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(54) **BELL MOUTH AND FAN UNIT**

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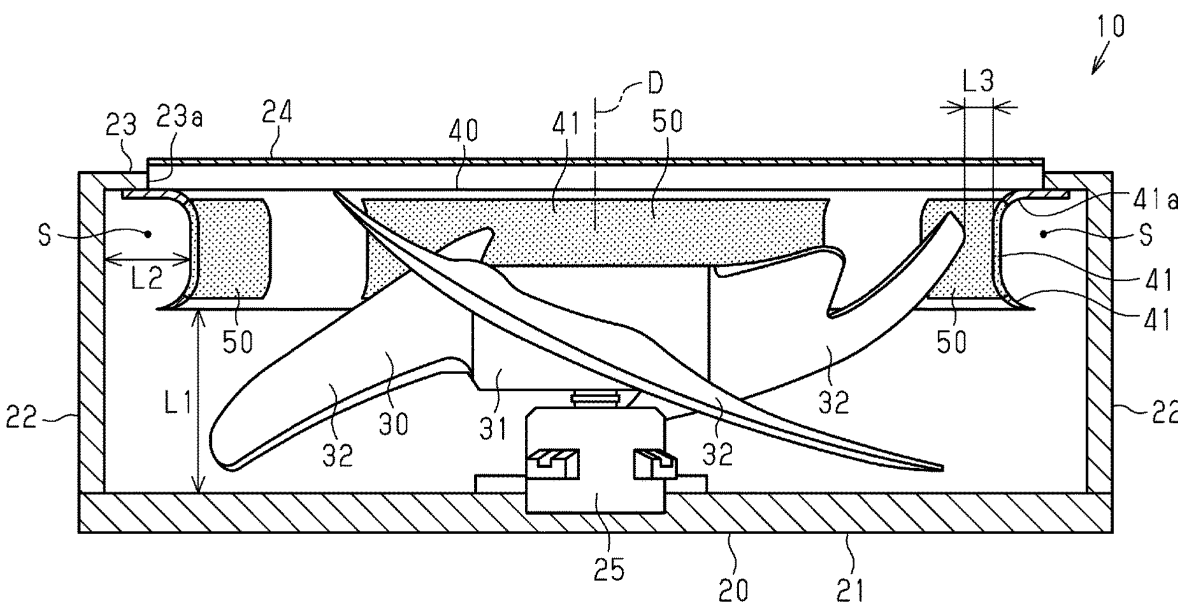
(57) **ABSTRACT**

A bell mouth includes a circumferential wall, and a pressure changing component permeable portion arranged in the circumferential wall at a location where a separated distance from an axial fan is minimal. A fan unit includes the bell mouth, an axial fan, and a case that accommodates the axial fan and the bell mouth. The fan unit has an air layer between the circumferential wall of the bell mouth and the case.



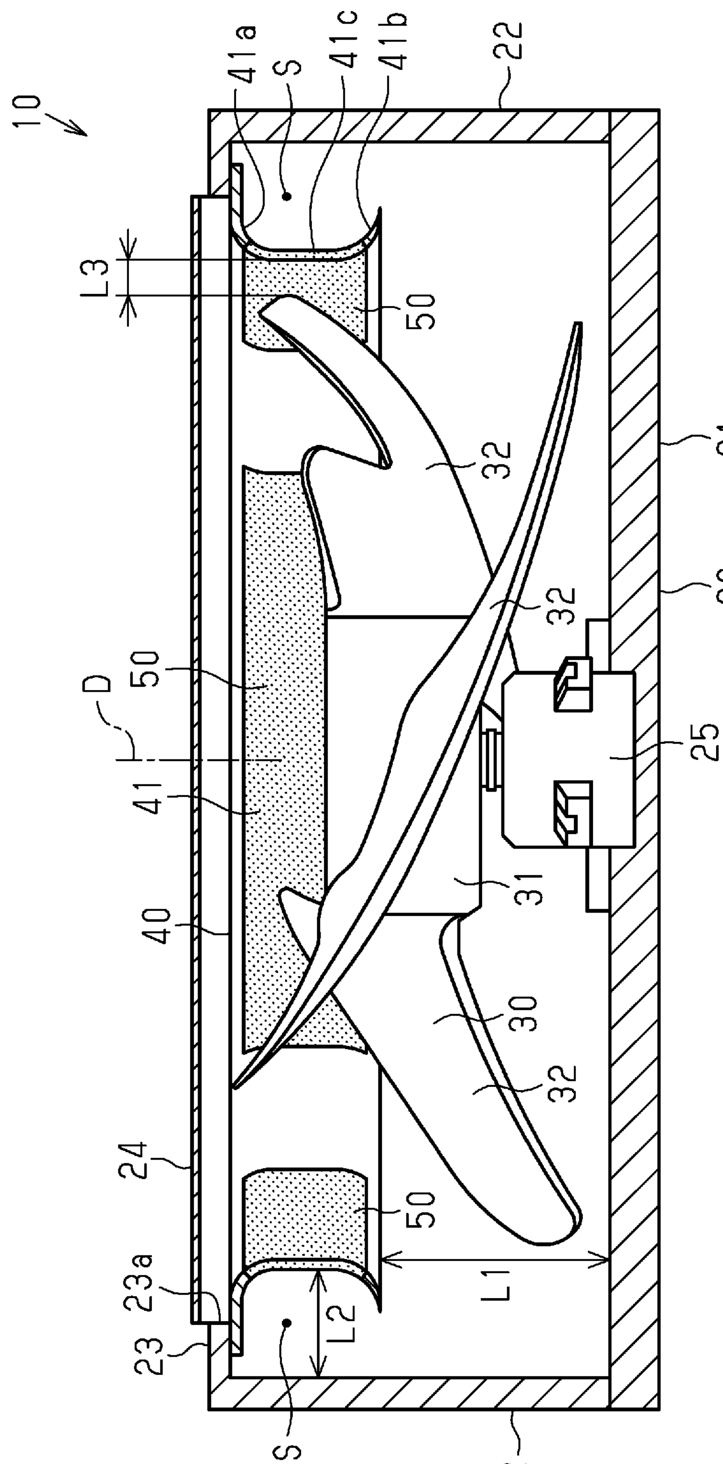



Fig.1

Fig.2

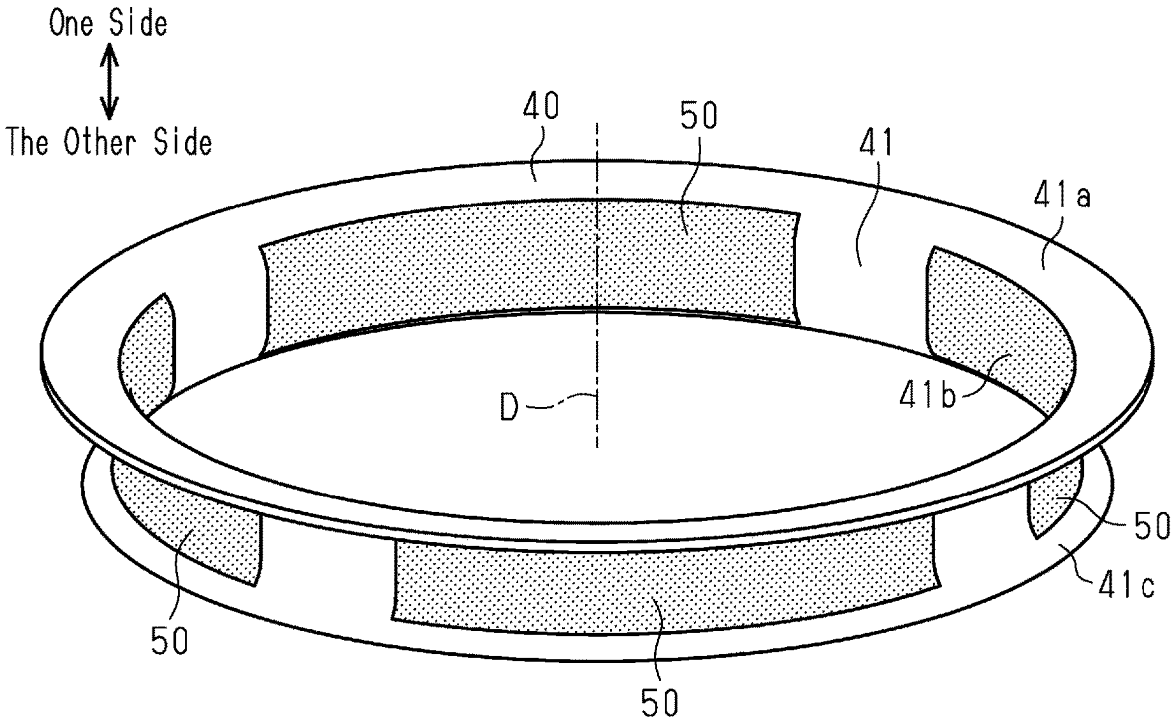

One Side
The Other Side
40
50
41
41a
41b
D
50
41c
50
50

Fig.3

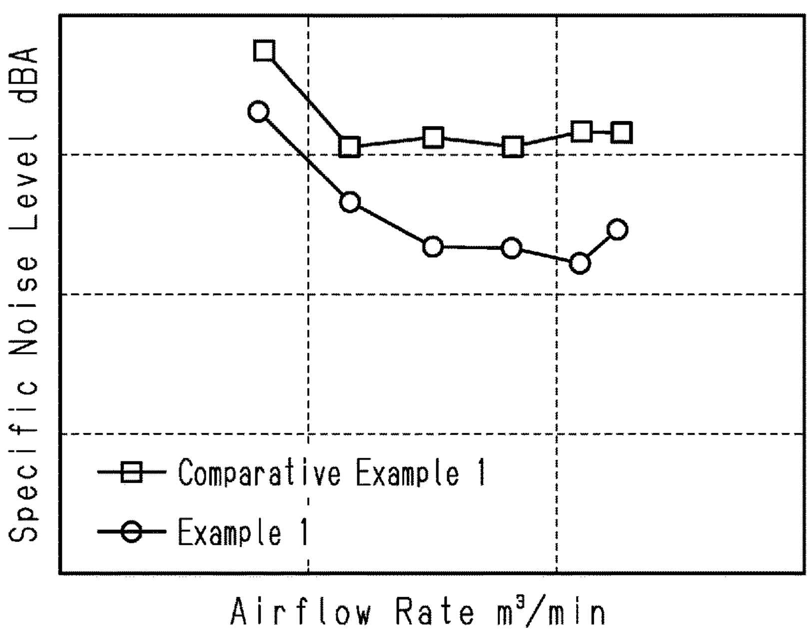

Specific Noise Level dBA
Comparative Example 1
Example 1
Airflow Rate m³/min

Fig.4

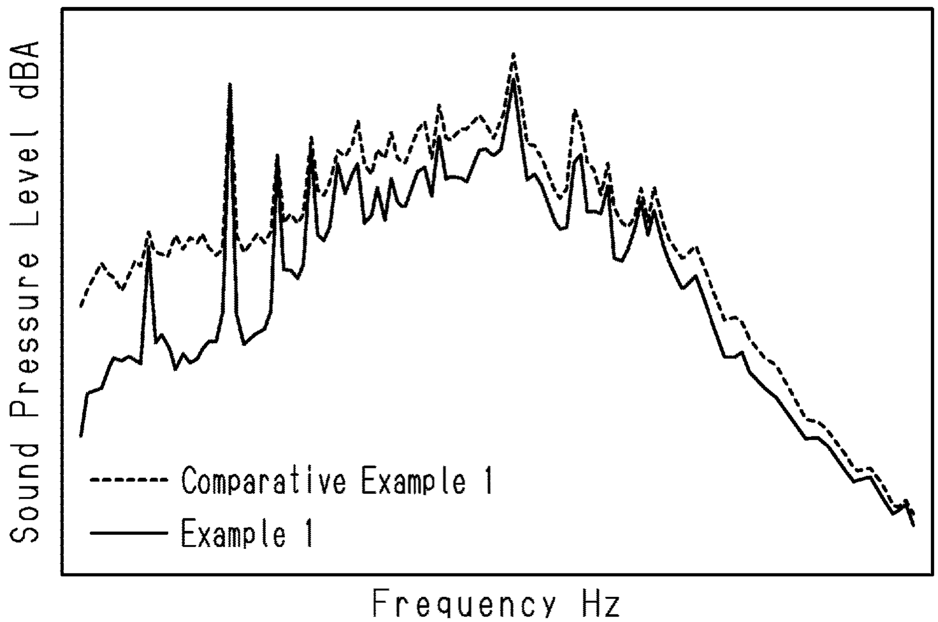
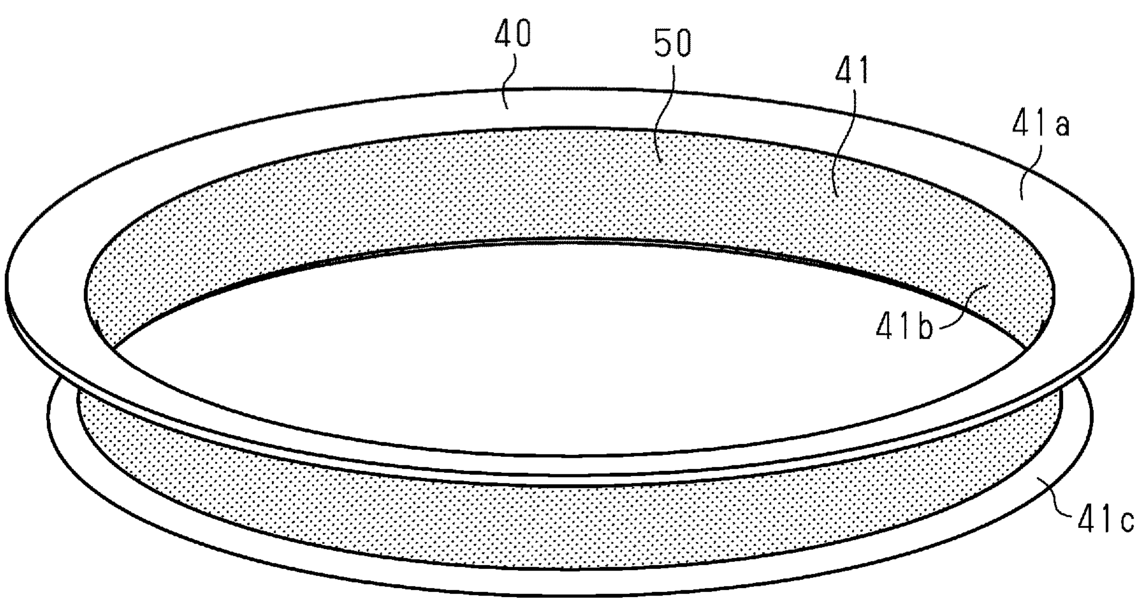

Sound Pressure Level dBA
Comparative Example 1
Example 1
Frequency Hz

Fig.5


40
50
41
41a
41b
41c

# BELL MOUTH AND FAN UNIT

## TECHNICAL FIELD

**[0001]** The present disclosure relates to a bell mouth and a fan unit.

## BACKGROUND ART

**[0002]** Patent Literature 1 describes a known technique related to a fan shroud of an axial fan. Patent Literature 1 describes that the fan shroud is entirely or partly made of a through-pore material such as plastic or sintered aluminum alloy. When the blades of the axial fan approach the fan shroud, the pressure of the flowing air changes in a sudden manner and produces impulsive noise that is absorbed by the through-pore material. This reduces NZ noise, which is blade pitch noise.

## CITATION LIST

### Patent Literature

**[0003]** Patent Literature 1: Microfilm of Japanese Utility Model Application No. 04-68593 (Japanese Laid-Open Utility Model Application No 06-25597)

## SUMMARY OF INVENTION

### Technical Problem

**[0004]** In addition to the NZ noise, it is desired that the bell mouth of the axial fan reduces wind noise generated at the surface of the bell mouth.

### Solution to Problem

**[0005]** A bell mouth that solves the above problem includes a circumferential wall and pressure changing component permeable portions in the circumferential wall at a location where a separated distance from an axial fan is minimal.

**[0006]** With this structure, when the pressure changes in the air passing by the axial fan, the air in the vicinity of the circumferential wall readily passes through the pressure changing component permeable portions. Thus, the change in pressure is reduced. This mitigates surface vortices generated on the circumferential wall and suitably reduces wind noise caused by the surface vortices.

**[0007]** In the above bell mouth, the pressure changing component permeable portions include pores connecting the opposite sides of the circumferential wall in the thickness direction. The pores have an average pore diameter of 1000 μm or less.

**[0008]** When the pressure changes, this structure allows the air in the vicinity of the circumferential wall to pass through the pressure changing component permeable portions, and excessive air does not pass through the pressure changing component permeable portions. This reduces loss in the air that passes through the axial fan.

**[0009]** In the above bell mouth, the pressure changing component permeable portions include pores connecting the opposite sides of the circumferential wall in the thickness direction. The pores have an average pore diameter of 700 μm or less.

**[0010]** This structure allows the air in the vicinity of the circumferential wall to pass through the pressure changing component permeable portions, and further reduces loss in the air that passes through the axial fan.

**[0011]** In the above bell mouth, the pressure changing component permeable portions are arranged at intervals in the circumferential direction of the circumferential wall.

**[0012]** This structure allows for the arrangement of the pressure changing component permeable portions, while maintaining the strength of the bell mouth in a preferred manner.

**[0013]** In the above bell mouth, the thickness of the circumferential wall is 1 mm or greater.

**[0014]** This structure ensures that air passes through the pressure changing component permeable portions over a flow path length. Thus, a function for allowing for the permeable of the air in the vicinity of the circumferential wall through the pressure changing component permeable portions and a function for limiting the permeable of excessive air through the pressure changing component permeable portions are both obtained.

**[0015]** In the above bell mouth, the thickness of the circumferential wall is 10 mm or less.

**[0016]** With this structure, the thickness of the circumferential wall is relatively thin. Thus, the cost for manufacturing the bell mouth is reduced.

**[0017]** A fan unit that solves the above problem includes the axial fan, the bell mouth, and a case, which accommodates the axial fan and the bell mouth. Further, in the fan unit, an air layer extends between the circumferential wall of the bell mouth and the case.

**[0018]** With this structure, air that has passed through the pressure changing component permeable portions is released to the air layer. This readily reduces pressure changes in the pressure changing component permeable portions.

## BRIEF DESCRIPTION OF DRAWINGS

**[0019]** FIG. **1** is a partial cross-sectional view of a fan unit.

**[0020]** FIG. **2** is a perspective view of a bell mouth.

**[0021]** FIG. **3** is a graph showing the comparison result of the characteristics of Example 1 and the characteristics of Comparative Example 1.

**[0022]** FIG. **4** is a graph showing the comparison result of the characteristics of Example 1 and the characteristics of Comparative Example 1.

**[0023]** FIG. **5** is a perspective view of a bell mouth in a modified example.

## DESCRIPTION OF EMBODIMENTS

### Fan Unit

**[0024]** A fan unit **10** will now be described with reference to FIG. **1**.

**[0025]** As shown in FIG. **1**, the fan unit **10** includes a case **20**, an axial fan **30**, and a bell mouth **40**. The case **20** includes a bottom wall **21**, having the form of a rectangular plate, and side walls **22**, each extending from the sides of the bottom wall **21** in the thickness direction of the bottom wall **21**. The case **20** also includes a top wall **23** on the ends of the side walls **22** opposite to the bottom wall **21**. The top wall **23** includes a circular opening **23*a***. A netted outlet grille **24** is attached to the opening **23*a*** in the top wall **23**. An axial fan motor **25** is attached to the bottom wall **21**.

**[0026]** The axial fan **30** and the bell mouth **40** are accommodated in the case **20**.

**[0027]** The axial fan **30** includes a rotary shaft **31** and three blades **32** connected to the rotary shaft **31**. The axial fan **30** is accommodated in the case **20** in a state in which the rotary shaft **31** is connected to the axial fan motor **25**.

**[0028]** The bell mouth **40** is accommodated in the case and attached to the edge of the opening **23***a* in the top wall **23**.

**[0029]** As shown in FIG. **1**, the fan unit **10** is configured so that air drawn through an inlet (not shown) of the case **20** is blown out of the opening **23***a* by the rotation of the blades **32** of the axial fan **30**. The opening **23***a* of the case **20** is also referred to as an outlet.

**[0030]** The fan unit **10** is used as an air blower. Specifically, the fan unit **10** is used as the outdoor unit of an air conditioner for cooling or heating an indoor space such as an office.

Bell Mouth

**[0031]** A bell mouth **40** will now be described with reference to FIGS. **1** and **2**.

**[0032]** The bell mouth **40** includes a circumferential wall **41** that is annular in plan view. The circumferential wall **41** includes an outlet portion **41***a*, a tubular portion **41***b*, and an inlet portion **41***c*.

**[0033]** As shown in FIG. **2**, the outlet portion **41***a* is located at the end of the bell mouth **40** located at one side of the bell mouth **40** in a direction parallel to the axis D of the bell mouth **40**. The outlet portion **41***a* is curved so that the inner diameter decreases toward the end at the other side of the bell mouth **40** in the direction parallel to the axis D of the bell mouth **40**.

**[0034]** The tubular portion **41***b* extends continuously from the end of the outlet portion **41***a* at the other side of the outlet portion **41***a* toward the other side of the bell mouth **40**. The inner diameter of the tubular portion **41***b* is fixed. The axis of the tubular portion **41***b* coincides with the axis D of the bell mouth **40**.

**[0035]** The inlet portion **41***c* extends continuously from the end of the tubular portion **41***b* at the other side. The inlet portion **41***c* is curved so that the inner diameter increases from the end of the tubular portion **41***b* at the other side of the tubular portion **41***b* toward the other side of the bell mouth **40**.

**[0036]** The thickness of the circumferential wall **41** is not particularly limited. For example, the thickness is preferably 1 mm or greater, and more preferably, 2 mm or greater. Further, the thickness is preferably 10 mm or less, and more preferably, 5 mm or less.

**[0037]** The material of the circumferential wall **41** is not particularly limited, and a known material of the bell mouth **40** may be used. Examples of the known material of the bell mouth **40** include plastic, ceramic, metal, and the like. In particular, resin is preferred since the weight can be reduced while maintaining strength.

**[0038]** As shown in FIGS. **1** and **2**, the circumferential wall **41** of the bell mouth **40** includes four pressure changing component permeable portions **50** at predetermined intervals in the circumferential direction. In FIG. **1**, the cross section of each pressure changing component permeable portion **50** is shaded for convenience. The pressure changing component permeable portion **50** will be described in detail later.

**[0039]** As shown in FIG. **1**, when the bell mouth **40** is accommodated in the case **20**, a predetermined gap L**1** is provided parallel to the axis D of the bell mouth **40** between the inlet portion **41***c* of the bell mouth **40** and the bottom wall **21** of the case **20**.

**[0040]** As shown in FIG. **1**, in a direction orthogonal to the axis D, a predetermined gap is provided between the outer circumference of the bell mouth **40** and the case **20**. In other words, the fan unit **10** includes open space extending between the outer circumference of the bell mouth **40** and the side walls **22** of the case **20**. The open space functions as an air layer S. The air layer S is not particularly limited in size. However, a maximum distance L**2** from the side wall **22** of the case **20** to the circumferential wall **41** is preferably 1 cm or greater, and more preferably, 3 cm or greater. In FIG. **1**, the maximum distance L**2** from the side wall **22** of the case **20** to the circumferential wall **41** indicates the distance from the side wall **22** of the case **20** to the tubular portion **41***b* of the bell mouth **40**.

Pressure Changing Component Permeable Portion

**[0041]** The pressure changing component permeable portion **50** will now be described with reference to FIG. **2**.

**[0042]** Four pressure changing component permeable portions **50** are arranged in the circumferential wall **41** of the bell mouth **40** at predetermined intervals in the circumferential direction. The pressure changing component permeable portions **50** are arranged at equal intervals. The pressure changing component permeable portions **50** are arranged in the tubular portion **41***b* of the circumferential wall **41**, and extend over part of the outlet portion **41***a* and part of the inlet portion **41***c*.

**[0043]** Each pressure changing component permeable portion **50** is flush along the surface of the tubular portion **41***b*, the outlet portion **41***a*, and the inlet portion **41***c* of the circumferential wall **41**. The thickness of the pressure changing component permeable portion **50** is substantially the same as the thickness of parts of the circumferential wall **41** other than the pressure changing component permeable portion **50**.

**[0044]** The pressure changing component permeable portion **50** is formed by a porous body. The porous body extends through the circumferential wall **41** in the thickness direction. The porous body includes open pores connected to the outside. The open pores connect the opposite sides of the circumferential wall **41** in the thickness direction. The average pore diameter of the open pores is not particularly limited. However, the average pore diameter is preferably 1000 μm or less, and more preferably, 700 μm or less.

**[0045]** The method for measuring the average pore diameter is not particularly limited. For example, the average pore diameter can be measured through, for example, a gas adsorption method also referred to as a BET method.

**[0046]** The material of the pressure changing component permeable portion **50** is not particularly limited, and the material of a known porous body may be used. Examples of the known porous body material include plastic, ceramic, metal, and the like. Resin foam may be used as the plastic. A porous sintered body may be used as the ceramic or the metal. Further, a netted body also referred to as a mesh can be used as the metal. In particular, the porous sintered body is preferred because the average pore diameter can be readily adjusted.

**[0047]** As shown in FIG. **1**, the separated distance L**3** of the circumferential wall **41** of the bell mouth **40** from the axial fan **30** is minimal at the tubular portion **41***b*. The separated distance L**3** from the axial fan **30** indicates the distance between the blades **32** of the axial fan **30** and the circumferential wall **41** of the bell mouth **40** in a direction orthogonal to the axial direction of the axial fan **30**. The pressure changing component permeable portions **50** are arranged in the tubular portion **41***b* of the bell mouth **40**. Thus, the pressure changing component permeable portions **50** are provided in the circumferential wall **41** at a location where the separated distance L**3** from the axial fan **30** is minimal. In FIG. **1**, the axial direction of the axial fan **30** corresponds to the direction in which the axis D of the bell mouth **40** extends.

**[0048]** The arrangement of the pressure changing component permeable portions **50** in the circumferential wall **41** of the bell mouth **40** is not particularly limited. For example, the pressure changing component permeable portions **50** are formed having predetermined shapes. Further, the bell mouth **40** is formed with openings in the circumferential wall **41** for fitting the pressure changing component permeable portions **50**. Then, the pressure changing component permeable portions **50** are fitted into the openings of the circumferential wall **41** of the bell mouth **40**. This arranges the pressure changing component permeable portions **50** in the circumferential wall **41** of the bell mouth **40**. Further, the pressure changing component permeable portions **50** may be bonded to the circumferential wall **41** of the bell mouth **40** with a known adhesive.

**[0049]** FIG. **3** is a graph illustrating the comparison result of the characteristics of Example 1, which is the embodiment, and the characteristics of Comparative Example 1. Comparative Example 1 is a bell mouth that does not include the pressure changing component permeable portions **50**. The bell mouth **40** of Example 1 includes the pressure changing component permeable portions **50** shown in FIG. **2**. The pressure changing component permeable portions **50** are formed by a porous sintered body having an average pore diameter of 100 μm.

**[0050]** FIG. **3** shows the magnitude of the airflow noise with respect to the airflow rate at a bell mouth surface. As shown in FIG. **3**, in the bell mouth **40** of Example 1, the airflow noise was reduced in all of the measured airflow rate ranges.

**[0051]** FIG. **4** is a graph illustrating the comparison result of the characteristics of Example 1 and the characteristics of Comparative Example 1.

**[0052]** FIG. **4** shows the magnitude of the airflow noise with respect to frequency. In FIG. **4**, the peaks of a sound pressure level are caused by NZ noise, and parts other than the peaks are caused by wind noise at the surface of the bell mouth.

**[0053]** As shown in FIG. **4**, the sound pressure level of the bell mouth **40** of Example 1 was lower in all frequency ranges than Comparative Example 1. In addition, there were no significant differences in the heights of the peaks caused by the NZ noise between the bell mouth of Comparative Example 1 and the bell mouth **40** of Example 1. Thus, the bell mouth **40** of Example 1 reduced the wind noise at the surface of the bell mouth **40** in a preferred manner, but had a small NZ noise reducing effect.

Operation and Advantages

**[0054]** The operation of the present embodiment will now be described.

**[0055]** The bell mouth **40** of the present embodiment includes the pressure changing component permeable portions **50** in the circumferential wall **41** at a location where the separated distance L**3** from the axial fan **30** is minimal. Thus, when the pressure changes in the air passing by the axial fan **30**, the air readily passes through the pressure changing component permeable portions **50**. In other words, when the pressure of air changes, the air can be released quickly through the pressure changing component permeable portions **50**. This limits pressure changes in the vicinity of the circumferential wall **41**, thereby mitigating surface vortices generated at the circumferential wall **41**.

**[0056]** Further, the fan unit **10** of the present embodiment includes the air layer S between the outer circumference of the bell mouth **40** and the side walls **22** of the case **20**. This allows the air passing through the pressure changing component permeable portions **50** to be readily released into the air layer S. Thus, surface vortices generated at the circumferential wall **41** of the bell mouth **40** are further efficiently mitigated.

**[0057]** The present embodiment has the following advantages.

**[0058]** (1) The bell mouth **40** of the present embodiment includes the pressure changing component permeable portions **50** in the circumferential wall **41** at a location where the separated distance L**3** from the axial fan **30** is minimal.

**[0059]** With this structure, when the pressure changes in the air passing by the axial fan **30**, the air in the vicinity of the circumferential wall **41** readily passes through the pressure changing component permeable portions **50**. Thus, the change in pressure is reduced. This mitigates surface vortices generated on the circumferential wall **41** and suitably reduces wind noise caused by the surface vortices.

**[0060]** (2) The pressure changing component permeable portions **50** include pores connecting the opposite sides of the circumferential wall **41** in the thickness direction. The pores have an average pore diameter of 1000 μm or less.

**[0061]** When the pressure changes, this structure allows the air in the vicinity of the circumferential wall **41** to pass through the pressure changing component permeable portions **50**, and excessive air does not pass through the pressure changing component permeable portions **50**. This reduces loss in the air that passes through the axial fan **30** and is blown out from the outlet.

**[0062]** (3) The pressure changing component permeable portions **50** include pores connecting the opposite sides of the circumferential wall **41** in the thickness direction. The pores have an average pore diameter of 700 μm or less.

**[0063]** This structure allows the air in the vicinity of the circumferential wall **41** to pass through the pressure changing component permeable portions **50**, and further reduces loss in the air that passes through the axial fan **30** and is blown out from the outlet.

**[0064]** (4) The pressure changing component permeable portions **50** are arranged at intervals in the circumferential direction of the circumferential wall **41**.

**[0065]** This structure allows for the arrangement of the pressure changing component permeable portions **50**, while maintaining the strength of the bell mouth **40** in a preferred manner.

**[0066]** (5) The thickness of the circumferential wall **41** is 1 mm or greater.

**[0067]** This structure ensures that air passes through the pressure changing component permeable portions **50** over a flow path length. Thus, a function for allowing for the permeable of the air in the vicinity of the circumferential wall **41** through the pressure changing component permeable portions **50** and a function for limiting the permeable of excessive air through the pressure changing component permeable portions **50** are both obtained.

**[0068]** (6) The thickness of the circumferential wall **41** is 10 mm or less.

**[0069]** With this structure, the thickness of the circumferential wall **41** is relatively thin. Thus, the cost for manufacturing the bell mouth **40** is reduced. In a fan shroud of the related art, NZ noise is reduced by absorbing impulsive noise of the flowing air with a through-pore material. Thus, the circumferential wall needs to be thick. In contrast, the bell mouth **40** of the present embodiment releases air, when the pressure changes, through the pressure changing component permeable portions **50**. This allows the thickness of the circumferential wall to be reduced.

**[0070]** (7) The fan unit **10** includes the axial fan **30**, the bell mouth **40**, and the case **20**, which accommodates the axial fan **30** and the bell mouth **40**. Further, the air layer S extends between the circumferential wall **41** of the bell mouth **40** and the case **20**.

**[0071]** With this structure, air that has passed through the pressure changing component permeable portions **50** is released to the air layer S. This readily reduces pressure changes in the pressure changing component permeable portions **50**.

Modifications

**[0072]** In addition to the above embodiment, the bell mouth **40** and the fan unit **10** of the present disclosure may be in the form of, for example, the modifications described below and a combination of at least two modifications that do not contradict each other.

**[0073]** In the present embodiment, the four pressure changing component permeable portions **50** are arranged in the circumferential wall **41** of the bell mouth **40** at equal intervals in the circumferential direction. However, this structure may be modified. The quantity of the pressure changing component permeable portions **50** may be three or less or may be five or greater. The pressure changing component permeable portions **50** may be arranged at random intervals.

**[0074]** As shown in FIG. **5**, the pressure changing component permeable portion **50** may be arranged over the entire circumferential wall **41** of the bell mouth **40**. Further, the circumferential wall **41** of the bell mouth **40** may be entirely formed by the pressure changing component permeable portion **50**.

**[0075]** In the present embodiment, the pressure changing component permeable portions **50** are arranged in the tubular portion **41***b* of the circumferential wall **41**, and extend over part of the outlet portion **41***a* and part of the inlet portion **41***c*. However, this structure may be modified. The pressure changing component permeable portions **50** may be arranged in only the tubular portion **41***b* of the circumferential wall **41**.

**[0076]** In the present embodiment, the circumferential wall **41** of the bell mouth **40** includes the outlet portion **41***a*, the tubular portion **41***b*, and the inlet portion **41***c* but is not limited to such a structure. The circumferential wall **41** of the bell mouth **40** does not need to include the tubular portion **41***b*. In the circumferential wall **41** of the bell mouth **40**, the outlet portion **41***a* and the inlet portion **41***c* may be formed continuously.

**[0077]** In the present embodiment, the porous body forming the pressure changing component permeable portions **50** is not limited to resin foam or a porous sintered body. The pressure changing component permeable portions **50** may each be a porous body including multiple through-holes that extend in one direction. For example, the porous body including multiple through-holes that extend in one direction can be formed by repeatedly inserting a needle member into a solid plastic body in one direction.

**[0078]** While the bell mouth **40** and the fan unit **10** according to the embodiment have been described, it will be understood that various changes in form and detail may be made without departing from the spirit and scope of the bell mouth **40** and the fan unit **10** described in the claims.

**1**. A bell mouth, comprising:

a circumferential wall; and

a pressure changing component permeable portion arranged in the circumferential wall at a location where a separated distance from an axial fan is minimal.

**2**. The bell mouth according to claim **1**, wherein

the pressure changing component permeable portion includes pores connecting opposite sides of the circumferential wall in a thickness direction, and

the pores have an average pore diameter of 1000 μm or less.

**3**. The bell mouth according to claim **1**, wherein

the pressure changing component permeable portion includes pores connecting opposite sides of the circumferential wall in a thickness direction, and

the pores have an average pore diameter of 700 μm or less.

**4**. The bell mouth according to claim **1**, wherein

the pressure changing component permeable portion is one of multiple pressure changing component permeable portions arranged at intervals in a circumferential direction of the circumferential wall.

**5**. The bell mouth according to claim **1**, wherein

the circumferential wall has a thickness of 1 mm or greater.

**6**. The bell mouth according to claim **1**, wherein

the circumferential wall has a thickness of 10 mm or less.

**7**. A fan unit including the bell mouth according to claim **1**, the fan unit further comprising:

an axial fan; and

a case that accommodates the axial fan and the bell mouth,

the fan unit having an air layer between the circumferential wall of the bell mouth and the case.

**8**. The bell mouth according to claim **4**, wherein

the circumferential wall has a thickness of 1 mm or greater.

**9**. The bell mouth according to claim **4**, wherein

the circumferential wall has a thickness of 10 mm or less.

**10**. A fan unit including the bell mouth according to claim **4**, the fan unit further comprising:

an axial fan; and

a case that accommodates the axial fan and the bell mouth, the fan unit having an air layer between the circumferential wall of the bell mouth and the case.

**11**. The bell mouth according to claim **5**, wherein

the circumferential wall has a thickness of 10 mm or less.

**12**. A fan unit including the bell mouth according to claim **5**, the fan unit further comprising:

an axial fan; and

a case that accommodates the axial fan and the bell mouth,

the fan unit having an air layer between the circumferential wall of the bell mouth and the case.

**13**. A fan unit including the bell mouth according to claim **6**, the fan unit further comprising:

an axial fan; and

a case that accommodates the axial fan and the bell mouth,

the fan unit having an air layer between the circumferential wall of the bell mouth and the case.

* * * * *