferably, the relative density of the panel material is 1.20-1.45, and the tensile strength is 56-66 MPa.

[0076] In other embodiments, the outer side of the panel of the bone conduction speaker is wrapped with a vibration transmitting layer, which is in contact with the skin. The vibration system composed of the panel and the vibration transmitting layer transmits the generated sound vibration to the human tissues. Preferably, a vibration transmitting layer is wrapped around the outer side of the panel, and more preferably, multiple vibration transmitting layers are wrapped around the outer side of the panel. The vibration transmitting layer can be made of one or more materials, and the material composition of different vibration transmitting layers can be the same or different. The multiple vibration transmitting layers can be stacked on top of each other in the vertical direction of the panel, or arranged horizontally in the horizontal direction of the panel, or in a combination of the above two arrangements. The area of the vibration transmitting layer can be disposed to different sizes, preferably, the area of the vibration transmitting layer is not less than 1 cm², more preferably, the area of the vibration transmitting layer is not less than 2 cm², and further preferably, the area of the vibration transmitting layer is not less than 6 cm².

[0077] The composition of the vibration transmitting layer can be materials with certain adsorption, flexibility, and chemical properties, such as plastics (such as but not limited to high molecular weight polyethylene, blow molded nylon, engineering plastics, etc.), rubber, or other single or composite materials that can achieve the same performance. The rubbers are, for example, but not limited to general-purpose rubber and specialty rubber. General purpose rubbers include but are not limited to natural rubber, isoprene rubber, styrene butadiene rubber, cis-polybutadiene, chloroprene rubber, etc. Special rubbers include but are not limited to nitrile rubber, silicone rubber, fluororubber, polysulfide rubber, polyurethane rubber, chlorohydrin rubber, acrylic rubber, epoxy propane rubber, etc. Among them, styrene butadiene rubbers include but are not limited to lotion polymerized styrene butadiene rubber and solution polymerized styrene butadiene rubber. Composite materials include, for example but are not limited to glass fiber, carbon fiber, boron fiber, graphite fiber, fiber, graphene fiber, silicon carbide fiber, aramid fiber and other reinforced materials. They can also be composite of other organic and/or inorganic materials, such as glass fiber reinforced unsaturated polyester, epoxy resin, or various types of glassfiber composed of phenolic resin matrix. Other materials that can be used to make vibration transmitting layers include combinations of one or more of silicone, Poly Urethane, and Poly Carbonate.

[0078] The presence of the vibration transmitting layer can affect the frequency response of the system, change the sound quality of the bone conduction speaker, and also provide protection for the components inside the housing. For example, the vibration transmitting layer can change the vibration mode of the panel, making the overall frequency response of the system smoother. The vibration mode of the panel is influenced by factors such as the properties of the panel itself, the connection method between the panel and the vibrating plate, the connection method between the panel and the vibration transmitting layer, and the vibration frequency. The properties of the panel itself include but are not limited to its quality, size, shape, rigidity, vibration damping, etc. Preferably, a panel with uneven thickness can be used (such as but not limited to, the center thickness of the panel being greater than the edge thickness). The connection methods between the panel and the vibration board include but are not limited to adhesive bonding, clamping, or welding; the connection between the panel and the vibration transmitting layer includes but is not limited to adhesive connection; different vibration frequencies correspond to different vibration

modes of the panel, including overall translation and varying degrees of torsional translation. Choosing a panel with a specific vibration mode within a specific frequency range can change the sound quality of the bone conduction speaker. Preferably, the specific frequency range referred to here can be between 20 Hz-20,000 Hz, more preferably, the frequency range can be between 400 Hz-10,000 Hz, further preferably, the frequency range can be between 500 Hz-2,000 Hz, and even further preferably, the frequency range can be between 800 Hz-1,500 Hz.

[0079] Preferably, the vibration transmitting layer described above is wrapped around the outside of the panel, forming one side of the vibration unit. The transmission effect of vibration varies in different regions of the vibration transmitting layer. For example, there is a first contact surface area and a second contact surface area on the vibration transmitting layer. Preferably, the first contact surface area is not in contact with the panel, and the second contact surface area is in contact with the panel; more preferably, when the vibration transmitting layer comes into direct or indirect contact with the user, the clamping force on the first contact surface area is less than the clamping force on the second contact surface area (the clamping force refers to the pressure between the contact surface of the vibration unit and the user); further preferably, the first contact surface area is not in direct contact with the user, and the second contact surface area is in direct contact with the user and transmits vibration. The area of the first contact surface area is not equal to that of the second contact surface area. Preferably, the area of the first contact surface area is smaller than that of the second contact surface area. More preferably, there are small holes in the first contact surface area to further reduce the area of the first contact surface area; the outer surface of the vibration transmitting layer (i.e. the surface facing the user) can be flat or uneven, and preferably, the first contact surface area and the second contact surface area are not on the same plane; more preferably, the second contact surface area is higher than the first contact surface area; further preferably, the second contact surface area and the first contact surface area form a stepped structure; more preferably, the second contact surface area is in contact with the user, while the first contact surface area is not in contact with the user. The composition materials of the first contact surface area and the second contact surface area can be the same or different, and can be a combination of one or more of the vibration transmitting layer materials described above. The above description of the clamping force on the contact surface is only one manifestation of the present invention. Those skilled in the art can modify the structure and method described above according to actual needs, and these modifications are still within the scope of protection of the present invention. For example, the vibration transmitting layer may not be necessary, and the panel can be in direct contact with the user. Different contact surface areas can be disposed on the panel, wherein different contact surface areas have similar properties to the first and second contact surface areas described above. For example, a third contact surface area can be disposed on the contact surface, and structures different from the first and second contact surface areas can be disposed on the third contact surface area, and these structures can achieve certain effects in reducing housing vibration, suppressing sound leakage, and improving the frequency response curve of the vibration unit.

[0080] As a specific embodiment, figures 5-A and 5-B respectively show the front and side view of the panel connected to the vibration transmitting layer. Among them, the panel 501 and the vibration transmitting layer 503 are bonded with adhesive 502, wherein the adhesive bonding area is located at both ends of the panel 501, and the panel 501 is located inside the housing formed by vibration transmitting layer 503 and the housing 504. Preferably, the projection of the panel 501 onto the vibration transmitting layer 503 is the second contact surface area, and the area surrounding the second contact surface area is the first contact surface area.

[0081] The panel and the vibration transmitting layer can be thoroughly bonded with adhesive, which effectively changes the quality, size, shape, rigidity, vibration damping, vibration mode and other properties of the panel, and also makes the vibration transmission efficiency higher; the panel and the vibration transmitting layer can also be partially bonded with adhesive, and then there is gas conduction in the non-adhesive area between the panel and the transmitting layer, which can enhance the transmission of low-frequency vibrations and improve the effect of low frequencies in sound. Preferably, the adhesive area accounts for 1%-98% of the panel area, more preferably, the adhesive area accounts for 5%-90% of the panel area, even more preferably, the adhesive area accounts for 10%-60% of the panel area, and even more preferably, the adhesive area accounts for 20%-40% of the panel area; adhesive may not be used to bond the panel and the vibration transmitting layer, and then the vibration transmission efficiency between the panel and the transmitting layer can also be different from the case of using adhesive for bonding, which can also change the sound quality of the bone conduction speaker. In specific embodiments, changing the adhesive bonding method can change the vibration mode of the corresponding components in the bone conduction speaker, thereby changing the sound generation and transmission effect. Furthermore, the properties of the adhesive can also affect the sound quality of bone conduction speakers, such as the hardness, shear strength, tensile strength, and ductility of the adhesive. For example, preferably, the tensile strength of the adhesive is not less than

1 MPa, more preferably, the tensile strength is not less than 2 MPa, and further preferably, the tensile strength is not less than 5 MPa; Preferably, the elongation at break of the adhesive is 100%-500%, and more preferably, the elongation at break is 200%-400%; Preferably, the shear strength of the adhesive is not less than 2 MPa, and more preferably, the shear strength is not less than 3 MPa; Preferably, the Shore hardness of the adhesive is between 25-30, and more preferably, the Shore hardness is between 30-50. One type of adhesive can be used, or adhesives with different properties can be combined. The bonding strength between the adhesive and the panel, as well as between the adhesive and the plastic, can also be disposed within a certain range, such as but not limited to 8 MPa-14 MPa. It shall be noted that the vibration transmitting layer material in the embodiments is not limited to silicone, and plastic, biomaterials, or other materials with certain adsorption, flexibility, and chemical properties can also be used. Those skilled in the art can also decide on the type and properties of adhesive as well as the panel material and vibration transmitting layer material bonded with the adhesive according to actual needs, which to some extent determines the sound quality of bone conduction speakers.

[0082] Figure 6 is a specific embodiment of the connection method of various components in the vibration generation portion of the bone conduction speaker. The energy conversion device 610 is connected to the housing 620, and the panel 630 is bonded to the vibration transmitting layer 640 with adhesive 650. The edge of the vibration transmitting layer 640 is connected to the housing 620. In different embodiments, the frequency response of the bone conduction speaker can be altered by changing the distribution, hardness, or amount of adhesive 650, or by changing the hardness of the transmitting layer 640, thereby changing the sound quality. Preferably, adhesive may not be applied between the panel and the vibration transmitting layer. More preferably, the panel and the vibration transmitting layer can be thoroughly applied with adhesive. Further preferably, some areas between the panel and the vibration transmitting layer can be applied with adhesive, and even more preferably, the area of the region applied with adhesive between the panel and the vibration transmitting layer is not greater than the area of the panel.

[0083] Those skilled in the art can decide the amount of adhesive to be applied according to actual needs, so as to achieve the effect of adjusting the sound quality of the speaker. As shown in figure 7, in one embodiment, the influence of different adhesive connection methods on the frequency response of bone conduction speakers is reflected. The three curves correspond to the frequency response when there is no vibration transmitting layer and adhesive, when the vibration transmitting layer and panel are not thoroughly applied with adhesive, and when the vibration transmitting layer and panel are thoroughly applied with adhesive. It can be known that compared to the case of thoroughly applied adhesive, when a small amount of adhesive is applied or adhesive is not applied between the vibration transmitting layer and the panel, the resonant frequency of the bone conduction speaker will shift towards lower frequencies. The bonding between the vibration transmitting layer and the panel using adhesive can reflect the influence of the vibration transmitting layer on the vibration system. Therefore, changing the bonding method of the adhesive can cause a significant change in the frequency response curve of the bone conduction speaker.

[0084] Those skilled in the art can adjust and improve the bonding method and amount of adhesive according to actual frequency response requirements, thereby improving the sound quality of the system. Similarly, in another embodiment, figure 8 reflects the influence of the hardness of different vibration transmitting layers on the vibration response curve. The solid line represents the vibration response curve of a bone conduction speaker with a harder transmitting layer, while the dashed line represents the vibration response curve of a bone conduction speaker with a softer transmitting layer. It can be known that using vibration transmitting layers of different hardness can enable bone conduction speakers to achieve different frequency responses. The greater the hardness of the vibration transmitting layer, the stronger its ability to transmit high-frequency vibrations; the smaller the hardness of the vibration transmitting layer, the stronger its ability to transmit low-frequency vibrations. Choosing vibration transmitting layers made of different materials (not limited to silicone, plastic, etc.) can achieve different sound qualities. For example, using a vibration transmitting layer made of 45-degree silicone on a bone conduction amplifier can achieve good low-frequency effects, while using a vibration transmitting layer made of 75-degree silicone can achieve good high-frequency effects. The low frequency referred to here refers to sound below 500 Hz, the medium frequency refers to sound in the range of 500 Hz-4,000 Hz, and the high frequency refers to sound above 4,000 Hz.

[0085] Of course, the above description of adhesive and the vibration transmitting layer is only an embodiment that can affect the sound quality of bone conduction speakers and shall not be considered as the only feasible implementation solution. Obviously, for those skilled in the art, after understanding the basic principles that affect the sound quality of bone conduction speakers, they may adjust and change the various components and connection methods in the vibration generating portion of the bone conduction speaker without deviating from the principles. However, these adjustments and changes are still within the scope of protection described above. For example, the material of the vibration transmitting layer can be arbitrary or customized according to the user's usage habits. The use of adhesive with different hardness after curing between the vibration transmitting layer and the panel may also

affect the sound quality of bone conduction speakers. In addition, increasing the thickness of the vibration transmitting layer can be equivalent to increasing the mass in the composed vibration system, and can also achieve the effect of reducing the resonant frequency of the system. Preferably, the thickness of the transmitting layer is 0.1 mm-10 mm, more preferably, the thickness is 0.3 mm-5 mm, even more preferably, the thickness is 0.5 mm-3 mm, and further preferably, the thickness is 1 mm-2 mm. The tensile strength, viscosity, hardness, tear strength, elongation, etc. of the transmitting layer can also affect the sound quality of the system. The tensile strength of the transmitting layer material refers to the force required per unit range to cause tearing of the transmitting layer sample. Preferably, the tensile strength is 3.0 MPa-13 MPa, more preferably, the tensile strength is 4.0 MPa-12.5 MPa, and further preferably, the tensile strength is 8.7 MPa-12 MPa. Preferably, the Shore hardness of the transmitting layer is 5-90, more preferably, the Shore hardness is 10-80, and further preferably, the Shore hardness is 20-60. The elongation of the transmitting layer refers to the percentage increase relative to the original length when the transmitting layer breaks. Preferably, the elongation is between 90% and 1,200%, more preferably, the elongation is between 160% and 700%, and further preferably, the elongation is between 300% and 900%. The tear strength of the transmitting layer refers to the resistance that hinders the expansion of the cut or scratch when force is applied to the transmitting layer with a cut. Preferably, the tear strength is between 7 kN/m-70 kN/m, more preferably, the tear strength is between 11 kN/m-55 kN/m, and further preferably, the tear strength is between 17 kN/m-47 kN/m. [0086] In the vibration system composed of the panel and the vibration transmitting layer described above, in addition to changing the physical properties of the panel and the transmitting layer, as well as the bonding method between the panel and the vibration transmitting layer, the performance of the bone conduction speaker can also be changed from other aspects.

[0087] A carefully designed vibration generating portion containing a vibration transmitting layer can further effectively reduce the sound leakage of bone conduction speakers. Preferably, making holes on the surface of the vibration transmitting layer can reduce sound leakage. In an embodiment as shown in figure 9, the vibration transmitting layer 940 is bonded to the panel 930 with adhesive 950. The bonded area between the vibration transmitting layer and the panel is raised higher than the non-bonded area on the vibration transmitting layer 940, and there is a cavity below the non-bonded area. The non-bonded area on the vibration transmitting layer 940 and the surface of the housing 920 are respectively provided with sound holes 960. Preferably, the non-bonded area where some sound holes are made shall not come into contact with the user. On the one hand, the sound hole 960 can effectively reduce the non-bonded area on the vibration transmitting layer 940, allowing for air permeability inside and outside the vibration transmitting layer, reducing the pressure difference between the inside and outside air, and thus reducing vibration in the non-bonded area; On the other hand, the sound hole 960 can guide the sound waves formed by the vibration of the air inside the housing 920 to the outside of the housing 920, and offset the sound leakage waves formed by the vibration of the housing 920 pushing the air outside the housing, thereby reducing the amplitude of the sound leakage waves. Specifically, the amplitude of sound leakage of a bone conduction speaker at any point in space is proportional to the sound pressure P at that point,

[0088] Wherein,

$$[0089] P = P_0 + P_1 + P_2 \quad (3)$$

[0090] P_0 is the sound pressure generated by the housing (including the portion of the vibration transmitting layer that does not come into contact with the skin) at the above-mentioned point, P_1 is the sound pressure transmitted by the sound hole on the side of the housing at the above-mentioned point, P_2 is the sound pressure transmitted by the sound hole on the vibration transmitting layer at the above-mentioned point, and P_0 , P_1 , and P_2 are respectively as follows:

$$[0091] P_0(x, y, z) = -j\omega\rho_0 \iint_{S_0} W_0(x', y') \cdot \frac{\exp(j(kR(x', y') + \phi(x', y')))}{4\pi R(x', y')} dx' dy' \quad (4)$$

$$[0092] P_1(x, y, z) = -j\omega\rho_0 \iint_{S_1} W_1(x', y') \cdot \frac{\exp(j(kR(x', y') + \phi(x', y')))}{4\pi R(x', y')} dx' dy' \quad (5)$$

$$[0093] P_2(x, y, z) = -j\omega\rho_0 \iint_{S_2} W_2(x', y') \cdot \frac{\exp(j(kR(x', y') + \phi(x', y')))}{4\pi R(x', y')} dx' dy' \quad (6)$$

[0094] Among them, k represents the wave vector, ρ_0 represents the air density, ω represents the angular frequency of vibration, $R(x', y')$ represents the distance from a point on the sound source to a point in space, S_0 is the housing area that is not in contact with the human face, S_1 is the opening area of the sound hole on the side of the housing, S_2 is the opening area of the sound hole on the vibration transmitting layer, $W(x, y)$ represents the intensity of the sound source per unit area, and ϕ represents the phase difference of the sound

pressure generated by different sound sources at a point in space. It is worth noting that there are some areas on the vibration transmitting layer that do not come into contact with the skin (such as the edge area where the sound hole 960 on the vibration transmitting layer 940 is located in figure 9). These areas are affected by the vibration of the panel and the housing, which generate vibration and radiate sound to the outside. The housing area mentioned above shall include the portions of the vibration transmitting layer that do not come into contact with the skin. The sound pressure at any point in space (at an angular frequency of ω) can be expressed as:

$$[0095] \quad P = (A_0 + A_1 \exp(j\varphi_1) + A_2 \exp(j\varphi_2)) \exp(j\omega t) \quad (7)$$

[0096] Our goal is to minimize the value of P as much as possible so as to achieve the effect of reducing sound leakage. In practical use, the coefficient A_1 and A_2 can be adjusted by adjusting the size and quantity of the sound holes, and adjusting the position of the sound hole can adjust the value of the phase φ_1 and φ_2 . After understanding the principle that the vibration system composed of the panel, the energy conversion device, the vibration transmitting layer, and the housing can affect the sound quality of bone conduction speakers, those skilled in the art can adjust the shape, opening position, quantity, size, and damping of the sound hole according to actual needs, so as to achieve the goal of suppressing sound leakage. For example, the quantity of sound holes can be one or more, preferably the number is over one. For sound holes arranged in a circular pattern on the side of the housing, the number of sound holes in each distribution area can be one or more, such as 4-8. The shape of the sound hole can be circular, elliptical, rectangular, or elongated. The sound holes on a bone conduction speaker can be of the same shape or a combination of multiple different shapes of sound holes. For example, sound holes in different shapes and quantities are arranged on the vibration transmitting layer and the side of the housing, and the quantity and density of sound holes on the vibration transmitting layer are higher than those on the side of the housing. For example, arranging multiple small holes on the vibration transmitting layer can effectively reduce the area of the vibration transmitting layer that does not come into contact with the skin, thereby reducing the sound leakage generated by that portion. For example, adding damping or sound absorbing materials to the sound holes on the vibration transmitting layer/housing side can further enhance the purpose of suppressing sound leakage. Furthermore, the sound hole can be made with other materials or structures that facilitate the transmission of air vibrations inside the housing to the outside. For example, using phase adjusting materials (such as but not limited to sound absorbing materials) as portion of the housing material, so that the phase of the air vibration transmitted is within the range of 90° to 270° with the vibration phase of other portions of the housing, thereby achieving the purpose of sound offsetting. The description of the arrangement of sound holes on the housing occurred in Chinese patent application number 201410005804.0 submitted on January 6, 2014, titled "A Method for Suppressing Sound leakage in Bone Conduction Speakers and Bone Conduction Speakers". The full text of this patent document is cited here for reference. Furthermore, by adjusting the connection method between the energy conversion device and the housing, the phase of vibration in other portions of the housing can be changed, and the phase difference between it and the sound transmitted from the sound hole can be within the range of 90° to 270° , thus achieving the purpose of sound offsetting. For example, elastic connection members are used between the energy conversion device and the housing. The materials of the connection members can be, for example but not limited to steel (such as but not limited to stainless steel, carbon steel, etc.), lightweight alloys (such as but not limited to aluminum alloy, beryllium copper, magnesium alloy, titanium alloy, etc.), and plastics (such as but not limited to high molecular weight polyethylene, blow molded nylon, engineering plastics, etc.), and can also be other single or composite materials that can achieve the same performance. Composite materials can be, for example but not limited to reinforced materials such as glass fiber, carbon fiber, boron fiber, graphite fiber, graphene fiber, silicon carbide fiber, or aramid fiber. The materials that are used to make the connection member can also be composites of other organic and/or inorganic materials, such as glass fiber reinforced unsaturated polyester, epoxy resin, or various types of glassfiber composed of phenolic resin matrix. The thickness of the connection member is not less than 0.005 mm, preferably, the thickness is between 0.005 mm-3 mm, more preferably, the thickness is between 0.01 mm-2 mm, even more preferably, the thickness is between 0.01 mm-1 mm, and further preferably, the thickness is between 0.02 mm-0.5 mm. The structure of the connection member can be disposed as a ring, preferably including at least one ring, preferably including at least two rings, which can be concentric rings or non-concentric rings. The rings are connected by at least two support rods, which radiate from the outer ring to the center of the inner ring. Furthermore, it is preferred to include at least one elliptical ring, and further preferred to include at least two elliptical rings. Different elliptical rings have different curvature radii, and the rings are connected by support rods. Furthermore, it is preferred to include at least one square ring. The connection member structure can also be designed as a sheet, preferably with a hollow pattern on the sheet. More preferably, the area of the hollow pattern is not less than the area of the non-hollow portion of the connection member. It is worth noting that the materials, thicknesses, and structures of the connection members described above can be combined in any way to form different connection members. For example, circular connection members can have different thickness distributions. Preferably,

the thickness of the support rod is equal to the thickness of the circular ring, further preferably, the thickness of the support rod is greater than the thickness of the circular ring, and further preferably, the thickness of the inner ring is greater than that of the outer ring.

[0097] The above description of the sound hole is an embodiment of the present invention and does not constitute a limitation on the bone conduction speaker in improving sound quality, suppressing sound leakage, etc. Inventors in this field can make various modifications and improvements to the above described embodiments, which are still within the scope of protection described above. For example, preferably, the sound hole is only made on the vibration transmitting layer, more preferably, the sound hole starts only in the area where the vibration transmitting layer does not overlap with the panel, further preferably, the sound hole is made in the area not in contact with the user, and even more preferably, the sound hole is made in a cavity inside the vibration unit. For example, the sound holes can also be made on the bottom wall of the housing. The number of sound holes made on the bottom wall can be one arranged at the center of the bottom wall, or more arranged in a circular and evenly distributed manner around the center of the bottom wall. For example, the sound holes can be made on the side walls of the housing, and the number of sound holes made on the side walls of the housing can be one or more, evenly distributed in the circumferential direction.

[0098] The above description of vibration transmission in bone conduction speakers is only a specific example and shall not be considered as the only feasible implementation solution. Obviously, for those skilled in the art, after understanding the basic principles of bone conduction speakers, they may make various modifications and changes to the vibration description of bone conduction speakers in form and detail without deviating from the principles, but these modifications and changes are still within the scope of the above description. For example, using implantable bone conduction hearing aids can be directly attached to the bones of the human body, transmitting sound vibrations directly to the bones without passing through the skin or subcutaneous tissues. This can to some extent avoid attenuation and changes in frequency response caused by the skin or subcutaneous tissues during vibration transmission. For example, in some applications, the conduction site can be tooth, that is, the bone conduction device can be attached to tooth to transmit sound vibrations to bones and surrounding tissues via tooth, which, to a certain extent, can also reduce the influence of skin on frequency response during vibration. The above introduction to the application scenarios of bone conduction is only for descriptive purposes. After understanding the basic principles of bone conduction, those skilled in the art can apply bone conduction technology to different scenarios. In these scenarios, the transmission of sound can be a partial change to the transmission pathways described above, and these changes are still within the scope of protection described above.

[0099] In step 104, the sound quality perceived by the human body is also related to the human hearing system, and different populations may have varying levels of sensitivity to sounds in different frequency ranges. In some embodiments, the sensitivity of the human body to sounds of different frequencies can be reflected via an equal loudness curve. Some populations are not sensitive to sounds within a specific frequency range in the sound signal, resulting in a lower response intensity at the corresponding frequency on the equal loudness curve compared to other frequencies. For example, some populations are not sensitive to high-frequency sound signals, that is, they exhibit a lower intensity response at the corresponding high-frequency signal than at other frequencies on the equal loudness curve; Some populations are not sensitive to mid- to low-frequency sound signals, and on the equal loudness curve, the intensity response to the corresponding mid- to low-frequency signals is lower than that to other frequencies. The low frequency referred to here refers to sound below 500 Hz, the medium frequency refers to sound in the range of 500 Hz-4,000 Hz, and the high frequency refers to sound above 4,000 Hz.

[0100] Of course, the low and high frequencies of sound can be relative. For certain special populations, the hearing system can selectively change or adjust the distribution of sound intensity produced by bone conduction speakers within the corresponding frequency range to achieve different sound experiences. It is worth noting that the high frequency, mid frequency, or low frequency portions of the sound signal discussed above can be descriptions of the corresponding portions within the hearing range of a normal human ear, or descriptions of the corresponding portions within the natural sound range that the speaker is intended to exhibit.

[0101] In one embodiment, the equal loudness curve of the hearing system of certain population is shown as curve 3 in figure 10. A peak occurs near the frequency of point A, indicating that this population is more sensitive to sounds at frequencies near point A than at other frequency points (such as point B in the figure). When designing bone conduction speakers, it is possible to compensate for the insensitive frequency portions in the human auditory system. Curve 4 in the figure is a frequency response curve of a bone conduction speaker that compensates for hearing curve 3, and there is a resonance peak near the frequency of point B.

By combining the equal loudness curve 3 when the human ear receives sound and the frequency response curve 4 generated by the bone conduction speaker, the final sound heard by the human body is more ideal and the sound perception is wider. As a specific example, the frequency at point A can be selected at around 500 Hz, and the frequency at point B can be selected at around 2,000 Hz. It shall be noted that the above examples of frequency compensation for bone conduction speakers shall not be considered as the only feasible implementation solution. After understanding their principles, those skilled in the art can dispose appropriate peak values and compensation methods for practical application scenarios.

[0102] Obviously, for those skilled in the art, after understanding the relevant basic principles, they may make various modifications and changes in form and detail to the specific methods and choices of implementing bone conduction speakers without deviating from the principles. However, these modifications and changes are still within the scope described above. For example, bone conduction hearing aids are also applicable to the frequency response compensation method for bone conduction speakers mentioned above. That is, one or several hearing aid frequency response characteristics can be designed for the hearing response curve of the hearing-impaired population to compensate for their possible insensitivity to specific frequency ranges. In practical applications, bone conduction hearing aids can intelligently select or adjust their frequency response based on user input information. For example, the system automatically obtains or the user inputs their own equal loudness curve, and adjusts the frequency response of the bone conduction speaker based on this curve to compensate for specific frequencies of sound. In one embodiment, for points on the equal loudness curve with relatively low loudness (such as the minimum point on the curve), the frequency response amplitude of the bone conduction speaker near the frequency corresponding to that point can be increased to achieve ideal sound quality. Similarly, for points on the equal loudness curve with relatively high loudness (such as the maximum point on the curve), the frequency response amplitude of the bone conduction speaker near the frequency corresponding to that point can be reduced. Furthermore, there can be multiple maximum or minimum points on the frequency response curve or the human ear's equal loudness curve described above, and the corresponding compensation curve (frequency response curve) can also have multiple maximum or minimum values. For those skilled in the art, in the above description of human hearing sensitivity, the term "equal loudness curve" can be replaced by similar expressions, such as "equal loudness contour", "hearing response curve", etc. In fact, the sensitivity of the human body to hearing can also be considered as a frequency response of sound. In the description of various embodiments of the present invention, the sensitivity of the human body to sound and the frequency response of bone conduction speakers are combined to ultimately reflect the sound quality of bone conduction speakers.

[0103] Under normal circumstances, the sound quality of bone conduction speakers is influenced by various factors such as the physical properties of each portion of the speaker itself, the vibration transmitting relationship between each portion, the vibration transmitting relationship between the speaker and the outside, and the efficiency of the vibration transmitting system in transmitting vibrations. The various portions of the bone conduction speaker itself include portions that generate vibration (such as but not limited to energy conversion device), portions that fix the speaker (such as but not limited to earphone holder/strap), and portions that transmit vibration (such as but not limited to panel, vibration transmitting layer, etc.). The vibration transmitting relationship between each portion and the vibration transmitting relationship between the speaker and the outside are determined by the contact mode between the speaker and the user (such as but not limited to clamping force, contact area, contact shape, etc.). As shown in figure 11, an equivalent schematic diagram of a vibration generating and transmitting system for a bone conduction speaker includes a fixed end 1101, a sensing terminal 1102, a vibration unit 1103, and an energy conversion device 1104. Among them, the fixed end 1101 is connected to the vibration unit 1103 via the transmission means K_1 (k_4 in figure 11), the sensing terminal 1102 is connected to the vibration unit 1103 via the transmission means K_2 (R_3 , k_3 in figure 11), and the vibration unit 1103 is connected to the energy conversion device 1104 via the transmission means K_3 (R_4 , k_5 in figure 11).

[0104] The vibration unit referred to here is a vibrating unit composed of a panel and an energy conversion device, and the transmission means K_1 , K_2 , and K_3 are descriptions of the interaction relationships between the corresponding portions in the equivalent system of a bone conduction speaker (which will be described in detail below). The vibration equation of an equivalent system can be expressed as:

$$[0105] m_3 \ddot{x}_3 + R_3 \dot{x}_3 - R_4 \dot{x}_4 + (k_3 + k_4)x_3 + k_5(x_3 - x_4) = f_3 \quad (8)$$

$$[0106] m_4 \ddot{x}_4 + R_4 \dot{x}_4 - k_5(x_3 - x_4) = f_4 \quad (9)$$

[0107] Among them, m_3 is the equivalent mass of vibration unit 1103, m_4 is the equivalent mass of energy conversion device 1104, x_3 is

the equivalent displacement of vibration unit 1103, x_4 is the equivalent displacement of energy conversion device 1104, k_3 is the equivalent elastic coefficient between sensing terminal 1102 and vibration unit 1103, k_4 is the equivalent elastic coefficient between fixed terminal 1101 and vibration unit 1103, k_5 is the equivalent elastic coefficient between energy conversion device 1104 and vibration unit 1103, R_3 is the equivalent damping between sensing terminal 1102 and vibration unit 1103, R_4 is the equivalent damping between energy conversion device 1104 and vibration unit 1103, and f_3 and f_4 are the interaction forces between vibration unit 1103 and energy conversion device 1104, respectively. The equivalent amplitude A_3 of the vibration unit in the system is:

$$A_3 = \frac{m_4 \omega^2}{(m_3 \omega^2 + j\omega R_3 - (k_3 + k_4 + k_5))(m_4 \omega^2 + j\omega R_4 - k_5) - k_5(k_5 - j\omega R_4)} \cdot f_0 \quad (10)$$

[0108]

[0109] Among them, f_0 represents the unit driving force, and ω represents the vibration frequency. From this, it can be known that factors that affect the frequency response of bone conduction speakers include the vibration generating portion (such as but not limited to the vibration unit, energy conversion device, housing, and interconnection method, such as m_3 , m_4 , k_5 , and R_4 in equation (10)), the vibration transmitting portion (such as but not limited to the skin contact method, and the properties of the earphone holder/strap, such as k_3 , k_4 , and R_3 in equation (10)). Changing the structure of each portion of the bone conduction speaker and the parameters of the connections between its portions, such as changing the clamping force, is equivalent to changing the magnitude of k_4 , changing the bonding method of the adhesive is equivalent to changing the magnitude of R_4 and k_5 , changing the hardness, elasticity, damping, etc. of related materials is equivalent to changing the magnitude of k_3 and R_3 , which can all alter the frequency response and sound quality of the bone conduction speaker.

[0110] In a specific embodiment, the fixed end 1101 can be a relatively fixed point or area of the bone conduction speaker during vibration, which can be considered as the fixed end of the bone conduction speaker during vibration. The fixed end can be composed of specific portions or determined by the overall structure of the bone conduction speaker. For example, bone conduction speakers can be suspended, bonded, or attached near the human ear with specific devices, or the structure and shape of the bone conduction speaker can be designed to allow the bone conduction site to attach to human skin.

[0111] The sensing terminal 1102 is a hearing system for the human body to receive sound signals. The vibration unit 1103 is a portion of the bone conduction speaker used to protect, support, and connect the energy conversion device, including the vibration transmitting layer or panel that are in direct or indirect contact with the user and transmits vibration to the user, as well as the housing that protects and supports other vibration generating portions. The energy conversion device 1104 is a device for generating sound vibrations, which can be a combination of one or more of the energy conversion devices discussed above.

[0112] The transmission means K_1 connects the fixed end 1101 and the vibration unit 1103, representing the vibration transmitting relationship between the vibration generating portion of the bone conduction speaker and the fixed end during operation. K_1 depends on the shape and structure of the bone conduction device. For example, bone conduction speakers can be fixed to the human head in the form of a U-shaped earphone holder/strap, or installed on helmet, fire mask, or other special purpose mask, glasses, and other equipment. The shape and structure of different bone conduction speakers will affect the vibration transmitting relationship K_1 . Furthermore, the structure of the speaker also includes the physical properties such as the composition materials and mass of different portions of the bone conduction speaker. The transmission means K_2 connects the sensing terminal 1102 and the vibration unit 1103.

[0113] K_2 depends on the composition of the transmission system, which includes but is not limited to transmitting sound vibrations via the user's tissues to the hearing system. For example, when sound is transmitted to the hearing system via skin, subcutaneous tissues, bones, etc., the physical properties and interconnections of different human tissues can affect K_2 . Furthermore, the vibration unit 1103 is in contact with human tissues. In different embodiments, the contact surface on the vibration unit can be a vibration transmitting layer or a side surface of a panel. The surface shape, size, and interaction force between the contact surface and human tissues all affect the transmission coefficient K_2 .

[0114] The transmission means K_3 between the vibration unit 1103 and the energy conversion device 1104 is determined by the internal connection properties of the vibration generating device of the bone conduction speaker. The connection of the energy conversion device and the vibration unit by rigid or elastic means or the change of the relative position of the connection member between the energy conversion device and the vibration unit will change the transmission efficiency of the energy conversion device to the vibration unit, especially the panel, thereby affecting the transmission means K_3 .

[0115] During the use of bone conduction speakers, the generation and transmission of sound can affect the final sound quality perceived by the human body.

For example, the fixed end, human sensory terminal, vibration unit, energy conversion device, and transmission means K_1 , K_2 , and K_3 mentioned above may all have an impact on the sound quality of bone conduction speakers. It shall be noted that K_1 , K_2 , and K_3 here are only representations of different device portions or system connection methods involved in the vibration transmitting process, which may include but are not limited to physical connection methods, force transmission methods, sound transmission efficiency, etc.

[0116] The above description of the equivalent system of bone conduction speaker is only a specific example and shall not be considered as the only feasible implementation solution. Obviously, for those skilled in the art, after understanding the basic principles of bone conduction speakers, they may make various modifications and changes in form and detail to the specific ways and steps that affect the vibration transmitting of bone conduction speakers without deviating from the principles. However, these modifications and changes are still within the scope described above. For example, K_1 , K_2 , and K_3 described above can be simple vibration or mechanical transmission methods, or they can include complex nonlinear transmission systems. The transmission means can be formed by directly connecting various portions, or it can be transmitted with non-contact methods.

[0117] In a specific embodiment, the structure of the bone conduction speaker is shown in figure 12, including an earphone holder/strap 1201, a vibration unit 1202, and an energy conversion device 1203. The vibration unit 1202 comprises a contact surface 1202a, a housing 1202b, and an energy conversion device 1203 located inside and connected to the vibration unit 1202. Preferably, the vibration unit 1202 comprises the panel and the vibration transmitting layer described above, and the contact surface 1202a is the surface where the vibration unit 1202 comes into contact with the user, and preferably, it is the outer surface of the vibration transmitting layer.

[0118] During use, the earphone holder/strap 1201 secures the bone conduction speaker to a specific site of the user (e.g., the head), providing a clamping force between the vibration unit 1202 and the user. The contact surface 1202a is connected to the energy conversion device 1203 and maintains contact with the user, transmitting sound to the user via vibration. The fixed end 1101 shown in figure 11 can be approximately selected as a point with a relatively fixed position during the operation of the bone conduction speaker. If the bone conduction speaker has a symmetrical structure and it is assumed that the driving force provided by the energy conversion devices on two sides during operation is equal in magnitude and opposite in direction, then the center point position on the earphone holder/strap can be selected as the equivalent fixed end, such as the position shown in 1204; If the bone conduction speaker can provide stereo sound, that is, the instantaneous driving force provided by the two energy conversion devices is not equal, or if there is asymmetry in the structure of the bone conduction speaker, other points or areas on or outside the earphone holder/strap can be selected as the equivalent fixed ends. The fixed end referred to here can be regarded as the equivalent end of the bone conduction speaker that is relatively fixed in position during the vibration process. The fixed end 1101 and the vibration unit 1202 are connected via an earphone holder/strap 1201, and the transmission means K_1 is related to the earphone holder/strap 1201 and the clamping force provided by the earphone holder/strap 1201, depending on the physical properties of the earphone holder/strap 1201. Preferably, changing the physical quantities such as the clamping force provided by the earphone holder/strap, and the mass of the earphone holder/strap can alter the sound transmission efficiency of the bone conduction speaker, affecting the frequency response of the system within a specific frequency range. For example, an earphone holder/strap made of high-strength materials and an earphone holder/strap made of low-strength materials will provide different clamping forces, or changing the structure of the earphone holder/strap or adding an auxiliary device that can provide elastic force to the earphone holder/strap can also alter the clamping force, thereby affecting the efficiency of sound transmission; the change in size of the earphone holder/strap during wearing can also affect the magnitude of the clamping force, which increases with the increase of the distance between the vibration units at both ends of the earphone holder/strap.

[0119] To obtain an earphone holder/strap that meets specific clamping force conditions, general technical personnel in this field can choose materials with different rigidity and modulus to make the earphone holder/strap or adjust the size of the earphone holder/strap according to the actual situation. It shall be noted that the clamping force of the earphone holder/strap not only affects the efficiency of sound transmission, but also affects the user's sound experience in the low-frequency range. The clamping force referred to here is the pressure between the contact surface and the user. Preferably, the clamping force is between 0.1 N-5 N, more preferably, the clamping force is between 0.2 N-4 N, further preferably, the clamping force is between 0.2 N-3 N, even more preferably, the clamping force is between 0.2 N-1.5 N, and even further preferably, the clamping force is between

0.3 N-1.5 N.

[0120] The material of the earphone holder/strap can determine the magnitude of the clamping force. Preferably, the material of the earphone holder/strap can be plastic with a certain degree of hardness. The materials include but are not limited to acrylonitrile butadiene styrene (ABS), polystyrene (PS), high impact polystyrene (HIPS), polypropylene (PP), polyethylene terephthalate (PET), polyester (PES), polycarbonate (PC), polyamides (PA), polyvinyl chloride (PVC), polyurethane (PU), polyvinylidene chloride, polyethylene (PE), polymethyl methacrylate (PMMA), polyetheretherketone (PEEK), phenolics (PF), Urea-formaldehyde (UF), melamine formaldehyde (MF). More preferably, the materials that are used to make the earphone holder/strap may include some metals, alloys (such as aluminum alloy, chromium molybdenum steel, scandium alloy, magnesium alloy, titanium alloy, magnesium lithium alloy, nickel alloy, etc.) or composite materials. Further preferably, the material of the earphone holder/strap can be selected from materials with memory function. Memory materials include but are not limited to memory alloy materials, high molecular weight memory materials, inorganic non-memory materials, etc. Memory alloys include but are not limited to titanium nickel copper memory alloys, titanium nickel iron memory alloys, titanium nickel chromium memory alloys, copper nickel memory alloys, copper aluminum memory alloys, copper zinc memory alloys, iron memory alloys, etc. Polymer memory materials include but are not limited to polynorbornene, trans-polyisoprene, styrene butadiene copolymer, cross-linked polyethylene, polyurethane, polylactone, fluorinated polymers, polyamides, cross-linked polyolefins, polyesters, etc. Inorganic non-memory materials include but are not limited to memory ceramics, memory glass, garnet, mica, etc. Further preferably, the memory material of the earphone holder/strap has a selected memory temperature, preferably, the memory temperature can be selected to be no less than 10°C, more preferably, the memory temperature is selected to be no less than 40°C, further preferably, the memory temperature is selected to be no less than 60°C, and even more preferably, the memory temperature is selected to be no less than 100°C. The proportion of memory material in the earphone holder/strap material is not less than 5%, preferably, the proportion is not less than 7%, more preferably, the proportion is not less than 15%, further preferably, the proportion is not less than 30%, and even more preferably, the proportion is not less than 50%. The earphone holder/strap referred to here refers to the rear hanging structure that generates clamping force on the bone conduction speaker. The memory material is located at different positions on the earphone holder/strap. Preferably, the memory material is located at a stress concentration position on the earphone holder/strap, such as but not limited to the connection portion between the earphone holder/strap and the vibration unit, near the symmetrical center of the earphone holder/strap, or at a densely distributed position of lines within the earphone holder/strap. In one embodiment, a memory alloy is used to make the earphone holder/strap, which provides less difference in the clamping force for different sizes of heads of users, resulting in higher wearing consistency and higher sound quality consistency affected by the clamping force. In another embodiment, the earphone holder/back hanger made of memory alloy has good elasticity and can recover to its original shape normally after undergoing large deformations. Moreover, it can stably maintain the clamping force even after prolonged deformation. In another embodiment, the earphone holder/back hanger made of memory alloy is light in weight and can provide greater flexibility in deformation, allowing it to better fit the user.

[0121] The clamping force provides pressure between the contact surface of the bone conduction speaker vibration generating portion and the user. Figures 13-A and 13-B show the vibration response curves of a bone conduction speaker under different pressures between the contact surface and the user in an embodiment. During the process of vibration transmission, a clamping force below a certain threshold is not conducive to the transmission of mid-frequency and high-frequency vibrations. As shown in (a), for the same vibration source (sound source), when the clamping force is 0.1 N, the vibration (sound) received by the wearer in the mid-frequency and high-frequency portion is significantly less than that received when the clamping force is 0.2 N and 1.5 N. That is to say, in terms of sound quality, when the clamping force is 0.1 N, the mid-frequency and high-frequency portion show weaker performance than those when the clamping force is 0.2 N-1.5 N. Meanwhile, in this embodiment, a clamping force of 0.1 N can ensure that the bone conduction earphone is worn on the user without falling off. Similarly, in the process of vibration transmission, a clamping force greater than

a certain threshold is not conducive to the transmission of low-frequency vibrations. As shown in (b), for the same vibration source (sound source), when the clamping force is 5.0 N, the low-frequency portion of the vibration (sound) received by the wearer is significantly less than the vibration (sound) received when the clamping force is 0.2 N and 1.5 N, that is to say, in terms of sound quality, the low-frequency portion shows weaker performance when the clamping force is 5.0 N than that when the clamping force is 0.2 N-1.5 N. Meanwhile, in this embodiment, a clamping force of 5.0 N causes significant pain sensation for the user.

[0122] In specific embodiments, the pressure between the contact surface and the user is maintained within an appropriate range by selecting appropriate earphone holder/strap materials and setting appropriate earphone holder/strap. The pressure between the contact surface and the user is greater than a certain threshold, preferably, the threshold is 0.1 N, more preferably, the threshold is 0.2 N, further preferably, the threshold is 0.3 N, and even more preferably, the threshold is 0.5 N. The pressure between the contact surface and the user is less than another threshold, preferably, the threshold is 5.0 N, more preferably, the threshold is 4 N, further preferably, the threshold is 3 N, and even more preferably, the threshold is 1.5 N. After understanding the basic principle of how the clamping force of bone conduction speakers changes the frequency response of the bone conduction system, those skilled in the art can modify and replace the materials and structures of the earphone holder/strap to set clamping force ranges that meet different sound quality requirements. These modifications and replacements are still within the scope of protection of this description.

[0123] The clamping force of bone conduction speakers can be measured with specific equipment or methods. Figures 14-A and 14-B are specific embodiments for measuring the clamping force of a bone conduction speaker. Points A and B are the two points near the vibration unit on the bone conduction speaker earphone holder/strap in this embodiment. During the testing process, point A or point B are fixed, and the other point is connected to the forcemeter. When the distance L between point A and point B is between 125 mm and 155 mm, the clamping force is obtained. Figure 14-C shows the frequency vibration response curves of a bone conduction speaker under different clamping force states, with three curves corresponding to the clamping forces of 0 N, 0.61 N, and 1.05 N, respectively. Figure 14-C shows that as the clamping force of the bone conduction speaker increases, the load generated by the face on the vibration unit of the bone conduction speaker (such as the panel, the vibration transmitting layer connected to the panel, etc.) will also increase, and the vibration of the vibration surface will be weakened. Insufficient or excessive clamping force can cause uneven frequency response of bone conduction speakers during vibration (such as in the range of 500 Hz-800 Hz on the curve of clamping force of 0 N and 1.05 N). If the clamping force is too high (such as the curve corresponding to a clamping force of 1.05 N), it will cause discomfort to the wearer, and at the same time, the vibration of the speaker will weaken and the sound will decrease; If the clamping force is too low (such as the curve corresponding to a clamping force of 0 N), the wearer will feel a more noticeable vibration sensation.

[0124] It shall be noted that the above description of the method of changing the clamping force of the bone conduction speaker is only a specific example and shall not be considered as the only feasible implementation solution. Obviously, for those skilled in the art, after understanding the basic principles of bone conduction speakers, it is possible to change the clamping force of bone conduction speakers for different shapes and structures without deviating from the principles, but these changes are still within the scope described above. For example, the bone conduction speaker holder can be made using materials with memory function (such as memory metal), which can adjust the opening curvature according to the head shape of people and have good elasticity, maximizing the comfort of wearing and adjusting the clamping force. Furthermore, an elastic bandage 1501 can be placed on the bone conduction speaker holder to adjust the clamping force, as shown in figure 15. During the process of the earphone holder/strap deviating from the balance position and contracting or pulling apart, the elastic bandage can provide additional restoring force.

[0125] The transmission means K_2 between the sensing terminal 1102 and the vibration unit 1103 also affects the frequency response of the bone conduction system. The sound heard by the human ear depends on the energy received by the cochlea, which is influenced by different physical quantities during transmission and can be expressed with the following equation:

$$[0126] P = \int \int S \alpha f(a, R) \cdot L \cdot ds \quad (11)$$

[0127] Among them, P is proportional to the energy received by the cochlea, S is the area of contact between the contact surface and the face, α is a coefficient of dimensional conversion, $f(a, R)$ represents the effect of acceleration at a point on the contact surface and the tightness degree R of contact between the contact surface and the skin on energy transfer, and L is the impedance of mechanical wave transmission at any contact point, that is, the transmission impedance per unit area.

[0128] According to (11), the transmission of sound is affected by the transmission impedance L , and the vibration transmission efficiency of the bone conduction system is related to L . The frequency response curve of the bone conduction system is the superposition of the frequency response curves of each point on the contact surface. Without loss of generality, when describing the structure of the contact surface of the bone conduction system, the term "contact surface" can refer to a surface that is in direct or indirect contact with the user at least partially, or a "contact layer" with a certain thickness that is in direct or indirect contact with the user at least partially. The factors that affect impedance include the size, shape, roughness, force magnitude, or force distribution of the energy transfer area. For example, by changing the structure and shape of the vibration unit 1202, the sound transmission effect can be altered, thereby changing the sound quality of the bone conduction speaker. Just as an example, changing the corresponding physical characteristics of the contact surface 1202a of the vibration unit 1202 can achieve the effect of changing sound transmission.

[0129] A carefully designed contact surface is provided with a gradient structure, which refers to the area where the contact surface has a height variation. The gradient structure can be a convex/concave or stepped structure on the outer side of the contact surface (the side in contact with the user), or a convex/concave or stepped structure on the inner side of the contact surface (the side facing away from the user). The embodiment of a vibration unit of a bone conduction speaker is shown in figure 16-A, wherein there are convex or concave portions (not shown in figure 16-A) on the contact surface 1601 (outer side of the contact surface). During the operation of the bone conduction speaker, the convex or concave portions come into contact with the facial skin, changing the pressure at different positions on the contact surface 1601 when in contact with the face. The convex portion is in closer contact with the face, and the skin and subcutaneous tissues in contact with it are subjected to greater pressure than other portions; Correspondingly, the skin and subcutaneous tissues in contact with the concave portion are subjected to less pressure than other portions. For example, in figure 16-A, there are three points A, B, and C on the contact surface 1601, which are located on the non-convex portion, the edge of the convex portion, and the convex portion of the contact surface 1601, respectively. During contact with the skin, the clamping force exerted on the skin at points A, B, and C is as follows: $F_C > F_A > F_B$. In some embodiments, the clamping force at point B is zero, meaning that point B is not in contact with the skin. The facial skin and subcutaneous tissues exhibit different impedance and response to sound under different pressures. The portions under a high pressure have a lower impedance and a filtering characteristic that tends towards high pass for sound waves, while the portions under a low pressure have a higher impedance and a filtering characteristic that tends towards low pass. The impedance characteristics L of each portion of the contact surface 1601 are different. According to equation (11), the frequency response of different portions to sound transmission is different. The effect of sound transmission via the entire contact surface is equivalent to the sum of sound transmission in each portion. Finally, when the sound is transmitted to the brain, a smooth frequency response curve is formed, avoiding the occurrence of excessively high resonance peaks at low or high frequencies, thus obtaining the ideal frequency response within the entire audio bandwidth. Similarly, the material and thickness of the contact surface 1601 can also affect the transmission of sound, thereby affecting the sound quality effect. For example, when the contact surface material is soft, the sound wave transmission effect in the low-frequency range is better than that in the high-frequency range, and when the contact surface material is hard, the sound wave transmission effect in the high-frequency range is better than that in the low-frequency range.

[0130] Figure 16-B shows the frequency response of a bone conduction speaker with different contact surfaces. The dashed line corresponds to the frequency response of the bone conduction speaker with convex structures on the contact surface, while the solid line corresponds to the frequency response of the bone conduction speaker without convex structures on the contact surface. In the mid- to low-frequency range, the vibration without convex structures is significantly weakened compared to the vibration with convex structures, forming a "deep pit" on the frequency response curve, manifested as an less ideal frequency response, thereby affecting the sound quality of the bone conduction speaker.

[0131] The above description of figure 16-B is only an explanation for specific examples. For those skilled in the art, after understanding the basic principles that affect the frequency response of bone conduction speakers, various modifications and changes can be made to the structure and portions of bone conduction speakers to obtain different frequency response effects.

[0132] It shall be noted that for general technical personnel in this field, the shape and structure of the contact surface 1601 are not limited to the above description, but can also be those meeting the other specific requirements. For example, the convex proportions or concave portions on the contact surface can be distributed at the edges or in the middle of the contact surface. The contact surface may contain one or more convex proportions or concave portions, which can be distributed simultaneously on the contact surface. The material of the convex or concave portions on the contact surface

can be other materials different from the contact surface material, such as flexible, rigid, or materials more suitable for generating specific pressure gradients; it can be memory material or non-memory material; and it can be a single property material or a composite material. The structural shapes of the convex or concave portion of the contact surface include but are not limited to axisymmetric shapes, centrosymmetric shapes, rotational symmetric shapes, asymmetric shapes, etc. The structural shape of the convex or concave portion of the contact surface can be one type of shape, or a combination of two or more types of shapes. The contact surface includes but is not limited to having a certain degree of smoothness, roughness, waviness, etc. The position distribution of the convex or concave portion of the contact surface includes but is not limited to axisymmetric, centrosymmetric, rotational symmetric, asymmetric distribution, etc. The convex or concave portion of the contact surface can be located at the edge of the contact surface or distributed inside the contact surface.

[0133] In figure 17, 1704-1711 are specific embodiments of the contact surface structure described above.

[0134] Among them, 1704 in the figure is an example of multiple convex proportions with similar shapes and structures on the contact surface. The convex proportions can be made of the same or similar materials as those for other portions of the panel, or different materials for the other portions. Specifically, the convex proportion can be made of both memory material and vibration transmitting layer material, with the proportion of memory material not less than 10%, and preferably, the proportion of memory material in the convex proportion is not less than 50%. The area of a single convex portion accounts for 1%-80% of the total area, preferably 5%-70% of the total area, and more preferably 8%-40% of the total area. The total area of all convex portions accounts for 5%-80% of the total area, preferably, the proportion is 10%-60%. There can be at least one convex portion, preferably one convex portion, more preferably 2 convex portions, and further preferably at least 5 convex portions. The shape of the convex portion can be circular, elliptical, triangular, rectangular, trapezoidal, irregular polygon, or other similar shapes. The structure of the convex portion can be symmetrical or asymmetrical, and the position distribution of the convex portion can also be symmetrical or asymmetrical. The number of convex portions can be one or more, and the height of the convex portions can be the same or different. The height and distribution of the convex portions can form a certain gradient.

[0135] The structure shown in 1705 of the figure is an example of a combination of two or more shapes, where the number of convex portions in different shapes can be one or more. Two or more shapes of the convex portions can be any combination of two or more of circles, ellipses, triangles, rectangles, trapezoids, irregular polygons, or other similar shapes. The material, quantity, area, symmetry, etc. of the convex portions are similar to those of 1704 in the figure.

[0136] In the figure, 1706 is an example of the distribution of convex portions on the edge and inside of the contact surface, wherein the number of convex portions is not limited to what is shown in the figure. The number of convex portions located at the edge of the contact surface accounts for 1%-80% of all convex portions, preferably 5%-70%, more preferably 10%-50%, and further preferably 30%-40%. The material, quantity, area, shape, symmetry, etc. of the convex portions are similar to those of 1704 in the figure.

[0137] In the figure, 1707 is a structural shape of the concave portion of the contact surface. The structure of the concave portion can be symmetrical or asymmetrical, and the position distribution of the concave portion can also be symmetrical or asymmetrical. The number of concave portions can be one or more, and the shape of the concave portions can be the same or different. The concave portion can be hollow. The area of a single concave portion accounts for 1%-80% of the total area, preferably 5%-70% of the total area, and more preferably 8%-40% of the total area. The total area of all concave portions accounts for 5%-80% of the total area, and preferably, this proportion is 10%-60%. There can be at least one concave portion, preferably there is one concave portion, more preferably, there are 2 concave portions, and further preferably, there are at least 5 concave portions. The shape of concave portion can be circular, elliptical, triangular, rectangular, trapezoidal, irregular polygon, or other similar shapes.

[0138] In the figure, 1708 is an example of a contact surface with both convex and concave portions, and the number of convex and concave portions is not limited to one or more. The ratio of the number of concave portions to the number of convex portions is 0.1-100, preferably 1-80, more preferably 5-60, and further preferably 10-20. The material, area, shape, symmetry, etc. of a single convex portion/concave portion are similar to those of 1704 in the figure.

[0139] In the figure, 1709 is an example of a contact surface with a certain degree of waviness. Waves are arranged by two or more convex portions/concave portions or a combination of them, preferably with equal distances between adjacent convex portions/concave portions, and more preferably with equidistant distances between convex portions/concave portions.

[0140] In the figure, 1710 is an example of a contact surface with a convex portion having a relatively large area. The area of the convex portion accounts for 30%-80% of the total contact surface area. Preferably, a portion of the edge of the convex portion and a portion of the edge of the contact surface are basically in contact with each other.

[0141] In the figure, 1711 is a type of contact surface with a first larger convex portion and a second smaller convex portion on the top of the first convex portion. The larger convex portion accounts for 30%-80% of the total contact surface area, while the smaller convex portion accounts for 1%-30% of the total contact surface area, and preferably, this proportion is 5%-20%. The area of the smaller convex portion accounts for 5%-80% of the area of larger convex portion, preferably 10%-30%.

[0142] The above description of the contact surface structure of bone conduction speakers is only for specific examples and shall not be considered as the only feasible implementation solutions. Obviously, for those skilled in the art, after understanding the basic principle that the contact surface structure of bone conduction speakers affects the sound quality of bone conduction speakers, they may make various modifications and changes to the specific methods, forms, and details of implementing the contact surface of bone conduction speakers without deviating from this principle. However, these modifications and changes are still within the scope described above. For example, the number of convex portions or concave portions is not limited to what is shown in figure 17, and modifications can also be made to the surface shapes of the convex portions, concave portions, or contact surfaces described above, which are still within the scope of protection described above. Moreover, the contact surfaces of at least one or more vibration units contained in bone conduction speakers can be made with the same or different shapes and materials as described above. The vibration effects transmitted on different contact surfaces will also vary depending on the properties of the contact surfaces, ultimately resulting in different sound quality effects.

[0143] From figure 11, it can be known that the vibration mode of the energy conversion device 1104 in the bone conduction speaker vibration system, as well as the way K₃ is connected to the vibration unit 1103, will also affect the sound effect of the system. Preferably, the energy conversion device comprises a vibrating plate, a vibration transmitting plate, a set of coils, and a magnetic circuit system. More preferably, the energy conversion device comprises a composite vibration device composed of multiple vibrating plates and vibration transmitting plates. The frequency response of sound generated by the system is influenced by the physical properties of the vibrating plate and the vibration transmitting plate. Choosing specific sizes, shapes, materials, thicknesses, and vibration transmission methods of the vibrating plate and the vibration transmitting plate can produce sound effects that meet practical requirements.

[0144] The embodiment of a composite vibration device, as shown in figures 18-A and 18-B, comprises: a composite vibration portion consisting of a vibration transmitting plate 1801 and a vibrating plate 1802, wherein the vibration transmitting plate 1801 is arranged as a first circular ring 1813, and three first support rods 1814 that converge towards the center are arranged inside the first circular ring, with the convergence center position fixed to the center of the vibrating plate 1802. The center of the vibrating plate 1802 is a groove 1820 that matches the convergence center and the first support rod. The vibrating plate 1802 is provided with a second circular ring 1821 with a radius different from that of the vibration transmitting plate 1801, and three second support rods 1822 with a thickness different from that of the first support rod 1814. During assembly, the first support rod 1814 and the second support rod 1822 are staggered and can form an angle of 60 degrees, but not limited to such degree.

[0145] The first and second support rods mentioned above can both be straight rods or designed in other shapes that meet specific requirements. The number of support rods can be disposed to two or more, arranged symmetrically or asymmetrically to meet economic and practical requirements. The vibration transmitting plate 1801 has a thin thickness and can increase elasticity, and the vibration transmitting plate 1801 is clamped in the center of the groove 1820 of the vibrating plate 1802. A voice ring 1808 is provided on the lower side of the second circular ring 1821 attached to the vibrating plate 1802. The composite vibration device also comprises a base plate 1812, on which an annular magnet 1810 is arranged, and an inner magnet 1811 is coaxially arranged inside the annular magnet 1810; an inner magnetic plate 1809 is provided on the top surface of the inner magnet 1811, and an annular magnetic plate 1807 is provided on the annular magnet 1810. A washer 1806 is fixedly provided above the annular magnetic plate 1807, and the first annular body 1813 of the vibration transmitting plate 1801 is fixedly connected to the washer 1806. The entire composite vibration device is connected to the outside with a panel 1830,

wherein the panel 1830 is fixedly connected to the convergence center position of the vibration transmitting plate 1801 and clamped and fixed at the center position of the vibration transmitting plate 1801 and the vibrating plate 1802.

[0146] Using a composite vibration device composed of a vibrating plate and a transmission plate, a frequency response as shown in figure 19 was obtained. Two resonance peaks were generated by the dual composite vibration. By adjusting the size and material parameters of the two components, the resonance peaks were shifted, with the low-frequency resonance peak moving towards lower frequencies and the high-frequency resonance peak moving towards higher frequencies. Preferably, the rigidity coefficient of the vibrating plate is greater than that of the transmission plate. Finally, the frequency response curve of the dashed line shown in figure 19 can be fitted, which is the ideal flat frequency response. The range of these resonance peaks can be disposed within or outside the frequency range of audible sounds to the human ear. Preferably, both resonance peaks are not within the frequency range of audible sounds to the human ear; More preferably, one resonance peak is within the frequency range of audible sounds to the human ear, and the other resonance peak is outside the frequency range of audible sounds to the human ear; More preferably, both resonance peaks are within the frequency range audible to the human ear; Furthermore, preferably, both resonance peaks are within the frequency range of audible sound to the human ear, and their peak frequencies are between 80 Hz and 18,000 Hz; Furthermore, preferably, both resonance peaks are within the frequency range audible to the human ear, and their peak values are between 200 Hz and 15,000 Hz; Furthermore, preferably, both resonance peaks are within the frequency range audible to the human ear, and their peak values are between 500 Hz and 12,000 Hz; Furthermore, preferably, both resonance peaks are within the frequency range audible to the human ear, and their peak values are between 800 Hz and 11,000 Hz. It is better to have a certain frequency difference between the peak values of the resonance peaks, for example, the peak values of two resonance peaks differ by at least 500 Hz; Preferably, the peak values of two resonance peaks differ by at least 1,000 Hz; Further preferably, the peak values of two resonance peaks differ by at least 2,000 Hz; Furthermore, preferably, the peak values of two resonance peaks differ by at least 5,000 Hz. To achieve better results, both resonance peaks can be within the audible range of the human ear, and the peak frequencies of the resonance peaks differ by at least 500 Hz; Preferably, both resonance peaks can be within the audible range of the human ear, and the peak values of the two resonance peaks differ by at least 1,000 Hz; Further preferably, both resonance peaks can be within the audible range of the human ear, and the peak values of the two resonance peaks differ by at least 2,000 Hz; Furthermore, preferably, both resonance peaks can be within the audible range of the human ear, and the peak values of the two resonance peaks differ by at least 3,000 Hz; and furthermore, preferably, both resonance peaks are within the audible range of the human ear, and the peak values of the two resonance peaks differ by at least 4,000 Hz. One of the two resonance peaks can be within the audible range of the human ear, while the other is outside the audible range of the human ear, and the peak frequencies of the two resonance peaks differ by at least 500Hz; Preferably, one resonance peak is within the audible range of the human ear, while the other is outside the audible range of the human ear, and the peak frequencies of the two resonance peaks differ by at least 1,000 Hz; More preferably, one resonance peak is within the audible range of the human ear, while the other is outside the audible range of the human ear, and the peak frequencies of the two resonance peaks differ by at least 2,000 Hz; Further preferably, one resonance peak is within the audible range of the human ear, while the other is outside the audible range of the human ear, and the peak frequencies of the two resonance peaks differ by at least 3,000 Hz; Further preferably, one resonance peak is within the audible range of the human ear, while the other is outside the audible range of the human ear, and the peak frequencies of the two resonance peaks differ by at least 4000 Hz. Both resonance peaks can be between frequencies of 5 Hz-30,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 400 Hz; Preferably, both resonance peaks can be between frequencies of 5 Hz-30,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 1,000 Hz; More preferably, both resonance peaks can be between frequencies of 5 Hz-30,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 2,000 Hz; Further preferably, both resonance peaks can be between frequencies of 5 Hz-30,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 3,000 Hz; Further preferably, both resonance peaks can be between frequencies of 5 Hz-30,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 4,000 Hz. Both resonance peaks can be between frequencies of 20 Hz-20,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 400 Hz; Preferably, both resonance peaks can be between frequencies of 20 Hz-20,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 1,000 Hz; More preferably, both resonance peaks can be between frequencies of 20 Hz-20,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 2,000 Hz; Further preferably, both resonance peaks can be between frequencies of 20 Hz-20,000 Hz, and the peak

frequencies of the two resonance peaks differ by at least 3,000 Hz; Further preferably, both resonance peaks can be between frequencies of 20 Hz-20,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 4,000 Hz. Both resonance peaks can be between frequencies of 100 Hz-18,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 400 Hz; Preferably, both resonance peaks can be between frequencies of 100 Hz-18,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 1,000 Hz; More preferably, both resonance peaks can be between frequencies of 100 Hz-18,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 2,000 Hz; Further preferably, both resonance peaks can be between frequencies of 100 Hz-18,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 3,000 Hz; Further preferably, both resonance peaks can be between frequencies of 100 Hz-18,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 4,000 Hz. Both resonance peaks can be between frequencies of 200 Hz-12,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 400 Hz; Preferably, both resonance peaks can be between frequencies of 200 Hz-12,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 1,000 Hz; More preferably, both resonance peaks can be between frequencies of 200 Hz-12,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 2,000 Hz; Further preferably, both resonance peaks can be between frequencies of 200 Hz-12,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 3,000 Hz; Further preferably, both resonance peaks can be between frequencies of 200 Hz-12,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 4,000 Hz. Both resonance peaks can be between frequencies of 500 Hz-10,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 400 Hz; Preferably, both resonance peaks can be between frequencies of 500 Hz-10,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 1,000 Hz; More preferably, both resonance peaks can be between frequencies of 500 Hz-10,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 2,000 Hz; Further preferably, both resonance peaks can be between frequencies of 500 Hz-10,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 3,000 Hz; Further preferably, both resonance peaks can be between frequencies of 500 Hz-10,000 Hz, and the peak frequencies of the two resonance peaks differ by at least 4,000 Hz. This broadens the resonance response range of the speaker and obtains sound quality that meets the conditions. It is worth noting that in practical use, multiple vibration transmitting plates and vibrating plates can be disposed to form a multi-layer vibration structure, corresponding to different frequency response ranges, to achieve high-quality speaker vibration in the full frequency range, or to make the frequency response curve meet the usage requirements in certain specific frequency ranges. For example, in bone conduction hearing aids, to meet normal hearing requirements, an energy conversion device consisting of one or more vibrating plates and vibration transmitting plates with resonant frequencies in the range of 100 Hz-10,000 Hz can be selected. The description of the composite vibration device composed of a vibrating plate and a vibration transmitting plate occurred in the patent application titled "A Bone Conduction Speaker and Its Composite Vibration Device" filed on December 23, 2011 in China with patent application number 201110438083.9. The full text of this patent document is cited here for reference.

[0147] As shown in figure 20, in another embodiment, the vibration system comprises a vibrating plate 2002, a first vibration transmitting plate 2003, and a second vibration transmitting plate 2001, wherein the first vibration transmitting plate 2003 fixes the vibrating plate 2002 and the second vibration transmitting plate 2001 to the housing 2019, the composite vibration system composed of the vibrating plate 2002, the first vibration transmitting plate 2003, and the second vibration transmitting plate 2001 can generate no less than two resonance peaks, producing a flatter frequency response curve within the audible range of the hearing system, thereby improving the sound quality of the bone conduction speaker. The equivalent model of the vibration system is shown in figure 21-A:

[0148] Among them, 2101 is the housing, 2102 is the panel, 2103 is the voice ring, 2104 is the magnetic circuit vibration, 2105 is the first vibration transmitting plate, 2106 is the second vibration transmitting plate, and 2107 is the vibrating plate, wherein the first vibration transmitting plate, the second vibration transmitting plate, and the vibrating plate are all abstracted to contain elastic and damping portions, and the housing, panel, voice ring, and magnetic circuit system can all be abstracted to be equivalent mass blocks. The vibration equation of the system can be expressed as:

$$[0149] m_6 \ddot{x}_6 + R_6(\dot{x}_6 - \dot{x}_5) + k_6(x_6 - x_5) = F \quad (12)$$

$$[0150] m_7 \ddot{x}_7 + R_7(\dot{x}_7 - \dot{x}_5) + k_7(x_7 - x_5) = -F \quad (13)$$

$$[0151] m_5 \ddot{x}_5 - R_6(\dot{x}_6 - \dot{x}_5) - R_7(\dot{x}_7 - \dot{x}_5) + R_8 \dot{x}_5 + k_8 x_5 - k_6(x_6 - x_5) - k_7(x_7 - x_5) = 0 \quad (14)$$

[0152] Where F is the driving force, k_6 is the equivalent rigidity coefficient of the second vibration transmitting plate, k_7 is the equivalent rigidity coefficient of the vibrating plate, k_8 is the equivalent rigidity coefficient of the first vibration transmitting plate, R_6 is the equivalent damping of the second vibration transmitting plate, R_7 is the equivalent damping of the vibrating plate, R_8 is the equivalent damping of the first vibration transmitting plate, m_5 is the mass of the panel, m_6 is the mass of the magnetic circuit system, m_7 is the mass of the voice ring, x_5 is the displacement of the panel, x_6 is the displacement of the magnetic circuit system, and x_7 is the displacement of the voice ring. The amplitude of the panel 2102 can be obtained as:

$$A_5 = \frac{(-m_6\omega^2(jR_7\omega - k_7) + m_7\omega^2(jR_6\omega - k_6))}{\begin{pmatrix} (-m_5\omega^2 - jR_8\omega + k_8)(-m_6\omega^2 - jR_6\omega + k_6)(-m_7\omega^2 - jR_7\omega + k_7) \\ -m_6\omega^2(-jR_8\omega + k_8)(-m_7\omega^2 - jR_7\omega + k_7) \\ -m_7\omega^2(-jR_7\omega + k_7)(-m_6\omega^2 - jR_6\omega + k_6) \end{pmatrix}} f_0 \quad (15)$$

[0153]

[0154] Wherein, ω represents the angular frequency of vibration, and f_0 represents the unit driving force.

[0155] The vibration system of the bone conduction speaker transmits vibration to the user via the panel. According to equation (15), the vibration efficiency of the system is related to the rigidity coefficient and vibration damping of the vibrating plate, the first vibration transmitting plate, and the second vibration transmitting plate. Preferably, the rigidity coefficient k_7 of the vibrating plate is greater than the second vibration coefficient k_6 , and the rigidity coefficient k_7 of the vibrating plate is greater than the first vibration coefficient k_8 . Among them, the triple composite vibration system with the first vibration transmitting plate generates more resonance peaks than the composite vibration system without the first vibration transmitting plate, preferably at least three resonance peaks; More preferably, at least one resonance peak is not within the audible range of the human ear; More preferably, the resonance peaks are within the audible range of the human ear; Further preferably, the resonance peaks are within the audible range of the human ear, and their peak frequencies are not higher than 18,000 Hz; Furthermore, preferably, the resonance peaks are within the frequency range audible to the human ear, and their peak values are between 100 Hz-15,000 Hz; Furthermore, preferably, the resonance peaks are within the frequency range audible to the human ear, and their peak values are between 200 Hz-12,000 Hz; Furthermore, preferably, the resonance peaks are within the frequency range audible to the human ear, and their peak values are between 500 Hz-11,000 Hz. It is better to have a certain frequency difference between the peak values of the resonance peaks, for example, there are at least two resonance peaks whose peak values differ by at least 200 Hz; Preferably, there are at least two resonance peaks whose peak values differ by at least 500 Hz; More preferably, there are at least two resonance peaks whose peak values differ by at least 1,000 Hz; Furthermore, preferably, there are at least two resonance peaks whose peak values differ by at least 2,000 Hz; Furthermore, preferably, there are at least two resonance peaks whose peak values differ by at least 5,000 Hz. To achieve better results, the resonance peaks can all be within the audible range of the human ear, and there are at least two resonance peaks with peak frequencies that differ by at least 500 Hz; Preferably, the resonance peaks can all be within the audible range of the human ear, and there are at least two resonance peaks whose peak values differ by at least 1,000 Hz; More preferably, the resonance peaks can all be within the audible range of the human ear, and there are at least two resonance peaks whose peak values differ by at least 1,000 Hz; Furthermore, preferably, the resonance peaks are all within the audible range of the human ear, and there are at least two resonance peaks whose peak values differ by at least 2,000 Hz; Furthermore, preferably, the resonance peaks can all be within the audible range of the human ear, and there are at least two resonance peaks whose peak values differ by at least 3,000 Hz; Furthermore, preferably, the resonance peaks are all within the audible range of the human ear, and there are at least two resonance peaks whose peak values differ by at least 4,000 Hz. There can be two resonance peaks within the audible range of the human ear and one outside the audible range of the human ear, and there are at least two resonance peaks with peak frequencies that differ by at least 500 Hz; Preferably, two resonance peaks are within the audible range of the human ear, and the other resonance peak is outside the audible range of the human ear, and there are at least two resonance peaks with peak frequencies that differ by at least 1,000 Hz; More preferably, two resonance peaks are within the audible range of the human ear, and the other resonance peak is outside the audible range of the human ear, and there are at least two resonance peaks with peak frequencies that differ by at least 2,000 Hz; Further preferably, two resonance peaks are within the audible range of the human ear, and the other resonance peak is outside the audible range of the human ear, and there are at least two resonance peaks with peak frequencies that differ by at least 3,000 Hz; Furthermore, preferably, the two resonance peaks are within the audible range of the human ear, and the other peak is outside the audible range of the human ear, and there are at least two resonance peaks with peak frequencies that differ by at least 4,000 Hz. One of the resonance peaks can be within the audible range of the human ear, while the other two are outside the audible range of the human ear, and there are at least two resonance peaks with peak frequencies that differ by at least 500 Hz; Preferably, one resonance peak is within the audible range of the human ear, and the other two resonance peaks are outside the audible range of the human ear, and there are at least two resonance peaks with peak frequencies that differ by at least 1,000 Hz; More preferably, one resonance peak is within the audible range of the human ear,

[illegible]

resonance peaks can be within the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is not higher than 1,000 Hz. Preferably, at least two resonance peaks can be within the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is not higher than 500 Hz. Preferably, at least two resonance peaks can be within the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is not higher than 300 Hz. Preferably, at least two resonance peaks can be within the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is not higher than 200 Hz. Preferably, at least two resonance peaks can be within the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is in the range of 20-20,000 Hz. Preferably, at least two resonance peaks can be within the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is within the range of 20-10,000 Hz. Preferably, at least two resonance peaks can be within the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is within the range of 20-5,000 Hz. Preferably, at least two resonance peaks can be within the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is within the range of 20-2,000 Hz. Preferably, at least two resonance peaks can be within the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is within the range of 20-1,000 Hz. Preferably, at least two resonance peaks can be within the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is within the range of 20-500 Hz. Preferably, at least two resonance peaks can be within the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is in the range of 20-300 Hz. Preferably, at least two resonance peaks can be within the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is in the range of 20-200 Hz. More preferably, the energy conversion device generates at least two resonance peaks within the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is not higher than 20,000 Hz. More preferably, the energy conversion device generates at least two resonance peaks within the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is not higher than 10,000 Hz. More preferably, the energy conversion device generates at least two resonance peaks within the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is not higher than 5,000 Hz. More preferably, the energy conversion device generates at least two resonance peaks within the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is not higher than 2,000 Hz. More preferably, the energy conversion device generates at least two resonance peaks within the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is not higher than 1,000 Hz. More preferably, the energy conversion device generates at least two resonance peaks within the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is not higher than 500 Hz. More preferably, the energy conversion device generates at least two resonance peaks within the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is not higher than 300 Hz. More preferably, the energy conversion device generates at least two resonance peaks within the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is not higher than 200 Hz. More preferably, the energy conversion device generates at least two resonance peaks in the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is in the range of 20-20,000 Hz. More preferably, the energy conversion device generates at least two resonance peaks in the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is in the range of 20-10,000 Hz. More preferably, the energy conversion device generates at least two resonance peaks in the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is in the range of 20-5,000 Hz. More preferably, the energy conversion device generates at least two resonance peaks in the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is in the range of 20-2,000 Hz. More preferably, the energy conversion device generates at least two resonance peaks in the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is in the range of 20-1,000 Hz. More preferably, the energy conversion device generates at least two resonance peaks in the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is in the range of 20-500 Hz. More preferably, the energy conversion device generates at least two resonance peaks within the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is within the range of 20-300 Hz. More preferably, the energy conversion device generates at least two resonance peaks within the audible range of the human ear, and the resonance peak generated by the first vibration transmitting plate is within the range of 20-200 Hz. In one embodiment, by utilizing a triple composite vibration system consisting of a vibrating plate, a first vibration transmitting plate, and a second vibration transmitting plate, a frequency response as shown in figure 21-B can be obtained. The triple composite vibration system with the first vibration transmitting plate produces three distinct resonance peaks, resulting in a flatter frequency response and improved sound quality.

[0156] By changing the size and material parameters of the first vibration transmitting plate, the resonance peak can be shifted, ultimately achieving the desired frequency response. For example, reducing the rigidity coefficient of the first vibration transmitting plate to the design value can shift the resonance peak to the lower frequency to the design position, which can greatly improve the sensitivity of the frequency response of the bone conduction speaker in the low frequency range, making it easier to obtain

better sound quality. As shown in figure 21-C, when the rigidity coefficient of the first vibration transmitting plate gradually decreases (i.e. the first vibration transmitting plate changes from hard to soft), the resonance peak moves towards the low frequency direction, and the sensitivity of the bone conduction speaker frequency response in the low frequency range is significantly improved. Preferably, the first vibration transmitting plate is an elastic plate. The elasticity is determined by various factors such as the material, thickness, and structure of the first vibration transmitting plate. The material of the first vibration transmitting plate can include, for example but not limited to steel (such as but not limited to stainless steel, carbon steel, etc.), lightweight alloys (such as but not limited to aluminum alloy, beryllium copper, magnesium alloy, titanium alloy, etc.), plastics (such as but not limited to high molecular weight polyethylene, blow molded nylon, engineering plastics, etc.), and other single or composite materials that can achieve the same performance. Composite materials can include, for example but not limited to reinforced materials such as glass fiber, carbon fiber, boron fiber, graphite fiber, graphene fiber, silicon carbide fiber, or aramid fiber, as well as composites of other organic and/or inorganic materials, such as glass fiber reinforced unsaturated polyester, epoxy resin, or various types of glassfiber composed of phenolic resin matrix. The thickness of the first vibration transmitting plate is not less than 0.005 mm, preferably, the thickness is between 0.005 mm-3 mm, more preferably, the thickness is between 0.01 mm-2 mm, even more preferably, the thickness is between 0.01 mm-1 mm, and further preferably, the thickness is between 0.02 mm-0.5 mm. The structure of the first vibration transmitting plate can be disposed as a ring, preferably including at least one ring, preferably including at least two rings, which can be concentric rings or non-concentric rings. The rings are connected by at least two support rods, which radiate from the outer ring to the center of the inner ring. Further preferably, the first vibration transmitting plate includes at least one elliptical ring, and further preferably, at least two elliptical rings. Different elliptical rings have different curvature radii, and the rings are connected by support rods. Further preferably, the first vibration transmitting plate includes at least one square ring. The first vibration transmitting plate structure can also be designed as a sheet, preferably with a hollow shape on the top, wherein the area of the hollow shape is not less than the area without hollow shape. The materials, thickness, and structure described above can be combined for different vibration transmitting plates. For example, the annular vibration transmitting plate has different thickness distributions. Preferably, the thickness of the support rod is equal to the thickness of the annular ring, further preferably, the thickness of the support rod is greater than the thickness of the annular ring, and even further preferably, the thickness of the inner ring is greater than that of the outer ring.

[0157] Specific embodiments

[0158] Embodiment 1

[0159] A bone conduction speaker comprising: a U-shaped earphone holder/strap, two sound vibration units, and an energy conversion device fixedly connected in the sound vibration unit. The vibration unit comprises a contact surface and a housing, wherein the contact surface is the outer side of the silicone transmitting layer. There is a gradient structure on the contact surface, wherein the gradient structure comprises a convex structure. The clamping force provided by the earphone holder/strap in contact with the skin is unevenly distributed on the contact surface. The gradient structure portion and the non-gradient structure portion have different sound transmission efficiencies.

[0160] Embodiment 2

[0161] The difference between this embodiment and embodiment 1 is that the composition of the earphone holder/strap comprises an alloy with memory function, wherein the earphone holder/strap can fit the head curves of different users and has good elasticity, providing better wearing comfort. After a certain period of deformation, the earphone holder/strap can still return to its original shape. A certain period of time here can refer to ten minutes, thirty minutes, one hour, two hours, five hours, as well as one day, two days, ten days, one month, one year, or even longer. The clamping force provided by the earphone holder/strap remains stable and will not gradually decrease over time. The pressure of the bone conduction speaker in contact with the surface of the human body is within an appropriate range, so that the human body does not feel excessive pressure and produces pain or obvious vibration when wearing it. During use, the clamping force of the bone conduction speaker is within the range of 0.2 N to 1.5 N.

[0162] Embodiment 3

[0163] The difference between this embodiment and embodiment 1 or 2 is that the elasticity coefficient of the earphone holder/strap is maintained within a specific range, so that the frequency response curve of the bone conduction speaker near the low frequencies (e.g. below 500 Hz) is higher than that near the high frequencies (e.g. above 4,000 Hz) during use.

[0164] Embodiment 4

[0165] The difference between this embodiment and embodiment 1 is that the bone conduction speaker is integrated on the eyeglass frame or inside the helmet or mask with special function.

[0166] Embodiment 5

[0167] The difference between this embodiment and embodiment 1 is that the vibration unit of the bone conduction speaker comprises two or more panels, and the gradient structure on the contact surface between different panels or vibration transmitting layers connected to the panels and the user is different. For example, one of the contact surfaces has a convex structure, while the other contact surface has a concave structure; or the gradient structures on both contact surfaces are either convex or concave, but there is at least one difference between the shape and quantity of the convex structure.

[0168] Embodiment 6

[0169] In a portable bone conduction hearing aid, multiple frequency response curves can be selected, and the user or tester can select the appropriate hearing aid response curve for compensation based on the actual response curve of the hearing system. In addition, according to actual needs, the vibration device in bone conduction hearing aids enables the hearing aid to produce a relatively ideal frequency response within a specific frequency range, such as 500 Hz to 4,000 Hz.

[0170] Embodiment 7

[0171] The vibration generating portion of a bone conduction speaker is shown in figure 22-A. Among them, the energy conversion device comprises a magnetic circuit system composed of a magnetic plate 2210, a magnet 2211 and a magnetic body 2212, a vibrating plate 2214, a coil 2215, a first vibration transmitting plate 2216, and a second vibration transmitting plate 2217. The panel 2213 protrudes from the housing 2219 and is bonded to the vibrating plate 2214 with adhesive. The first vibration transmitting plate 2216 connects and fixes the energy conversion device to the housing 2219, forming a suspension structure.

[0172] During the operation of the bone conduction speaker, the triple vibration system composed of the vibrating plate 2214, the first vibrating plate 2216, and the second vibrating plate 2217 can generate a flatter frequency response curve, thereby improving the sound quality of the bone conduction speaker. The first vibration transmitting plate 2216 elastically connects the energy conversion device to the housing 2219, which can reduce the vibration transmitted by the energy conversion device to the housing, effectively reducing the sound leakage caused by the housing vibration, and also reducing the impact of the housing vibration on the sound quality of the bone conduction speaker. The response curves of the housing vibration intensity of the vibration generating proportion and panel vibration intensity with frequency are shown in figure 22-B. Among them, the thick line shows the frequency response of the vibration generating portion after using the first vibration transmitting plate 2216, while the thin line shows the frequency response of the vibration generating portion without using the first vibration transmitting plate 2216. It can be known that in the frequency range above 500 Hz for the device without using the first vibration transmitting plate 2216, the vibration of the speaker housing is greater than that of the device with using the first vibration transmitting plate 2216. Figure 22-C shows a comparison of sound leakage between using the first vibration transmitting plate 2216 and not using the first vibration transmitting plate 2216 in the vibration generating portion. Among them, the sound leakage of the device using the first vibration transmitting plate 2216 in the mid-frequency range (e.g. around 1,000 Hz) is smaller than that of the device not using the first vibration transmitting plate 2216 in the corresponding frequency range. From this, it can be known that using the first vibration transmitting plate between the panel and the housing can effectively reduce the vibration of the housing, thereby reducing sound leakage.

[0173] The first vibration transmitting plate can be made of materials such as, but not limited to, stainless steel, beryllium copper, plastic, polycarbonate, etc., with a thickness ranging from 0.01 mm to 1 mm.

[0174] Embodiment 8

[0175] The difference between this embodiment and embodiment 7 is that, as shown in figure 23, a vibration transmitting layer 2320 (such as but not limited to silicone) is added to the panel 2313, wherein the vibration transmitting layer 2320 can produce certain deformation to adapt to the shape of the skin. The portion of the vibration transmitting layer 2320 in contact with the panel 2313 is higher than the portion of the vibration transmitting layer 2320 not in contact with the panel 2313, forming a stepped structure. One or more small holes 2321 are designed in the portion of the vibration transmitting layer 2320 that is not in contact with the panel 2313 (the non-convex portion of the vibration transmitting layer 2320 in figure 23). Designing small holes in the vibration transmitting layer can reduce sound leakage: the connection between the panel 2313 and the housing 2319 via the vibration transmitting layer 2320 becomes weaker, and the vibration transmitted from the panel 2313 to the housing 2319 via the vibration transmitting layer 2320 is reduced,

thereby reducing the sound leakage caused by the vibration of the housing 2319; the area of the non-convex portion of the vibration transmitting layer 2320 is reduced by disposing small holes 2321, which reduces the amount of air that can be driven and reduces the sound leakage caused by air vibration; after disposing small holes 2321 in the non-convex portion of the vibration transmitting layer 2320, the sound waves formed by the air vibration inside the housing are guided out of the housing and offset the sound leakage waves formed by the air vibration caused by the housing 2319, reducing the sound leakage.

[0176] Embodiment 9

[0177] The difference between this embodiment and embodiment 7 is that the panel protrudes from the speaker housing and is connected to the speaker housing using a first vibration transmitting plate, which greatly reduces the coupling degree between the panel and the housing, and in addition, the first vibration transmitting plate can provide a certain degree of deformation, allowing the panel to have higher degrees of freedom in fitting with the user and better adapt to complex fitting surfaces (as shown in the right section of figure 24-A). The first vibration transmitting plate can cause the panel to tilt at a certain angle relative to the housing. Preferably, the tilt angle does not exceed 5°.

[0178] Furthermore, the vibration efficiency of the speaker varies with different fitting states. A good fitting state has higher vibration transmission efficiency. As shown in figure 24-B, the thick line shows the vibration transmission efficiency in the state of good fit, while the thin line shows the vibration transmission efficiency in the state of poor fit. It can be known that the vibration transmission efficiency is higher in the state of good fit.

[0179] Embodiment 10

[0180] The difference between this embodiment and embodiment 7 is that a surrounding edge is added to the edge of the housing, which can make the force distribution more uniform during the contact between the housing and the skin, and increase the comfort of wearing the bone conduction speaker. As shown in figure 25, there is a height difference d_0 between the surrounding edge 2510 and the panel 2513. The force exerted by the skin on the panel 2513 reduces the distance d between the panel 2513 and the surrounding edge 2510. When the pressure between the bone conduction speaker and the user is greater than the force exerted when the first vibrating plate 2516 deforms into d_0 , the excess clamping force will be transmitted to the skin via the surrounding edge 2510 without affecting the clamping force of the vibrating portion, resulting in higher consistency of the clamping force and ensuring sound quality.

[0181] Embodiment 11

[0182] The panel shape is shown in figure 26, and the connecting portion 2620 between panel 2610 and the energy conversion device (not shown in figure 26) is indicated by the dashed line. The energy conversion device transmits vibration to the panel 2610 via the connecting portion 2620, and the position of the connecting portion 2620 is the vibration center of the panel 2610. The distance between the center O of the connecting component 2620 and the two sides of the panel 2610 is L_1 and L_2 , respectively. By changing the size of the panel 2610, the position of the connecting portion 2620 on the panel 2610 can alter the adhesion performance between the panel and the skin, as well as the efficiency of vibration transmission. Preferably, the ratio of L_1 to L_2 is set to be greater than 1, more preferably, the ratio of L_1 to L_2 is set to be greater than 1.61, and further preferably, the ratio of L_1 to L_2^2 is set to be greater than 2. For example, large, medium, and small panels can be used to act on the vibration device. The large panel referred to here refers to the panel described in figure 26, wherein the area of the panel 2610 is larger than that of the connecting portion 2620, the middle panel refers to the situation where the area of the panel 2610 is the same as that of the connecting portion 2620, and the small panel refers to the situation where the area of panel 2610 is smaller than that of the connecting portion 2620. The vibrations transmitted by panels of different sizes and the positions of different connecting portions 2620 have different distributions on the fitting surface of the wearer, resulting in differences in volume and sound quality.

[0183] Embodiment 12

[0184] This embodiment relates to various configurations of gradient structures on the outer side of the contact surface of the vibration unit of a bone conduction speaker. As shown in figure 27, the gradient structure consists of different numbers of convex portions, which are located at different positions on the outer side of the contact surface. In scheme 1, there is a convex portion located near the edge of the contact surface; In Scheme 2, there is a convex portion located at the center of the contact surface; In scheme 3, there are two convex portions on the contact surface, located near the edges of the contact surface respectively; In scheme 4, there are three convex portions; In scheme 5, there are four convex portions. The number and position of convex portions will have different effects on the vibration transmission efficiency of the contact surface. As shown in figures 28-A and 28-B, the frequency response curves exhibited by the contact surfaces with no convex structures are different from those with convex structures in schemes 1-5. It can be known that after adding gradient structures (convex portions) on the bonded surface, the frequency response curve has significantly increased in the range of 300 Hz-1100 Hz,

indicating that the mid- and low-frequency portion of the sound has been significantly improved after adding gradient structures.

[0185] Embodiment 13

[0186] This embodiment relates to various configurations of gradient structures on the inner side of the vibration contact surface of a bone conduction speaker. As shown in figure 29, the gradient structure of the contact surface is located on the inner side of the contact surface, that is, on the side facing away from the user. In scheme A, the inner side of the vibration transmitting layer is in contact with the panel, and there is a certain inclination angle between the contact surface and the outer side of the vibration transmitting layer; In scheme B, there is a step structure on the inner side of the vibration transmitting layer, which is located at the edge of the vibration transmitting layer; In scheme C, there is another step structure on the inner side of the vibration transmitting layer, which is located at the center of the vibration transmitting layer; In scheme D, there are multiple step structures on the inner side of the vibration transmitting layer. Due to the gradient structure on the inner side of the contact surface, different positions on the bonded surface between the contact surface and the panel have different vibration transmission efficiencies, which can broaden the frequency response curve of the vibration and make the frequency response "flatter" within a certain frequency range, thereby improving the sound quality of the bone conduction speaker.

[0187] Embodiment 14

[0188] The difference between this embodiment and the embodiment 8 is that, as shown in figure 30, sound holes are designed on both the vibration transmitting layer 3020 and the housing 3019. The sound waves formed by the air vibration inside the housing are guided out of the housing through the sound holes, and offset each other with the sound leakage waves formed by the air vibration caused by the housing 3019, reducing the sound leakage.

[0189] The above embodiments only express several specific embodiments of the present invention, and their descriptions are more specific and detailed, but shall not be understood as limiting the scope of the present invention patent. It shall be pointed out that for general technical personnel in this field, several modifications and improvements can be made without departing from the concept of the present invention. For example, the several ways of changing bone conduction sound transmission disclosed in this description can be combined and modified arbitrarily, but these modifications and combinations are still within the scope of protection of the claims of the present invention.

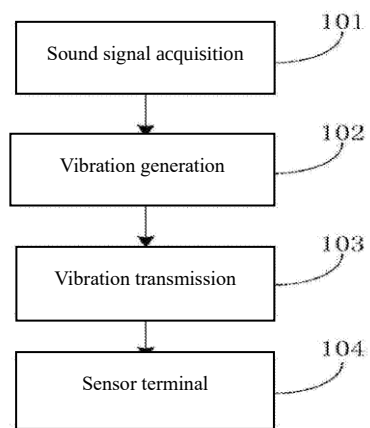


Figure 1

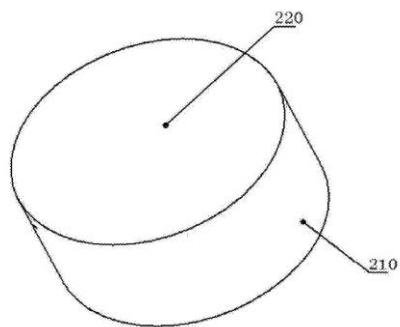


Figure 2-A

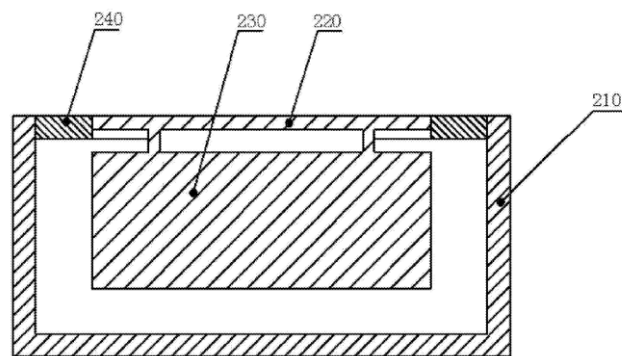


Figure 2-B

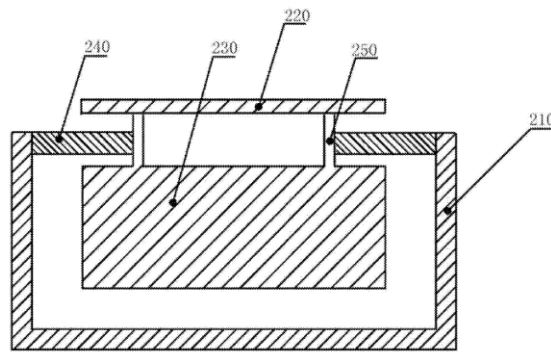


Figure 2-C

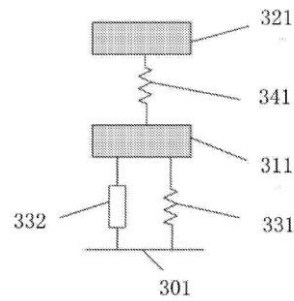


Figure 3-A

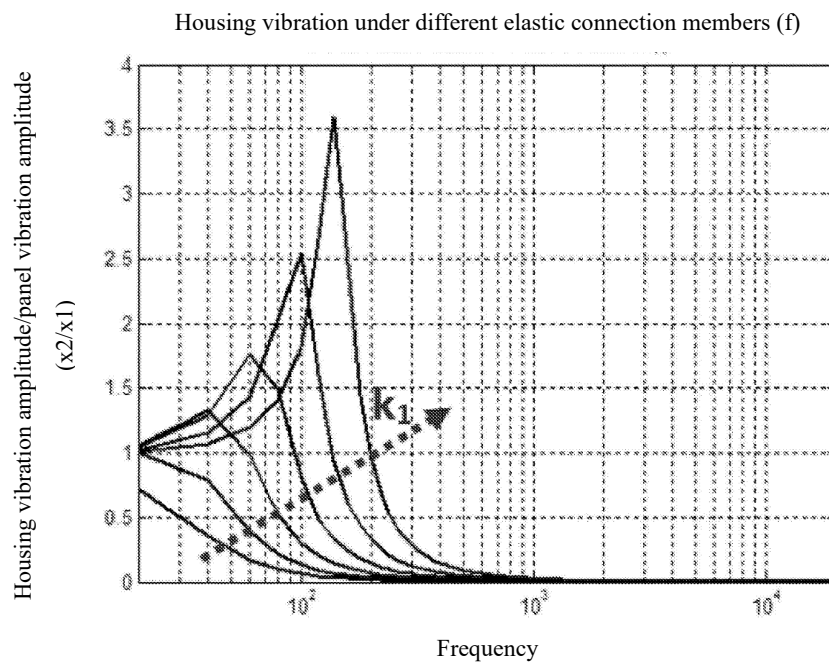


Figure 3-B

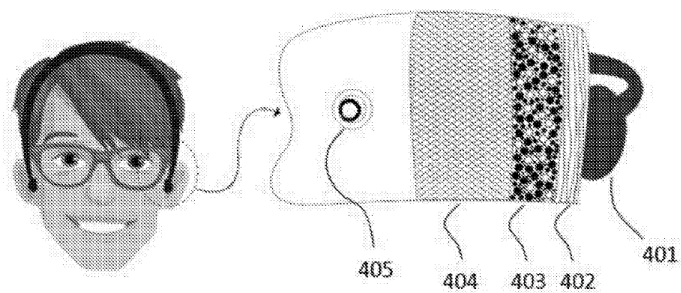


Figure 4

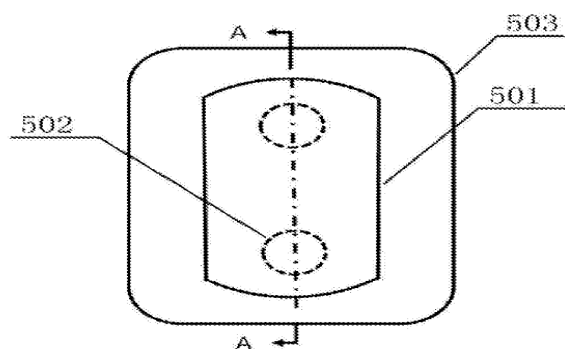


Figure 5-A

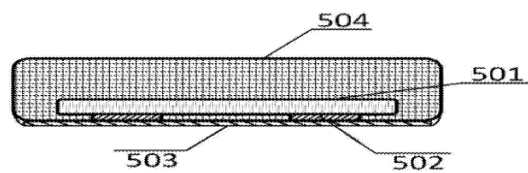


Figure 5-B

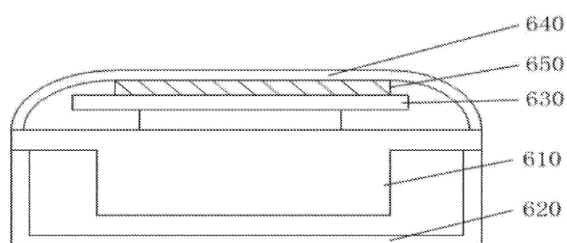


Figure 6

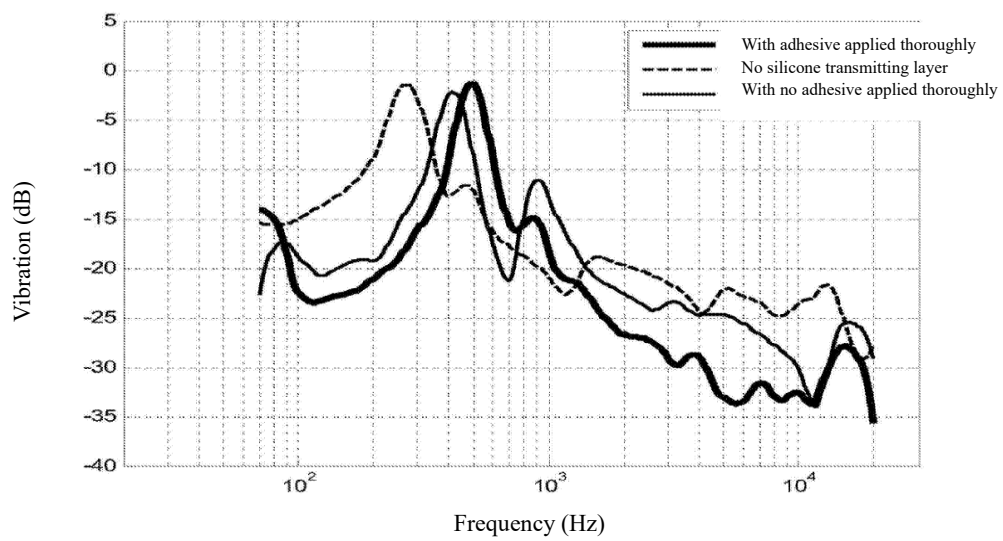


Figure 7

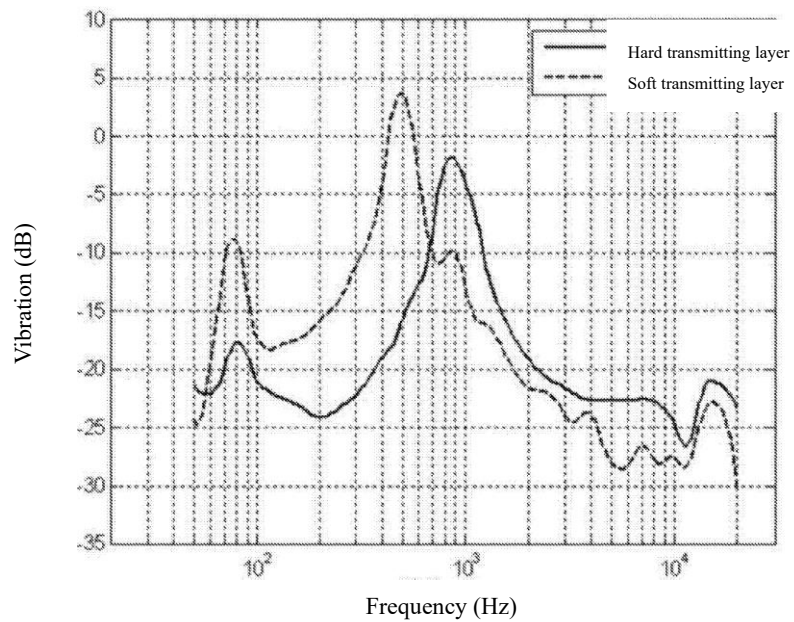


Figure 8

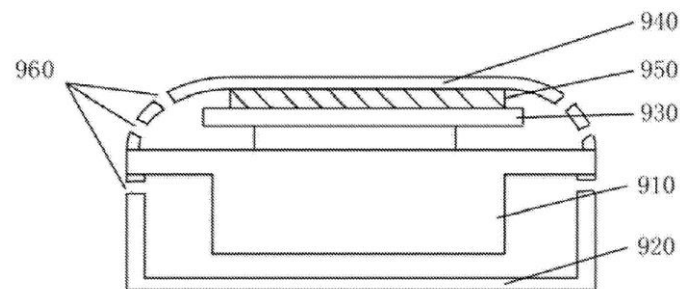


Figure 9

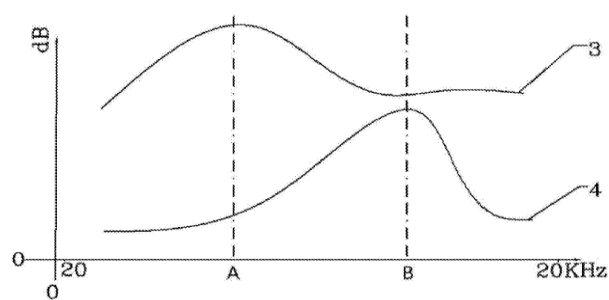


Figure 10

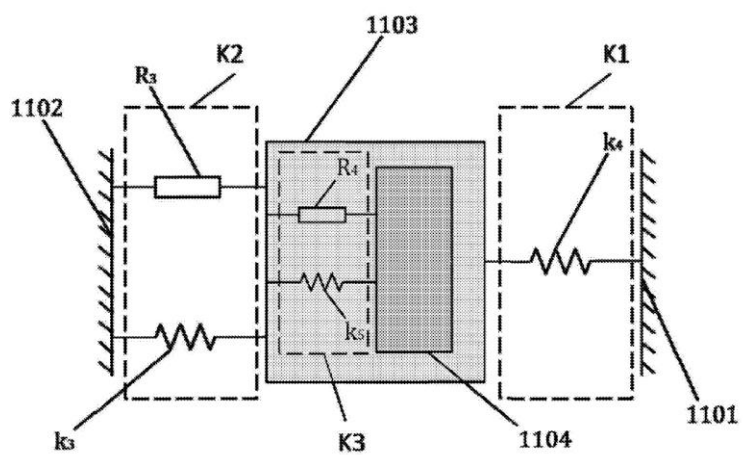


Figure 11

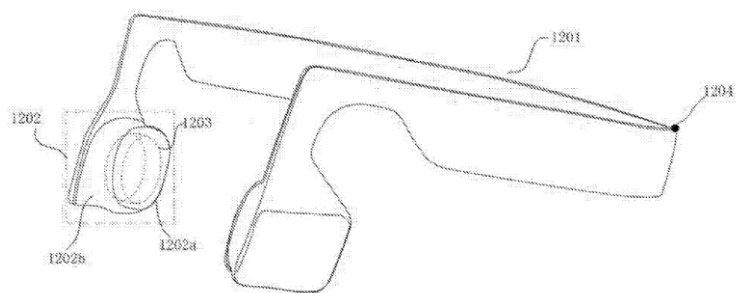


Figure 12

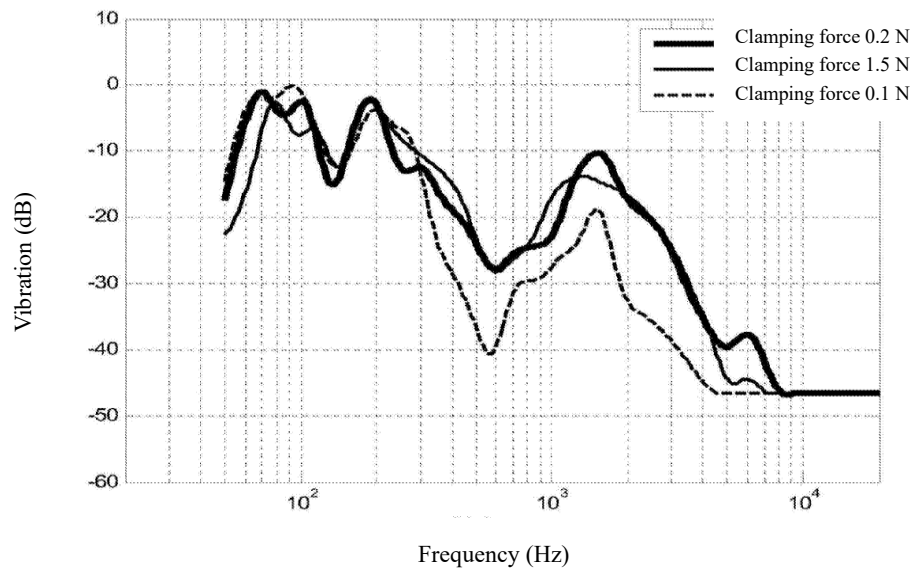


Figure 13-A

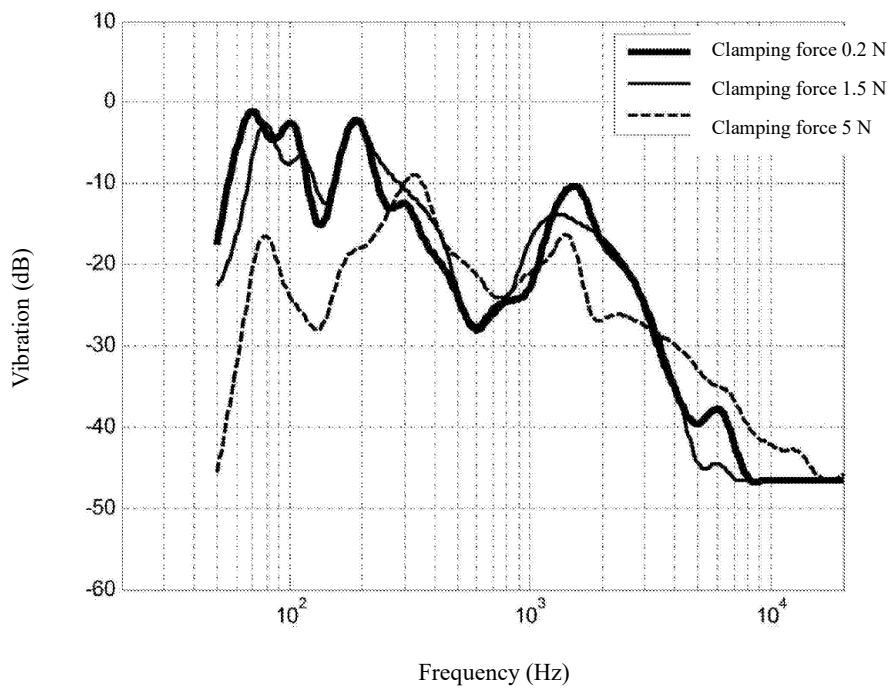


Figure 13-B

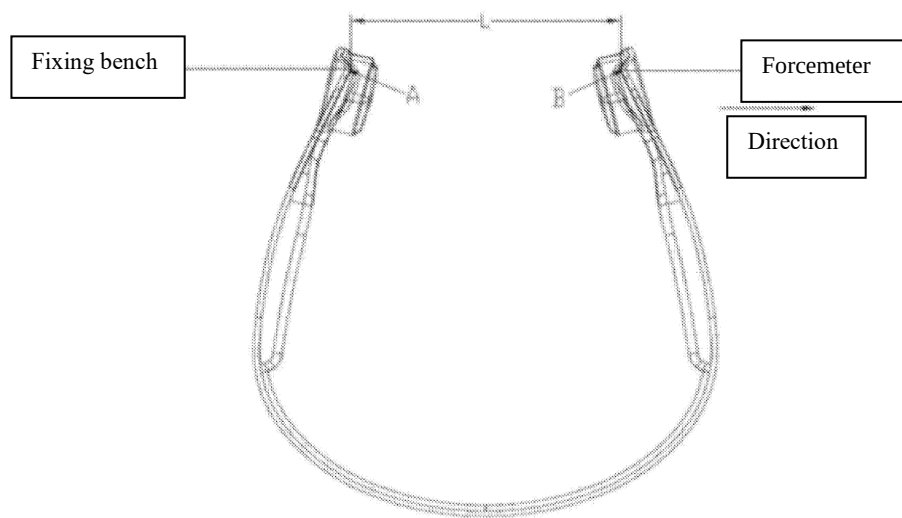


Figure 14-A

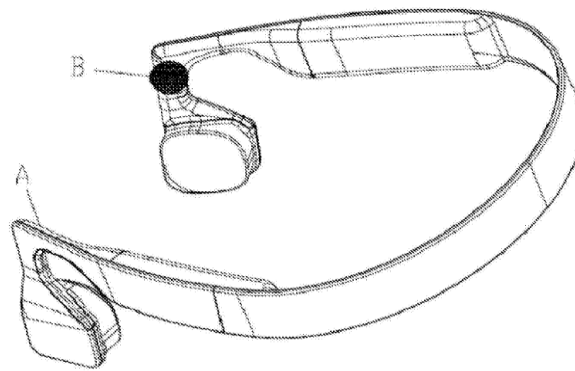


Figure 14-B

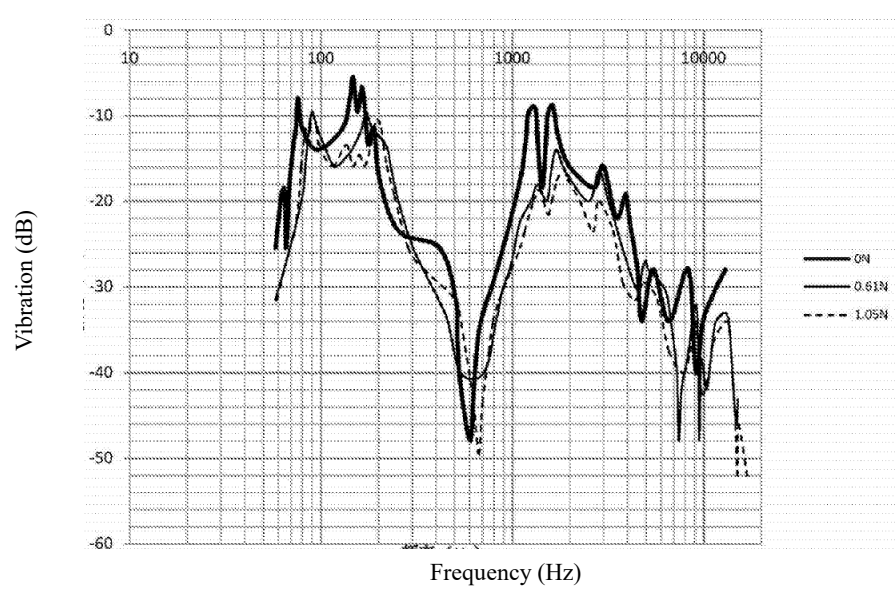


Figure 14-C

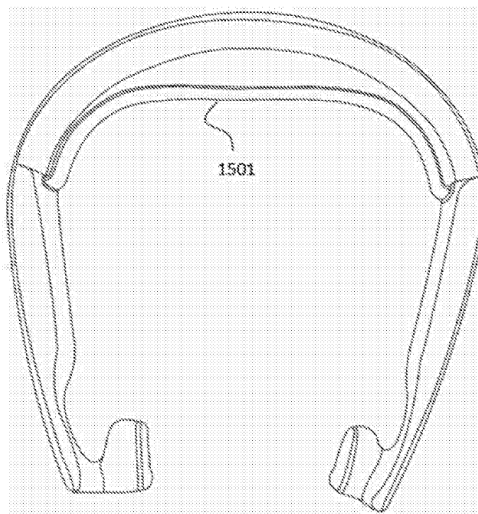


Figure 15

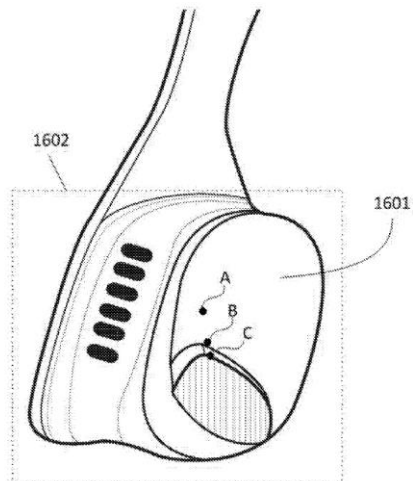


Figure 16-A

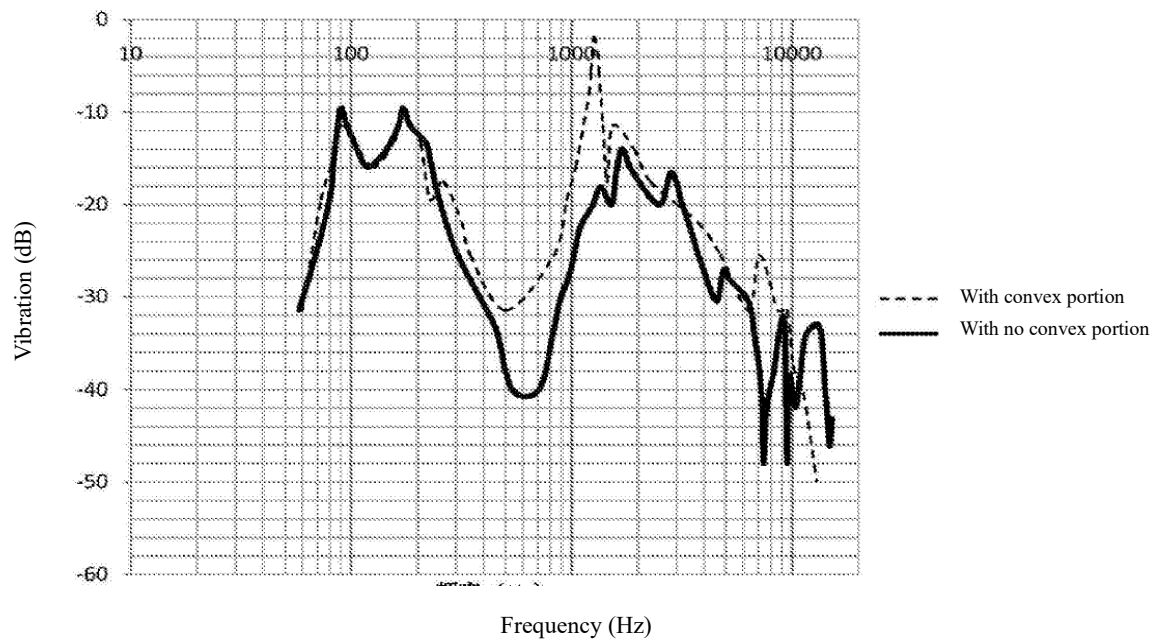


Figure 16-B

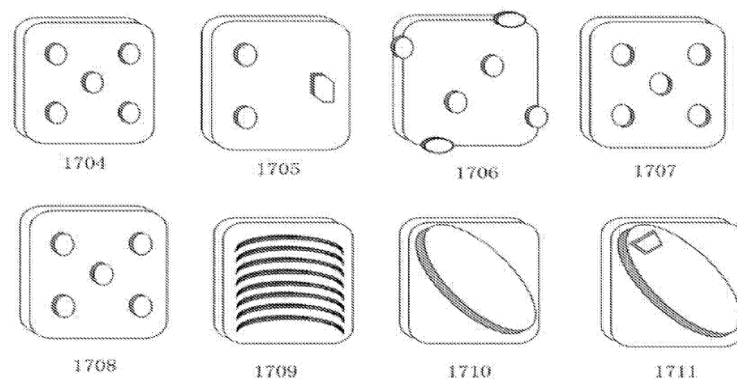


Figure 17

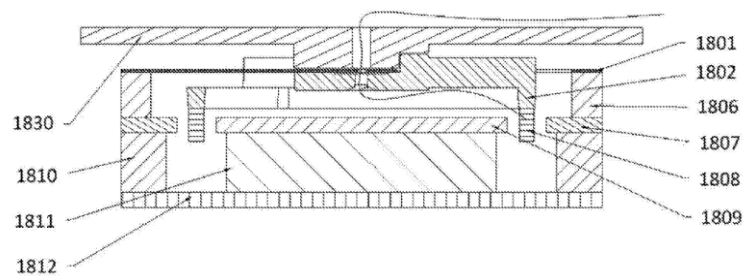


Figure 18-A

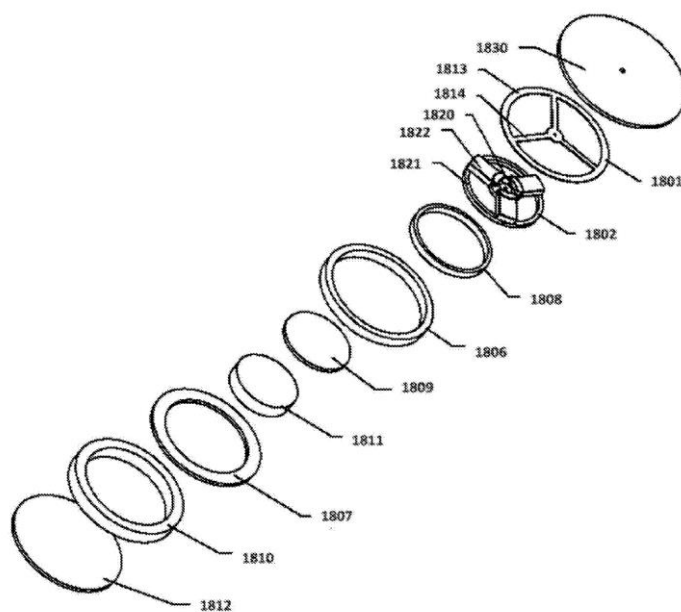


Figure 18-B

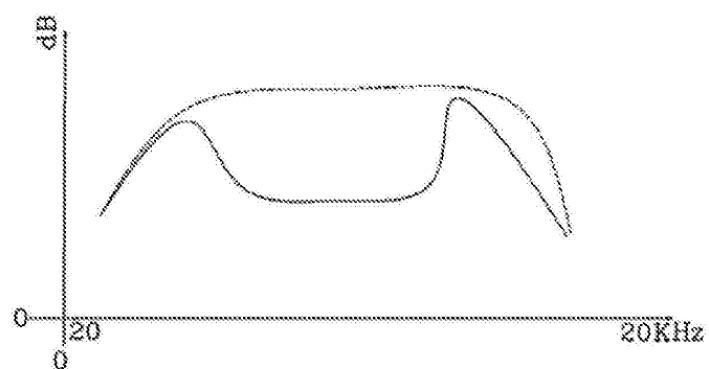


Figure 19

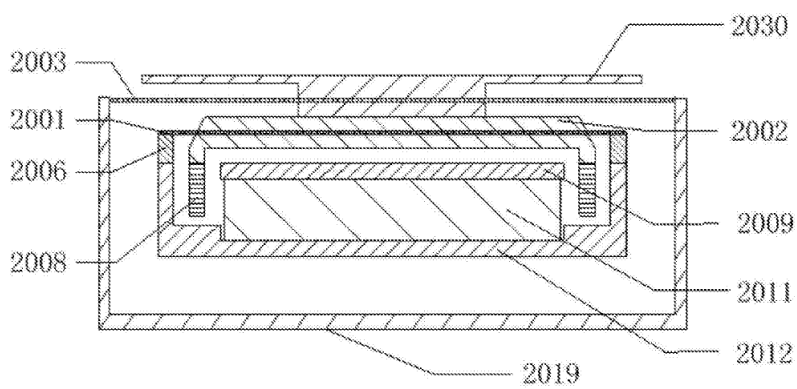


Figure 20

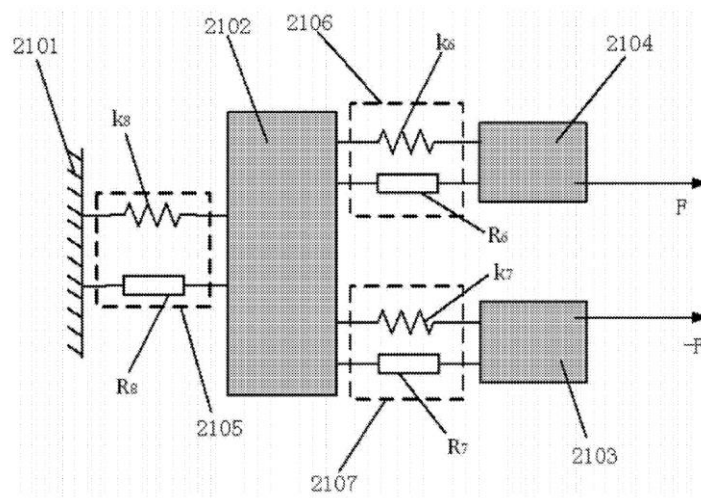


Figure 21-A

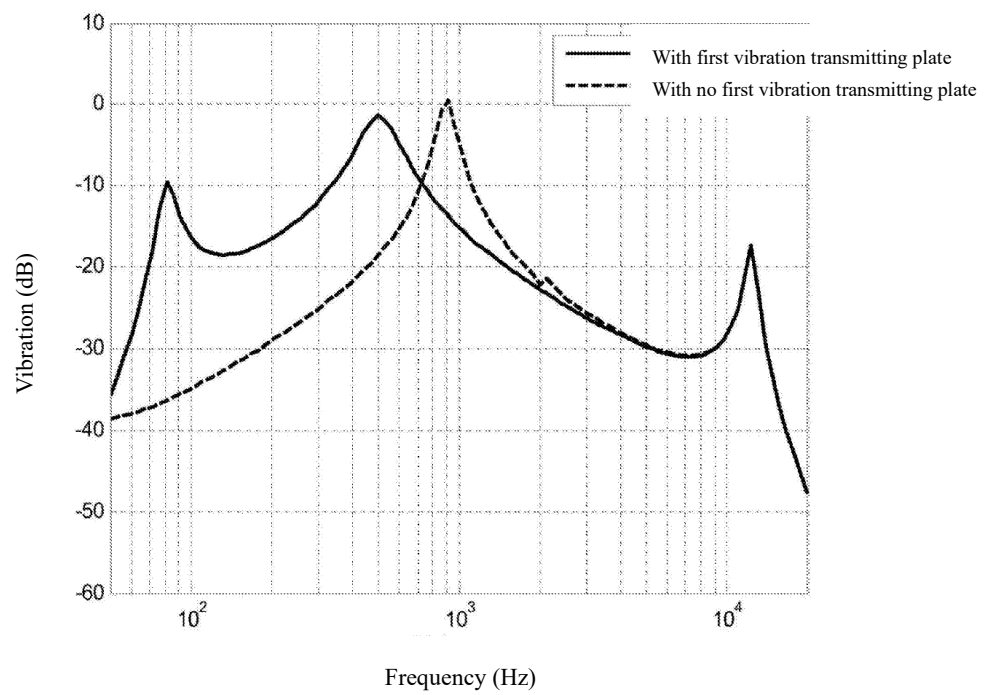


Figure 21-B

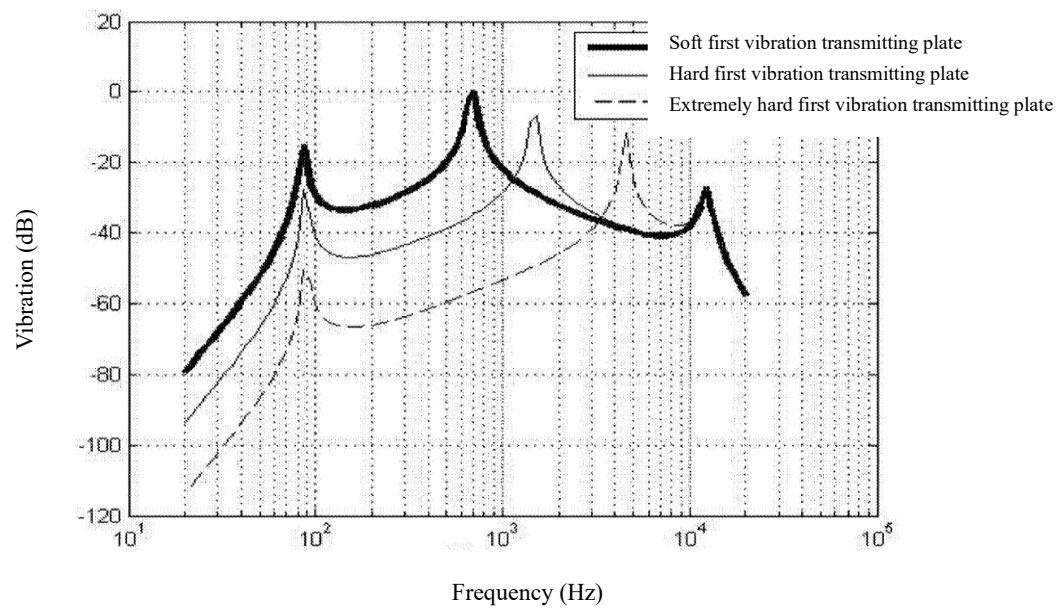


Figure 21-C

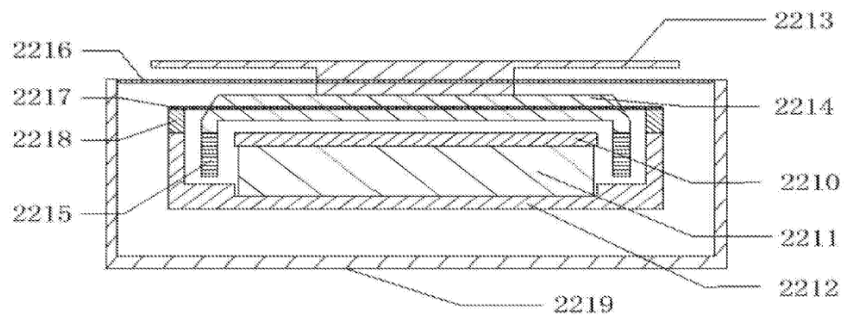


Figure 22-A

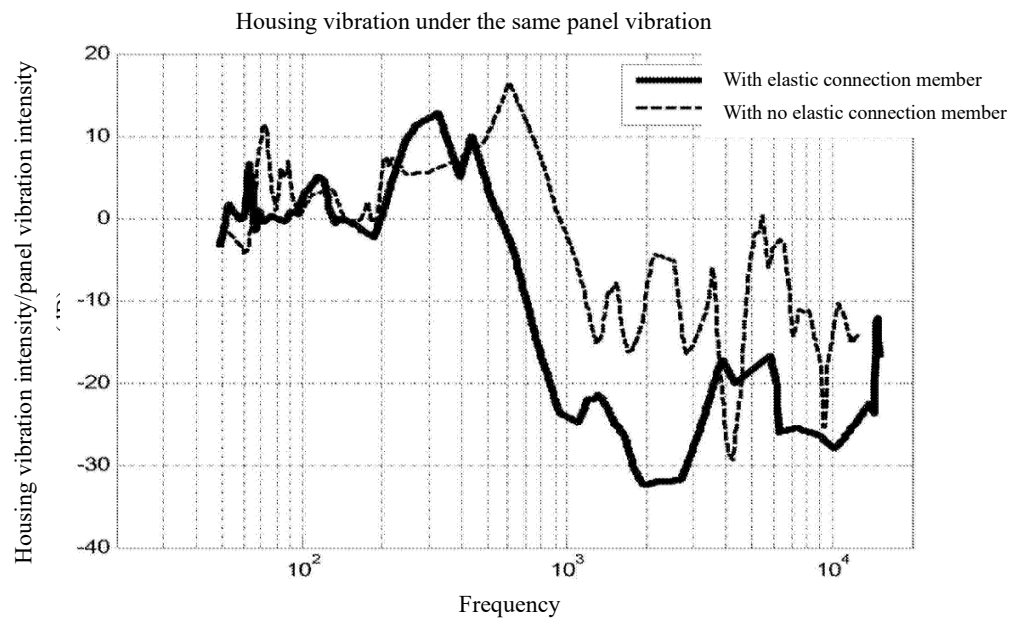


Figure 22-B

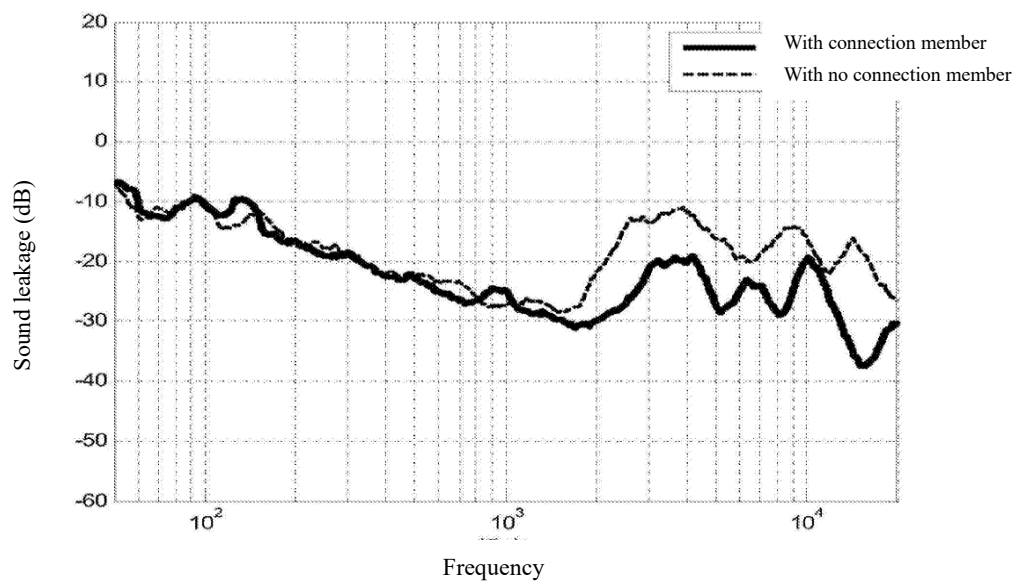


Figure 22-C

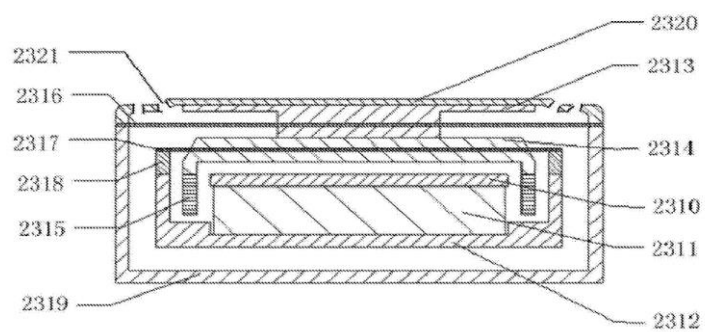


Figure 23

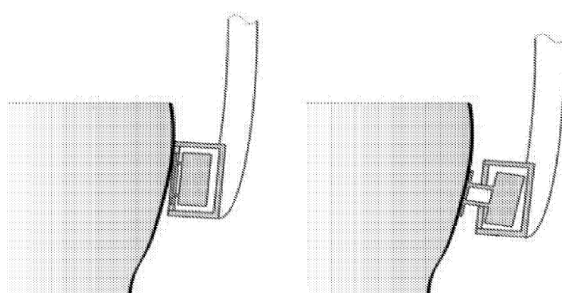


Figure 24A

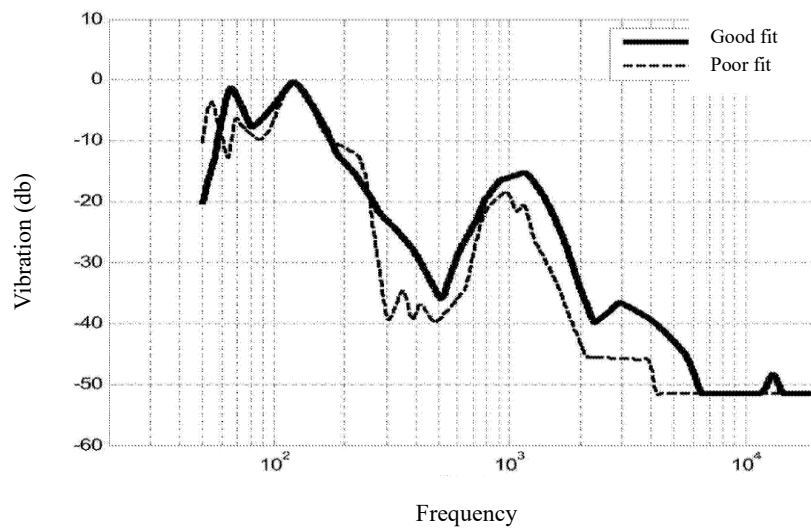


Figure 24-B

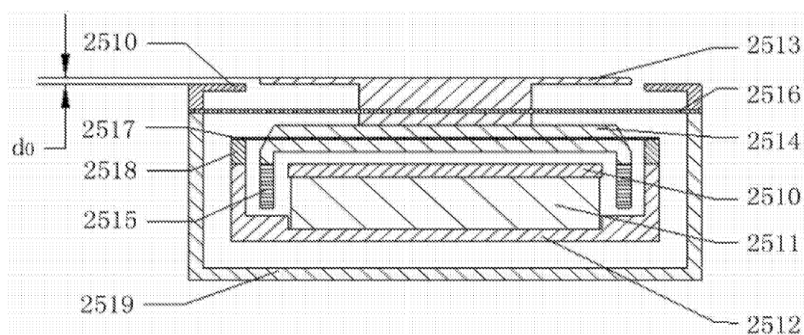


Figure 25

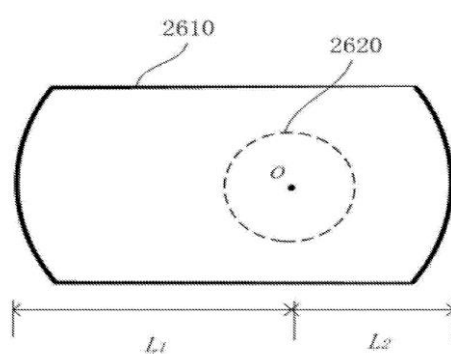


Figure 26

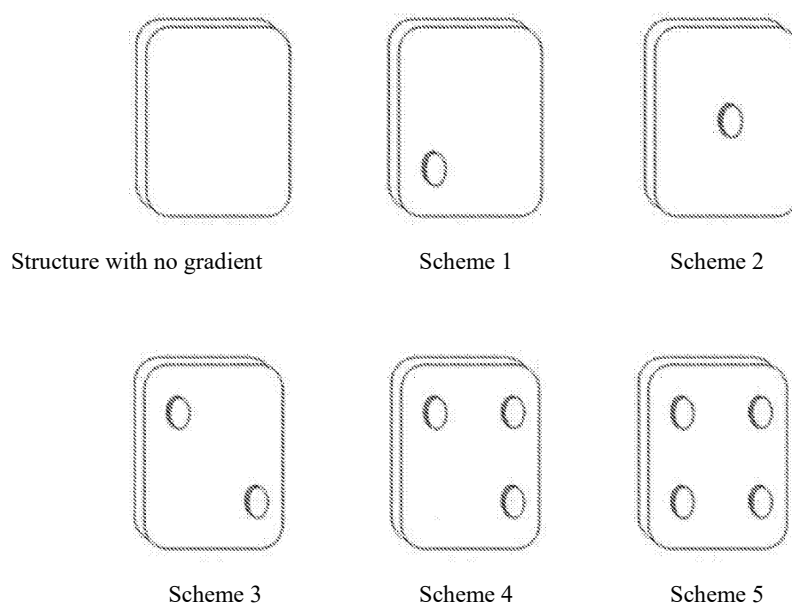


Figure 27

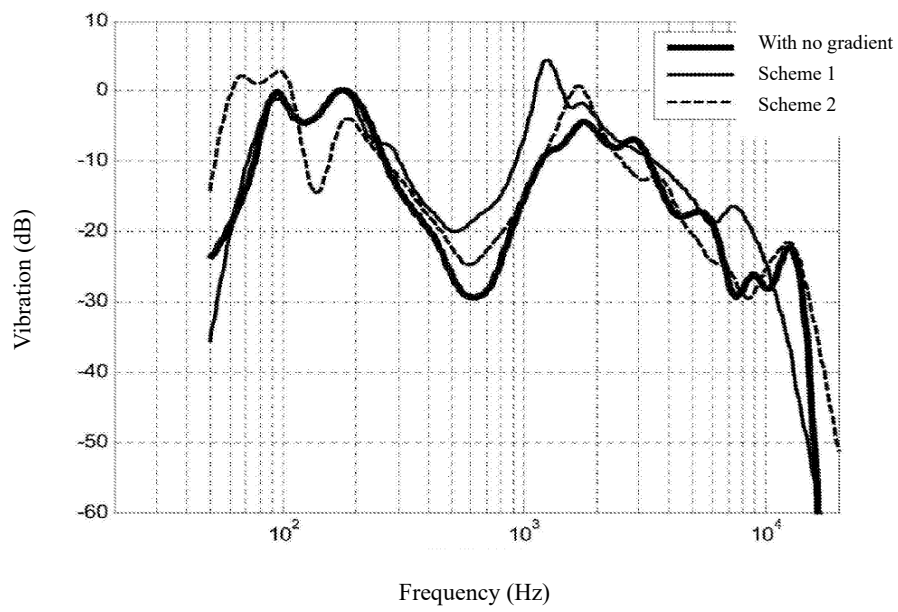


Figure 28-A

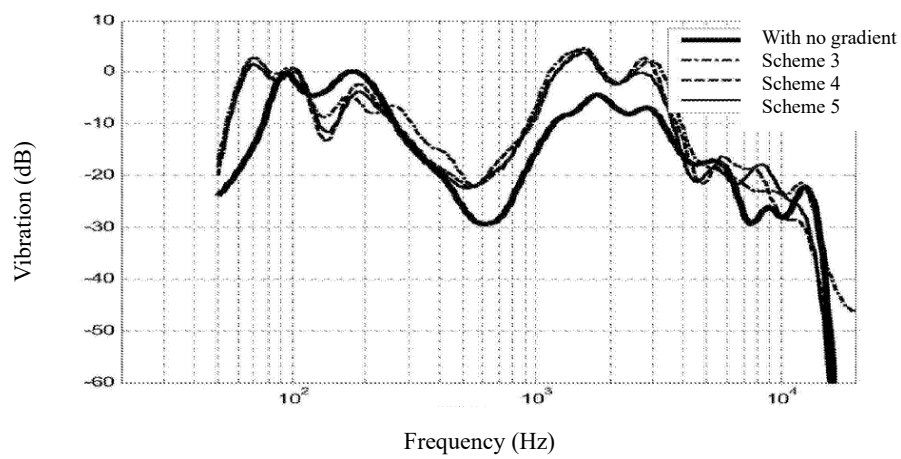


Figure 28-B

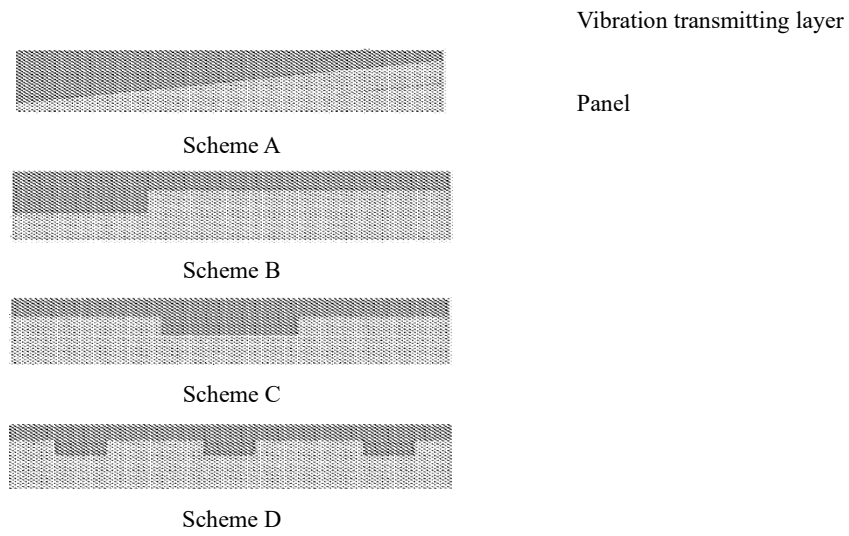


Figure 29

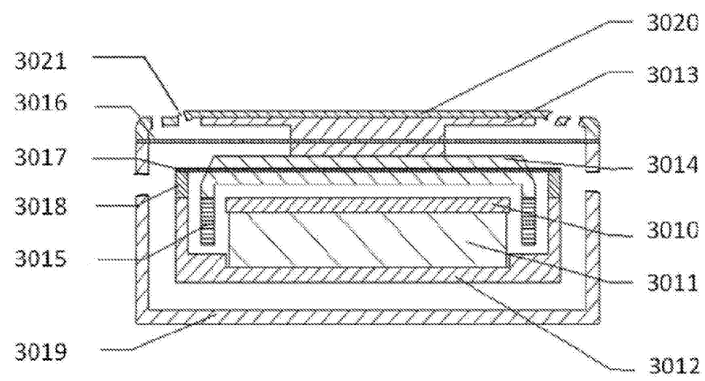


Figure 30

TRANSLATION CERTIFICATION

Date: 2025/05/08

To whom it may concern:

This is to certify that the attached translation is an accurate representation of the documents received by this office. The translation was completed from:

- Chinese (PRC)

To:

- English (USA)

The documents are designated as:

- 'CN106937222A'

Oscar Ojeda, Project Manager in this company, attests to the following:

“Under penalty of perjury under the laws of the United States of America, to the best of my knowledge, the aforementioned documents are a true, full and accurate translation of the specified documents.”



Signature of **Oscar Ojeda**, Project Manager

QUESTEL CONFIDENTIAL

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