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(54) **HEAT EXCHANGE APPARATUS**

(57) Provided is a heat exchanger capable of performing heat exchange between a refrigerant and air continuously even if frost forms thereon. A heat exchanger (1) that exchanges heat between a refrigerant and air includes: a plurality of heat transfer tubes (3) extending in an internal flow direction in which the refrigerant flows; and a corrugated member (4) having a corrugated shape. The corrugated member (4) includes: fins (5) that are arranged at at least two different pitches, a relatively large first pitch (P1) and a relatively small second pitch (P2), in the internal flow direction; and folded portions (6) that are bonded alternately in the internal flow direction to the heat transfer tubes (3) that are adjacent to each other.

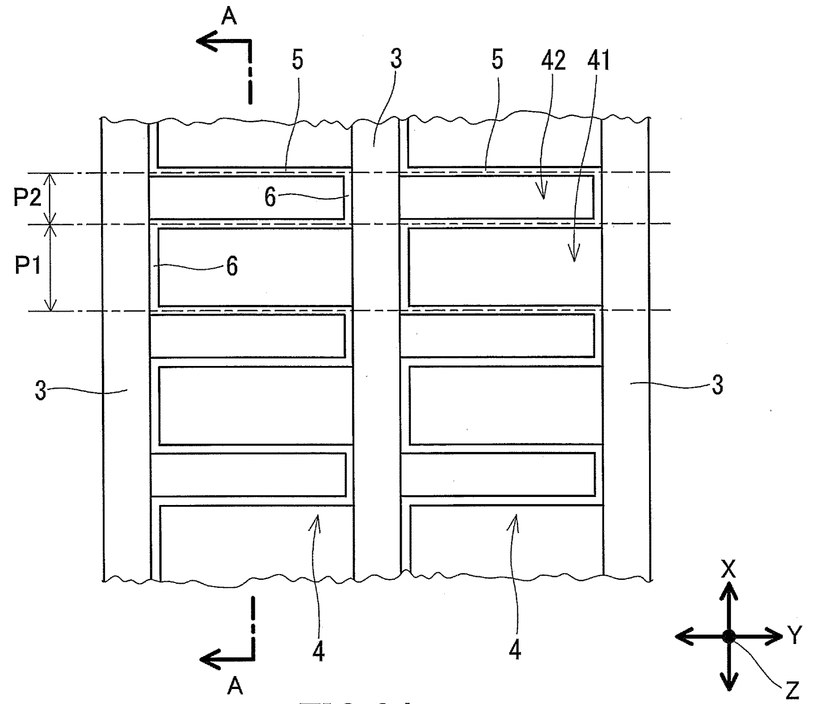

FIG.3A

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Description

TECHNICAL FIELD

[0001] The present invention relates to a heat exchanger that exchanges heat between a refrigerant and air.

BACKGROUND ART

[0002] Conventionally, heat exchangers for exchanging heat between a refrigerant and air are used in air conditioners and the like. For example, Patent Literature 1 discloses a heat exchanger including flat tubes in which a refrigerant flows and corrugated members disposed between the flat tubes. The corrugated members each have flat portions arranged in a direction in which the flat tubes extend and raised portions arranged between the flat portions to join them, and form flow passages for allowing the air to flow therethrough.

CITATION LIST

Patent Literature

[0003] Patent Literature 1: JP 2004-317002 A

SUMMARY OF INVENTION

Technical Problem

[0004] In the heat exchanger of Patent Literature 1, the flat portions are arranged at a constant pitch. Therefore, in the case where this heat exchanger is used as an outdoor heat exchanger for an air conditioner, if frost forms thereon during heating operation, the frost blocks all the air flow passages between the flat portions simultaneously, which may make it impossible to continue heat exchange between the refrigerant and air.

[0005] Under these circumstances, it is an object of the present invention to provide a heat exchanger capable of performing heat exchange between a refrigerant and air continuously even if frost forms thereon.

Solution to Problem

[0006] In order to solve the above problem, the heat exchanger of the present invention is a heat exchanger that exchanges heat between a refrigerant and air and includes: a plurality of heat transfer tubes extending in an internal flow direction in which the refrigerant flows; and a corrugated member having a corrugated shape. The corrugated member includes: a plurality of fins that are arranged at at least two different pitches, a relatively large first pitch and a relatively small second pitch, in the internal flow direction; and a plurality of folded portions that are bonded alternately in the internal flow direction to the heat transfer tubes that are adjacent to each other.

Advantageous Effects of Invention

[0007] In the configuration described above, the fins are arranged at irregular pitches. Therefore, for example, even if frost forms on the outdoor heat exchanger during heating operation and narrower air flow passages formed between the fins with a smaller pitch are blocked, wider air flow passages formed between the fins with a larger pitch are less likely to be blocked. Rather, when the narrower air flow passages formed between the fins with the smaller pitch are blocked, the flow rate of the air increases between the fins arranged at the larger pitch, which makes the blockage of the wider air flow passages less likely to occur. This is because the frost is removed from the air flow passages by the air flowing therein at a high flow rate before the frost grows thick enough. Therefore, the heat exchanger can perform heat exchange between the refrigerant and the air continuously.

BRIEF DESCRIPTION OF DRAWINGS

[0008]

FIG.1 is a front view of a heat exchanger according to a first embodiment of the present invention.
FIG. 2 is an enlarged perspective view of the main part of the heat exchanger shown in FIG. 1.
FIG. 3A is an enlarged front view of the main part of the heat exchanger shown in FIG. 1.
FIG. 3B is a cross-sectional view taken along the line A-A in FIG. 3A.
FIG. 4 is a diagram illustrating how the heat exchanger works when frost forms thereon.
FIG. 5 is a perspective view of a corrugated member according to the first embodiment of the present invention.
FIG. 6A is an enlarged front view of the main part of a heat exchanger according to a modification of the first embodiment of the present invention.
FIG. 6B is a cross-sectional view taken along the line B-B in FIG. 6A.
FIG. 7A is an enlarged front view of the main part of a heat exchanger according to a second embodiment of the present invention.
FIG. 7B is a cross-sectional view taken along the line C-C in FIG. 7A.
FIG. 8 is a perspective view of a corrugated member according to the second embodiment of the present invention.
FIG. 9A is a diagram illustrating how the heat exchanger works when frost forms thereon.
FIG. 9B is a diagram illustrating how the heat exchanger works on meltwater.
FIG. 10A is an enlarged front view of the main part of a heat exchanger according to a modification of the second embodiment of the present invention.
FIG. 10B is a cross-sectional view taken along the line D-D in FIG. 10A.

FIG. 11 is a perspective view of a corrugated member according to a modification of the second embodiment.

FIG. 12A is an enlarged front view of the main part of a heat exchanger according to another modification of the second embodiment.

FIG. 12B is a cross-sectional view taken along the line E-E in FIG. 12A.

FIG. 13 is a diagram illustrating how the heat exchanger works when frost forms thereon and how it works on meltwater.

FIG. 14 is a perspective view of a corrugated member according to another modification of the second embodiment.

DESCRIPTION OF EMBODIMENTS

[0009] A first aspect of the present disclosure provides a heat exchanger that exchanges heat between a refrigerant and air, including: a plurality of heat transfer tubes extending in an internal flow direction in which the refrigerant flows; and a corrugated member having a corrugated shape. The corrugated member includes: a plurality of fins that are arranged at at least two different pitches, a relatively large first pitch and a relatively small second pitch, in the internal flow direction; and a plurality of folded portions that are bonded alternately in the internal flow direction to the heat transfer tubes that are adjacent to each other.

[0010] A second aspect of the present disclosure provides the heat exchanger as set forth in the first aspect, wherein each of the fins includes a plurality of flat portions that are arranged in a staggered or stepped manner in an external flow direction perpendicular to the internal flow direction and a direction in which the heat transfer tubes are arranged, and slits opening in the external flow direction are formed between the flat portions. According to the second aspect, water resulting from melting of frost runs down through the slits formed between the flat portions. Therefore, the water is well drained.

[0011] A third aspect of the present disclosure provides the heat exchanger as set forth in the second aspect, wherein the fins are arranged in such a manner that the fins coincide with each other by parallel displacement in the internal flow direction. According to the third aspect, between the two adjacent fins, the flat portions of one of the fins and the counterpart flat portions of the other fin face each other in the internal flow direction such that the distance between these facing flat portions in the internal direction is kept constant at any position in the external flow direction. In addition, since the air is likely to flow at a constant rate in the air passage, a less turbulent air flow can be formed. Furthermore, such a corrugated member can be produced easily.

[0012] A fourth aspect of the present disclosure provides the heat exchanger as set forth in the second aspect or the third aspect, wherein widths of the flat portions are equal in the external flow direction. According to the fourth aspect, the ratio between the surface area and the volume of each of the flat portions is constant. Therefore, the heat transfer efficiency of the fins is optimized.

[0013] A fifth aspect of the present disclosure provides the heat exchanger as set forth in any one of the second to fourth aspects, wherein the flat portions are first flat portions and second flat portions that are arranged in a staggered manner in the external flow direction. According to the fifth aspect, a relatively large slit can be formed between the first flat portion and the second flat portion. In addition, an air flow passage extending straight in the external flow direction can be formed. Furthermore, since the upper and lower edges of the fins are in direct contact with the heat transfer tubes, these fins can achieve a higher fin efficiency than louvered fins and the like.

[0014] A sixth aspect of the present disclosure provides the heat exchanger as set forth in the fifth aspect, wherein the slits are formed between the first flat portions and the second flat portions, and a dimension of each of the slits in the internal flow direction is one half or less of the second pitch. According to the sixth aspect, the largest possible air passages can be obtained.

[0015] A seventh aspect of the present disclosure provides the heat exchanger as set forth in any one of the second to fourth aspects, wherein the flat portions form a series of steps descending in a direction inclined with respect to the external flow direction and the internal flow direction. According to the seventh aspect, drainage of meltwater resulting from melting of frost can be facilitated.

[0016] An eighth aspect of the present disclosure provides the heat exchanger as set forth in any one of the first to seventh aspects, wherein the fins are arranged so that the second pitch appears before and after the first pitch. According to the eighth aspect, spread of frost in the internal flow direction can be inhibited.

[0017] A ninth aspect of the present disclosure provides the heat exchanger as set forth in any one of the first to seventh aspects, wherein the first pitch and the second pitch appear alternately. According to the ninth aspect, spread of frost in the internal flow direction can be inhibited.

[0018] A tenth aspect of the present disclosure provides the heat exchanger as set forth in any one of the first to seventh aspects, wherein when an odd number of the fins are arranged in series from above in the internal flow direction, and odd-numbered fins are defined as first fins and even-numbered fins are defined as second fins, a total sum of the pitches between the first fins and the fins adjacent to and below the first fins is equal to a total sum of the pitches between the second fins and the fins adjacent to and below the second fins. According to the tenth aspect, the total sum of the areas of bonding between one of the two adjacent heat transfer tubes and the corrugated member is equal or almost equal to the total sum of the areas of bonding between the other one of the adjacent heat transfer tubes and the corrugated member. Therefore, the adjacent heat transfer tubes have the same or almost the same area for heat transfer to/from the corrugated member.

[0019] An eleventh aspect of the present disclosure provides the heat exchanger as set forth in any one of the first to tenth aspects, wherein the first pitch is 1.2 times or more and 3.0 times or less the second pitch. According to the eleventh aspect, it is possible to allow the corrugated member to have a sufficiently large heat transfer area as a whole while inhibiting blockage of the air flow passages due to frost formation.

[0020] A twelfth aspect of the present disclosure provides the heat exchanger as set forth in any one of the first to eleventh aspects, wherein the plurality of heat transfer tubes includes at least four of the heat transfer tubes, and a pair of the corrugated members having the same shape are bonded to both sides of each of the heat transfer tubes interposed between the two adjacent heat transfer tubes in such a manner that the corrugated members coincide with each other by parallel displacement in an arbitrary direction. According to the twelfth aspect, in the heat transfer tubes interposed between the two adjacent heat transfer tubes, the total sums of the areas of bonding to the corrugated members are equal or almost equal to each other. Therefore, these heat transfer tubes have the same or almost the same area for heat transfer to/from the corrugated members.

[0021] A thirteenth aspect of the present disclosure provides the heat exchanger as set forth in any one of the first to twelfth aspects, wherein the adjacent heat transfer tubes are flat tubes that are parallel to each other.

[0022] Hereinafter, embodiments of the present invention will be described with reference to the drawings. It should be noted that the following description of the present invention is merely exemplary and is not intended to limit the present invention.

(First Embodiment)

[0023] FIG. 1 shows a heat exchanger 1 according to the first embodiment of the present invention. This heat exchanger 1 exchanges heat between a refrigerant and air, and is used, for example, in a room air conditioner or a car air conditioner. As the refrigerant, a HFC refrigerant, a HC refrigerant, CO_2, or the like can be used.

[0024] Specifically, the heat exchanger 1 includes a plurality of heat transfer tubes 3 in which the refrigerant flows and a pair of headers 2 to which both ends of each of the heat transfer tubes 3 are connected. The heat transfer tubes 3 extend in a specific direction, and are arranged in a direction perpendicular to the specific direction. Here, the refrigerant flows in the specific direction in the heat transfer tubes 3. The pair of headers 2 extend in the arrangement direction of the heat transfer tubes 3. Hereinafter, in order to simplify the description, the specific direction (an internal flow direction of the present invention), the arrangement direction of the heat transfer tubes 3, and the direction perpendicular to these directions (an external flow direction of the present invention) are referred to as an X direction, a Y direction, and a Z direction, respectively.

[0025] In this embodiment, the Y direction and the Z direction are the horizontal directions, and the X direction is the vertical direction. In other words, the pair of headers 2 extend in the horizontal direction, and the heat transfer tubes 3 disposed between the headers 2 extend in the vertical direction. The heat transfer tubes 3 do not necessarily have to extend in the vertical direction, and may extend in an oblique direction or in the horizontal direction. The pair of headers 2 do not necessarily have to extend in the horizontal direction, and may extend in the vertical direction.

[0026] As shown in FIG. 2, the adjacent heat transfer tubes 3 are flat tubes that are parallel to each other, and have a cross-sectional shape extended in the Z direction. The corrugated member 4 is disposed between each pair of adjacent heat transfer tubes 3.

[0027] As shown in FIG. 3A and FIG. 3B, the corrugated member 4 has a corrugated shape including fins 5 that are arranged in the X direction and folded portions 6 that are bonded alternatively to the adjacent heat transfer tubes 3. That is, the folded portions 6 are bonded alternately in the X direction to the adjacent heat transfer tubes 3. Thus, air flow passages 41 and 42 each exposed to one of the two adjacent heat transfer tubes 3 and extending in the Z direction are formed between the fins 5. In this embodiment, as shown in FIG. 5, the fins 5 have a straight shape extending in the Z direction. In other words, the fins 5 have a flat shape extending in the Y and Z directions.

[0028] The fins 5 are arranged at at least two different pitches, a relatively large first pitch P1 and a relatively small second pitch P2, in the X direction. As shown in FIG. 3A and FIG. 3B, in this embodiment, the fins 5 are arranged so that the second pitch P2 appears before and after the first pitch P1. The term "pitch" refers to the center-to-center distance between the adjacent fins 5, and in this embodiment, the center of the fin 5 refers to the center line of the flat-shaped fin 5 in its thickness direction (X direction).

[0029] The first pitch P1 and the second pitch 2 are defined by the X-direction dimensions of the folded portions 6 that join the adjacent fins 5. In this embodiment, as shown in FIG. 3A, the folded portion 6 that is bonded to one of the two adjacent heat transfer tubes 3 (the left or central heat transfer tube 3 in FIG. 3A) is elongated in the X direction compared to the folded portion 6 that is bonded to the other heat transfer tube 3 (the central or right heat transfer tube in FIG. 3A). Therefore, the first pitch P1 and the second pitch P2 appear alternately. In other words, the air flow passage 42 exposed to one of the two adjacent heat transfer tubes 3 is narrower, while the air flow passage 41 exposed to the other heat transfer tube 3 is wider.

[0030] In the heat exchanger 1 of this embodiment, the fins 5 are arranged at irregular pitches. Therefore, as shown in FIG. 4, for example, even if frost forms on the outdoor heat exchanger during heating operation and the narrower air flow passages 42 are blocked, the wider air flow passages 41 are less likely to be blocked. Rather, when the narrower air flow passages 42 are blocked, the flow rate of the air increases in the wider air flow passages 41, which makes the blockage thereof less likely to occur. Therefore, the heat exchanger can perform heat exchange between the refrigerant and the air continuously.

[0031] Preferably, the first pitch P1 is 1.2 times or more and 3.0 times or less the second pitch P2. When the ratio P1/P2 is 1.2 or more, the likelihood of blockage of the wider air flow passages 41 due to frost formation can be reduced sufficiently. When the ratio of P1/P2 is 3.0 or less, the corrugated members 4 are allowed to have a sufficiently large heat transfer area as a whole. In view of these, it is preferable that the ratio P1/P2 satisfy $1.5 \leq P1/P2 \leq 1.8$.

[0032] As shown in FIG. 1, the heat exchanger 1 has at least four (seven in FIG. 1) heat transfer tubes 3. As shown in FIG. 2 or FIG. 3A, a pair of corrugated members 4 having the same shape are bonded to both sides of the heat transfer tube 3 (the central heat transfer tube 3 in FIG. 2 or FIG. 3A) interposed between the two adjacent heat transfer tubes 3 in such a manner that these corrugated members 4 coincide with each other by parallel displacement in the Y direction. Therefore, in the heat transfer tubes 3 interposed between the two adjacent heat transfer tubes 3 (five heat transfer tubes 3 in FIG. 1), the total sums of the areas of bonding to the corrugated members 4 are equal or almost equal to each other. Thus, these heat transfer tubes 3 interposed between the two adjacent heat transfer tubes 3 have the same or almost the same area for heat transfer to/from the corrugated members 4. Therefore, the refrigerant flowing in each of these heat transfer tubes 3 is uniformly heated by the air.

[0033] The two corrugated members 4 having the same shape only have to be bonded to both sides of the heat transfer tube 3 interposed between the two adjacent heat transfer tubes 3 in such a manner that these corrugated members 4 coincide with each other by parallel displacement in an arbitrary direction. For example, the two corrugated members 4 having the same shape may be bonded to both sides of the heat transfer tube 3 interposed between the two adjacent heat transfer tubes 3 in such a manner that these corrugated members 4 coincide with each other by parallel displacement in the X and Y directions. Instead, the two corrugated members 4 having the same shape may be bonded to both sides of the heat transfer tube 3 interposed between the two adjacent heat transfer tubes 3 in such a manner that these corrugated members 4 coincide with each other by parallel displacement in the Y and Z directions. Furthermore, the two corrugated members 4 having the same shape may be bonded to both sides of the heat transfer tube 3 interposed between the two adjacent heat transfer tubes 3 in such a manner that these corrugated members 4 coincide with each other by parallel displacement in the X, Y and Z directions. In any of these configurations, the heat transfer tubes 3 interposed between the two adjacent heat transfer tubes 3 have the same or almost the same area for heat transfer to/from the corrugated members 4. Therefore, the refrigerant flowing in each of the heat transfer tubes 3 is uniformly heated by the air.

(Modification)

[0034] The heat exchanger 1 of the first embodiment can be modified from various points of view. For example, each of the fins 5 may be provided with louvers that are inclined with respect to the fin 5 and arranged in the Z direction.

[0035] The fins 5 do not have to be arranged so that the second pitch P2 appears before and after the first pitch P1. In order to inhibit blockage of the air flow passages when frost forms, the fins 5 have to be arranged so that at least one first pitch P1 appears.

[0036] The first pitch P1 and the second pitch P2 do not necessarily have to appear alternately. A series of the second pitches may appear either before or after the first pitch or before and after the first pitch. For example, the fins 5 may be arranged as shown in FIG. 6A and FIG. 6B. When it is assumed that an odd number of (seven in FIG. 6B) fins 5 are arranged in series from above in the X direction, the odd-numbered fins 5 are defined as first fins and the even-numbered fins 5 are defined as second fins. In this case, as shown in FIG. 6B, for these odd-numbered fins 5, the total sum of the pitches between the first fins and the fins adjacent to and below the first fins is equal to the total sum of the pitches of the second fins and the fins adjacent to and below the second fins. In FIG. 6B, these total sums of the pitches are both $2 \times P2 + P1$. In this configuration, the total sum of the areas of bonding between one of the two adjacent heat transfer tubes 3 and the corrugated member 4 is equal or almost equal to the total sum of the areas of bonding between the other heat transfer tube 3 and the corrugated member 4 in a range including positions corresponding to the odd number of fins 5. Thus, the heat transfer tubes 3 have the same or almost the same area for heat transfer to/from the corrugated member 4. Therefore, the refrigerant flowing in each of the heat transfer tubes 3 is uniformly heated by the air. In this case, it is preferable that the fins 5 be formed so that the above relation is satisfied in the entire corrugated member 4. However, the fins 5 may be formed so that the above relation is satisfied in a part of the corrugated member 4.

[0037] The fins 5 do not necessarily have to be arranged at two different pitches, and they may be arranged at three or more different pitches. For example, in the case where the fins 5 are arranged at three different pitches, the smallest pitch may be regarded as the second pitch as defined in this embodiment, and the medium or largest pitch may be regarded as the first pitch as defined in this embodiment. Instead, the medium pitch may be regarded as the second pitch as defined in this embodiment, and the largest pitch may be regarded as the first pitch as defined this embodiment.

[0038] The corrugated members 4 having the fins 5 that are arranged at irregular pitches do not have to be disposed between all pairs of heat transfer tubes 3, and they may be disposed between at least one pair of adjacent heat transfer tubes 3. For example, the heat exchanger may be configured such that the corrugated member having the fins 5 that are arranged at a constant pitch is disposed between a pair of heat transfer tubes 3 in a region where the air flows at the highest rate in the heat exchanger (for example, the central region of the heat exchanger) and the corrugated members 4 having the fins 5 that are arranged at irregular pitches are disposed between the other pairs of heat transfer tubes 3.

(Second Embodiment)

[0039] Next, a second embodiment of the present invention is described. The second embodiment can be configured in the same manner as in the first embodiment, unless otherwise stated. The same or corresponding components are denoted by the same reference numerals as in the first embodiment, and the description thereof may be omitted.

[0040] As shown in FIG. 7A and FIG. 7B, the each of the fins 5 is composed of a plurality of flat portions that are arranged in a staggered manner in the Z direction. In other words, the plurality of flat portions are arranged in the Z direction so that slits opening in the Z direction are formed between the flat portions. Specifically, the fin 5 undulates in the X direction, and is composed of first flat portions 51 and second flat portions 52 that are arranged in a staggered manner in the Z direction. The first flat portions 51 and the second flat portions 52 extend perpendicular to the X direction, and slits 53 opening in the Z direction are formed between them. The fins 5 are arranged in such a manner that the fins 5 coincide with each other by parallel displacement in the X direction. Therefore, between the two adjacent fins 5, the first and second flat portions 51 and 52 of one of the adjacent fins and the counterpart first and second flat portions 51 and 52 of the other fin face each other in the X direction so that the distance between the facing first flat portions 51 and the distance between the facing second flat portions 52 are kept constant at any position in the Z direction. It is preferable that the width of the first flat portion 51 is equal to that of the second flat portion 52 in the Z direction.

[0041] As shown in FIG. 7A and FIG. 7B, the fins 5 are arranged at two different pitches, the first pitch P1 and the second pitch P2, in the X direction. In this embodiment, the center of the fin 5 is the reference line of the undulations of the fin 5 located at the midpoint between the first flat portions 51 and the second flat portions 52 of the fin 5.

[0042] The corrugated member 4 configured as described above can be produced by making cuts in a flat metal plate (for example, an aluminum plate) to form the first flat portions 51 and the second flat portions 52 and then pressing the metal plate into shape or passing the metal plate through a pair of transfer rollers. In the corrugated member 4 produced in this manner, the thickness of the first flat portions 51 and the second flat portions 52 is almost equal to the thickness of the folded portions 6.

[0043] Also in this embodiment, the fins 5 are arranged at irregular pitches. Therefore, for example, even if frost forms on the outdoor heat exchanger during heating operation and the narrower air flow passages 42 are blocked, the wider air flow passages 41 are less likely to be blocked. Rather, when the narrower air flow passages 42 are blocked, the flow rate of the air increases in the wider air flow passages 41, which makes the blockage thereof less likely to occur. Therefore, the heat exchanger can perform heat exchange between the refrigerant and the air continuously.

[0044] In addition, in this embodiment, each of the fins 5 is composed of the first flat portions 51 and the second flat portions 52, and the slits 53 are formed between them. Therefore, as shown in FIG. 9A, even if the inlet side of the narrower air flow passages 42 is blocked by frost, the air can be introduced into the narrower air flow passages 42 through the slits 53 on the downstream side of the passages 42. As a result, a decrease in the heating capacity can be suppressed. Furthermore, during defrosting operation for melting the frost, meltwater resulting from the melting of the frost runs down through the slits 53, as shown in FIG. 9B. Therefore, the water is well drained. In addition, the staggered arrangement of the first flat portions 51 and the second flat portions 52 in the Z direction creates straight air flows in the Z direction through the slits 53. These straight air flows push the meltwater resulting from the melting of the frost out in the Z direction.

[0045] From the viewpoint of maximizing the area of the narrower air flow passages 42, the X-direction dimension L of the slit 53 formed between the first flat portion 51 and the second flat portion 52 (see FIG. 7B) is preferably one half or less of the second pitch P2. Preferably, the dimension L is at least as large as the thickness of the first flat portion 51 or at least as large as the thickness of the second flat portion 52. For example, the X-direction dimension L of the slit 53 may be equal to the shortest distance between the first flat portions 51 or the second flat portions 52 of the fins 5 joined by the folded portion 6 that defines the second pitch P2.

(Modification)

[0046] The heat exchanger 1 of the second embodiment can be modified from various points of view. For example, it can be modified based on the viewpoint described as the modification in the first embodiment.

[0047] In each of the fins, the plurality of flat portions may be arranged in the form of at least two steps in the

Z direction. For example, as shown in FIG. 10A, FIG. 10B, and FIG. 11, each of the fins 5 may be composed of three different flat portions, upper flat portions 55, middle flat portions 56, and lower flat portions 57. The upper flat portion 55 forms the top of the steps. The lower flat portion 57 forms the bottom of the steps. The middle flat portion 56 is formed at an intermediate position between the upper flat portion 55 and the lower flat portion 57. Slits 58 opening in the Z direction are formed between the upper flat portions 55 and the middle flat portions 56 and between the middle flat portions 56 and the lower flat portions 57. The upper flat portions 55, the middle flat portions 56, and the lower flat portions 57 are arranged in the Z direction so that ascending portions and descending portions appear alternately. However, they do not necessarily have to be arranged in this order.

[0048] In this modification, the center of the fin 5 is located at the intermediate position between the upper flat portion 53 and the lower flat portion 55 and coincides with the center line of the middle flat portion 54 in its thickness direction. Also in this modification, as shown in FIG. 10B, the fins 5 are arranged at irregular pitches (the first pitch P1 and the second pitch P2) in the X direction. The slits 58 are formed between the upper flat portions 53 and the middle flat portions 54 and between the middle flat portions 54 and the lower flat portions 55. Therefore, according to this modification, the same effects as those of this embodiment can be exerted.

[0049] Furthermore, as shown in FIG. 12A, FIG. 12B, and FIG. 14, the plurality of flat portions of each of the fins 5 may form a series of steps descending in a direction inclined with respect to the Z direction and the X direction. As shown in FIG. 12B, in each of the fins 5, the plurality of flat portions 51A to 51F (six flat portions in this figure) are arranged in the form of steps descending from the inlet side of the air flow passages 41 and 42 toward the outlet side thereof. Slits 53A opening in the Z direction are formed between the adjacent flat portions 51A to 51 F.

[0050] In this modification, the center of the fin 5 is the reference line located at the midpoint between the flat portion 51 A disposed on the inlet side of the air flow passage 41 or 42 and the flat portion 51 F disposed on the outlet side of the air flow passage 41 or 42. As shown in FIG. 12B, the fins 5 are arranged at irregular pitches (the first pitch P1 and the second pitch P2) in the X direction. The slits 53A are formed between the adjacent flat portions 51A to 51 F. Therefore, according to this modification, the same effects as those of this embodiment can be exerted. Furthermore, as shown in FIG. 13, water resulting from melting of frost during defrosting operation is pushed by the air flowing in the air flow passages 41 and 42 toward the outlets of the air flow passages 41 and 42 along a series of descending flat portions 51A to 51F. Therefore, according to this modification, drainage of water resulting from melting of frost can be facilitated.

Claims

1. A heat exchanger that exchanges heat between a refrigerant and air, comprising:

a plurality of heat transfer tubes extending in an internal flow direction in which the refrigerant flows; and
a corrugated member having a corrugated shape, comprising: a plurality of fins that are arranged at at least two different pitches, a relatively large first pitch and a relatively small second pitch, in the internal flow direction; and a plurality of folded portions that are bonded alternately in the internal flow direction to the heat transfer tubes that are adjacent to each other.

2. The heat exchanger according to claim 1, wherein each of the fins comprises a plurality of flat portions that are arranged in a staggered or stepped manner in an external flow direction perpendicular to the internal flow direction and a direction in which the heat transfer tubes are arranged, and
slits opening in the external flow direction are formed between the flat portions.

3. The heat exchanger according to claim 2, wherein the fins are arranged in such a manner that the fins coincide with each other by parallel displacement in the internal flow direction.

4. The heat exchanger according to claim 2, wherein widths of the flat portions are equal in the external flow direction.

5. The heat exchanger according to claim 2, wherein the flat portions are first flat portions and second flat portions that are arranged in a staggered manner in the external flow direction.

6. The heat exchanger according to claim 5, wherein the slits are formed between the first flat portions and the second flat portions, and a dimension of each of the slits in the internal flow direction is one half or less of the second pitch.

7. The heat exchanger according to claim 2, wherein the flat portions form a series of steps descending in a direction inclined with respect to the external flow direction and the internal flow direction.

8. The heat exchanger according to claim 1, wherein the fins are arranged so that the second pitch appears before and after the first pitch.

9. The heat exchanger according to claim 1, wherein the first pitch and the second pitch appear alternately.

10. The heat exchanger according to claim 1, wherein when an odd number of the fins are arranged in series from above in the internal flow direction, and odd-numbered fins are defined as first fins and even-numbered fins are defined as second fins, a total sum of the pitches between the first fins and the fins adjacent to and below the first fins is equal to a total sum of the pitches between the second fins and the fins adjacent to and below the second fins.

11. The heat exchanger according to claim 1, wherein the first pitch is 1.2 times or more and 3.0 times or less the second pitch.

12. The heat exchanger according to claim 1, wherein the plurality of heat transfer tubes comprises at least four of the heat transfer tubes, and
a pair of the corrugated members having the same shape are bonded to both sides of each of the heat transfer tubes interposed between the two adjacent heat transfer tubes in such a manner that the corrugated members coincide with each other by parallel displacement in an arbitrary direction.

13. The heat exchanger according to claim 1, wherein the adjacent heat transfer tubes are flat tubes that are parallel to each other.

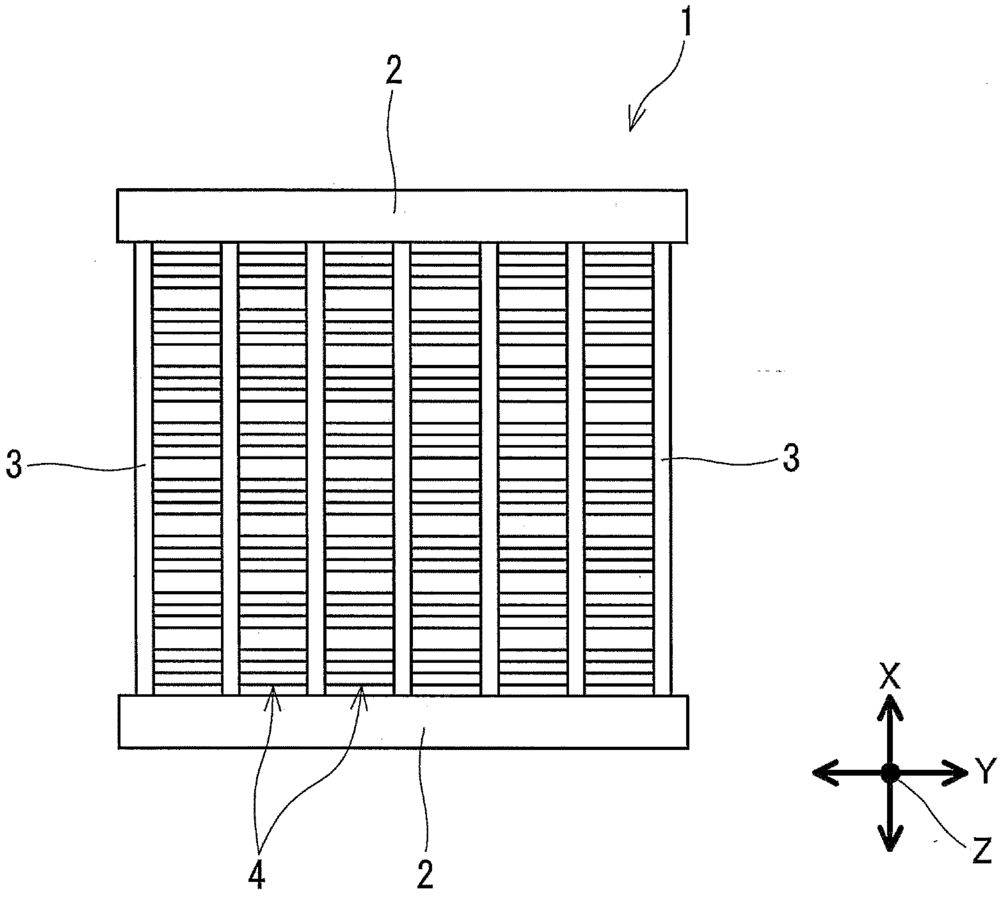


FIG.1

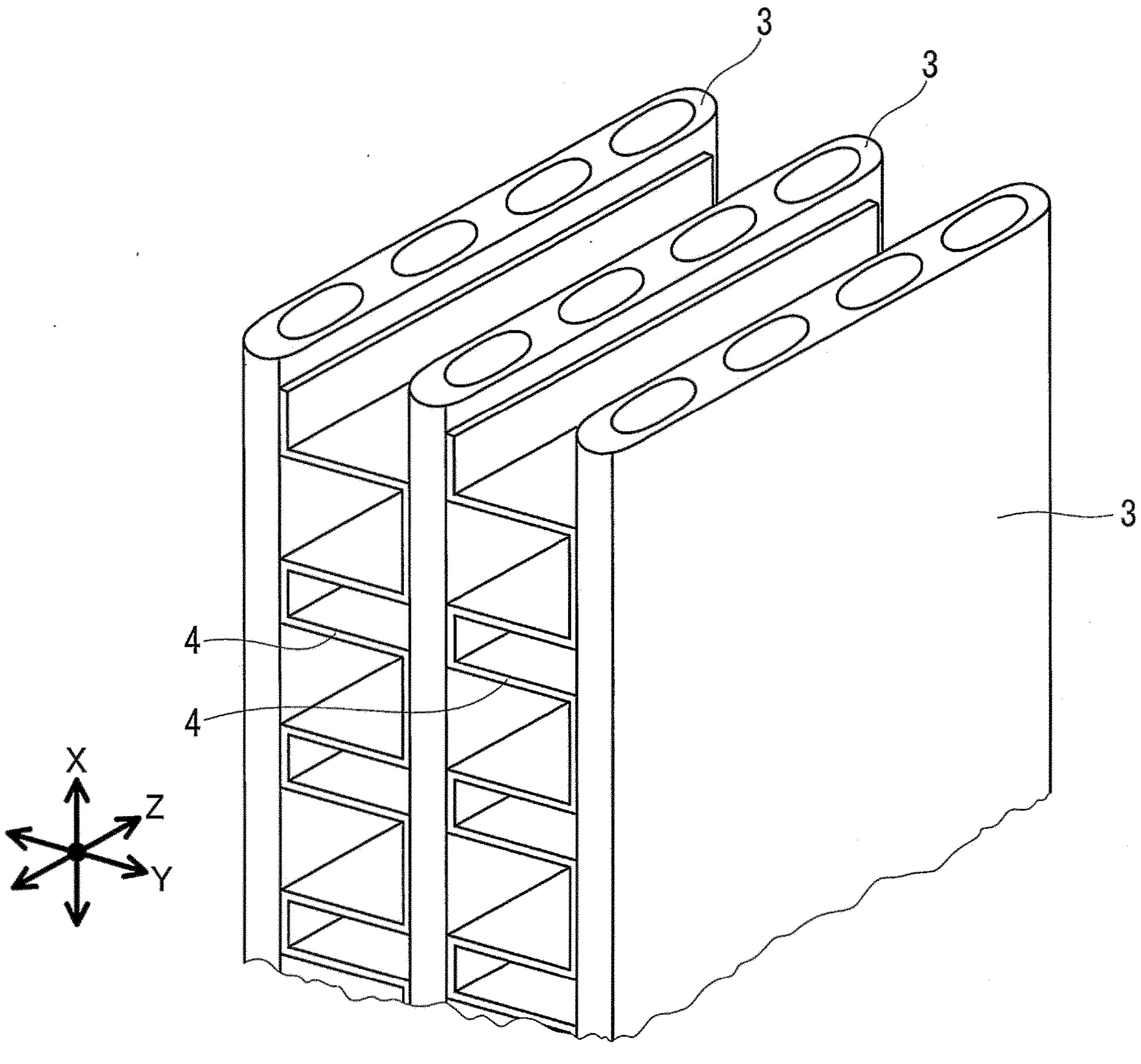


FIG.2

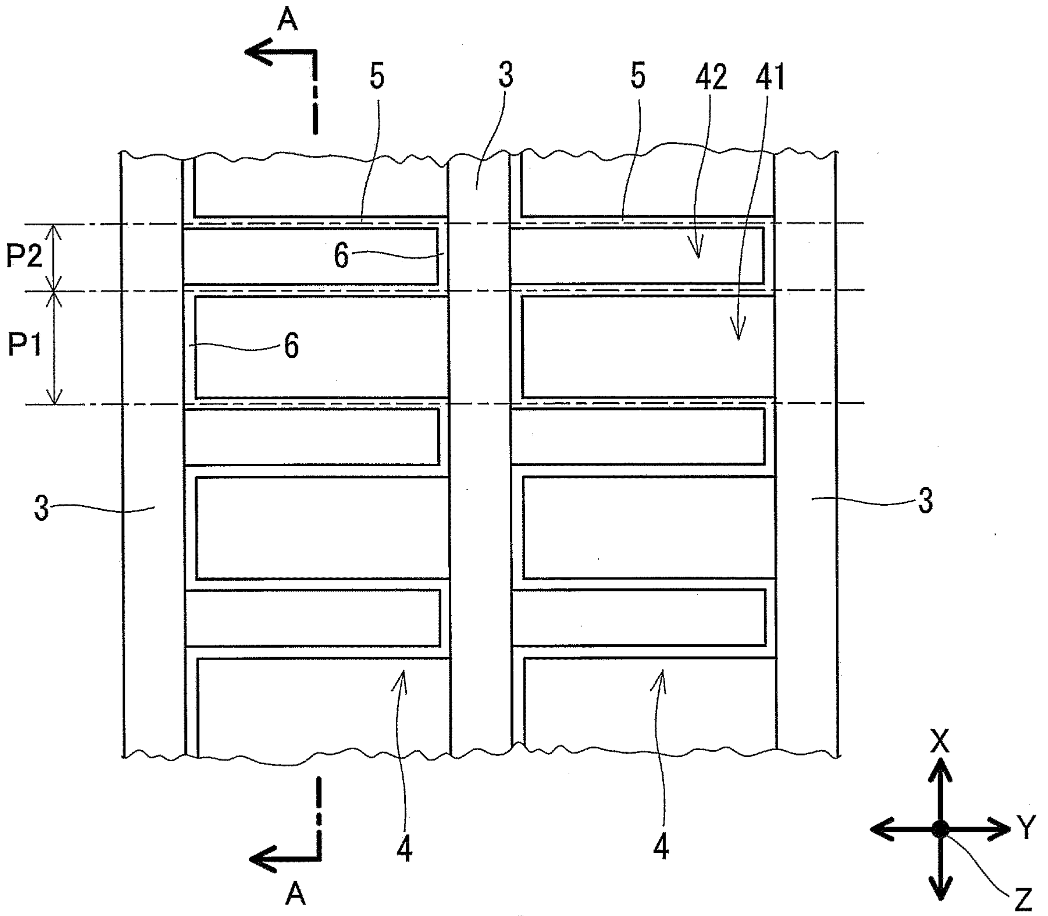


FIG.3A

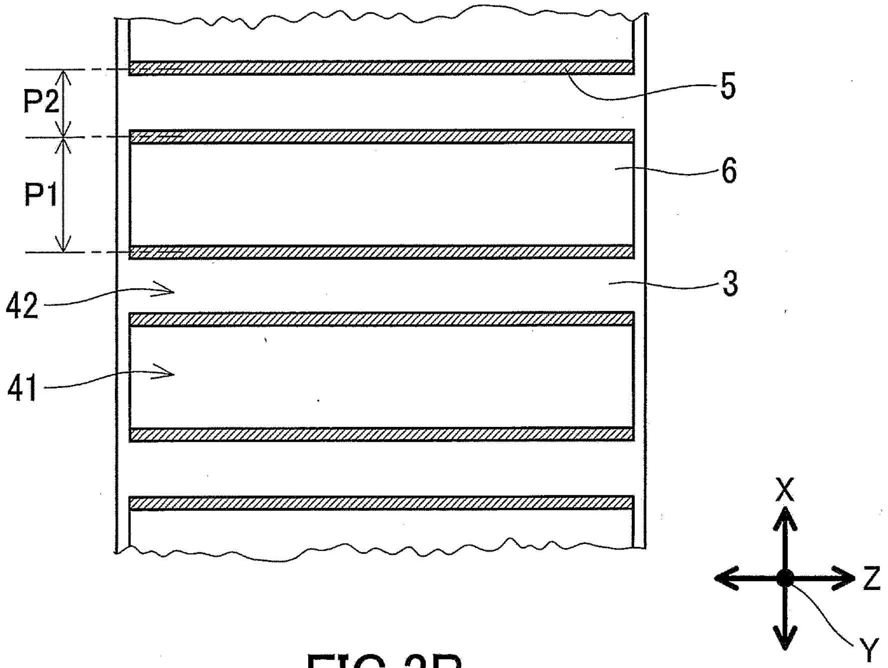


FIG.3B

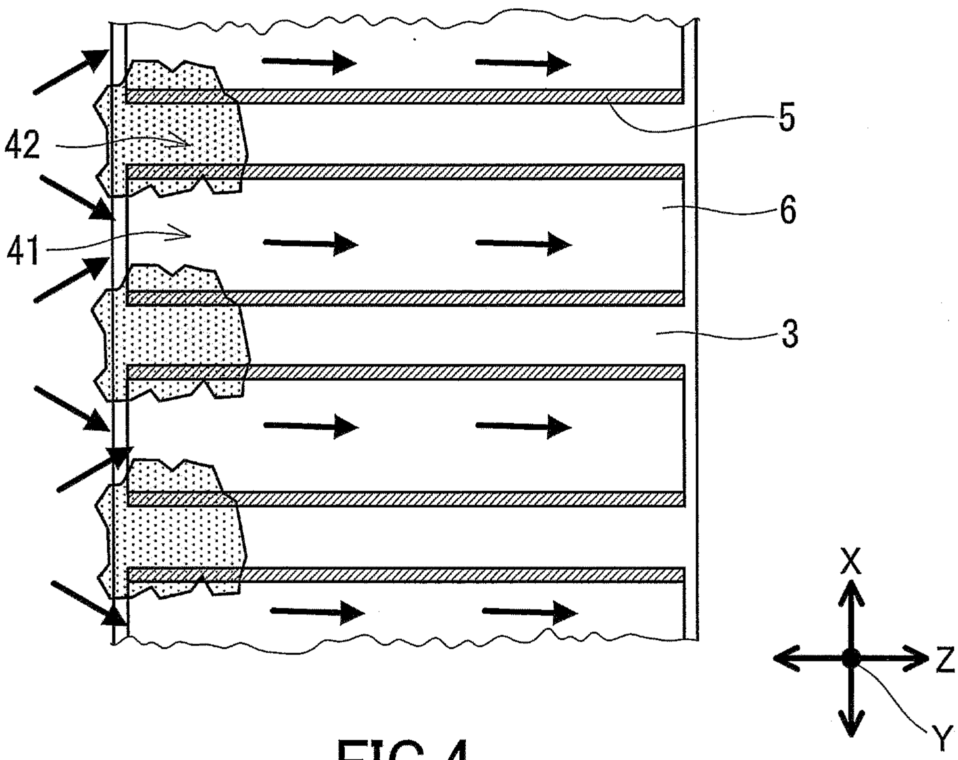


FIG.4

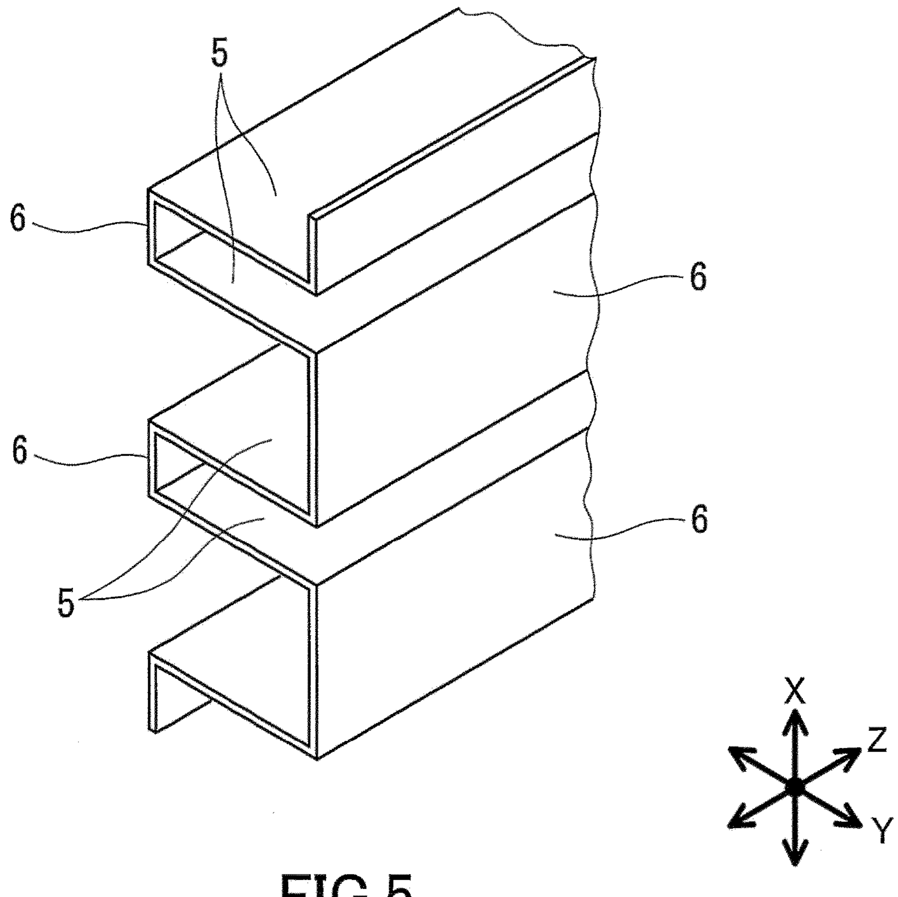


FIG.5

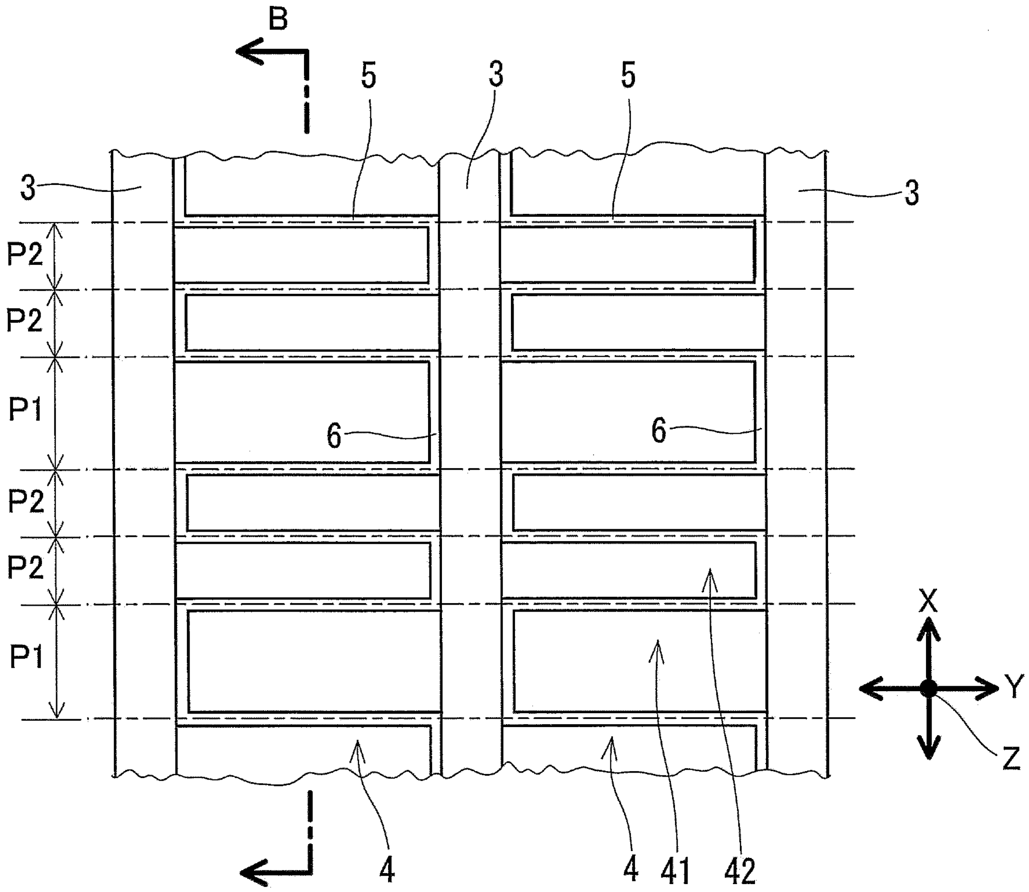
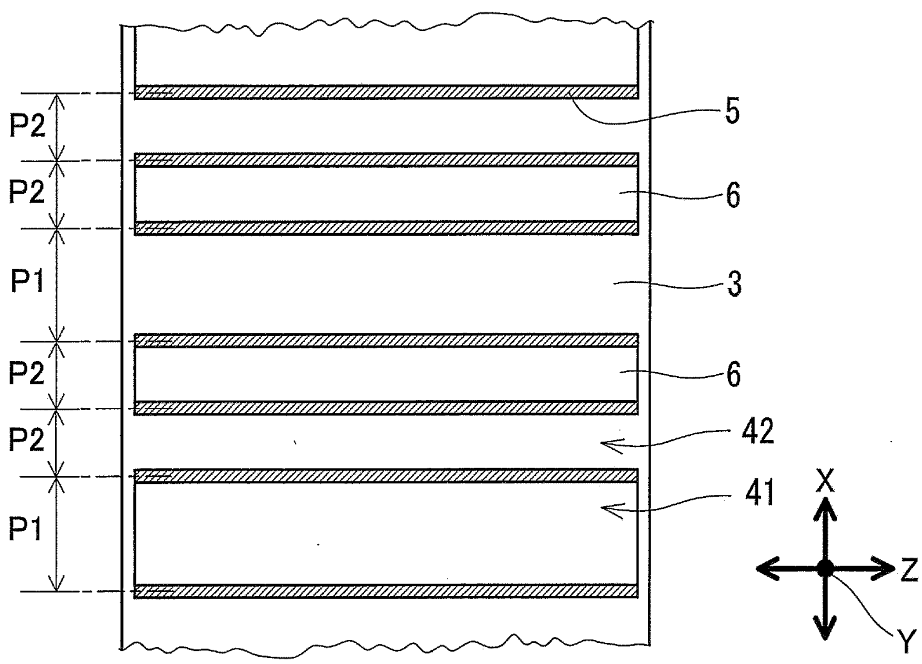

B
5
3
5
3
3
P2
P2
P1
6
6
P2
P2
P1
X
Y
Z
4
4
41
42
B

FIG.6A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P2
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P1
3
P2
6
P2
42
P1
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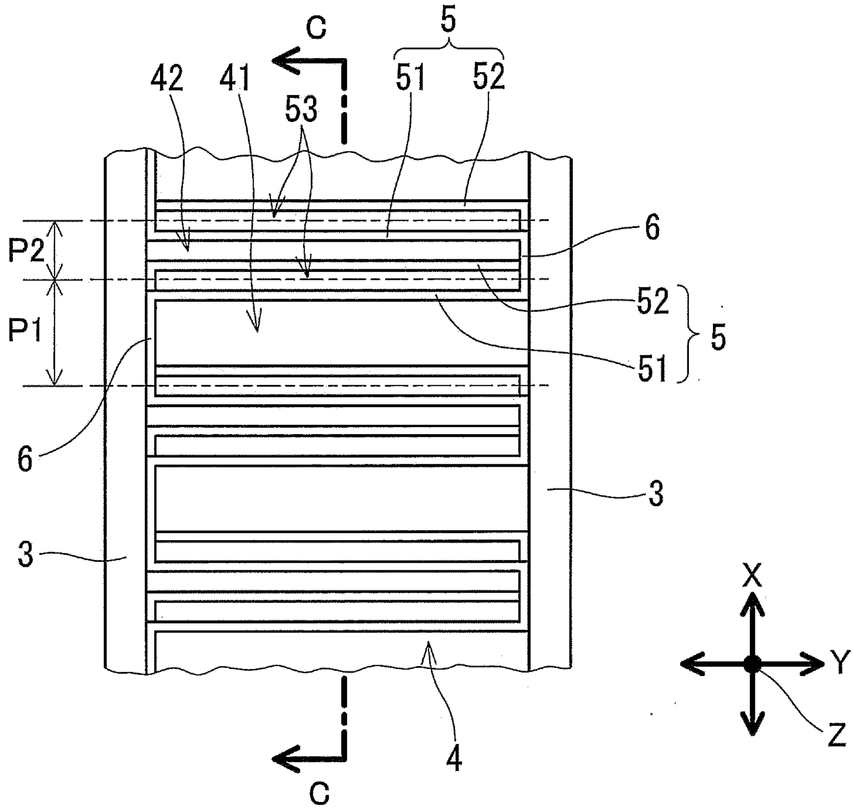
X
Z
Y

FIG.6B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P2
P1
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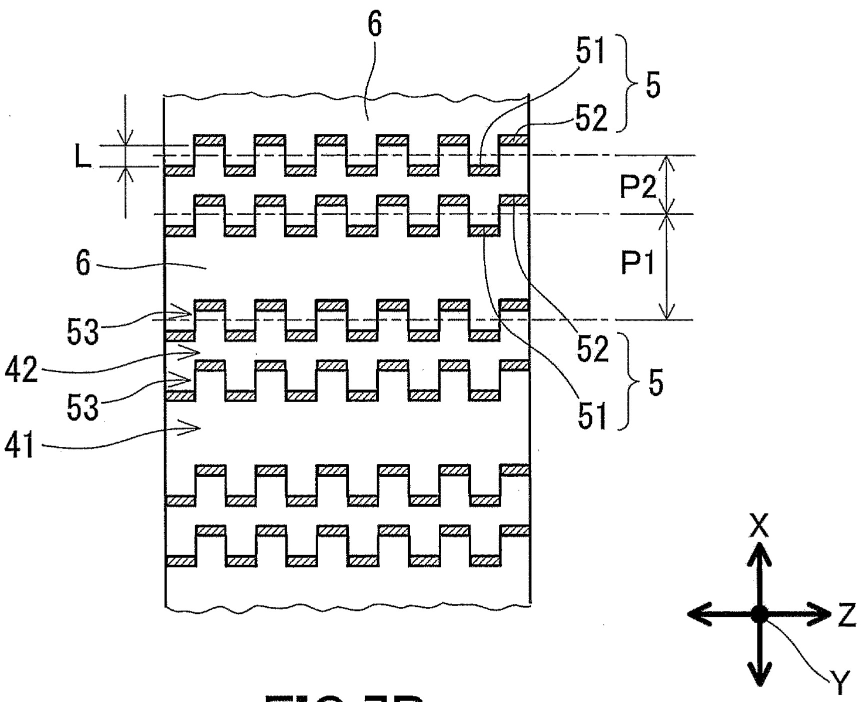
X
Y
Z
4
C

FIG.7A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L
P2
P1
6
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42
53
41
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5
51
X
Z
Y

FIG.7B

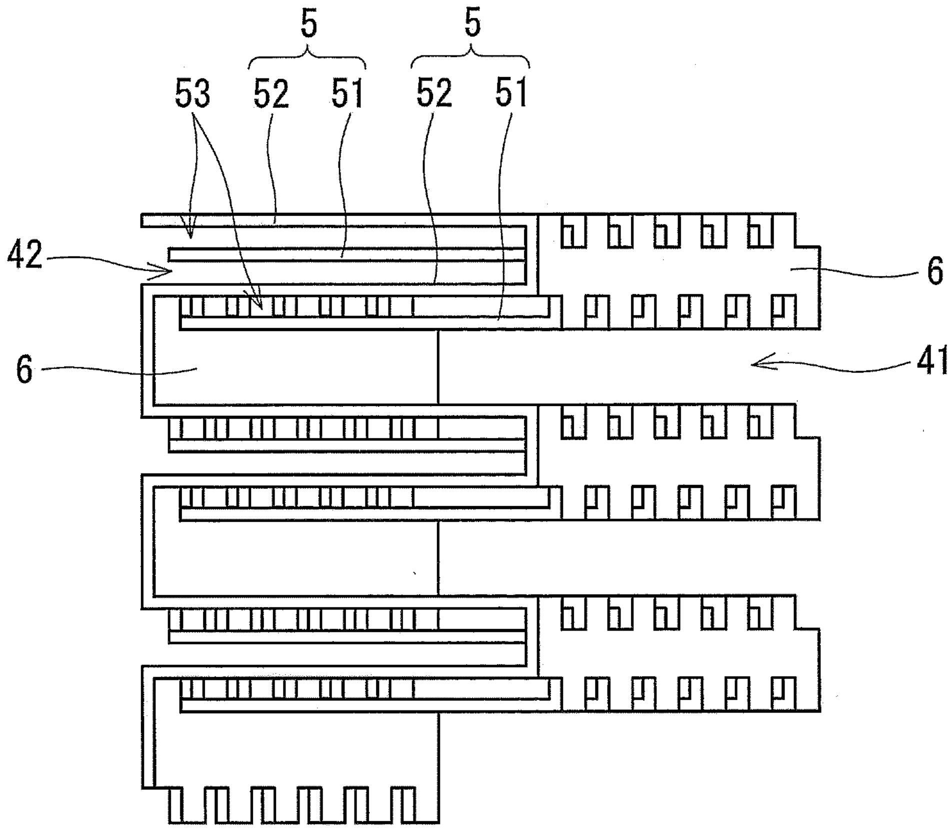

FIG.8

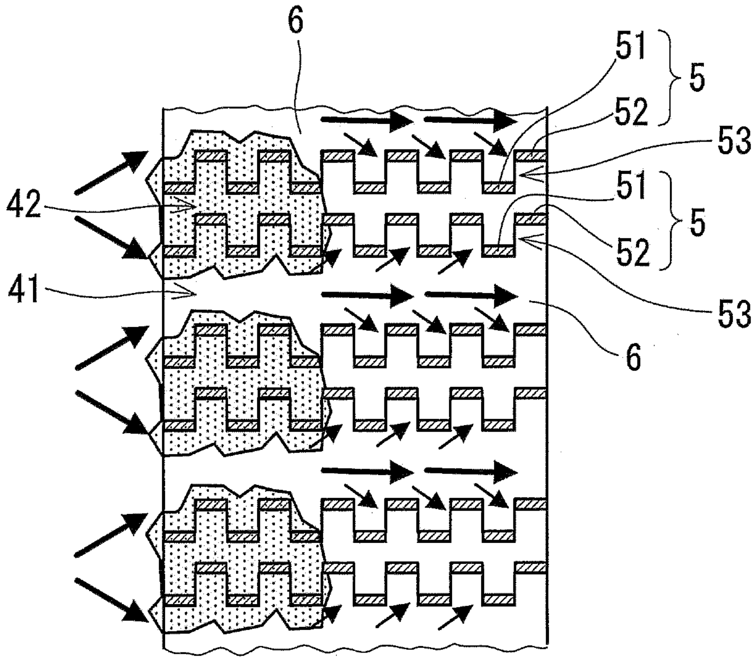

FIG.9A

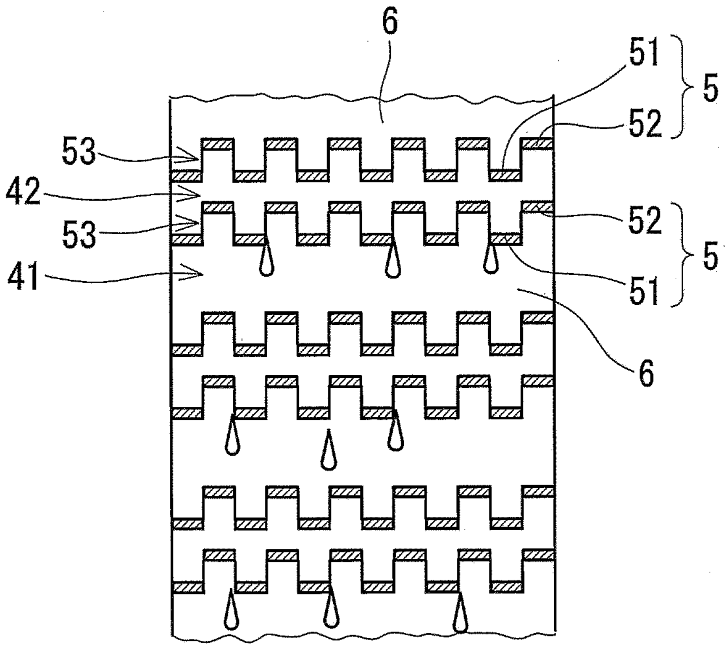

FIG.9B

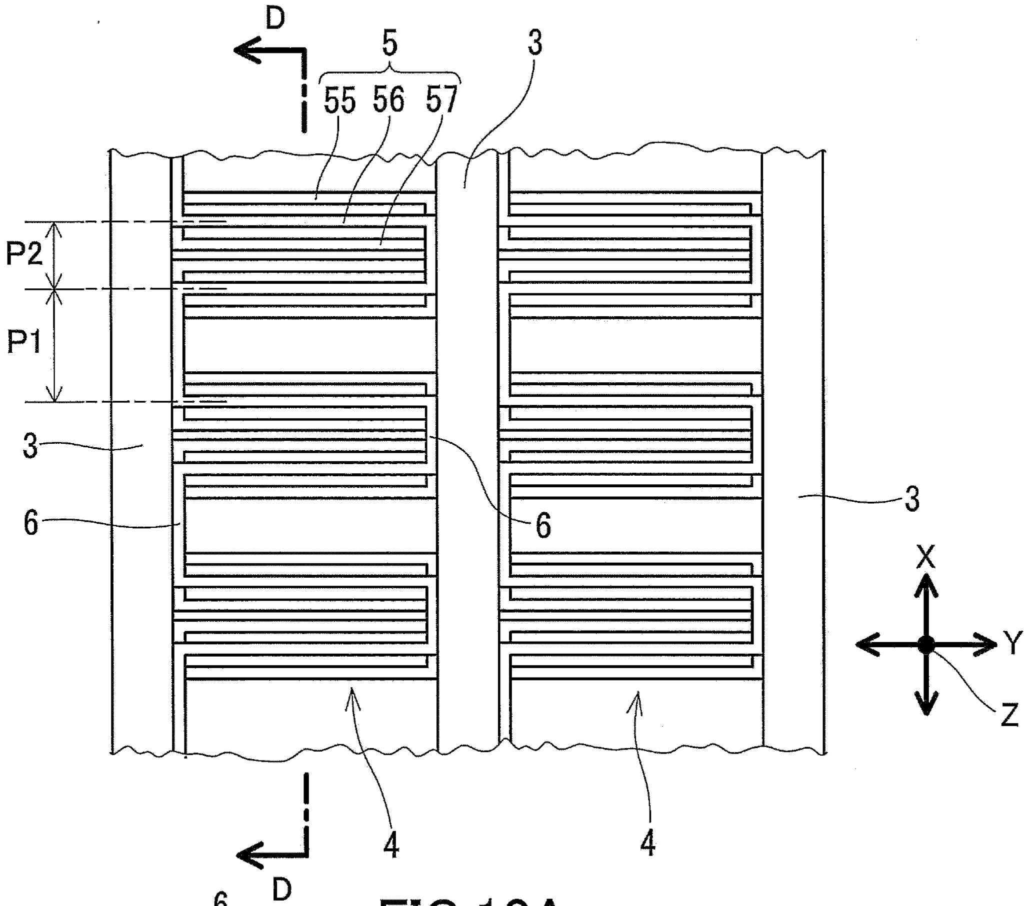

FIG.10A

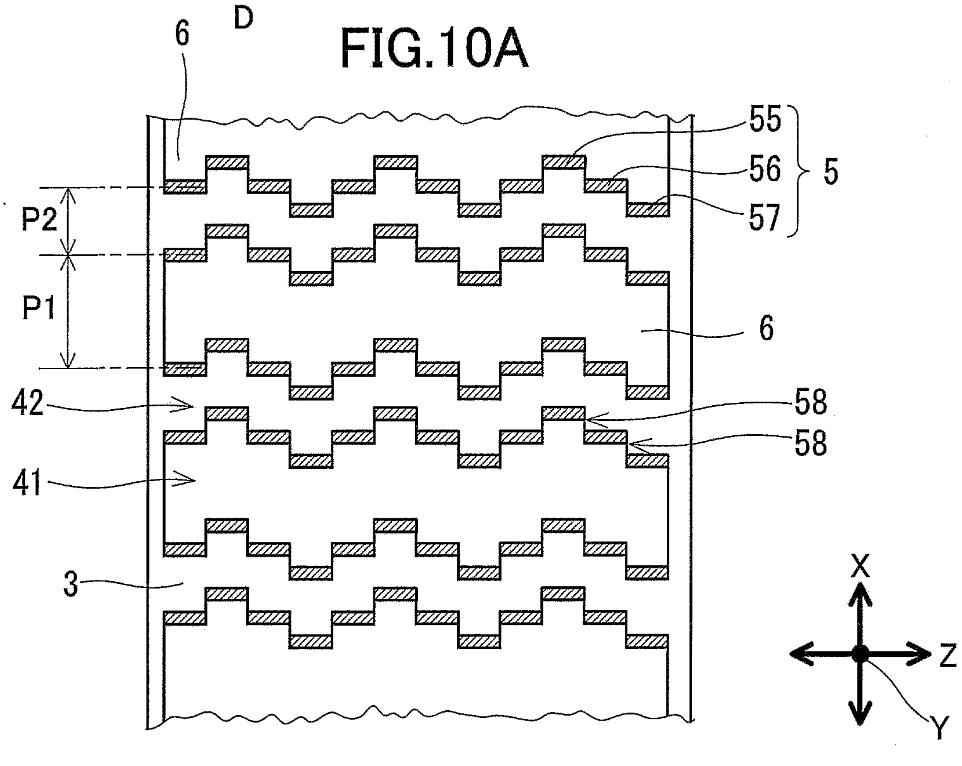

FIG.10B

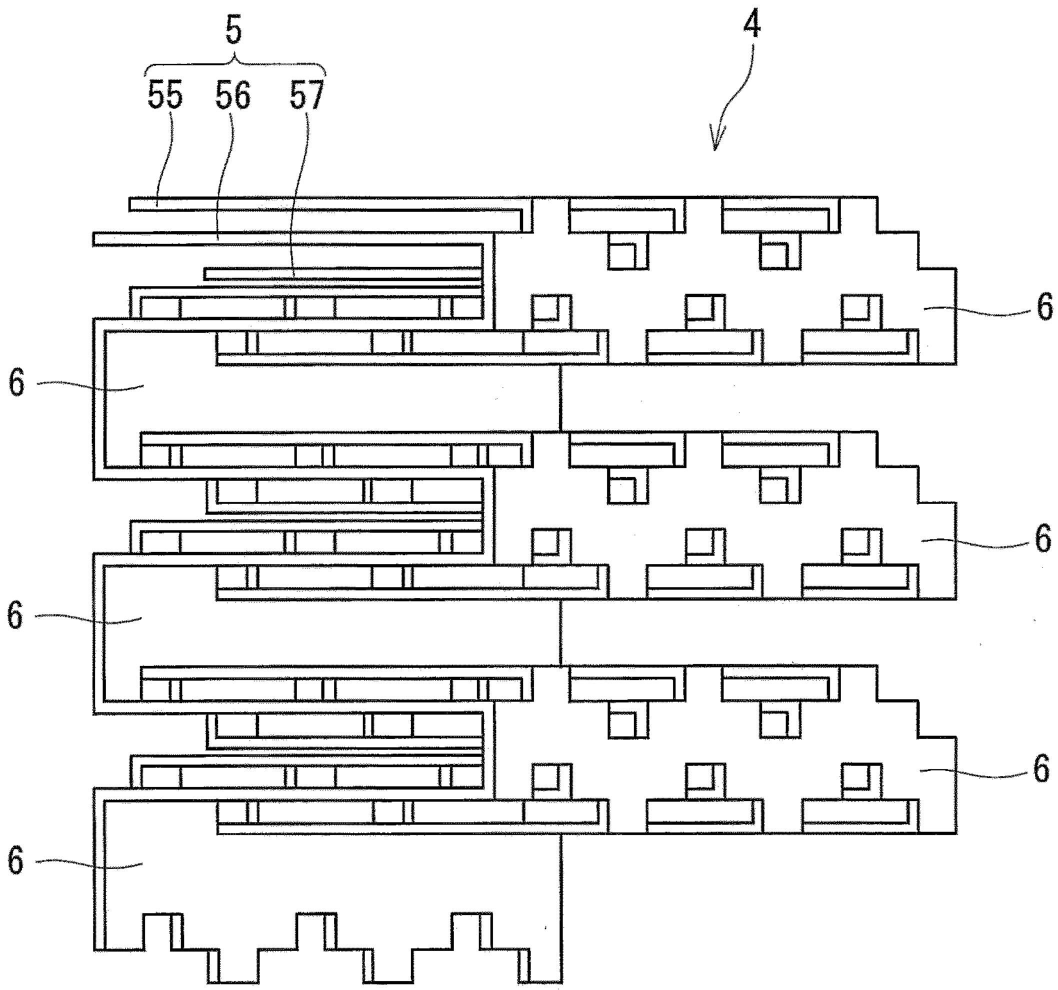

FIG.11

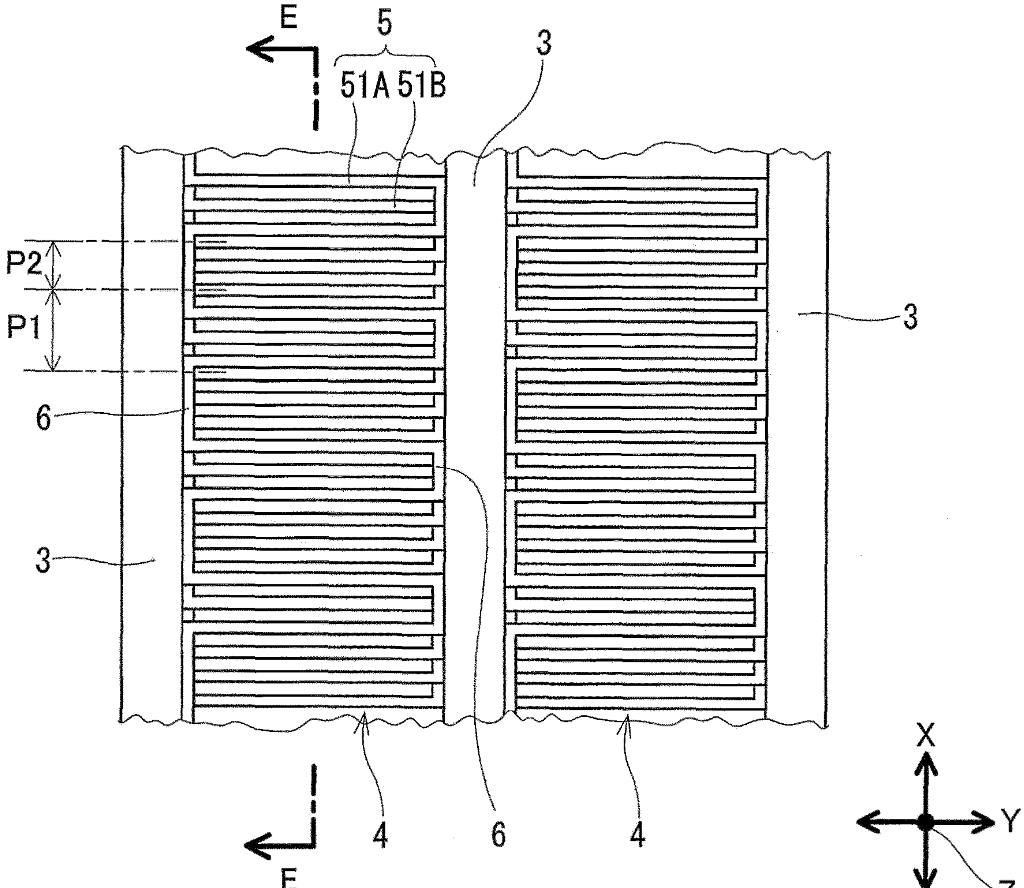

FIG.12A

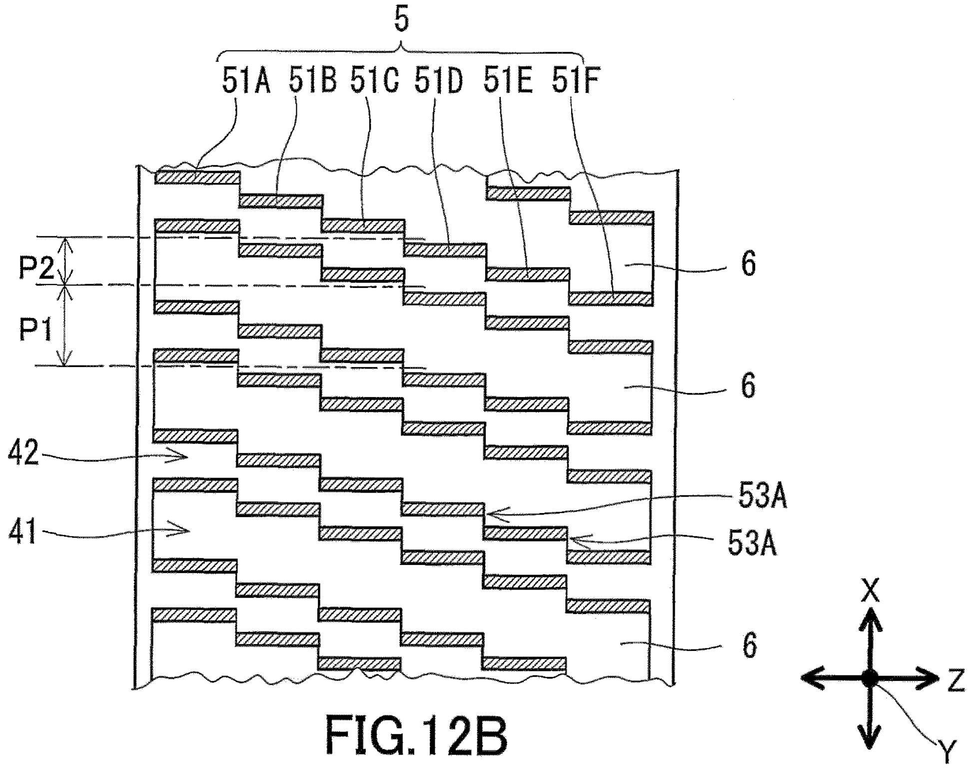

FIG.12B

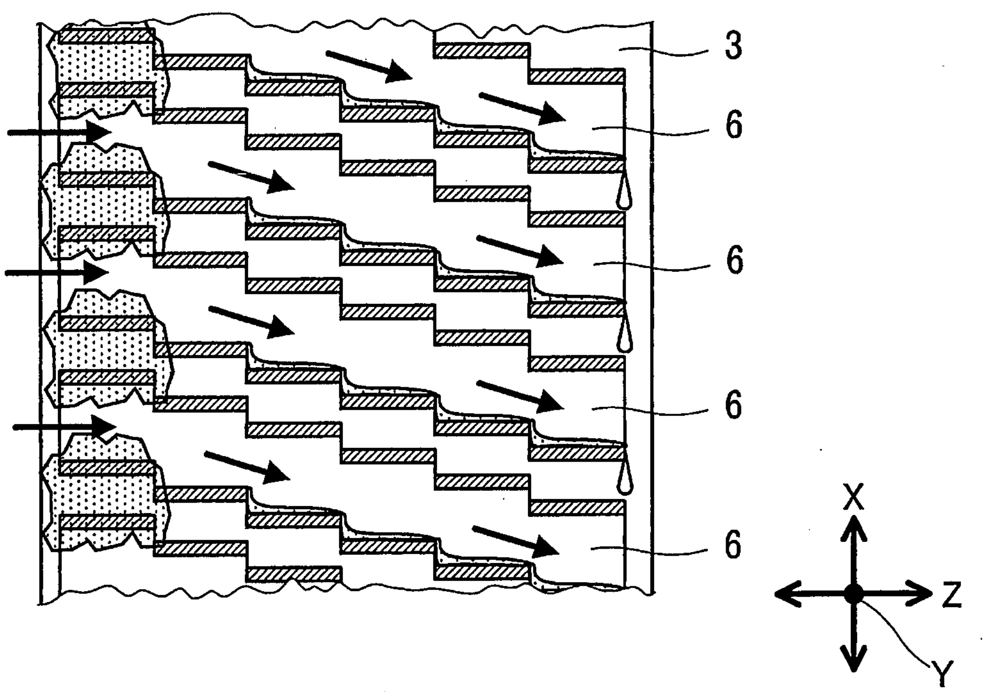

FIG.13

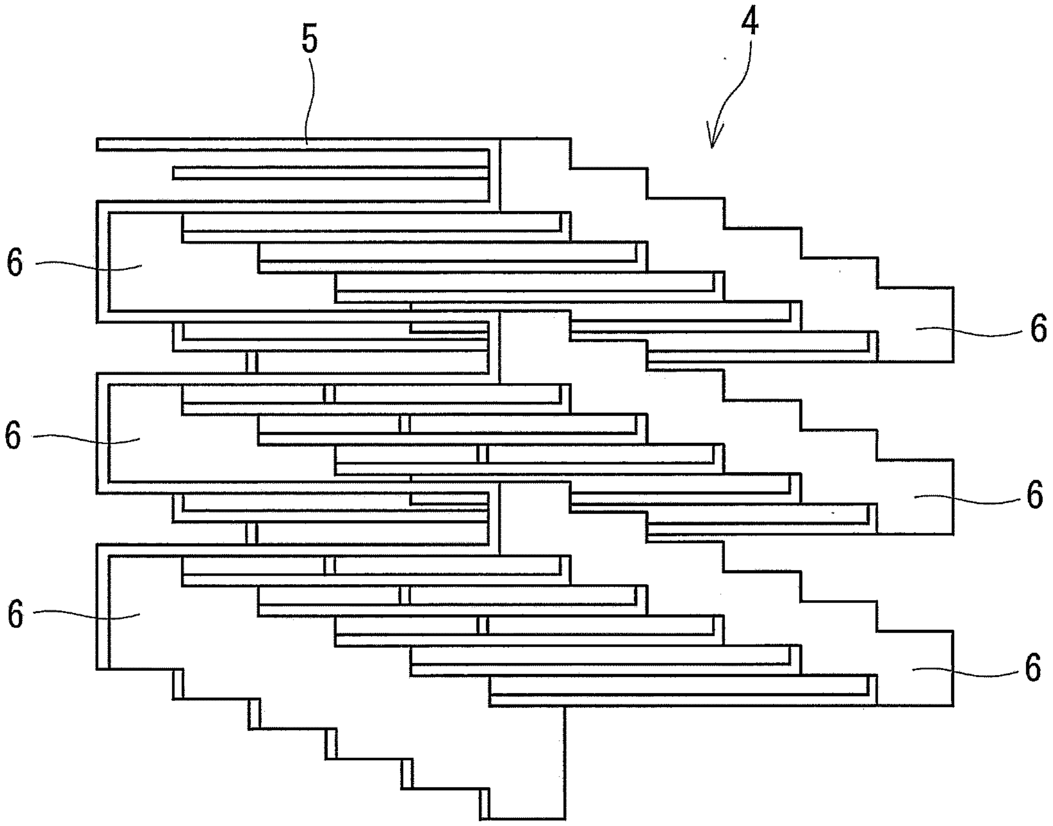

FIG.14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/006689

A. CLASSIFICATION OF SUBJECT MATTER
F28F1/30(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)
F28F1/30, 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	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

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 Y A	JP 2006-29615 A (T. RAD Co., Ltd.), 02 February 2006 (02.02.2006), claim 3; paragraphs [0001] to [0021] (particularly, paragraphs [0018], [0020], [0021]; fig. 2, 3) (Family: none)	1,3,8,12,13 2,4-7 9,10
X Y A	JP 2004-150710 A (Denso Corp.), 27 May 2004 (27.05.2004), entire text; all drawings (particularly, paragraphs [0011], [0023], [0024]; fig. 2) (Family: none)	1,3,11-13 2,4-7 9,10

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

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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"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
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"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	Date of mailing of the international search report
16 November, 2012 (16.11.12)	27 November, 2012 (27.11.12)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/006689

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 10-141805 A (Toyota Central Research and Development Laboratories, Inc.), 29 May 1998 (29.05.1998), entire text; all drawings (particularly, paragraph [0013]; fig. 3) (Family: none)	2,5-7
Y	JP 2009-204279 A (Nippon Light Metal Co., Ltd.), 10 September 2009 (10.09.2009), entire text; all drawings (particularly, paragraphs [0032], [0035], [0036]; fig. 1) (Family: none)	7

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REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2004317002 A **[0003]**