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(71) Applicant: **Mitsubishi Heavy Industries, Ltd.
Tokyo (JP)**

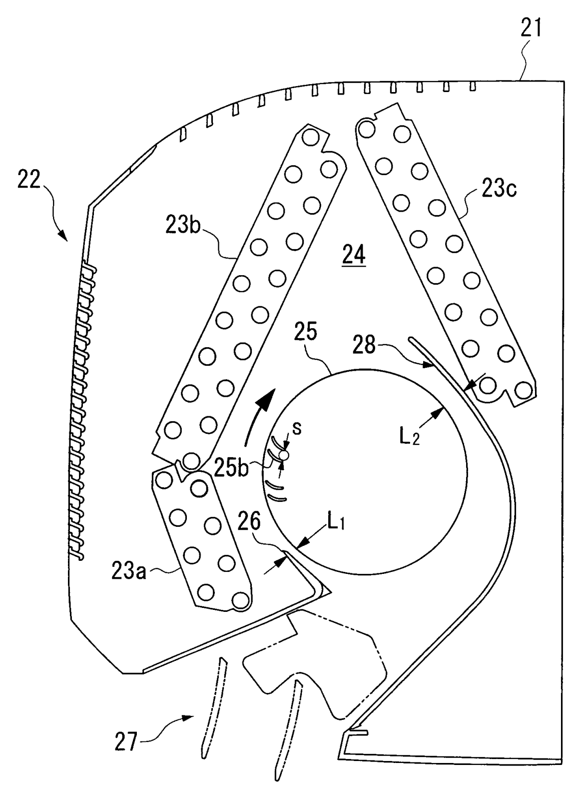
(72) Inventors:
- **Suzuki, Kazuhiro, c/o Mitsubishi Heavy Ind.,Ltd. Nishi-Kasugai-gun, Aichi-ken (JP)**
- **Izumi, Hajime, Mitsubishi Heavy Ind., Ltd. Takasago-shi, Hyogo-ken (JP)**
- **Suenaga, Kiyoshi, c/o Mitsubishi Heavy Ind., Ltd. Takasago-shi, Hyogo-ken (JP)**
- **Tominaga, Tetsuo, c/o Mitsubishi Heavy Ind., Ltd. Takasago-shi, Hyogo-ken (JP)**

(74) Representative: **Henkel, Feiler, Hänzel
Möhlstrasse 37
81675 München (DE)**

(54) **Air conditioner and indoor unit therefor**

(57) An air conditioner provides an indoor unit (20) whose internal parts are optimally designed in dimensions and arrangement to satisfy prescribed relationships in order to actualize a noticeable reduction in noise without unwanted enlargement of dimensions. With respect to the distances L_1 and L_2 ranging from the tangential fan (25) to the stabilizer (26) and casing (28) respectively, the indoor unit is designed to satisfy at least one ofthe three relationships $L_1 < L_2$, $1.0s \leqq L_1 \leqq 1.3s$, and $1.2s \leqq L_2 \leqq 2.0s$. With respect to the distance L between the tangential fan and its proximate indoor heat exchanger (23a), the relationship of $2.5d \leqq L \leqq 3.5d$ is established. With respect to the distances L_1 and L_2 ranging from the tangential fan to the adjoining indoor heat exchangers (23a, 23b) respectively, the relationship of $1.5L_1 \leqq L_2 \leqq 3.5L_1$ is established.

FIG. 2



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] This invention relates to air conditioners that cool or warm the air to condition room environments as demanded, and particularly to indoor units of air conditioners.

Description of the Related Art

[0002] Generally, air conditioners have been widely used and installed in many houses to adjust or condition the room air in temperature or humidity. A typical example of an air conditioner installed in a typical house is composed of an indoor unit and an outdoor unit. FIG. 10 shows a mechanical structure of the indoor unit, an internal section of which is observed from the lateral side. Herein, reference numeral 1 designates a body or casing of the indoor unit; reference numeral 2 designates an air inlet surface having numerous slits; reference numerals 3a, 3b, and 3c designate indoor heat exchangers; reference numeral 4 designates an air duct; reference numeral 5 designates a tangential fan; reference numeral 6 designates a stabilizer; and reference numeral 7 designates an air outlet.

[0003] Next, the operation of the indoor unit will be described. When the tangential fan 5 is driven, negative pressure or depression occurs in the air duct 4 at its upstream side, so that the room air is inhaled into the body 1 from the air inlet surface 2. While the air passes through the heat exchangers 3a, 3b, and 3c, it is cooled or warmed so that the cooled or warmed air flows into the air duct 4. Due to the exhausting action of the tangential fan 5, the cooled or warmed air flowing into the air duct 4 is forced to be blown out into the room from the air outlet 7.

[0004] Next, a detailed description will be given with respect to the exhausting action of the tangential fan 5, which cooperates with the stabilizer 6 arranged proximately thereto. When the tangential fan 5 rotates in the direction of the arrow in FIG. 10, vortex or eddy flow (or circulating flow) is caused to occur inside of the tangential fan 5 due to the action of the stabilizer 6. Due to the effect of the vortex flow, the air in the air duct 4 is drawn into the inside of the tangential fan 5 and is then exhausted towards the air outlet 7.

[0005] The conventional air conditioner using the aforementioned indoor unit suffers from various problems, which will be described below.

[0006] In order to improve the aerodynamic performance and to increase the exhausting force for exhausting air from the air outlet 7, the indoor unit provides two narrow areas (or small gaps) in the periphery of the tangential fan 5. One is provided between the tangential fan 5 and the stabilizer 6, and the other is provided between the tangential fan 5 and a casing 8, which is a part of an inwardly bent portion of the body frame and is arranged opposite to the stabilizer 6 via the tangential fan 5.

[0007] By the provision of the two narrow areas, it is possible to noticeably improve the exhausting effect of the tangential fan 5. Herein, the air must pass through the narrow areas around the tangential fan 5 at a high speed, and therefore, this may cause relatively large amounts of noise.

[0008] When the indoor air flows into the air duct 4 under the effect of the negative pressure, it encounters refrigerant pipes of the indoor heat exchangers 3a, 3b, and 3c respectively, so that it is varied in flow direction, intensity, and speed. That is, flows of the indoor air transmitted through the indoor heat exchangers may have different velocities, which depends upon the transmitted positions of the indoor heat exchangers. Therefore, it is possible to estimate various distributions of velocities with respect to the flows of the indoor air transmitted through the indoor heat exchangers, respectively. In particular, the flow of the indoor air transmitted through the indoor heat exchanger 3a, which is arranged proximately to the tangential fan 5, becomes extreme in the velocity distribution. The aforementioned flow of the indoor air is continuously cut by the blades of the tangential fan 5 that is rotating. This causes a particular kind of noise called 'Nz' sound in the indoor unit 1.

[0009] Normally, it may be possible to prevent the Nz sound from occurring by arranging the indoor heat exchanger 3a to be further apart from the tangential fan 5. However, such a 'separated' arrangement of the indoor heat exchanger 3a to be separated from the tangential fan 5 causes an increase of the size of the indoor unit 1. This is unfavorable because consumers of home electrical appliances may prefer more compact indoor units of air conditioners these days.

SUMMARY OF THE INVENTION

[0010] It is an object of the invention to provide an air conditioner that is capable of reducing noise of an indoor unit in its operation mode while maintaining good aerodynamic performance in circulation of air.

[0011] It is another object of the invention to provide an air conditioner whose indoor unit exhibits noticeable reduction in the noise without increasing its size.

[0012] An air conditioner of this invention is basically composed of an outdoor unit and an indoor unit. The outdoor unit has an outdoor heat exchanger for performing heat exchanging between outdoor air and refrigerant that is cooled or warmed by indoor air. The indoor unit contains indoor heat exchangers for performing heat exchanging between the indoor air and the refrigerant that is cooled or warmed by the outdoor air, a tangential fan forcing the indoor air to flow through the indoor heat exchangers, and a stabilizer that is arranged in proximity to the tangential fan.

[0013] In a first aspect of this invention, dimensions of the indoor unit are determined to satisfy at least one of the three relationships as follows:

$$L_1 < L_2$$

$$1.0s \leqq L_1 \leqq 1.3s$$

$$1.2s \leqq L_2 \leqq 2.0s$$

where 'L_1' denotes a distance between the circumferential surface of the tangential fan and the stabilizer, 'L_2' denotes a distance between the circumferential surface of the tangential fan and a casing that is arranged opposite to the stabilizer via the tangential fan, and 's' denotes a minimal gap between adjoining blades of the tangential fan.

[0014] In a second aspect of this invention, dimensions of the indoor unit are determined to satisfy the relationship $2.5d \leqq L$, where 'L' denotes a distance between the circumferential surface of the tangential fan and its proximate indoor heat exchanger, and 'd' denotes a flow diameter of a refrigerant circulation pipe installed in the indoor heat exchanger. In addition, it is possible to introduce another relationship $L \leqq 3.5d$.

[0015] In a third aspect of this invention, dimensions of the indoor unit are determined to satisfy the relationship $1.5L_1 \leqq L_2$, where 'L_1' denotes a distance between the circumferential surface of the tangential fan and its opposite surface of the proximate indoor heat exchanger, and 'L_2' denotes a distance between the circumferential surface of the tangential fan and the boundary between the proximate indoor heat exchanger and its adjoining indoor heat exchanger. In addition, it is possible to introduce another relationship $L_2 \leqq 3.5L_1$.

[0016] By employing the aforementioned relationships for dimensions and arrangement of internal parts (particularly, the indoor heat exchangers and tangential fan) of the indoor unit of the air conditioner, it is possible to noticeably reduce noise during the operation of the indoor unit without requiring undesirable increase in unit size.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] These and other objects, aspects, and embodiments of the present invention will be described in more detail with reference to the following drawing figures, in which:

FIG. 1 is a perspective view partly in section showing an indoor unit and an outdoor unit for an air conditioner in accordance with a first embodiment of the invention;

FIG. 2 is a lateral sectional view of the indoor unit of the air conditioner shown in FIG. 1;

FIG. 3 is a graph showing variations in noise level, measured in the indoor unit whose wind power is fixed, against dimensionless values of L_1/s;

FIG. 4 is a graph showing variations in noise level, measured in the indoor unit whose wind power is fixed, against dimensionless values of L_2/s;

FIG. 5 is a lateral sectional view of an indoor unit of an air conditioner in accordance with a second embodiment of the invention;

FIG. 6A shows an example of a refrigerant circulation pipe surrounded by radiator fins partially deformed in an indoor heat exchanger installed in the indoor unit;

FIG. 6B shows another example of a refrigerant circulation pipe surrounded by radiator fins in the indoor heat exchanger installed in the indoor unit;

FIG. 7 is a graph showing variations in noise level that measured in the indoor unit against dimensionless values of L/d;

FIG. 8 is a lateral sectional view of an indoor unit of an air conditioner in accordance with a third embodiment of the invention;

FIG. 9 is a graph showing variations of the noise level that is measured in the indoor unit against dimensionless values of L_2/L_1; and

FIG. 10 is a lateral sectional view showing an internal mechanical structure of an indoor unit of a conventional air conditioner.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0018] This invention will be described in further detail by way of examples with reference to the accompanying drawings.

First Embodiment

[0019] With reference to Figures 1 to 4, an air conditioner and its indoor unit will be described in accordance with a first embodiment of the invention. FIG. 1 shows an outline layout and construction of the air conditioner of the first embodiment. The air conditioner is basically composed of two units, namely an outdoor unit 10 and an indoor unit 20, between which refrigerant circulates via a refrigerant pipe 30. The outdoor unit 10 is composed of an outdoor heat exchanger 11, a compressor 12, and a propeller fan. The outside heat exchanger 11 performs heat exchanging between the outdoor air and the refrigerant that is cooled or warmed by the indoor air. The compressor 12 sends the refrigerant to the outdoor heat exchanger 11 or indoor heat exchangers, which will be described later. The propeller fan 13 forces the outdoor air to flow into the outdoor heat exchanger 11.

[0020] The indoor unit 20 is composed of indoor heat exchangers 23a, 23b, and 23c, a tangential fan 25, and a stabilizer 26. The indoor heat exchangers 23a, 23b, and 23c perform heat exchanging between the indoor air and the refrigerant that is cooled or warmed by the outdoor air. The tangential fan 25 rotates to cause movement or flow of the indoor air through the indoor heat exchangers 23a, 23b, and 23c. The stabilizer 26 is arranged proximately to the tangential fan 25 to produce an exhausting force for the indoor air.

[0021] FIG. 2 shows an internal mechanical structure of the indoor unit 20 in detail. In addition to the aforementioned parts, namely, the heat exchangers 23a, 23b, and 23c, the tangential fan 25, and the stabilizer 26, the indoor unit 20 also contains a body or casing 21, an air inlet surface 22, an air duct 24, and an air outlet 27.

[0022] The air inlet surface 22 covers the front side and upper side of the body 21 of the indoor unit 20. The air inlet surface 22 has numerous slits that may substantially block the indoor heat exchangers 23a, 23b, and 23c from view and that ensures air inflow in an effective manner.

[0023] The indoor heat exchangers 23a, 23b, and 23c are arranged in proximity to the front side and upper side of the body 21 of the indoor unit 20. That is, they are arranged to substantially encompass the tangential fan 25 with appropriate gaps therebetween. The present embodiment uses three indoor heat exchangers; however, the number and arrangement of the indoor heat exchangers may vary greatly depending upon the size and type of the indoor unit. Therefore, it can be said that the number and arrangement of the indoor heat exchangers is not a main factor in this invention.

[0024] The air duct 24 provides air flows between the indoor heat exchangers 23a, 23b, and 23c and the tangential fan 25 respectively, and it is defined by the body 21 and a casing 28, which corresponds to a part of an inwardly bent portion of the body frame.

[0025] Both ends of the tangential fan 25 are defined by circular disks 25a, the center of which is pivotally supported by a shaft and the like. Between the circular disks 25a, the prescribed number of blades 25b are arranged at equal spacing therebetween in the circumferential direction of the tangential fan 25. A drive motor (not shown) drives the tangential fan 25 to rotate in the direction of the arrow shown in FIG. 2.

[0026] The stabilizer 26 is 'horizontally' elongated to have substantially the same length as the tangential fan 25. That is, the stabilizer 26 is arranged just above the air outlet 27 and is arranged in parallel to and in proximity to the tangential fan 25.

[0027] Next, descriptions will be given with respect to operations of the aforementioned air conditioner at its warming drive mode and cooling drive mode respectively.

[0028] In the warming drive mode, the refrigerant is compressed by the compressor 12 to produce high temperature and high pressure 'gaseous' refrigerant, which is sent to the indoor unit 20 via a refrigerant pipe 30. Therefore, the gaseous refrigerant circulates through the indoor heat exchangers 23a, 23b, and 23c. In the indoor unit 20, the heat of the high temperature and high pressure gaseous refrigerant that passes through the indoor heat exchangers 23a, 23b, and 23c is transferred to the indoor air that is input due to the rotation of the tangential fan 25. Therefore, the warmed air will be supplied into the room by the indoor unit 20.

[0029] The high temperature and high pressure gaseous refrigerant whose heat may be exhausted in the indoor air is subjected to condensation and liquefaction by the indoor heat exchangers 23a, 23b, and 23c, so that it is converted to high temperature and high pressure 'liquid' refrigerant. The high temperature and high pressure liquid refrigerant is sent back to the outdoor unit 10 via the refrigerant pipe 30, wherein it passes through an expansion valve (not shown). While passing through the expansion valve, it is converted to low temperature and low pressure liquid refrigerant, which is forwarded to the outdoor heat exchanger 11. In the outdoor unit 10, the low temperature and low pressure liquid refrigerant passing through the outdoor heat exchanger 11 removes the heat from the outdoor air, which is input due to the rotation of the propeller fan 13. Thus, it is subjected to evaporation and gasification, and is converted to low temperature and low pressure 'gaseous' refrigerant. The low temperature and low pressure gaseous refrigerant is again sent to the compressor 12. Thus, the aforementioned processes are repeated.

[0030] In the cooling drive mode, the refrigerant inversely flows through the refrigerant pipe 30. That is, the high temperature and high pressure gaseous refrigerant that is compressed by the compressor 12 is sent to the outdoor heat exchanger 11 via the refrigerant pipe 30. The heat of the high temperature and high pressure gaseous refrigerant is transferred to the outdoor air, so that the gaseous refrigerant is subjected to condensation and liquefaction, and is converted to high temperature and high pressure liquid refrigerant, which is supplied to the expansion valve in the outdoor unit 10. While passing through the expansion valve, it is converted to low temperature and low pressure liquid refrigerant, which is sent to the indoor unit 20 via the refrigerant pipe 30. Therefore, the low temperature and low pressure liquid refrigerant sequentially passes through the indoor heat exchangers 23a, 23b, and 23c. In the indoor unit 20, the low temperature and low pressure liquid refrigerant removes the heat from the indoor air, so that it is subjected to evaporation and gasification, and is converted to low temperature and low pressure gaseous refrigerant, which is again sent to the compressor 12. Thus, the aforementioned processes are repeated.

[0031] The outstanding technical feature of the air conditioner of the present embodiment is unique determination of prescribed measurements and dimensions with respect to the positional relationship between the tangential fan 25, stabilizer 26, and casing 28 in the indoor unit 20. Herein, reference symbol L_1 designates a distance between the circumferential surface of the tangential fan 25 and the stabilizer 26, wherein the circumferential surface of the tangential fan 25 is defined by outer edges of the blades 25b that are subjected to circumferential movement during rotation. In addition, reference symbol L_2 designates the shortest distance between the circumferential surface of the tangential fan 25 and the casing 28, which is arranged opposite to the stabilizer 26 via the tangential fan 25. Reference symbol 's' designates a minimal gap between adjoining blades 25b of the tangential fan 25. The prescribed dimensions are established based on the following relationships (a), (b), and (c).

$$L_1 < L_2 \quad (a)$$

$$1.0s \leqq L_1 \leqq 1.3s \quad (b)$$

$$1.2s \leqq L_2 \leqq 2.0s \quad (c)$$

[0032] In the indoor unit 20, the distance L_1 is arranged close to the vortex flow. As the distance L, becomes smaller, the air blowing power (or wind power) increases; however, the noise level also increases correspondingly. In addition, as the distance L_2 becomes smaller, the air blowing power increases. Because the aforementioned relationship (a) is established between the distances L_1 and L_2, the indoor unit 20 can exhibit good aerodynamic performance in any one of the warming mode, cooling mode, and dry mode (dehumidifying mode) while demonstrating noticeable reduction in noise.

[0033] Because the aforementioned relationship (b) is established between the distance L_1 and the minimal gap s of the adjoining blades 25b, the indoor unit 20 can exhibit good aerodynamic performance in any one of the warming mode, cooling mode, and dry mode while demonstrating noticeable reduction in noise. To demonstrate the effects of the present embodiment, prescribed measurements were performed with respect to noise levels actually produced by the indoor unit 20. The measurement result is shown in FIG. 3, which is created using the 'fixed' wind power for the air outlet 27 against each of'dimensionless' values that are produced by dividing the distance L_1 between the tangential fan 25 and stabilizer 26 by the minimal gap s of the adjoining blades 25b. In FIG. 3, the horizontal axis represents the dimensionless value 'L_1/s', and the vertical axis represents the noise level dB(A).

[0034] In the range of L_1/s <1.0 (i.e., L_1<1.0s), FIG. 3 shows that the aerodynamic performance is improved while the noise level is extremely increased. In the range of L_1/s>1.3 (i.e., L_1>1.3s), FIG. 3 also shows that the noise level is greatly increased. It can be assumed that the indoor unit 20 causes a relatively large amount of noise because the tangential fan 25 may perform the exhausting action insufficiently to allow the occurrence of the back flow of the air into the air duct 24. If the indoor unit 20 is designed to meet the aforementioned range of L_1>1.3s, it may be necessary to accept the unwanted reduction of the aerodynamic performance and the increase of the size of the indoor unit 20.

[0035] In the range of $1.0 \leqq L_1/s \leqq 1.3$ (i.e., $1.0s \leqq L_1 \leqq 1.3s$), FIG. 3 shows that the noise level is adequately reduced. That is, the noise level becomes minimal at L_1=1.1s and would not be increased by +1dB(A) or so.

[0036] Because the aforementioned relationship (c) is established between the distance L_2 and the minimal gap 's' between the adjoining blades 25b of the tangential fan 25, the indoor unit 20 could demonstrate good aerodynamic performance in either the cooling or warming operation while demonstrating noticeable reduction in noise. To demonstrate the effects of the present embodiment, prescribed measurements were performed with respect to the noise levels actually produced by the indoor unit 20. The measurement results are shown in FIG. 4, which is created using the 'fixed' wind power for the air outlet 27 against each of the 'dimensionless' values that are produced by dividing the distance L_2 between the casing 28, arranged opposite to the stabilizer 26, and the circumferential surface of the tangential fan 25 by the minimal gap s of the adjoining blades 25b. In FIG. 4, the horizontal axis represents the dimensionless value 'L_2/s', and the vertical axis represents the noise level dB(A).

[0037] FIG. 4 shows that in the range of L_2/s<1.2 (i.e., L_2<1.2s), the aerodynamic performance is improved while the noise level is extremely increased. In the range of L_2/s>2.0 (i.e., L_2>2.0s), the noise level is increased as well. Herein, it can be assumed that the indoor unit 20 causes a relatively large noise because the tangential fan 25 may perform the exhausting action insufficiently to allow the occurrence of the back flow of the air into the air duct 24. If the indoor unit 20 is designed to meet the aforementioned range of L_2>2.0s, it may be necessary to accept the unwanted reduction of the aerodynamic performance and the increase of the size of the indoor unit 20.

[0038] In the range of $1.2 \leqq L_2/s \leqq 2.0$ (i.e., $1.2s \leqq L_2 \leqq 2.0s$), FIG. 4 shows that the noise level is adequately reduced. That is, the noise level becomes minimal at L_2=1.5s and would not be increased by +1dB(A) or so.

[0039] As described above, the present embodiment determines dimensions of the indoor unit 20 to simultaneously satisfy the aforementioned relationships (a), (b), and (c) with respect to the two narrow areas that are arranged around the tangential fan 25. Thus, it is possible to demonstrate good aerodynamic performance while demonstrating a noticeable reduction in noise in the operation mode of the indoor unit 20.

[0040] The present embodiment is designed to simultaneously satisfy the aforementioned relationships (a), (b), and (c) with respect to the two narrow areas around the tangential fan 25. However, it is not always required to simultaneously satisfy the aforementioned three relationships (a), (b), and (c). That is, it is expected to demonstrate certain effects by determining dimensions of the indoor unit 20 based on at least one relationship only. For this reason, it is possible to provide various modifications as follows:

(1) An air conditioner having an indoor unit whose dimensions are determined based on one relationship selected from among the three relationships (a), (b), and (c).
(2) An air conditioner having an indoor unit whose dimensions are determined based on two relationships selected from among the three relationships (a), (b), and (c).

Second Embodiment

[0041] FIG. 5 shows an internal mechanical structure of an indoor unit of an air conditioner in accordance with a second embodiment of the invention, wherein parts identical to those shown in FIG. 2 are designated by the same reference numerals; hence, the description thereof will be omitted.

[0042] The indoor unit of the second embodiment shown in FIG. 5 is partially modified in dimensions as compared with the indoor unit of the first embodiment shown in FIG. 2. That is, the outstanding technical feature of the second embodiment is to establish the following relationship between the tangential fan 25 and its proximate indoor heat exchanger 23a in which the prescribed number of refrigerant circulation pipes are arranged.

$$2.5d \leqq L \leqq 3.5d$$

where 'L' denotes a distance between the circumferential surface of the tangential fan 25 and its proximate indoor heat exchanger 23a, and 'd' denotes a 'flow' diameter of a refrigerant circulation pipe 23t installed in the indoor heat exchanger 23a.

[0043] In the above, the flow diameter 'd' is defined as the outermost diameter of the prescribed part of the refrigerant circulation pipe 23t that is exposed to the air flow in the indoor heat exchanger 23a. Details will be described with reference to Figures 6A and 6B. In the case of FIG. 6A, the refrigerant circulation pipe 23t is surrounded by radiator fins 23f that are partially deformed due to the influence of an expansion pipe (not shown), which is provided to expand the refrigerant circulation pipes in the manufacturing process of the heat exchanger. In this case, the flow diameter of the refrigerant circulation pipe 23t is measured to include the radiator fins 23f. In the case of FIG. 6B where the radiator fins 23f are not deformed, the flow diameter directly matches the outer diameter of the refrigerant circulation pipe 23t.

[0044] By employing the aforementioned relationship established between the distance L and the flow diameter d shown in FIG. 5, the indoor unit 20 of the second embodiment could demonstrate a noticeable reduction in noise level without extremely increasing the external dimensions thereof. To demonstrate the effects of the present embodiment, the prescribed measurements were performed with respect to the noise levels actually produced by the indoor unit 20. The measurement results are shown in FIG. 7, which was created using the 'fixed' air blowing power for the air outlet 27 against each of 'dimensionless' values that are produced by dividing the distance L between the circumferential surface of the tangential fan 25 and its proximate indoor heat exchanger 23a by the flow diameter d of the refrigerant circulation pipe 23t. In FIG. 7, the horizontal axis represents the dimensionless value 'L/d', and the vertical axis represents the noise level dB(A).

[0045] FIG. 7 shows that in the range of $L/d<2.5$ (i.e., $L<2.5d$), the noise level is extremely increased. In the range of $L/d>3.5$ (i.e., $L>3.5d$), the noise level is controlled without problem. In order to realize the aforementioned range of $L>3.5d$, the indoor unit 20 should be increased in size, particularly by increasing the depth dimensions thereof.

[0046] In the range of $2.5\leqq L/d\leqq 3.5$ (i.e., $2.5d\leqq L\leqq 3.5d$), FIG. 7 shows that the noise level is adequately reduced. That is, the noise level becomes minimal at $L=3.5d$ and would not be increased by +1dB(A) or so. Therefore, the air conditioner of the second embodiment is designed to realize this range in the indoor unit 20. That is, the arrangement and dimensions of the indoor heat exchanger 23a and the tangential fan 25 are determined to satisfy the aforementioned relationship. Thus, the present embodiment could demonstrate a noticeable reduction in noise level without increasing the size of the indoor unit 20.

[0047] The present embodiment introduces the aforementioned relationship for the actualization of the noise reduction and the unwanted enlargement of the dimensions of the indoor unit 20. However, if the indoor unit 20 is not necessarily designed in consideration of the dimensional enlargement thereof, it is possible to modify the present embodiment in accordance with the relationship $2.5d\leqq L$. By merely employing this relationship, it is possible to realize the noise reduction during the operation of the air conditioner.

Third Embodiment

[0048] FIG. 8 shows an internal mechanical structure of an indoor unit of an air conditioner in accordance with a third embodiment of the invention, wherein parts identical to those shown in Figures 2 and 5 are designated by the same reference numerals; hence, the description thereof will be omitted.

[0049] The indoor unit of the third embodiment shown in FIG. 8 is partially modified in dimensions as compared with the indoor units of the foregoing first and second embodiments shown in Figures 2 and 5. That is, the outstanding technical feature of the third embodiment is to establish the following relationship between the tangential fan 25 and its proximate indoor heat exchanger 23a.

$$1.5L_1 \leqq L_2 \leqq 3.5L_1$$

where 'L_1' denotes a distance between the circumferential surface of the tangential fan 25 and its opposite surface of the indoor heat exchanger 23a, and 'L_2' denotes a distance between the circumferential surface of the tangential fan 25 and the boundary between the indoor heat exchangers 23a and 23b.

[0050] By employing the aforementioned relationship established between the distances L_1 and L_2 shown in FIG. 8, the indoor unit 20 of the third embodiment exhibited noticeable reduction in noise level without extremely increasing the external dimensions thereof. To demonstrate the effects of the present embodiment, prescribed measurements were performed with respect to noise levels actually produced by the indoor unit 20. The measurement results are shown in FIG. 9, which was created using the 'fixed' air blowing power for the air outlet 27 against each of the 'dimensionless' values that are produced by dividing the distance L_2 between the circumferential surface of the tangential fan 25 and the edge of the indoor heat exchanger 23b by the distance L_1 between the circumferential surface of the tangential fan 2 5 and its opposite surface of the indoor heat exchanger 23a. In FIG. 9, the horizontal axis represents the dimensionless value 'L_2/L_1', and the vertical axis repre sents the noise level dB(A).

[0051] FIG. 9 shows that in the range of $L_2/L_1<1.5$ (i.e., $L_2<1.5L_1$), the noise level is extremely increased. In the range of $L_2/L_1>3.5$ (i.e., $L_2>3.5L_1$), the noise level is controlled without problem. In order to realize the aforementioned range of $L_2>3.5L_1$, the indoor unit 20 should be increased in size, particularly by increasing the depth dimensions thereof.

[0052] In the range of $1.5\leqq L_2/L_1\leqq 3.5$ (i.e., $1.5L_1 \leqq L_2\leqq 3.5L_1$), FIG. 9 shows that the noise level is adequately reduced. That is, the noise level becomes minimal at $L_2=3.5L_1$ and would not be increased by +1dB (A) or so. Therefore, the air conditioner of the third embodiment is designed to realize this range in the indoor unit 20. That is, the arrangement and dimensions of the indoor heat exchangers 23a and 23b, and the tangential fan 25 are determined to satisfy the aforementioned relationship. Thus, the present embodiment could demonstrate a noticeable reduction in noise levels without increasing the size of the indoor unit 20.

[0053] The present embodiment introduces the aforementioned relationship for the actualization of the noise reduction and the undesirable increase in the dimensions of the indoor unit 20. However, if the indoor unit 20 is not necessarily designed in consideration of the dimensional enlargement thereof, it is possible to modify the present embodiment in accordance with the relationship of $1.5L_1\leqq L_2$. By merely employing this relationship, it is possible to realize the noise reduction during the operation of the air conditioner.

[0054] As this invention may be embodied in several forms without departing from the spirit or essential characteristics thereof, the present embodiments are therefore illustrative and not restrictive, since the scope of the invention is defined by the appended claims rather than by the description preceding them, and all changes that fall within metes and bounds of the claims, or equivalents of such metes and bounds are therefore intended to be embraced by the claims.

Claims

1. An indoor unit for an air conditioner comprising:

a plurality of indoor heat exchangers (23a,23b, 23c) for performing heat exchange between indoor air and refrigerant that is cooled or warmed by outdoor air;
a tangential fan (25) for forcing the indoor air to flow through the indoor heat exchangers; and
a stabilizer (26) that is arranged in proximity to the tangential fan,

wherein dimensions of the indoor unit are determined to satisfy at least one of the following relationships:

a) $L_1 < L_2$;

b) $1.0s \le L_1 \le 1.3s$;

c) $1.2s \le L_2 \le 2.0s$;

d) $2.5d \le L$;

and

e) $1.5L_{1'} \le L_{2'}$;

where

'L_1' denotes a distance between a circumferential surface of the tangential fan (25) and the stabilizer,

'L_2' denotes a distance between the circumferential surface of the tangential fan (25) and a casing (28) that is arranged opposite to the stabilizer (26) via the tangential fan (25),

's' denotes a minimal gap between adjoining blades (25b) of the tangential fan (25),

'L' denotes a distance between a circumferential surface of the tangential fan (25) and its proximate indoor heat exchanger (23a),

'd' denotes a flow diameter of a refrigerant circulation pipe (23t) installed in the indoor heat exchanger,

'$L_{1'}$' denotes a distance between a circumferential surface of the tangential fan (25) and its opposite surface of the proximate indoor heat exchanger (23a), and

'$L_{2'}$' denotes a distance between the circumferential surface of the tangential fan (25) and a boundary between the proximate indoor heat exchanger and its adjoining indoor heat exchanger (23b).

2. An indoor unit for an air conditioner according to claim 1, wherein dimensions of the indoor unit are determined to satisfy at least two of the relationships a) to c).

3. An indoor unit of an air conditioner according to claim 1, wherein the dimensions of the indoor unit are determined to satisfy the relationship $2.5d \leq L$ and the relationship $L \leq 3.5d$.

4. An indoor unit of an air conditioner according to claim 1, wherein the dimensions of the indoor unit are determined to satisfy the relationship $1.5L_{1'} \leq L_{2'}$ and the relationship $L_{2'} \leq 3.5L_{1'}$.

5. An air conditioner comprising:

an outdoor unit (10) having an outdoor heat exchanger (11) for performing heat exchanging between outdoor air and refrigerant that is cooled or warmed by indoor air; and
an indoor unit (20) as defined in any -one of claims 1 to 4 for performing heat exchange between the indoor air and the refrigerant that is cooled or warmed by the outdoor air.

FIG. 1

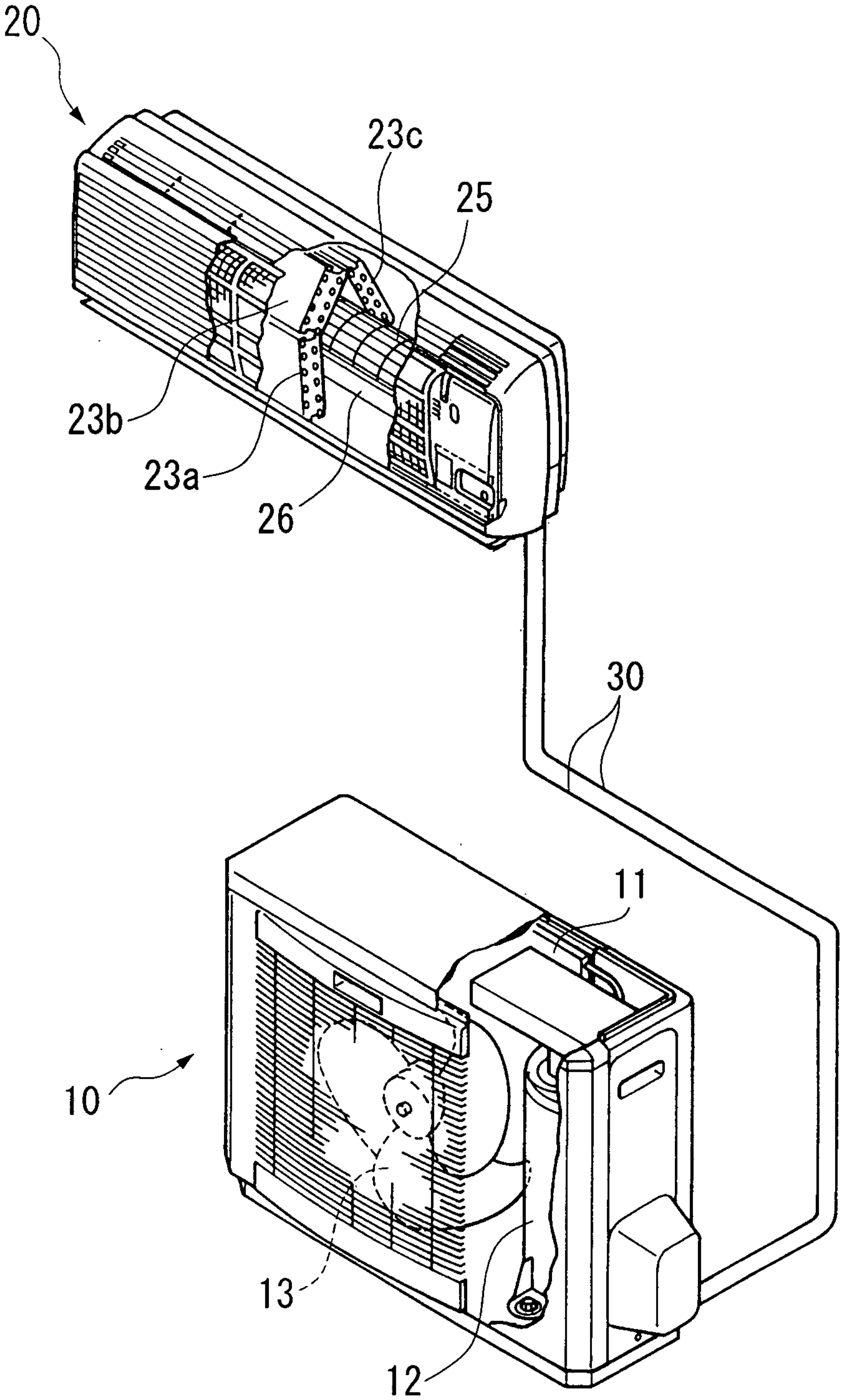

FIG. 2

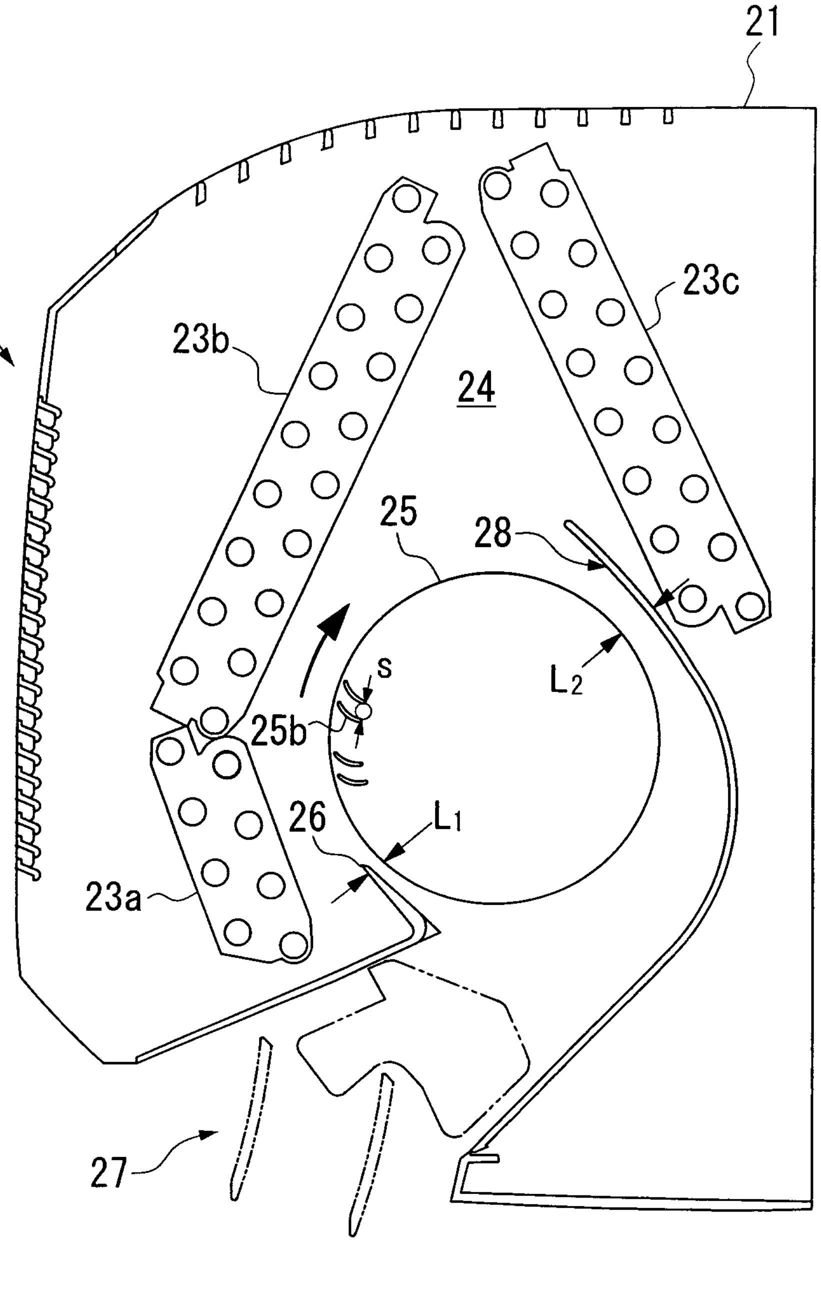

FIG. 3

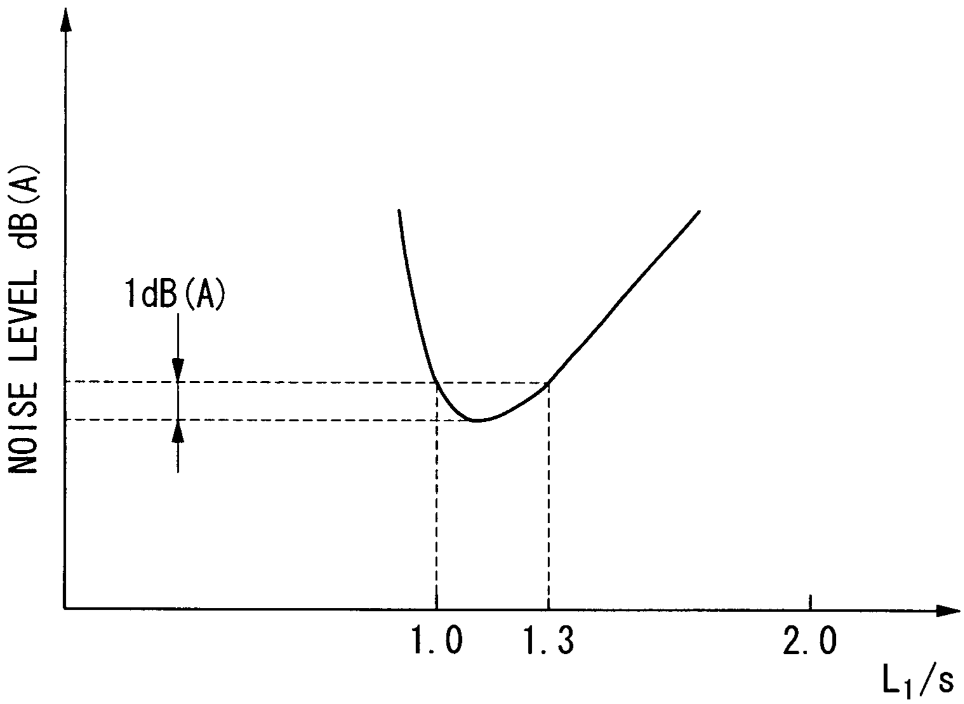
NOISE LEVEL dB(A)
1dB(A)
1.0
1.3
2.0
L1/s

FIG. 4

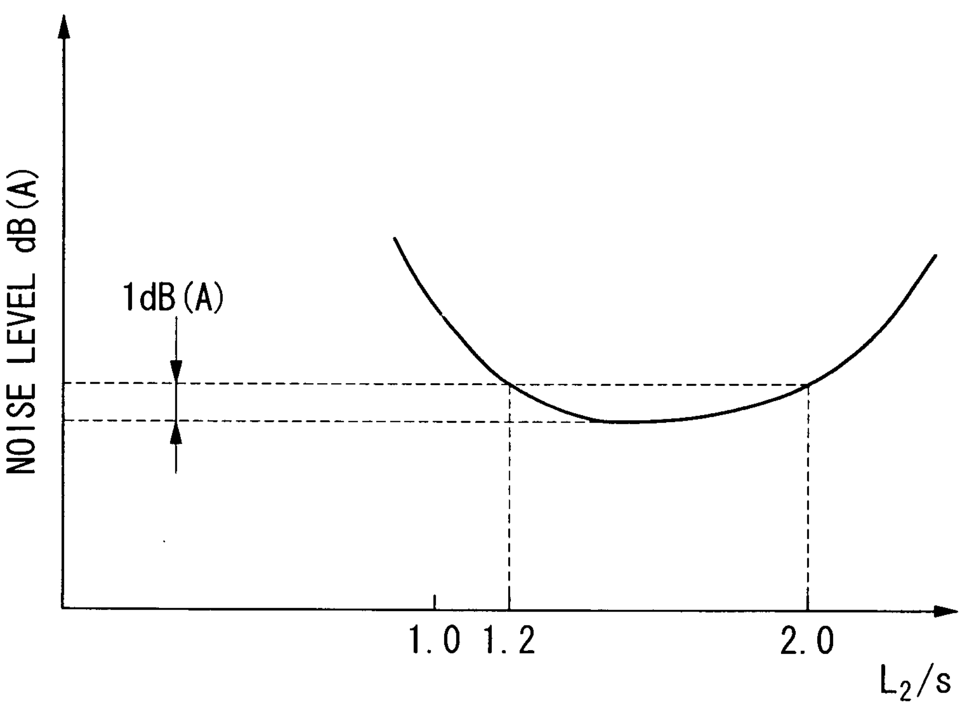
NOISE LEVEL dB(A)
1dB(A)
1.0
1.2
2.0
L2/s

FIG. 5

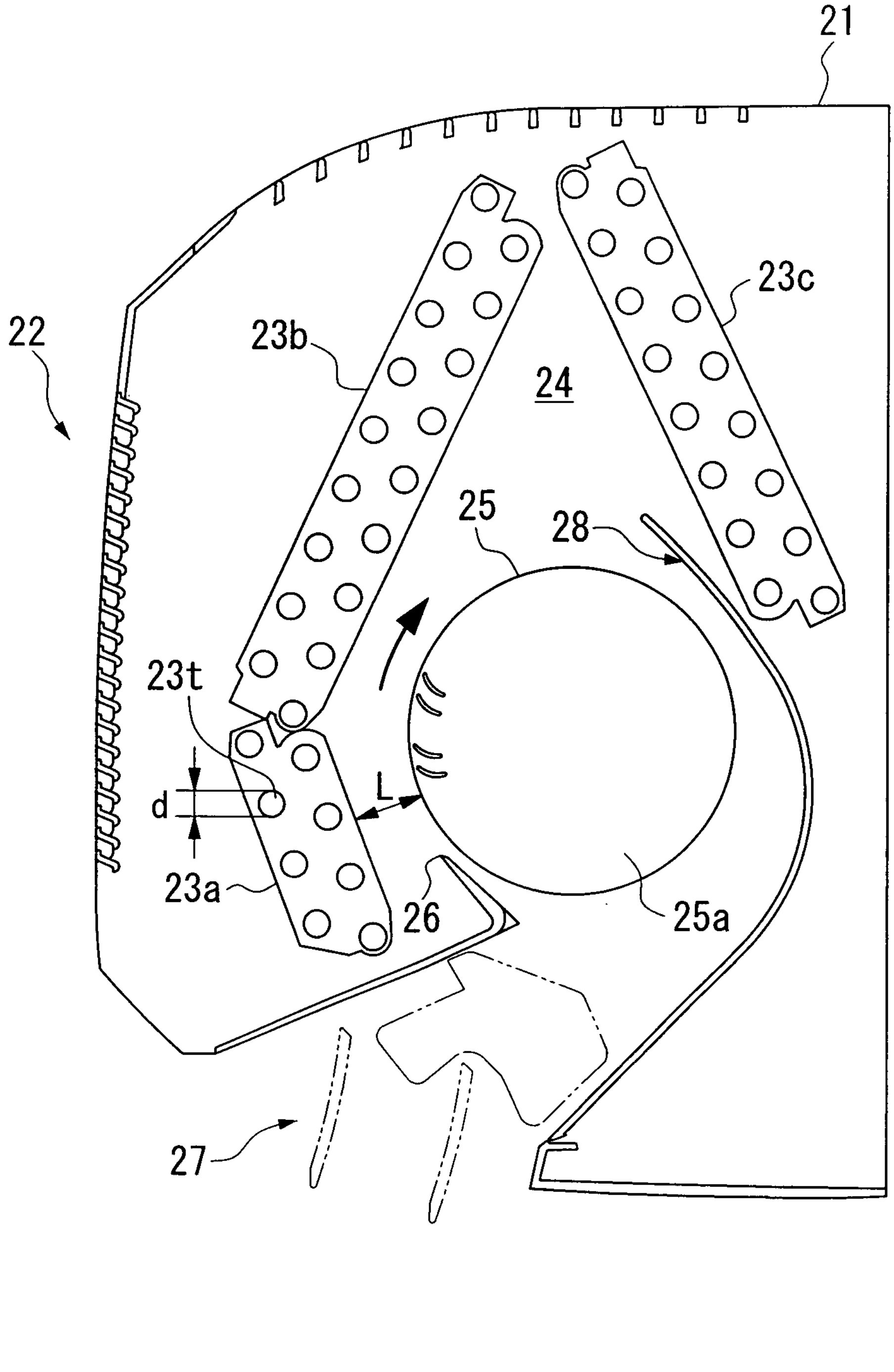

FIG. 6A

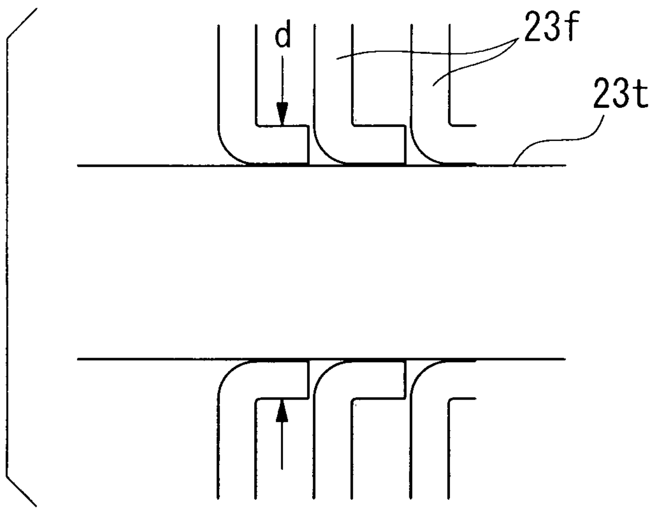

FIG. 6B

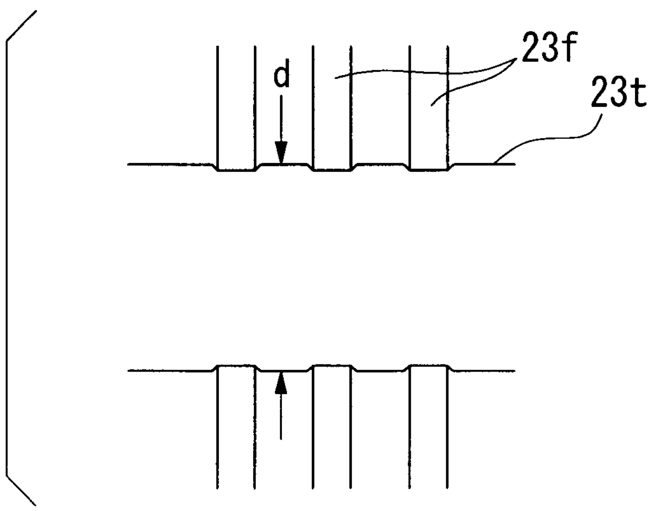

FIG. 7

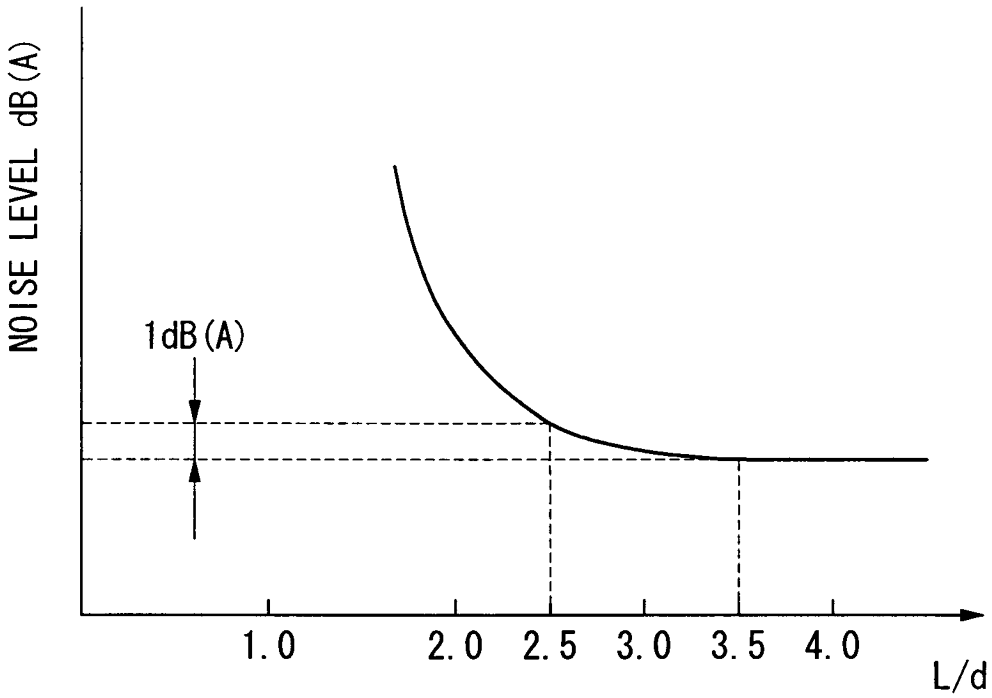
NOISE LEVEL dB(A)
1dB(A)
1.0
2.0
2.5
3.0
3.5
4.0
L/d

FIG. 9

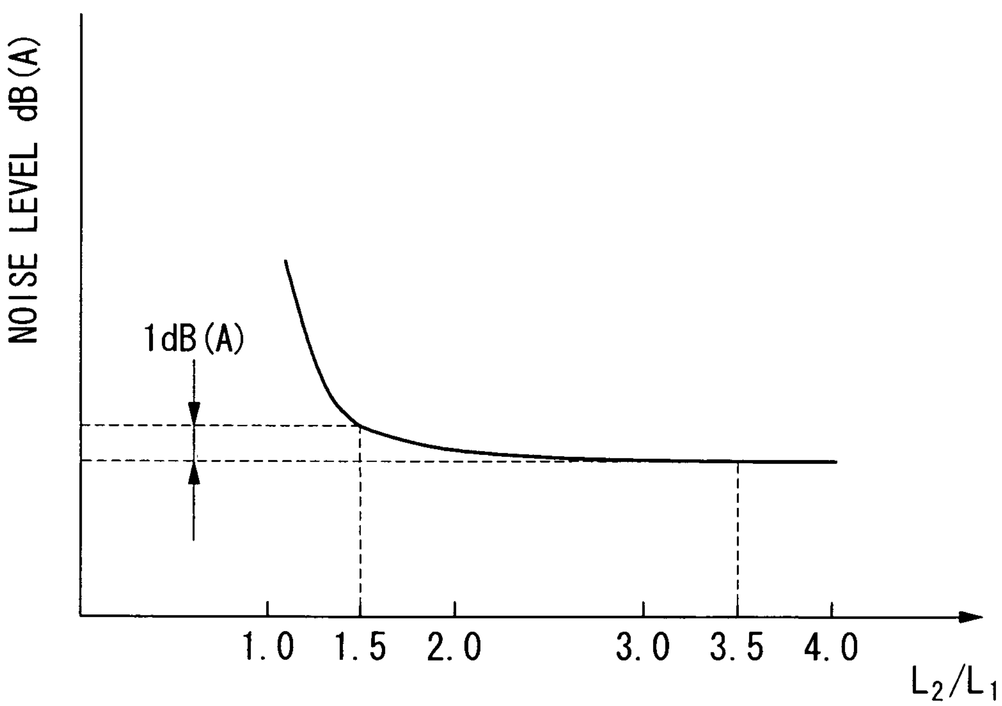
NOISE LEVEL dB(A)
1dB(A)
1.0
1.5
2.0
3.0
3.5
4.0
L2/L1

FIG. 8

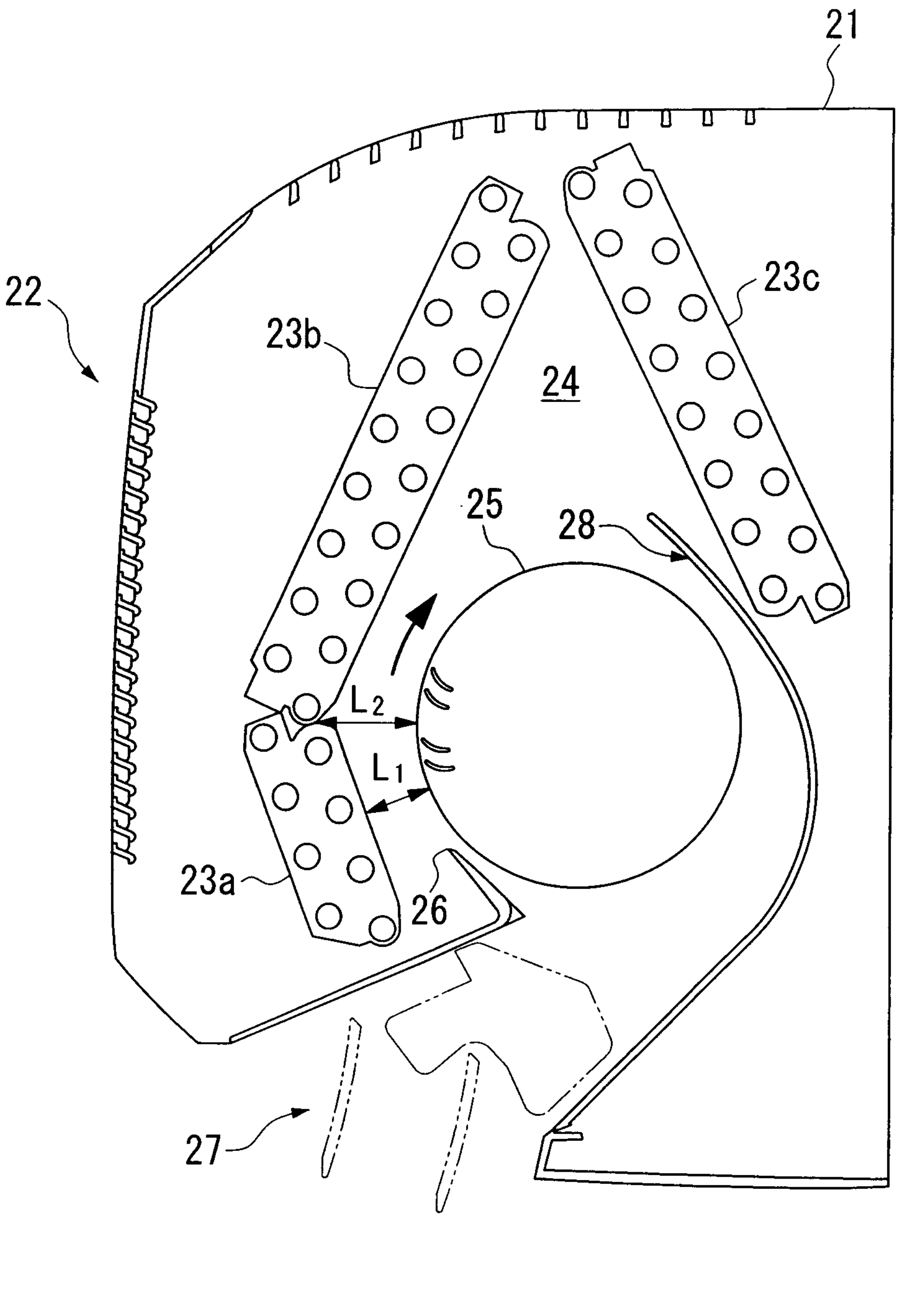

FIG. 10