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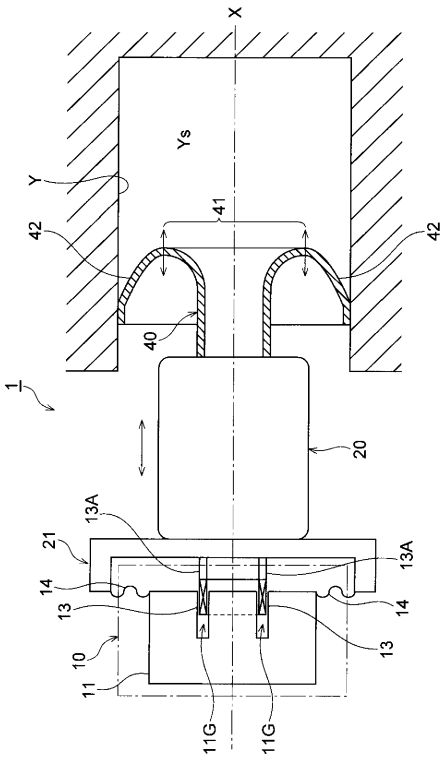
(54) EARPHONES

(57) A low sound range can be reproduced even if an earphone is small. An earphone 1 includes a vibration means 10 which vibrates in an uniaxial direction, a housing 20 which supports the vibration means 10 and vibrates in response to the vibration of the vibration means 10, and an ear tip 40 mounted on the housing 20, wherein the ear tip 40 is arranged around the uniaxial direction and includes a vibration part 41 which vibrates in response to the vibration of the housing 20 and a holding part 42 which holds the housing in the ear canal.

[Fig. 1]



EP 2 701 399 A1

Description

FIELD OF THE INVENTION

[0001] The present invention relates to an earphone.

BACKGROUND OF THE INVENTION

[0002] An earphone as described in the below-described patent literature 1 includes a unit having a leading sound tube and an ear tip mounted on the leading sound tube in the unit, wherein the ear tip is used while being inserted into the outer ear canal of a user.

PRIOR ART

[0003] [Patent literature 1] Japanese Unexamined Patent Application Publication No. 2010-10885

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0004] In a conventional insert-type earphone, a speaker unit of the earphone is held via an ear tip which is inserted into an outer ear canal, and therefore the speaker unit needs to be downsized to hold the speaker unit with an appropriate holding force. However, a small-sized speaker unit has difficulty in acquiring vibrations in the required low sound range, and thus has a problem that a favorable sound quality cannot be acquired in the low sound range during the reproduction of a music source and so forth including the low sound range.

[0005] Further, an ear tip included in the conventional insert-type earphone is designed focusing on the adhesion onto the inner surface of an ear canal (outer ear canal), and thus the compliance in the direction along the ear canal is small so that the low sound range cannot be effectively reproduced by vibrating the ear tip itself.

[0006] The present invention addresses such a problem. That is, the objective of the present invention is to provide an earphone capable of reproducing the low sound range even if the earphone includes a relatively small speaker unit and thus to allow for the sound reproduction creating the feeling of being at a live performance by reproducing the low sound range even if the earphone is small.

MEANS FOR SOLVING THE PROBLEM

[0007] To achieve such an objective, an earphone according to the present invention includes at least the following configuration:

[0008] An earphone comprising: a vibration means which vibrates in an uniaxial direction; a housing which supports said vibration means and vibrates in response to the vibration of the vibration means; and an ear tip which is mounted on said housing, wherein said ear tip is arranged around said uniaxial direction and includes a vibration part which vibrates in response to the vibration of said housing and a holding part which holds said housing in ear canal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Fig. 1 is a conceptual view showing a basic configuration of an earphone according to an embodiment of the present invention.

Fig. 2 is a view illustrating an example of more specific configuration of an earphone according to an embodiment of the present invention.

Fig. 3 is a view illustrating an example of a sound pressure frequency characteristic acquired by an earphone according to an embodiment of the present invention.

Fig. 4 is a view illustrating an example of the form of an ear tip when driving only a vibration unit in an earphone according to an embodiment of the present invention.

Fig. 5 is a view illustrating an example of the form of an ear tip when driving only a vibration unit in an earphone according to an embodiment of the present invention.

BEST MODE FOR PRACTICING THE INVENTION

[0010] Hereinafter, an embodiment according to the present invention is described with reference to the drawings. Fig. 1 is a conceptual view showing a basic configuration of an earphone according to an embodiment of the present invention. An earphone 1 comprises: a vibration means (vibration unit) 10 which vibrates in an uniaxial direction (direction of the X axis shown in the drawing); a housing 20 which supports the vibration means 10 and vibrates in response to the vibration of the vibration means 10; and an ear tip 40 mounted on the housing 20.

[0011] The ear tip 40 is arranged around the uniaxial direction (direction of the X axis shown in the drawing), that is, around the vibration direction of the vibration means 10. The ear tip 40 holds the housing 20 in an ear canal(outer ear canal) Y while vibrating by itself in response to the vibration of the housing 20, and has a vibration part 41 which vibrates in response to the vibration of the housing 20 and a holding part 42 which holds the housing 20 in ear canal.

[0012] The vibration means (hereinafter referred to as "vibration unit") is supported by a vibration unit support 21 in the housing 20. The vibration unit 10 is provided with a magnetic circuit 11 including a magnetic gap 11G, an excitation coil 13 positioned in the magnetic gap 11G, and a suspension 14 which supports the magnetic circuit 11 at the vibration unit support 21 of the housing 20. The excitation coil 13 is fixed to the vibration unit support 21 of the housing 20 directly or via a support section 13A.

[0013] In such an earphone 1, an excitation signal is input into the excitation coil 13 to vibrate the vibration unit 10 in the direction of the X axis and the vibration is transmitted to the housing 20 to vibrate the housing 20 in the direction of the X axis. Further, in response to the vibration of the housing 20, the ear tip 40 arranged around the vibration direction vibrates. The holding part 42 that is the outer peripheral part of the ear tip 40 keeps in contact with the inner surface of the ear canal Y so that the vibration of the vibration part 41 creates a pressure fluctuation in the space Ys inside the ear canal Y, and the pressure fluctuation allows for the reproduction of the low sound range.

[0014] The holding part 42 of the ear tip 40 is held by the ear canal Y so that the entire circumference of the holding part 42 is arranged in close contact with the inner surface of the ear canal Y. Thereby, the space Ys inside the ear canal Y is hermetically or semi-hermetically sealed so that the vibration of the vibration part 41 of the ear tip 40 effectively creates a pressure fluctuation in the space Ys, and thus allows for higher quality reproduction of the low sound range by driving the volume of the hermetically or semi-hermetically sealed space Ys.

[0015] Fig. 2 is a view illustrating an example of more specific configuration of the earphone 1 according to an embodiment of the present invention. According to the example shown in the drawing, the earphone 1 includes a speaker unit 30 and a vibration unit 10, which are housed in the housing 20. The speaker unit 30 emits a sound in response to an audio signal and has a voice coil 31 to which the audio signal is input. When an audio signal is input, the voice coil 31 vibrates in the vibration direction (X-axis direction) of the vibration unit (vibration means) 10.

[0016] Further, the speaker unit 30 includes a magnetic circuit 32 having a magnetic gap 32G and the voice coil 31 is arranged in the magnetic gap 32G. The magnetic circuit 32 includes, for example, a magnet 32A, a yoke 32B and a plate 32C, and the magnetic gap 32G is formed between the yoke 32B and the plate 32C. A diaphragm 33 is attached to the voice coil 31 and the diaphragm 33 is supported by a frame 34. The frame 34 is provided with an opening 34A for emitting the sound created by the diaphragm 33.

[0017] The vibration unit 10 includes the magnetic circuit 11, the excitation coil 13, and the suspension 14 as described above, and the magnetic circuit 11 is supported via the suspension 14 by the vibration unit support 21 of the housing 20 to which the excitation coil is fixed. The magnetic circuit 11 includes a magnet 11A, a yoke 11B and a plate 11C, and a magnetic gap 11C is formed between the yoke 11B and the plate 11C.

[0018] Further, a weight part 12 is provided on the magnetic circuit 11, and the mass of the magnetic circuit 11 including the weight part 12 is substantially the same as the total mass of the housing 20 and the speaker unit 30.

[0019] The housing 20 includes a tubular leading sound part 22 for leading the sound emitted from the speaker unit 30 and an opening 23 formed at one end of the leading sound part 22. The leading sound part 22 and the opening 23 are provided inside the ear tip 40. Further, the speaker unit 30 in the housing 20 is positioned closer to the leading sound part 22 than the vibration unit 10 in the housing 20.

[0020] In the example shown in the drawing, the vibration part 41 of the ear tip 40 has an inner peripheral part 41A which is supported by the housing 20, and an edge part 43 is provided between the vibration part 41 and the holding part 42. The aforementioned leading sound part 22 and the opening 23 are provided inside the inner peripheral part 41A of the ear tip 40. Further, the effective vibration area Va for the vibration of the ear tip 40 is acquired by the vibration part 41 and a part of the edge part 43. By making larger the effective vibration area Va, the sound pressure produced by the vibration of the ear tip 40 can be increased.

[0021] In the example shown in the drawing, the ear tip 40 is annularly provided on the circumference of the housing 20, and the outer periphery of the vibration part 41 is connected to the inner periphery of the edge part 43, and the outer periphery of the edge part 43 is connected the inner periphery of the holding part 42. Such a formation can be created by integrally molding the vibration part 41, the edge part 43, and the holding part 42.

[0022] In the earphone 1 according to an embodiment of the present invention, it is preferable that the ear tip 40 itself is soft and has a desirable elasticity, while having a large compliance with respect to a force in the axial direction (X-axis direction). Also, it is preferable that the holding part 42 of the earphone 1 is arranged in close contact with the inner surface of the ear canal so that the space in the ear canal is hermetically or semi-hermetically sealed.

[0023] The form of the edge part 43 is important for the ear tip 40 to have such a characteristic. In the example shown in the drawing, the edge part 43 has a cross-sectional shape with a wave shape in the uniaxial direction (X-axis direction). Further, the thickness tb of the edge part 43 is formed thinner than the thickness ta of the vibration part 41. The edge part 43 formed in such a manner has a relatively large compliance with respect to a force in the direction of the X axis, and allows the holding part 42 to keep in close contact with the inner surface of the ear canal by having a force to elastically expand the holding part 42 toward the outside thereof. In the example shown in the drawing, the maximum diameter of the holding part 42 of the ear tip 40 is larger than the maximum diameter of the housing 20. According to this formation, it is possible to allow the holding part 42 to keep in close contact with the inner surface of the ear canal by expanding the holding part 42 toward the outside thereof, and thus to hermetically seal the space in the ear canal.

[0024] Such a earphone 1 can be driven by a common signal which is input into the voice coil 31 of the speaker unit 30 as an audio signal while being input into the excitation coil 13 of the vibration unit 10 as an excitation

signal. According to this configuration, the vibration part 41 of the ear tip 40 effectively reproduces low frequency sound, and thus even if the earphone is made small, it is possible to reproduce a sufficient low sound range in both vibration and sound pressure. The ear tip 40 has a large compliance and thus makes it easy to cut low-to-mid range frequencies that may cause an unwanted dull sound so that a high-quality low frequency sound can be reproduced by the vibration of the vibration part 41 with no use of an electric filter. Further, the diaphragm 33 of the speaker unit 30 can reproduce a relatively high frequency sound, thereby expanding reproduction frequency band.

[0025] Fig. 3 is a view illustrating an example of a sound pressure frequency characteristic acquired by the earphone 1 according to an embodiment of the present invention. This example shows a high sound pressure level in low frequencies no more than 100Hz. The necessary frequency band and sound pressure can be adjusted by properly setting the mass of the magnetic circuit 11 including the weight part 12 of the vibration unit 10, the mass of the housing 20 including the speaker unit 30, the spring constant of the suspension 14, and the spring constant and compliance of the ear tip 40 for the earphone 1 according to an embodiment of the present invention. Specifically, the resonant frequency for the mass of the magnetic circuit 11 including the weight part 12 of the vibration unit 10 and the resonant frequency for the mass of the housing 20 including the speaker unit 30 produce a sound (vibration), and the peaks of these two resonant frequencies represent a frequency characteristic. Any frequency characteristic can be simply acquired by positioning both resonant frequencies for these two peaks closer to each other through adjustment of a spring constant and by adjusting resonance sharpness through the addition of a resistor.

[0026] The performance required for the ear tip 40 of the earphone 1 is, for example, to increase the effective vibration area Va in order to increase sound pressure caused by vibration; to employ a shape which allows for a broad design scope of compliance in order to set any frequency characteristic; and to improve the adhesion onto the wall surface of the ear canal in order to efficiently convert the vibration of the ear tip 40 to the pressure fluctuation in the volume of the ear canal.

[0027] By increasing the effective vibration area Va of the ear tip 40 the sound pressure sensitivity can be increased. It is preferable to increase the width of the edge part 34 in a direction intersecting with the X axis or the edge part 43 is arranged further outside from the center of the housing 20 in order to increase the effective vibration area Va.

[0028] By increasing the compliance of the ear tip 40 the resonant frequency of vibration is shifted to a lower sound range, and thus a lower sound range can be reproduced. The form of the edge part 43 needs to be devised so as to increase the compliance.

[0029] Figs. 4 and 5 are views illustrating examples of the form of an ear tip when driving only a vibration unit in an earphone according to an embodiment of the present invention. Not only the cross-sectional shape of wave shape for the edge part 43 of the ear tip 40 shown in the example of Fig. 2, but also various types of cross-sectional shapes as shown in Figs. 4 and 5 allow for the increase of the compliance of the ear tip 40.

[0030] Figs. 4(a) to 4(c) and Figs. 5(a) and 5(b) show the cross-sectional shapes of the ear tip 40 in the vibration direction (X-axis direction) of the vibration unit 10. The ear tips 40 (40A to 40E) shown in Figs. 4(a) to 4(c) and Figs. 5(a) and 5(b) are arranged around the vibration direction (X-axis direction shown in the drawing) of the vibration unit 10 in the same manner as the example described above, and include the vibration part 41 which vibrates in response to the vibration of the housing 20 and the holding part 42 which holds the housing 20 in the ear canal. Further, the ear tip 40 includes the edge part 43 between the vibration part 41 and the holding part 42.

[0031] In the ear tip 40 (40A) shown in Fig. 4(a), the edge part 43 extends in a direction intersecting with the X axis and is arranged annularly around X-axis, and the cross-sectional shape of the edge part 43 in the direction intersecting with the vibration direction (in the direction of the X axis) is formed in a convex (or concave) shape in the direction of the X axis. Further, the example shown in Fig. 4(a) illustrates that the holding part 42 provided outside the edge part 43 has an uprise part 42a which rises up from the outer end of the edge part 43 along the X axis and an umbrella-shaped part 42b which extends in the direction opposite the uprise part 42a from the end of the uprise part 42a. According to this example, by increasing the width of the edge part 43, it is possible to increase compliance while increasing the effective vibration diameter. Further, even if the compliance of the edge part 43 is increased, since the uprise part 42a is provided, it is possible to increase adhesion onto the inner surface of ear canal via the elastic force of the uprise part 42a and the umbrella-shaped part 42b.

[0032] In the ear tip 40 (40B) shown in Fig. 4(b), the edge part 43 extends in the direction along the X axis and is provided annularly around X-axis, and the cross-sectional shape of the edge part 43 in the direction intersecting with the vibration direction (X-axis direction) is formed in a convex (or concave) shape in the direction intersecting with X-axis. According to this example, by having the inner peripheral part 41A projecting outwards, the position of the edge part 43 is arranged outwards, and thereby creating a relatively large effective vibration diameter. Further, similarly to the aforementioned example, the ear tip 40B includes the uprise part 42a extending along the X axis from the end of the edge part 43 and the umbrella-shaped part 42 extending in the direction opposite the uprise part 42a from the end of the uprise part 42a so that even if compliance is increased, the elastic force of the uprise part 42a and the umbrella-shaped part 42b can improve adhesion toward the inner surface

of ear canal.

[0033] In the ear tip 40 (40C) shown in Fig. 4(c), the edge part 43 extend in the direction along the X axis and is provided annularly around X-axis, and the cross-sectional shape of the edge part 43 in a direction intersecting with the vibration direction (in the direction of the X-axis) is formed in a concavo-convex shape in a direction intersecting with X-axis. Particularly, in the illustrated example, the edge part 43 has a rectangular concavo-convex shape. According to this example, the vibration of the housing 20 can be converted to sound pressure on the concavo-convex surface of the edge part 43 intersecting with the X axis so that the amplitude of the housing 20 can be effectively converted to sound pressure.

[0034] In the ear tip 40 (40D, 40E) shown in Figs. 5(a) and 5(b), the edge part 43 is tubularly formed along the circumference in the direction of the X axis and is provided annularly around the X axis. The inside of the tubular edge part 43 can be filled with air or other gas, liquid or solid. In the example shown in Fig. 5(a), a vibration part 41 for mounting the ear tip 40 (40D) onto the housing 20 extends in a direction intersecting with X-axis, while in the example shown in Fig. 5(b), the vibration part 41 for mounting the ear tip 40 (40E) onto the housing 20 extends along the X axis so that the edge part 43 is supported in the manner of a cantilever.

[0035] According to such an ear tip 40 (40D, 40E), a suitable spring constant in addition to a large compliance can be acquired by the tubular edge part 43. The shape of the edge part 43 allows for a large compliance in the direction of the X axis, and the compliance can be easily adjusted by adjusting the diameter of the tubular edge part 43. Further, the ear tip 40 is configured to easily support the housing 20 horizontally along an ear canal even if the edge part has a relatively large compliance.

[0036] The ear tip 40 (40D, 40E) as shown in Fig. 5 is also provided with the holding part 42 extending outside the edge part 42 like an umbrella. Even when the edge part 43 has a large compliance, it is possible to improve adhesion onto the inner surface of the ear canal by forming the holding part 42 into a shape which extends to the outside thereof. Thereby, it is possible to effectively create the space Ys in the ear canal in a hermetically or semi-hermetically sealed state.

[0037] In the earphone 1 according to such an embodiment the ear tip 40 is vibrated by vibrating the vibrating unit 10 via the housing 20 in the direction of the X axis with reference to the inner surface of the ear canal Y (human body), and thereby effectively driving the air volume of the space Ys in the ear canal, which is hermitically or semi-hermetically sealed. Accordingly, the ear tip 40 having a large compliance with respect to the force in the direction of the X axis functions as a diaphragm, and thereby reproducing a high-quality low frequency range with little dull sound. Further, the vibration of the ear tip 40 creates a pressure fluctuation in the space Ys in the ear canal, and the pressure fluctuation allows for the reproduction of low sound range. As such, the earphone 1 according to the embodiment of the present invention allows for the sound reproduction creating the feeling of being at a live performance even if the earphone is small.

[0038] Further, in the earphone 1 according to an embodiment of the present invention the resonant frequency of vibration is shifted to a lower sound range by increasing the compliance of the ear tip 40 in the direction of the X axis. Therefore, since the frequency of the sound pressure excited by the vibration of the vibration unit 10 is in a lower sound range, unprecedented reproduction of low frequency range can be achieved. Further, the sound pressure sensitivity due to vibration can be increased by increasing the effective vibration diameter of the ear tip 1.

[0039] Although the embodiments of the present invention have been described with reference to the drawings, specific configurations are not limited to these embodiments, and a design modification and so forth without departing from the subject matter of the present invention should be also included in the present invention. The descriptions illustrated in the respective drawings concerning the above described embodiments can be mutually combined as long as no inconsistencies or problems exist in the objectives, configurations and so forth thereof. Further the descriptions of respective drawings can be mutually independent embodiment and the embodiments according to the present invention are not limited to a single embodiment created by combining the respective drawings.

Claims

1. An earphone comprising:

   a vibration means which vibrates in an uniaxial direction;
   a housing which supports said vibration means and vibrates in response to the vibration of the vibration means; and
   an ear tip which is mounted on said housing,
   wherein said ear tip is arranged around said uniaxial direction and
   includes a vibration part which vibrates in response to the vibration of said housing and a holding part which holds said housing in ear canal.

2. The earphone according to claim 1, wherein an edge part is provided between said vibration part and said holding part.

3. The earphone according to claim 2, wherein the cross-sectional shape of said edge part in said uniaxial direction has a wave shape.

4. The earphone according to claim 3, wherein the thickness of said edge part is formed thinner than the thickness of said vibration part.

5. The earphone according to claim 2, wherein said edge part is tubularly formed along the circumference of said uniaxial direction.

6. The earphone according to claim 2, wherein said ear tip is annularly provided around said housing,
wherein the outer periphery of said vibration part is connected to the inner periphery of said edge part and the outer periphery of said edge part is connected to the inner periphery of said holding part.

7. The earphone according to claim 6, wherein said vibration part, said edge part and said holding part are integrally molded.

8. The earphone according to claim 1, wherein the maximum diameter of said holding part is larger than the maximum diameter of said housing.

9. The earphone according to claim 1, wherein said housing houses a speaker unit which emits a sound in response to an audio signal and a vibration unit as a vibration means which vibrates in response to an excitation signal.

10. The earphone according to claim 9, wherein said housing includes a tubular leading sound part for leading the sound emitted from said speaker unit and an opening formed at one end of the leading sound part.

11. The earphone according to claim 10, wherein said leading sound part and said opening are provided inside said vibration part.

12. The earphone according to claim 10, wherein said speaker unit in said housing is positioned closer to said leading sound part than said vibration unit in said housing.

13. The earphone according to claim 9, wherein said vibration unit includes a magnetic circuit including a magnetic gap,
an excitation coil positioned in said magnetic gap, and
a suspension for supporting said magnetic circuit on said housing, wherein said excitation coil is fixed to said housing.

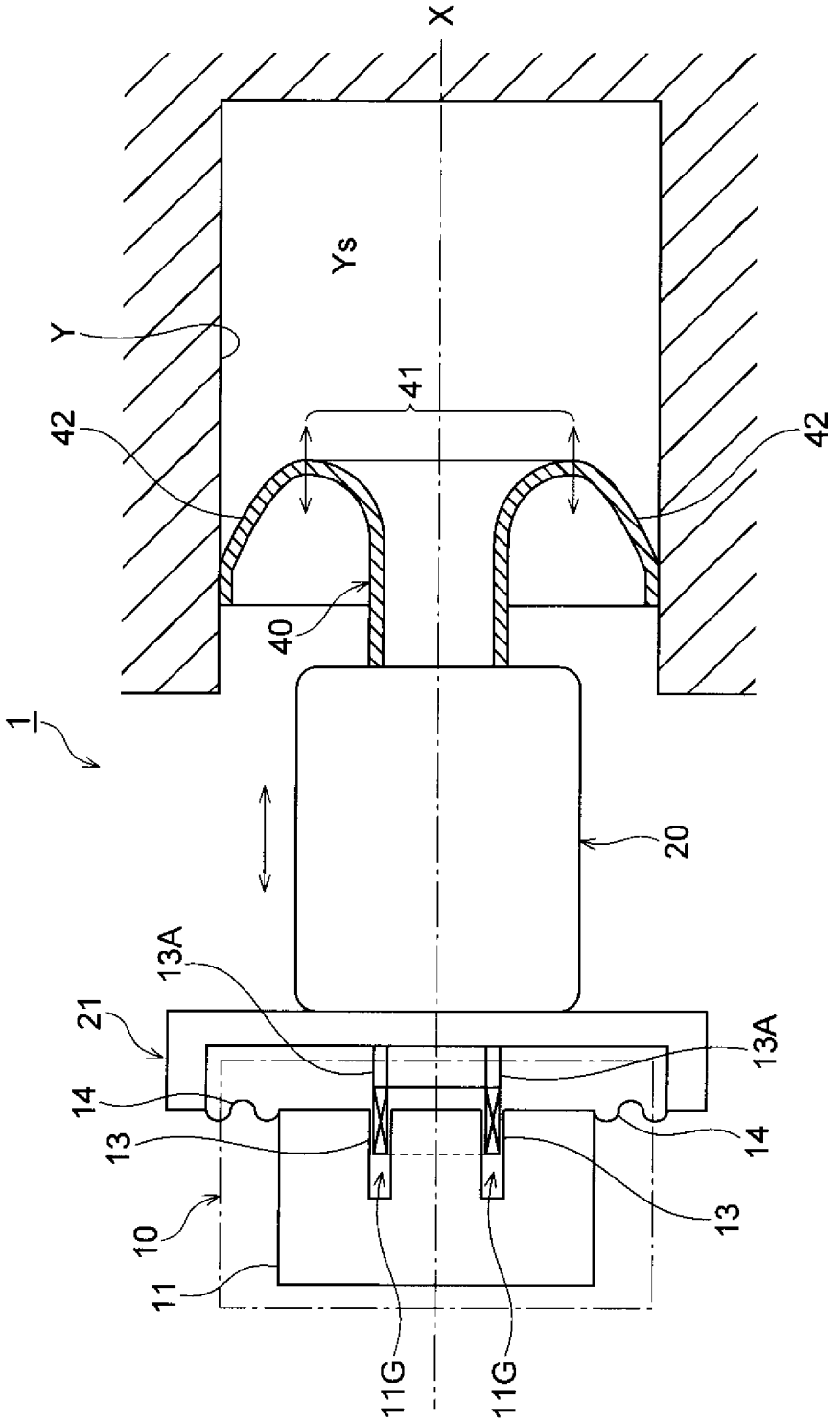
14. The earphone according to claim 9, wherein said speaker unit includes a voice coil to which said audio signal is input, wherein said voice coil vibrates in the vibration direction of said vibration means.

15. The earphone according to claim 9, wherein said magnetic circuit is provided with a weight part.

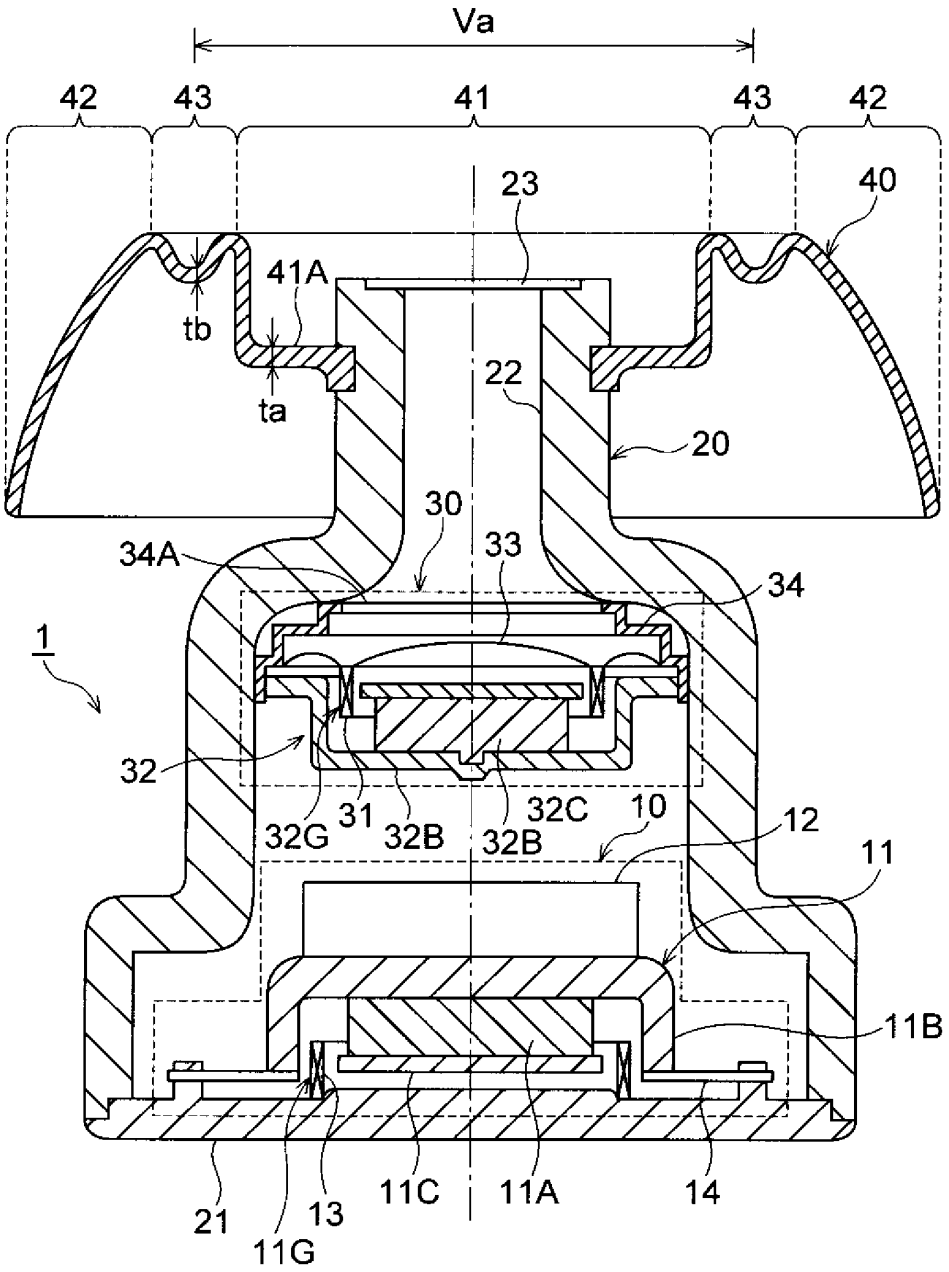
16. The earphone according to claim 15, wherein the mass of said magnetic circuit including said weight part is substantially same as the total mass of said housing and said speaker unit.

17. The earphone according to claim 9, wherein a common signal is input into said speaker unit as an audio signal while being input into said vibration unit as an excitation signal.

[Fig. 1]



[Fig. 2]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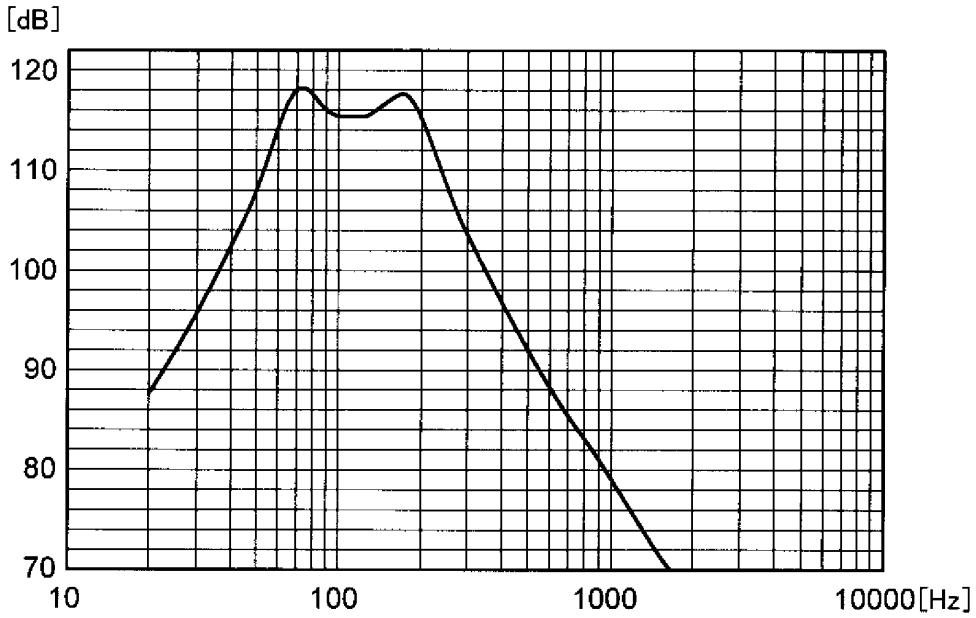
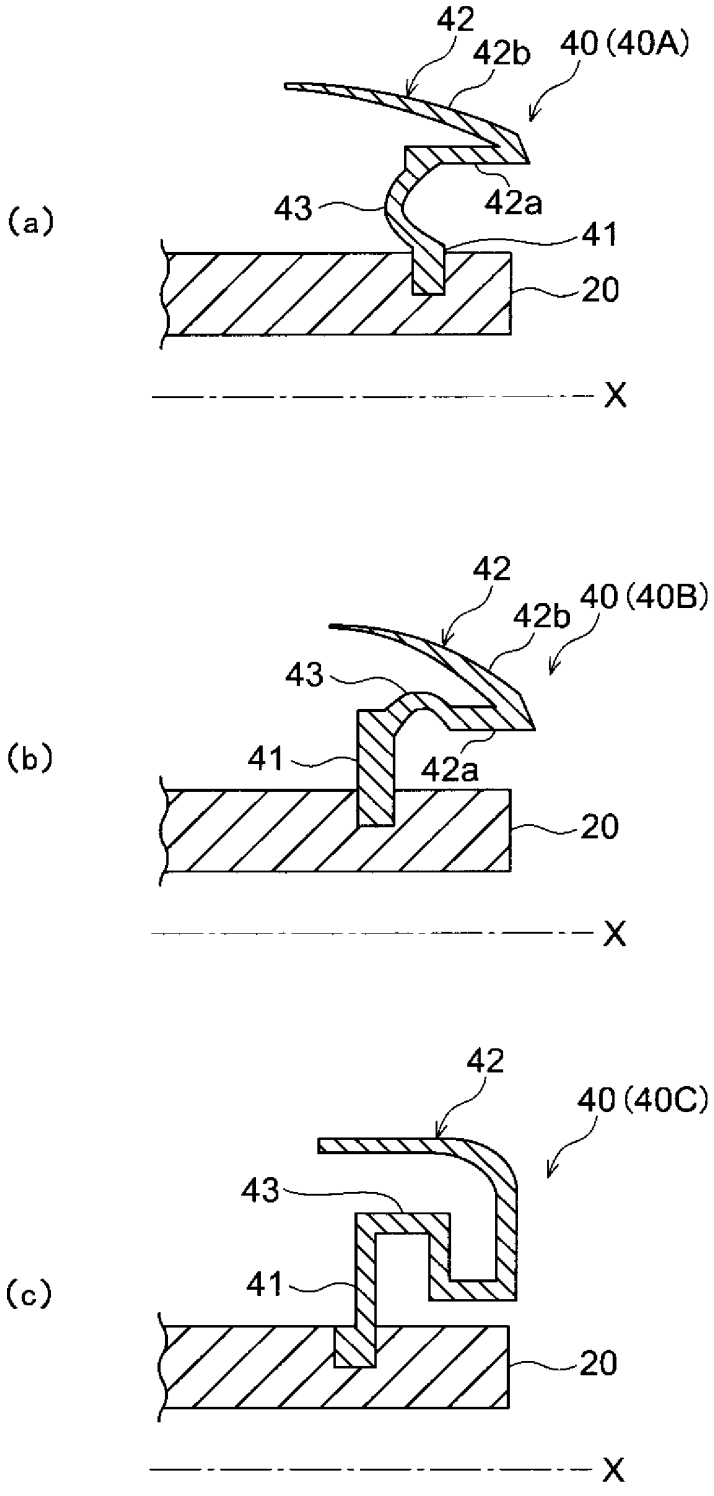
[Fig. 3]



[Fig. 4]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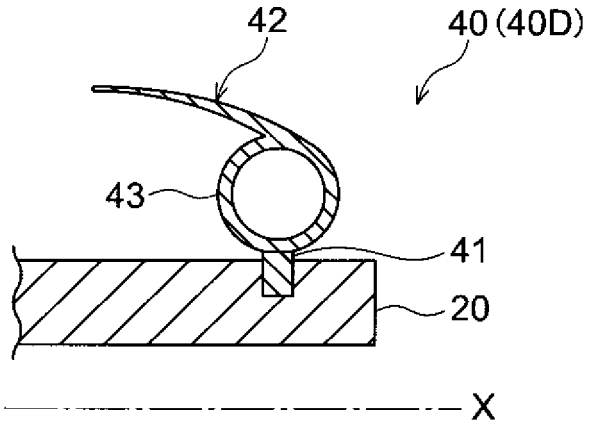
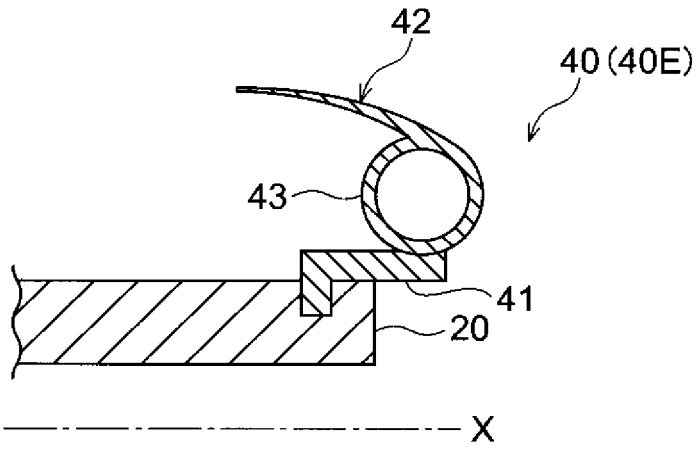
[Fig. 5]

(a)



(b)



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/059761

A. CLASSIFICATION OF SUBJECT MATTER
H04R1/10(2006.01)i, *H04R1/24*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04R1/10, H04R1/24

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2011
Kokai Jitsuyo Shinan Koho	1971-2011	Toroku Jitsuyo Shinan Koho	1994-2011

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 60-84096 A (Pioneer Corp.), 13 May 1985 (13.05.1985), entire text; fig. 14 (Family: none)	1,2,5-14,17 3,4,15,16
Y A	WO 2009/141912 A1 (Nippon MMI Technology Inc.), 26 November 2009 (26.11.2009), paragraphs [0032], [0033], [0040]; fig. 1 (Family: none)	1,2,5-14,17 3,4,15,16
Y	JP 2010-010885 A (Star Micronics Co., Ltd.), 14 January 2010 (14.01.2010), entire text; fig. 1 & WO 2009/157125 A1	8

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

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 May, 2011 (31.05.11)	07 June, 2011 (07.06.11)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/059761

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	JP 2-044899 A (Matsushita Electric Industrial Co., Ltd.), 14 February 1990 (14.02.1990), entire text; fig. 1 (Family: none)	1-17

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REFERENCES CITED IN THE DESCRIPTION

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