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(54) EARPHONE

(57) An earphone in which acoustic characteristics of a reproduced sound can be adjusted by a simple constitution. Though the earphone closely contacts with the outer ear of each user, the acoustic characteristics can be adjusted. The earphone (1) has a speaker casing part (2) having a built-in speaker main body part(3) and an opening part (21) for outputting acoustic waves from the speaker main body part (3), a cylindrical acoustic control tube (4) comprising an internal structure which controls the acoustic waves outputted through the opening part (21) from the speaker main body part (3) to have predetermined acoustic characteristics, and an earplug (9) comprising a cylindrical part (91) mounted to and communicated with the acoustic control tube (4) and having an outer periphery part formed in an elastically deformable manner. The acoustic control tube (4) is fixed detachably by a fixing member (7) while the connection part (42) formed at its one end is connected with a connected part (22) formed at the opening part (21) of the speaker casing part (2). The acoustic control tube (4) can be replaced with one having desired different acoustic characteristics.

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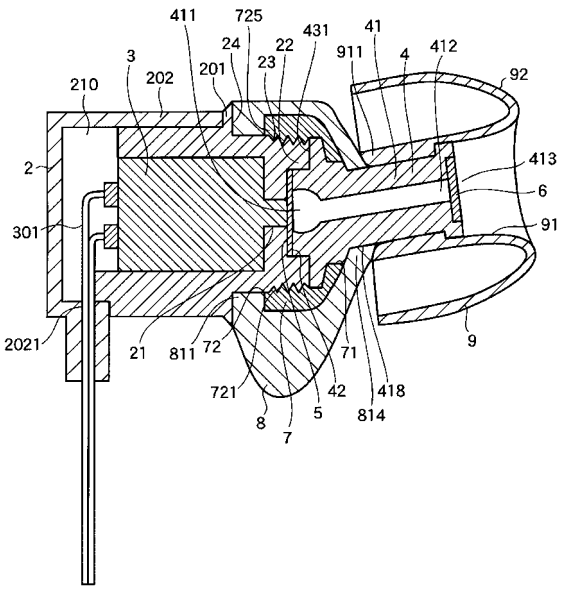

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Description

FIELD OF THE INVENTION

[0001] The invention is related to an earphone.

BACKGROUND OF THE INVENTION

[0002] A small speaker fixed in an ear, specifically an earphone inserted and used in an ear canal is well known, as shown in the Japanese patent publication 2001-512943. The earphone is also called an "In-ear monitor".

[0003] The earphone is designed to emit sound waves, from a receiver assembly (speaker body part) fixed in the ear canal, into the ear canal through an opening formed in an acoustic coupler (earplug part). Further, the earphone includes an elastically deformable acoustic seal to adapt the acoustic coupler to a contour of the ear canal.

DISCLOSURE OF THE INVENTION

PROBLEMS SOLVED BY THE INVENTION

[0004] It is known to have a sound-processing circuit capable of adjusting acoustic characteristics applied in the side of a sound-reproducing-circuit to adjust the acoustic characteristics to meet the respective preferences of users. However, the above-described method requires applying a sound-processing circuit in the side of a sound-reproducing-circuit, which causes the sound-processing-circuit to be more expensive.

[0005] Accordingly, an earphone is expected to be capable of making reproduced sounds to meet each respective preference of users with a function of adjusting acoustic characteristic. However, the earphone disclosed in the above patent publication cannot adjust acoustic characteristic, though the earphone is equipped with a detachable acoustic coupler adapted to the contour of ear canal. In addition, the outer ears of different users are respectively different in form and the acoustic characteristic is affected fairly largely by the degree of contact between the earphone and the outer ear and sound leakages when fixing the earphone. Therefore, an earphone is expected to be capable of tightly contacting with the respective outer ears of the users and adjusting the acoustic characteristic.

[0006] An objective of the present invention is to meet the expectation described above. In other words, the objectives of the invention include offering an earphone capable of adjusting the acoustic characteristics of reproduced sounds with simple configurations and an earphone capable of adjusting the acoustic characteristic and contacting tightly with the respective outer ears of users.

MEANS FOR SOLVING THE PROBLEMS

[0007] To achieve the objectives as described above, at least the following configurations are provided according to the present invention.

[0008] According to one aspect of the invention, there is provided an earphone including a speaker case housing a speaker body part and having an opening part for emitting a sound wave from the speaker body part, a tubular acoustic control tube having an internal structure for regulating an acoustic characteristic for the sound wave emitted from the speaker body part through the opening part into a predetermined acoustic characteristic, and an earplug having a tubular part fixed to the acoustic control tube and communicating with the acoustic control tube and an elastically deformable outer periphery, wherein the acoustic control tube is detachably fixed with a fixing element, a first connector part of the acoustic control tube being connected with a second connector part of the speaker case, wherein the first connector part is formed at an end of the acoustic control tube, and the second connector part is formed in proximity of the opening part of the speaker case.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Fig. 1 is a sectional view of an earphone according to one embodiment of the present invention;

Fig. 2 is an exploded perspective view of the earphone shown in Fig. 1;

Fig. 3 is a perspective view of the earphone viewed from behind (opposite to the acoustic wave emitting direction);

Fig. 4 is a view illustrating an earphone 1 fixed in an outer ear;

Fig. 5 is a view illustrating acoustic control tubes of the earphone shown in Fig. 1. Specifically, Fig. 5 (A) is a perspective view of the acoustic control tube; Fig. 5 (B) is a back view of the acoustic control tube; Fig. 5 (C) is a front view of the acoustic control tube; Fig. 5 (D) is a sectional view of the acoustic control tube according to a first embodiment; Fig. 5 (E) is a sectional view of the acoustic control tube according to a second embodiment, and Fig. 5 (F) is a sectional view of the acoustic control tube according to a third embodiment;

Fig. 6 is a detailed view illustrating the acoustic control tube of the earphone shown in Fig. 1;

Fig. 7 is a view illustrating acoustic characteristics of the acoustic control tubes according to the inven-

tion. Specifically, (A) illustrates acoustic characteristics of a plurality of acoustic control tubes with different inner diameters, and (B) illustrates acoustic characteristics of acoustic control tubes with different lengths of the tubular parts in a longitudinal direction;

Fig. 8 is a view illustrating an earflap inserting body 8 of the earphone shown in Fig. 1; and

Fig. 9 is an exploded perspective view of the earphone according to one embodiment of the invention.

BEST MODE OF THE INVENTION

[0010] According to one aspect of one embodiment of the present invention, an earphone is provided with replaceable acoustic control tubes with different acoustic characteristics. Specifically, an earphone according to the present invention includes, a speaker case housing a speaker body part and having an opening part for emitting a sound wave from the speaker body part, a tubular acoustic control tube having an internal structure for regulating an acoustic characteristic for the sound wave emitted from the speaker body part through the opening part into a predetermined acoustic characteristic, and an earplug fixed to the acoustic control tube, wherein the earplug has a tubular part communicating with the acoustic control tube and an elastically deformable periphery, the acoustic control tube is detachably fixed with a fixing element with a first connector part formed at a first end of the acoustic control tube being connected with a second connector part formed in proximity of the opening part of the speaker case. Preferably, the earphone includes a plurality of acoustic control tubes having internal structures respectively different in inner diameters and lengths, and the acoustic control tubes are formed replaceable with each other. Further, preferably, the earphone includes a plurality of replaceable earplugs having shapes different from each other. Further preferably, the earphone includes replaceable elastic earflap inserting body enclosing at least acoustic control tube and speaker case in whole or in part.

[0011] According to the earphone configured as above, the replaceable acoustic control tube with different acoustic characteristic can be detachably fixed with a fixing element with a connector part formed at one end of the acoustic control tube connecting with a connector counterpart formed at an opening part of the speaker case. Thus, the acoustic characteristic of reproduced sound can be adjusted with this simple configuration.

[0012] Moreover, the earphone according to the invention includes a plurality of replaceable earplugs and earflap inserting bodies with different forms. Thus, it is possible to provide the earphone capable of contacting tightly with the respective outer ears of users and adjusting the acoustic characteristic. Hereinafter, the earphone according to one embodiment of the invention is described with reference to the drawings.

[0013]

Fig. 1 is a sectional view of an earphone according to one embodiment of the invention.

Fig. 2 is an exploded perspective view of the earphone shown in Fig. 1.

Fig. 3 is a perspective view of the earphone viewed from behind (opposite to the acoustic wave emitting direction).

[0014] The earphone 1 according to the embodiment (also called "speaker device") includes a speaker case (case) 2, speaker body part 3, acoustic control tube 4, sound absorption member 5, filter 6, fixing member 7, earflap inserting body 8 and earplug 9.

[0015] The speaker case 2 corresponds to a speaker case according to one embodiment of the present invention; the speaker body part 3 corresponds to a speaker body part according to one embodiment of the present invention; the acoustic control tube 4 corresponds to an acoustic control tube according to one embodiment of the present invention; the sound absorption member 5 corresponds to a sound absorption member or an acoustic control sheet according to one embodiment of the present invention; the filter 6 corresponds to an acoustic control sheet according to one embodiment of the present invention; the fixing member 7 corresponds to a fixing element according to one embodiment of the present invention; the earflap inserting body 8 corresponds to an earflap inserting body according to one embodiment of the present invention; and the earplug 9 corresponds to an earplug according to one embodiment of the present invention. Hereinafter, the respective components of the earphone 1 are described with reference to drawings.

[Speaker case (case) 2]

[0016] The case 2 houses a speaker body part 3, for example as shown in Fig. 1. Specifically, the case 2 has a housing 210 for housing the speaker body part 3. The speaker body part 3 is housed in the housing 210. The case 2 includes a first housing 201 and a second housing 202. The case 2 can be taken apart to house the speaker body part 3 in the housing 210. The case 2 has at its bottom an outlet passage 2021 for a speaker cord 301 extending from the back side of the speaker body part 3 (in an opposite side to the acoustic wave emitting direction).

[0017] Further, the case 2 has an opening 21 part formed for emitting sound wave from the speaker body part 3 at the end of the case2 in the acoustic wave emitting side. In this embodiment, a protruding part of the speaker body part 3 forming an acoustic wave emitting port is fitted with the opening part 21. Specifically, the case 2 has a concave connector counterpart 22 connected to

the acoustic control tube 4. The concave connector counterpart 22 is formed at the end of the case 2 where the opening part 21 is formed in the side of emitting acoustic wave. Further, the end of case 2 where the opening part 21 is formed has a smaller outer diameter than the back side of the case 2, and its outer periphery has a fixing part for detachably fixing the fixing member 7. More specifically, the end of the case 2 where the opening part 21 is formed in the side of emitting acoustic wave has a screw counterpart 23 to be threadably connected to the fixing member 7.

[0018] Further the case 2 has a step portion 24 formed substantially at its center portion. The step portion 24 is formed around the case 2 and has a smaller diameter in the outer periphery than that of the back side of the case 2. In this embodiment, the step portion 24 is arranged to contact with the earflap inserting body 8. The step portion 24 serves as part of a locking counterpart for locking the locking part of the earflap inserting body 8.

[0019] Further, as shown in Fig. 3, a flat portion 2025 is formed at the lateral surface near the rear end of the case 2, in a direction substantially orthogonal to the protruding direction of the convex part of the earflap inserting body 8.

[0020] Fig. 4 is a view illustrating an earphone 1 fixed in an outer ear. As shown in Fig. 4, the flat portion 2025 is formed to contact with the protruding portion 152 of the earflap 151 of outer ear 150 when fixed in the outer ear 150 of a user. The flat portion 2025 formed at the case 2 enables to relatively increase the degree of contact between the earphone 1 and the outer ear of the user as shown in Fig. 4, thus reducing the sound leakage. Further, the earphone 1 having a relatively high degree of contact can produce better acoustic characteristics than having a low degree of contact. In particular, it enables to broaden low frequency band of the reproduced sound. Further, the flat portion2025 of the earphone 1 is positioned and fixed with the flat portion 2025 being contacted with the protruding portion 152 of the earflap 151, thus the displacement of the earphone 1 can be reduced even when a relatively large external force is applied.

[0021] Further, the acoustic control tube 4 has a concave locking counterpart 418 formed in the outer periphery of a tubular part 41 with which the earflap inserting body 8 and the earplug 9 are fitted.

[Speaker body part 3]

[0022] The speaker body part 3 emits sound wave according to an electric signal inputted from the speaker cord 301. Well-known speakers such as an electromagnetic speaker, dynamic speaker, electrostatic speaker, or piezoelectric speaker can be adopted as the speaker body part 3. An electromagnetic speaker is adopted as the speaker body part 3 according to the present embodiment. The electromagnetic speaker includes a moving core. The moving core is arranged between magnetic poles of permanent magnets and vibrates by AC magnetic field having a fixed coil. The moving core can be connected to a diaphragm, or the moving core itself can serve as the diaphragm. The electromagnetic speaker structured as above is smaller in size than, for example, a dynamic speaker. Although the dynamic speaker has an advantage in that the low frequency band of reproduced sound is broad, it has a disadvantage in that downsizing is difficult and the earphone can hardly house it. In contrast, the electromagnetic speaker can be housed in a small sized earphone since it can be downsized, though the low frequency band of reproduced sound is narrower than that of the dynamic speaker. The speaker body part 3 according to the embodiment as described above is housed in the speaker 2. More specifically, the speaker body part 3 as shown in Fig. 1 is formed substantially in a rectangular shape, having a protruding part provided at its end in the side of emitting acoustic wave. The sound wave is emitted through an air hole formed at the protruding part.

[Acoustic control tube 4]

[0023] Fig. 5 is a view illustrating acoustic control tubes of the earphone shown in Fig. 1. Specifically, Fig. 5 (A) is a perspective view of an acoustic control tube; Fig. 5 (B) is a back view of the acoustic control tube; Fig. 5 (C) is a front view of the acoustic control tube; Fig. 5 (D) is a sectional view of the acoustic control tube according to a first embodiment; Fig. 5 (E) is a sectional view of the acoustic control tube according to a second aspect, and Fig. 5(F) is a sectional view of the acoustic control tube according to a third aspect. Fig. 6 is a detailed view illustrating the acoustic control tube of the earphone shown in Fig. 1.

[0024] The acoustic control tube 4 includes a tubular part 41, a connector part 42 and a flange 43. The acoustic control tube 4 has an internal structure for regulating the acoustic characteristic of the sound wave emitted from the speaker body part 3 through the opening part 21 of the case 2 into predetermined acoustic characteristic. Specifically, the acoustic control tube 4 is detachably fixed by a fixing member 7 with a connector part 42 formed at one end of the acoustic control tube being connected with a connector counterpart 22 formed at the opening part 21 of the speaker case 2. The acoustic control tube 4 configured as above guides sound wave emitted from the speaker body part 3 from an acoustic wave inlet 411 formed at one end of the tubular part 41 through a waveguide 412 to an acoustic wave outlet 413 formed at the other end of the tubular part 41.

[0025] The acoustic control tube 4 has a tubular part 41 with a predetermined inner diameter, length and material, etc. for example as shown in Fig. 5 (A) to 5(F) and can provide a predetermined acoustic characteristic. Accordingly the acoustic control tube 4 determines predetermined acoustic characteristic, resonance frequency according to the above structure. Further, the earphone 1 according to the preferred embodiment includes a plu-

rality of the acoustic control tubes 4 of internal structures with different inner diameters or lengths, and the acoustic control tubes 4 are adapted to be replaceable with each other. For example, the acoustic control tube 4 shown in Fig. 5 (D) is smaller in inner diameter than that of Fig. 5 (E) while it has a longer tubular part 41 in the longitudinal direction than that of Fig. 5 (F).

[0026] As shown in Fig. 6, the acoustic control tube 4 has the structure that the end (acoustic wave inlet 411) with the connector part 42 has an inner diameter L411 larger than the inner diameter L413 of the other end (acoustic wave outlet 413). Specifically, the acoustic control tube 4 has a concave portion 4110 with an inner diameter L411 and a predetermined length.

[0027] The acoustic control tube 4 having the concave portion 4110 as configured above, it can prevent an acoustic pressure from decreasing in a high frequency band of the acoustic characteristic, compared to an acoustic control tube having a tubular part with a constant inner diameter. Further, the acoustic control tube 4 configured as above can be easily produced by injection molding. When producing acoustic control tube 4 with tubular part having different inner diameter, it is easy to change the inner diameter L413 in the side of the acoustic wave outlet 413 and keep constant the inner diameter L411 of the acoustic wave inlet 411. Further when designing acoustic control tubes 4 with tubular portions having different inner diameters, it is easy to set the acoustic characteristic by having the different inner diameter L413 of the acoustic wave outlet 413 from each other while keeping constant the inner diameter L411 of the acoustic wave inlet 411.

[0028] Fig. 7 is a view illustrating acoustic characteristics of the acoustic control tubes according to the invention. Specifically, Fig. 7(A) illustrates acoustic characteristics of a plurality of acoustic control tubes with different inner diameters, and Fig. 7(B) illustrates acoustic characteristics of acoustic control tubes with different lengths of the tubular parts in the longitudinal direction. The horizontal axis is frequency F (Hz), while the vertical axis is SPL (Sound Pressure Level) (dB).

[First Measurement]

[0029] The inventor did computer simulations for the acoustic control tubes 4 with the tubular parts 41 having an inner diameter of a reference value L (about 3 mm), the reference value L + 4 mm, the reference value L + 8 mm, and the reference value L + 10 mm, and lengths in the longitudinal direction of predetermined values respectively. As a result, the acoustic characteristics as shown in Fig. 7 (A) were obtained. As shown in Fig. 7 (A), the acoustic characteristics of the acoustic control tubes 4 are such that SPL has a substantially constant value of 112 dB from around 100 Hz to 900 Hz in frequency, SPL increases at around 900 Hz to 2500 Hz, SPL has a maximal value 120 dB at around 2500 Hz being a first resonance frequency F1 in the present embodiment, SPL decreases at around 2500 Hz to 3500 Hz, SPL has a maximal value at a second resonance frequency F2 (4300 Hz), and SPL drops precipitously above the resonance frequency. Further, as the inner diameter of the tubular part 41 increases from a reference value L (about 3 mm), the reference value L + 4 mm, the reference value L + 8 mm, and the reference value L + 10 mm, the second resonance frequency F2 shifts towards the high frequency band, and the peak value decreases.

[Second Measurement]

[0030] The inventor did computer simulations for acoustic control tubes 4 with a tubular parts 41 having the lengths in the longitudinal direction of the reference value T + 1 mm, the reference value T, the reference value T - 1 mm, and the reference value T - 2 mm, and the reference value T-4 mm and inner diameters of predetermined values respectively. As a result, the acoustic characteristics as shown in Fig. 7 (B) were obtained. As the length of the tubular part 41 decreases, in particular the second resonance frequency F2 shifts towards the high frequency band, and the peak value decreases.

[0031] As described above, the earphone 1 having a plurality of acoustic control tubes 4 with different lengths and inner diameters, a user can listen to the produced sound with the acoustic characteristic which meet the preference of the user by selecting the acoustic control tube 4 with desired acoustic characteristic from the plurality of acoustic control tubes 4, and attaching it to the case 2.

[0032] As shown in Figs. 1, 2, 5, and 6, in the acoustic control tube 4 the longitudinal direction of the tubular part 41 is adapted to be at a predetermined angle with reference to the acoustic wave emitting direction of the speaker body part 3. The acoustic control tube 4 as configured above can be inserted in and tightly contacted with the ear canal of the outer ear 150 while the earphone 1 is fixed in the outer ear 150 of the user, based on the configuration that the longitudinal direction of the tubular part 41 is adapted to be at a predetermined angle with reference to the acoustic wave emitting direction of the speaker body part 3.

[0033] The flange 43 is formed at the end having a connector part 42 and outer diameter of the flange 43 is larger than that of the other end. The flange 43 is formed such that the flat part 431 contacts one end of the case 2 in the acoustic wave emitting side as shown in Fig. 1.

[0034] Further, the longitudinal directions of the acoustic control tubes for left-ear and right-ear earphones are adapted to be at predetermined angles with reference to the acoustic wave emitting direction of the speaker body part so as to be substantially mirror symmetrical to each other. The configuration can improve the degree of contact when the left-ear and right-ear earphones are fixed into the left and right ear of the user respectively since the ear canals of left and right ears are formed substan-

tially mirror-symmetrical.

[0035] The acoustic control tubes of earphones for left and right ears are different from each other in the direction of tilt. Therefore, if the respective cases 2 for left and right ears were to have wrong acoustic control tubes 4 erroneously fixed thereto, the degree of contact would be lowered. The earphone 1 according to one embodiment of the present invention are adapted to have different connection structures between acoustic control tube 4 and case 2 respectively for left-ear and right-ear earphones. Specifically, as shown in Fig. 2 the end of the case 2 has a fitting counterpart 221 while the end of acoustic control tube 4 has a fitting part 432 at the location corresponding to the fitting counterparts 221. The case 2 and the acoustic control tube 4 are positioned and fixed to each other as the fitting counterparts 221 and the fitting parts 432 are fitted with each other. More specifically as shown in Fig. 2, two convex fitting counterparts 221 are formed at a predetermined interval while two concave fitting parts 432 are formed at the end of acoustic control tube 4 at the location corresponding to the fitting counterparts 221. One of the left-ear and right-ear earphones has two convex parts, protruding in the acoustic wave emitting direction, arranged respectively in the circumferential direction and these protrusions are formed at an interval of 1/4 or 3/4 in the circumferential direction as shown in Fig. 2. In particular, left-ear and right-ear earphones include the structure such as shapes and locations of these fitting counterparts 221 and fitting parts 432 which are respectively different from each other.

[0036] As described above, the case 2 has the fitting counterparts 221 while the acoustic control tube 4 has the fitting part 432, which can prevent displacement between the case 2 and acoustic control tube 4 in a circumferential direction respectively when the case 2 and acoustic control tube 4 connects to one another. The connection structure between the case 2 and the acoustic control tube 4 is not limited to the structure described above. For example, a concave part can be formed on the connection surface of the case 2 and a convex part can be formed on the connection surface of the acoustic control tube 4. Alternatively, a connection structure with corrugated shapes respectively different in pitch for left-ear and right-ear earphones can be adopted. Any connection structures can be adopted if they can prevent wrong connections between the case 2 and the acoustic control tube 4 for left and right ears.

[0037] The two convex parts can be formed on the connection surface of the case 2 at a different interval from the above interval for the other earphone of the left-ear and right-ear earphones, for example a half round interval. Alternatively, the convex part and the concave part can be adapted to be opposite for the left-ear and right-ear earphones. As described above, with different connection structures between the case 2 and the acoustic control tube 4 for the left-ear and right-ear earphones, for example the case 2 for the left-ear earphone can be prevented from being fixed with the acoustic control tube 4 for the right-ear earphone, thus the case 2 of the left-ear earphone can be certainly fixed with the acoustic control tube 4 of the left-ear earphone. In the similar manner, the case 2 of the right-ear earphone can be certainly fixed with the acoustic control tube 4 of the right-ear earphone.

[Sound Absorption Member 5]

[0038] The sound absorption member 5 is arranged between the acoustic control tube 4 and the case 2. The sound absorption member 5 absorbs, for example the sound wave reflected off the earplug 9 and the acoustic control tube 4, thus preventing mutual interference between the sound wave emitted from the speaker body part 3 and the sound wave reflected off the earplug 9 and the acoustic control tube 4 and reducing adverse effects on the acoustic characteristic of the earphone 1. In particular, the reflected sound wave occurs with the acoustic control tube 4 having different inner diameters at both ends adjacent to the speaker body part 3 and the earplug 9. However, the sound absorption member 5 can eliminate such reflected wave. For example, nonwoven cloth and woven fabric can be adopted as the sound absorption member 5.

[Filter 6]

[0039] The filter 6 (acoustic control sheet) is arranged at one or the other end of the acoustic control tube 4. The filter 6 is arranged, for example at the front surface of the acoustic control tube 4 (adjacent to acoustic wave outlet 413). For example, if an electromagnetic speaker is adopted as the speaker body part 3, it has the acoustic characteristic having a relatively large acoustic pressure in high frequency band. The filter 6 being arranged at the front surface of the acoustic control tube 4, it can reduce large acoustic pressure in high frequency band, the electromagnetic speaker can have a flat frequency characteristic from low frequency band to mid frequency band and from mid frequency band to high frequency band. For example, nonwoven cloth and woven fabric can be adopted as the filter 6.

[Fixing Member 7]

[0040] The fixing member 7 detachably fixes the acoustic control tube to the case 2. Specifically, the connecting part 42 formed at an end of acoustic control tube 4 is detachably fixed due to the fixing member 7, in the condition of connecting with the connecting counterpart 22 formed at the opening part 21 of case2. Specifically, the fixing member 7 has one opening end 71 of a smaller inner diameter than the outer diameter of the other end of the acoustic control tube 4 (acoustic wave outlet 413) and outer diameter of flange 43. The other opening end 72 has a larger inner diameter than the outer diameter of the flange 43, having screw part 721 adapted to screw together with screw counterpart 23 provided at the end

of the speaker case 2. The fixing member 7 is not limited to the above structure as long as it can detachably fix the acoustic control tube to the case 2.

[Earflap Inserting Body 8]

[0041] Fig. 8 is a view illustrating an earflap inserting body 8 of the earphone shown in Fig. 1. The earflap inserting body 8 is formed to enclose the acoustic control tube 4 and case 2, in whole or in part. As formation materials of earflap inserting body 8, for example an elastic body such as resin and rubber can be adopted. The earflap inserting body 8 has a lateral surface formed according to the earflap of a user as shown in Fig.4.

[0042] The earflap inserting body 8 includes opening part 81 and protruding part for earflap 82 as shown, for example, in Figs. 1 to 4 and Fig. 8. The opening part 81 is formed at the center, the inner diameter of one end is adapted to be substantially the same as the outer diameter of the tubular part 41 of the acoustic control tube 4, while the inner diameter of the other end is adapted to be substantially the same as the outer diameter of the leading portion (acoustic wave emitting side) of the case 2. The other opening end of the opening part 81 has a locking part 811 protruding inward. The earflap inserting body 8 configured as above, having a locking part 811 locked in a step-shaped locking counterpart 725 formed at the end of the fixing member 7, the earflap inserting body 8 is positioned and fixed to the case 2, with the fixing member 7 being fixed to the speaker case 2.

[0043] Further, the earflap inserting body 8 has locking part 814 formed at the opening end in the acoustic wave emitting side locked in concave locking counterpart 418 with smaller outer diameter than the end in the acoustic wave emitting side, formed substantially at the central portion of the tubular part 41 of the acoustic control tube 4.

[0044] The protruding part for earflap 82 of earflap inserting body 8 is formed to protrude principally in one direction or in a direction orthogonal, for example as shown in Fig. 4. The protruding part for earflap 82 has a lateral surface formed according to the earflap of a user.

[0045] Further, as shown in Fig. 8, the locking part 811 of the earflap inserting body 8 has a cutout 812 and as shown in Fig. 2, the cutout 812 is fitted with protrusion 28 formed adjacent to the end in the acoustic wave emitting side of the case 2, thus the case 2 and the earflap inserting body 8 are positioned and fixed to each other. According to the connection structure between the case 2 and the earflap inserting body 8, the earflap inserting body 8 can be certainly fixed to the case 2 at a predetermined position.

[Earplug 9]

[0046] The earplug 9 is inserted in an external ear canal of the user. As shown in Fig. 1, the earplug 9 is fixed to the acoustic control tube 4 and includes a tubular part 91 communicating with the acoustic control tube 4, having an elastically deformable outer periphery 92. The earplug 9 is molded with a soft material such as silicon rubber.

[0047] The tubular part 91 is formed with the inner diameter of the outer end (acoustic wave emitting end) being larger than the inner diameter of the acoustic control tube 4. According to the structure of the earplug 9 communicating with the acoustic control tube 4, its internal structure is formed in a horn shape to improve the acoustic characteristic. Further the tubular part 91 has a locking part 911 protruding inside, formed at the end for fixing (opposite to the end of acoustic wave emitting side). The locking part 911 is locked in a concave locking counterpart 418 with a smaller outer diameter than the end in the acoustic wave emitting side, formed substantially at the central portion of the acoustic control tube 4.

[0048] Outer periphery 92 is formed in an umbrella shape, the umbrella part being formed to be elastically deformable.

[0049] Fig. 9 is an exploded perspective view of the earphone according to one embodiment of the invention. The earphone 1, for example as shown in Figs.1 and 9, includes a plurality of the acoustic control tubes 4 having internal structures with different inner diameters or lengths, which are adapted to be replaceable. Further, the earphone 1 is includes a plurality of the earplugs 9 with respective shapes different from each other, which are adapted to be replaceable. Further, the earphone 1 is provided with a plurality of the earflap inserting bodies 8 with different forms, which are adapted to be replaceable. Further, the earphone 1 includes a plurality of the filters 6 for regulating the predetermined acoustic characteristic respectively, which are adapted to be replaceable. Furthermore, the earphone 1 includes a plurality of the sound absorption members 5 with different sound absorption characteristics, which are adapted to be replaceable.

[Operation]

[0050] Hereinafter, described is an operation of changing an acoustic control tube 4 of earphone 1 as configured above with reference to the drawings.

[0051] Specifically, in the initial state, the acoustic control tube 4 is fixed to the case 2 with the fixing member 7, while the acoustic control tube 4, the fixing member 7 and the case 2 are partially covered with the earflap inserting body 8 and fixed to each other for example as shown in Fig. 1. Further, the sound absorption member 5 is attached to one end of the acoustic control tube 4 (case 2 side) while the filter 6 is fixed to the other end (acoustic wave emitting side), and the earplug 9 is attached to the acoustic control tube 4. After being removed from the earphone 1 in the initial state, the acoustic control tube 4 is replaced by another acoustic control tube 4 regulating different acoustic characteristic. Next, the replacement operation is described.

[Removal of Earplug 9]

[0052] The earplug 9 is removed from the acoustic control tube 4 by applying a pulling force to the locking part 911 of the earplug 9 in an acoustic wave emitting direction while the earplug 9 is deformed around the ends of its tubular part by pressing near the center portion of the earplug 9, for example with an index finger and thumb. The earplug 9 is made of an elastic body like a rubber, restored to its original state from the deformed state with the restoring force within a predetermined time.

[Removal of the Earflap Inserting Body 8]

[0053] When the earflap inserting body 8 is removed, the locking part 811 is unlocked from the step-shaped locking counterpart 725 formed at the end of the fixing member 7 by pressing, for example the protruding part for earflap 82 of the earflap inserting body 8 with fingers, for example in an acoustic wave emitting direction to elastically deform the earflap inserting body 8. Subsequently pressed further toward the acoustic wave emitting direction, the earflap inserting body 8 is removed from the acoustic control tube 4 with the opening part of the earflap inserting body 8 sliding to the end of the acoustic control tube 4 in a longitudinal direction along the outer surface of the tubular part 41 of the acoustic control tube 4.

[Removal of the Acoustic Control Tube 4]

[0054] Next, the fixing member 7 is rotated and removed from the case 2. Then, the acoustic control tube 4 is removed from the case 2.

[Attaching of Acoustic Control Tube 4 with Different Acoustic Characteristics]

[0055] Next described is an operation of attaching the acoustic control tube 4 with different acoustic characteristic. First, the connector part 42 of the acoustic control tube 4 is fitted with the concave connector counterpart 22 of the case 2. At this time, the convex fitting counterparts 221 formed in the case 2 is fitted with the concave fitting parts 432 formed at the end of the acoustic control tube 4. Subsequently, the fixing member 7 is rotated and attached to the case 2, whereas the acoustic control tube 4 and the case 2 are fixed by the fixing member 7. Specifically, the screw part 721 of the fixing member 7 is screwed together with the screw counterpart 23 formed in the end of the speaker case 2.

[Attaching of Earflap Inserting Body 8]

[0056] Next, an earflap inserting body 8 in a desired shape is attached. Specifically, the locking part 811 is locked in the step-shaped locking counterpart 725 formed in the end of the fixing member 7 by inserting with fingers, etc. the tubular part 41 of the acoustic control tube 4 through the opening part of the earflap inserting body 8, then pressing it, for example in a direction opposite to the acoustic wave emitting direction to elastically deform the earflap inserting body 8.

[Attaching of Earplug 9]

[0057] Next, a desired shaped earplug 9 in a desired shape is attached. Specifically, the tubular part 91 of the earplug 9 is attached to the acoustic control tube 4. At this time, the locking part 911 formed at the tubular part 91 is locked in the concave locking counterpart 418 with smaller outer diameter than the end in the acoustic wave emitting side, formed substantially at the central portion of the acoustic control tube 4. As described above, the earphone 1 can include the acoustic control tubes 4 with different acoustic characteristics, which are replaced according to the preferences of the users.

[0058] The invention is not limited to the embodiments described above. Various modifications of the embodiments are available. For example, the configurations of the case 2, the speaker body part 3, the acoustic control tube 4, the sound absorption member 5, the filter 6, the fixing member 7, the earflap inserting body 8, and the earplug 9 can be modified and not limited to the above described aspects. An electromagnetic speaker is adopted as the speaker body part 3, but the speaker body part is not limited to this type. Further, the case 2 and the fixing member 7 are fixed to each other by both screw counterpart 23 and screw part 721 being screwed to one another, but the invention is not limited to this embodiment as long as the case 2 and the fixing member 7 can be detachably attached to one another.

[0059] As described above, the earphone 1, according to one embodiment of the invention, includes the speaker case 2 housing the speaker body part 3 and having the opening part 21 for emitting an sound wave from the speaker body part 3, the tubular acoustic control tube 4 having a structure for regulating predetermined acoustic characteristics for the sound wave emitted from the speaker body part 3 through the opening part 21, and the earplug 9, the earplug having a tubular part 91 fixed to the acoustic control tube 4 and communicating with the acoustic control tube 4 and elastically deformable periphery, where the acoustic control tube 4 is detachably fixed by the fixing member 7 with the connector part 42 formed at one end of the acoustic control tube 4 being connected with the connector counterpart 22 formed at the opening part 21 of the speaker case 2. Thus, the acoustic control tube 4 can be replaced by another desired acoustic control tube 4 with different acoustic characteristic, and the acoustic characteristic of reproduced sound can be easily adjusted.

Claims

1. An earphone, comprising:

a speaker case housing a speaker body part and having an opening part for emitting a sound wave from the speaker body part;
a tubular acoustic control tube having an internal structure for regulating an acoustic characteristic for the sound wave emitted from the speaker body part through the opening part into a predetermined acoustic characteristic; and
an earplug having a tubular part fixed to the acoustic control tube and communicating with the acoustic control tube and an elastically deformable outer periphery, wherein
the acoustic control tube is detachably fixed with a fixing element, a first connector part of the acoustic control tube being connected with a second connector part of the speaker case, wherein
the first connector part is formed at an end of the acoustic control tube, and
the second connector part is formed in proximity of the opening part of the speaker case.

2. The earphone according to claim 1, comprising a plurality of the acoustic control tubes having different internal structures in inner diameters or in lengths; wherein
the acoustic control tubes are formed to be replaceable.

3. The earphone according to claim 1, comprising a plurality of the earplugs having different shapes each other, wherein
the earplugs are formed to be replaceable.

4. The earphone according to claim 1, comprising an elastic earflap inserting body enclosing the acoustic control tube and the speaker case in whole or in part.

5. The earphone according to claim 4, comprising a plurality of the earflap inserting bodies having different shapes each other, wherein
the earflap inserting bodies are formed to be replaceable.

6. The earphone according to claim 1, comprising an acoustic control sheet disposed at an end of the acoustic control tube.

7. The earphone according to claim 6, comprising a plurality of the acoustic control sheets regulating into different acoustic characteristics, wherein
the acoustic control sheets are formed to be replaceable.

8. The earphone according to claim 1, comprising a sound absorption member arranged between the acoustic control tube and the speaker case.

9. The earphone according to claim 8, comprising a plurality of the sound absorption members having different sound absorption characteristics, wherein
the sound absorption members are formed to be replaceable.

10. The earphone according to claim 1, wherein the acoustic control tube has a first end having the first connector part and a second end, and
an inner diameter of the acoustic control tube at the first end is greater than that of the acoustic control tube at the second end.

11. The earphone according to claim 1, wherein
the speaker body part is an electromagnetic speaker device.

12. The earphone according to claim 1, wherein
an inner diameter of the tubular part at an outer end is greater than an inner diameter of the acoustic control tube.

13. The earphone according to claim 1, wherein
the acoustic control tube includes a flange at a first end,
an outer diameter of the flange is greater than that of the acoustic tube at the second end, the fixing element has a tubular shape,
a first opening end of the fixing element has an inner diameter greater than an outer diameter of the acoustic control tube at the second end,
the inner diameter of the first opening end is smaller than an outer diameter of the flange,
a second opening end of the fixing element has an inner diameter greater than the outer diameter of the flange,
the second opening end has a first screw part for screwing with a second screw part formed at an end of the speaker case.

14. The earphone according to claim 13, wherein
the second opening end of the fixing element has an outer diameter greater than an outer diameter at the end of the speaker case,
the fixing element being fixed with the speaker case,
a first locking part of the earflap inserting body formed at an opening end is locked in a second locking part formed at an end of the fixing element, wherein
the first locking part has a shape protruding inward,
the second locking part has a stepped shape.

15. The earphone according to claim 3, wherein
the acoustic control tube has a concave second locking part substantially at a central portion of the tubular part,
an outer diameter of the second locking part is smaller than that of the acoustic control tube at an end in

the acoustic emitting side,
the earplug has a first locking part protruding inward,
the first locking part is formed at an end in a fixing side of the tubular part,
the first locking part of the earplug is locked in the second locking part of the acoustic control tube.

16. The earphone according to claim 15, wherein
a first locking part is formed at an opening end of the earflap inserting body in the acoustic wave emitting side,
the first locking part of the earflap inserting body is locked in the second locking part of the acoustic control tube.

17. The earphone according to claim 1, wherein
a longitudinal direction of the acoustic control tube forms a predetermined angle with an acoustic wave emitting direction of the speaker body part.

18. The earphone according to claim 1, wherein
longitudinal directions of the acoustic control tubes form predetermined angles with acoustic wave emitting directions of the speaker body parts to be substantially mirror symmetrical in a left-ear and a right-ear earphones,
connection structures between the acoustic control tubes and the speaker cases are different each other in the left-ear earphone and the right-ear earphone.

19. The earphone according to claim 1, wherein
a flat portion is formed at a side surface part of the speaker case.

FIG. 1

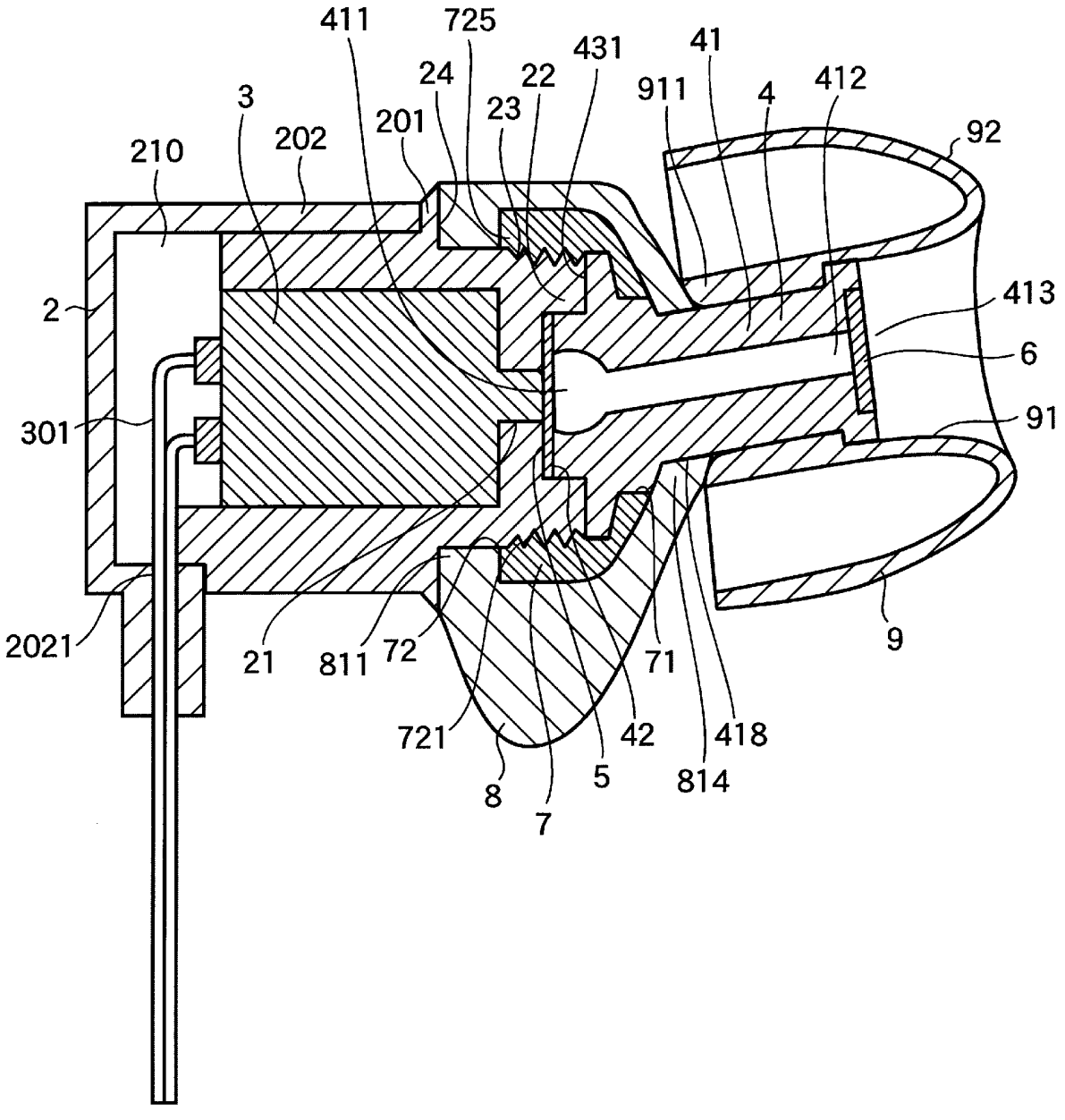
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Fig.2

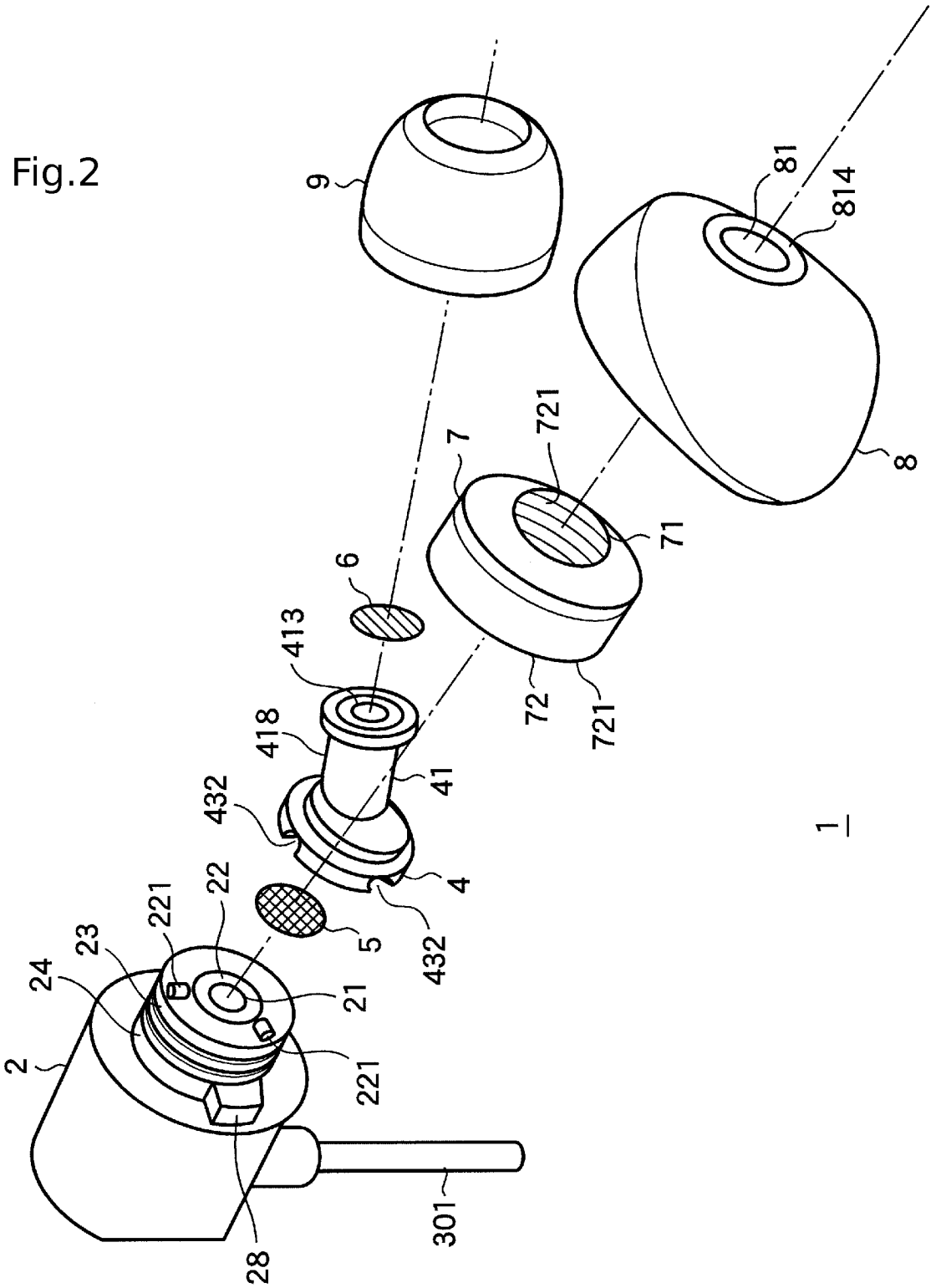
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FIG. 3

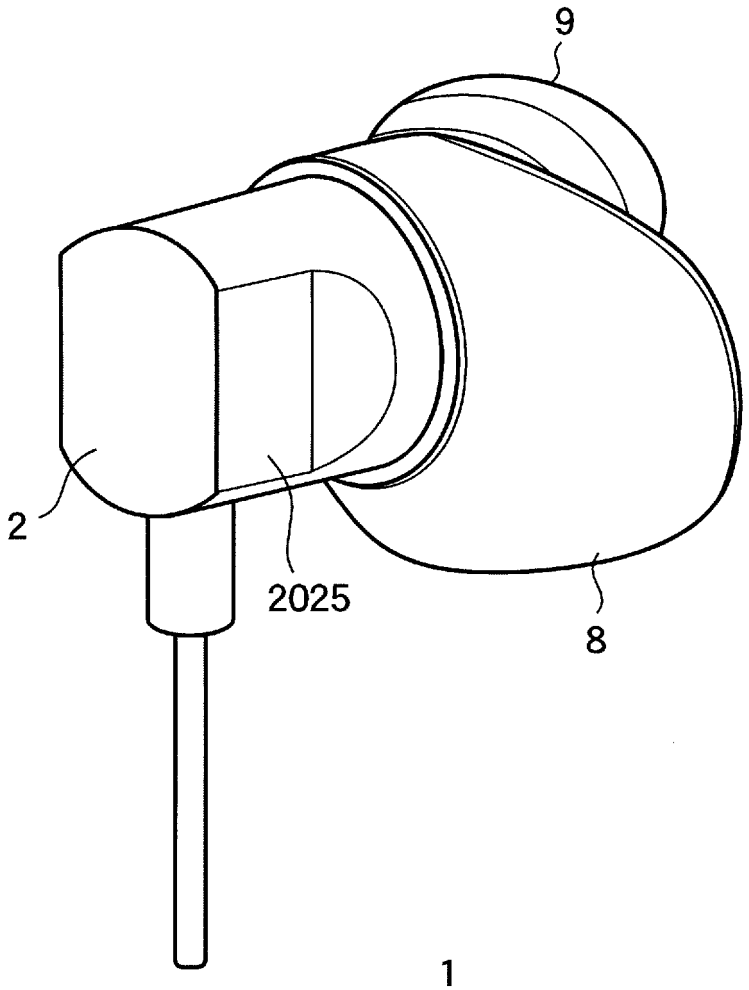

FIG. 4

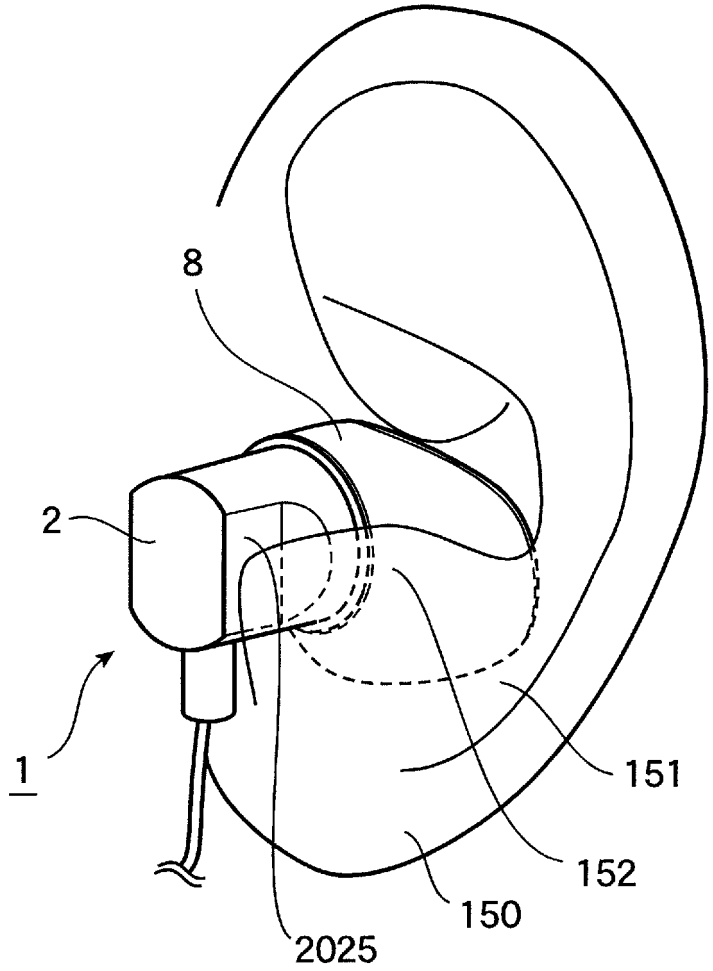

FIG. 5

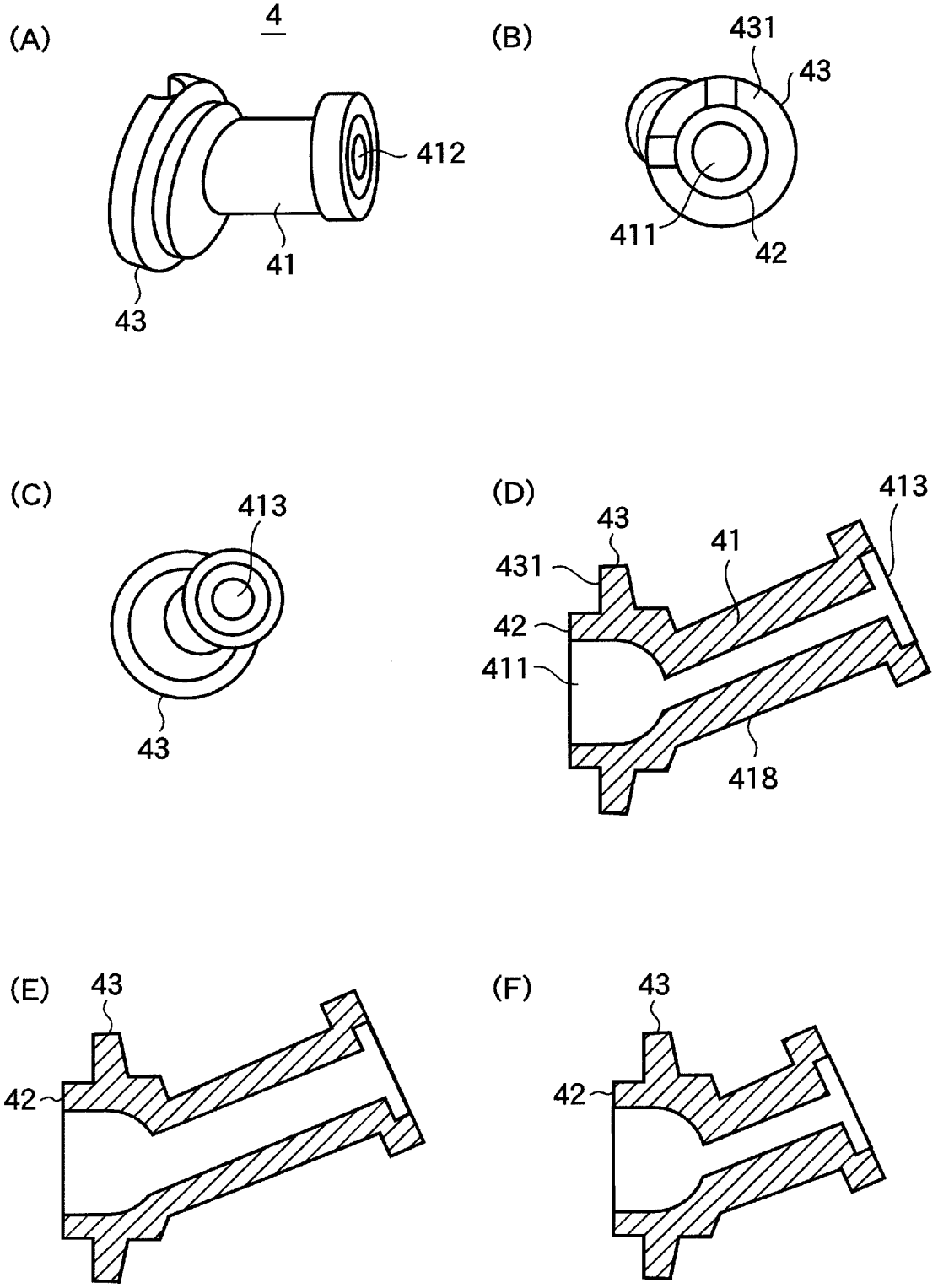
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FIG. 6

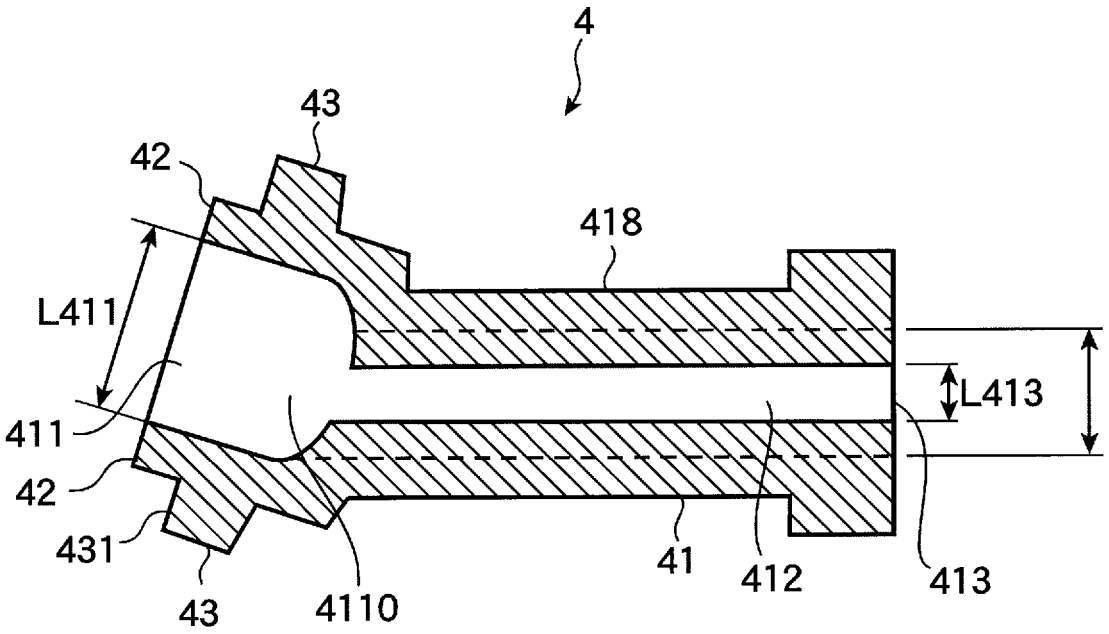
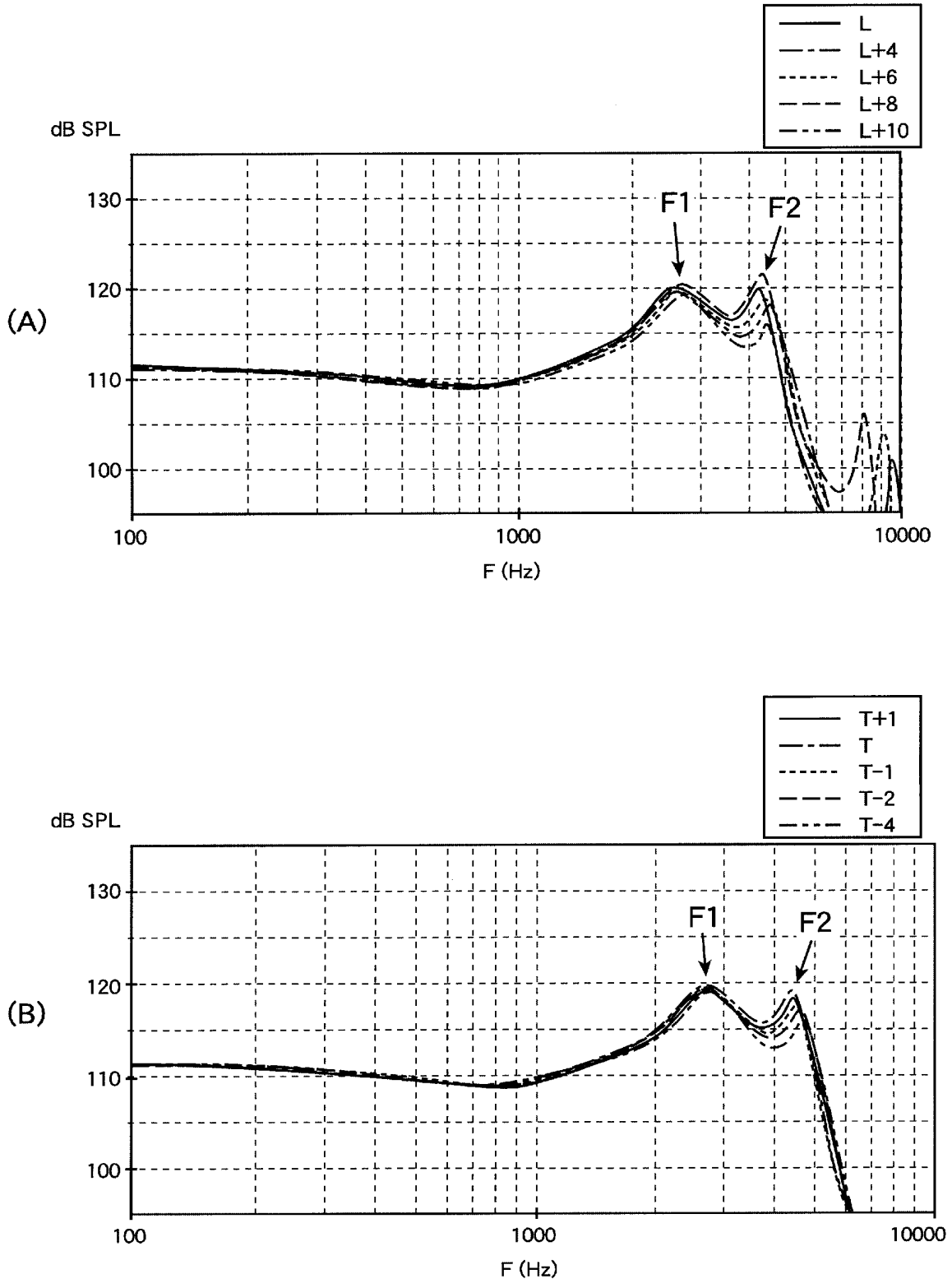


FIG. 7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110
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F1
F2
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(B)
dB SPL
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FIG. 8

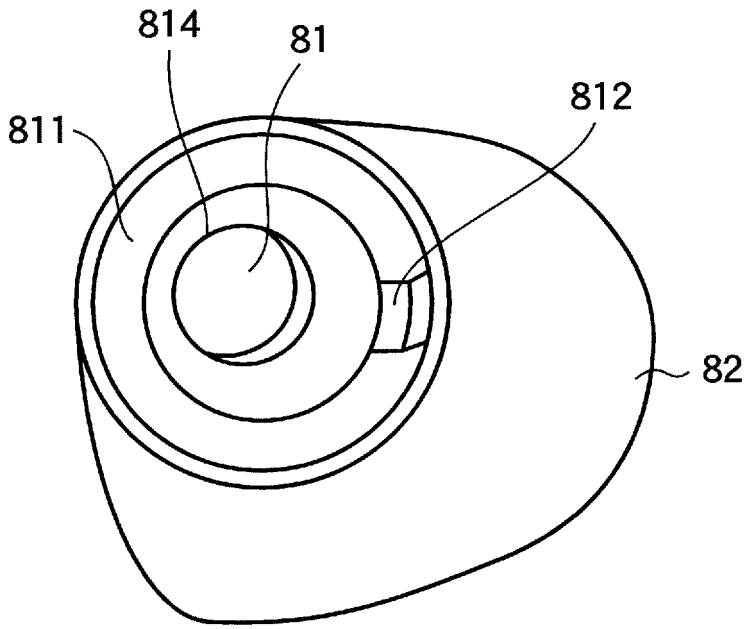

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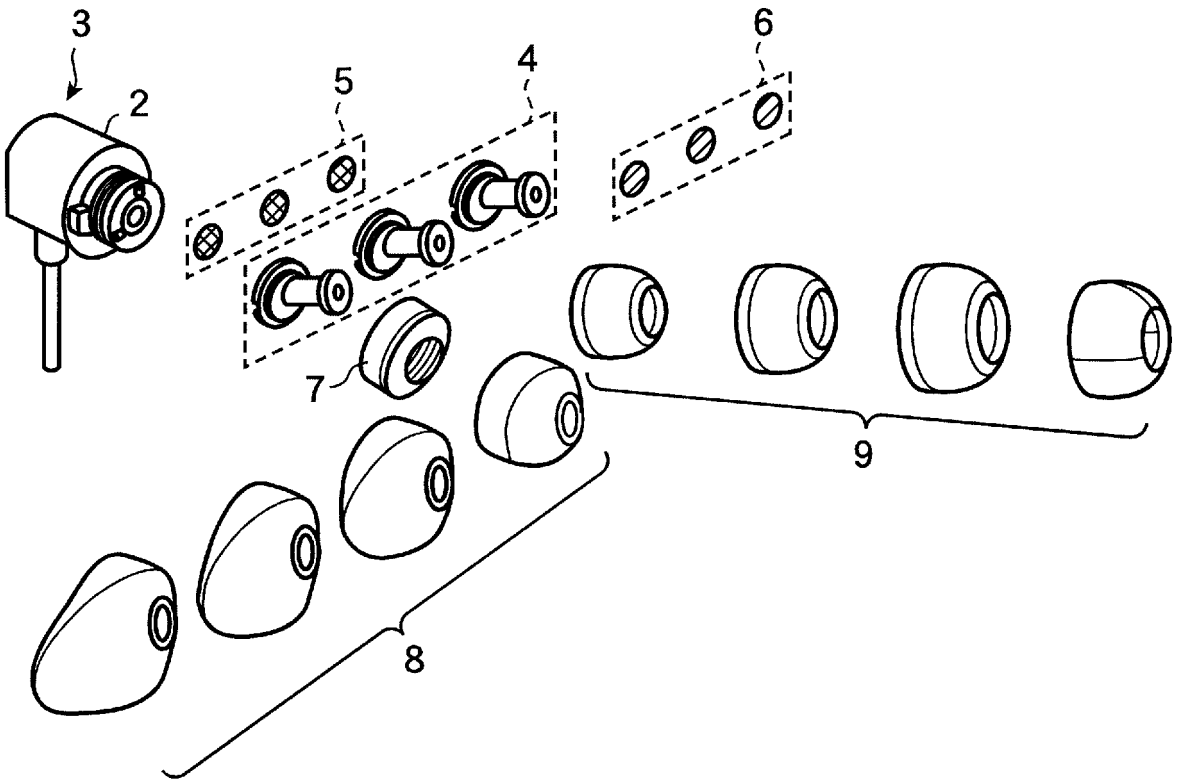
FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/067517

A. CLASSIFICATION OF SUBJECT MATTER
H04R1/10(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

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 1996-2007
Kokai Jitsuyo Shinan Koho 1971-2007 Toroku Jitsuyo Shinan Koho 1994-2007

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.
X Y A	JP 2003-143684 A (Star Micronics Co., Ltd.), 16 May, 2003 (16.05.03), Full text; all drawings & US 2003/0081794 A1	1-2,6-9, 11-12,19 3-5,10,17-18 13-16
Y	JP 2006-295533 A (Nappu Enterprise Kabushiki Kaisha), 26 October, 2006 (26.10.06), Full text; all drawings (Family: none)	3
Y	JP 2007-37188 A (Sony Corp.), 08 February, 2007 (08.02.07), Full text; all drawings (Family: none)	4-5

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

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Date of the actual completion of the international search	Date of mailing of the international search report
25 September, 2007 (25.09.07)	09 October, 2007 (09.10.07)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/067517

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2007-104616 A (Asia Optical Industries Ltd.), 19 April, 2007 (19.04.07), Full text; all drawings (Family: none)	10
Y	JP 2007-189468 A (Sony Corp.), 26 July, 2007 (26.07.07), Full text; all drawings (Family: none)	17-18

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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