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• **KAMADA, Toshimitsu**
Sakai-shi
Osaka 591-8511 (JP)
• **NAKATA, Haruo**
Sakai-shi
Osaka 591-8511 (JP)

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(71) Applicant: **Daikin Industries, Ltd.**
Osaka 530-8323 (JP)

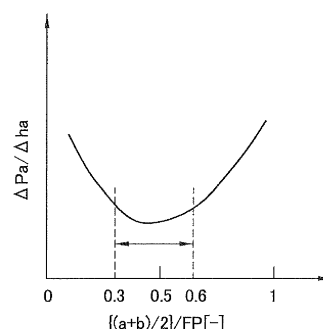
(74) Representative: **HOFFMANN EITLE**
Patent- und Rechtsanwälte
Arabellastraße 4
81925 München (DE)

(72) Inventors:
• **FUJINO, Hirokazu**
Sakai-shi
Osaka 591-8511 (JP)

(54) **FIN-TUBE HEAT EXCHANGER**

(57) A fin tube type heat exchanger (1) that includes: a plurality of heat transfer fins (2), the heat transfer fins being lined up such that they are spaced apart in the plate thickness directions and being disposed in a gas current; and a plurality of heat transfer tubes (3), the heat transfer tubes being inserted into the plurality of heat transfer fins (2) and being disposed in directions substantially orthogonal to a gas current flow direction. In each of the heat transfer fins (2), a plurality of cut and raised parts, the cut and raised parts being lined up from the upstream side to the downstream side in the gas current flow direction, are formed on both sides of each of the heat transfer tubes (3) in the vertical directions; the heights of each of the cut and raised parts with respect to the heat transfer fin surface increase gradually toward the downstream side in the gas current flow direction; and for each of the cut and raised parts, the value calculated by dividing the average height of the front end height (a), which is the height of the gas current flow direction front end with respect to the heat transfer fin surface, and the rear end height (b), which is the height of the gas current flow direction rear end with respect to the heat transfer fin surface, by a fin pitch (FP) is greater than 0.3 and less than 0.6.

FIG. 6



Description

TECHNICAL FIELD

[0001] The present invention relates to a fin tube type heat exchanger and more particularly relates to a fin tube type heat exchanger that comprises multiple heat transfer fins, which are disposed in a gas current such that they are lined up and spaced apart in the plate thickness directions, and multiple heat transfer tubes, which are inserted into the heat transfer fins and disposed in directions substantially orthogonal to the gas current flow direction, wherein multiple cut and raised parts, which are lined up from the upstream side to the downstream side in the gas current flow direction, are formed by a cutting and raising fabrication process in the heat transfer fin surfaces on both sides of each of the heat transfer tubes in the vertical directions.

BACKGROUND ART

[0002] In one known fin tube type heat exchanger used in an air conditioner and the like, as shown in **FIG 1** and **FIG 2**, to reduce the size of a dead water area formed in portions of each heat transfer fin **102** on the downstream side of each heat transfer tube **103** in an air current flow direction and to promote the transfer of heat by, for example, updating the boundary layers of the heat transfer fins **102**, cut and raised parts **104a-104c**, **104d-104f**, which are inclined with respect to the air current flow direction, are formed by a cutting and raising fabrication process in heat transfer fin surfaces **102b** on both sides of each of the heat transfer tubes **103** in the vertical directions such that an air current in the vicinity of each of the heat transfer tubes **103** is guided to the rear side of the heat transfer tube **103** in the air current flow direction; furthermore, to prevent drain water generated by the exchange of heat between air and a thermal medium, such as a refrigerant, from pooling in the cut and raised parts **104a-104c**, **104d-104f** and thereby reducing drainage performance, the cut and raised parts **104a-104c**, **104d-104f** are divided into sets of three and lined up from the upstream side to the downstream side in the air current flow direction. Furthermore, the cut and raised parts **104a-104c**, which are lined up from the upstream side to the downstream side in the air current flow direction, and the cut and raised parts **104d-104f**, which are lined up from the upstream side to the downstream side in the air current flow direction, are formed such that their heights from the heat transfer fin surfaces increase gradually over the entire span toward the downstream side in the air current flow direction (as Patent Document 1, refer to Japanese Laid-open Patent Application Publication No. 2008-111646).

SUMMARY OF THE INVENTION

[0003] A fin tube type heat exchanger according to a

first aspect of the present invention comprises a plurality of heat transfer fins and a plurality of heat transfer tubes. The heat transfer fins are lined up such that they are spaced apart in the plate thickness directions and are disposed in a gas current. The heat transfer tubes are inserted into the plurality of heat transfer fins and are disposed in directions substantially orthogonal to a gas current flow direction. Furthermore, in each of the heat transfer fins, a plurality of cut and raised parts, the cut and raised parts being lined up from the upstream side to the downstream side in the gas current flow direction, are formed by a cutting and raising fabrication process on both sides of each of the heat transfer tubes in the vertical directions; the plurality of cut and raised parts are inclined with respect to the gas current flow direction such that the gas current in the vicinity of each of the heat transfer tubes is guided to a rear side in the gas current flow direction of that heat transfer tube; the heights of each of the cut and raised parts with respect to the heat transfer fin surface increase gradually toward the downstream side in the gas current flow direction; and, for each of the cut and raised parts, the value calculated by dividing the average height of the front end height, which is the height of the gas current flow direction front end with respect to the heat transfer fin surface, and the rear end height, which is the height of the gas current flow direction rear end with respect to the heat transfer fin surface, by a fin pitch, which is the spacing between the heat transfer fins, is greater than 0.3 and less than 0.6.

[0004] As in the conventional art, the adoption of a configuration wherein the heat transfer fins are formed such that, with respect to the heat transfer fin surface, the heights of the multiple cut and raised parts lined up from the upstream side to the downstream side in the gas current flow direction increase gradually over the entire span toward the downstream side in the air current flow direction makes it easy to obtain the guide effect wherein the air current in the vicinity of each of the heat transfer tubes is guided to the rear side in the air current flow direction or that heat transfer tube, thereby reducing the corresponding dead water area, as well as to prevent, as much as possible, any increase in ventilation resistance at the cut and raised parts on the upstream side in the air current flow direction; however, attendant with the adoption of such a configuration, if the heights of the cut and raised parts on the upstream side in the air current flow direction with respect to the heat transfer fin surface are too low, then the effect of producing longitudinal vortices behind the cut and raised parts decreases, thereby making it difficult to obtain the heat transfer promotion effect produced by these longitudinal vortices, which is a problem.

[0005] Consequently, when the multiple cut and raised parts, which are lined up from the upstream side to the downstream side in the gas current flow direction, are formed in the heat transfer fin, it is necessary to determine the height of each of the cut and raised parts with respect to the heat transfer fin surface such that the given cut and raised part yields both heat transfer performance

and ventilation performance; if this viewpoint is not taken into consideration, then it cannot definitively be said to be preferable to form the multiple cut and raised parts, which are lined up from the upstream side to the downstream side in the gas current flow direction, in the heat transfer fin such that their heights with respect to the heat transfer fin surface increase gradually over the entire span toward the downstream side in the air current flow direction.

[0006] In contrast, in the fin tube type heat exchanger wherein the multiple cut and raised parts, which are lined up from the upstream side to the downstream side in the gas current flow direction, are arranged to be inclined with respect to the gas current flow direction such that the gas current in the vicinity of each of the heat transfer tubes is guided to the rear side in the gas current flow direction of that heat transfer tube, the inventors of the present application evaluated the heat transfer performance of the cut and raised parts taking ventilation resistance into account and discovered that the heat transfer performance per unit of ventilation resistance can be increased by making the heights of each of the cut and raised parts with respect to the heat transfer fin surface increase gradually toward the downstream side in the gas current flow direction (i.e., making, for each of the cut and raised parts, the rear end height, which is the height with respect to the heat transfer fin surface at the rear end in the gas current flow direction, greater than the front end height, which is the height with respect to the heat transfer fin surface at the front end in the gas current flow direction) and setting the value calculated by dividing the average height of the front end height and the rear end height by the fin pitch to a value greater than 0.3 and less than 0.6.

[0007] Furthermore, in the present fin tube type heat exchanger, because the rear end height is assumed to be greater than the front end height for each of the multiple cut and raised parts, which are arranged to be inclined with respect to the gas current flow direction so that the gas current in the vicinity of each of the heat transfer tubes is guided to the rear side in the gas current flow direction of that heat transfer tube, and the relationship between the average height and the fin pitch discussed above applies, regarding the cut and raised parts on the upstream side in the gas current flow direction, the heights of the cut and raised parts that are on the upstream side in the gas current flow direction with respect to the heat transfer fin surface are no longer insufficient; thereby, the effect of generating a longitudinal vortex to the rear of each of the cut and raised parts increases, which makes it possible to improve the heat transfer performance per unit of ventilation resistance (i.e., to improve the heat transfer performance while minimizing any increase in ventilation resistance). In addition, the heights of the cut and raised parts that are on the downstream side in the gas current flow direction with respect to the heat transfer fin surface are no longer excessive, which makes it easy to obtain the guide effect wherein the gas

current in the vicinity of each of the heat transfer tubes is guided to the rear side in the gas current flow direction of that heat transfer tube; thereby, the heat transfer performance per unit of ventilation resistance can be improved (i.e., it is possible to prevent an increase in ventilation resistance while maximizing the guide effect).

[0008] Thus, in the present fin tube type heat exchanger, it is possible to achieve both heat transfer performance and ventilation performance of the cut and raised parts and thereby to make a high performance heat exchanger.

[0009] A fin tube type heat exchanger according to a second aspect of the present invention is the fin tube type heat exchanger according to the first aspect of the present invention, wherein an inclination angle, which is an angle formed between a ridge of each of the cut and raised parts and the heat transfer fin surface, is less than 30°.

[0010] In the fin tube type heat exchanger according to the first aspect of the present invention discussed above, because the rear end height is assumed to be greater than the front end height and the relationship between the average height and the fin pitch discussed above applies, if, for example, the front end height of each of the cut and raised parts was made extremely small, then it would be necessary to increase the rear end height of each of the cut and raised parts; thereby, an inclination angle formed by the ridge of each of the cut and raised parts and the heat transfer fin surface would increase.

[0011] However, if the inclination angle is excessively large, then the heat transfer performance per unit of ventilation resistance will adversely decline; furthermore, the application of the relationship between the average height and the fin pitch discussed above with the assumption that the rear end height is greater than the front end height will hinder improvement in the heat transfer performance per unit of ventilation resistance.

[0012] Accordingly, the inventors of the present application evaluated the relationship between the inclination angle and the heat transfer performance per unit of ventilation resistance and discovered that, by making the inclination angle less than 30°, a high heat transfer performance per unit of ventilation resistance can be maintained.

[0013] Furthermore, in the present fin tube type heat exchanger, because the condition of the inclination angle discussed above is further applied with respect to each of the multiple cut and raised parts, which are arranged to be inclined with respect to the gas current flow direction so that the gas current in the vicinity of each of the heat transfer tubes is guided to the rear side in the gas current flow direction of that heat transfer tube, it is possible to reliably obtain the effect of improving heat transfer performance per unit of ventilation resistance by the application of the relationship between the average height and the fin pitch discussed above.

[0014] A fin tube type heat exchanger according to a

third aspect of the present invention is the fin tube type heat exchanger according to the first or second aspect of the present invention, wherein the plurality of cut and raised parts are disposed such that their average heights sequentially increase at a greater rate in the cut and raised parts on the downstream side in the gas current flow direction than in the cut and raised parts on the upstream side in the gas current flow direction.

[0015] In the fin tube type heat exchanger according to the first or second aspect of the present invention discussed above, because just the shape is defined for each of the cut and raised parts, cases might arise wherein the heights of the cut and raised parts on the upstream side in the gas current flow direction with respect to the heat transfer fin surface are greater than the heights of the cut and raised parts on the downstream side in the gas current flow direction with respect to the heat transfer fin surface; thereby, compared with the case wherein a configuration is adopted wherein the heat transfer fins are formed such that the heights of the multiple cut and raised parts, which are lined up from the upstream side to the downstream side in the gas current flow direction, increase gradually over the entire span toward the downstream side in the gas current flow direction with respect to the heat transfer fin surface, there is a risk that it will become difficult to obtain the guide effect wherein the air current in the vicinity of each of the heat transfer tubes is guided to the rear side in the gas current flow direction of that heat transfer tube.

[0016] Accordingly, in the present fin tube type heat exchanger, disposing the cut and raised parts such that their average heights increase sequentially at a greater rate in the cut and raised parts on the downstream side in the gas current flow direction than in the cut and raised parts on the upstream side in the gas current flow direction makes it easier to obtain the guide effect wherein the gas current in the vicinity of each of the heat transfer tubes is guided to the rear side in the gas current flow direction of that heat transfer tube, which in turn makes it possible to reduce the size of the corresponding dead water area.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

FIG. 1 is a cross sectional view of a conventional fin tube type heat exchanger.

FIG. 2 is a cross sectional view taken along the I-I line in **FIG. 1**.

FIG. 3 is a cross sectional view of a fin tube type heat exchanger according to one embodiment of the present invention.

FIG. 4 is a cross sectional view taken along the I-I line in **FIG. 3**.

FIG. 5 is a diagram that schematically shows a cross sectional view taken along the II-II line or along the III-III line in **FIG. 3**.

FIG. 6 shows the effect of the shape (i.e., the average height) of the cut and raised part on the promotion of heat transfer.

FIG. 7 shows the effect of the shape (i.e., the inclination angle) of the cut and raised part on the promotion of heat transfer.

FIG. 8 is a cross sectional view of a fin tube type heat exchanger according to a modified example.

FIG. 9 is a cross sectional view taken along the I-I line in **FIG. 8**.

DESCRIPTION OF EMBODIMENTS

[0018] The following text explains an embodiment of a fin tube type heat exchanger according to the present invention, referencing the drawings.

[0019] **FIG. 3** through **FIG. 7** show the principal parts of a fin tube type heat exchanger **1** according to one embodiment of the present invention. Here, **FIG. 3** is a cross sectional view of the fin tube type heat exchanger **1**. **FIG. 4** is a cross sectional view taken along the I-I line in **FIG. 3**. **FIG. 5** is a diagram that schematically shows a cross sectional view taken along the II-II line or along the III-III line in **FIG. 3**. **FIG. 6** shows the effect of the shape (i.e., the average height) of the cut and raised part on the promotion of heat transfer. **FIG. 7** shows the effect of the shape (i.e., the inclination angle) of the cut and raised part on the promotion of heat transfer.

(1) Basic Configuration of the Fin Tube Type Heat Exchanger

[0020] The fin tube type heat exchanger **1** is a cross fin and tube type heat exchanger and principally comprises multiple plate shaped heat transfer fins **2** and multiple heat transfer tubes **3**. The heat transfer fins **2** are lined up such that they are spaced apart by a prescribed spacing in the plate thickness directions in the state wherein their flat surfaces generally run along the direction of flow of a current of gas, such as air. Multiple through holes **2a**, which are spaced apart in directions substantially orthogonal to the gas current flow direction, are formed in each of the heat transfer fins **2**. The portion that surrounds each of the through holes **2a** is an annular collar part **8**, which projects in one of the plate thickness directions of each of the heat transfer fins **2**. Each of the collar parts **8** is configured such that it makes contact with the surface that is on the side opposite the surface whereon the collar part **8** of the heat transfer fin **2** that is adjacent in the plate thickness directions is formed and thereby maintains a prescribed spacing between the heat transfer fins **2** in the plate thickness directions (hereinbelow, this prescribed spacing is called a fin pitch *FP*). Each of the heat transfer tubes **3** is a tube member where-through a thermal medium, such as a refrigerant, flows; furthermore, the heat transfer tubes **3** are inserted into the multiple heat transfer fins **2** and are disposed in the directions substantially orthogonal to the gas current flow

direction. Specifically, the heat transfer tubes **3** are inserted through the through holes **2a** formed in the heat transfer fins **2** and are tightly sealed to the inner surfaces of the collar parts **8** by a tube expanding procedure that is performed when the fin tube type heat exchanger **1** is assembled.

[0021] In addition, the fin tube type heat exchanger **1** of the present embodiment is used in the state wherein the fin tube type heat exchanger **1** is installed such that the directions in which the multiple heat transfer tubes **3** are arrayed are substantially the vertical directions (namely, **FIG. 3** shows only two heat transfer tubes **3** of the multiple heat transfer tubes **3**). Consequently, the gas current flows such that it traverses the fin tube type heat exchanger **1** in substantially a horizontal direction. Furthermore, when the terms "upstream," "above," "downstream," and "below" are used in the explanation below, they refer to the direction in which the heat transfer tubes **3** are arrayed.

(2) Detailed Shape of the Heat Transfer Fins

[0022] Next, the detailed shape of the heat transfer fins **2** used in the fin tube type heat exchanger **1** of the present embodiment will be explained.

[0023] In each of the heat transfer fins **2**, multiple cut and raised parts **4a-4f** are formed in a heat transfer fin surface **2b** by a cutting and raising fabrication process on both sides of each of the heat transfer tubes **3** in the vertical directions (namely, above and below each of the heat transfer tubes **3**) such that they are lined up from the upstream to the downstream side in the gas current flow direction (in the present embodiment, three below each of the heat transfer tubes **3** and three above each of the heat transfer tubes **3**). Here, the three cut and raised parts below each of the heat transfer tubes **3** are the first cut and raised parts **4a-4c**, and the three cut and raised parts above each of the heat transfer tubes **3** are the second cut and raised parts **4d-4f**. Each of the cut and raised parts **4a-4f** is a substantially trapezoidal portion formed by making a cut in the heat transfer fin **2** and then raising the cut portion in the plate thickness directions of the heat transfer fin **2**. Furthermore, attendant with the cutting and raising of the cut and raised parts **4a-4f**, substantially trapezoidal slit holes **7a-7f** are formed corresponding to each of the cut and raised parts **4a-4f** in portions adjacent to each of the cut and raised parts **4a-4f** of each of the heat transfer fins **2**.

[0024] The first cut and raised parts **4a-4c** and the second cut and raised parts **4d-4f** are arranged to be inclined with respect to the gas current flow direction such that the gas current in the vicinity of each of the heat transfer tubes **3** is guided to the rear side of the heat transfer tube **3** in the gas current flow direction. More specifically, the first cut and raised parts **4a-4c** are disposed such that an angle of attack $\alpha 1$ of each of the first cut and raised parts **4a-4c** with respect to the gas current flow direction is positive and such that they are lined up straightly along

a straight line **M1**. In addition, the second cut and raised parts **4d-4f** are disposed such that an angle of attack $\alpha 2$ of each of the second cut and raised parts **4d-4f** with respect to the gas current flow direction is positive and such that they are lined up straightly along a straight line **M2**. Here, the angle of attacks $\alpha 1$, $\alpha 2$ are positive if each of the cut and raised parts **4a-4f** are inclined such that each of gas current flow direction front ends **5a-5f** of the cut and raised parts **4a-4f** are positioned farther from the corresponding heat transfer tube **3** than are each of gas current flow direction rear ends **6a-6f** of the cut and raised parts **4a-4f**.

[0025] In addition, in the present embodiment, the heights of each of the cut and raised parts **4a-4f** from the heat transfer fin surface **2b** gradually increase toward the downstream side in the gas current flow direction. More specifically, in the first cut and raised part **4a**, the height of the rear end **6a** with respect to the heat transfer fin surface **2b** is greater than the height of the front end **5a** with respect to the heat transfer fin surface **2b**; in the first cut and raised part **4b**, the height of the rear end **6b** with respect to the heat transfer fin surface **2b** is greater than the height of the front end **5b** with respect to the heat transfer fin surface **2b**; in the first cut and raised part **4c**, the height of the rear end **6c** with respect to the heat transfer fin surface **2b** is greater than the height of the front end **5c** with respect to the heat transfer fin surface **2b**; in the second cut and raised part **4d**, the height of the rear end **6d** with respect to the heat transfer fin surface **2b** is greater than the height of the front end **5d** with respect to the heat transfer fin surface **2b**; in the second cut and raised part **4e**, the height of the rear end **6e** with respect to the heat transfer fin surface **2b** is greater than the height of the front end **5e** with respect to the heat transfer fin surface **2b**; and in the second cut and raised part **4f**, the height of the rear end **6f** with respect to the heat transfer fin surface **2b** is greater than the height of the front end **5f** with respect to the heat transfer fin surface **2b**. Furthermore, if we let front end height a be the height of each of the cut and raised parts **4a-4f** with respect to the heat transfer fin surface **2b** at the front end in the gas current flow direction, rear end height b be the height of each of the cut and raised parts **4a-4f** with respect to the heat transfer fin surface **2b** at the rear end in the gas current flow direction, and average height H be the average value of the front end height a and the rear end height b (i.e., $(a + b)/2$) (refer to **FIG. 5**), then the value calculated by dividing the average height H by the fin pitch FP (i.e., $\{(a + b)/2\}/FP$) is set such that the value is greater than 0.3 and less than 0.6. In the fin tube type heat exchanger **1** wherein multiple cut and raised parts **4a-4f**, which are lined up from the upstream side to the downstream side in the gas current flow direction, are arranged to be inclined with respect to the gas current flow direction so that gas current in the vicinity of each of the heat transfer tubes **3** is guided to the rear side in the gas current flow direction of that heat transfer tube **3**, the inventor of the present application discovered the

relationship between the average height H of each of the cut and raised parts **4a-4f** and the fin pitch FP by evaluating the heat transfer performance of the cut and raised parts **4a-4f** while taking ventilation resistance into account. Specifically, in the fin tube type heat exchanger **1** wherein multiple cut and raised parts **4a-4f**, which are lined up from the upstream side to the downstream side in the gas current flow direction, are arranged to be inclined with respect to the gas current flow direction so that the gas current in the vicinity of each of the heat transfer tubes **3** is guided to the rear side in the gas current flow direction of that heat transfer tube **3**, when the inventors of the present application evaluated the heat transfer performance of the cut and raised parts **4a-4f** taking ventilation resistance into account, they discovered the relationship between the value calculated by dividing a ventilation resistance rate of increase ΔPa when the number of cut and raised parts was increased by a coefficient of heat transfer rate of increase Δha when the number of cut and raised parts was increased (i.e., $\Delta Pa/\Delta ha$) and the value $\{(a+b)/2\}/FP$ discussed above to be as shown in **FIG 6**; furthermore, based on this relationship, the range of $\{(a+b)/2\}/FP$ wherein the promotion factor of the heat transfer performance per unit of ventilation resistance increases was derived as greater than 0.3 and less than 0.6.

[0026] Furthermore, in the fin tube type heat exchanger **1** of the present embodiment, because the rear end height b is assumed to be greater than the front end height a for each of the multiple cut and raised parts **4a-4f**, which are arranged to be inclined with respect to the gas current flow direction so that the gas current in the vicinity of each of the heat transfer tubes **3** is guided to the rear side in the gas current flow direction of that heat transfer tube **3**, and the relationship between the average height H and the fin pitch FP discussed above applies, regarding the cut and raised parts **4a-4f** on the upstream side in the gas current flow direction, the heights of the cut and raised parts **4a-4f** that are on the upstream side in the gas current flow direction (e.g., the cut and raised parts **4a, 4d**, which are disposed most on the upstream side in the gas current flow direction) with respect to the heat transfer fin surface **2b** are no longer insufficient; thereby, the effect of generating a longitudinal vortex to the rear of each of the cut and raised parts **4a-4f** increases, which makes it possible to improve the heat transfer performance per unit of ventilation resistance (i.e., to improve the heat transfer performance while minimizing any increase in ventilation resistance). In addition, the heights of the cut and raised parts **4a-4f** that are on the downstream side in the gas current flow direction (e.g., the cut and raised parts **4c, 4f**, which are disposed most on the downstream side in the gas current flow direction) with respect to the heat transfer fin surface **2b** are no longer excessive, which makes it easy to obtain the guide effect wherein the gas current in the vicinity of each of the heat transfer tubes **3** is guided to the rear side in the gas current flow direction of that heat transfer tube **3**; thereby,

the heat transfer performance per unit of ventilation resistance can be improved (i.e., it is possible to prevent an increase in ventilation resistance while maximizing the guide effect).

[0027] Thus, in the fin tube type heat exchanger **1** of the present embodiment, it is possible to achieve both heat transfer performance and ventilation performance of the cut and raised parts **4a-4f** and thereby to make a high performance heat exchanger.

[0028] Incidentally, in the fin tube type heat exchanger **1** of the present embodiment, because the rear end height b is assumed to be greater than the front end height a and the relationship between the average height H and the fin pitch FP discussed above applies, if, for example, the front end height a of each of the cut and raised parts **4a-4f** was made extremely small, then it would be necessary to increase the rear end height b of each of the cut and raised parts **4a-4f**; thereby, an inclination angle θ (refer to **FIG 5**) formed by the ridge of each of the cut and raised parts **4a-4f** and the heat transfer fin surface **2b** would increase. Here, the ridges of each of the cut and raised parts **4a-4f** refer to the lines that connect the tips of the front ends **5a-5f** of the cut and raised parts **4a-4f** that are farthest from the heat transfer fin surface **2b** and the tips of the rear ends **6a-6f** of the cut and raised parts **4a-4f** that are farthest from the heat transfer fin surface **2b**. In addition, the inclination angle θ is the narrow angle formed between the ridge of each of the cut and raised parts **4a-4f** and the heat transfer fin surface **2b**.

[0029] However, if the inclination angle θ is excessively large, then the heat transfer performance per unit of ventilation resistance will adversely decline (refer to **FIG. 7**); furthermore, the application of the relationship between the average height H and the fin pitch FP discussed above with assumption that the rear end height b is greater than the front end height a will hinder improvement in the heat transfer performance per unit of ventilation resistance, and therefore it is preferable to limit the inclination angle θ so as to maintain a high heat transfer performance per unit of ventilation resistance.

[0030] Accordingly, the inventors of the present application evaluated the relationship between the inclination angle θ and the heat transfer performance per unit of ventilation resistance and discovered that, as shown in **FIG. 7**, there is a relationship between the inclination angle θ and the value calculated by dividing the ventilation resistance rate of increase ΔPa when the number of cut and raised parts was increased by the coefficient of heat transfer rate of increase Δha when the number of cut and raised parts was increased (i.e., $\Delta Pa/\Delta ha$) and, based on this relationship, derived the inclination angle θ wherein a high heat transfer performance per unit of ventilation resistance can be maintained to be in the range of less than 30°.

[0031] Furthermore, in the fin tube type heat exchanger **1** of the present embodiment, because the condition of the inclination angle θ discussed above is further ap-

plied with respect to each of the multiple cut and raised parts **4a-4f**, which are arranged to be inclined with respect to the gas current flow direction so that the gas current in the vicinity of each of the heat transfer tubes **3** is guided to the rear side in the gas current flow direction of that heat transfer tube **3**, it is possible to reliably obtain the effect of improving heat transfer performance per unit of ventilation resistance by the application of the relationship between the average height H and the fin pitch FP discussed above.

[0032] In addition, in the present embodiment, if just the shape were defined for each of the cut and raised parts **4a-4f** (i.e., if just the relationship between the average height H and the fin pitch FP discussed above applied or if just the relationship between the average height H and the fin pitch FP discussed above and the condition of the inclination angle θ discussed above applied), then cases might arise wherein the heights of the cut and raised parts on the upstream side in the gas current flow direction of the first cut and raised parts **4a-4c** with respect to the heat transfer fin surface **2b** are greater than the heights of the cut and raised parts on the downstream side in the gas current flow direction of the first cut and raised parts **4a-4c** with respect to the heat transfer fin surface **2b** or wherein the heights of the cut and raised parts on the upstream side in the gas current flow direction of the second cut and raised parts **4d-4f** with respect to the heat transfer fin surface **2b** are greater than the heights of the cut and raised parts on the downstream side in the gas current flow direction of the second cut and raised parts **4d-4f** with respect to the heat transfer fin surface **2b**; thereby, compared with the case wherein a configuration is adopted wherein the heat transfer fins **2** are formed such that the heights of the multiple cut and raised parts **4a-4f**, which are lined up from the upstream side to the downstream side in the gas current flow direction, increase gradually over the entire span toward the downstream side in the gas current flow direction with respect to the heat transfer fin surface **2b**, there is a risk that it will become difficult to obtain the guide effect wherein the air current in the vicinity of each of the heat transfer tubes **3** is guided to the rear side in the gas current flow direction of that heat transfer tube **3**.

[0033] Accordingly, in the fin tube type heat exchanger **1** of the present embodiment, disposing the first cut and raised parts **4a-4c** such that their average heights H increase sequentially at a greater rate in the cut and raised parts on the downstream side in the gas current flow direction than in the cut and raised parts on the upstream side in the gas current flow direction and disposing the second cut and raised parts **4d-4f** such that their average heights H sequentially increase at a greater rate in the cut and raised parts on the downstream side in the gas current flow direction than in the cut and raised parts on the upstream side in the gas current flow direction makes it easier to obtain the guide effect wherein the gas current in the vicinity of each of the heat transfer tubes **3** is guided to the rear side in the gas current flow direction of that

heat transfer tube **3**, which in turn makes it possible to reduce the size of the corresponding dead water area.

(3) Modified Example

[0034] In the embodiment discussed above (refer to **FIG. 3** and **FIG. 4**), flat plate shaped fins are used as the heat transfer fins, but the present invention is not limited thereto, and waffle shaped heat transfer fins may be used as the heat transfer fins.

[0035] For example, as shown in **FIG. 8** and **FIG. 9**, in the embodiment discussed above (refer to **FIG. 3** and **FIG. 4**), heat transfer fins **12**, which have creases **19a-19c** that are parallel to the vertical directions, may be adopted as the heat transfer fins and three first cut and raised parts **14a-14c**, which are lined up from the upstream side to the downstream side in the gas current flow direction, may be formed by a cutting and raising fabrication process on the lower side of each of the heat transfer tubes **3** in the vertical directions, specifically in a heat transfer fin surface **12c** between the gas current flow direction front end of the heat transfer fin **12** and the crease **19a** on the downstream side thereof, in a heat transfer fin surface **12d** between the crease **19a** and the crease **19b** on the downstream side thereof, and in a heat transfer fin surface **12e** between the crease **19b** and the crease **19c** on the downstream side thereof; furthermore, three second cut and raised parts **14d-14f**, which are lined up from the upstream side to the downstream side in the gas current flow direction may be formed on the upper side of each of the heat transfer tubes **3** in the vertical directions, specifically in the heat transfer fin surfaces **12c-12e**. Here, in the creases **19a-19c**, the creases **19a**, **19c** constitute mountain folds and the crease **19b** constitutes a valley fold. In addition, in a heat transfer fin surface **12f**, no cut and raised part is formed. Furthermore, each part of the heat transfer fins **12** in the present modified example is assigned a reference numeral that is calculated by adding 10 to the value of the same part in the first embodiment discussed above, the angle of attacks in the present modified example are defined by adding a numeral "1" behind the reference symbol used for the same angle of attack in the embodiment discussed above, and explanations of each part of each of the heat transfer fins **12** excepting the creases **19a-19c** and the heat transfer fin surfaces **12c-12f** are therefore omitted.

[0036] In the fin tube type heat exchanger **1** of the present modified example, too, it is possible to obtain the same effects as those of the embodiment discussed above.

(4) Other Embodiments

[0037] The above text explained an embodiment and a modified example thereof of the present invention based on the drawings, but the specific constitution is not limited to this embodiment and modified example, and it is understood that variations and modifications may

be effected without departing from the spirit and scope of the invention.

INDUSTRIAL APPLICABILITY

[0038] The present invention can be widely adapted to a fin tube type heat exchanger that comprises: multiple heat transfer fins, which are lined up such that they are spaced apart in the plate thickness directions and disposed in a gas current; and multiple heat transfer tubes, which are inserted into the multiple heat transfer fins and disposed in directions substantially orthogonal to the gas current flow direction; wherein, on the heat transfer fin surface on both sides of each of the heat transfer tubes in the vertical directions, multiple cut and raised parts, which are lined up from the upstream side to the downstream side in the gas current flow direction, are formed by a cutting and raising fabrication process.

REFERENCE SIGNS LIST

[0039]

1	Fin tube type heat exchanger
2, 12	Heat transfer fins
3	Heat transfer tube
4a-4f, 14a-14f	Cut and raised parts
a	Front end height
b	Rear end height
FP	Fin pitch
H	Average height
θ	Inclination angle

CITATION LIST

PATENT LITERATURE

PATENT LITERATURE 1

[0040] Japanese Laid-open Patent Application Publication No. 2008-111646

Claims

1. A fin tube type heat exchanger (1), comprising:

a plurality of heat transfer fins (2, 12), the heat transfer fins being lined up such that they are spaced apart in the plate thickness directions and being disposed in a gas current; and a plurality of heat transfer tubes (3), the heat transfer tubes being inserted into the plurality of heat transfer fins and being disposed in directions substantially orthogonal to a gas current flow direction; wherein, in each of the heat transfer fins, a plurality of cut

and raised parts (4a-4f, 14a-14f), the cut and raised parts being lined up from the upstream side to the downstream side in the gas current flow direction, are formed by a cutting and raising fabrication process on both sides of each of the heat transfer tubes in the vertical directions;

the plurality of cut and raised parts are inclined with respect to the gas current flow direction such that the gas current in the vicinity of each of the heat transfer tubes is guided to a rear side in the gas current flow direction of that heat transfer tube;

the heights of each of the cut and raised parts with respect to the heat transfer fin surface increase gradually toward the downstream side in the gas current flow direction; and for each of the cut and raised parts, the value calculated by dividing the average height of the front end height, which is the height of the gas current flow direction front end with respect to the heat transfer fin surface, and the rear end height, which is the height of the gas current flow direction rear end with respect to the heat transfer fin surface, by a fin pitch, which is the spacing between the heat transfer fins, is greater than 0.3 and less than 0.6.

2. The fin tube type heat exchanger (1) according to claim 1, wherein an inclination angle, which is an angle formed between a ridge of each of the cut and raised parts (4a-4f, 14a-14f) and the heat transfer fin surface, is less than 30°.

3. The fin tube type heat exchanger (1) according to claim 1 or claim 2, wherein the plurality of cut and raised parts (4a-4f, 14a-14f) are disposed such that their average heights sequentially increase at a greater rate in the cut and raised parts on the downstream side in the gas current flow direction than in the cut and raised parts on the upstream side in the gas current flow direction.

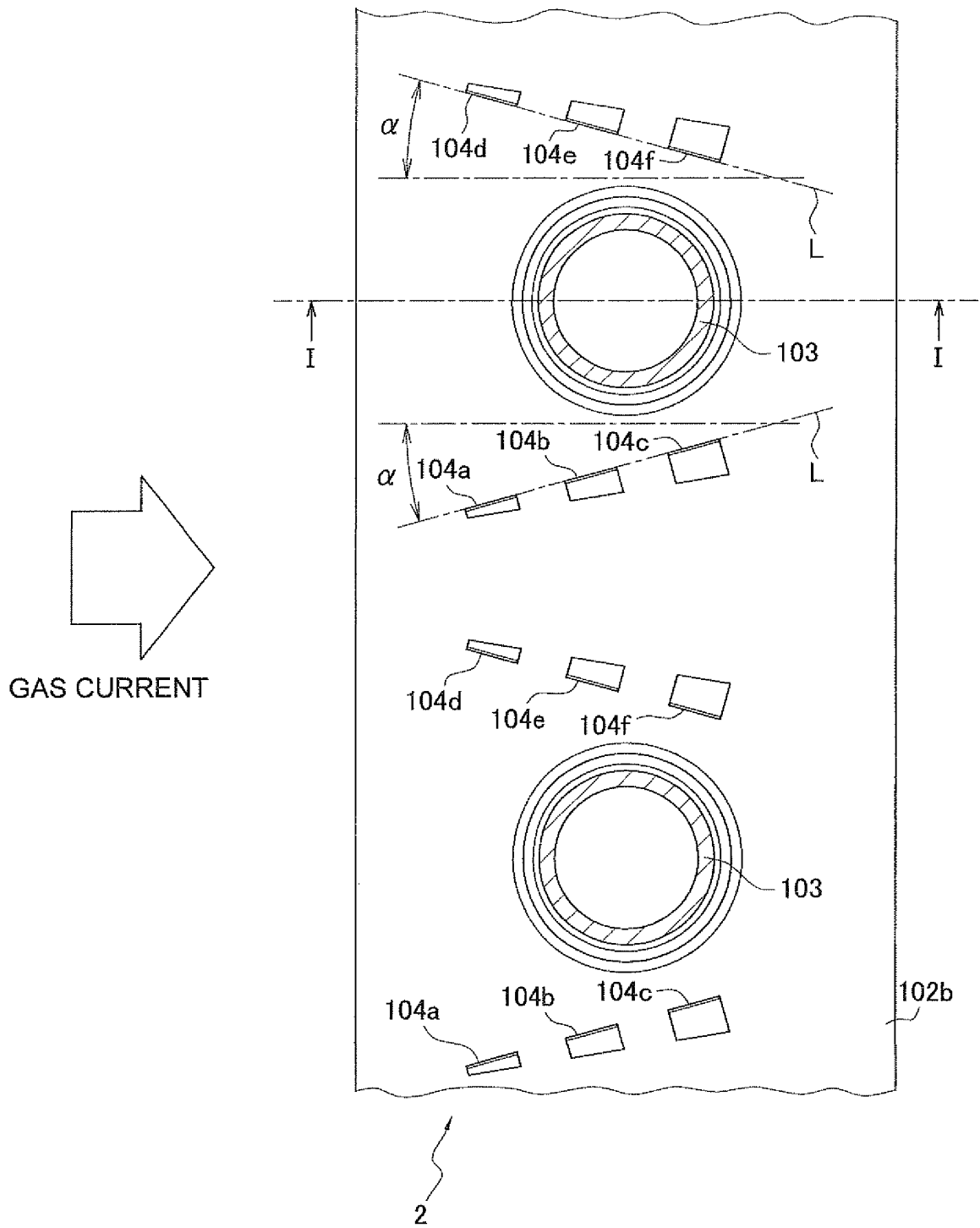


FIG. 1

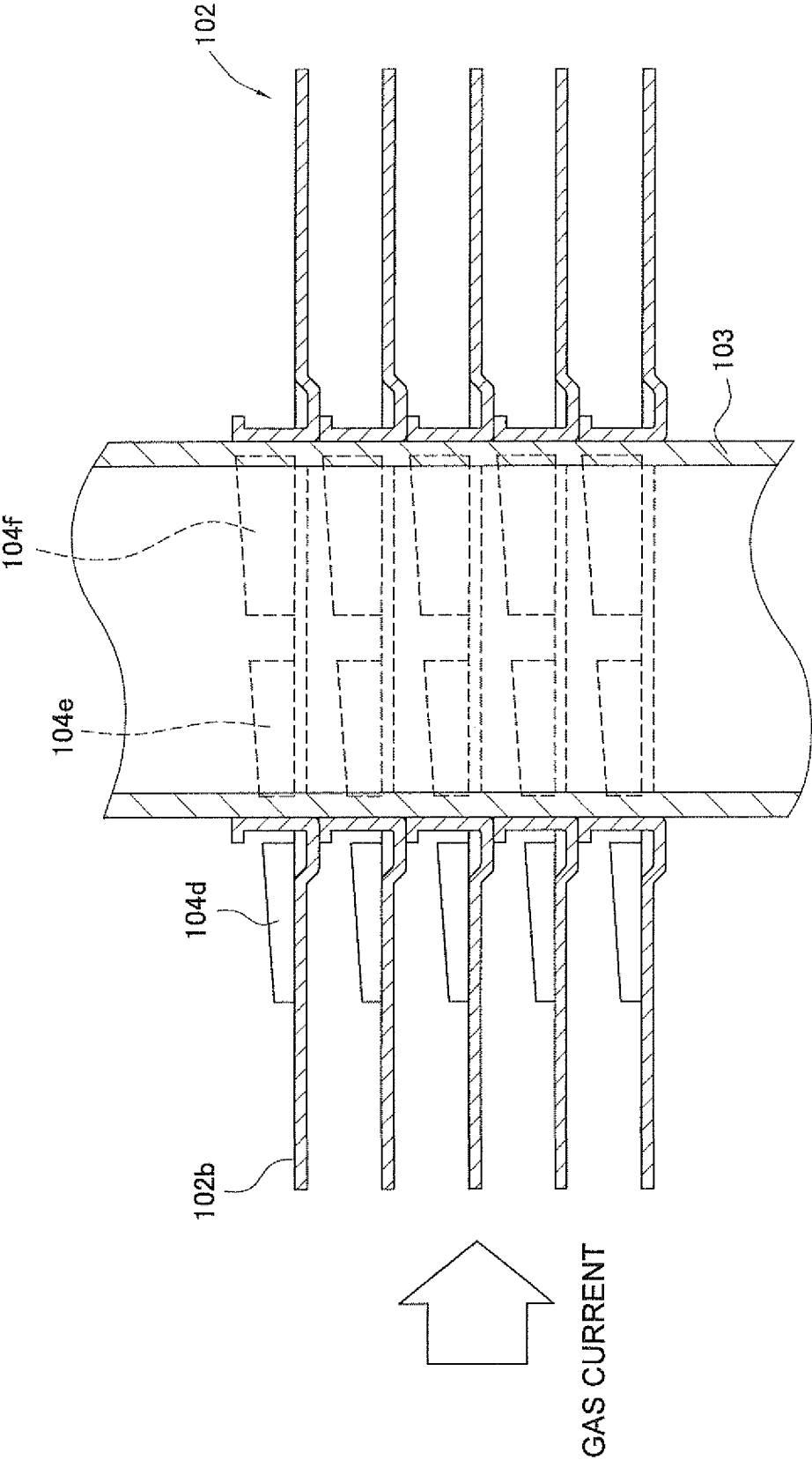


FIG. 2

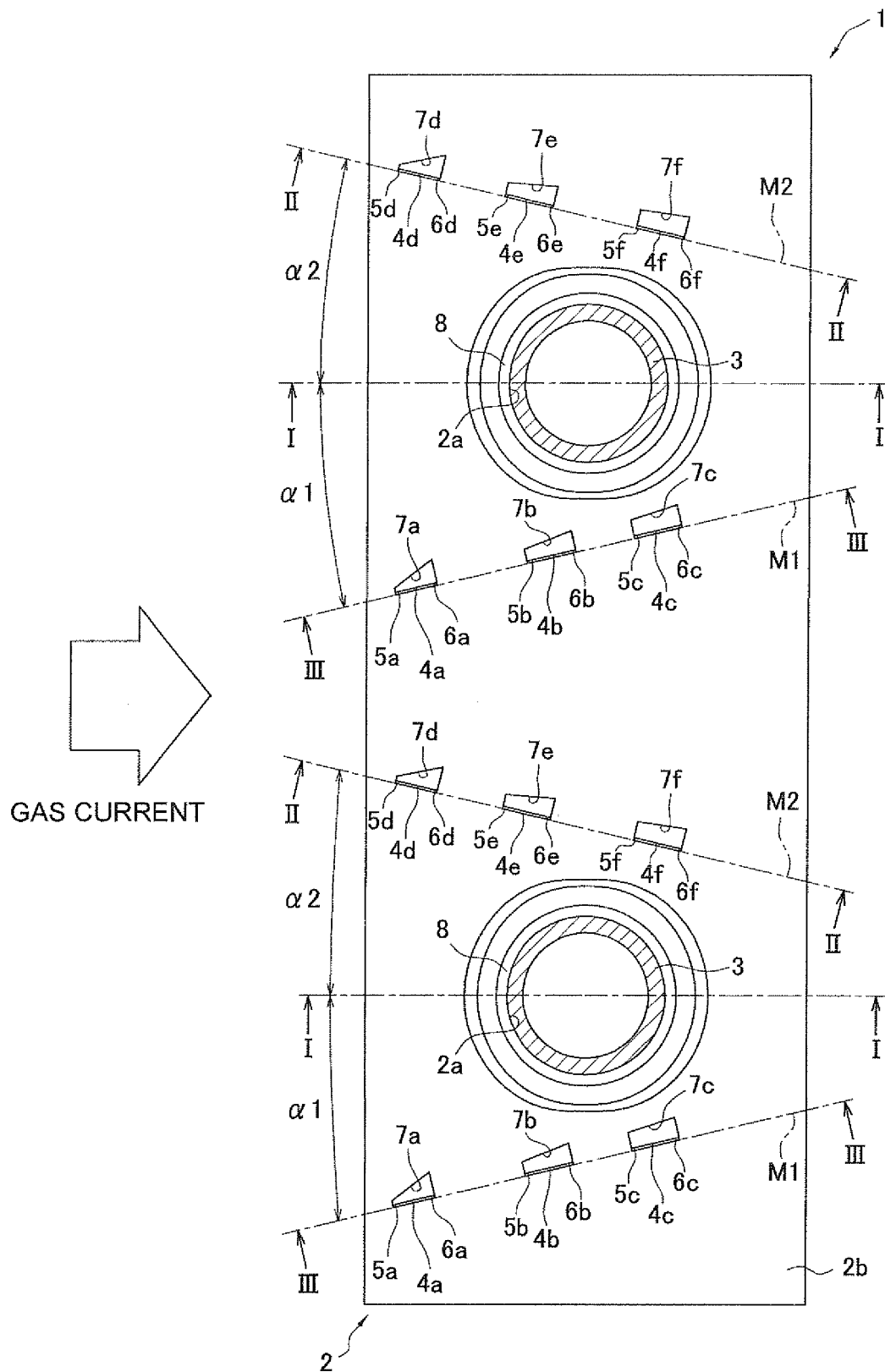


FIG. 3

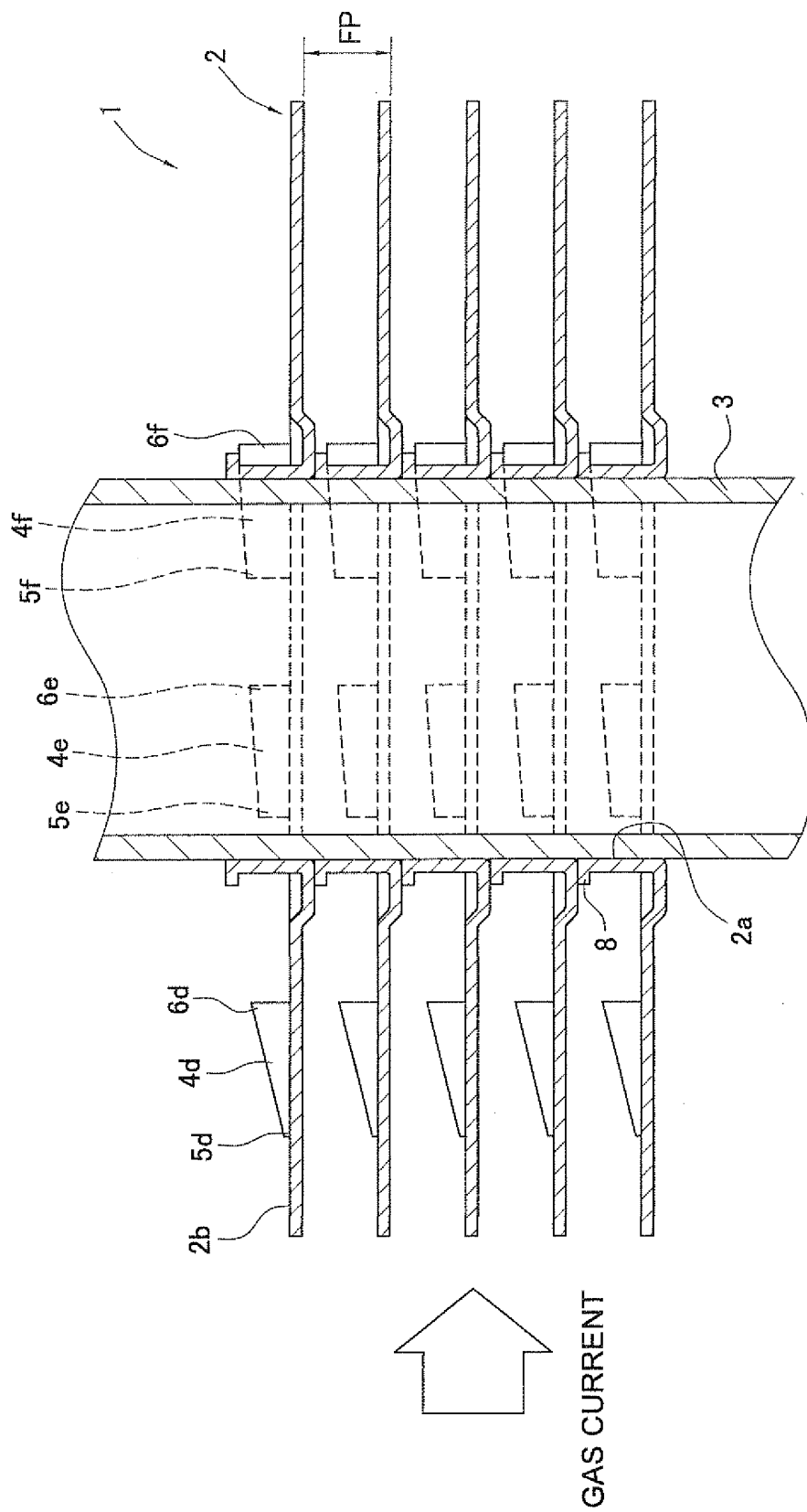


FIG. 4

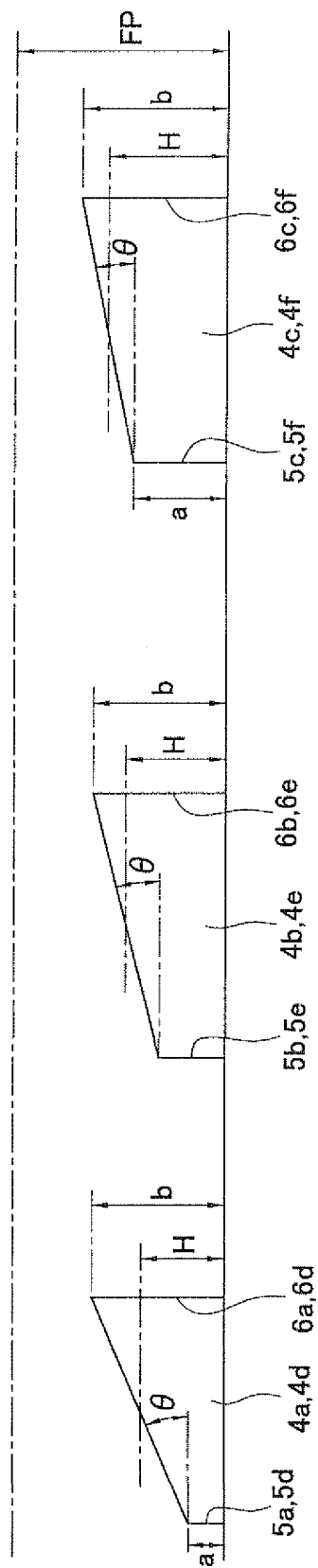


FIG. 5

FIG. 6

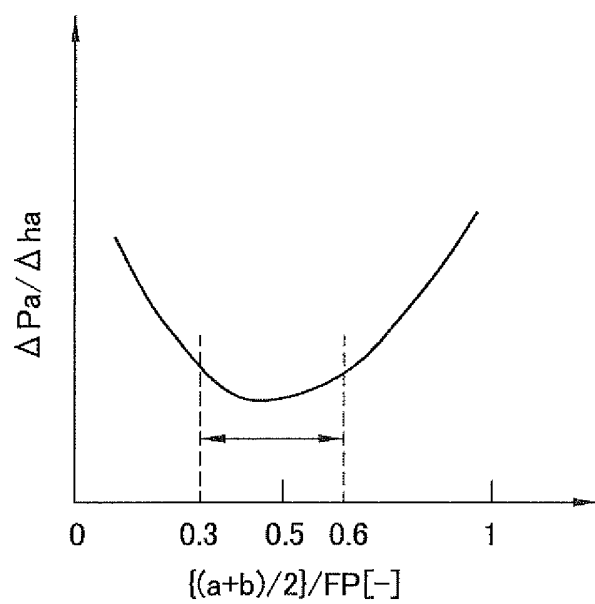
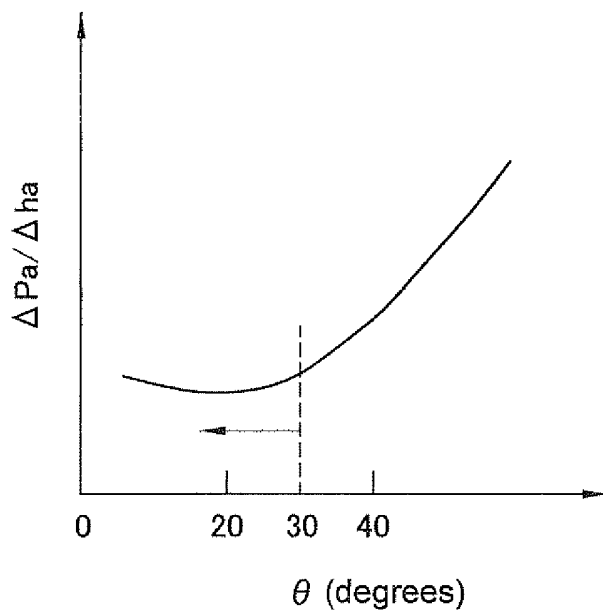


FIG. 7



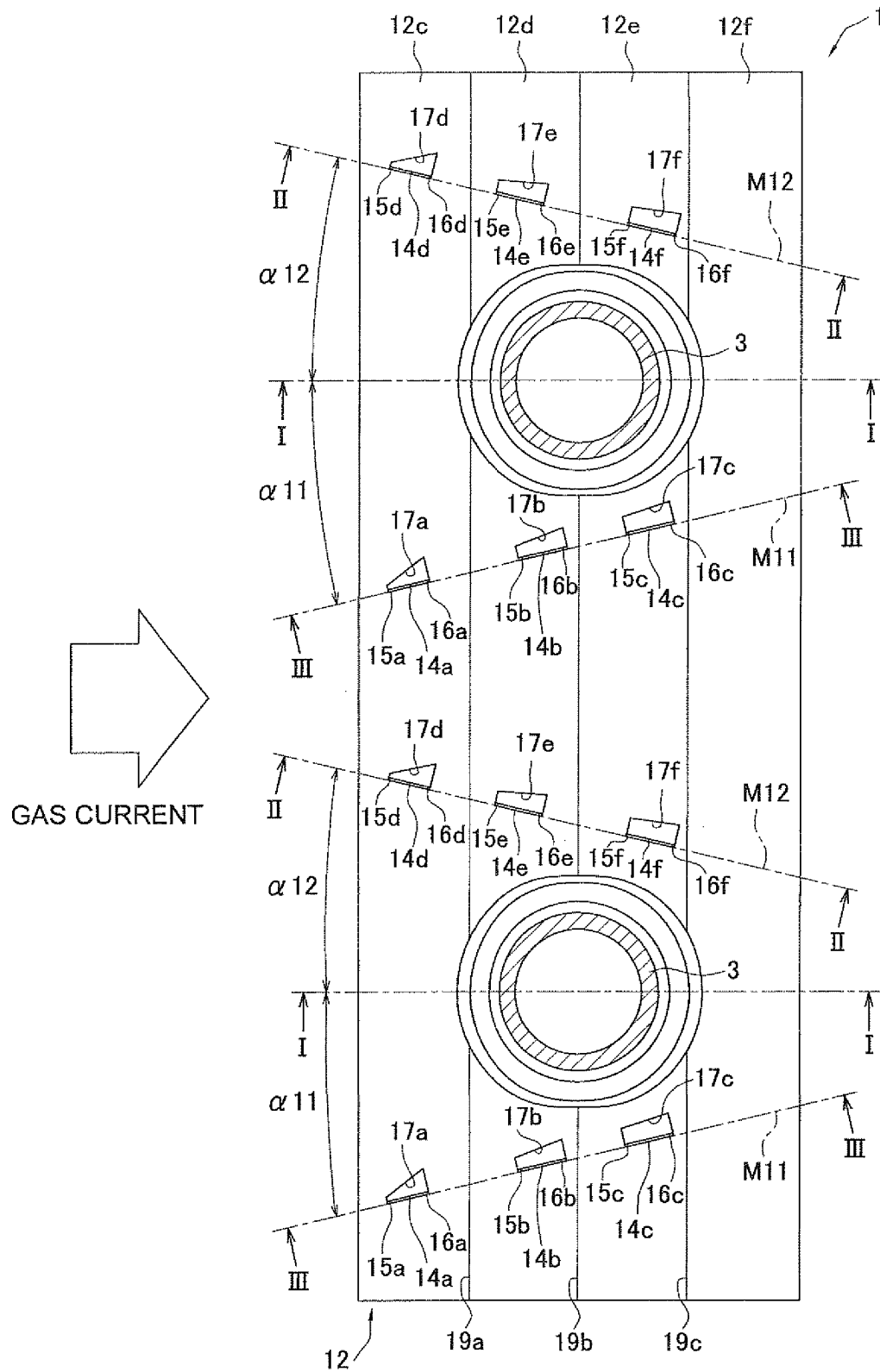


FIG. 8

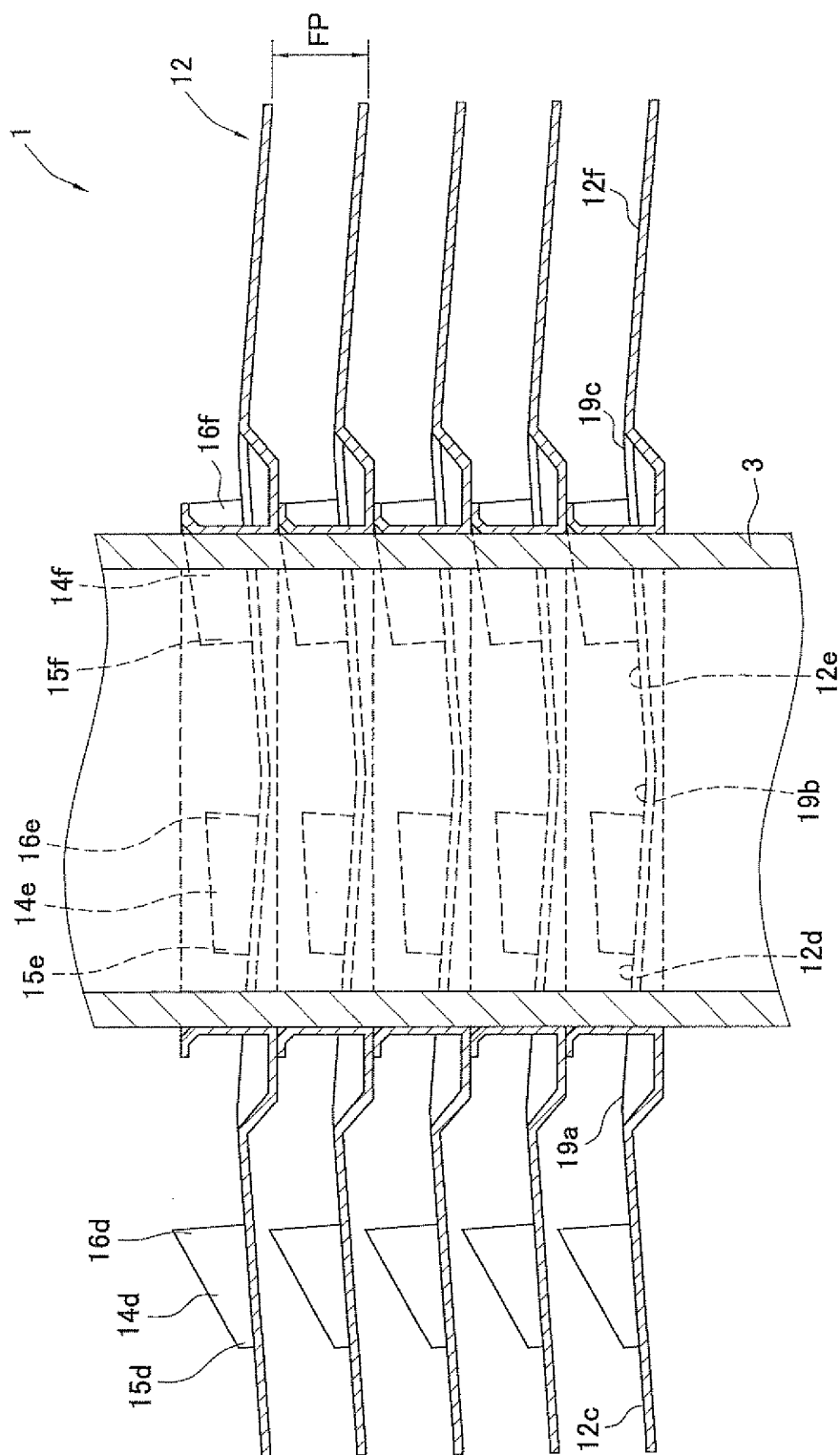


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/002292

A. CLASSIFICATION OF SUBJECT MATTER

F28F1/32 (2006.01) i, F25B39/02 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F28F1/32, F25B39/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2009

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2007/004457 A1 (Daikin Industries, Ltd.), 01 November, 2007 (01.11.07), Full text; all drawings & JP 2007-10279 A & EP 1906129 A1 & KR 10-2008-0011445 A & CN 101208575 A	1-3
X	JP 2008-89237 A (Daikin Industries, Ltd.), 17 April, 2008 (17.04.08), Full text; Fig. 3 (Family: none)	1-3

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

* Special categories of cited documents:

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
11 June, 2009 (11.06.09)Date of mailing of the international search report
23 June, 2009 (23.06.09)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

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Patent documents cited in the description

- JP 2008111646 A [0002] [0040]