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(54) **WATERPROOF SOUND TRANSMITTING MEMBER**

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See application file for complete search history.

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(51) **Int. Cl.**

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| H04R 1/08 | (2006.01) |
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(57) **ABSTRACT**

A waterproof sound transmitting member according to the present invention includes: a waterproof sound transmitting membrane having a first surface and a second surface opposite to the first surface; and a first adhesive sheet and a second adhesive sheet that are disposed on the first surface. When viewed in a direction perpendicular to the first surface, the first adhesive sheet has a closed frame shape, and the second adhesive sheet is disposed within the frame formed by the first adhesive sheet and is spaced from the first adhesive sheet. This waterproof sound transmitting member has a structure suitable for preventing deterioration in sound quality due to sagging of the waterproof sound transmitting membrane.

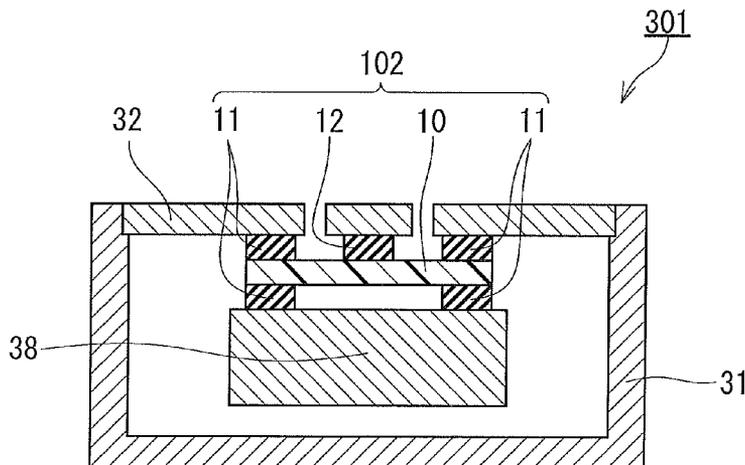
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(2013.01); **H04M 1/03** (2013.01); **H04M 1/18**
(2013.01); **H04R 7/10** (2013.01); **H04R**
2499/11 (2013.01)

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H04R 2420/07; H04R 1/025; H04R 1/021;
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14 Claims, 4 Drawing Sheets



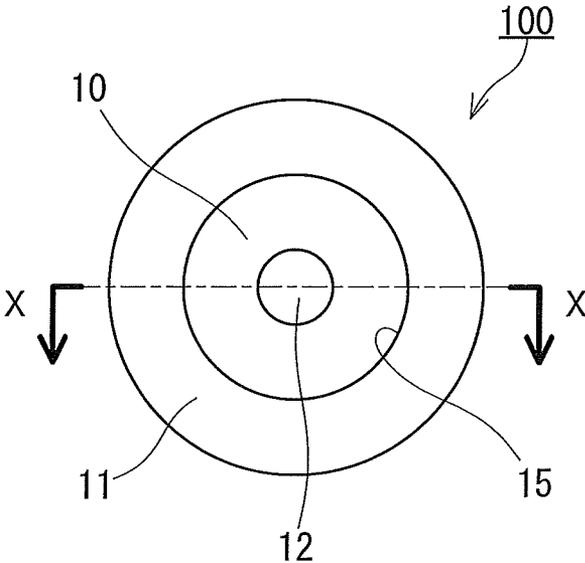


FIG. 1

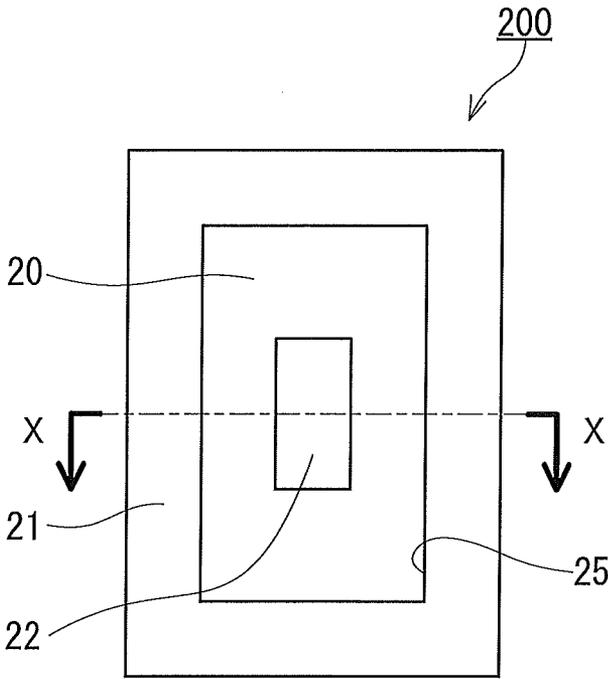


FIG. 2

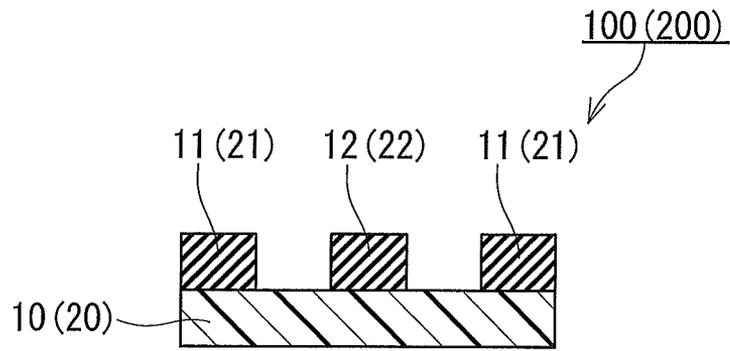


FIG.3

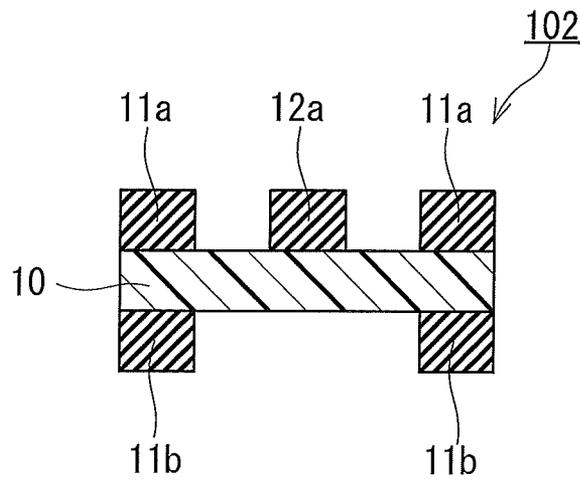


FIG.4

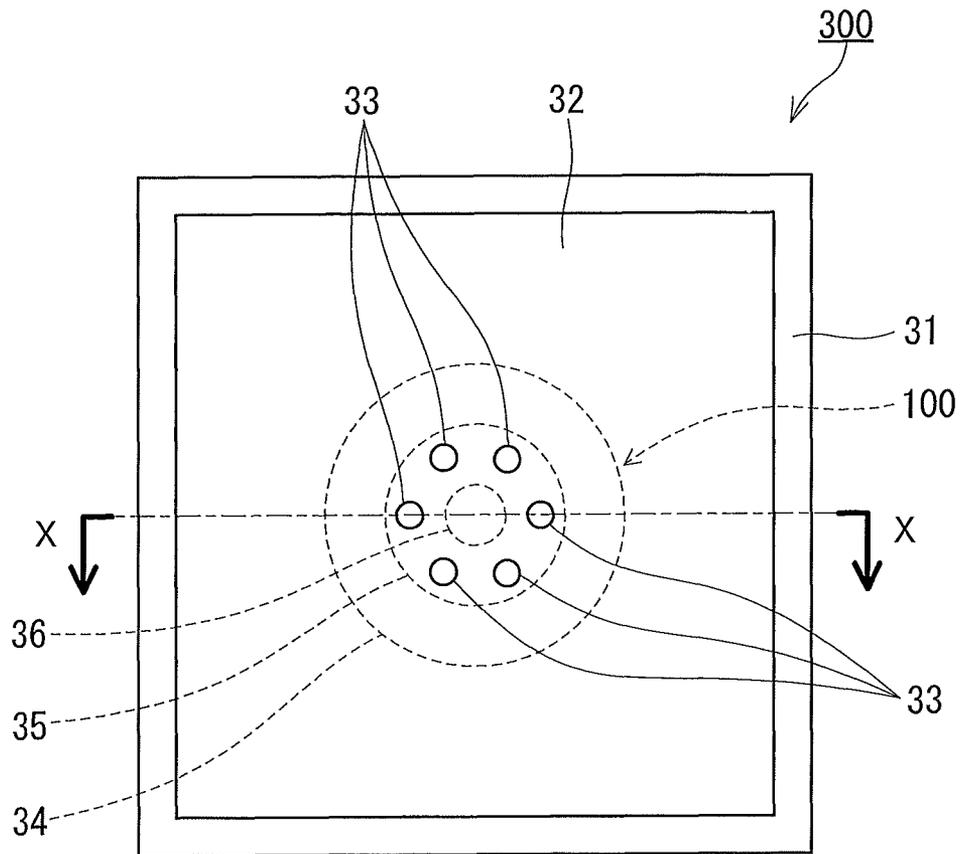


FIG.5

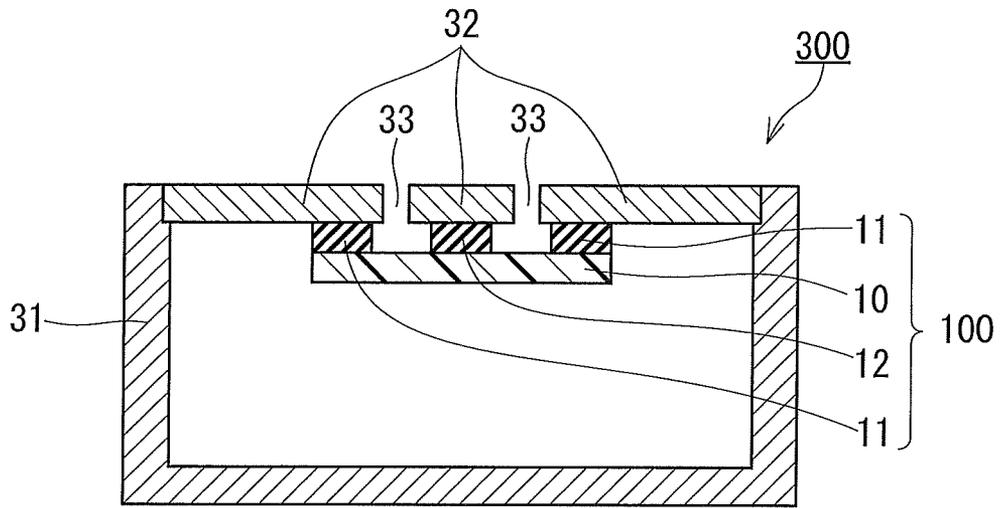


FIG.6

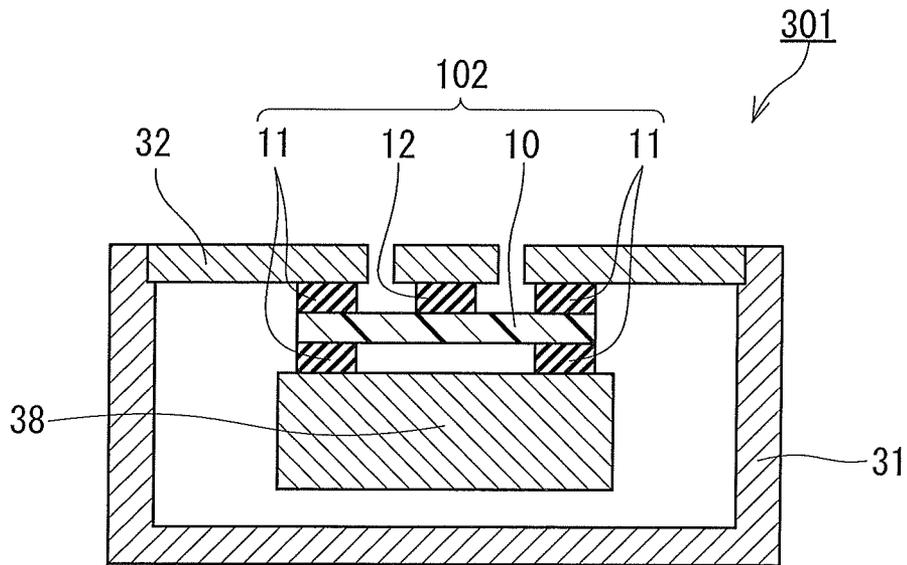


FIG.7

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WATERPROOF SOUND TRANSMITTING MEMBER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a waterproof sound transmitting member suitable for providing waterproof function to electronic devices equipped with acoustic components such as microphones and speakers, and in particular, to a waterproof sound transmitting member including a waterproof sound transmitting membrane.

2. Description of Related Art

Portable electronic devices, such as cellular phones, cordless phones, smartphones, notebook computers, tablet computers, electronic notebooks, digital cameras, and portable game machines, are required to be waterproof because the devices are often used outdoors. In these electronic devices, acoustic components, specifically, transducers serving as sound transmitters or sound receivers, such as speakers, microphones, and buzzers, need to transmit sound to the outside of the devices and to receive sound from the outside thereof. Therefore, various studies have been conducted to achieve both sound transmission and waterproofness.

One of the known ways to provide both waterproofness and sound transmission (waterproof sound transmission function) to an electronic device is to attach a waterproof sound transmitting membrane to a housing of the electronic device to cover an opening formed in the housing. Nonwoven fabrics or porous polymer membranes and films are used as waterproof sound transmitting membranes. Waterproof sound transmitting members each including a waterproof sound transmitting membrane and a fixing member for fixing the waterproof sound transmitting membrane are disclosed in JP 2001-148897 A, JP 2004-083811 A, and JP 2012-165353 A, for example. JP 2012-165353 A discloses a waterproof sound transmitting member including a waterproof sound transmitting membrane in which two sheets having different stiffnesses are laminated together to reduce chattering noise.

SUMMARY OF THE INVENTION

As the fixing member for fixing the waterproof sound transmitting membrane, an adhesive sheet or an adhesive disposed or applied between the edge of the opening to be protected from water and the outer edge of the waterproof sound transmitting membrane is known. However, when an adhesive sheet or an adhesive is used as the fixing member, the waterproof sound transmitting membrane is usually attached to the inner surface of the housing. Therefore, the waterproof sound transmitting membrane sagging under its own weight may come into contact with the transducer and other components around the transducer, resulting in distortion of sound. Since electronic devices have recently become smaller and lighter, the risk that sagging of a waterproof sound transmitting membrane may cause deterioration in sound quality has increased. In particular, a waterproof sound transmitting membrane having a large diameter is more likely to come into contact with the surrounding components.

In view of the above, it is an object of the present invention to provide a waterproof sound transmitting member having a structure suitable for preventing deterioration in sound quality due to sagging of the waterproof sound transmitting membrane.

The present invention provides a waterproof sound transmitting member including: a waterproof sound transmitting membrane that allows sound to pass therethrough and pre-

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vents water from passing therethrough, the waterproof sound transmitting membrane having a first surface and a second surface opposite to the first surface; and a first adhesive sheet and a second adhesive sheet that are disposed on the first surface. When viewed in a direction perpendicular to the first surface, the first adhesive sheet has a closed frame shape, and the second adhesive sheet is disposed within the frame formed by the first adhesive sheet and is spaced from the first adhesive sheet.

In the waterproof sound transmitting member of the present invention, the waterproof sound transmitting membrane and the first adhesive sheet block the passage of water through the opening to be protected from water. The second adhesive sheet also is disposed on the waterproof sound transmitting membrane so that the first and second adhesive sheets are placed on the same surface. The second adhesive sheet allows to ensure good sound transmission while preventing sagging of the waterproof sound transmitting membrane.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top view showing an embodiment of a waterproof sound transmitting member of the present invention.

FIG. 2 is a top view showing another embodiment of the waterproof sound transmitting member of the present invention.

FIG. 3 is an example of a cross-sectional view of the waterproof sound transmitting member, taken along the line X-X in FIG. 1 or FIG. 2.

FIG. 4 is another example of the cross-sectional view of the waterproof sound transmitting member.

FIG. 5 is a top view showing an embodiment of an acoustic component including the waterproof sound transmitting member.

FIG. 6 is a cross-sectional view of the acoustic component, taken along the line X-X in FIG. 5.

FIG. 7 is a cross-sectional view of the acoustic component including the waterproof sound transmitting member in FIG. 4.

DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, embodiments of the present invention will be described with reference to the drawings, but the present invention is not limited to the following description. As is apparent from the following description and drawings, a "principal surface" in this specification refers to the surface extending in a direction perpendicular to the thickness direction of a membrane or a sheet.

FIG. 1 is a view of a waterproof sound transmitting member **100** according to an embodiment of the present invention, as seen from above in a direction perpendicular to the principal surface of a waterproof sound transmitting membrane **10**. FIG. 3 is a cross-sectional view of the waterproof sound transmitting member **100**, taken along the line X-X. The waterproof sound transmitting member **100** includes the waterproof sound transmitting membrane **10** that allows sound to pass therethrough and prevents liquid from passing therethrough, and a first adhesive sheet **11** and a second adhesive sheet **12** that are disposed on a first surface of the waterproof sound transmitting membrane **10**. The first surface is one principal surface of the waterproof sound transmitting membrane **10** selected from two principal surfaces thereof. No adhesive sheet is disposed on a second surface of the waterproof sound transmitting membrane **10**. The second surface is the other principal surface of the waterproof sound transmitting membrane **10**. For example, the first adhesive

sheet 11 and the second adhesive sheet 12 are adhesive sheets, both sides of which have adhesive properties. That is, they are double-sided adhesive tapes. The waterproof sound transmitting membrane 10 is a membrane member whose principal surface has a circular outline. The first adhesive sheet 11 is a closed frame having a disk-shaped window formed in the center of a disk-shaped sheet. More specifically, the first adhesive sheet 11 is a ring-shaped member disposed on the waterproof sound transmitting membrane 10 such that the outer edge of the first adhesive sheet 11 and the outer edge of the waterproof sound transmitting membrane 10 coincide with each other. The second adhesive sheet 12 is disposed within the frame formed by the first adhesive sheet 11, that is, in a region surrounded by the inner edge 15 of the first adhesive sheet 11, and is spaced from the first adhesive sheet 11, when viewed in a direction perpendicular to the first surface of the waterproof sound transmitting membrane 10. The second adhesive sheet 12 has a circular shape smaller than a circular region surrounded by the inner edge 15, when viewed in the direction perpendicular to the first surface. Thus, the first surface of the waterproof sound transmitting membrane 10 is divided into a ring-shaped region covered by the first adhesive sheet 11, a ring-shaped region to which the waterproof sound transmitting membrane 10 is exposed between the first adhesive sheet 11 and the second adhesive sheet 12, and a circular region covered by the second adhesive sheet 12, in order from the outer edge side. The area of the principal surface of the waterproof sound transmitting membrane 10 is larger than the total of the area of the principal surface of the first adhesive sheet 11 and the area of the principal surface of the second adhesive sheet 12.

FIG. 2 is a top view showing a waterproof sound transmitting member 200 according to another embodiment of the present invention. The waterproof sound transmitting member 200 is the same as the waterproof sound transmitting member 100 shown in FIG. 1, except for the shape of a waterproof sound transmitting membrane 20, the shape of a first adhesive sheet 21, and the shape of a second adhesive sheet 22, as seen from above in the direction perpendicular to the first principal surface of the waterproof sound transmitting membrane 20. FIG. 3 shows the cross-sectional view of the waterproof sound transmitting member 200, taken along the line X-X in FIG. 2. The waterproof sound transmitting membrane 20 is a membrane member whose principal surface has a rectangular outline. The first adhesive sheet 21 has a closed frame shape having a rectangular window formed in the center of a rectangular sheet. More specifically, the first adhesive sheet 21 is a rectangular frame-shaped member disposed on the waterproof sound transmitting membrane 20 such that the outer edge of the first adhesive sheet 21 and the outer edge of the waterproof sound transmitting membrane 20 coincide with each other. The second adhesive sheet 22 is disposed within the frame formed by the first adhesive sheet 21, that is, in a region surrounded by the inner edge 25 of the first adhesive sheet 21, and is spaced from the first adhesive sheet 21, when viewed in the direction perpendicular to the first surface of the waterproof sound transmitting membrane 20. The second adhesive sheet 22 has a rectangular shape smaller than a rectangular region surrounded by the inner edge 25 of the first adhesive sheet 21, when viewed in the direction perpendicular to the first surface. Thus, the first surface of the waterproof sound transmitting membrane 20 is divided into a rectangular frame-shaped region covered by the first adhesive sheet 21, a rectangular frame-shaped region to which the waterproof sound transmitting membrane 20 is exposed between the first adhesive sheet 21 and the second adhesive sheet 22, and a rectangular region covered by the

second adhesive sheet 22, in order from the outer edge side. The area of the principal surface of the waterproof sound transmitting membrane 20 is larger than the total of the area of the principal surface of the first adhesive sheet 21 and the area of the principal surface of the second adhesive sheet 22.

Preferably, the area of the second adhesive sheet 12 (22) is not more than one half the area of a region surrounded by the inner edge 15 (25) of the frame formed by the first adhesive sheet 11 (21), when viewed in the direction perpendicular to the first surface of the waterproof sound transmitting member 10 (20). When the area of the second adhesive sheet 12 (22) satisfies the above condition, it is easier to ensure good sound transmission of the waterproof sound transmitting member 100 (200) while preventing sagging of the waterproof sound transmitting membrane 10 (20). The lower limit of the area of the second adhesive sheet 12 (22) is not particularly limited, but it is, for example, at least one tenth the area of the region surrounded by the inner edge 15 (25) of the frame formed by the first adhesive sheet 11 (21), when viewed in the direction perpendicular to the first surface of the waterproof sound transmitting member 10 (20).

FIG. 5 is a top view showing an embodiment of an acoustic component 300 including the waterproof sound transmitting member 100. FIG. 6 is a cross-sectional view of the acoustic component 300, taken along the line X-X in FIG. 5. In the acoustic component 300, a housing is formed of a storage cabinet 31 and a perforated plate 32 covering an opening of the case 31. A transducer (for example, a speaker, a microphone, or a buzzer) not shown is placed in the storage cabinet 31. The perforated plate 32 has formed therein holes 33 for allowing passage of sound between the interior and exterior of the housing. In FIG. 5, a broken line 34 indicates the position of the outer edge of the first adhesive sheet 11 and that of the waterproof sound transmitting membrane 11, a broken line 35 indicates the position of the inner edge of the first adhesive sheet 11, and a broken line 36 indicates the position of the outer edge of the second adhesive sheet 12. The waterproof sound transmitting member 100 is fixed to the inner surface of the perforated plate 32 by the first adhesive sheet 11 and the second adhesive sheet 12 so as to cover the holes 33. When viewed in the direction perpendicular to the first surface of the waterproof sound transmitting membrane 10, the holes 33 are located in a ring-shaped region inside the line 35 of the inner edge of the first adhesive sheet 11 and outside the line 36 of the outer edge of the second adhesive sheet 12.

The first adhesive sheet 11 fixes the waterproof sound transmitting membrane 10 and the housing together and prevents water from entering the housing together with the waterproof sound transmitting membrane 10. Thus, the first adhesive sheet 11 serves to provide waterproof function to the acoustic component 300. The second adhesive sheet 12 fixes the waterproof sound transmitting membrane 10 and the housing together in the region surrounded by the first adhesive sheet 11. Thus, the second adhesive sheet 12 serves to prevent sagging of the waterproof sound transmitting membrane 10. Preventing sagging of the waterproof sound transmitting membrane 10 makes it possible to avoid a contact of the waterproof sound transmitting membrane 10 with the surrounding components and sound distortion. Since the second adhesive sheet 12 is spaced from the first adhesive sheet 11, the region to which the waterproof sound transmitting membrane 10 is exposed forms a single continuous region. When the membrane is divided into regions, the sound energy passing through a smaller area region does not sufficiently contribute to increase the total sound energy passing through the membrane. Therefore, a configuration in which the water-

proof sound transmitting membrane is exposed to a single continuous region is advantageous in reducing the loss of sound energy.

The shapes of the waterproof sound transmitting membrane **10**, the first adhesive sheet **11**, and the second adhesive sheet **12** may be determined as appropriate depending on the position, shape, size, etc. of the holes **33** of the perforated plate **32**. For example, the shape of the first adhesive sheet **11** may be determined so that the holes **33** to be protected from water can be located inside the inner edge **35** of the first adhesive sheet **11**. The shape of the first adhesive sheet **11** may be determined so that the outer edge **34** of the first adhesive sheet **11** and the outer edge of the waterproof sound transmitting membrane **10** coincide with each other.

The second adhesive sheet **12** is disposed inside the inner edge **35** of the first adhesive sheet **11** and is spaced from the first adhesive sheet **11**. The shape of the second adhesive sheet **12** may be determined so that the second adhesive sheet **12** does not extend into the region in which the holes **33** are formed. In order to cause the waterproof sound transmitting membrane **10** to vibrate uniformly and reduce the loss of sound energy, it is preferable that the center of gravity of the second adhesive sheet **12** (**22**) coincide with that of the region surrounded by the inner edge **15** (**35**) of the first adhesive sheet **11** (**21**), when viewed in the direction perpendicular to the first surface of the waterproof sound transmitting membrane **10** (**20**), as in the waterproof sound transmitting member **100** (**200**) shown in FIG. 1 (FIG. 2). It is more preferable that the center of gravity of the second adhesive sheet **12** (**22**) also coincide with that of the waterproof sound transmitting membrane **10** (**20**).

In the waterproof sound transmitting member **100** (**200**) shown in FIG. 1 (FIG. 2), the adhesive sheets **11** (**21**) and **12** (**22**) are disposed on only one of the two principal surfaces (i.e., the first surface) of the waterproof sound transmitting membrane **10** (**20**), as shown in FIG. 3. However, the arrangement of adhesive sheets is not limited to this. For example, as in a waterproof sound transmitting member **102** shown in FIG. 4, adhesive sheets may be arranged so that a first adhesive sheet **11a** and a second adhesive sheet **12a** are disposed on the first surface of the waterproof sound transmitting membrane **10** and a third adhesive sheet **11b** having a closed frame shape is disposed on the principal surface (second surface) opposite to the first surface. No other adhesive sheet than the third adhesive sheet **11b** is disposed on the second surface. Preferably, the third adhesive sheet **11b** has the same shape as the first adhesive sheet **11a**.

In the case where the waterproof sound transmitting member **102** having a cross-sectional structure shown in FIG. 4 is used, for example, an acoustic component **301** having a cross-sectional structure shown in FIG. 7 can be obtained. The acoustic component **301** includes a transducer **38** inside the housing formed of the storage cabinet **31** and the perforated plate **32**. The waterproof sound transmitting member **102** is fixed to the perforated plate **32** by the first adhesive sheet **11** and the second adhesive sheet **12** that are disposed on one of the principal surfaces of the waterproof sound transmitting membrane **10**, and is fixed to the transducer **38** by the adhesive sheet (third adhesive sheet) disposed on the other principal surface of the waterproof sound transmitting membrane **10**.

Sound passes through the region to which the waterproof sound transmitting membrane **10** is exposed, that is, the frame-shaped region between the inner edge of the first adhesive sheet **11** and the outer edge of the second adhesive sheet **12**, and thus is transmitted. The larger the exposure area of the waterproof sound transmitting membrane **10**, the smaller the

loss of sound energy caused by the passage of sound through the waterproof sound transmitting membrane **10**. Therefore, in the case where the waterproof sound transmitting membrane **10** includes the third adhesive sheet, it is preferable that, as shown in FIG. 4, the first adhesive sheet **11a** and the third adhesive sheet **11b** not only have the same shape but also be located at the same position when viewed in the direction perpendicular to the principal surface of the waterproof sound transmitting membrane **10**. That is, it is preferable that the outer edge and the inner edge of the frame-shaped first adhesive sheet **11a** coincide with those of the frame-shaped third adhesive sheet **11b** in the thickness direction of the waterproof sound transmitting membrane **10**.

The thickness of the waterproof sound transmitting membrane **10** can be adjusted as appropriate depending on the waterproofness, strength and sound transmission required, the configuration of the acoustic component **300**, etc. The thickness of the waterproof sound transmitting membrane **10** is, for example, 5 to 100 μm .

Preferably, the unwrinkled and unsagged waterproof sound transmitting membrane **10** having a flat principal surface is attached to the housing with the first adhesive sheet **11** and the second adhesive sheet **12** interposed therebetween. In order to facilitate the attachment of the membrane, it is preferable that the first adhesive sheet **11** and the second adhesive sheet **12** have the same thickness. The thinner first and second adhesive sheets **11** and **12** are preferred in terms of miniaturization of the acoustic component **300**. However, if the thickness of the first adhesive sheet **11** and the second adhesive sheet **12** is too small, the waterproof sound transmitting membrane **10** vibrated by sound waves may come into contact with other components such as the perforated plate **32**, or the waterproof sound transmitting membrane **10** may be more susceptible to damage from outside foreign substances passing through the holes **33**, depending on the structure of the acoustic component **300**. The thickness of the first adhesive sheet **11** and the second adhesive sheet **12** may be, for example, 30 μm to 200 μm .

The width of the frame formed by the first adhesive sheet **11**, that is, the distance between the outer edge **34** and the inner edge **35** of the first adhesive sheet **11** is suitably 0.5 mm to 5 mm, for example, for ensuring waterproofness, although the suitable width may vary depending on the structure of the acoustic component **300** to which the waterproof sound transmitting member **100** is to be attached.

The materials that can be used for the waterproof sound transmitting membrane **10** are, for example, polymer films made of polymers, such as polyethylene, polypropylene, polyimide, polyethylene terephthalate, and polytetrafluoroethylene (PTFE), and porous membranes made from the polymer films, water-repellent nonwoven fabrics, and nanofiber membranes. The waterproof sound transmitting membrane **10** is a single layer sheet, but it may be a layered product of sheets. Preferably, the waterproof sound transmitting membrane **10** includes a porous PTFE membrane because of its high water repellency and high sound transmission.

As the adhesive sheets such as the first adhesive sheet **11** and the second adhesive sheet **12**, double-sided adhesive tapes, in particular, sheets including a base material layer and an acrylic or silicone adhesive layers disposed on both sides of the base material layer are suitably used.

The present invention is particularly effective when it is applied to a waterproof sound transmitting member including a large-diameter waterproof sound transmitting membrane, because such a large-diameter waterproof sound transmitting membrane is likely to sag under its own weight and thus to come into contact with the surrounding components, causing

sound distortion. Therefore, it is preferable to apply the present invention to a waterproof sound transmitting member including a waterproof sound transmitting membrane with a maximum diameter of 3 mm or more, in particular, 5 mm or more, for example, 7 mm to 20 mm. As used herein, the maximum diameter refers to the longest length of a line passing through the center of gravity of the principal surface of the waterproof sound transmitting membrane.

The waterproof sound transmitting member of the present invention can be used as a member attachable to acoustic components in various acoustic devices. The waterproof sound transmitting member of the present invention has a structure suitable for preventing sagging of a waterproof sound transmitting membrane, while ensuring sound transmission. The waterproof sound transmitting member of the present invention is also suitable for reducing a space in a housing required for attachment of a waterproof sound transmitting member. The waterproof sound transmitting member of the present invention can be suitably used particularly for acoustic devices in small electronic devices, such as microphones in cellular phones.

The invention may be embodied in other forms without departing from the spirit or essential characteristics thereof. The embodiments disclosed in this specification are to be considered in all respects as illustrative and not limiting. The scope of the invention is indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are intended to be embraced therein.

What is claimed is:

1. An adhesive structure comprising a waterproof sound transmitting member and a housing,

the waterproof sound transmitting member comprising:
a waterproof sound transmitting membrane that allows sound to pass therethrough and prevents water from passing therethrough, the waterproof sound transmitting membrane having a first surface and a second surface opposite to the first surface; and

a first adhesive sheet and a second adhesive sheet that are disposed on the first surface,

wherein when viewed in a direction perpendicular to the first surface, the first adhesive sheet has a closed frame shape, and the second adhesive sheet is disposed within the frame formed by the first adhesive sheet and is spaced from the first adhesive sheet,

the first adhesive sheet fixes the waterproof sound transmitting membrane and the housing together, and the second adhesive sheet fixes the waterproof sound transmitting membrane and the housing together in a region surrounded by the first adhesive sheet.

2. The adhesive structure according to claim 1, wherein when viewed in the direction perpendicular to the first surface, an area of the second adhesive sheet is not more than one half an area of a region surrounded by an inner edge of the frame formed by the first adhesive sheet.

3. The adhesive structure according to claim 1, wherein no adhesive sheet is disposed on the second surface.

4. The adhesive structure according to claim 1, further comprising a third adhesive sheet disposed on the second surface,

wherein

no other adhesive sheet than the third adhesive sheet is disposed on the second surface, and the third adhesive sheet has the same closed frame shape as the first adhesive sheet.

5. The adhesive structure according to claim 1, wherein the waterproof sound transmitting membrane comprises a porous polytetrafluoroethylene membrane.

6. The adhesive structure according to claim 1, wherein the waterproof sound transmitting membrane has a maximum diameter of 7 mm to 20 mm.

7. The adhesive structure according to claim 2, wherein when viewed in the direction perpendicular to the first surface, the area of the second adhesive sheet is at least one tenth the area of the region surrounded by the inner edge of the frame formed by the first adhesive sheet.

8. The adhesive structure according to claim 1, wherein when viewed in the direction perpendicular to the first surface, a center of gravity of the second adhesive sheet coincides with a center of gravity of a region surrounded by an inner edge of the first adhesive sheet.

9. The adhesive structure according to claim 1, wherein the first adhesive sheet and the second adhesive sheet have the same thickness.

10. The adhesive structure according to claim 1, wherein a region to which the waterproof sound transmitting membrane is exposed is a frame-shaped region between an inner edge of the first adhesive sheet and an outer edge of the second adhesive sheet.

11. The adhesive structure according to claim 1, wherein a material of the waterproof sound transmitting membrane is selected from polymer films made of polymers and porous membranes made from the polymer films.

12. A waterproof sound transmitting member comprising:
a waterproof sound transmitting membrane that allows sound to pass therethrough and prevents water from passing therethrough, the waterproof sound transmitting membrane having a first surface and a second surface opposite to the first surface; and

a first adhesive sheet and a second adhesive sheet that are disposed on the first surface,

wherein when viewed in a direction perpendicular to the first surface, the first adhesive sheet has a closed frame shape, and the second adhesive sheet is disposed within the frame formed by the first adhesive sheet and is spaced from the first adhesive sheet, and

there is no adhesive on a part of the second surface that corresponds to a location of the second adhesive sheet.

13. The waterproof sound transmitting member according to claim 12, wherein no adhesive sheet is disposed on the second surface.

14. The waterproof sound transmitting member according to claim 12, further comprising a third adhesive sheet disposed on the second surface,

wherein

no other adhesive sheet than the third adhesive sheet is disposed on the second surface, and the third adhesive sheet has the same closed frame shape as the first adhesive sheet.