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(54) **HEAT EXCHANGER**

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(57) **ABSTRACT**

A heat exchanger includes: a heat transfer tube that extends in a second direction that crosses a first direction in which gas flows, and a fin that is provided to the heat transfer tube and has a surface that extends in the first direction and the second direction. The fin has a first extension part and a second extension part, the first extension part has a first heat-transfer-enhancement area that is located further upstream in a flow of the gas than the heat transfer tube in the first direction and improves a heat transfer coefficient, and the second extension part has a second heat-transfer-enhancement area that is located further downstream in the flow of the gas than the heat transfer tube in the first direction and improves a heat transfer coefficient.

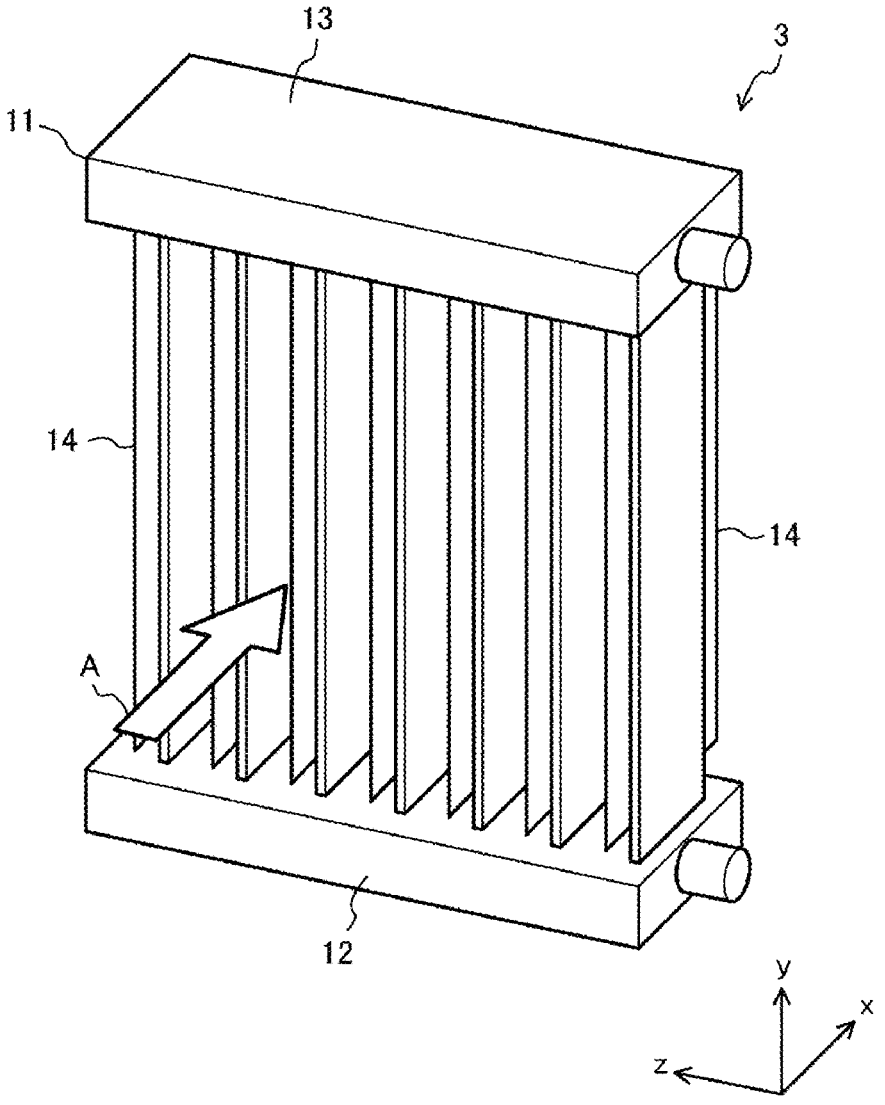


FIG. 1

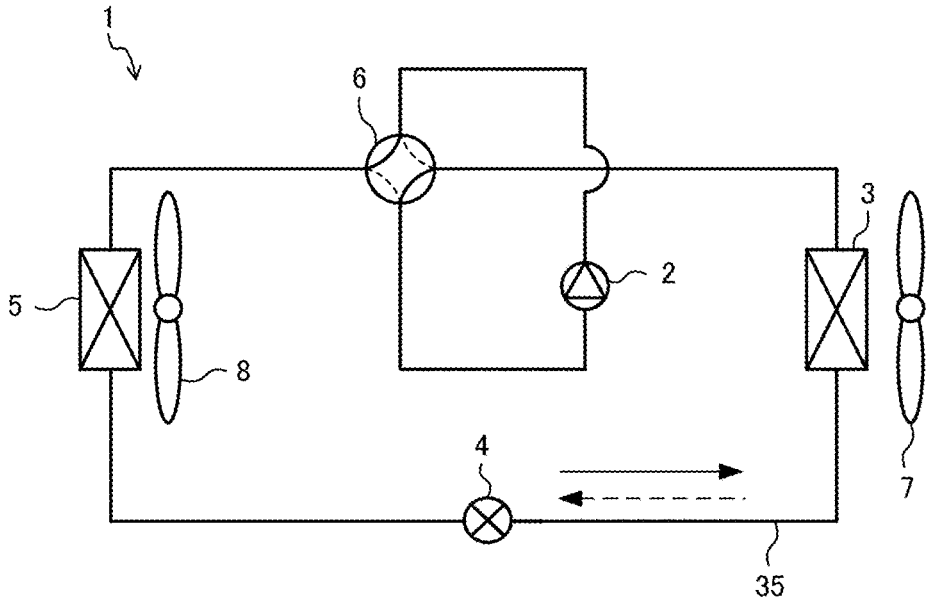


FIG. 2

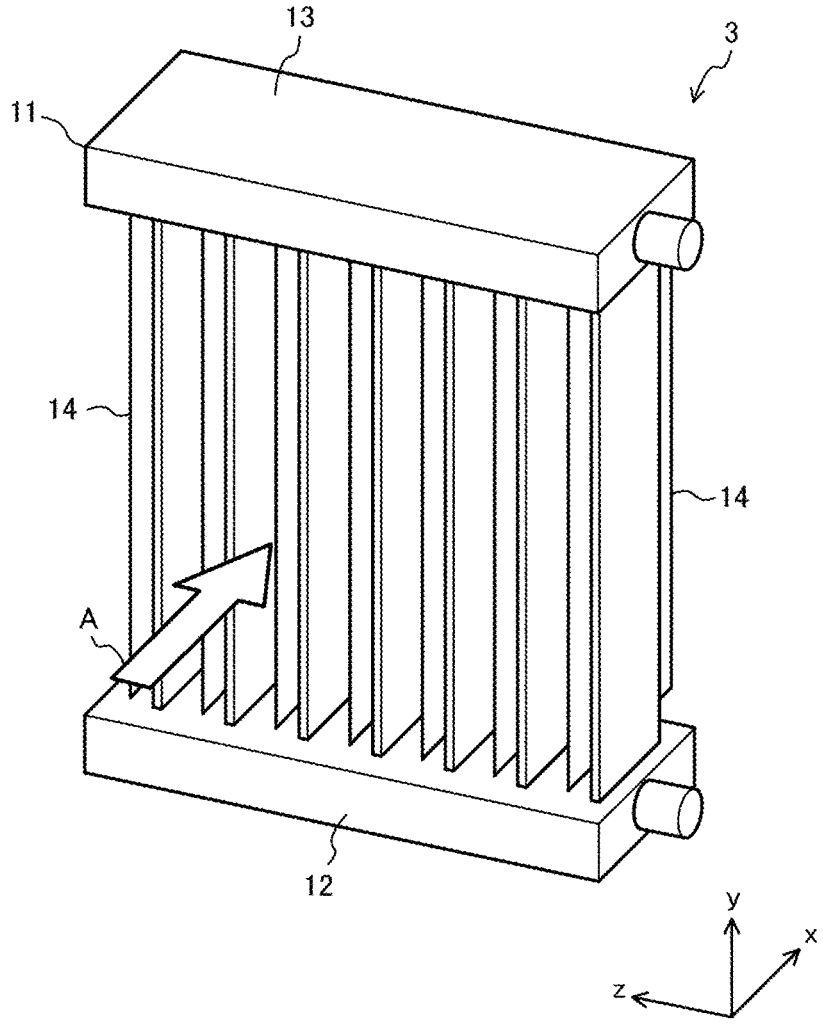


FIG. 3

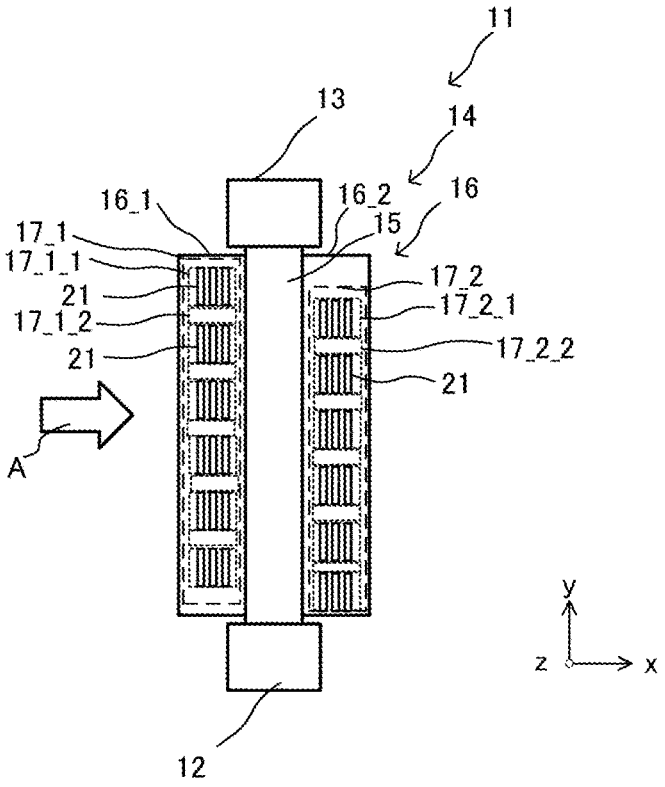

11
13
14
16_1
16_2
16
15
17_1
17_1_1
21
17_1_2
21
17_2
17_2_1
17_2_2
21
A
y
z
x
12

FIG. 4

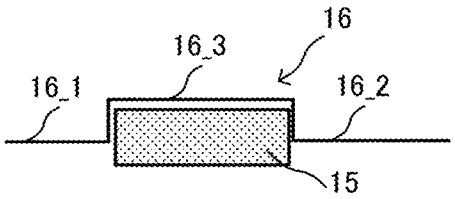

16
16_3
16_1
16_2
15

FIG. 5

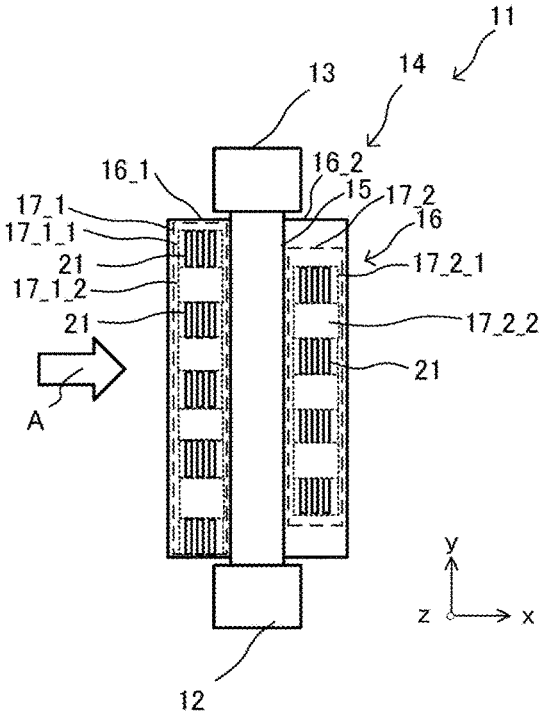

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17_1
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A
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12

FIG. 6

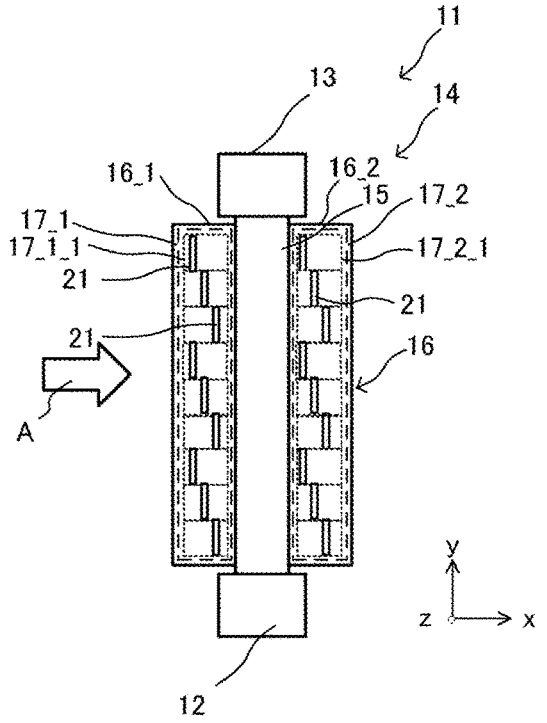

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FIG. 7

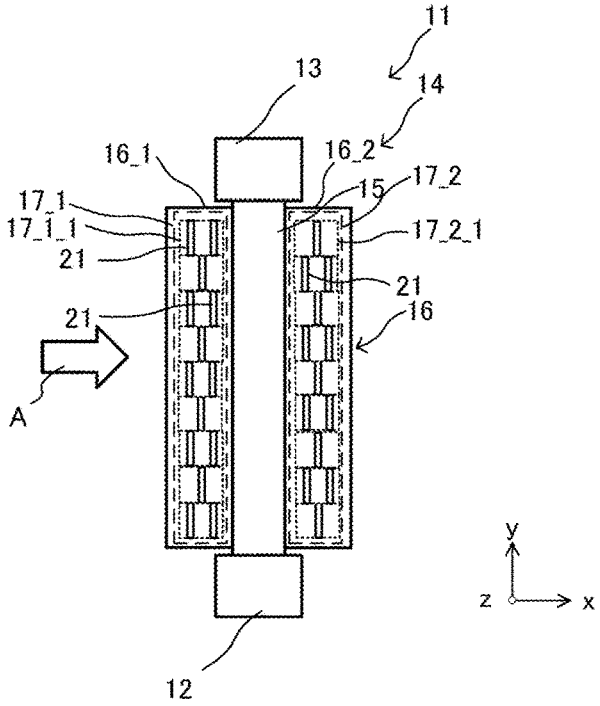

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FIG. 8

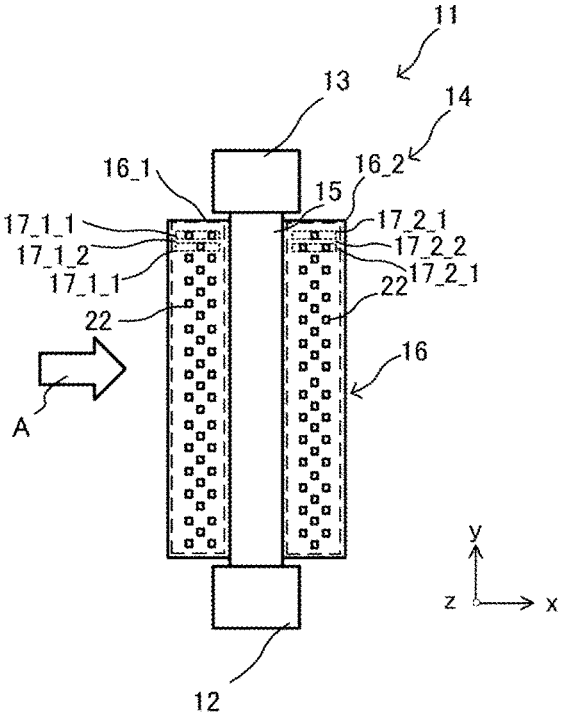

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16_1
16_2
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17_1_1
17_2_1
17_1_2
17_2_2
17_1_1
17_2_1
22
22
16
A
12
y
z
x

FIG. 9

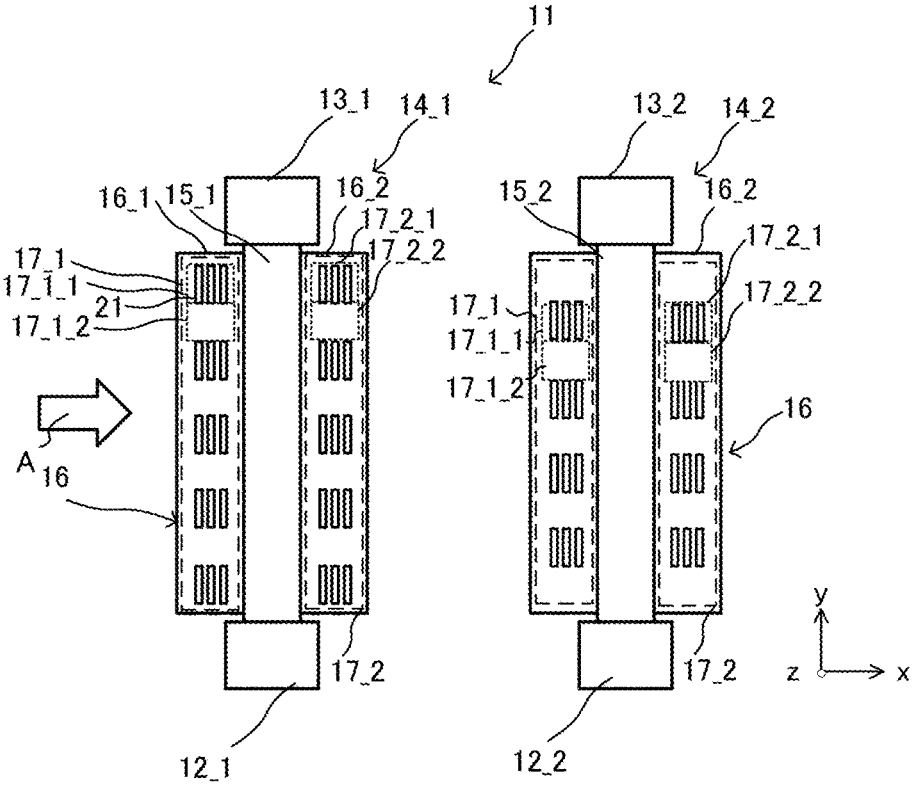

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17_1
17_1_1
21
17_1_2
17_2_2
17_1
17_1_1
17_1_2
A
16
16
17_2
17_2
12_1
12_2
y
z
x

FIG. 10

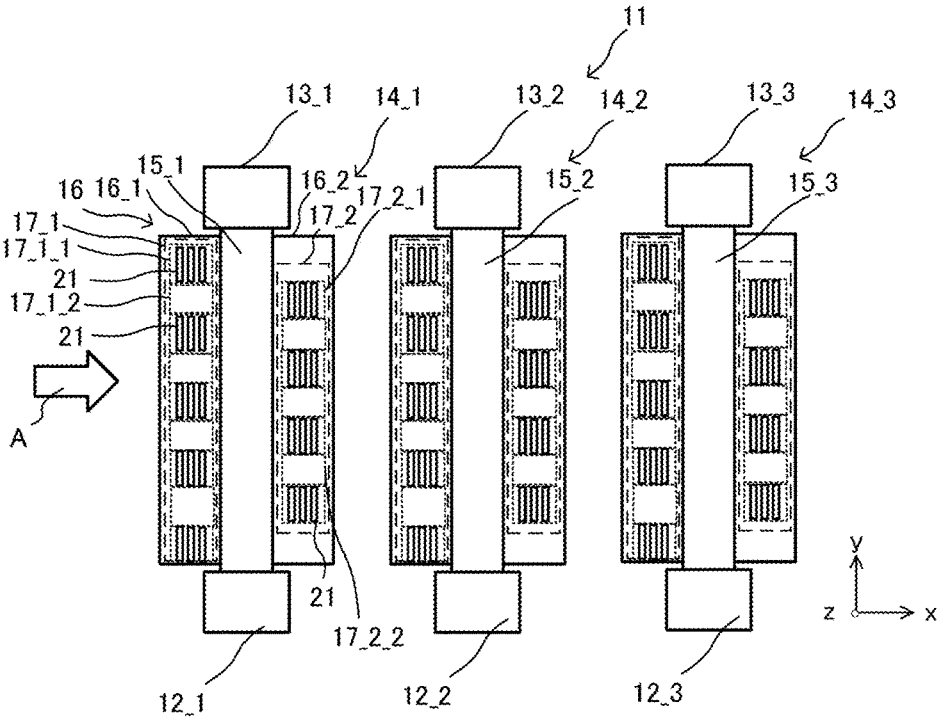

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16_1
16_2
17_2_1
15_2
15_3
17_1
17_2
17_1_1
21
17_1_2
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A
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17_2_2
y
z
x
12_1
12_2
12_3

FIG. 11

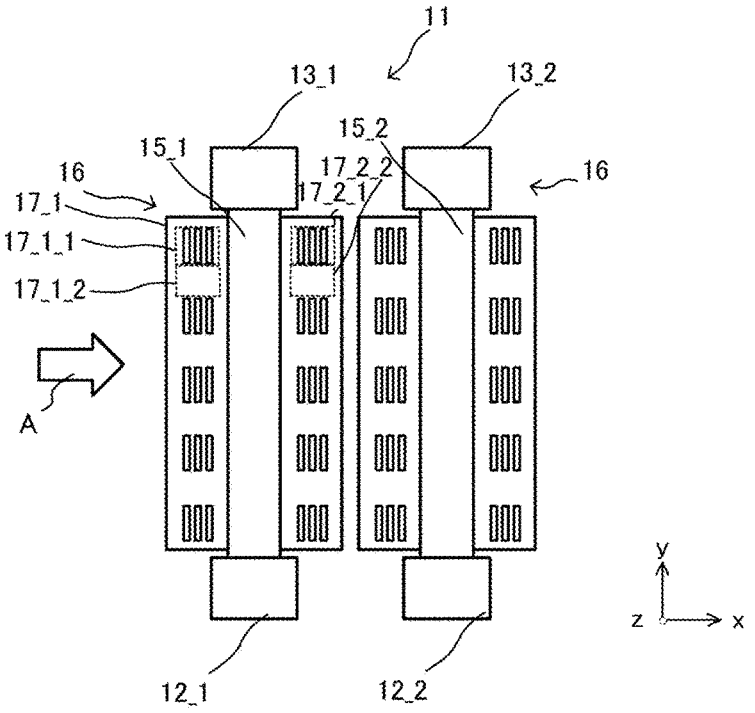

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13_2
15_2
15_1
17_2_2
16
16
17_2_1
17_1
17_1_1
17_1_2
A
y
z
x
12_1
12_2

FIG. 12

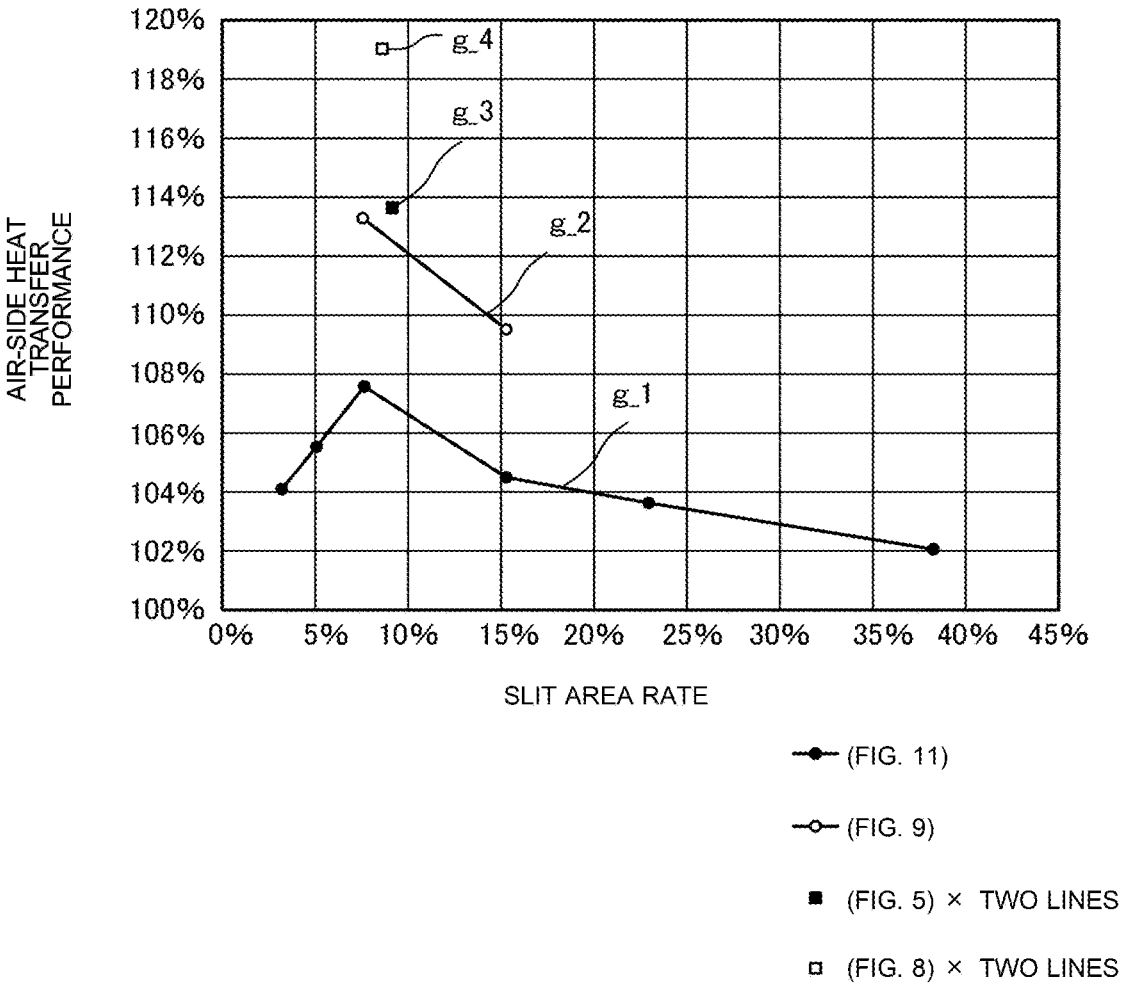

120%
118%
116%
114%
112%
110%
108%
106%
104%
102%
100%
AIR-SIDE HEAT TRANSFER PERFORMANCE
g_4
g_3
g_2
g_1
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
SLIT AREA RATE
(FIG. 11)
(FIG. 9)
(FIG. 5) × TWO LINES
(FIG. 8) × TWO LINES

FIG. 10

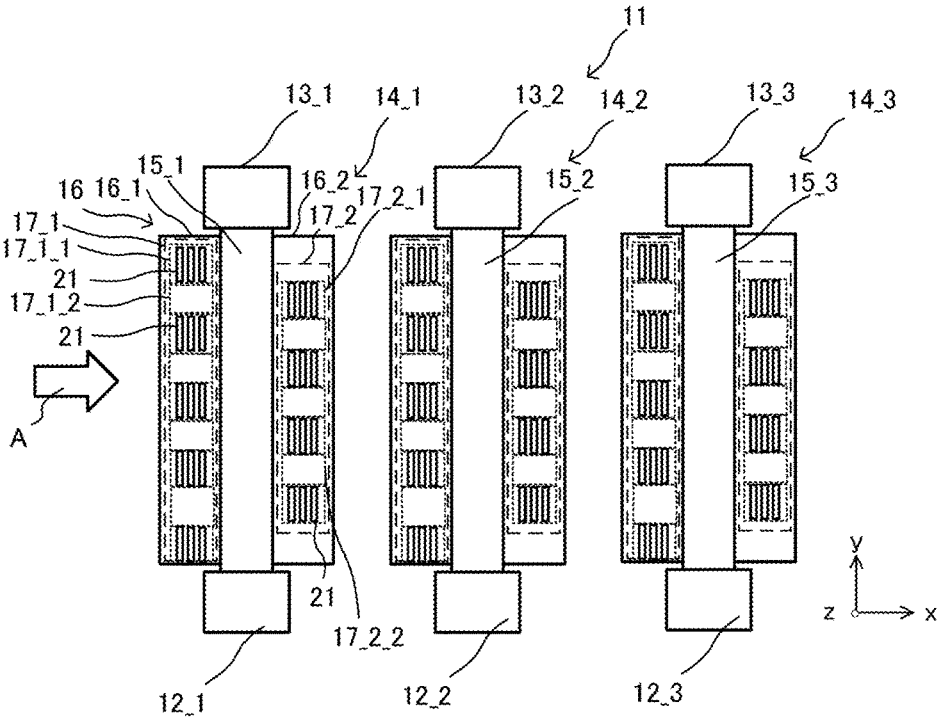
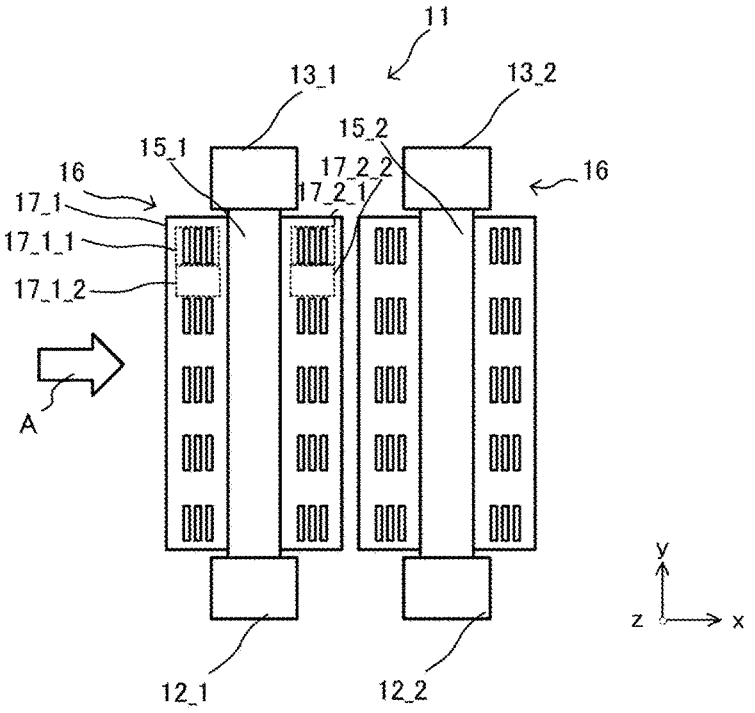


FIG. 11

Comparative Example



HEAT EXCHANGER

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application is a U.S. national stage application of PCT/JP2021/044701 filed on Dec. 6, 2021, the contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to a heat exchanger including a fin provided to a heat transfer tube.

BACKGROUND

[0003] There is a heat exchanger in which a heat-transfer-enhancement part is provided in a heat transfer plate that forms a fin provided to a heat transfer tube. The heat-transfer-enhancement part is a slit part, a cut and bent-up part, or a louver. The heat transfer plates are each located on the corresponding one of an upwind side and a downwind side of the heat transfer tube. The heat-transfer-enhancement part is provided in the heat transfer plate on the upwind side of a heat exchange part (see, for example, Patent Literature 1).

PATENT LITERATURE

[0004] Patent Literature 1: International Publication No. WO 2019/026243 (see FIG. 18)

[0005] However, the heat exchanger has a problem with the fin disclosed in Patent Literature 1 in that air bypasses the heat-transfer-enhancement part, which is provided in the heat transfer plate on the upwind side and has high pressure loss, and consequently the airflow concentrates on a flat part of the heat transfer plate, resulting in an insufficient heat transfer coefficient between gas and the fin.

SUMMARY

[0006] The present disclosure has been made in view of the above circumstances, and it is an object of the present disclosure to provide a heat exchanger including a fin that can improve a heat transfer coefficient between gas and the fin.

[0007] A heat exchanger according to an embodiment of the present disclosure includes: a heat transfer tube that extends in a second direction that crosses a first direction in which gas flows, and a fin that is provided to the heat transfer tube and has a surface that extends in the first direction and the second direction. The fin has a first extension part and a second extension part, the first extension part has a first heat-transfer-enhancement area that is located further upstream in a flow of the gas than the heat transfer tube in the first direction and improves a heat transfer coefficient, and the second extension part has a second heat-transfer-enhancement area that is located further downstream in the flow of the gas than the heat transfer tube in the first direction and improves a heat transfer coefficient.

[0008] According to an embodiment of the present disclosure, the first heat-transfer-enhancement area is provided in the first extension part of the fin located upstream in the flow of the gas, while the second heat-transfer-enhancement area is provided in the second extension part of the fin located further downstream in the flow of the gas than the first extension part. It is therefore possible to provide the heat exchanger in which the first heat-transfer-enhancement area and the second heat-transfer-enhancement area can improve a heat transfer coefficient between the fin and the gas passing through the fin.

BRIEF DESCRIPTION OF DRAWINGS

[0009] FIG. **1** is a schematic configuration diagram illustrating a refrigeration cycle apparatus according to Embodiment 1.

[0010] FIG. **2** is a perspective view illustrating an outdoor heat exchanger in FIG. **1**.

[0011] FIG. **3** illustrates a heat transfer part of the heat exchanger according to Embodiment 1.

[0012] FIG. **4** illustrates a modification of a method for attaching a fin to a heat transfer tube in the heat exchanger according to Embodiment 1.

[0013] FIG. **5** illustrates a heat transfer part of the heat exchanger according to Embodiment 2.

[0014] FIG. **6** illustrates a heat transfer part of the heat exchanger according to Embodiment 3.

[0015] FIG. **7** illustrates a heat transfer part of the heat exchanger according to Embodiment 4.

[0016] FIG. **8** illustrates a modification of the heat transfer part of the heat exchanger according to Embodiment 4.

[0017] FIG. **9** illustrates a heat exchange part of the heat exchanger according to Embodiment 5.

[0018] FIG. **10** illustrates a modification of the heat exchange part of the heat exchanger according to Embodiment 5.

[0019] FIG. **11** illustrates the arrangement of first heat-transfer-enhancement parts and second heat-transfer-enhancement parts, which are formed in a fin in Comparative Example.

[0020] FIG. **12** illustrates a relationship between a slit area rate and air-side heat transfer performance.

DETAILED DESCRIPTION

[0021] Hereinafter, an air-conditioning apparatus according to an embodiment will be described with reference to the drawings. Note that the same constituent elements in the drawings are denoted by the same reference signs, and redundant explanation will be omitted appropriately. The present disclosure may include all combinations of configurations that can be combined among the configurations explained in embodiments described below. In addition, the relationship of sizes of the components in the drawings may differ from that of actual ones. The forms of the constituent elements described throughout the entire specification are merely examples, and do not intend to limit the constituent elements to the forms described in the specification. In particular, the combination of constituent elements is not limited to only the combination in each embodiment, and the constituent elements described in one embodiment can be applied to another embodiment. In the embodiments below, in a case where a plurality of identical constituent elements are provided, these identical constituent elements may be denoted by the same reference sign followed by an underscore and a different number to distinguish the constituent elements from each other. However, when the plurality of identical constituent elements are collectively described, or when one of the identical constituent elements is described as a typical example, an underscore and a different number may not be placed after the reference sign.

Embodiment 1

[0022] FIG. **1** is a schematic configuration diagram illustrating a refrigeration cycle apparatus according to Embodiment 1. In Embodiment 1, the refrigeration cycle apparatus is used as an air-conditioning apparatus **1**. The air-conditioning apparatus **1** includes a compressor **2**, an outdoor heat exchanger **3**, an expansion valve **4**, an indoor heat exchanger **5**, and a four-way valve **6**. In this example, the compressor **2**, the outdoor heat exchanger **3**, the expansion valve **4**, and the four-way valve **6** are provided in an outdoor unit, while the indoor heat exchanger **5** is provided in an indoor unit.

[0023] The compressor **2**, the outdoor heat exchanger **3**, the expansion valve **4**, the indoor heat exchanger **5**, and the four-way valve **6** are connected to each other through refrigerant pipes, forming a refrigerant circuit through which refrigerant can circulate. In the air-conditioning apparatus **1**, when the compressor **2** operates, refrigeration cycle is performed in which the refrigerant circulates through the compressor **2**, the outdoor heat exchanger **3**, the expansion valve **4**, and the indoor heat exchanger **5** while the refrigerant changes in phase.

[0024] The outdoor unit is provided with an outdoor fan **7** configured to force outside air to pass through the outdoor heat exchanger **3**. Through the outdoor heat exchanger **3**, refrigerant exchanges heat with an airflow of the outside air generated by operation of the outdoor fan **7**. The indoor unit is provided with an indoor fan **8** configured to force room air to pass through the indoor heat exchanger **5**. Through the indoor heat exchanger **5**, refrigerant exchanges heat with an airflow of the room air generated by operation of the indoor fan **8**.

[0025] The air-conditioning apparatus **1** is capable of switching the operating mode between cooling mode and heating mode. The four-way valve **6** is a solenoid valve configured to switch refrigerant flow passages in response to the switching of the operating mode of the air-conditioning apparatus **1** between cooling mode and heating mode. During operation in cooling mode, the four-way valve **6** guides refrigerant flowing from the compressor **2** to the outdoor heat exchanger **3** and also guides refrigerant from the indoor heat exchanger **5** to the compressor **2**. During operation in heating mode, the four-way valve **6** guides refrigerant flowing from the compressor **2** to the indoor heat exchanger **5** and also guides refrigerant flowing from the outdoor heat exchanger **3** to the compressor **2**. In FIG. **1**, the refrigerant flow direction during operation in cooling mode is illustrated by the dotted arrow, while the refrigerant flow direction during operation in heating mode is illustrated by the solid arrow.

[0026] During operation of the air-conditioning apparatus **1** in cooling mode, refrigerant compressed by the compressor **2** is delivered to the outdoor heat exchanger **3**. At the outdoor heat exchanger **3**, the refrigerant transfers heat to the outside air and thus condenses. Thereafter, the refrigerant is delivered to the expansion valve **4**, is reduced in pressure by the expansion valve **4**, and is then delivered to the indoor heat exchanger **5**. Thereafter, the refrigerant receives heat from the room air at the indoor heat exchanger **5** and thus evaporates, and then flows back to the compressor **2**. Therefore, during operation of the air-conditioning apparatus **1** in cooling mode, the outdoor heat exchanger **3** serves as a condenser, while the indoor heat exchanger **5** serves as an evaporator.

[0027] During operation of the air-conditioning apparatus **1** in heating mode, refrigerant compressed by the compressor **2** is delivered to the indoor heat exchanger **5**. At the indoor heat exchanger **5**, the refrigerant transfers heat to the room air and thus condenses. Thereafter, the refrigerant is delivered to the expansion valve **4**, is reduced in pressure by the expansion valve **4**, and is then delivered to the outdoor heat exchanger **3**. Thereafter, the refrigerant receives heat from the outside air at the outdoor heat exchanger **3** and thus evaporates, and then flows back to the compressor **2**. Therefore, during operation of the air-conditioning apparatus **1** in heating mode, the outdoor heat exchanger **3** serves as an evaporator, while the indoor heat exchanger **5** serves as a condenser.

[0028] FIG. **2** is a perspective view illustrating the outdoor heat exchanger **3** in FIG. **1**. The outdoor heat exchanger **3** includes a heat exchanger **11** through which an airflow A passes. The airflow A is generated by operation of the outdoor fan **7**. The heat exchanger **11** includes a first header tank **12**, a second header tank **13**, and a plurality of heat exchange parts **14** connecting the first header tank **12** and the second header tank **13**. In the heat exchanger **11**, either a refrigerant pipe extending from the expansion valve **4** or a refrigerant pipe extending from the four-way valve **6** is connected to the first header tank **12**, while the other refrigerant pipe is connected to the second header tank **13**.

[0029] The first header tank **12** and the second header tank **13** are each located horizontally. The second header tank **13** is located above the first header tank **12**. The first header tank **12** and the second header tank **13** are located parallel to each other in a third direction, which is the z-direction in FIG. **2**.

[0030] While the first header tank **12** and the second header tank **13** each have a cuboid outer shape in FIG. **2**, their outer shape is not limited. The first header tank **12** and the second header tank **13** may have, for example, a circular cylindrical outer shape or an elliptical cylindrical outer shape. It is also possible to change the cross-sectional shape appropriately. The first header tank **12** and the second header tank **13** may also employ, for example, a cylindrical body structure with opposite ends of the cylindrical body closed, or a layered structure of plate-like bodies on which slits **21** are formed. In each of the first header tank **12** and the second header tank **13**, a refrigerant port is formed through which refrigerant can flow into and out from the header tank.

[0031] The plurality of heat exchange parts **14** are spaced apart from each other in the longitudinal direction of the first header tank **12** and the second header tank **13**, that is, in the z-direction in FIG. **2**. The plurality of heat exchange parts **14** are arranged parallel to each other. The plurality of heat exchange parts **14** extend longitudinally in the y-direction, which is a second direction that crosses the z-direction in FIG. **2**. The y-direction is an up-down direction in the present embodiment. In this example, the longitudinal direction of each heat exchange part **14** is perpendicular to the longitudinal direction of the first header tank **12** and the longitudinal direction of the second header tank **13**. In this example, any part is not allowed to be located in a space between the plurality of heat exchange parts **14**. This prevents any part from connecting to any of the opposite surfaces of the adjacent heat exchange parts **14** in this example.

[0032] The airflow A generated by operation of the outdoor fan **7** passes through gaps between the plurality of heat

exchange parts **14**. In this example, the airflow A passes through the gaps between the plurality of heat exchange parts **14** in a direction that crosses the longitudinal directions of the first header tank **12**, the second header tank **13**, and each heat exchange part **14**, that is, in the x-direction, which is a first direction in FIG. **2**. In the example in FIG. **2**, the x-direction is perpendicular to the y-direction in which the heat exchange parts **14** extend longitudinally.

[0033] FIG. **3** illustrates the heat exchange part **14** of the heat exchanger **11** according to Embodiment 1. In FIG. **3**, the heat exchange part **14** illustrated in FIG. **2** is viewed in the z-direction. In FIG. **3**, the open arrow shows the direction in which gas flows. FIG. **3** illustrates only one of the plurality of heat exchange parts **14** illustrated in FIG. **2** as an example.

[0034] The heat exchange part **14** includes a heat transfer tube **15** and a fin **16**.

[0035] As illustrated in FIG. **2**, the heat transfer tubes **15** are spaced apart from each other at predetermined intervals in the z-direction. Each of the heat transfer tubes **15** is a circular tube or a flat tube. As illustrated in FIG. **3**, the heat transfer tube **15** extends in the y-direction and connects the first header tank **12** and the second header tank **13**. The heat transfer tube **15** extends in the y-direction, that is, in the up-down direction. Refrigerant flowing into the heat transfer tube **15** from the first header tank **12** or the second header tank **13** flows inside the heat transfer tube **15** in the up-down direction.

[0036] As illustrated in FIG. **3**, the fin **16** has a surface extending in the x-direction and the y-direction. The fin **16** is provided to the heat transfer tube **15** such that the fin **16** extends longitudinally in the y-direction. The fin **16** has a first extension part **16_1** and a second extension part **16_2**.

[0037] The first extension part **16_1** and the second extension part **162** are positioned on the outer side of the heat transfer tube **15** in the x-direction. In the example in FIG. **3**, the first extension part **16_1** and the second extension part **16_2** have equal size and are provided to the heat transfer tube **15** such that the first extension part **161** and the second extension part **16_2** extend longitudinally in the y-direction. The first extension part **16_1** and the second extension part **16_2**, which are formed separately, are attached to the respective sides of the heat transfer tube **15** extending in the y-direction.

[0038] The first extension part **16_1** has a rectangular shape when viewed in the z-direction with one of the longer sides provided on the heat transfer tube **15**. The shorter sides of the first extension part **16_1** are located to extend in the x-direction toward the upwind side. The first extension part **16_1** has a first heat-transfer-enhancement area **17_1**, which is located upstream in a flow of gas passing through the fin **16** and improves a heat transfer coefficient between the gas and the first extension part **16_1**.

[0039] The first heat-transfer-enhancement area **17_1** has a plurality of first heat-transfer-enhancement parts **17_1_1**, which are located upstream in a flow of gas passing through the fin **16** and improve a heat transfer coefficient between the gas and the first extension part **16_1**. The plurality of first heat-transfer-enhancement parts **17_1_1** are arranged in the y-direction. The first heat-transfer-enhancement area **17_1** further has a first flat part **17_1_2** positioned between the first heat-transfer-enhancement part **17_1_1** located on the upper side in the y-direction and the first heat-transfer-enhancement part **17_1_1** located on the lower side in the y-direction. In the example in FIG. **3**, a plurality of first flat parts **17_1_2** are provided in the first heat-transfer-enhancement area **17_1**. The first heat-transfer-enhancement parts **17_1_1** and the first flat parts **17_1_2** are alternately arranged in the y-direction.

[0040] In each of the first heat-transfer-enhancement parts **17_1_1**, three slits **21** are arranged parallel to each other in the x-direction. The slits **21** are openings penetrating through the fin **16**. Instead of the slits **21** formed in the first heat-transfer-enhancement part **17_1_1**, a cut and bent-up part, a louver, or an uneven part may be provided. The cut and bent-up part is formed by bending up a portion between two parallel slit-like cuts provided in the face of the fin **16** in the z-direction. As a consequence of provision of the cut and bent-up part, an opening of the same shape as the cut and bent-up part is provided in the fin **16**. The cut and bent-up part protrudes from the face of the fin **16** in the z-direction. The louver is formed by slanting a portion between two slits formed in the face of the fin **16** from the face of the fin **16**. As a consequence of formation of the louver, an opening of the same shape as the louver is provided in the fin **16**. The uneven part protrudes or is recessed from the face of the fin **16** in the z-direction. It is also allowable in Embodiment 2 and other embodiments that the first heat-transfer-enhancement part **17_1_1** is a cut and bent-up part, a louver, or an uneven part.

[0041] The first flat part **17_1_2** is a rectangular-shaped flat area of the fin **16** between the first heat-transfer-enhancement parts **17_1_1**. The first flat part **17_1_2** has a smaller length in the y-direction than the length of the first heat-transfer-enhancement part **17_1_1** in the y-direction.

[0042] The second extension part **16_2** has a rectangular shape when viewed in the z-direction with one of the longer sides provided on the heat transfer tube **15**. The shorter sides of the second extension part **16_2** are located to extend in the x-direction toward the downwind side. The second extension part **16_2** has a second heat-transfer-enhancement area **17_2**, which is located downstream in the flow of gas passing through the fin **16** and improves a heat transfer coefficient between the gas and the second extension part **16_2**.

[0043] The second heat-transfer-enhancement area **17_2** has a plurality of second heat-transfer-enhancement parts **17_2_1**, which are located downstream in the flow of gas passing through the fin **16** and improve a heat transfer coefficient between the gas and the second extension part **16_2**. The plurality of second heat-transfer-enhancement parts **17_2_1** are arranged in the y-direction. The second heat-transfer-enhancement area **17_2** further has a second flat part **17_2_2** positioned between the second heat-transfer-enhancement part **17_2_1** located on the upper side in the y-direction and the second heat-transfer-enhancement part **17_2_1** located on the lower side in the y-direction. In the example in FIG. **3**, a plurality of second flat parts **17_2_2** are provided in the second heat-transfer-enhancement area **17_2**. The second heat-transfer-enhancement parts **17_2_1** and the second flat parts **17_2_2** are alternately arranged in the y-direction.

[0044] In each of the second heat-transfer-enhancement parts **17_2_1**, three slits **21** are arranged parallel to each other in the x-direction. The slits **21** are openings penetrating through the fin **16**. Instead of the slits **21** formed in the second heat-transfer-enhancement part **17_2_1**, a cut and bent-up part, a louver, or an uneven part may be provided.

The cut and bent-up part is formed by bending up a portion between two parallel slit-like cuts provided in the face of the fin **16** in the z-direction. As a consequence of provision of the cut and bent-up part, an opening of the same shape as the cut and bent-up part is provided in the fin **16**. The cut and bent-up part protrudes from the face of the fin **16** in the z-direction. The louver is formed by slanting a portion between two slits formed in the face of the fin **16** from the face of the fin **16**. As a consequence of formation of the louver, an opening of the same shape as the louver is provided in the fin **16**. The uneven part protrudes or is recessed from the face of the fin **16** in the z-direction. It is also allowable in Embodiment 2 and other embodiments that the second heat-transfer-enhancement part **17_2_1** is a cut and bent-up part, a louver, or an uneven part.

[0045] The second flat part **17_2_2** is a rectangular-shaped flat area of the fin **16** between the second heat-transfer-enhancement parts **17_2_1**. The second flat part **17_2_2** has a smaller length in the y-direction than the length of the second heat-transfer-enhancement part **17_2_1** in the y-direction.

[0046] In the second heat-transfer-enhancement area **17_2** downstream of the first heat-transfer-enhancement part **17_1_1** in a flow of gas in the x-direction, the second flat part **17_2_2** is located. In the second heat-transfer-enhancement area **17_2** downstream of the first flat part **17_1_2** in the flow of gas in the x-direction, the second heat-transfer-enhancement part **17_2_1** is located. That is, the heat exchange part **14** has an area where the first heat-transfer-enhancement part **17_1_1** and the second flat part **17_2_2** are arranged side by side in the x-direction, and an area where the first flat part **17_1_2** and the second heat-transfer-enhancement part **17_2_1** are arranged side by side in the x-direction. In the example in FIG. **3**, an area is further provided where the first heat-transfer-enhancement part **17_1_1** and the second heat-transfer-enhancement part **17_2_1** are arranged side by side in the x-direction.

[0047] In the heat exchanger **11** according to Embodiment 1, an airflow entering the heat exchanger **11** flows over the surface of the first heat-transfer-enhancement area **17_1** of the fin **16** in the x-direction. In the first heat-transfer-enhancement area **17_1**, the slits **21** formed in the first heat-transfer-enhancement parts **17_1_1** enhance heat transfer from or to portion of the airflow. An airflow entering the first flat parts **17_1_2** and another airflow bypassing the first heat-transfer-enhancement parts **17_1_1** flow over the surfaces of the first flat parts **17_1_2** in the x-direction.

[0048] Subsequently, the airflow passes through the surface of the heat transfer tube **15**, then exchanges heat with refrigerant flowing inside the heat transfer tube **15**, and thereafter flows over the surface of the second heat-transfer-enhancement area **17_2** in the x-direction. In the second heat-transfer-enhancement area **17_2**, the slits **21** formed in the second heat-transfer-enhancement parts **17_2_1** enhance heat transfer from or to portion of the airflow. An airflow entering the second flat parts **17_2_2** and another airflow bypassing the second heat-transfer-enhancement parts **17_2_1** flow over the surfaces of the second flat parts **17_2_2** in the x-direction.

[0049] FIG. **4** illustrates a modification of the method for attaching the fin **16** to the heat transfer tube **15** in the heat exchanger **11** according to Embodiment 1. In FIG. **4**, the heat transfer tube **15** and the fin **16** are viewed in the y-direction. In the above explanation, the example has been described in which the first extension part **16_1** and the second extension part **16_2** of the fin **16** are separately attached to the heat transfer tube **15**. However, as illustrated in FIG. **4**, the first extension part **16_1** and the second extension part **16_2** may be integrally formed into a single piece. The same applies to the other embodiments including Embodiments 2, 3, 4, and 5.

[0050] The fin **16** has the first extension part **16_1**, the second extension part **16_2**, and a main body part **16_3**. The fin **16** illustrated in FIG. **4** is formed by integrating the first extension part **16_1** and the second extension part **16_2** with the main body part **16_3** into a single piece. The main body part **16_3** is bent to be brought into contact with the heat transfer tube **15**. The bent main body part **16_3** is then attached to the heat transfer tube **15**. Even in this attachment mode, it is still possible to form the heat exchange part **14** of the present embodiment.

[0051] It is also possible to position the first extension part **16_1** and the second extension part **16_2** to the heat transfer tube **15** in the z-direction in the following manner. For example, as illustrated in FIG. **4**, the first extension part **16_1** and the second extension part **16_2** are arranged in alignment with the center of the heat transfer tube **15** in the z-direction. This arrangement is also applicable to a mode in which the first extension part **16_1** and the second extension part **16_2** are separately attached to the heat transfer tube **15**. It is allowable that the first extension part **16_1** and the second extension part **16_2** are not exactly aligned with the center of the heat transfer tube **15** in the z-direction. The first extension part **16_1** and the second extension part **16_2** may be located within the width of the heat transfer tube **15** in the z-direction. Note that although not illustrated, the first extension part **16_1** and the second extension part **16_2** may also be located flush with an end face of the heat transfer tube **15** in the z-direction.

[0052] As described above, the heat exchanger **11** according to Embodiment 1 includes the heat transfer tube **15**, which extends in the second direction, which crosses the first direction in which gas flows, and the fin **16**, which is provided to the heat transfer tube **15** and has a surface that extends in the first direction and the second direction. The fin **16** has the first extension part **16_1** having the first heat-transfer-enhancement area **17_1**, which is located further upstream in a flow of the gas than the heat transfer tube **15** in the first direction and improves a heat transfer coefficient to the gas. The fin **16** has the second extension part **16_2** having the second heat-transfer-enhancement area **17_2**, which is located further downstream in the flow of the gas than the heat transfer tube **15** in the first direction and improves a heat transfer coefficient to the gas. In the heat exchanger **11** in Embodiment 1, the first heat-transfer-enhancement area **17_1** is located upstream of the heat transfer tube **15**, while the second heat-transfer-enhancement area **17_2** is located downstream of the heat transfer tube **15**, so that the heat transfer coefficient between the fin **16** and the gas passing through the fin **16** can improve.

[0053] When gas is delivered toward the heat transfer tube **15**, the gas flows around the surface of the heat transfer tube **15** extending in the x-direction, while bypassing the heat transfer tube **15**. The gas is thus unlikely to flow to an upstream end and a downstream end of the heat transfer tube **15** in a direction in which the gas flows (the left and right end portions of the heat transfer tube **15** on the drawing of FIG. **4** illustrated as an example). However, in the present

embodiment, the first extension part **16_1** and the second extension part **16_2**, which extend in the x-direction in which gas flows are located respectively upstream and downstream of the heat transfer tube **15**. The first extension part **16_1** is provided with the first heat-transfer-enhancement area **17_1**, which improves a heat transfer coefficient to the gas. The second extension part **162** is provided with the second heat-transfer-enhancement area **17_2**, which improves a heat transfer coefficient to the gas. It is therefore possible to improve the heat transfer coefficient between the fin **16** and the gas flowing in the x-direction.

[0054] The second flat parts **17_2_2** are located in the second heat-transfer-enhancement area **17_2** and arranged side by side with the first heat-transfer-enhancement parts **17_1_1** in the x-direction. The second heat-transfer-enhancement parts **17_2_1** are located in the second heat-transfer-enhancement area **17_2** and arranged side by side with the first flat parts **17_1_2** in the x-direction. With this configuration, even when gas flowing in the x-direction flows through the first flat parts **17_1_2** on the upstream side, this gas still flows easily through the second heat-transfer-enhancement parts **17_2_1** on the downstream side. After having flowed around the first heat-transfer-enhancement parts **17_1_1** on the upstream side, gas flows through the first flat parts **17_1_2** on the downstream side. It is therefore possible to improve the heat transfer coefficient in the fin **16**. With this configuration, it is possible to increase the path length for an airflow to pass across the fin **16** in its entirety through the first flat parts **17_1_2** or the second flat parts **17_2_2**, and thus increase the substantial heat-transfer area of the fin **16**.

[0055] In the first heat-transfer-enhancement area **171**, the first heat-transfer-enhancement parts **17_1_1** and the first flat parts **17_1_2** are alternately arranged in the second direction, which is the y-direction. In the second heat-transfer-enhancement area **17_2**, the second heat-transfer-enhancement parts **17_2_1** and the second flat parts **17_2_2** are alternately arranged in the second direction, which is the y-direction. Due to this arrangement, with reference to a pressure-loss distribution across the fin **16** in its entirety, pressure loss of airflow in the y-direction shows almost a uniform distribution. Therefore, the volume of airflow that passes through the first flat parts **17_1_2** and the second flat parts **17_2_2** is reduced. This results in an improvement in the heat transfer coefficient between the airflow and the fin **16**.

Embodiment 2

[0056] The heat exchange part **14** of the heat exchanger **11** according to Embodiment 2 is different in size of the first flat parts **17_1_2** and the first flat parts **17_1_2** from the heat exchange part **14** of the heat exchanger **11** according to Embodiment 1.

[0057] FIG. **5** illustrates the heat exchange part **14** of the heat exchanger **11** according to Embodiment 2. In FIG. **5**, the open arrow shows the direction in which gas flows. FIG. **5** illustrates only one of the plurality of heat exchange parts **14** illustrated in FIG. **2** as an example.

[0058] As illustrated in FIG. **5**, in Embodiment 2, the first heat-transfer-enhancement part **17_1_1**, the first flat part **17_1_2**, the second heat-transfer-enhancement part **17_2_1**, and the second flat part **17_2_2** each have an equal length in the x-direction, while each having an equal length in the y-direction. Note that it is allowable that the first heat-transfer-enhancement part **17_1_1**, the first flat part **17_1_2**, the second heat-transfer-enhancement part **17_2_1**, and the second flat part **17_2_2** each have an equal length only in the y-direction.

[0059] The first heat-transfer-enhancement parts **17_1_1** are arranged in the y-direction at the same positions as the second flat parts **17_2_2** in the second heat-transfer-enhancement area **17_2** in the y-direction. The first flat parts **17_1_2** are arranged in the y-direction at the same positions as the second heat-transfer-enhancement parts **17_2_1** in the second heat-transfer-enhancement area **17_2** in the y-direction.

[0060] That is, the first heat-transfer-enhancement parts **17_1_1** and the second heat-transfer-enhancement parts **17_2_1**, which are formed in the fin **16** in the heat exchanger **11** according to Embodiment 2, are staggered in position from each other in the y-direction. Likewise, the first flat parts **17_1_2** and the second flat parts **17_2_2** are staggered in position from each other in the y-direction.

[0061] As described above, the heat exchanger **11** according to Embodiment 2 includes the heat transfer tube **15**, which extends in the second direction, which crosses the first direction in which gas flows, and the fin **16**, which is provided to the heat transfer tube **15** and has a surface that extends in the first direction and the second direction. The fin **16** has the first extension part **16_1** having the first heat-transfer-enhancement area **17_1**, which is located further upstream in a flow of the gas than the heat transfer tube **15** in the first direction and improves a heat transfer coefficient to the gas. The fin **16** has the second extension part **16_2** having the second heat-transfer-enhancement area **17_2**, which is located further downstream in the flow of the gas than the heat transfer tube **15** in the first direction and improves a heat transfer coefficient to the gas. In the heat exchanger **11** in Embodiment 1, the first heat-transfer-enhancement area **17_1** is located upstream of the heat transfer tube **15**, while the second heat-transfer-enhancement area **17_2** is located downstream of the heat transfer tube **15**, so that the heat transfer coefficient between the fin **16** and the gas passing through the fin **16** can improve.

[0062] When gas is delivered toward the heat transfer tube **15**, the gas flows around the surface of the heat transfer tube **15** extending in the x-direction, while bypassing the heat transfer tube **15**. The gas is thus unlikely to flow to an upstream end and a downstream end of the heat transfer tube **15** in a direction in which the gas flows (the left and right end portions of the heat transfer tube **15** on the drawing of FIG. **4** illustrated as an example). However, in the present embodiment, the first extension part **16_1** and the second extension part **16_2**, which extend in the x-direction in which gas flows are located respectively upstream and downstream of the heat transfer tube **15**. The first extension part **16_1** is provided with the first heat-transfer-enhancement area **17_1**, which improves a heat transfer coefficient to the gas. The second extension part **162** is provided with the second heat-transfer-enhancement area **17_2**, which improves a heat transfer coefficient to the gas. It is therefore possible to improve the heat transfer coefficient between the fin **16** and the gas flowing in the x-direction.

[0063] In Embodiment 2, the first heat-transfer-enhancement part **17_1_1**, the first flat part **17_1_2**, the second heat-transfer-enhancement part **17_2_1**, and the second flat part **17_2_2** each have an equal length in the x-direction, while each having an equal length in the y-direction. Due to

this configuration, when the fin **16** is manufactured, it is possible to form the first heat-transfer-enhancement parts **17_1_1** and the second heat-transfer-enhancement parts **17_2_1** in the fin **16** by use of progressive pressing.

Embodiment 3

[0064] The heat exchange part **14** of the heat exchanger **11** according to Embodiment 3 does not have the first flat parts **17_1_2** or the second flat parts **17_2_2** differently from the heat exchange part **14** of the heat exchanger **11** according to Embodiment 1.

[0065] FIG. **6** illustrates the heat exchange part **14** of the heat exchanger **11** according to Embodiment 3. In FIG. **6**, the open arrow shows the direction in which gas flows. FIG. **6** illustrates only one of the plurality of heat exchange parts **14** illustrated in FIG. **2** as an example.

[0066] As illustrated in FIG. **6**, in Embodiment 3, the first heat-transfer-enhancement area **17_1** has a plurality of first heat-transfer-enhancement parts **17_1_1**, which are arranged in the y-direction and improve a heat transfer coefficient to the gas. The second heat-transfer-enhancement area **17_2** has a plurality of second heat-transfer-enhancement parts **17_2_1**, which are arranged in the y-direction and improve a heat transfer coefficient to the gas.

[0067] Each of the first heat-transfer-enhancement parts **17_1_1** has one slit **21**. The slits **21** provided in the first heat-transfer-enhancement parts **17_1_1** adjacent to each other in the y-direction are at positions displaced from each other in the x-direction. It is allowable that a plurality of slits **21** are formed in the x-direction in each of the first heat-transfer-enhancement parts **17_1_1**.

[0068] As illustrated in FIG. **6**, in the first extension part **16_1**, three slits **21** are formed one by one in the y-direction at positions displaced from each other in the x-direction. This formation pattern is repeated.

[0069] Each of the second heat-transfer-enhancement parts **17_2_1** has one slit **21**. The slits **21** provided in the second heat-transfer-enhancement parts **17_2_1** adjacent to each other in the y-direction are at positions displaced from each other in the x-direction. It is allowable that a plurality of slits **21** are formed in the x-direction in each of the second heat-transfer-enhancement parts **17_2_1**.

[0070] As illustrated in FIG. **6**, in the second extension part **16_2**, three slits **21** are formed one by one in the y-direction at positions displaced from each other in the x-direction. This formation pattern is repeated.

[0071] In Embodiment 3, the sum of a count of slits **21** formed in the first heat-transfer-enhancement part **17_1_1** in the x-direction and a count of slits **21** formed in the second heat-transfer-enhancement part **17_2_1** in the x-direction is constant.

[0072] According to Embodiment 3, the plurality of first heat-transfer-enhancement parts **17_1_1** and the plurality of second heat-transfer-enhancement parts **17_2_1** are provided in the y-direction in the fin **16**. The sum of the count of slits **21** formed in the first heat-transfer-enhancement part **17_1_1** in the x-direction and the count of slits **21** formed in the second heat-transfer-enhancement part **17_2_1** in the x-direction is constant. That is, a plurality of sets of equal count of slits **21** provided in the x-direction (two slits in the example of FIG. **6**) are arranged in the y-direction. It is therefore possible to obtain a uniform pressure-loss distribution of airflow in the y-direction. This allows the fin **16** in the heat exchanger **11** to improve its heat transfer coefficient.

Embodiment 4

[0073] In the heat exchange part **14** of the heat exchanger **11** according to Embodiment 4, a first pattern of arrangement of the slits **21** formed in the first heat-transfer-enhancement parts **17_1_1**, and a second pattern of arrangement of the slits **21** formed in the second heat-transfer-enhancement parts **17_2_1** are displaced from each other in the x-direction.

[0074] FIG. **7** illustrates the heat exchange part **14** of the heat exchanger **11** according to Embodiment 4. In FIG. **7**, the open arrow shows the direction in which gas flows. FIG. **7** illustrates only one of the plurality of heat exchange parts **14** illustrated in FIG. **2** as an example.

[0075] As illustrated in FIG. **7**, in Embodiment 4, the first heat-transfer-enhancement area **17_1** has a plurality of first heat-transfer-enhancement parts **17_1_1**, which are arranged in the y-direction and improve a heat transfer coefficient to the gas. The second heat-transfer-enhancement area **17_2** has a plurality of second heat-transfer-enhancement parts **17_2_1**, which are arranged in the y-direction and improve a heat transfer coefficient to the gas.

[0076] In the plurality of first heat-transfer-enhancement parts **17_1_1**, the slits **21** are formed in the first pattern. In the first pattern, in the first heat-transfer-enhancement parts **17_1_1**, two slits **21** arranged side by side in the x-direction, and one slit **21** provided adjacent to the two slits **21** in the y-direction are formed in succession in the y-direction. In the example in FIG. **7**, at the intermediate position between the two slits **21** arranged side by side in the x-direction, one slit **21** adjacent to these two slits **21** in the y-direction is located.

[0077] In the plurality of second heat-transfer-enhancement parts **17_2_1**, the slits **21** are formed in the second pattern. In the second pattern, one slit **21** provided in the x-direction in the second heat-transfer-enhancement part **17_2_1**, and two slits **21** located below the one slit **21** in the y-direction and on respective opposite sides of the one slit **21** are formed in succession in the y-direction.

[0078] As illustrated in FIG. **7**, the first pattern of arrangement of the slits **21** and the second pattern of arrangement of the slits **21** are displaced from each other in the y-direction. In the x-direction, the sum of the count of slits **21** formed in the first heat-transfer-enhancement part **17_1_1** and the count of slits **21** formed in the second heat-transfer-enhancement part **17_2_1** is constant at three.

[0079] Note that the first pattern and the second pattern are not limited to the example illustrated in FIG. **7**, and various patterns with different counts of slits **21** can be employed. As an example of the arrangement pattern, a combination of three slits **21** arranged side by side in the x-direction with only one slit **21** provided in the x-direction is repeatedly formed in the y-direction.

[0080] FIG. **8** illustrates a modification of the heat exchange part **14** of the heat exchanger **11** according to Embodiment 4.

[0081] As illustrated in FIG. **8**, the first flat part **17_1_2** is located below the first heat-transfer-enhancement part **17_1_1** in the y-direction. The first heat-transfer-enhancement parts **17_1_1** are arranged in the y-direction with each of the first flat parts **17_1_2** interposed between the first heat-transfer-enhancement parts **17_1_1**.

[0082] In a plurality of first heat-transfer-enhancement parts **17_1_1**, square-shaped uneven parts **22** are formed in a first pattern. In the first pattern, two uneven parts **22**

arranged side by side in the x-direction in the first heat-transfer-enhancement part **17_1_1** and one uneven part **22** provided in the first heat-transfer-enhancement part **17_1_1** adjacent to the two uneven parts **22** in the y-direction are formed in succession in the y-direction with the first flat part **17_1_2** interposed between these first heat-transfer-enhancement parts **17_1_1**.

[0083] In a plurality of second heat-transfer-enhancement parts **17_2_1**, square-shaped uneven parts **22** are formed in a second pattern. In the second pattern, two uneven parts **22** arranged side by side in the x-direction in the second heat-transfer-enhancement part **17_2_1** and one uneven part **22** located in the second heat-transfer-enhancement part **17_2_1** below the two uneven parts **22** in the y-direction and located between the two uneven parts **22** are formed in succession in the y-direction with the second flat part **17_2_2** interposed between these second heat-transfer-enhancement parts **17_2_1**.

[0084] In FIG. **8**, the first pattern of arrangement of the uneven parts **22** and the second pattern of arrangement of the uneven parts **22** are also displaced from each other in the second direction, which is the y-direction. In the x-direction, the sum of the count of uneven parts **22** formed in the first heat-transfer-enhancement part **17_1_1** and the count of uneven parts **22** formed in the second heat-transfer-enhancement part **17_2_1** is constant at three.

[0085] Note that in FIG. **8**, it is allowable that the first flat parts **17_1_2** and the second flat parts **17_2_2** are not provided.

[0086] As described above, according to Embodiment 4, the first pattern of arrangement of the slits or uneven parts provided in the first heat-transfer-enhancement parts, and the second pattern of arrangement of the slits or uneven parts provided in the second heat-transfer-enhancement parts are displaced from each other in the second direction. It is therefore possible to narrow the pressure-loss distribution of airflow in the y-direction. This allows the fin **16** in the heat exchanger **11** to improve its heat transfer coefficient.

[0087] The first pattern of the first heat-transfer-enhancement parts **17_1_1** and the second pattern of the second heat-transfer-enhancement parts **17_2_1** are displaced from each other. This makes it possible to form the first pattern and the second pattern by use of progressive pressing.

Embodiment 5

[0088] Next, the heat exchanger **11** according to Embodiment 5 is described.

[0089] FIG. **9** illustrates the heat exchange part **14** of the heat exchanger **11** according to Embodiment 5. In FIG. **9**, the open arrow shows the direction in which gas flows. In FIG. **9**, at least two lines of the plurality of heat exchange parts **14** illustrated in FIG. **2** are provided in the x-direction. FIG. **9** illustrates only a heat exchange part **14_1** on the first line and a heat exchange part **14_2** on the second line as an example.

[0090] As illustrated in FIG. **9**, the fin **16** is provided to a first heat transfer tube **15_1** and extends in the y-direction, which is a vertical direction. The first heat transfer tube **15_1** is provided between a first header tank **12_1** and a second header tank **13_1**. The fin **16** has the first extension part **16_1** and the second extension part **16_2**.

[0091] The first extension part **16_1** of the fin **16** has a rectangular shape and is located with one of the longer sides attached to the first heat transfer tube **15_1** in the y-direction, and with the shorter sides extending in the x-direction toward the upwind side.

[0092] The second extension part **16_2** of the fin **16** has a rectangular shape and is located with one of the longer sides attached to the first heat transfer tube **15_1** in the y-direction, and with the shorter sides extending in the x-direction toward the downwind side.

[0093] The first extension part **16_1** is located upstream in a flow of gas passing through the fin **16**. The first extension part **161** has a rectangular shape when viewed in the z-direction with one of the longer sides located on the first heat transfer tube **15_1**. The first extension part **16_1** is provided with the first heat-transfer-enhancement area **17_1**, which improves a heat transfer coefficient of the first extension part **16_1** to the gas. The first heat-transfer-enhancement area **17_1** has a plurality of first heat-transfer-enhancement parts **17_1_1**, which are arranged in the y-direction and improve a heat transfer coefficient to the gas, and a plurality of first flat parts **17_1_2**, which are arranged in the y-direction. The first heat-transfer-enhancement parts **17_1_1** and the first flat parts **17_1_2** are alternately arranged in the y-direction.

[0094] In each of the first heat-transfer-enhancement parts **17_1_1**, three slits **21** are arranged parallel to each other in the x-direction. The first flat part **17_1_2** is a rectangular-shaped flat area of the fin **16** between the first heat-transfer-enhancement parts **17_1_1**. The first flat part **17_1_2** has a length in the y-direction equal to the length of the first heat-transfer-enhancement part **17_1_1** in the y-direction.

[0095] The second extension part **16_2** is located downstream in the flow of gas passing through the fin **16**. The second extension part **16_2** has a rectangular shape when viewed in the z-direction with one of the longer sides located on the first heat transfer tube **15_1**. The second extension part **16_2** is provided with the second heat-transfer-enhancement area **17_2**, which improves a heat transfer coefficient of the second extension part **16_2** to the gas. The second heat-transfer-enhancement area **17_2** has a plurality of second heat-transfer-enhancement parts **17_2_1**, which are arranged in the y-direction and improve a heat transfer coefficient to the gas, and a plurality of first flat parts **17_1_2**, which are arranged in the y-direction. The second heat-transfer-enhancement parts **17_2_1** and the second flat parts **17_2_2** are alternately arranged in the y-direction.

[0096] In each of the second heat-transfer-enhancement parts **17_2_1**, three slits **21** are arranged parallel to each other in the x-direction. The second flat part **17_2_2** is a rectangular-shaped flat area of the fin **16** between the second heat-transfer-enhancement parts **17_2_1**. The second flat part **17_2_2** has a length in the y-direction equal to the length of the second heat-transfer-enhancement part **17_2_1** in the y-direction.

[0097] The second heat-transfer-enhancement part **17_2_1** is located side by side with the first heat-transfer-enhancement part **17_1_1** in the x-direction. The second flat part **17_2_2** is located side by side with the first flat part **17_1_2** in the x-direction.

[0098] The fin **16** is provided to a second heat transfer tube **15_2** and extends in the y-direction. The second heat transfer tube **15_2** is provided between the first header tank **12_1** and the second header tank **13_1**. The fin **16** has the first extension part **16_1** and the second extension part **162**.

[0099] The first extension part **16_1** of the fin **16** has a rectangular shape and is located with one of the longer sides attached to the second heat transfer tube **15_2** in the y-direction, and with the shorter sides extending in the x-direction toward the upwind side.

[0100] The second extension part **16_2** of the fin **16** has a rectangular shape and is located with one of the longer sides attached to the second heat transfer tube **15_2** in the y-direction, and with the shorter sides extending in the x-direction toward the downwind side.

[0101] The first extension part **16_1** is located upstream in a flow of gas passing through the fin **16**. The first extension part **161** has a rectangular shape when viewed in the z-direction with one of the longer sides located on the first heat transfer tube **15_1**. The first extension part **16_1** is provided with the first heat-transfer-enhancement area **17_1**, which improves a heat transfer coefficient of the first extension part **16_1** to the gas. The first heat-transfer-enhancement area **17_1** has a plurality of first heat-transfer-enhancement parts **17_1_1**, which are arranged in the y-direction and improve a heat transfer coefficient to the gas, and a plurality of first flat parts **17_1_2**, which are arranged in the y-direction. The first heat-transfer-enhancement parts **17_1_1** and the first flat parts **17_1_2** are alternately arranged in the y-direction.

[0102] In each of the first heat-transfer-enhancement parts **17_1_1**, three slits **21** are arranged parallel to each other in the x-direction. The first flat part **17_1_2** is a rectangular-shaped flat area of the fin **16** between the first heat-transfer-enhancement parts **17_1_1**. The first flat part **17_1_2** has a length in the y-direction equal to the length of the first heat-transfer-enhancement part **17_1_1** in the y-direction.

[0103] The second extension part **16_2** is located downstream in the flow of gas passing through the fin **16**. The second extension part **16_2** has a rectangular shape when viewed in the z-direction with one of the longer sides located on the first heat transfer tube **15_1**. The second extension part **16_2** is provided with the second heat-transfer-enhancement area **17_2**, which improves a heat transfer coefficient of the second extension part **16_2** to the gas. The second heat-transfer-enhancement area **17_2** has a plurality of second heat-transfer-enhancement parts **17_2_1**, which are arranged in the y-direction and improve a heat transfer coefficient to the gas, and a plurality of first flat parts **17_1_2**, which are arranged in the y-direction. The second heat-transfer-enhancement parts **17_2_1** and the second flat parts **17_2_2** are alternately arranged in the y-direction.

[0104] In each of the second heat-transfer-enhancement parts **17_2_1**, three slits **21** are arranged parallel to each other in the x-direction. The second flat part **17_2_2** is a rectangular-shaped flat area of the fin **16** between the second heat-transfer-enhancement parts **17_2_1**. The second flat part **17_2_2** has a length in the y-direction equal to the length of the second heat-transfer-enhancement part **17_2_1** in the y-direction.

[0105] The second heat-transfer-enhancement part **17_2_1** is located side by side with the first heat-transfer-enhancement part **17_1_1** in the x-direction. The second flat part **17_2_2** is located side by side with the first flat part **17_1_2** in the x-direction.

[0106] The second heat-transfer-enhancement parts **17_2_1** are formed in the fin **16** provided to the first heat transfer tube **151** at positions different in the y-direction from the positions of the first heat-transfer-enhancement parts **17_1_1** formed in the fin **16** provided to the second heat transfer tube **15_2**.

[0107] FIG. **10** illustrates a modification of the heat exchange part **14** of the heat exchanger **11** according to Embodiment 5. In FIG. **10**, the open arrow shows the direction in which gas flows. In Embodiment 5, three lines of the plurality of heat exchange parts **14** illustrated in FIG. **2** are provided in the x-direction with the plurality of heat exchange parts **14** spaced apart from each other in the z-direction. FIG. **10** illustrates only the heat exchange part **14_1** on the first line, the heat exchange part **14_2** on the second line, and a heat exchange part **14_3** on the third line as an example.

[0108] The first heat-transfer-enhancement parts **17_1_1** and the first flat parts **17_1_2**, which are formed in the fin **16** provided to each of the first, second, and third heat transfer tubes **15_1**, **152**, and **15_3** are identical to those illustrated in FIG. **5**.

[0109] As illustrated in FIG. **10**, the second heat-transfer-enhancement parts **17_2_1** are provided to the first heat transfer tube **151** at positions different in the second direction from the positions of the first heat-transfer-enhancement parts **17_1_1** provided to the second heat transfer tube **15_2**. The second heat-transfer-enhancement parts **17_2_1** are provided to the second heat transfer tube **15_2** at positions different in the y-direction from the positions of the first heat-transfer-enhancement parts **17_1_1** provided to the third heat transfer tube **15_3**.

[0110] According to Embodiment 5, the first heat-transfer-enhancement parts **17_1_1** of the adjacent heat transfer tubes **15** are formed at different positions in the second direction. Therefore, a uniform pressure-loss distribution of airflow in the y-direction is obtained, and the volume of airflow that passes through the first flat parts **17_1_2** and the second flat parts **17_2_2** is reduced. This results in an improvement in the heat transfer coefficient between the airflow and the fin **16**.

[0111] Even when an airflow passes through the first flat parts **17_1_2** and the second flat parts **17_2_2**, a plurality of fins **16** are arranged in the x-direction, which is a direction of the airflow, increases the path length for the airflow, and thus can still increase the substantial heat-transfer area of the fins **16**.

[0112] Effects In a case where the heat transfer tube **15** is a circular tube or a flat tube, air is unlikely to flow to the upstream side and downstream side of the heat transfer tube **15**. Thus, originally there is not such a technical concept that the fin **16** is provided with both the first heat-transfer-enhancement area **17_1** and the second heat-transfer-enhancement area **17_2** as described in Embodiments 1 to 5. Further, there is not such a technical concept that a heat-transfer effect is to be enhanced by arrangement or combination of the first heat-transfer-enhancement parts **17_1_1** in the first heat-transfer-enhancement area **17_1** and the second heat-transfer-enhancement parts **17_2_1** in the second heat-transfer-enhancement area **17_2**.

[0113] In the heat exchanger **11** in Embodiments 1 to 5, the first heat-transfer-enhancement parts **17_1_1** are formed in the fin **16** extending toward the upwind side, while the second heat-transfer-enhancement parts **17_2_1** are formed in the fin **16** extending toward the downwind side. This exerts a significant influence on heat-conduction efficiency of the fin **16**.

[0114] It has been described in Embodiments 1 to 5 that the first heat-transfer-enhancement parts **17_1_1** and the second heat-transfer-enhancement parts **17_2_1** can be formed by any one or more of a cut and bent-up part, a slit, a louver, and an uneven part. In a case where the cut and bent-up part, the slit, or the louver is employed, the fin **16** is provided with openings. This results in a reduction in the area of planar portion of the fin **16**, that is, a reduction in the heat exchange area with gas. In a heat exchanger in a different mode from Embodiments 1 to 5, the heat transfer tube **15** penetrates through the fin **16** and is in contact on its entire outer circumferential surface with the fin **16**. Heat thus conducts from the heat transfer tube **15** to the fin **16** in 360-degree directions when the heat transfer tube **15** is viewed in cross section. Therefore, only a limited influence is exerted on the reduction in the heat exchange area due to the openings provided in the fin **16**. However, in the heat exchanger in Embodiments 1 to 5, the fin **16** is connected to the sides of the heat transfer tube **15** extending in the y-direction, or is connected to the x-y plane (FIG. **4**) of the heat transfer tube **15**. This limits the direction of heat conduction from the heat transfer tube **15** to the fin **16**. Therefore, in Embodiments 1 to 5, a more significant influence is exerted on the reduction in the heat exchange area due to the openings provided in the fin **16**, compared to the heat exchanger in the mode in which the heat transfer tube penetrates through the fin. In view of the above, the opening area of the fin **16**, and the arrangement of the first heat-transfer-enhancement parts **17_1_1** and the second heat-transfer-enhancement parts **17_2_1** in Embodiments 1 to 5 are described below.

[0115] FIG. **11** illustrates the arrangement of first heat-transfer-enhancement parts **17_1_1** and second heat-transfer-enhancement parts **17_2_1**, which are formed in the fin **16** in Comparative Example. FIG. **11** illustrates the first heat transfer tube **15_1** and the second heat transfer tube **15_2**, which are spaced apart from each other in the x-direction. As illustrated in FIG. **11**, each of the second heat-transfer-enhancement parts **17_2_1** is located side by side with the corresponding one of the first heat-transfer-enhancement parts **17_1_1** in the x-direction. Each of the second flat parts **17_2_2** is located side by side with the corresponding one of the first flat parts **17_1_2** in the x-direction.

[0116] FIG. **12** illustrates a relationship between a slit area rate and air-side heat transfer performance. The "SLIT AREA RATE" refers to slit area/area of the fin **16**. The "AIR-SIDE HEAT TRANSFER PERFORMANCE" refers to air-side heat transfer area of the fin **16**×air-side heat conductivity.

[0117] In FIG. **12**, g_**1** shows characteristics of the slit area rate and the air-side heat transfer performance of the heat exchanger **11** illustrated in FIG. **11**. g_**2** shows characteristics of the slit area rate and the air-side heat transfer performance of the heat exchanger **11** illustrated in FIG. **9**. g_**3** shows characteristics of the slit area rate and the air-side heat transfer performance of the heat exchanger **11** illustrated in FIG. **5** when two lines of the heat exchangers **11** are provided in the x-direction. g_**4** shows characteristics of the slit area rate and the air-side heat transfer performance of the heat exchanger **11** illustrated in FIG. **8** when two lines of the heat exchangers **11** are provided in the x-direction.

[0118] As illustrated in FIG. **12**, provided that the slit area rate is almost the same, the fin **16** illustrated in FIG. **8** exhibits the highest air-side heat transfer performance. The fin **16** illustrated in FIG. **5** and the fin **16** illustrated in FIG. **9** exhibit the second and third highest air-side heat transfer performance, respectively. The fins **16** illustrated in FIGS. **5**, **8**, and **9** exhibit higher air-side heat transfer performance than the air-side heat transfer performance of the fin **16** illustrated in FIG. **11** as Comparative Example. The other fins **16** described in Embodiments 1 to 5 also exhibit higher air-side heat transfer performance than the air-side heat transfer performance of the fin **16** illustrated in FIG. **11** as Comparative Example.

[0119] As illustrated by g_**2** in FIG. **12**, the heat exchanger **11** having the configuration of FIG. **9** exhibits higher air-side heat transfer performance when the slit area rate is 7.5% than the air-side heat transfer performance when the slit area rate is 15%. It is therefore desirable to set the slit area rate to 7.5% when the heat exchanger **11** employs the configuration of FIG. **9**. As illustrated by g_**1** in FIG. **12**, a peak of the air-side heat transfer performance appears when the slit area rate is 7.5%. In any of the patterns in Embodiments 1 to 5, it is desirable to set the slit area rate to 5 to 10%. The reasons for limiting the slit area rate to 5 to 10% are to prevent a decrease in heat conductivity that is ease of heat transfer across the fin **16** to improve a heat transfer coefficient of the first heat-transfer-enhancement parts **17_1_1** and the second heat-transfer-enhancement parts **17_2_1**.

[0120] In Embodiments 1 to 5, the first heat-transfer-enhancement parts **17_1_1** may have a shape different from a shape of the second heat-transfer-enhancement parts **17_2_1**. For example, each of the first heat-transfer-enhancement parts **17_1_1** may be formed into the slit **21**, while each of the second heat-transfer-enhancement parts **17_2_1** may be formed into an uneven shape. To avoid frost formation, a smaller count of slits **21** may be formed in the first heat-transfer-enhancement part **17_1_1** than the count of slits **21** to be formed in the second heat-transfer-enhancement part **17_2_1**.

[0121] The first heat-transfer-enhancement parts **17_1_1** may also have different shapes from each other. For example, the first heat-transfer-enhancement parts **17_1_1** may include the slits **21** and louvers. Likewise, the second heat-transfer-enhancement parts **17_2_1** may also have different shapes from each other. For example, the second heat-transfer-enhancement parts **17_2_1** may include the slits **21** and uneven shapes.

[0122] Embodiments 1 to 5 are merely described as examples, and are not intended to limit the scope of the claims. The embodiments can be implemented in various other forms. Various omissions, replacements, and changes can be made without departing from the gist of the embodiments. These embodiments and modifications of these embodiments are included in the scope and gist of the embodiments.

1. A heat exchanger comprising:

a heat transfer tube that extends in a second direction that crosses a first direction in which gas flows; and

a fin that is provided to the heat transfer tube and has a surface that extends in the first direction and the second direction,

the fin having a first extension part and a second extension part,

the first extension part having a first heat-transfer-enhancement area that is located further upstream in a flow of the gas than the heat transfer tube in the first direction and improves a heat transfer coefficient,

the second extension part having a second heat-transfer-enhancement area that is located further downstream in the flow of the gas than the heat transfer tube in the first direction and improves a heat transfer coefficient,

the first heat-transfer-enhancement area having

a plurality of first heat-transfer-enhancement parts that are arranged in the second direction and each improve a heat transfer coefficient, and

a first flat part provided between adjacent ones of the plurality of first heat-transfer-enhancement parts in the second direction,

the second heat-transfer-enhancement area having

a plurality of second heat-transfer-enhancement parts that are arranged in the second direction and each improve a heat transfer coefficient, and

a second flat part provided between adjacent ones of the plurality of second heat-transfer-enhancement parts in the second direction,

the plurality of first heat-transfer-enhancement parts, the plurality of second heat-transfer-enhancement parts, the first flat part, and the second flat part each having an equal length in the second direction,

the plurality of first heat-transfer-enhancement parts being each arranged in the second direction at a same position as the corresponding second flat part in the second heat-transfer-enhancement area in the second direction,

the first flat part being provided in the second direction at a same position as a corresponding one of the plurality of second heat-transfer-enhancement parts in the second heat-transfer-enhancement area in the second direction.

2. (canceled)

3. The heat exchanger of claim **1**, wherein

the plurality of first heat-transfer-enhancement parts and the first flat part are alternately arranged in the second direction,

the plurality of second heat-transfer-enhancement parts and the second flat part are alternately arranged in the second direction,

the second flat part is provided in the second heat-transfer-enhancement area side by side with the plurality of first heat-transfer-enhancement parts in the first direction, and

the plurality of second heat-transfer-enhancement parts are arranged in the second heat-transfer-enhancement area side by side with the first flat part in the first direction.

4. The heat exchanger of claim **1**, wherein the heat transfer tube has a plurality of heat transfer tubes spaced apart from each other at a predetermined interval in a third direction that crosses the first direction and the second direction.

5. (canceled)

6. The heat exchanger of claim **1**, wherein,

in the plurality of first heat-transfer-enhancement parts, any of a cut and bent-up part, a slit, a louver, and an uneven part is formed,

in the plurality of second heat-transfer-enhancement parts, any of a cut and bent-up part, a slit, a louver, and an uneven part is formed, and

a sum of a count of any of one or more of the cut and bent-up parts, slits, louvers, and uneven parts formed in the first direction in each of the plurality of first heat-transfer-enhancement parts, and a count of any of one or more of the cut and bent-up parts, slits, louvers, and uneven parts formed in the first direction in each of the plurality of second heat-transfer-enhancement parts is constant.

7. The heat exchanger of claim **1**, wherein

at least one of the plurality of first heat-transfer-enhancement parts are any of a cut and bent-up part, a slit, a louver, and an uneven part, and

at least one of the plurality of second heat-transfer-enhancement parts are any of a cut and bent-up part, a slit, a louver, and an uneven part.

8. The heat exchanger of claim **6**, wherein

any one of the slit, the louver, and the uneven part is formed in the plurality of first heat-transfer-enhancement parts in a first pattern,

any one of the slit, the louver, and the uneven part is formed in the plurality of second heat-transfer-enhancement parts in a second pattern, and

the first pattern and the second pattern are displaced from each other in the second direction.

9. A heat exchanger comprising:

a heat transfer tube that extends in a second direction that crosses a first direction in which gas flows; and

a fin that is provided to the heat transfer tube and has a surface that extends in the first direction and the second direction,

the fin having a first extension part and a second extension part,

the first extension part having a first heat-transfer-enhancement area that is located further upstream in a flow of the gas than the heat transfer tube in the first direction and improves a heat transfer coefficient,

the second extension part having a second heat-transfer-enhancement area that is located further downstream in the flow of the gas than the heat transfer tube in the first direction and improves a heat transfer coefficient,

the first heat-transfer-enhancement area having

a plurality of first heat-transfer-enhancement parts that are arranged in the second direction and each improve a heat transfer coefficient, and

a first flat part provided between adjacent ones of the plurality of first heat-transfer-enhancement parts in the second direction,

the second heat-transfer-enhancement area having

a plurality of second heat-transfer-enhancement parts that are arranged in the second direction and each improve a heat transfer coefficient, and

a second flat part provided between adjacent ones of the plurality of second heat-transfer-enhancement parts in the second direction,

the exchanger further comprising a first set including the heat transfer tube and the fin and a second set including the heat transfer tube and the fin,

the heat transfer tube in the second set being spaced apart from the heat transfer tube in the first set in the first direction,

the plurality of second heat-transfer-enhancement parts being formed in the fin in the first set at positions different in the second direction from positions of the plurality of first heat-transfer-enhancement parts formed in the fin in the second set.

10. The heat exchanger of claim **9**, wherein

the plurality of first heat-transfer-enhancement parts and the first flat part are alternately arranged in the second direction,

the plurality of second heat-transfer-enhancement parts and the second flat part are alternately arranged in the second direction,

the second flat part is provided in the second heat-transfer-enhancement area side by side with the plurality of first heat-transfer-enhancement parts in the first direction, and

the plurality of second heat-transfer-enhancement parts are arranged in the second heat-transfer-enhancement area side by side with the first flat part in the first direction.

11. The heat exchanger of claim **9**, wherein the heat transfer tube has a plurality of heat transfer tubes spaced apart from each other at a predetermined interval in a third direction that crosses the first direction and the second direction.

12. The heat exchanger of claim **9**, wherein,

in the plurality of first heat-transfer-enhancement parts, any of a cut and bent-up part, a slit, a louver, and an uneven part is formed,

in the plurality of second heat-transfer-enhancement parts, any of a cut and bent-up part, a slit, a louver, and an uneven part is formed, and

a sum of a count of any of one or more of the cut and bent-up parts, slits, louvers, and uneven parts formed in the first direction in each of the plurality of first heat-transfer-enhancement parts, and a count of any of one or more of the cut and bent-up parts, slits, louvers, and uneven parts formed in the first direction in each of the plurality of second heat-transfer-enhancement parts is constant.

13. The heat exchanger of claim **9**, wherein

at least one of the plurality of first heat-transfer-enhancement parts are any of a cut and bent-up part, a slit, a louver, and an uneven part, and

at least one of the plurality of second heat-transfer-enhancement parts are any of a cut and bent-up part, a slit, a louver, and an uneven part.

14. The heat exchanger of claim **12**, wherein

any one of the slit, the louver, and the uneven part is formed in the plurality of first heat-transfer-enhancement parts in a first pattern,

any one of the slit, the louver, and the uneven part is formed in the plurality of second heat-transfer-enhancement parts in a second pattern, and

the first pattern and the second pattern are displaced from each other in the second direction.

* * * * *