(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 239 959 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
13.10.2010 Bulletin 2010/41

(21) Application number: **09700720.7**

(22) Date of filing: **07.01.2009**

(51) Int Cl.:
H04R 7/14 *(2006.01)* ***H04R 9/02*** *(2006.01)*
H04R 31/00 *(2006.01)*

(86) International application number:
PCT/JP2009/050052

(87) International publication number:
WO 2009/088002 (16.07.2009 Gazette 2009/29)

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA RS

(30) Priority: **07.01.2008 JP 2008000345**
22.02.2008 JP 2008042113
22.02.2008 JP 2008042115
22.02.2008 JP 2008042118
22.02.2008 JP 2008042122

(71) Applicant: **Victor Company Of Japan, Limited**
Kanagawa-ku
Yokohama-shi
Kanagawa 221-8528 (JP)

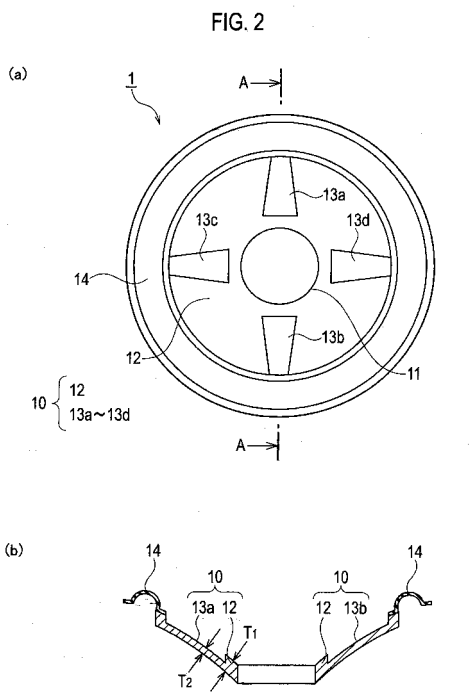
(72) Inventors:
- **IINO, Junji**
Yokohama-shi
Kanagawa (JP)
- **IMAMURA, Satoshi**
Yokohama-shi
Kanagawa (JP)
- **KAMIMURA, Shinji**
Yokohama-shi
Kanagawa (JP)

(74) Representative: **Emde, Eric**
Wagner & Geyer
Gewürzmühlstrasse 5
80538 München (DE)

(54) VIBRATION PLATE, SPEAKER, ACOUSTIC SYSTEM AND METHOD OF MANUFACTURING VIBRATION PLATE

(57) A diaphragm 1 includes a vibration member 10 including a first-region and second-region portions formed integrally with each other by using an isotropic material. The vibration member 10 has, in the first-region portion, reinforcement portions 13a to 13d in which a Young's modulus is higher than in the second-region portion. The reinforcement portions 13a to 13d are obtained by press molding in which a pressure applied to the first-region portion is stronger than a pressure applied to the second-region portion.

FIG. 2



EP 2 239 959 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a diaphragm, a speaker, an audio system and a manufacturing method of the diaphragm.

BACKGROUND ART

[0002] Materials such as paper, plastics and metal are relatively inexpensive and easy to process, and accordingly, have been widely used as materials of a diaphragm of audio equipment. However, in each of these materials, propagation speeds of vibrations and sounds are equal in every direction, and accordingly, in the case of manufacturing the diaphragm, a standing wave is prone to occur therein, and there is a case where the standing wave adversely affects acoustic characteristics of the diaphragm in various ways.

[0003] As a diaphragm that suppresses an occurrence of the standing wave, there is known a diaphragm of a wood cone type, which uses, as a diaphragm material, a wood material having propagation speeds different between a fiber direction and a non-fiber direction. There is also known a diaphragm of an oblique cone type, in which a cross-sectional shape is made asymmetric by shifting a position of a voice coil from a center of the diaphragm.

[0004] There is also known a diaphragm formed of paper, plastics, metal or the like, in which anisotropy is imparted to the propagation speed in such a manner that a laser beam is irradiated onto a surface of the diaphragm, and that a part of the raw material of the diaphragm is thereby modified (for example, refer to Patent Document 1).

[0005] However, there is a case where, in the diaphragm of the wood cone type, manufacturing cost thereof is increased since a manufacturing method thereof is complicated. Since the diaphragm of the oblique cone type has a bias in directivity, it is rather difficult for a sound to be emitted forward therefrom, and depending on a case, a sound field expression with a high density cannot sometimes be enjoyed.

[0006] In the method of irradiating the laser beam onto the surface of the diaphragm, the material of the modified portion is damaged, and accordingly, the modified portion becomes fragile as compared with peripheries thereof, and a product malfunction is prone to be brought about.

Patent Document 1: Japanese Patent Laid-Open Publication No. 2001-258091

DISCLOSURE OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0007] In consideration of the foregoing problems, the present invention provides a diaphragm, which is easy to manufacture, has a high product yield, is capable of suppressing the occurrence of the standing wave, and is excellent in sound field expression, provides a speaker and an audio system, which use the diaphragm, and provides a manufacturing method of the diaphragm.

MEANS FOR SOLVING THE PROBLEMS

[0008] In order to solve the foregoing problems, an aspect of the present invention provides a diaphragm including: a vibration member having first-region and second-region portions formed integrally with each other by using an isotropic material, the vibration member having, in the first-region portion, a reinforcement portion in which a Young's modulus is higher than in the second-region portion, the reinforcement portion being obtained by press molding in which a pressure applied to the first-region portion is stronger than a pressure applied to the second-region portion.

[0009] Another aspect of the present invention provides a speaker including: a vibration member having first-region and second-region portions formed integrally with each other by using an isotropic material, the vibration member having, in the first-region portion, a reinforcement portion in which a Young's modulus is higher than in the second-region portion, the reinforcement portion being obtained by press molding in which a pressure applied to the first-region portion is stronger than a pressure applied to the second-region portion.

[0010] Another aspect of the present invention provides a speaker that includes first and second speaker units arranged in line with each other on a front surface of a cabinet thereof, wherein each of the first and second speaker units includes a vibration member having first-region and second-region portions formed integrally with each other by using an isotropic material, the vibration member having, in the first-region portion, a reinforcement portion in which a Young's modulus is higher than in the second-region portion, and the speaker is composed by arranging the first and second speaker units so that at least a part of the reinforcement portion of the first speaker unit and at least a part of the reinforcement portion of the second speaker unit can be individually directed in a same direction.

[0011] Another aspect of the present invention provides a speaker including: a first speaker unit arranged on a front surface of a cabinet of the speaker and including a first vibration member having a substantially conical shape, the first vibration member including first-region and second-region portions formed integrally with each other by using an isotropic material, and having, in the first-region portion, a first reinforcement portion in which a Young's modulus is higher than in the second-region portion; and a second speaker unit arranged in line with the first speaker unit on the front surface of the cabinet of the speaker and including a second vibration member having a substantially conical shape, the second vibra-

tion member including third-region and fourth-region portions formed integrally with each other by using an isotropic material, and having, in the third-region portion, a second reinforcement portion in which a Young' s modulus is higher than in the fourth-region portion, wherein the speaker is composed by arranging the first and second speaker units so that at least a part of the first reinforcement portion and at least a part of the second reinforcement portion can be individually directed in a same direction.

[0012] Another aspect of the present invention provides an audio system including: amplifying means for amplifying an audio signal; and the first and second speakers to which the audio signal is supplied from the amplifying means, wherein the first speaker is a speaker, in which a surround audio signal for a left channel and a center-channel audio signal are supplied to the first speaker unit from the amplifying means, and a front audio signal for the left channel is supplied to the second speaker unit from the amplifying means, and the second speaker is a speaker, in which a surround audio signal for a right channel and the center-channel audio signal are supplied to the first speaker unit from the amplifying means, and a front audio signal for the right channel is supplied to the second speaker unit from the amplifying means.

[0013] Another aspect of the present invention provides an audio system including: amplifying means for amplifying an audio signal; and the first and second speakers according to any one of claims 15 to 30, to which the audio signal is supplied from the amplifying means, wherein the first speaker is a speaker in which identical audio signals for a left channel are supplied to the first and second speaker units from the amplifying means, and the second speaker is a speaker in which identical audio signals for a right channel are supplied to the first and second speaker units from the amplifying means.

[0014] Another aspect of the present invention provides a manufacturing method of a diaphragm, which includes the steps of: forming, at a specific position of a work formed of an isotropic material, a reinforcement portion in which a Young' s modulus is higher than in a peripheral portion of the specific position by press molding in which a pressure applied to the specific position is stronger than a pressure applied to the peripheral portion; and molding the diaphragm.

ADVANTAGEOUS EFFECT OF THE INVENTION

[0015] In accordance with the present invention, there can be provided: the diaphragm, which is easy to manufacture, has the high product yield, is capable of suppressing the occurrence of the standing wave, and is excellent in sound field expression; the speaker and the audio system, which use the diaphragm; and the manufacturing method of the diaphragm.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

[FIG. 1] FIG. 1 is a cross-sectional view showing a speaker unit according to an embodiment of the present invention.

[FIG. 2] FIG. 2 (a) is a plan view showing a diaphragm according to the embodiment of the present invention, and FIG. 2(b) is a cross-sectional view in a case where the diaphragm is viewed in an A-A direction of FIG. 2(a).

[FIG. 3] FIG. 3 is a graph showing propagation speeds of a reinforcement portion and a standard portion according to the embodiment of the present invention.

[FIG. 4] FIG. 4 is a graph showing internal losses of the reinforcement portion and the standard portion according to the embodiment of the present invention.

[FIG. 5] FIGS. 5 (a) to 5(d) are plan views showing arrangement examples of the reinforcement portions according to the embodiment of the present invention.

[FIG. 6] FIGS. 6(a) to 6(f) are plan views showing shape examples of the reinforcement portions according to the embodiment of the present invention.

[FIG. 7] FIG. 7 is an explanatory view explaining characteristics of vibration members according to the embodiment of the present invention.

[FIG. 8] FIG. 8 (a) is a graph representing measurement results of 8 kHz directivity characteristics, and FIG. 8 (b) is a graph representing measurement results of 12 kHz directivity characteristics.

[FIG. 9] FIG. 9 (a) is a graph showing frequency characteristics of a comparative example, and FIG. 9(b) is a graph showing frequency characteristics of a speaker according to the embodiment of the present invention.

[FIG. 10] FIGS. 10 (a) to 10 (g) are process cross-sectional and plan views showing a manufacturing method of the diaphragm according to the embodiment of the present invention.

[FIG. 11] FIG. 11 is a plan view showing a diaphragm according to a first modification example of the present invention.

[FIG. 12] FIGS. 12(a) to 12(c) are plan views showing shape examples of a reinforcement region of a cap.

[FIG. 13] FIG. 13 is an explanatory view of speakers according to a second modification example of the present invention.

[FIG. 14] FIG. 14 is a view showing an audio system according to a third modification example of the present invention.

[FIG. 15] FIGS. 15(a) to 15(e) are views showing other arrangement examples of speaker units in speakers shown in FIG. 14.

[FIG. 16] FIG. 16 is a cross-sectional view showing

a speaker unit according to a fourth modification example of the present invention.

[FIG. 17] FIG. 17 (a) is a plan view of a diaphragm according to the fourth modification example, and FIG. 17(b) is a cross-sectional view in a case where the diaphragm is viewed in a B-B direction of FIG. 17(a).

BEST MODE FOR CARRYING OUT THE INVENTION

[0017] A description is made below of an embodiment of the present invention with reference to the drawings. In the following description referring to the drawings, the same or similar reference numerals are assigned to the same or similar portions. The embodiment to be described below illustrates devices and methods for embodying the technical idea of this invention, and the technical idea of this invention does not specify structures, arrangements and the like of constituent components to those to be described below.

[0018] As shown in FIG. 1, a speaker unit (electroacoustic transducer) 3 according to the embodiment of the present invention includes: a magnetic circuit 34; a frame 33 arranged on the magnetic circuit 34; and a diaphragm 1 fixed to the frame 33. The magnetic circuit 34 includes: a doughnut-like plate 35; and a doughnut-like magnet 36 and a pole piece 30, which are provided under the plate 35.

[0019] A voice coil 31a is loosely inserted into a magnetic gap 37 between the plate 35 and the pole piece 30. A damper 32 is adhered to a voice coil bobbin 31b and the frame 33.

[0020] The diaphragm 1 has: a vibration member 10 in which a cross section has a conical shape; and a rubber edge 14 attached entirely on an outer circumferential portion (edge) of the vibration member 10. The rubber edge 14 is fixed to the frame 33 while interposing a gasket 39 therebetween.

[0021] As shown in FIG. 2(a), the diaphragm 1 has an opening portion 11 on a center thereof. On the opening portion 11, a cap 38 (refer to FIG. 1) for preventing entrance of a foreign object into the voice coil 31a is attached.

[0022] The vibration member 10 is formed of an isotropic material (uniform material). Here, the "isotropic material (uniform material)" refers to a material in which a sound propagation speed is substantially equal (isotropic) in every direction in the diaphragm unlike a wood material or the like in which the sound propagation speed is different between a fiber direction and a non-fiber direction. For example, the "isotropic material" in this embodiment includes paper such as pulp, plastics such as polypropylene, metal such as aluminum, and the like; however, is not limited to these.

[0023] As shown in FIG. 2(a) and FIG. 2(b), the vibration member 10 has: a standard portion 12; and band-like reinforcement portions 13a to 13d, which are integrated with the standard portion 12, and are radially arranged from the opening portion 11 toward an outer circumference side.

[0024] The reinforcement portions 13a to 13d are regions (first-region portions) pressed more strongly than the standard portion 12 (second-region portion) in a manufacturing process of the vibration member 10, which is to be described later. Therefore, a material density of the reinforcement portions 13a to 13d is higher by approximately 10 to 100% as compared with that of the standard portion 12. The material density differs depending on the materials for use. For example, in the case of using paper as the vibration member 10, the material density of the standard portion 12 is approximately 0.4 to 0.7 g/cm^3, and the material density of the reinforcement portions 13a to 13d is approximately 0.5 to 1.0 g/cm^3.

[0025] The reinforcement portions 13a to 13d are regions formed so that rigidity thereof can be higher as compared with that of the standard portion 12 by being pressed more strongly than the standard portion 12 in the manufacturing process of the vibration member 10. The reinforcement portions 13a to 13d are controlled so that a Young' s modulus thereof can be higher by approximately 5 to 15% as compared with that of the standard portion 12. The Young's modulus differs depending on the materials for use; however, for example, in the case of using paper as the vibration member 10, the Young's modulus of the standard portion 12 is approximately 1.2 to 2.0 Pa, and the Young's modulus of the reinforcement portions 13a to 13d is approximately 1.3 to 2.5 Pa.

[0026] A thickness of the reinforcement portions 13a to 13d is different by approximately 10 to 75% from that of the standard portion 12 by being pressed more strongly than the standard portion 12 in the manufacturing process of the vibration member 10. The thickness differs depending on the materials for use. For example, in the vibration member 10 shown in FIG. 2(b), the thickness T1 of the standard portion 12 is approximately 0.3 mm to 0. 35 mm, and the thickness T2 of the reinforcement portions 13a to 13d is approximately 0.2 mm to 0.25 mm.

[0027] FIG. 3 shows comparison in propagation speed between the standard portion 12 and the reinforcement portions 13a to 13d in the case of using paper as the material of the vibration member 10. The vibration member 10 is formed so that the propagation speed (m/s) of the reinforcement portions 13a to 13d can be higher by approximately 5 to 10% as compared with the propagation speed of the standard portion 12.

[0028] FIG. 4 shows internal losses of the standard portion 12 and the reinforcement portions 13a to 13d in the case of using paper as the material of the vibration member 10. The vibration member 10 is formed so that the internal loss (tanδ) of the reinforcement portions 13a to 13d can be higher by 3 to 10% as compared with the propagation speed of the standard portion 12.

[0029] As shown in FIG. 2(a), the reinforcement portions (first-direction reinforcement portions) 13a and 13b are arranged side by side in a first direction (up-and-down

direction of FIG. 2(a)) passing through a center of the vibration member 10. The reinforcement portions (second-direction reinforcement portions) 13c and 13d are arranged side by side in a second direction (right-and-left direction of FIG. 2(a)) passing through the center of the vibration member 10 and different from the first direction. In FIG. 2 (a), the first direction and the second direction are set so as to intersect each other substantially orthogonally at the center of the vibration member 10; however, the directions are not limited to intersect orthogonally.

[0030] The number of the reinforcement portions 13a to 13d is variously changeable in response to characteristics of a speaker system that mounts the vibration member 10 thereon. For example, as shown in FIG. 5 (a), two reinforcement portions 13a and 13b may only be arranged in an up-and-down direction of FIG. 5(a), or as shown in FIG. 5(b), four reinforcement portions 13a to 13d may be arranged along oblique directions of FIG. 5 (b). As shown in FIG. 5(c), half moon-like reinforcement portions 13a to 13d may be arranged, or as shown in FIG. 5(d), three reinforcement portions 13a to 13c extended radially from the opening portion 11 toward the outer circumference may be arranged.

[0031] As a shape of the reinforcement portions 13a and 13b, shapes as shown in FIG. 6(a) to FIG. 6(d) are adoptable. For example, as shown in FIG. 6(a) to FIG. 6 (c), shapes in each of which a width in a longitudinal direction is gradually thinned from the opening portion 11 side to the outer circumference side (not shown) are adopted, whereby a change is added to the propagation speed of the vibrations (sounds) transmitting through the reinforcement portions 13a and 13b. As a result, in terms of audibility, expansion comes to be felt more in a reproduction sound.

[0032] As described above, in accordance with the diaphragm 1 according to the embodiment of the present invention, on the vibration member 10, the reinforcement portions 13a to 13d are arranged, in each of which the Young' s modulus and the internal loss are higher and the propagation speed is faster as compared with those of the standard portion 12. Specifically, as illustrated in FIG. 7, regions in which sound speeds are faster than in the standard portion 12 are formed, and accordingly, in terms of the hearing sense, an impression that the sound comes more forward is obtained, and a sound field expression can be enriched.

[0033] Moreover, the reinforcement portions 13a to 13d are formed integrally and together with the standard portion 12 in press molding to be described later. Therefore, the reinforcement portions 13a to 13d do not peel off from the vibration member 10, and unlike the case of performing a surface process for the vibration member 10 by a laser beam, a part of the vibration member 10 is not damaged, either. Furthermore, the isotropic material such as paper, plastics and metal is used as the material of the vibration member 10, whereby a diaphragm that is inexpensive and easy to manufacture can be provided, and in addition, a loss of output energy owing to an occurrence of a standing wave generated in the case of using the isotropic material can be suppressed.

[0034] Sizes (areas) of all of the reinforcement portions 13a to 13d do not have to be the same. For example, in the case of defining a lower side of FIG. 7 as a mounting surface, the reinforcement portions 13a to 13d are formed so that surface areas of the reinforcement portions 13a and 13b can be larger than surface areas of the reinforcement portions 13c and 13d, whereby the sound speed in the vertical direction with respect to the mounting surface becomes fast. Accordingly, audibility that the sound comes more forward is obtained. Meanwhile, in the case of reducing the areas of the reinforcement portions 13a and 13b than the areas of the reinforcement portions 13c and 13d, audibility that the sound expands in a horizontal direction with respect to the mounting surface is obtained.

[0035] FIG. 8(a) and FIG. 8(b) represent evaluation results of directional sensitivity characteristic tests of a speaker using the diaphragm according to this embodiment. In the directional sensitivity characteristic tests, a speaker using a diaphragm that does not have the reinforcement portions is used as a "comparative example". The speakers according to the comparative example and this embodiment are individually mounted on a turntable, and a microphone is placed at a place radially apart from a center of the turn table by 1 m. While defining a front surface of each of the speakers as zero degree, the directional sensitivity characteristics are evaluated by rotating the turntable clockwise by 360 degrees.

[0036] As shown in FIG. 8(a), it is understood that, in the case of setting a measurement frequency at 8 kHz, a sound pressure level rises over the entire directions in the speaker according to this embodiment as compared with the comparative example. As shown in FIG. 8(b), in the case of setting the measurement frequency at 10 kHz, the sound pressure level of the sound outputted from a front side of the speaker using the diaphragm according to this embodiment largely rises as compared with the comparative example.

[0037] FIG. 9(a) shows frequency characteristics of the diaphragm that does not have the reinforcement portions 13a to 13d (comparative example), and FIG. 9(b) shows an example of frequency characteristics of the diaphragm according to this embodiment. In the case where sound pressures of these diaphragms are compared with each other at portions shown by dotted lines, that is, at a frequency band of 300 to 1000 kHz, it is understood that the sound pressure of the speaker (refer to FIG. 9(b)) according to this embodiment is higher by approximately 1 dB as compared with that of the comparative example (refer to FIG. 9(b)). When curves representing the frequency characteristics are observed, a dip is formed in a band of 2 to 3 kHz of FIG. 9(a) as the comparative example. Meanwhile, in the case shown in FIG. 9(b) as this embodiment, it is understood that the curve is flatter as compared with that of FIG. 9 (a) and

an occurrence of a peak (dip) is suppressed.

[0038] As described above, in accordance with the diaphragm 1 according to this embodiment, the reinforcement portions 13a to 13d are arranged, thus making it possible to raise an output level of a midrange in which many vocal components are contained. Moreover, the occurrence of the peak (dip) can be suppressed, and accordingly, in accordance with the diaphragm 1 according to this embodiment, a speaker that is excellent particularly in midrange sound quality can be provided.

[0039] Next, a description is made of a manufacturing method of the diaphragm 1 according to this embodiment by using FIG. 10(a) to FIG. 10(g). Note that the manufacturing method to be described below is merely an example, and it is a matter of course that it is possible to manufacture the diaphragm 1 by various methods other than the method to be described below.

[0040] First, as shown in FIG. 10(a), a paper making apparatus 21 is put into a pulp-dissolved solution 20. A net 22 in which a center portion is formed into a conical shape (conical frustum shape) in advance is mounted on an upper surface of the paper making apparatus 21. The net 22 can be formed of metal such as brass; however, without being limited to this, any raw material can be used as long as it is robust and has heat resistance.

[0041] As the pulp-dissolved solution 20, for example, a pulp-dissolved solution is usable, which is obtained by dispersing, into water, a mixed fiber product of 10 wt% of linters (cotton fiber) and 90 wt% of NBKP pulp (one formed by turning conifer fiber into pulp by a kraft process and bleaching the fiber thus turned into the pulp). In the paper making apparatus 21, an opening portion 23 is provided for draining extra liquid from a lower side of the net 22 at the time of paper making.

[0042] Next, as shown in FIG. 10 (b), the paper making apparatus 21 is gradually lifted toward the above of the pulp-dissolved solution 20, thereby depositing a paper material 24 on the net 22. Thereafter, hot air may be blown onto the paper material 24 on the net 22 in order to remove moisture from the paper material 24. After the paper material 24 is dried, the paper material 24 is detached from the net 22.

[0043] As shown in FIG. 10(c) and FIG. 10(d), the paper material 24 detached from the net 22 is sandwiched between a male die 27 and a female die 26, which compose a heated press machine 28, and is pressed with a predetermined pressure from an upper portion of the male die 27. At this time, since protruding portions 27a and 27b are selectively and partially formed on the male die 27, partial regions of the paper material 24, which are brought into contact with the protruding portions 27a and 27b, are pressed more strongly as compared with peripheral regions other than these. When the pressing pressure is raised too much, the paper material 24 is sometimes broken, and a variety of physical properties such as a sound propagation speed, which are inherent in the paper material 24, are sometimes affected. In this case of this embodiment, for example, it is preferable to set the pressing pressure at 3 to 5 kPa.

[0044] As shown in FIG. 10(e), an outer circumferential portion 25a of a work 25 molded into a predetermined shape is cut out by a cutting process. Subsequently, as shown in FIG. 10(f), the rubber edge 14 is attached entirely on the outer circumferential portion of the work 25, and an inner circumferential portion 15 is punched out. As shown in FIG. 10(g), the diaphragm 1 is fabricated, in which the opening portion 11 is provided on the center of the vibration member 10, and the rubber edge 14 is attached onto the outer circumferential portion.

[0045] In accordance with the diaphragm 1 according to this embodiment, by the press molding step shown in FIG. 10 (c) and FIG. 10(d), the paper material 24 is pressed in a lump so that a pressing pressure for a specific portion thereof can be stronger, and the vibration member 10 having the standard portion 12 and the reinforcement portions 13a to 13d is manufactured. Therefore, as compared with the case of processing the diaphragm by the laser beam, the diaphragm can be manufactured, which is easy to manufacture, and also has a high product yield.

(First Modification Example)

[0046] As shown in FIG. 11, a diaphragm 100 according to a first modification example is different from the diaphragm 1 shown in FIG. 2(a) and FIG. 2(b) in that the cap 38 is attached onto the opening portion 11. Others are substantially similar to those of the diaphragm 1 shown in FIG. 2(a) and FIG. 2(b), and accordingly, a description thereof is omitted.

[0047] The cap 38 is composed of: a band-like reinforcement region (cap reinforcement portion) 38a having a longitudinal direction thereof in the same direction as that of the reinforcement portions 13a and 13b; and a standard region 38b as a periphery of the reinforcement region 38a. As a material of the cap 38, the isotropic material such as paper, plastics and metal is suitable. The reinforcement region 38a and the standard region 38b are formed so as to be integrated with each other by the press molding.

[0048] The reinforcement region 38a is a region (first-cap-region portion) pressed more strongly than the standard region 38b, and a material density thereof is higher by approximately 10 to 100% as compared with that of the standard region 38b (second-cap-region portion). In the case of using paper as the material of the cap 38, the material density of the standard region 38b is approximately 0.4 to 0.7 g/cm^3, and the material density of the reinforcement region 38a is approximately 0.5 to 1.0 g/cm^3. A Young's modulus of the reinforcement region 38a is higher by approximately 5 to 15% as compared with that of the standard region 38b. In the case of using paper as the material of the cap 38, the Young's modulus of the standard region 38b is approximately 1.2 to 2.0 Pa, and the Young's modulus of the reinforcement region 38a is approximately 1.3 to 2.5 Pa.

[0049] Moreover, the reinforcement region 38a is pressed more strongly than the standard region 38b in the pressing process at the time of manufacturing the cap 38, and is thereby different in thickness from the standard region 38b. In the vibration member 10 shown in FIG. 11, a thickness of the standard region 38b is approximately 0.3 mm to 0. 35 mm, and a thickness of the reinforcement region 38a is approximately 0.2 mm to 0.25 mm.

[0050] A shape of the reinforcement region 38a is not particularly limited. For example, as shown in FIG. 12(a), the reinforcement region 38a may be formed into a band shape extending in the first direction passing through a center of the cap 38. As shown in FIG. 12(b), a V-shaped reinforcement region 38a may be formed, or alternatively, as shown in FIG. 12(c), a cross-shaped reinforcement region 38a may be formed.

[0051] In accordance with the diaphragm 1 according to the first modification example, the reinforcement region 38a and the standard region 38b are arranged also for the cap 38 in addition to the vibration member 10. In such a way, a sound speed of a sound transmitting through the cap 38 can be changed, and accordingly, the occurrence of the standing wave, which is observed in the case of adopting the isotropic member, can be suppressed, and a richer sound field expression becomes realizable.

(Second Modification Example)

[0052] FIG. 13 shows an example of speakers 4a and 4b, in each of which two diaphragms shown in FIG. 11 are arrayed one above the other. The reinforcement portions 13a and 13b are arranged side by side in the substantially vertical direction with respect to the mounting surface. The reinforcement portions 13c and 13d are arranged side by side in the substantially horizontal direction with respect to the mounting surface. The reinforcement region 38a provided on the cap 38 is arranged along the same direction as that of the reinforcement portions 13a and 13b.

[0053] In accordance with each of the speakers shown in FIG. 13, the speaker has the reinforcement portions 13a and 13b and the reinforcement region 38a, whereby the standing wave is prevented, and in addition, the output of the midrange is strengthened more, and audibility that the sound comes out forward can be thereby given to a user. Moreover, the reinforcement portions 13c and 13d are arranged, whereby the expansion feeling of the sound is also obtained in the horizontal direction with respect to the mounting surface, and accordingly, a speaker capable of realizing a denser sound field expression can be provided.

(Third Modification Example)

[0054] FIG. 14 shows an example of an audio system including: the speakers 4a and 4b shown in FIG. 13; and an amplifier 6 connected to the speakers 4a and 4b. On a front surface of a cabinet of the speakers 4a on a left side of FIG. 14, two speaker units 41 and 42 are arranged. On a front surface of a cabinet of the speaker 4b on a right side of FIG. 14, two speaker units 43 and 44 are arranged.

[0055] Each of the speaker units 41 to 44 has: the diaphragm 10 having the standard portion 12 and the reinforcement portions (first-direction reinforcement portions 13a and 13b and second-direction reinforcement portions 13c and 13d); and the cap 38 arranged on the opening portion of the diaphragm 10.

[0056] The first-direction reinforcement portions 13a and 13b are arranged in the substantially vertical direction with respect to the mounting surface. In such a way, the standing wave is suppressed, and in addition, the output of the midrange is strengthened more, and audibility that sound expansion is provided in the vertical direction and that the sound comes more forward can be given to the user. The second-direction reinforcement portions 13c and 13d are arranged in the substantially horizontal direction with respect to the mounting surface. By the second-direction reinforcement portions 13c and 13d, the expansion feeling of the sound is also obtained in the horizontal direction.

[0057] A lateral width of the first-direction reinforcement portions 13a and 13b is made larger than a lateral width of the second-direction reinforcement portions 13c and 13d, whereby the expansion feeling of the sound in the vertical direction is strengthened, and accordingly, this configuration is suitable for a speaker for music appreciation. On the contrary, the lateral width of the second-direction reinforcement portions 13c and 13d is made larger than the lateral width of the first-direction reinforcement portions 13a and 13b, whereby the expansion feeling of the sound in the horizontal direction is strengthened, and accordingly, this configuration is suitable for use in a home theater speaker for which a feeling of presence is required. Note that the speakers 4a and 4b shown in FIG. 14 are formed so that the lateral width of the first-direction reinforcement portions 13a and 13b can be larger by approximately 5 to 20% as compared with the lateral width of the second-direction reinforcement portions 13c and 13d. In such a way, high-quality speakers can be provided as the speakers for the music appreciation, and the speakers can also be sufficiently utilized as the home theater speakers offering the feeling of presence.

[0058] On each of the caps 38, the reinforcement region 38a having the longitudinal direction thereof in the substantially vertical direction with respect to the mounting surface is arranged. An orientation of the reinforcement region 38a is aligned with the same direction as that of the first-direction reinforcement portions 13a and 13b, whereby the expansion feeling of the sound can be provided in the vertical direction. For example, in the case of using the cap 38 of FIG. 12 (a) for the speaker mainly aimed at the music appreciation, it is preferable to ar-

range the reinforcement region 38a so that the orientation thereof can be in the same direction (that is, the vertical direction with respect to the mounting surface) as that of the first-direction reinforcement portions 13a and 13b.

[0059] In the case of using the cap of FIG. 12(b), for the upper speaker unit 41, the reinforcement region 38a is arranged so that a shape thereof can be "V-shaped" by rotating FIG. 12(b) counterclockwise by 90°. For the lower speaker unit 42, the reinforcement region 38a can also be arranged so that a shape thereof can be "mount-shaped (inverse V-shaped)" by rotating the cap of FIG. 12(b) clockwise by 90°. In such a way, a feeling of togetherness is created in the sounds emitted from the upper and lower speaker units 41 and 42.

[0060] The caps of FIG. 12(b) are mounted on the speaker units 43 and 44, and the caps of FIG. 12(b), which are inverted right and left, are mounted on the speaker units 41 and 42, whereby the expansion feeling of the sound is obtained in the horizontal direction, and accordingly, for example, even in the case of arranging the speakers 4a and 4b closely to each other, the expansion feeling of the sound is obtained as compared with the conventional apparatus.

[0061] In the case of using the cap of FIG. 12 (c), orientations of the cross of the reinforcement region 38a are aligned with the orientations of the first-direction reinforcement portions 13a and 13b and the orientations of the second-direction reinforcement portions 13c and 13d, whereby it becomes possible to reproduce a sound having the feeling of presence.

[0062] As shown in FIG. 14, the speaker unit 41 is connected to the amplifier 6 through a line L1. The speaker unit 42 is connected to the amplifier 6 through a line L2. The speaker unit 43 is connected to the amplifier 6 through a line L3. The speaker unit 44 is connected to the amplifier 6 through a line L4.

[0063] Note that, in the case of utilizing the audio system shown in FIG. 14 as a two-channel stereo reproduction system, left-channel audio signals (Lch) mutually identical to each other are inputted to the speaker units 41 and 42 from the amplifier 6 through the lines L1 and L2. Right-channel audio signals (Rch) mutually identical to each other are inputted to the speakers 43 and 44 from the amplifier 6 through the lines L3 and L4. At this time, in order to reproduce the sounds from the upper and lower speaker units 41 and 42 while giving the feeling of togetherness thereto, it is preferable to arrange the first-direction reinforcement portions 13a and 13b and the reinforcement region 38a so that the orientations thereof can be aligned with the vertical direction with respect to the mounting surface.

[0064] Moreover, in order to reproduce the sounds from the upper and lower speaker units 41 and 42 while giving the feeling of togetherness thereto in the case of utilizing the speaker units 41 and 42 for the two-channel stereo reproduction system, it is desirable to align the orientations of the first-direction reinforcement portions 13a and 13b between the speaker units 41 and 42, and to align the orientations of the second-direction reinforcement portions 13c and 13d between the speaker units 42 and 42.

[0065] In the case of utilizing the audio system shown in FIG. 14 as a reproduction system of five-channel surround signals, a surround signal for the left channel (surround L ch) and a center-channel signal (center ch) are inputted to the speaker unit 41 from the amplifier 6 to the line L1. A front signal for the left channel (front L ch) is inputted to the speaker unit 42 from the amplifier 6 through the line L2. A surround signal for the right channel (surround R ch) and a center-channel signal (center ch) are inputted to the speaker unit 43 from the amplifier 6 through the line L3. A front signal for the right channel (front R ch) is inputted to the speaker unit 42 from the amplifier 6 through the line L4.

[0066] At this time, in order to reproduce the sounds from the upper and lower speaker units 41 and 42 while giving the feeling of togetherness thereto, it is desirable to arrange the first-direction reinforcement portions 13a and 13b and the reinforcement region 38a so that the orientations thereof can be aligned with the vertical direction with respect to the mounting surface. Note that, for the speaker units 41 and 43 attached on the upper portions of the speakers 4a and 4b, the spots (reinforcement portions) in which the sound speeds are fast in the vertical direction with respect to the mounting surface are positively arranged in order to generate a sound effect, whereby a sound that expands in the vertical direction and has the feeling of presence like looming forward of the speakers 4a and 4b can be reproduced.

[0067] Note that, though an example of arranging the two speakers 4a and 4b has been illustrated in the example shown in FIG. 14, a plurality of speakers equivalent to the speakers 4a and 4b may be connected to the amplifier 6, or alternatively, woofers and tweeters may be added, and so on, whereby it is also possible to construct 5.1-channel and 7.1-channel audio systems. Moreover, with regard to the number of mounted speaker units 41 to 44, for example, three or more speaker units may be arranged in line for the one speaker 4a.

[0068] FIG. 15(a) to FIG. 15(e) show another arrangement example of the speakers 4a and 4b shown in FIG. 14.

[0069] As shown in FIG. 15(a), the first-direction reinforcement portions 13a and 13b and reinforcement regions 38a of the upper and lower speaker units 41 and 42 are arranged so that the longitudinal orientations thereof can be substantially horizontal with respect to the mounting surface of the speaker 4a, whereby the sound speeds in the horizontal direction become faster as compared with those of the other regions. As a result, a sound field in which the sound expansion in the horizontal direction is made much of can be created. If the same audio signal is inputted to the speaker units 41 and 42 of FIG. 15(a), then the feeling of togetherness can also be given to the sounds emitted from the speaker 4a.

[0070] As shown in FIG. 15(b), the first-direction rein-

forcement portions 13a and 13b and reinforcement regions 38a of the upper and lower speaker units 41 and 42 are arranged so that the orientations thereof can be substantially vertical with respect to the mounting surface of the speaker 4a, whereby the sound speeds in the vertical direction become faster as compared with those of the other regions. As a result, for example, in the case where the surround signal for the left channel in the reproduction system of the five-channel surround signal is inputted to the speaker unit 41 of FIG. 15(b), audibility that the sound looms forward of the speaker 4a can be given to the user. Meanwhile, in the case of utilizing the speaker 4a of FIG. 15(b) as the speaker for the two-channel stereo reproduction, the same signal is inputted to the speaker units 41 and 42, whereby the feeling of togetherness can be given to the reproduction sounds emitted from the respective speaker units 41 and 42.

[0071] As shown in FIG. 15(c), configurations of the lower speaker units 42 and 44 are set similar to those of FIG. 14, and the first-direction reinforcement portions 13a and 13b and reinforcement regions 38a of the upper speaker units 41 and 43 are arranged so that the orientations thereof can be inclined obliquely with respect to the mounting surface. In such a way, a sound field in which the sounds are diffused in the horizontal direction and the oblique directions can be created.

[0072] As shown in FIG. 15(d), the configuration of the lower speaker unit 42 is set similar to the configuration of FIG. 14, and the orientations of the first-direction reinforcement portions 13a and 13b and reinforcement region 38a of the upper speaker unit 41 are directed in the horizontal direction with respect to the mounting surface, whereby a sound field can be created, in which the sound expansion in the horizontal direction is emphasized.

[0073] As shown in FIG. 15(e), the configuration of the lower speaker unit 42 is set similar to the configuration of FIG. 14, and the orientations of the first-direction reinforcement portions 13a and 13b and reinforcement region 38a of the upper speaker unit 41 are directed in the vertical direction with respect to the mounting surface, whereby a sound field can be created, in which the sound expansion in the vertical direction is emphasized.

(Fourth Modification Example)

[0074] As mentioned above, in FIG. 1 to FIG. 15, the descriptions have been made by taking as an example the conical vibration member 10; however, as shown in FIG. 16 and FIG. 17, a vibration member 50 in which a cross section has a dome shape can also be used. A speaker unit 9 shown in FIG. 16 includes: a magnetic circuit 91; a housing portion 92 that houses the magnetic circuit 91 therein; a diaphragm 5 arranged on the magnetic circuit 91; and a frame 93 that fixes the diaphragm 5.

[0075] Note that Fig. 16 is a cross-sectional view showing the speaker unit according to the fourth modification example, FIG. 17 (a) is a plan view of the diaphragm according to the fourth modification example, and FIG. 17 (b) is a cross-sectional view in the case of viewing FIG. 17(a) in a B-B direction.

[0076] The diaphragm 5 has: the vibration member 50 in which the cross section has the dome shape; and an edge 54 formed entirely on an outer circumferential portion of the vibration member 50. As the vibration member 50, there can be used the above-mentioned isotropic materials, silk, cotton, hemp, chemical fiber, a resin film, and the like.

[0077] The vibration member 50 has: a standard portion 50b; and a reinforcement portion 50a provided into a band shape on a center portion of the vibration member 50. The reinforcement portion 50a is a region pressed more strongly than the standard portion 50b in a manufacturing process of the vibration member 50, and a material density of the reinforcement portion 50a is higher as compared with that of the standard portion 50b. In the case of using paper as a material of the vibration member 50, the material density of the standard portion 50b is approximately 0.4 to 0.7 g/cm^3, and the material density of the reinforcement portion 50a is approximately 0. 5 to 1.0 g/cm^3. A Young's modulus of the reinforcement portion 50a is higher by approximately 5 to 15% as compared with that of the standard portion 50b. The Young's modulus of the standard portion 50b is approximately 1.2 to 2.0 Pa, and the Young's modulus of the reinforcement portion 50a is approximately 1.3 to 2.5 Pa. Moreover, a thickness of the standard portion 50b is approximately 0.04 mm to 0.3 mm, and a thickness of the reinforcement portion 50a is approximately 0.020 mm to 0.25 mm.

[0078] A shape of the reinforcement portion 50a is not particularly limited. For example, substantially similar shapes to those of the reinforcement regions 38a shown in FIG. 12(a) to FIG. 12(c) can be adopted.

[0079] A curvature of a dome portion of the vibration member 50 is relatively large. Accordingly, for example, in the case of pasting a raw material in which a sound speed is faster than in a material of a general diaphragm onto a surface of the diaphragm, the raw material is prone to peel off from the diaphragm. In accordance with the diaphragm according to the third modification example, the reinforcement portion 50a and the standard portion 50b are integrated with each other by the press molding, and accordingly, the reinforcement portion 50a does not peel off from a surface of the vibration member 50. Moreover, the vibration member 50 is formed by being pressed, whereby the vibration member 50 is not damaged as compared with the case of processing the surface of the vibration member 50 by a chemical solution, a laser and the like. Hence, the diaphragm 5 is obtained, in which stable quality is maintained for a long period of time.

[0080] The present invention has been described based on the above-described embodiments; however, it should not be understood that the descriptions and the drawings, which form a part of the disclosure, limit this invention. The entire contents of Japanese Patent Application No. P2008-000345 filed on January 7, 2008 and

Japanese Patent Application Nos. P2008-042113, P2008-042115, P2008-042118 and P2008-042122 filed on February 22, 2008 are incorporated herein by reference. It is a matter of course that the present invention incorporates a variety of embodiments and the like, which are not described herein, and from this disclosure, a variety of alternative embodiments, examples and operation technologies will be obvious for those skilled in the art.

INDUSTRIAL APPLICABILITY

[0081] The present invention can be applied to the diaphragm, which is capable of suppressing the occurrence of the standing wave, is excellent in sound field expression, is easy to manufacture, and has a high product yield, to the speaker and the audio system, which use the diaphragm, and to the manufacturing method of the diaphragm.

Claims

1. A diaphragm comprising:

a vibration member including first-region and second-region portions formed integrally with each other by using an isotropic material, the vibration member having, in the first-region portion, a reinforcement portion in which a Young's modulus is higher than in the second-region portion, the reinforcement portion being obtained by press molding in which a pressure applied to the first-region portion is stronger than a pressure applied to the second-region portion.

2. The diaphragm according to claim 1, wherein the vibration member has a substantially conical shape.

3. The diaphragm according to claim 2, wherein a plurality of the reinforcement portions are provided in a band shape radially from a small-diameter side of the vibration member toward a large-diameter side of the vibration member.

4. The diaphragm according to any one of claims 1 to 3, wherein the reinforcement portion includes:

a first-direction reinforcement portion arranged in a first direction passing through a center of the vibration member; and
a second-direction reinforcement portion arranged in a second direction passing through the center of the vibration member, the second direction being different from the first direction.

5. The diaphragm according to claim 4, wherein a surface area of the first-direction reinforcement portion is larger as compared with a surface area of the second-direction reinforcement portion.

6. The diaphragm according to any one of claims 1 to 5, wherein the reinforcement portion is thinner in thickness than the second-region portion.

7. The diaphragm according to any one of claims 1 to 6, further comprising: a cap that covers an opening portion of the vibration member,
wherein the cap includes first-cap-region and second-cap-region portions formed integrally with each other by using an isotropic material, and has, in the first-cap-region portion, a cap reinforcement portion in which a Young's modulus is higher than in the second-cap-region portion, the reinforcement portion being obtained by press molding in which a pressure applied to the first-cap-region portion is stronger than a pressure applied to the second-cap-region portion.

8. A speaker comprising:

a vibration member including first-region and second-region portions formed integrally with each other by using an isotropic material, the vibration member having, in the first-region portion, a reinforcement portion in which a Young's modulus is higher than in the second-region portion, the reinforcement portion being obtained by press molding in which a pressure applied to the first-region portion is stronger than a pressure applied to the second-region portion.

9. The speaker according to claim 8, wherein the vibration member has a substantially conical shape.

10. The speaker according to claim 9, wherein a plurality of the reinforcement portions are reinforcement portions provided in a band shape radially from a small-diameter side of the vibration member toward a large-diameter side of the vibration member.

11. The speaker according to any one of claims 8 to 10, wherein the reinforcement portion includes:

a first-direction reinforcement portion arranged in a first direction passing through a center of the vibration member; and
a second-direction reinforcement portion arranged in a second direction passing through the center of the vibration member, the second direction being different from the first direction.

12. The speaker according to claim 11, wherein a surface area of the first-direction reinforcement portion is larger as compared with a surface area of the second-direction reinforcement portion.

13. The speaker according to any one of claims 8 to 12, wherein the reinforcement portion is thinner in thickness than the second-region portion.

14. The speaker according to any one of claims 8 to 13, further comprising: a cap that covers an opening portion of the vibration member,
wherein the cap is a cap including first-cap-region and second-cap-region portions formed integrally with each other by using an isotropic material, and has, in the first-cap-region portion, a cap reinforcement portion in which a Young's modulus is higher than in the second-cap-region portion, the reinforcement portion being obtained by press molding in which a pressure applied to the first-cap-region portion is stronger than a pressure applied to the second-cap-region portion.

15. A speaker that includes first and second speaker units arranged in line with each other on a front surface of a cabinet thereof,
wherein each of the first and second speaker units includes a vibration member including first-region and second-region portions formed integrally with each other by using an isotropic material, the vibration member having, in the first-region portion, a reinforcement portion in which a Young's modulus is higher than in the second-region portion, and
the speaker is composed by arranging the first and second speaker units so that at least a part of the reinforcement portion of the first speaker unit and at least a part of the reinforcement portion of the second speaker unit can be individually directed in a same direction.

16. The speaker according to claim 15,
wherein each of the reinforcement portions includes:

a first-direction reinforcement portion arranged in a first direction passing through a center of the vibration member; and
a second-direction reinforcement portion arranged in a second direction passing through the center of the vibration member, the second direction being different from the first direction.

17. The speaker according to claim 16, wherein the speaker is composed by arranging the first and second speaker units so that the first-direction reinforcement portion of the first speaker unit and the first-direction reinforcement portion of the second speaker unit can be individually directed in the same direction.

18. The speaker according to claim 17, wherein the speaker is composed by arranging the first and second speaker units so that the second-direction reinforcement portion of the first speaker unit and the second-direction reinforcement portion of the second speaker unit can be individually directed in the same direction.

19. The speaker according to any one of claims 16 to 18, wherein a surface area of the first-direction reinforcement portion is larger as compared with a surface area of the second-direction reinforcement portion.

20. The speaker according to any one of claims 16 to 19, wherein the first direction includes a substantially vertical direction with respect to a mounting surface of the speaker.

21. The speaker according to any one of claims 15 to 20, wherein the reinforcement portions are thinner in thickness than the second-portion region.

22. The speaker according to any one of claims 15 to 21, further comprising: a cap that covers an opening portion of the vibration member,
wherein the cap includes first-cap-region and second-cap-region portions formed integrally with each other by using an isotropic material, and has, in the first-cap-region portion, a cap reinforcement portion in which a Young's modulus is higher than in the second-cap-region portion.

23. A speaker comprising:

a first speaker unit arranged on a front surface of a cabinet of the speaker and including a first vibration member having a substantially conical shape, the first vibration member including first-region and second-region portions formed integrally with each other by using an isotropic material, and having, in the first-region portion, a first reinforcement portion in which a Young' s modulus is higher than in the second-region portion; and
a second speaker unit arranged in line with the first speaker unit on the front surface of the cabinet of the speaker and including a second vibration member having a substantially conical shape, the second vibration member including third-region and fourth-region portions formed integrally with each other by using an isotropic material, and having, in the third-region portion, a second reinforcement portion in which a Young' s modulus is higher than in the fourth-region portion,
wherein the speaker is composed by arranging the first and second speaker units so that at least a part of the first reinforcement portion and at least a part of the second reinforcement portion can be individually directed in a same direction.

24. The speaker according to claim 23, wherein each of the first and second reinforcement portions is a plurality of reinforcement portions provided in a band shape radially from a small-diameter side of each of the vibration members toward a large-diameter side of each thereof.

25. The speaker according to either one of claims 23 and 24, wherein the first reinforcement portion includes:

a first-direction reinforcement portion arranged in a first direction passing through a center of the first vibration member; and
a second-direction reinforcement portion arranged in a second direction passing through the center of the first vibration member, the second direction being different from the first direction, and
the second reinforcement portion includes:

a third-direction reinforcement portion arranged in a third direction passing through a center of the second vibration member; and
a fourth-direction reinforcement portion arranged in a fourth direction passing through the center of the second vibration member, the fourth direction being different from the third direction.

26. The speaker according to claim 25, wherein the speaker is composed by arranging the first and second speaker units so that the first-direction reinforcement portion and the third-direction reinforcement portion can be individually directed in a same direction.

27. The speaker according to claim 26, wherein the speaker is composed by arranging the first and second speaker units so that the second-direction reinforcement portion and the fourth-direction reinforcement portion can be individually directed in a same direction.

28. The speaker according to any one of claims 25 to 27, wherein a surface area of the first-direction reinforcement portion is larger as compared with a surface area of the second-direction reinforcement portion, and a surface area of the third-direction reinforcement portion is larger as compared with a surface area of the fourth-direction reinforcement portion.

29. The speaker according to any one of claims 23 to 28, wherein the first reinforcement portion is thinner in thickness than the second-region portion, and the second reinforcement portion is thinner in thickness than the fourth-region portion.

30. The speaker according to anyone of claims 23 to 29, further comprising: caps which individually cover opening portions of the first and second vibration members,
wherein each of the caps includes first-cap-region and second-cap-region portions formed integrally with each other by using an isotropic material, and has, in the first-cap-region portion, a cap reinforcement portion in which a Young's modulus is higher than in the second-cap-region portion.

31. The speaker according to any one of claims 15 to 30, wherein a surround audio signal and a center-channel audio signal are inputted to the first speaker unit, and a front-channel audio signal is inputted to the second speaker unit.

32. The speaker according to any one of claims 15 to 30, wherein audio signals identical to each other are individually inputted to the first and second speaker units.

33. An audio system comprising:

amplifying means for amplifying an audio signal; and
the first and second speakers according to any one of claims 15 to 30, to which the audio signal is supplied from the amplifying means,
wherein the first speaker is a speaker, in which a surround audio signal for a left channel and the center-channel audio signal are supplied to the first speaker unit from the amplifying means, and a front audio signal for the left channel is supplied to the second speaker unit from the amplifying means, and
the second speaker is a speaker, in which a surround audio signal for a right channel and the center-channel audio signal are supplied to the first speaker unit from the amplifying means, and a front audio signal for the right channel is supplied to the second speaker unit from the amplifying means.

34. An audio system comprising:

amplifying means for amplifying an audio signal; and
the first and second speakers according to any one of claims 15 to 30, to which the audio signal is supplied from the amplifying means,
wherein the first speaker is a speaker in which identical audio signals for a left channel are supplied to the first and second speaker units from the amplifying means, and
the second speaker is a speaker in which iden-

tical audio signals for a right channel are supplied to the first and second speaker units from the amplifying means.

35. A manufacturing method of a diaphragm, comprising the steps of:

forming, at a specific position of a work formed of an isotropic material, a reinforcement portion in which a Young' s modulus is higher than in a peripheral portion of the specific position by press molding in which a pressure applied to the specific position is stronger than a pressure applied to the peripheral portion; and
molding the diaphragm.

36. The manufacturing method of a diaphragm according to claim 35,
wherein the step of forming the reinforcement portion includes a step of selectively forming a plurality of the reinforcement portions in a first direction passing through a center of the work and a second direction different from the first direction, the reinforcement portions individually having a band shape.

FIG. 1

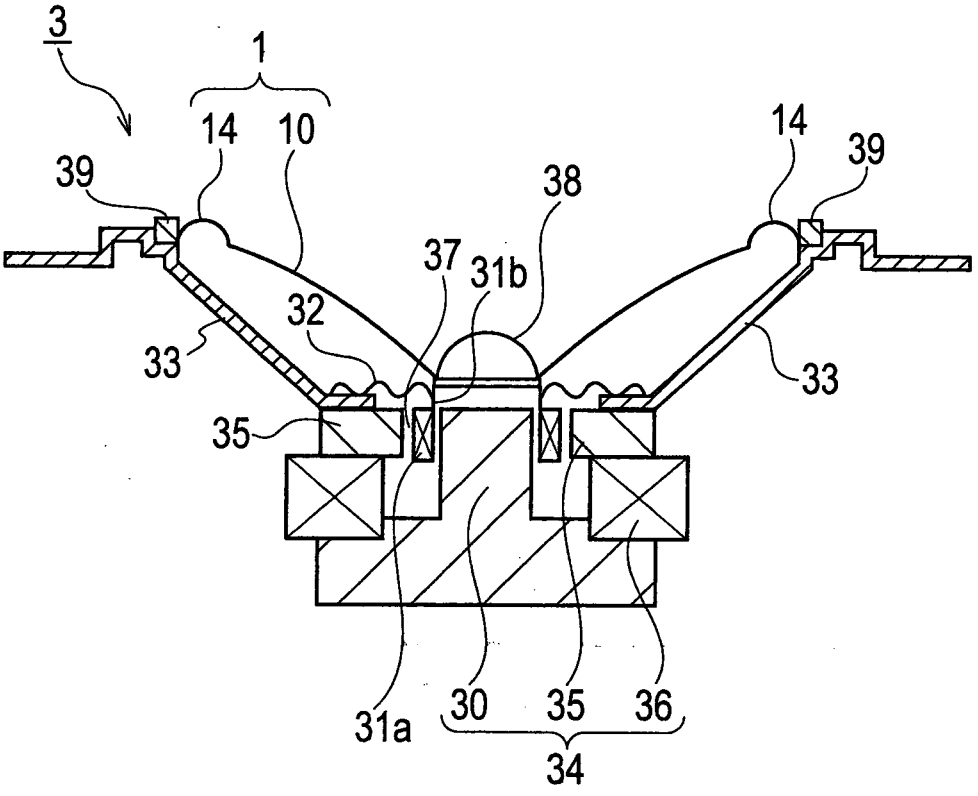
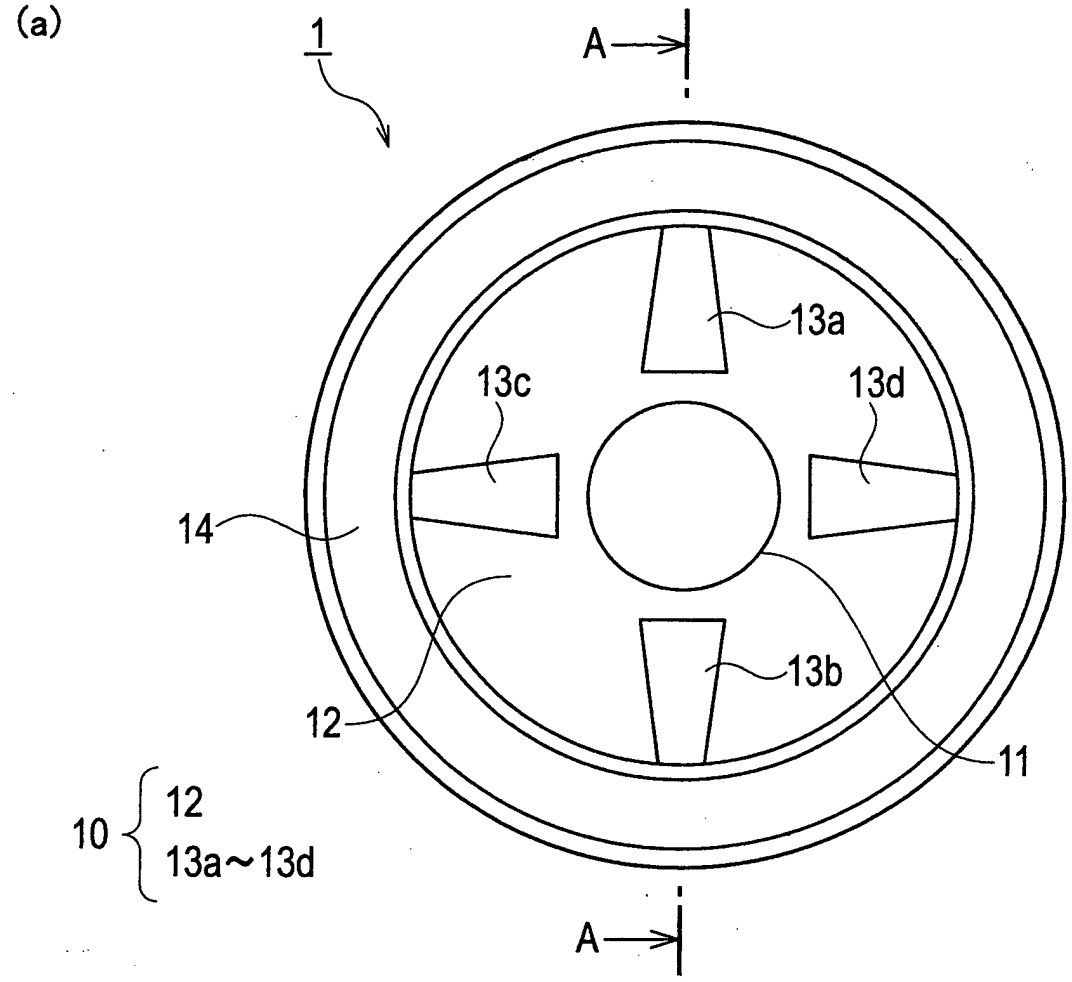


FIG. 2


(a)
1
A
13a
13c
13d
14
12
13b
11
10
12
13a~13d
A

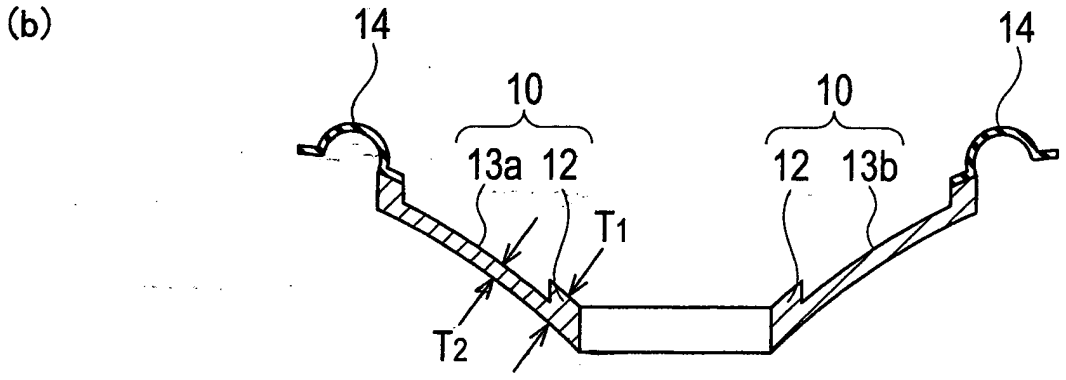

(b)
14
10
13a
12
T1
T2
10
12
13b
14

FIG. 3

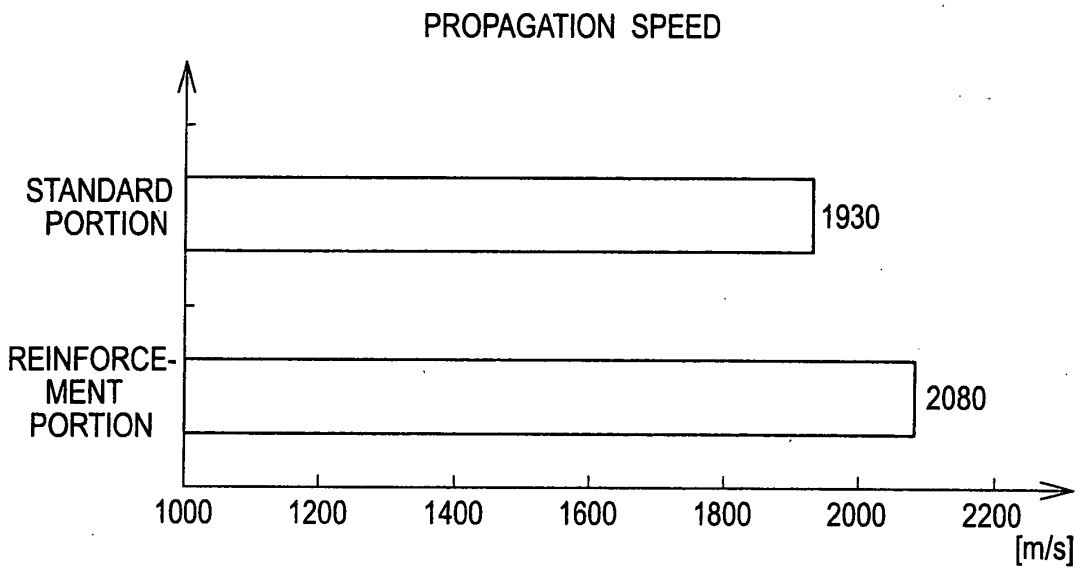

PROPAGATION SPEED
STANDARD PORTION
1930
REINFORCE-MENT PORTION
2080
1000
1200
1400
1600
1800
2000
2200
[m/s]

FIG. 4

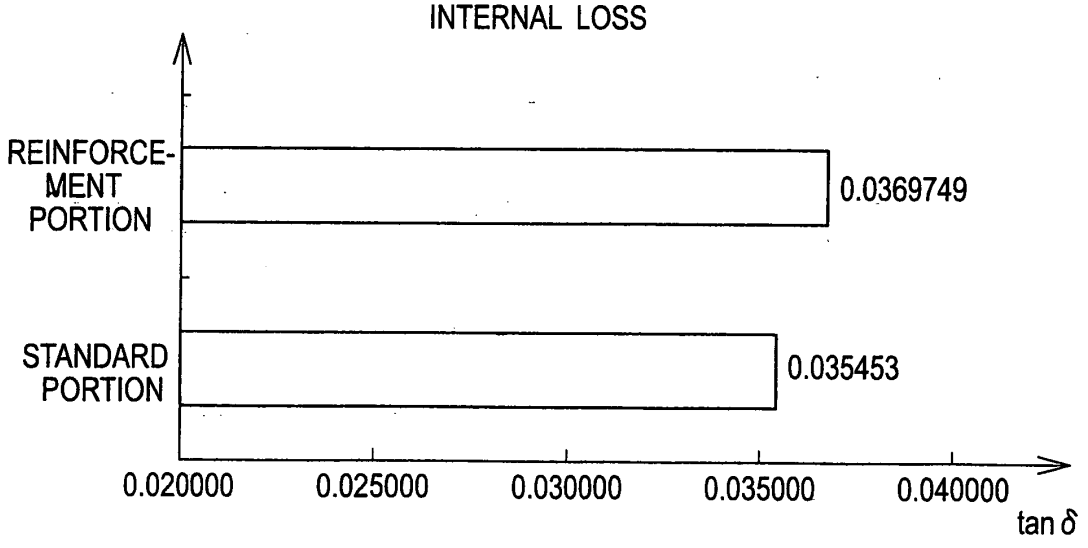

INTERNAL LOSS
REINFORCE-MENT PORTION
0.0369749
STANDARD PORTION
0.035453
0.020000
0.025000
0.030000
0.035000
0.040000
tan δ

FIG. 5

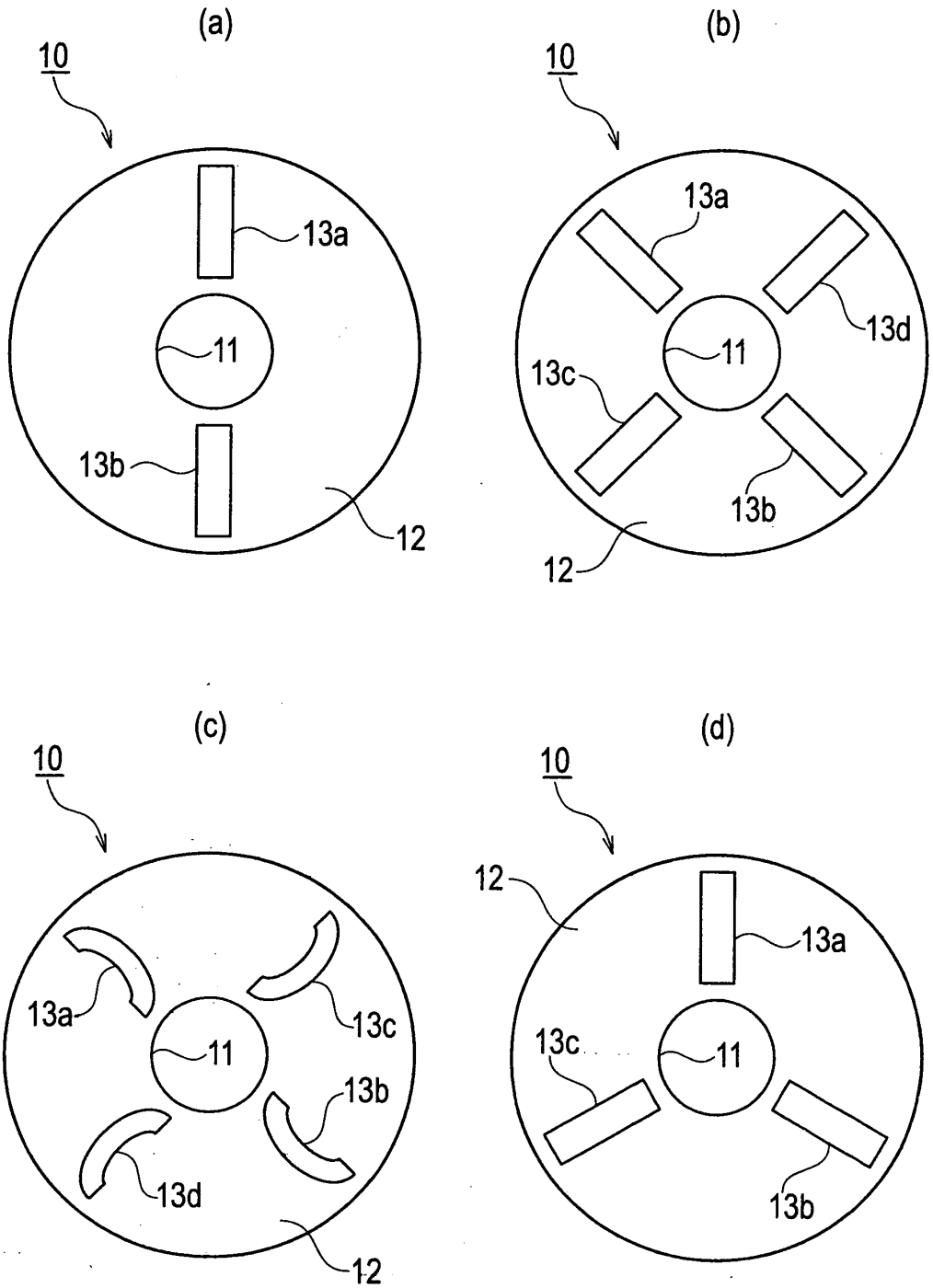

(a)
10
13a
11
13b
12
(b)
10
13a
13d
11
13c
13b
12
(c)
10
13a
13c
11
13b
13d
12
(d)
10
12
13a
13c
11
13b

FIG. 6

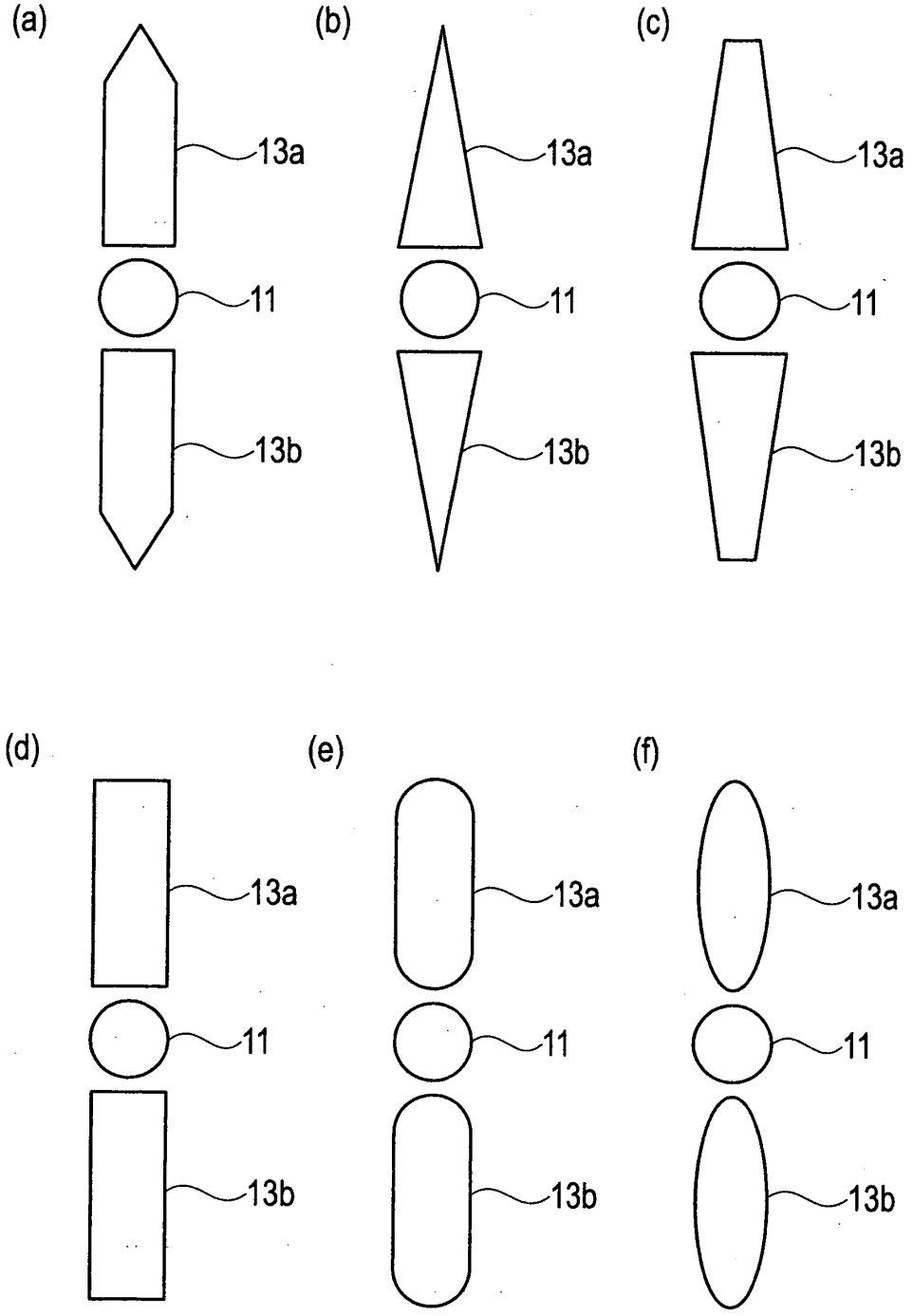

(a)
13a
11
13b
(b)
13a
11
13b
(c)
13a
11
13b
(d)
13a
11
13b
(e)
13a
11
13b
(f)
13a
11
13b

FIG. 7

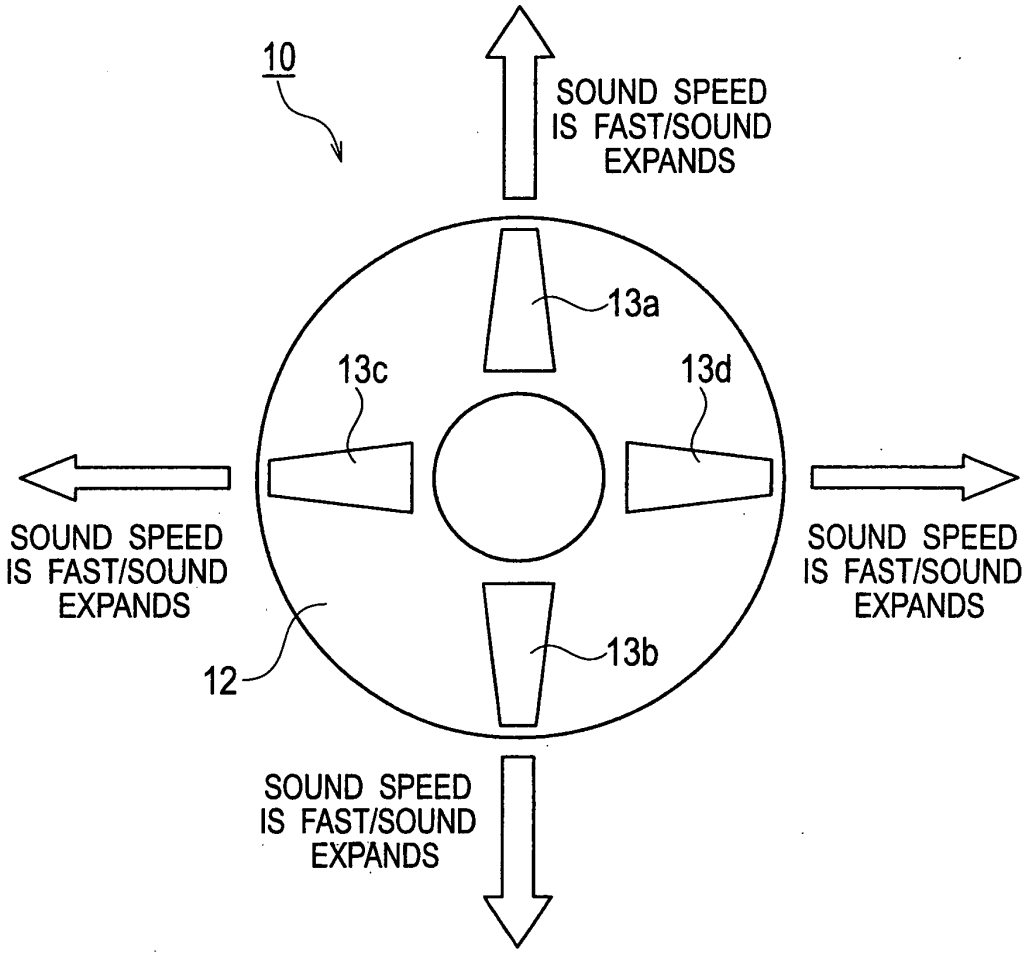

10
SOUND SPEED IS FAST/SOUND EXPANDS
13a
13c
13d
SOUND SPEED IS FAST/SOUND EXPANDS
SOUND SPEED IS FAST/SOUND EXPANDS
12
13b
SOUND SPEED IS FAST/SOUND EXPANDS

FIG. 8

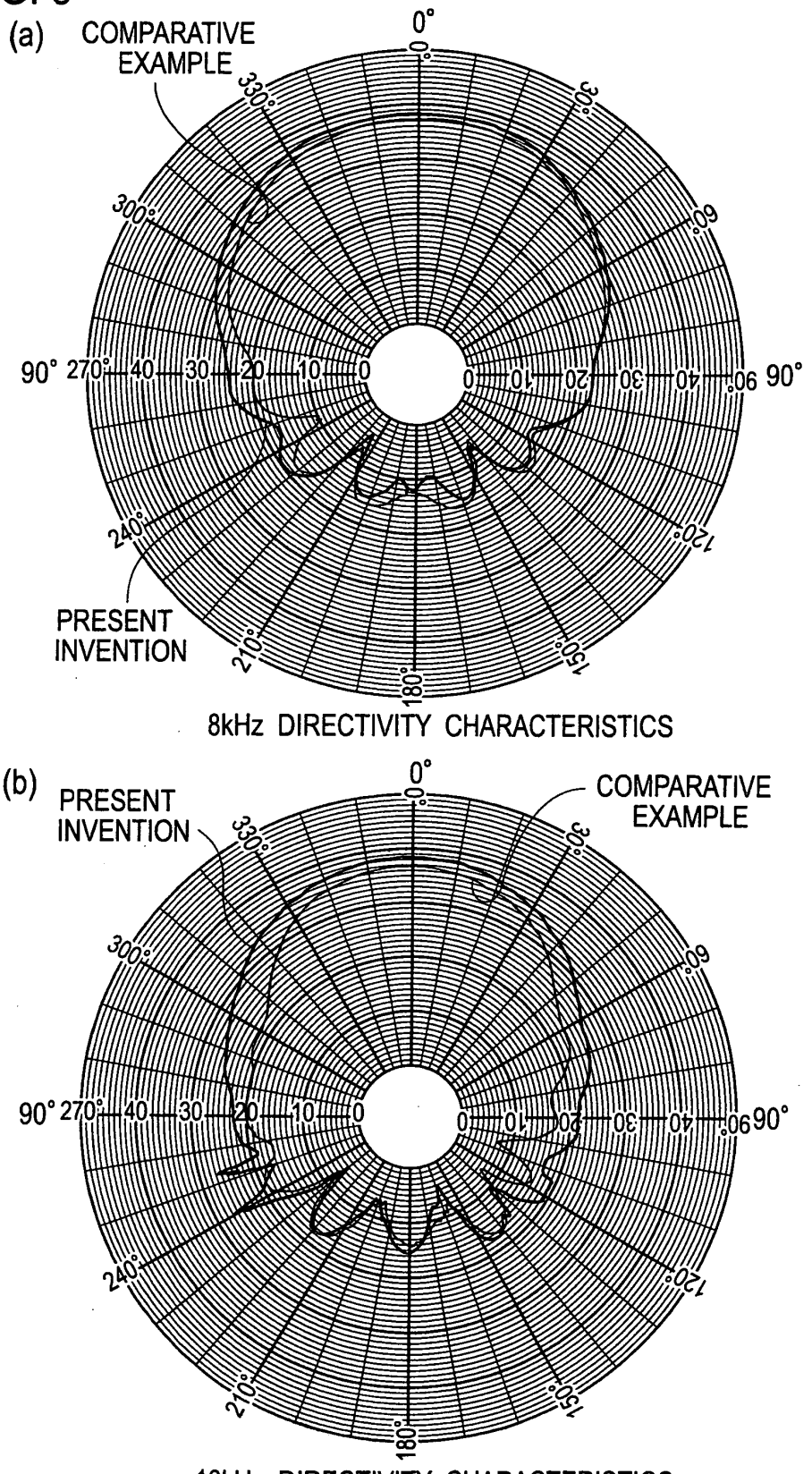

(a)
COMPARATIVE EXAMPLE
PRESENT INVENTION
0°
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
0
10
20
30
40
8kHz DIRECTIVITY CHARACTERISTICS
(b)
PRESENT INVENTION
COMPARATIVE EXAMPLE
10kHz DIRECTIVITY CHARACTERISTICS

FIG. 9

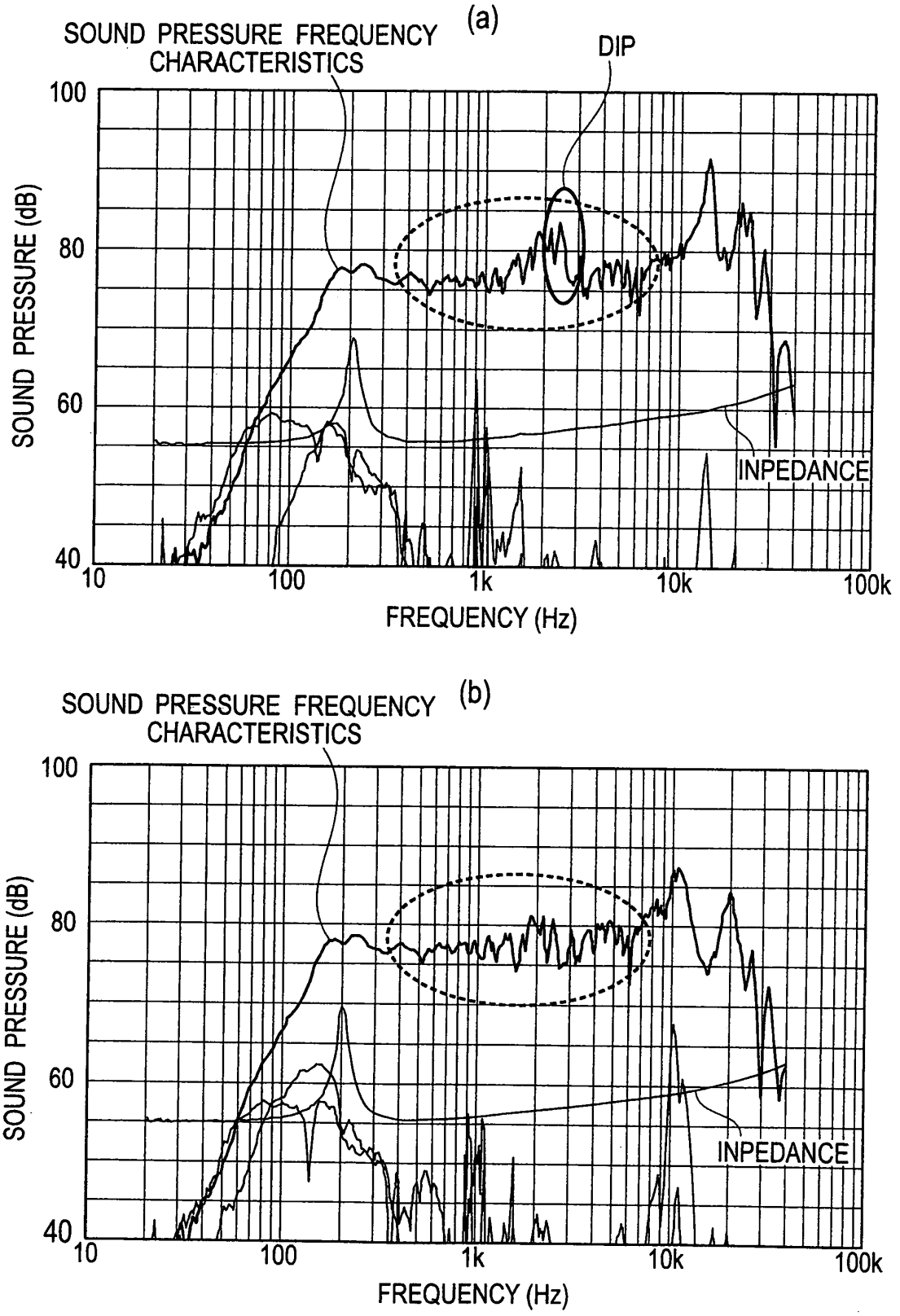

(a)
SOUND PRESSURE FREQUENCY CHARACTERISTICS
DIP
100
80
60
40
SOUND PRESSURE (dB)
10
100
1k
10k
100k
FREQUENCY (Hz)
INPEDANCE
(b)
SOUND PRESSURE FREQUENCY CHARACTERISTICS
100
80
60
40
SOUND PRESSURE (dB)
10
100
1k
10k
100k
FREQUENCY (Hz)
INPEDANCE

FIG. 10

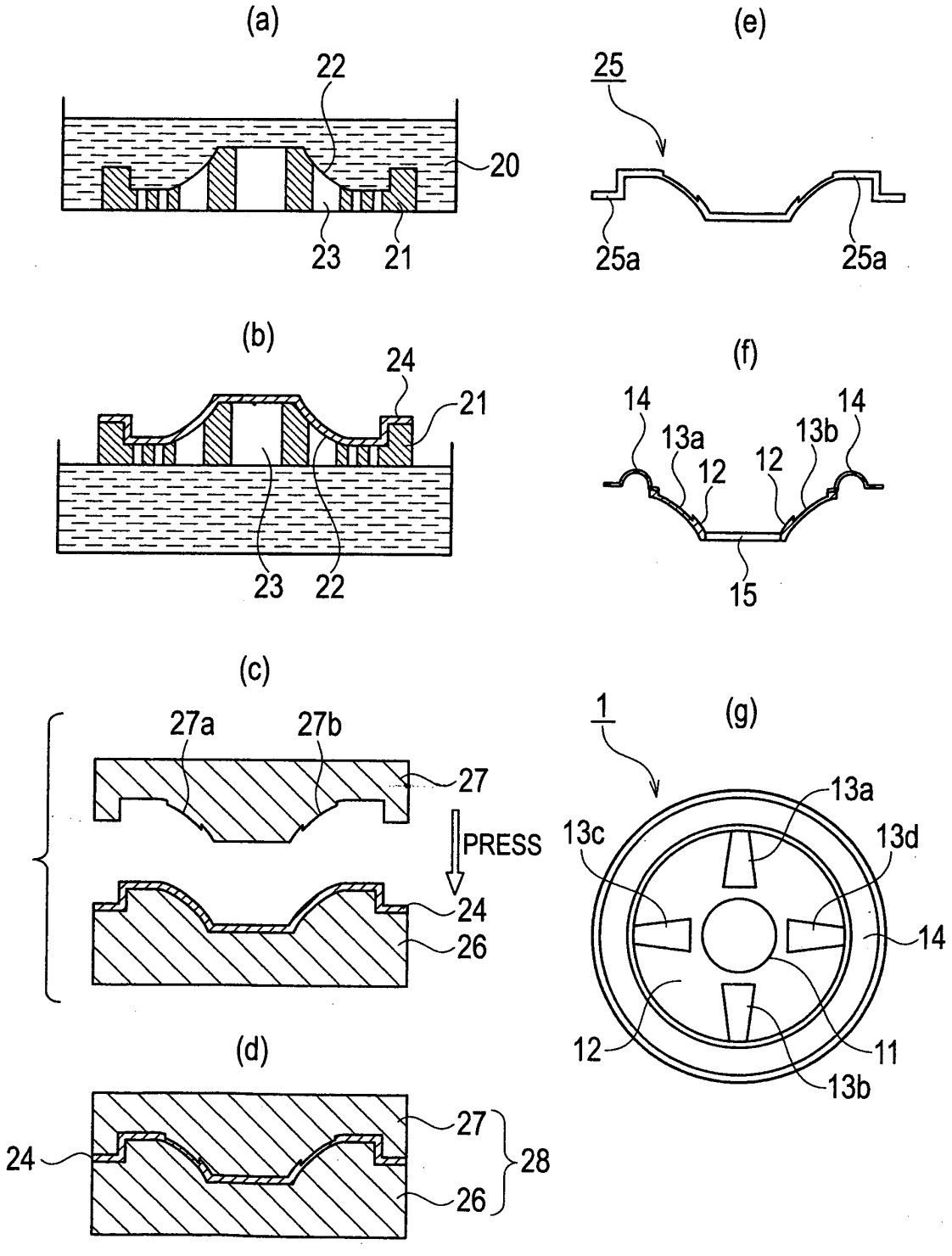

(a)
22
20
23
21
(b)
24
21
23
22
(c)
27a
27b
27
PRESS
24
26
(d)
24
27
28
26
(e)
25
25a
25a
(f)
14
13a
12
12
13b
14
15
(g)
1
13a
13c
13d
14
12
11
13b

FIG. 11

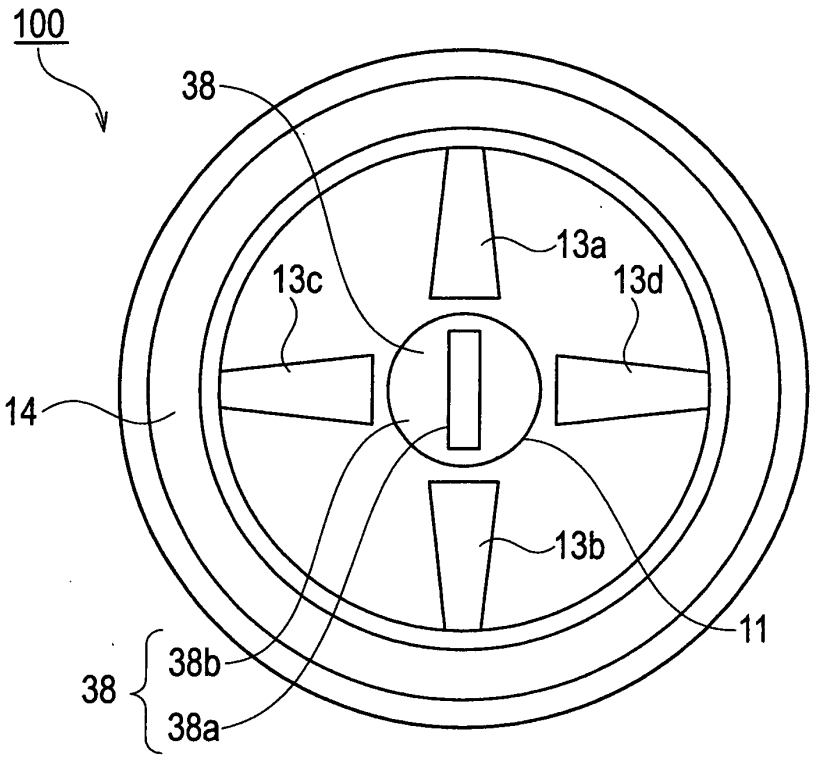

100
38
13a
13c
13d
14
13b
11
38
38b
38a

FIG. 12

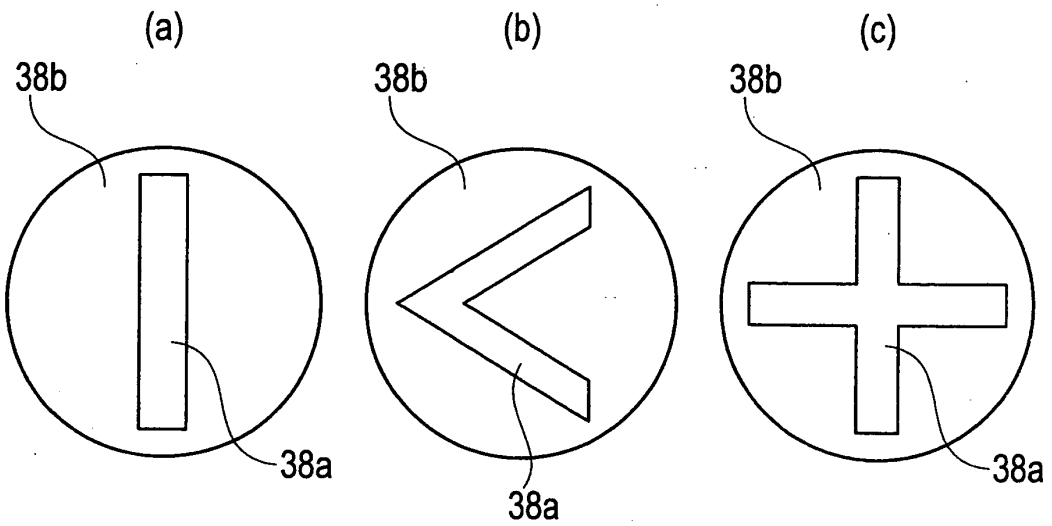

(a)
(b)
(c)
38b
38b
38b
38a
38a
38a

FIG. 13

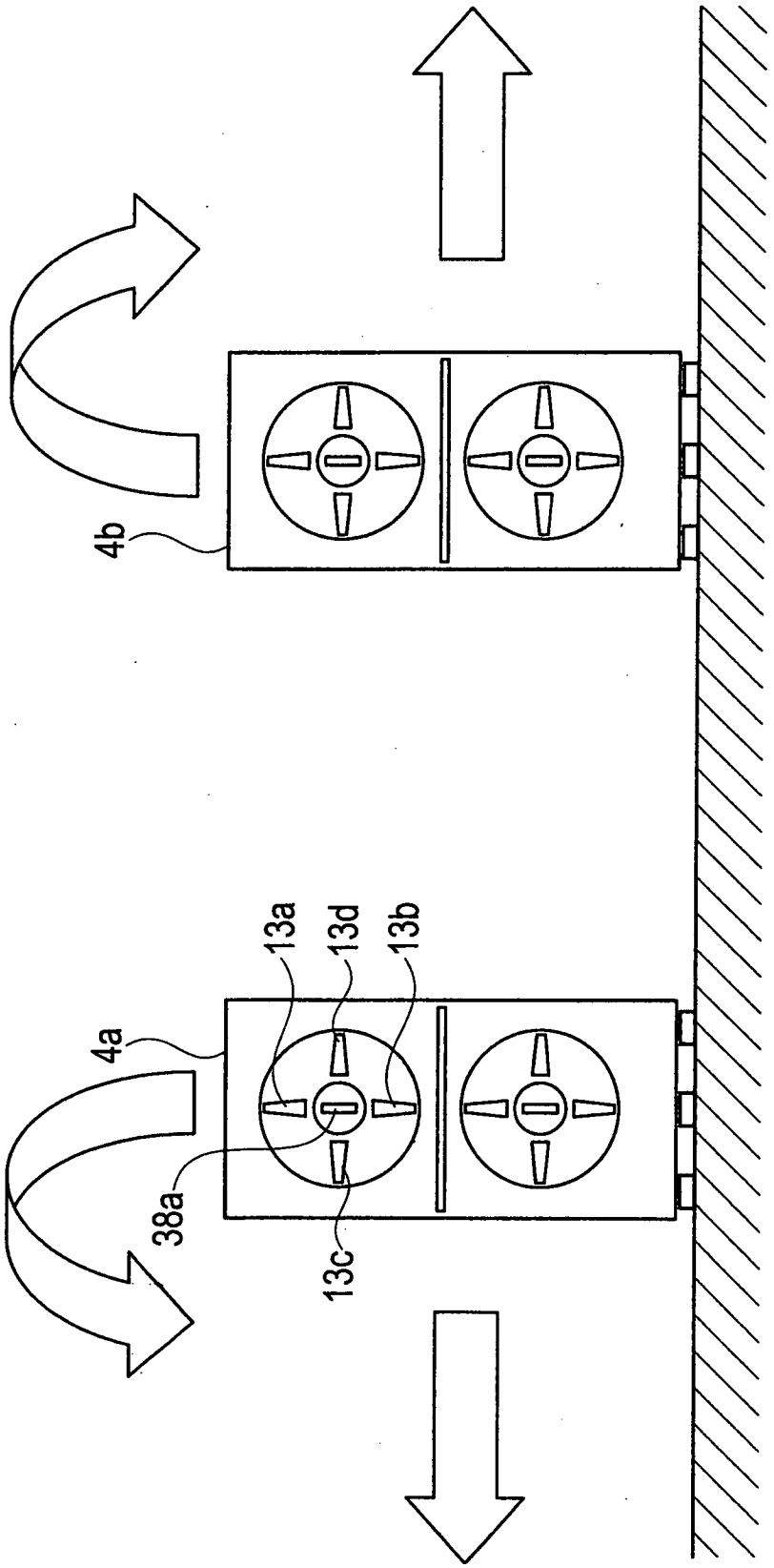


FIG. 14

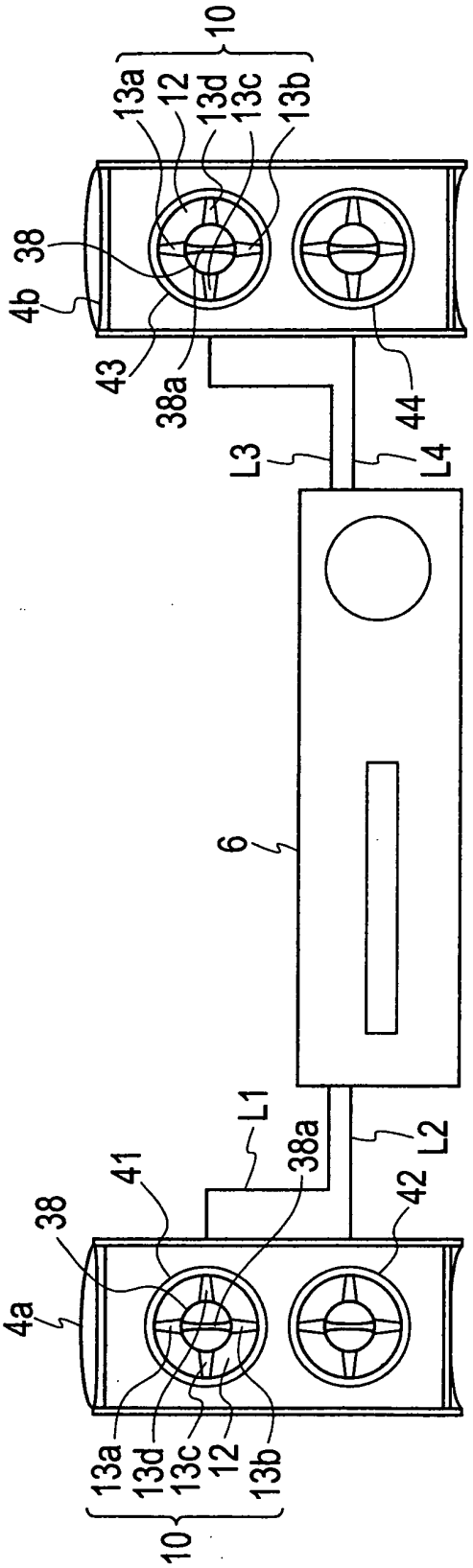

10
13a
12
13d
13c
13b
38
4b
43
38a
44
L3
L4
6
L1
38a
L2
41
42
38
4a
13a
13d
13c
12
13b
10

FIG. 15

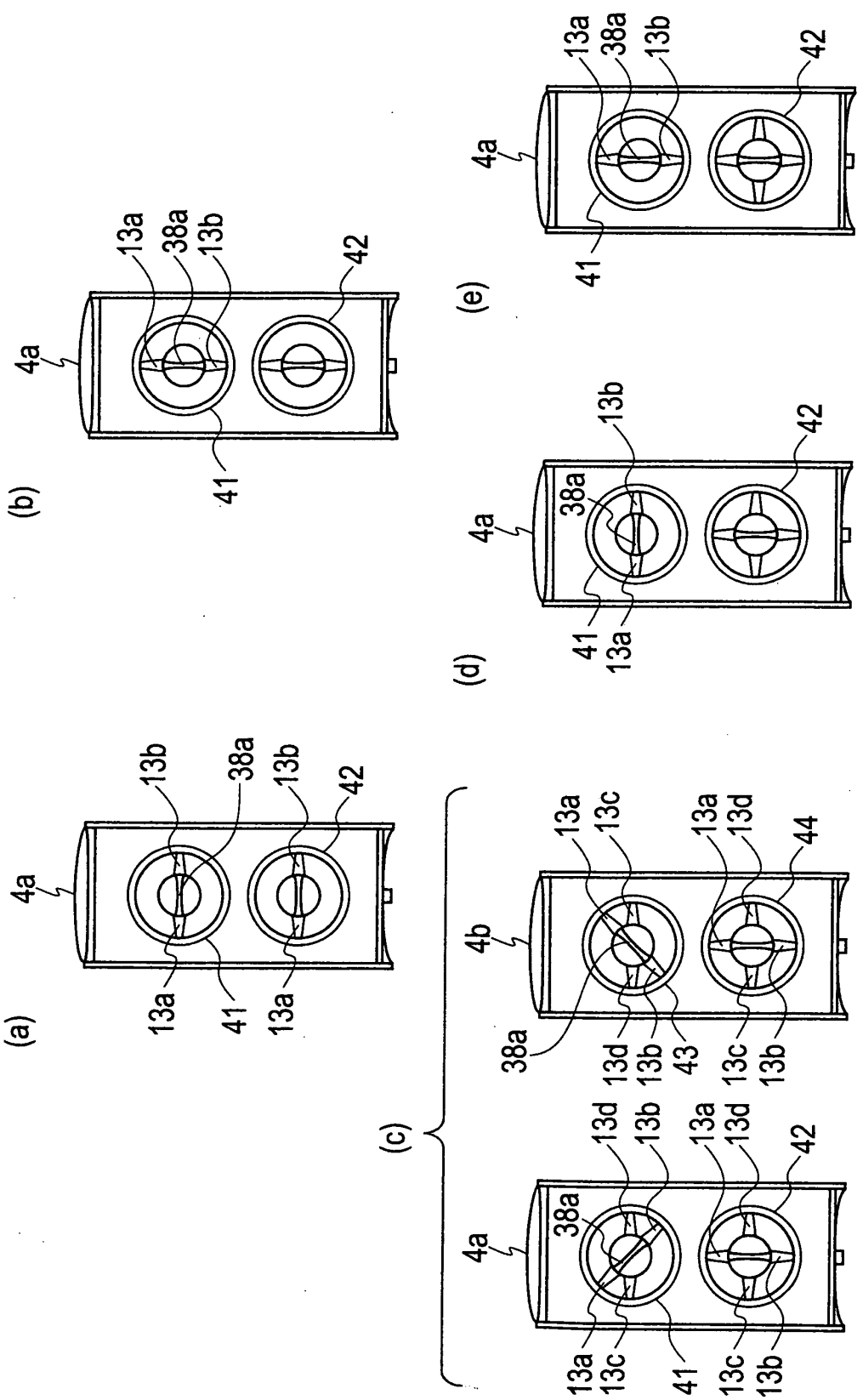

(a)
4a
13b
38a
13b
42
13a
41
13a
(b)
4a
13a
38a
13b
42
41
(c)
4b
13a
13c
13a
13d
44
38a
13d
13b
43
13c
13b
4a
38a
13d
13b
13a
13d
42
13a
13c
41
13c
13b
(d)
4a
13b
42
38a
41
13a
(e)
4a
13a
38a
13b
42
41

FIG. 16

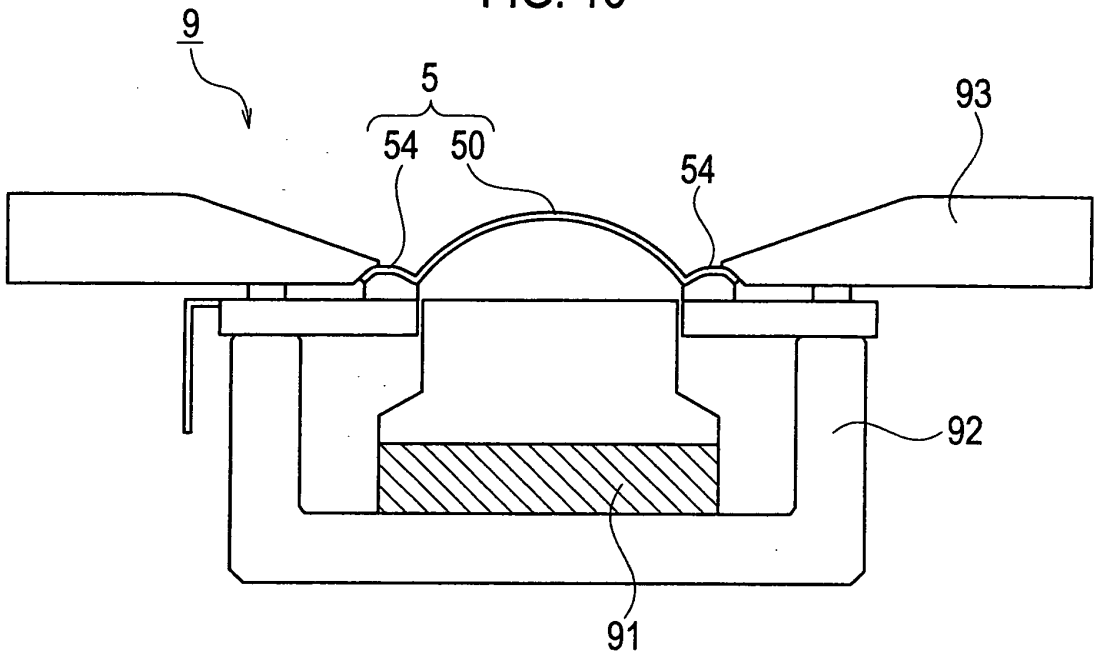
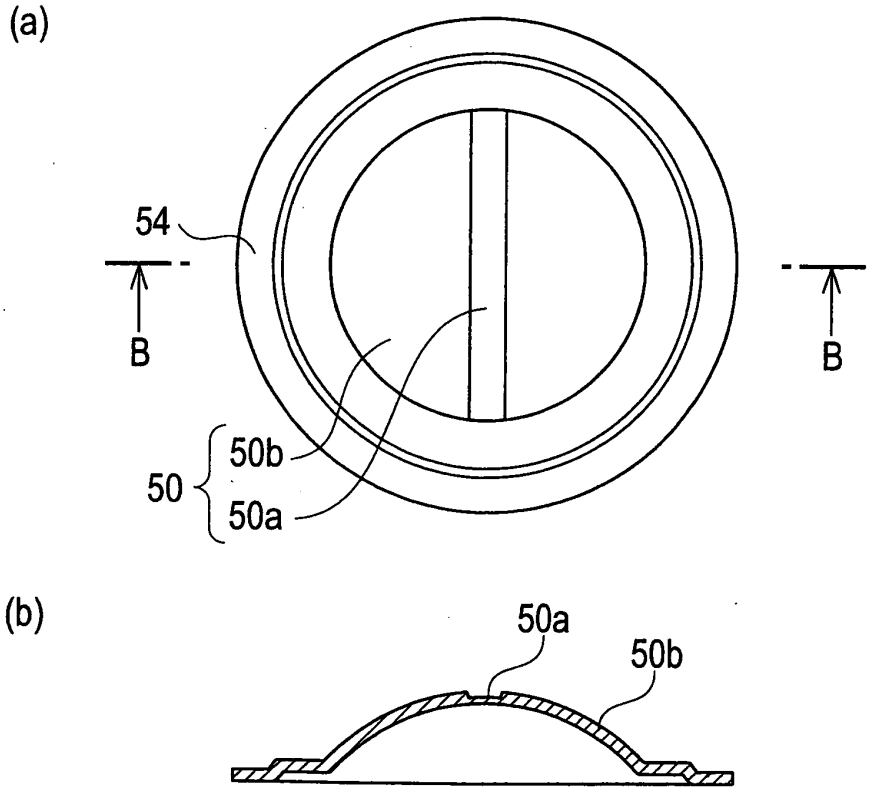


FIG. 17



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/050052

A. CLASSIFICATION OF SUBJECT MATTER
H04R7/14(2006.01)i, *H04R9/02*(2006.01)i, *H04R31/00*(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)
H04R7/14, H04R9/02, H04R31/00

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 1996-2009
Kokai Jitsuyo Shinan Koho 1971-2009 Toroku Jitsuyo Shinan Koho 1994-2009

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	JP 51-145312 A (Mitsubishi Electric Corp.), 14 December, 1976 (14.12.76), Page 1, lower right column, line 11 to page 2, lower left column, line 2; Figs. 2 to 5 (Family: none)	1-3,6,8-10, 13,35 4,5,7,11,12, 14-34,36
Y	JP 61-047479 B2 (Mitsubishi Electric Corp.), 20 October, 1986 (20.10.86), Column 3, line 19 to column 4, line 24; Figs. 4 to 6 (Family: none)	4,5,7,11,12, 14-34,36
Y	JP 2005-223807 A (Pioneer Corp. et al.), 18 August, 2005 (18.08.05), Par. Nos. [0014] to [0059]; Figs. 3, 6 & CN 1655647 A	4,5,7,11,12, 14-34,36

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"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
21 April, 2009 (21.04.09)	12 May, 2009 (12.05.09)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/050052

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 53-119023 A (Kenzo INOUE), 18 October, 1978 (18.10.78), Page 3, line 1 to page 4, upper right column, line 16; Fig. 3 & US 4132872 A & GB 1586907 A & DE 2812222 A1	7,14,22,30
Y	JP 62-269599 A (Mitsubishi Electric Corp.), 24 November, 1987 (24.11.87), Page 4, lower left column, lines 7 to 16; Figs. 1, 2 (Family: none)	15-34
Y	JP 2005-286828 A (Victor Company Of Japan, Ltd.), 13 October, 2005 (13.10.05), Par. Nos. [0022] to [0039]; Figs. 1 to 5 (Family: none)	31,33
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 128724/1989(Laid-open No. 069999/1991) (Sharp Corp.), 12 July, 1991 (12.07.91), Page 5, line 2 to page 6, line 11; Fig. 1 (Family: none)	32,34

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/050052

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

The present international application includes four inventions that do not comply with the requirement of unity of invention because of the following reasons:
Main invention: claims 1-6 and 8-13, claim 7 including the structure in claim 4, claim 14 including the structure in claim 11, and claims 35 and 36
Second invention: claim 7 not including the structure in claim 4 and claim 14 not including the structure in claim 11
Third invention: claims 15-22 and claims 31-34 including the structure in claim 15 (To be continued to the extra sheet)

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

the

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/050052

Continuation of Box No.III of continuation of first sheet(2)

Fourth invention: claims 23-30 and claims 31-34 including the structure in claim 23.

Document 1: JP 51-145312 A (Mitsubishi Electric Corp.), 14 December, 1976 (14.12.76), page 1, lower right column, line 11-page 2, lower left column, line 2, Figs. 2 and 3, (no family)

Since a result of the search that has been conducted for claims 1-7 deemed as "the first described invention (the main invention)" shows that a technical feature in claims 1-3 is disclosed in the document 1 as prior art, it has become clear that the technical feature is not novel. "The isotropic material", "the first area portion" and "the second area portion" in claim 1 are disclosed as "the paper", "B portion" and "A portion" in the document 1. "The reinforcing member" in claim 1 is disclosed in the document 1 as "B portion" that is higher in stiffness than "A portion" by changing press pressure. Further, that "the vibration member has a substantially cone shape" in claim 2 is disclosed in Fig. 3 of the document 1 as a vibration plate that is a cone in shape. In addition, that "the reinforcing members are provided radially in a strip-like shape heading from a small radius side of the vibration member to a large radius side of the vibration member" in claim 3 is disclosed in Figs. 2 and 5(b) of the document 1 as B portion that is provided radially in stripe-like shape heading from the central portion to the outer circumference.

Thus, the technical feature in claims 1-3 is not deemed to be "the special technical feature" in the meaning of PCT Rule 13.2, second sentence.

As far as claim 4 is compared with the prior art, "a (tentative) special technical feature" of the main invention is that "the reinforcing members include a first direction reinforcing member arranged in a first direction that passes through the center of the vibration member and a second direction reinforcing member arranged in a second direction that passes through the center of the vibration member but is arranged differently from the first direction.

Further, as far as claim 7 (the second invention) is compared with the prior art, "a (tentative) special technical feature" of the second invention is "further provided with a cap to cover an aperture of the vibration member, wherein the cap is provided with a first cap area portion and a second cap area portion that are integrally formed by using an isotropic material and the first cap area portion has a cap reinforcing member obtained by press molding with pressure to be more strongly applied to the first cap area portion than pressure to be applied to the second cap area portion, so that the cap reinforcing member is higher in Young's modulus than the second cap area portion".

(to be continued to the next extra sheet)

Form PCT/ISA/210 (extra sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/050052

Further, as far as claim 15 (the third invention) is compared with the prior art, "a (tentative) special technical feature" of the third invention is "a speaker including a first speaker unit and a second speaker unit that are arranged in parallel with each other on the front surface of a cabinet, wherein each of the first speaker unit and the second speaker unit is provided with a vibration member having a first area portion and a second area portion integrally formed by using an isotropic material, the first area portion has a strip-like reinforcing member that is higher in Young's modulus than the second area portion, the first and second speaker units are arranged to make at least a part of the reinforcing member of the first speaker unit and at least a part of the reinforcing member of the second speaker unit face the same direction".

Further, as far as claim 23 (the fourth invention) is compared with the prior art, "a (tentative) special technical feature" of the fourth invention is "a speaker including a first speaker unit that is arranged on the front surface of a cabinet, has a substantially cone shape, is provided with a first area portion and a second area portion integrally formed by using an isotropic material, wherein the first area portion has a first vibration member having a first reinforcing member that is higher in Young's modulus than the second area portion; and a second speaker unit that is arranged in parallel with the first speaker unit on the front surface of a cabinet, has a substantially cone shape, is provided with a third area portion and a fourth area portion integrally formed by using an isotropic material, wherein the third area portion has a second vibration member having a second reinforcing member that is higher in Young's modulus than the fourth area portion, wherein the first and second speaker units are arranged to make at least a part of the first reinforcing member and at least a part of the second reinforcing member face the same direction".

Therefore, there are no technical relationships including one or more of the same or corresponding special technical features among the main invention and the second through fourth inventions.

Additionally, since the invention in claim 6 not including the structure in claim 4 is deemed to be such an invention that well known art is merely added to claim 1, claim 6 is categorized into the same invention as claim 1. Further, since the inventions in claims 8-14 are deemed to be such inventions that well known art is merely added to claims 1-7, claims 8-14 are categorized into the same inventions as claims 1-7. Since claims 35 and 36 are such inventions that claims 1 and 4 corresponding to claims 36 and 36 are merely changed into the category of inventions of manufacturing methods, the claims 35 and 36 are categorized into the same inventions in claims 1 and 4.

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2001258091 A **[0006]**
- JP P2008000345 B **[0080]**
- JP P2008042113 B **[0080]**
- JP P2008042115 B **[0080]**
- JP P2008042118 B **[0080]**
- JP P2008042122 B **[0080]**