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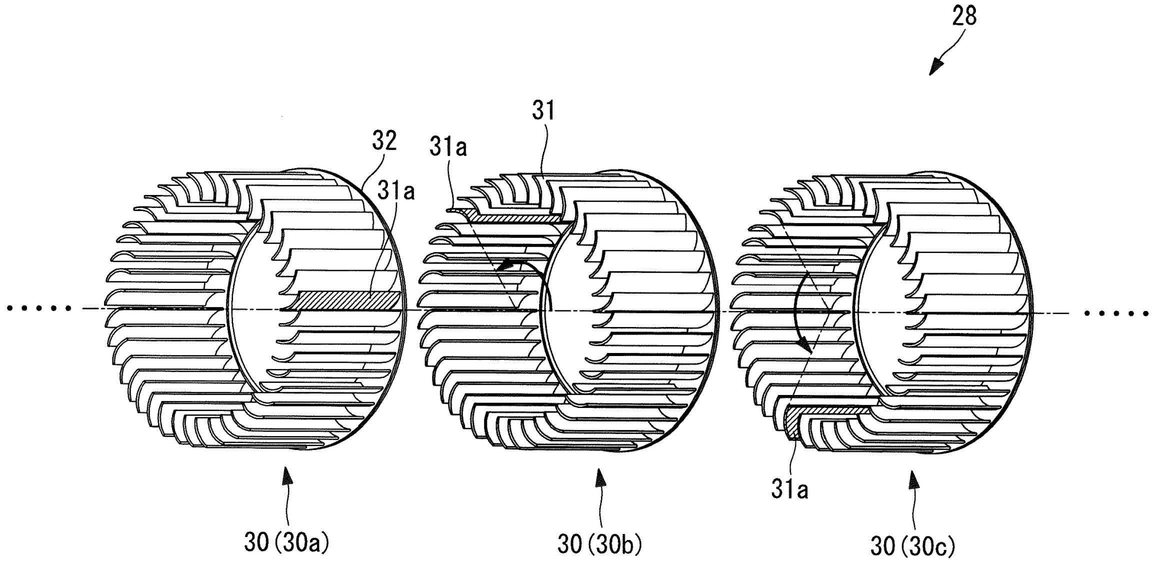
(54) TANGENTIAL FAN AND AIR CONDITIONER

(57) A tangential fan that is composed of one kind of impeller and has a reduced noise, and an air conditioner are provided. The tangential fan 28 includes plural impellers 30 connected to each other in a rotational axis direction, each impeller 30 including plural blades 31 circularly arranged about the rotational axis to form a cylindrical outer shape of the impeller 30, the tangential fan 28 blowing out a fluid led into an inside of the tangential fan 28 by rotation of the impellers 30, wherein the blades 31 are arranged in each impeller 30 at random pitches, a value derived by dividing 360° by a total number of the blades 31 is defined as a virtual average pitch angle, each of the plural impellers 30 includes the blades 31 in the same arrangement, and adjacent impellers 30 of the plural impellers 30 are connected to each other at a circular connection displacement angle that is larger than the virtual average pitch angle.

FIG. 3



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Description

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

[0001] The present invention relates to a tangential fan and an air conditioner.

2. DESCRIPTION OF RELATED ART

[0002] A tangential fan has been known as a fan used for apparatuses such as an indoor unit of an air conditioner. Unlike an axial fan and a centrifugal fan, the tangential fan is long in a width direction (rotational axis direction) and its shape is formed of plural impellers connected to each other. In each impeller, plural blades are arranged in a circumferential direction, and a peculiar sound such as Blade Pass Frequency noise ($f=i \times (N/60) \times Z$; f: frequency; i: integer of order; N: number of rotations (rpm); Z: number of blades) may be generated due to reasons such as an interference of each blade and the surroundings.

[0003] Since the tangential fan is long in the width direction, sounds of the same frequencies generated by rotation may produce a peak noise unpleasant to a user, due to amplification, interference or resonance of the sounds.

[0004] To reduce the noise, several countermeasures have been taken by changing a configuration of the tangential fan.

[0005] For example, the Publication of Japanese Patent No. 2770677 discloses arranging circular arc vanes (blades) in a circumferential direction at random pitches and displacing impellers each by 1° to 4° in the circumferential direction.

[0006] Also, the Publication of Japanese Patent No. 3460350 discloses arranging circular arc vanes in a circumferential direction at random pitches and making at least one phase difference in the impellers different from the other phase differences.

[0007] Also, the Publication of Japanese Patent No. 3564462 discloses connecting impellers while alternately displacing the impellers.

[0008] Also, the Publication of Japanese Patent No.4831707 discloses calculating a formula using the number of blades and impellers to determine the displacement of impellers.

[0009] However, the invention of each of the above documents displaces the impellers within one interval of the blades. Accordingly, even when the blades are arranged in each impeller at random pitches, the blades at the respective same positions may be aligned with each other at certain time intervals. When the blades at the respective same positions are aligned with each other at certain time intervals, frequencies of sounds generated by the tangential fan are not completely different from each other in phase, making it difficult to effectively reducing noise.

[0010] To complicate the displacement of impellers, for example, different impellers, namely impellers each having blades arranged at different random pitches may be prepared. However, this increases the number of components and thus increases management and manufacturing costs.

[0011] The present invention has been made in view of the above circumstances and aims to provide a tangential fan that is composed of one kind of impeller and has reduced noise, and an air conditioner.

BRIEF SUMMARY OF THE INVENTION

[0012] To solve the above problem, the tangential fan and the air conditioner of the present invention adopt the following solutions.

[0013] The tangential fan according to a first aspect of the present invention is a tangential fan including plural impellers connected to each other in a rotational axis direction, each impeller including plural blades circularly arranged about the rotational axis to form a cylindrical outer shape of the impeller, the tangential fan blowing out a fluid led into an inside of the tangential fan by rotation of the impellers, wherein the blades are arranged in the impeller at random pitches, and a value derived by dividing 360° by a total number of the blades is defined as a virtual average pitch angle, each of the plural impellers includes the blades in the same arrangement, and adjacent impellers of the plural impellers are connected to each other at a circular connection displacement angle that is larger than the virtual average pitch angle.

[0014] According to the present aspect, in the tangential fan including plural impellers connected to each other in a rotational axis direction each including plural blades circularly arranged about the rotational axis to form a cylindrical outer shape of the impeller, and blowing out a fluid led into an inside of the tangential fan by rotation of the impellers, the blades are arranged in the impeller at random pitches, the impeller includes the blades in the same arrangement, and adjacent impellers are connected to each other at the circular connection displacement angle that is larger than the virtual average pitch angle derived by dividing 360° by a total number of the blades. This complicates the arrangement of the blades in the rotational axis direction and positions almost all of the blades at respective different positions.

[0015] As a result, the blades of the impellers pass the same point at different timings, making frequencies of generated sounds deviated from each other. This complicates frequencies of sounds generated by the tangential fan. With a nonuniform arrangement of the impellers, phases of the generated frequencies deviate from each other, and this allows to reduce discrete frequency noise, which has a peak at a single frequency.

[0016] Further, the tangential fan more effectively exerts the effects of the random pitch arrangement, namely irregularizing the periodicities of sound sources and dispersing Blade Pass Frequency noise to plural low peaks.

[0017] Moreover, since each impeller includes the blades in the same arrangement, the tangential fan may be composed of one kind of impeller, eliminating the need for increasing the number of components and increasing management and manufacturing costs.

[0018] In the above first aspect, the circular connection displacement angle may be larger than a value twice the virtual average pitch angle.

[0019] According to the present aspect, the circular connection displacement angle is larger than the value twice the virtual average pitch angle, and this makes the arrangement of the blades further nonperiodic and complicated, allowing to position almost all of the blades at respective different positions.

[0020] The air conditioner according to a second aspect of the present invention is an air conditioner including an indoor unit and an outdoor unit, wherein the air conditioner includes, inside the indoor unit, the tangential fan of the above aspect.

[0021] According to the present invention, the impellers are connected to each other at the circular connection displacement angle that is larger than the virtual average pitch angle, and this allows to vary the timings at which the respective blades pass the same point.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0022]

FIG. 1 is a perspective view illustrating a configuration example of an air conditioner according to one embodiment of the present invention.

FIG. 2 is a front view illustrating a tangential fan according to one embodiment of the present invention.

FIG. 3 is a disassembled perspective view illustrating the tangential fan according to one embodiment of the present invention.

FIG. 4 is a front view illustrating pitch intervals of a tangential fan without any displacement of impellers as a Reference Example.

FIG. 5 is a graph illustrating frequency characteristics of sounds of the tangential fan without any displacement of impellers as the Reference Example.

FIG. 6 is a front view illustrating pitch intervals of a tangential fan having impellers displaced within one pitch as a Reference Example.

FIG. 7 is a graph illustrating frequency characteristics of sounds of the tangential fan having impellers displaced within one pitch as the Reference Example.

FIG. 8 is a representative front view illustrating pitch intervals of the tangential fan according to one embodiment of the present invention.

FIG. 9 is a graph illustrating frequency characteristics of sounds of the tangential fan according to one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0023] Hereinafter, one embodiment of the tangential fan and the air conditioner according to the present invention will be explained with reference to the attached drawings.

[0024] Hereinafter, one embodiment of the present invention will be explained using FIGS. 1 to 9.

[0025] FIG. 1 illustrates a configuration example of the air conditioner according to the present embodiment.

[0026] As shown in FIG. 1, the air conditioner 1 for performing air conditioning (cooling, heating and dehumidifying) of an indoor space and the like is an apparatus that mainly consists of an outdoor unit 10 and an indoor unit 20. The outdoor unit 10 and the indoor unit 20 are connected with a refrigerant pipe 50 to form a closed refrigerant circuit. The outdoor unit 10 and the indoor unit 20 are also connected with electric wires (not shown in the figure) for power supply and control.

[0027] Note that the reference numeral 51 in the figure denotes a remote controller for controlling operations, by which various operating conditions of the air conditioner 1 are set.

[0028] The outdoor unit 10 includes, inside a housing 11 of a substantially rectangular parallelepiped shape, a compressor 12 for compressing a refrigerant, an outdoor heat exchanger 13 for exchanging heat between the refrigerant and an outdoor air, and an outdoor fan 14 facilitating the heat exchange between the refrigerant and the outdoor air in the outdoor heat exchanger 13. A four-way valve, an electronic expansion valve, a control unit and the like (not shown in the figure) are also installed inside the housing 11.

[0029] By switching a circulation direction of the refrigerant with the four-way valve, the outdoor heat exchanger 13 functions as a condenser in a cooling operation and as an evaporator in a heating operation.

[0030] The indoor unit 20 includes a housing 21 of a laterally long, substantially rectangular parallelepiped shape. The housing 21 mostly consists of a base body 22, a front cover 23 attached to the base body 22 so as to cover a front part of the base body 22 from top, bottom, left, right and front sides when installed on a wall, and a front panel 24 attached to a front face of the front cover 23.

[0031] The indoor unit 20 mainly consists of a suction grill (air inlet) 25 provided to the front cover 23 to take in preconditioned air (hereinafter referred to as "fresh air") from a room, an indoor heat exchanger 26 provided to cool or heat the fresh air taken in by the suction grill 25, an air outlet 27 provided to the front panel 24 to return air undergone the heat exchange in the indoor heat exchanger 26 (hereinafter referred to as "conditioned air") to the room, and a tangential fan 28 provided to take in the fresh air from the suction grill 25 and blow out the conditioned air from the air outlet 27 to the room. Hereinafter, an impeller for a tangential fan formed by connecting a plurality of impellers in the axial direction will be referred to as a "tangential fan" for the sake of convenience.

[0032] The indoor heat exchanger 26 and the tangential fan 28 are supported by the base body 22 inside the housing 21.

[0033] The reference numeral 29 in the figure denotes a filter that is provided to remove impurities such as dust and refuse contained in the fresh air led into the indoor heat exchanger 26 through the suction grill 25. Note that the air outlet 27 is provided with a louver and a flap (not shown in the figure) to adjust a blowing direction of the conditioned air.

[0034] Depending on the circulation direction of the refrigerant, the indoor heat exchanger 26 functions as an evaporator in a cooling operation, and as a condenser in a heating operation.

[0035] In the indoor unit 20 of the above described configuration, the tangential fan 28 driven by a motor is rotatably supported by the base body 22, which constitutes the housing 21 of the indoor unit 20. The tangential fan 28 is arranged on an air passage formed in the base body 22 so as to connect the suction grill 25 and the air outlet 27.

[0036] FIG. 2 is a front view of the tangential fan provided to the indoor unit of the present embodiment.

[0037] FIG. 3 is a disassembled perspective view of a part of the tangential fan provided to the indoor unit of the present embodiment.

[0038] As shown in FIGS. 2 and 3, the tangential fan 28 of the present embodiment includes plural impellers 30 connected to each other via intermediate plates 32 in a direction of a rotational axis CL. Each impeller 30 has a cylindrical shape formed by, for example, thirty-five (plural) blades (vanes) 31 circularly arranged about the rotational axis CL. By rotation of the impellers 30, the tangential fan 28 blows out a fluid led into the inside of the tangential fan 28 to the outside.

[0039] The blades 31 of each impeller 30 are arranged at random pitches, whereby each pitch, namely an interval between two adjacent blades 31 is unequal to each other. In the present embodiment, the impellers 30 are the same as each other; that is, the blades 31 of each impeller 30 are arranged at the same random pitches.

[0040] An average angle of pitch intervals between each two blades 31 is a value calculated by dividing 360° by a total number of the blades 31 (thirty-five blades in the representative example of the present embodiment; 360°/35 = 10.3°), and this value is defined as a virtual average pitch angle.

[0041] Next, relationship between connecting angles of the impellers 30 of the tangential fan 28 and generated noises will be described.

[0042] FIG. 4 is a front view illustrating pitch intervals of a tangential fan without any displacement of impellers as a Reference Example.

[0043] FIG. 4 shows arrangement and intervals of a part of the blades 31 of the four impellers 30 of impellers 30a, 30b, 30c and 30d. Each impeller 30 rotates, and the blades 31 move from the top to the bottom in the figure.

[0044] In the case shown in FIG. 4, the impellers 30 having a random pitch arrangement are not displaced from each other in a moving direction (circumferential direction) of the blades 31, and all of the blades 31 adjacent to each other via the intermediate plates 32 between the impellers 30 are arranged at the respective same positions.

[0045] In this case, all of the blades 31 pass a reference point indicated by the broken line at the same timing as indicated by the bold lines.

[0046] In the following explanation, when the impellers 30 are distinguished from each other, each impeller 30 is denoted by a reference numeral 30 with a trailing character of any one of a to d, and when the impellers 30 are not distinguished from each other, these trailing characters of a to d are omitted.

[0047] FIG. 5 is a graph illustrating frequency characteristics of sounds of the tangential fan without any displacement of impellers as the Reference Example.

[0048] In FIG. 5, the vertical axis indicates a sound pressure level (noise level at each frequency) Lp, and the horizontal axis indicates a frequency Hz of sounds.

[0049] Since the tangential fan 28 is long in the width direction and the blades 31 are circularly arranged, a peculiar sound, for example Blade Pass Frequency noise ($f=i \times (N/60) \times Z$; f: frequency; i: integer of order; N: the number of rotations (rpm) of tangential fan 28; Z: the number of blades 31) having a peak at some frequencies may be generated due to reasons such as interference with the surroundings.

[0050] As shown in the graph, when the impellers 30 are not displaced from each other, Blade Pass Frequency noise is generated even with the random pitch arrangement.

[0051] FIG. 6 is a front view illustrating pitch intervals of a tangential fan having impellers displaced within one pitch as a Reference Example.

[0052] Arrangement of a part of the blades 31 in each of the four impellers 30 of the impellers 30a, 30b, 30c and 30d is indicated by the horizontal bars and their intervals. Each impeller 30 rotates, and the blades 31 move from the top to the bottom in the figure.

[0053] Each impeller 30 is connected to an adjacent impeller 30 while being displaced at a constant interval within the virtual average pitch angle of 10.3°. One pitch of the tangential fan 28 can be defined as an interval between two blades 31 represented by the virtual average pitch angle.

[0054] In this case, since the blades 31 of each impeller 30 corresponding to the respective same positions are displaced from each other at constant intervals, the blades 31 pass a reference point indicated by the broken line at certain timings (periods) as indicated by the bold lines.

[0055] FIG. 7 is a graph illustrating frequency characteristics of sounds of the tangential fan having impellers displaced within one pitch as the Reference Example.

[0056] In FIG. 7, the vertical axis indicates a sound pressure level (noise level at each frequency) Lp, and the horizontal axis indicates a frequency Hz of sounds.

[0057] As shown in the graph, with the impellers 30 displaced from each other within one pitch, such a pitch displacement generates a phase difference from a waveform of the frequency of $i \times (N/60) \times Z$ component in a time axis direction, and the waveforms cancel each other to be attenuated. However, although the sound pressure level of the Blade Pass Frequency noise is lowered as compared to the case where no displacement is made, the peaks of the Blade Pass Frequency noise are still present.

[0058] Accordingly, in the present embodiment, the impellers 30 are displaced from each other by more than one pitch.

[0059] FIG. 8 illustrates pitch intervals of the tangential fan according to one embodiment of the present invention (a representative figure illustrating displacement of one pitch + within one pitch).

[0060] Arrangement of a part of the blades 31 in each of the four impellers 30 of the impellers 30a, 30b, 30c and 30d are indicated by the horizontal bars and their intervals. Each impeller 30 rotates, and the blades 31 move from the top to the bottom in the figure.

[0061] With one impeller 30 as a reference, the adjacent impeller 30 is rotated by one pitch, and further displaced within one pitch as is conventional, and the impellers 30 are connected to each other in this state. Here, this further displacement of the impeller 30 within one pitch as is conventional is made in order to avoid the situation where all of the blades 31 of any two impellers 30 are aligned at the respective same positions, which may occur with the displacement of one pitch alone. In the present embodiment, the displacement within one pitch is 10% to 50% of the virtual average pitch angle.

[0062] A circular connection displacement angle θ of the impeller 30 with respect to the adjacent impeller 30 is expressed by the following formula (1):

(Formula 1)

$$\theta = 360°/35 \times (360°/35) \times (0.1 \text{ to } 0.5) \quad \ldots \quad (1)$$

[0063] In the formula (1), "360°/35" means the displacement of one pitch, namely the virtual average pitch angle, and "(360°/35) × (0.1 to 0.5)" means the displacement within one pitch.

[0064] The impeller 30 is connected to the adjacent impeller 30 while being displaced at the circular connection displacement angle θ.

[0065] In this case, the blades 31 of each impeller 30 at the respective same positions are displaced by more than one pitch since the impellers 30 are connected to each other at the circular connection displacement angle θ, which is larger than the virtual average pitch angle. Accordingly, the blades 31 have random intervals between adjacent impellers 30 like the blades 31 of the impellers 30b, 30c and 30d indicated by the long and short dashed lines with respect to the blade 31 of the impeller 30a indicated by the bold line, and thus the blades 31 pass a reference point indicated by the broken line at different timings.

[0066] Also, not the blade 31 of the adjacent impeller 30 but the blade 31 of a distant impeller 30 may pass the reference point earlier, like the blade 31 of the impeller 30d indicated by the bold broken line.

[0067] By connecting the impellers 30 at the circular connection displacement angle θ, each blade 31 is arranged in a completely different manner in a circumferential direction by virtue of the random pitch arrangement, and thus all of the blades 31 are positioned at different positions when the impellers 30 are compared with each other at the same point like the above reference point.

[0068] As a result, the blades 31 of the impellers 30 pass the same point at different timings, and this makes frequencies of generated sounds deviated from each other.

[0069] FIG. 9 is a graph illustrating frequency characteristics of sounds of the tangential fan according to one embodiment of the present invention.

[0070] In FIG. 9, the vertical axis indicates the sound pressure level (noise level at each frequency) Lp, and the horizontal axis indicates the frequency Hz of sounds.

[0071] As shown in the graph, when the impellers 30 are displaced from each other at the circular connection displacement angle θ, which is larger than one pitch, the blades 31 of respective adjacent impellers 30 are positioned in a complicated arrangement and the blades 31 pass the same point at complicated timings, by which the frequencies are deviated. As a result, the frequencies are further deviated than in the case of displacing the impellers 30 within one pitch, and this lowers the peaks of the Blade Pass Frequency noise, leading to reduced noise.

[0072] Further, the circular connection displacement angle may be any other value as long as the value is larger than one pitch. For example, as the value of the circular connection displacement angle, an adjacent impeller 30 may be rotated by 30% in the circumferential direction, instead of one pitch.

[0073] With one impeller 30 as a reference, the adjacent impeller 30 is rotated by 30% in the circumferential direction, and further displaced within one pitch as is conventional, and the impellers 30 are connected to each other in this state. Here, this further displacement of the impeller 30 within one pitch as is conventional is made in order to avoid the situation where all of the blades 31 of any two impellers 30 are aligned at the respective same positions, which may occur with the 30% rotation alone. In the present embodiment, the displacement within one pitch is 10% to 50% of the virtual average pitch angle.

[0074] The circular connection displacement angle, which is a displacement angle of each impeller 30, is expressed by the following formula (2) (30% rotation in the circumferential direction + displacement within one pitch):

(Formula 2)

$$\pm (360° \times 0.3) + (360°/35) \times (0.1 \text{ to } 0.5) \quad \ldots \quad (2)$$

[0075] In the formula (2), "(360°× 0.3)" means the angle of 30% rotation in the circumferential direction, "(360°/35)" means the virtual average pitch angle, and "(360°/35) × (0.1 to 0.5)" means the displacement within one pitch.

[0076] FIG. 3 illustrates a schematic view of the impellers 30 connected to each other with each adjacent impeller 30 being rotated by 30% in the circumferential direction and further displaced within one pitch.

[0077] In each of the impellers 30a, 30b and 30c, the blades 31 are arranged at random pitches, and each of the impellers 30a, 30b and 30c has the blades 31 in the same arrangement. When one blade 31a of the impeller 30a is selected, the blades 31a arranged at the same positions in the respective impellers 30b and 30c can be selected.

[0078] As shown in FIG. 3, with the blade 31a of the impeller 30a as a reference, the blade 31a of the adjacent impeller 30b is rotated by 30% in the circumferential direction and further displaced to a position within one pitch. In this state, the impeller 30a and the impeller 30b are connected to each other. Likewise, with the blade 31a of the impeller 30b as a reference, the blade 31a of the adjacent impeller 30c is rotated by 30% in the circumferential direction and further displaced to a position within one pitch. In this state, the impeller 30b and the impeller 30c are connected to each other.

<Modified Example 1>

[0079] In the present Modified Example 1, the circular connection displacement angle is defined as two pitches or more.

[0080] In the present Modified Example 1, with one impeller 30 as a reference, the adjacent impeller 30 is rotated or reversely rotated in the circumferential direction by n times the virtual average pitch angle (n is an integer of 2, 3, ... 34), and further displaced within one pitch as is conventional. The impellers 30 are connected to each other in this state. In the present embodiment, the displacement within one pitch is 10% to 50% of the virtual average pitch angle.

[0081] The circular connection displacement angle, which is a displacement angle of each impeller 30, is expressed by the following formula (3).

(Formula 3)

$$\pm (360°/35) \times n + (360°/35) \times (0.1 \text{ to } 0.5) \quad \ldots \quad (3)$$

[0082] In the formula (3), "360°/35" means the virtual average pitch angle, and "(360°/35) × (0.1 to 0.5)" means the displacement within one pitch. Also, n is an integer of 2 to 34.

[0083] With the circular connection displacement angle of two pitches or more and the selectable n, an appropriate combination thereof can be set according the kind of the random pitch arrangement and a combination of units on which the impellers 30 are mounted.

[0084] Further, the circular connection displacement angle can be determined according to the frequency of sounds to be reduced among generated sounds, and this allows to connect the impellers 30 based on their characteristics such as the configuration of each impeller 30 and the kind of the random pitch arrangement. The manner of connecting the impellers 30, namely the manner of setting the circular connection displacement angle of each impeller 30 may be determined from tests to derive a value at which the noise can be most effectively reduced.

<Modified Example 2>

[0085] In the present Modified Example 2, the circular connection displacement angle is set according to the number of blades 31.

[0086] In the present Modified Example 2, with one impeller 30 as a reference, the adjacent impeller 30 is rotated or reversely rotated in the circumferential direction by n times the virtual average pitch angle (n is an integer of 1, 2, ... z-1), and further displaced within one pitch as is conventional. The impellers 30 are connected to each other in this state. In the present embodiment, the displacement within one pitch is 10% to 50% of the virtual average pitch angle.

[0087] The circular connection displacement angle, which is a displacement angle of each impeller 30, is expressed by the following formula (4).

(Formula 4)

$$\pm (360^\circ/z) \times (n) + (360^\circ/z) \times (0.1 \text{ to } 0.5) \quad \ldots \quad (4)$$

[0088] In the formula (4), z is the number of blades 31 arranged in the impeller 30, "360°/z" is the virtual average pitch angle, "(360°/z) × (0.1 to 0.5)" is the displacement within one pitch. Also, n is an integer of 1 to (z - 1).

[0089] With the circular connection displacement angle of one pitch or more and the selectable n and with the selectable number of blades 31, an appropriate combination thereof can be set according to the kind of the random pitch arrangement, a combination of units on which the impellers 30 are mounted and the number of blades.

[0090] Further, the circular connection displacement angle can be determined according to the frequency of sounds to be reduced among generated sounds, and this allows to connect the impellers 30 based on their characteristics such as the configuration of each impeller 30 and the kind of the random pitch arrangement. The manner of connecting the impellers 30, namely the manner of setting the circular connection displacement angle of each impeller 30 may be determined from tests to derive a value at which the noise can be most effectively reduced.

[0091] As described above, the tangential fan and the air conditioner according to the present embodiment produce the following functions and effects.

[0092] The tangential fan 28 includes plural impellers 30 connected to each other in a rotational axis direction each including plural blades 31 circularly arranged about the rotational axis to form a cylindrical outer shape of each impeller 30, and the tangential fan 28 blows out a fluid led into an inside of the tangential fan 28 by rotation of the impellers 30. In the tangential fan 28, the blades 31 are arranged in each impeller 30 at random pitches, each impeller 30 includes the blades 31 in the same arrangement, and the adjacent impellers 30 are connected to each other at the circular connection displacement angle that is larger than the virtual average pitch angle derived by dividing 360° by a total number of the blades 31. This complicates the arrangement of the blades 31 in the rotational axis direction, making almost all of the blades 31 positioned at respective different positions.

[0093] This varies the timings at which the respective blades 31 pass the same point in each impeller 30 and deviates the frequencies of sounds generated by the blades 31, which in turn complicates the frequencies of sounds generated by the tangential fan. With a nonuniform arrangement of the impellers 30, phases of the generated frequencies deviate from each other, and this allows to reduce discrete frequency noise, which has a peak at a single frequency.

[0094] Further, the tangential fan 28 more effectively exerts the effects of the random pitch arrangement, namely irregularizing the periodicities of sound sources and dispersing Blade Pass Frequency noise to plural low peaks.

[0095] Moreover, since the arrangement of the blades 31 in each impeller 30 is the same as each other, the tangential fan 28 may be composed of one kind of impeller 30, eliminating the need for increasing the number of components and increasing management and manufacturing costs.

[0096] Further, according to the present embodiment, since the circular connection displacement angle is larger than the value twice the virtual average pitch angle, the arrangement of the blades 31 is made further nonperiodic and complicated, allowing to position almost all of the blades 31 at respective different positions.

[0097] One embodiment of the present invention has been described in detail with reference to the drawings, but specific configurations of the present invention are not limited to the above embodiment. For example, although the tangential fan 28 is provided to the indoor unit 20 of the air conditioner 1 in the above embodiments, the tangential fan 28 may be provided to any other air operation apparatus such as a blower.

Reference signs list

[0098]

1 Air conditioner
20 Indoor unit
28 Tangential fan
30 Impeller
31 Blade

Claims

1. A tangential fan comprising a plurality of impellers connected to each other in a rotational axis direction, each impeller including a plurality of blades circularly arranged about the rotational axis to form a cylindrical outer shape of the impeller, the tangential fan blowing out a fluid led into an inside of the tangential fan by rotation of the impellers, wherein the blades are arranged in the impeller at random pitches, and a value derived by dividing 360° by a total number of the blades is defined as a virtual average pitch angle,
each of the plurality of impellers includes the blades in the same arrangement, and
adjacent impellers of the plurality of impellers are connected to each other at a circular connection displacement angle that is larger than the virtual average pitch angle.

2. The tangential fan according to claim 1, wherein the circular connection displacement angle is larger than a value twice the virtual average pitch angle.

3. An air conditioner comprising an indoor unit and an outdoor unit, wherein
the air conditioner includes, inside the indoor unit, the tangential fan according to claim 1 or 2.

FIG. 1

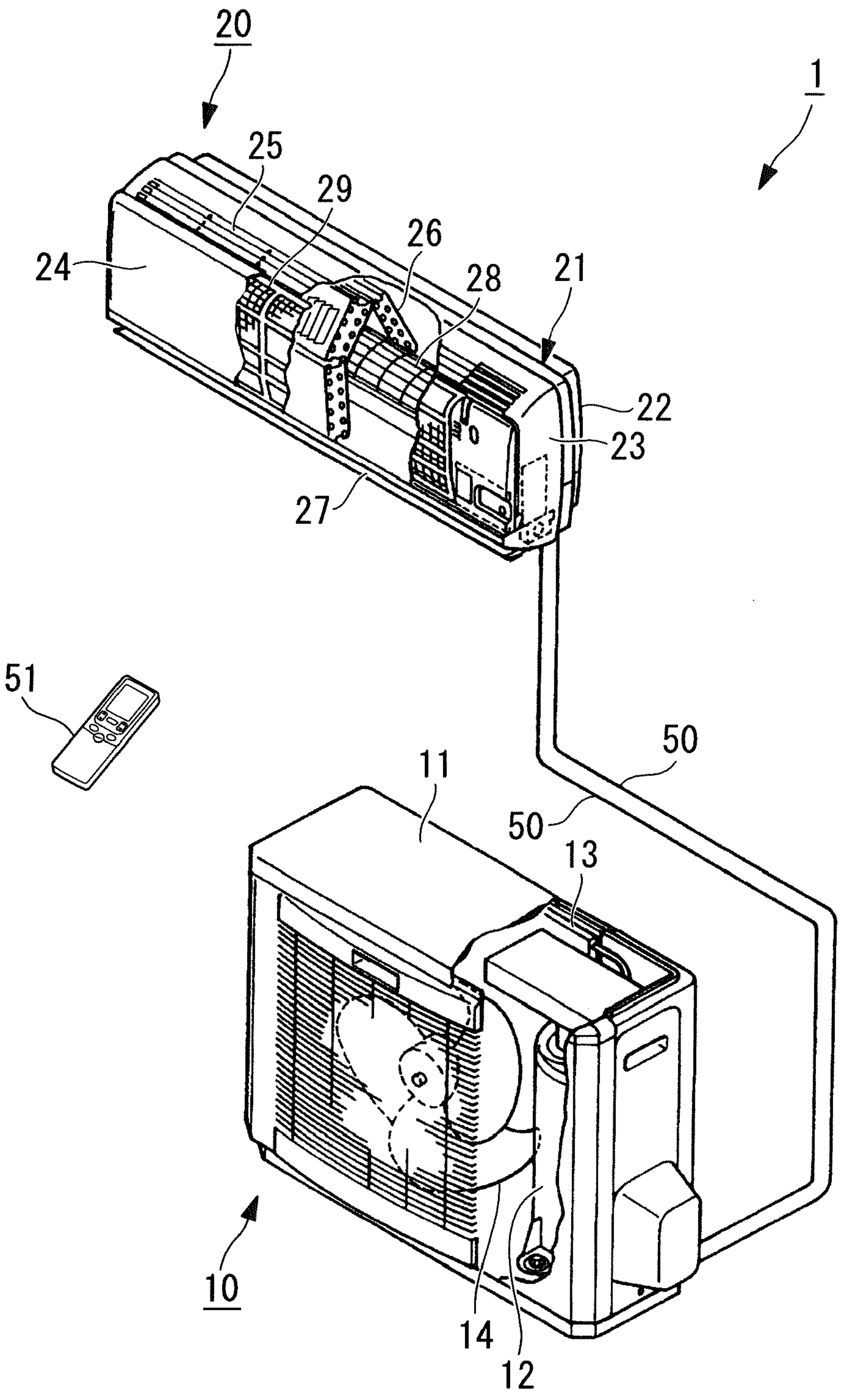


FIG. 2

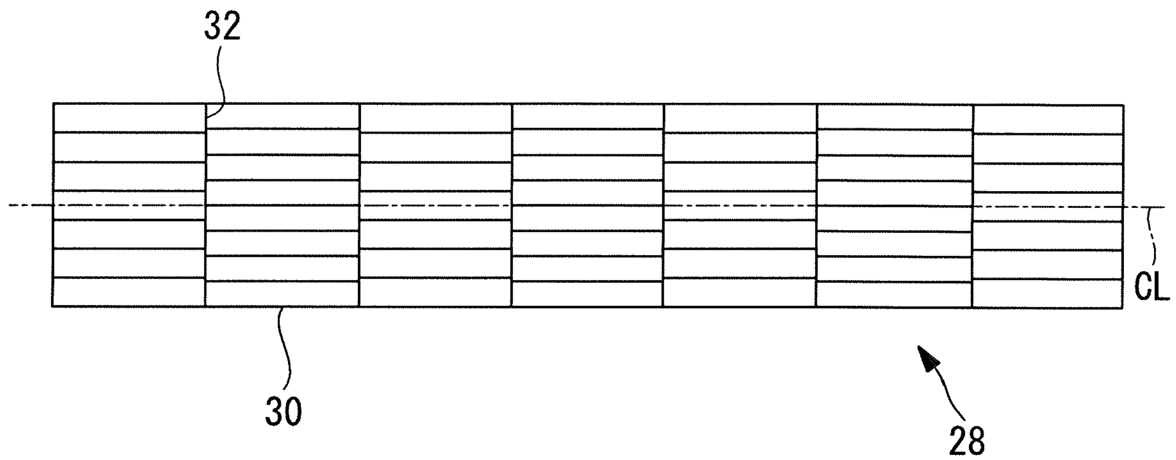


FIG. 3

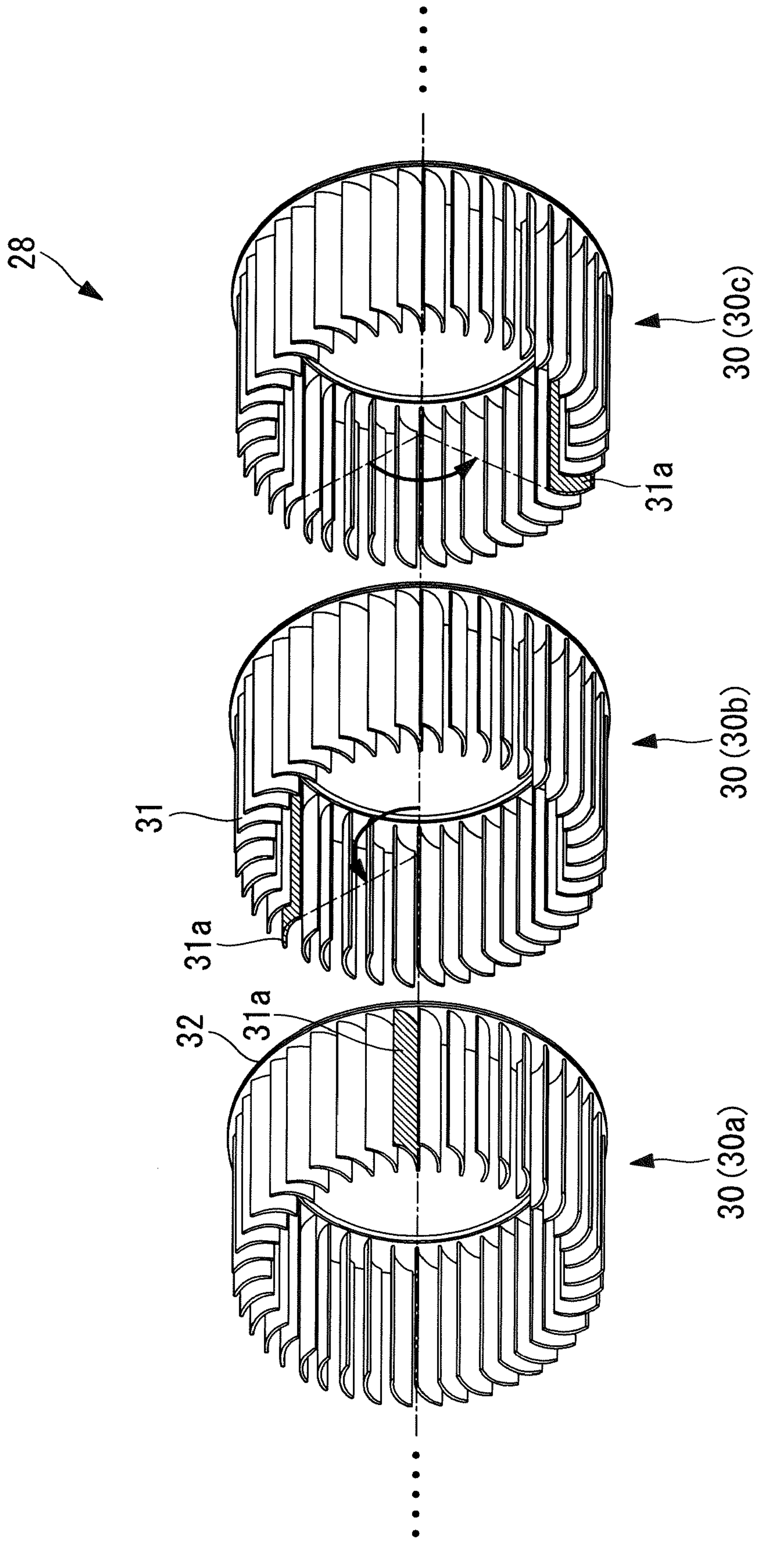


FIG. 4

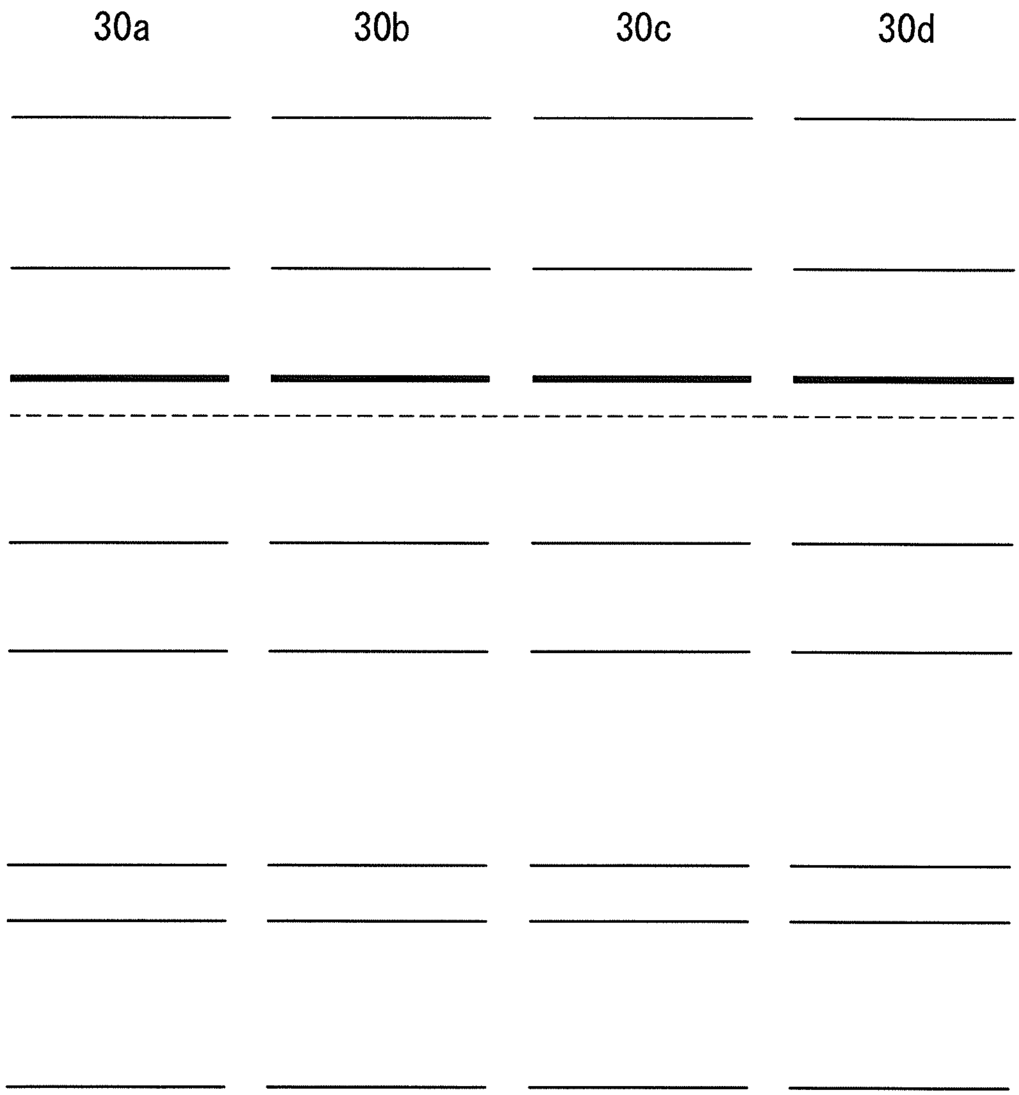


FIG. 5

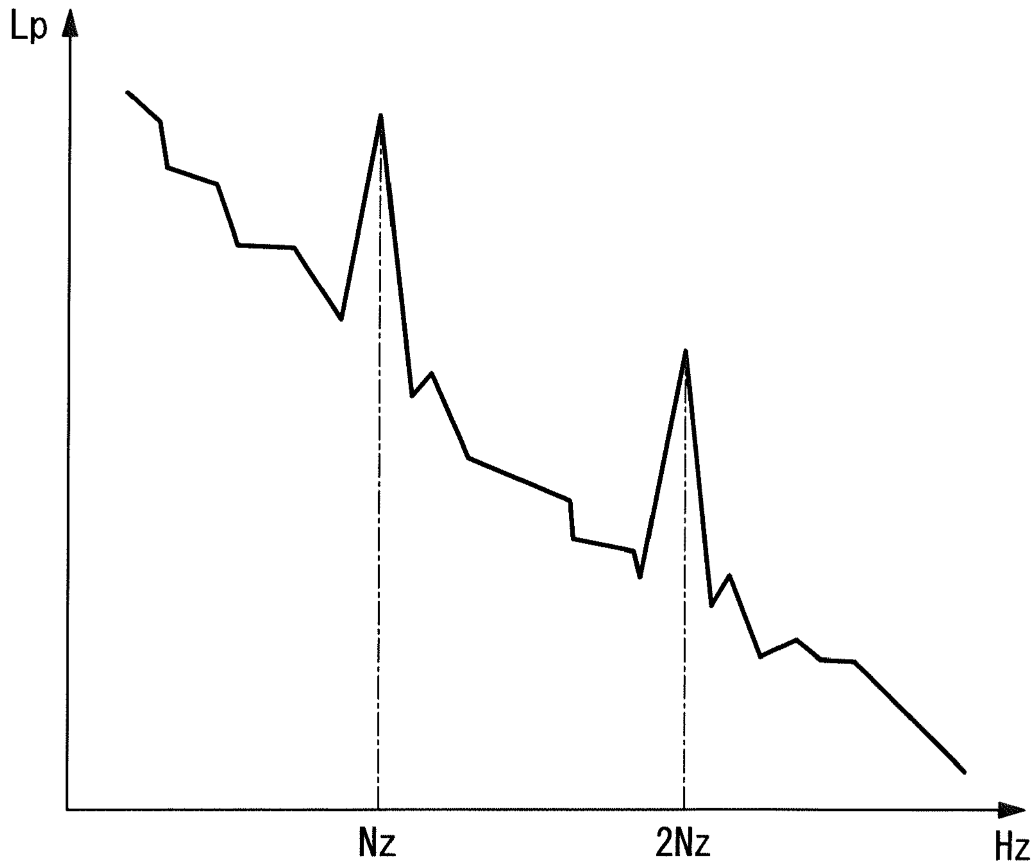


FIG. 6

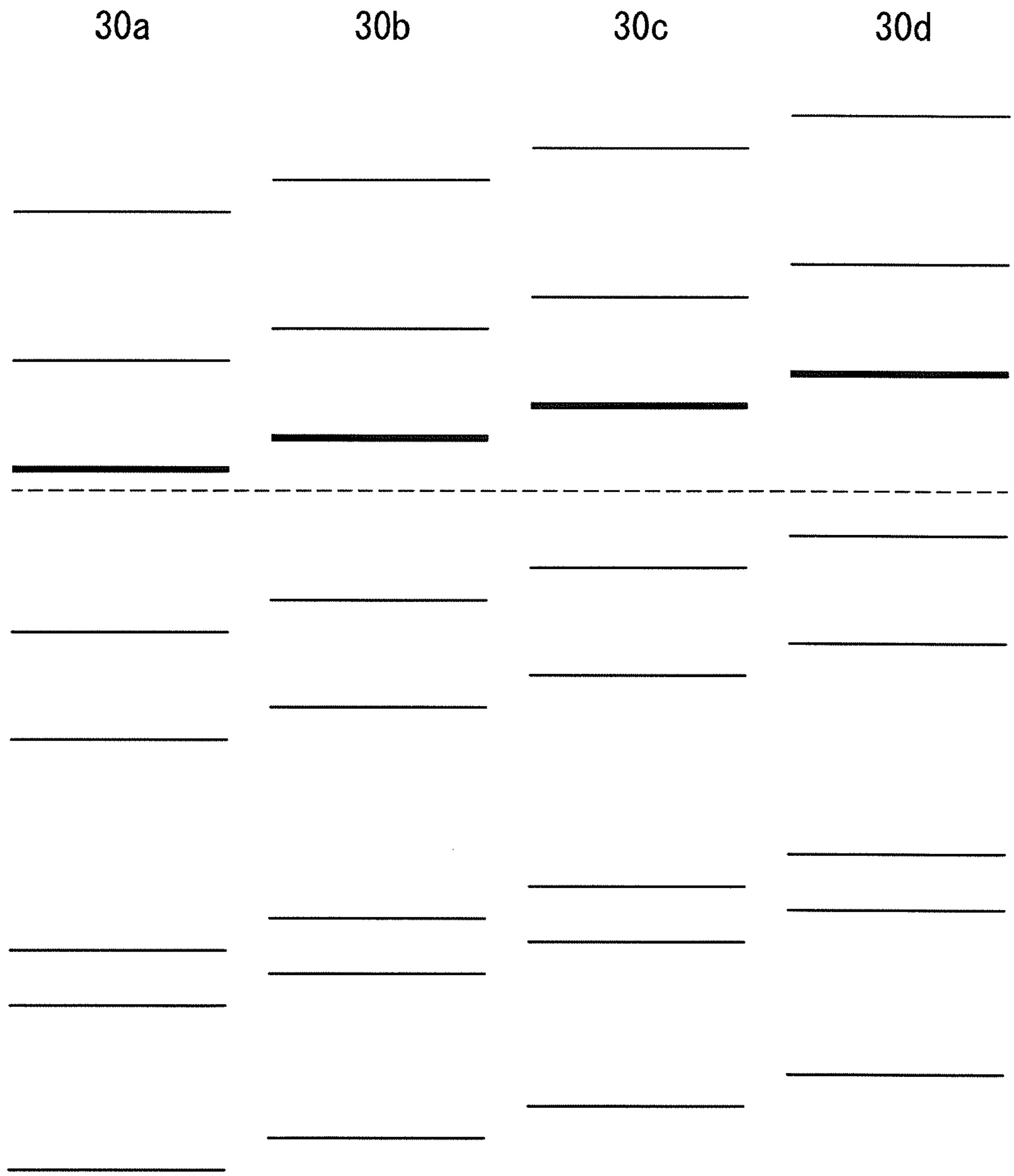


FIG. 7

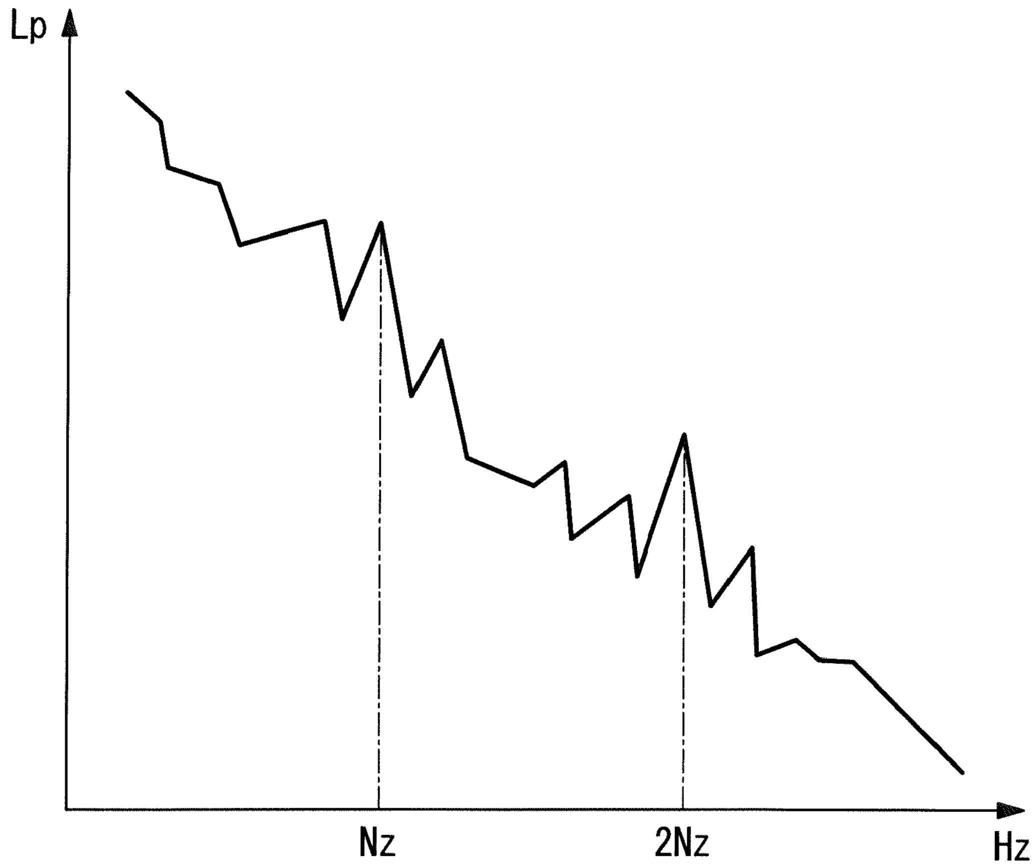


FIG. 8

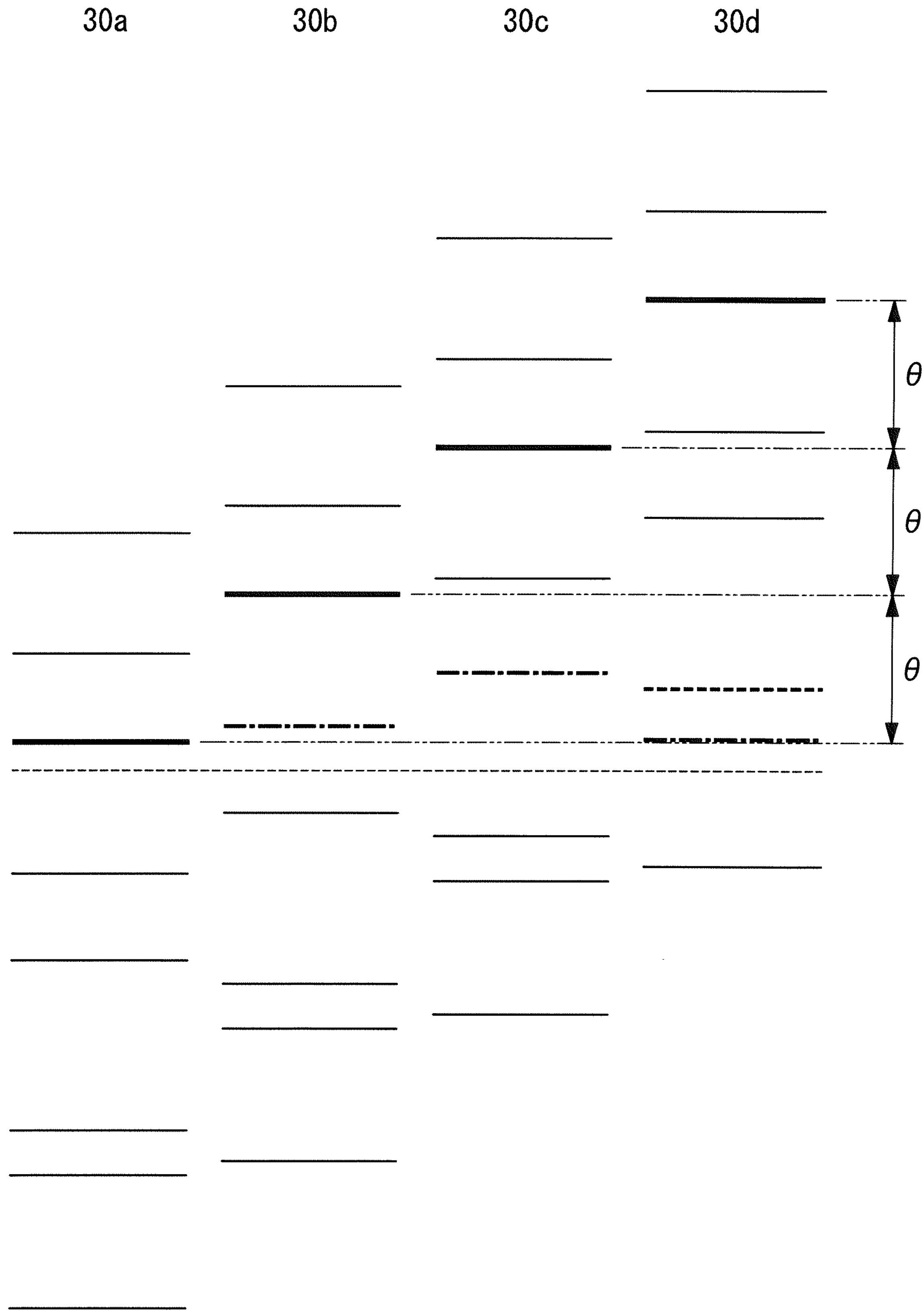
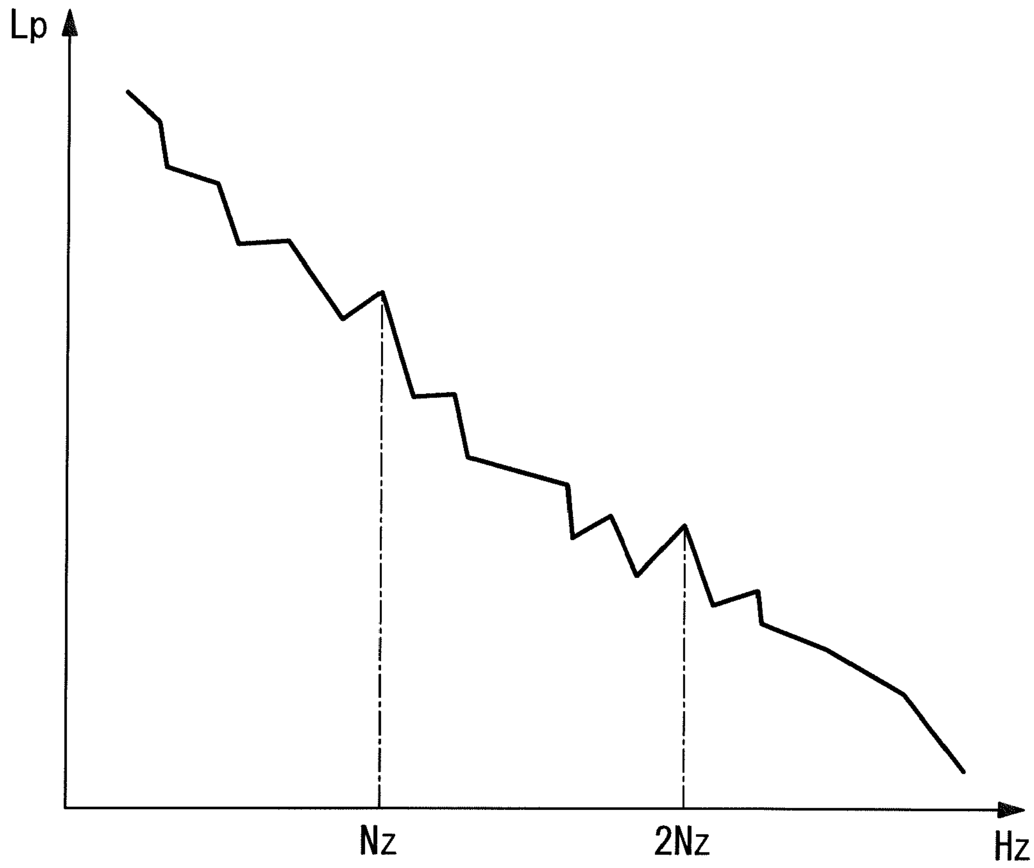


FIG. 9



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EUROPEAN SEARCH REPORT

Application Number
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F04D
F24F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	4 December 2018	De Tobel, David

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