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## HEAT EXCHANGER AND AIR-CONDITIONING APPARATUS


### Abstract

A heat exchanger includes heat transfer tubes and a fin disposed between the heat transfer tubes. The fin includes a fin portion defining a flat surface and one or more heat transfer promoter groups including heat transfer promoters. The heat transfer promoters extend from one adjacent heat transfer tube to the other adjacent heat transfer tube and slope relative to the fin portion. The heat transfer promoters include a first heat transfer promoter disposed most upstream in the air flow direction. A first drain space is provided between the first heat transfer promoter and an air upstream part of the fin portion that is located closest to and upstream of the first heat transfer promoter in the air flow direction. A second drain space is provided between the heat transfer promoters that are adjacent. The first drain space has a larger area than the second drain space.



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## Background/Summary

TECHNICAL FIELD

[0001] The present disclosure relates to a heat exchanger and an air-conditioning apparatus.

BACKGROUND ART

[0002] Corrugated-fin and tube heat exchangers are in widespread use. This type of heat exchanger includes multiple flat heat transfer tubes connected between a pair of headers through which refrigerant passes and a corrugated fin disposed between the multiple flat heat transfer tubes.

[0003] A gas passes as a flow between the flat heat transfer tubes, between which the corrugated fin is disposed. In such a heat exchanger, a surface temperature of at least either the flat heat transfer tubes or the corrugated fin may be at or below the freezing point of water. As the surface temperature drops, moisture in the air near a surface condenses into water. As the surface temperature further drops to or below the freezing point of water, the water freezes. Some heat exchangers include fin portions having slits to drain water so that water deposited on the surfaces of the fin portions can be drained through the slits (refer to Patent Literature 1, for example).

CITATION LIST

Patent Literature

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2015-183908

SUMMARY OF INVENTION

Technical Problem

[0004] As described above, a related-art heat exchanger has a structure to drain water deposited on the surface of a corrugated fin. However, the corrugated fin needs to have a large opening area to drain condensate water. This results in a decrease in heat transfer area of the corrugated fin, causing a decrease in heat transfer performance.

[0005] In response to the above issue, it is an object of the present disclosure to provide a heat exchanger that can reduce a decrease in heat transfer area with enhanced drainage performance to reduce a decrease in heat transfer performance and an air-conditioning apparatus.

Solution to Problem

[0006] A heat exchanger according to an embodiment of the present disclosure includes a plurality of heat transfer tubes spaced in a direction orthogonal to an air flow direction and a corrugated fin disposed between the plurality of heat transfer tubes. The corrugated fin includes a fin portion defining a flat surface and one or more heat transfer promoter groups each including a plurality of heat transfer promoters. The plurality of heat transfer promoters extend from one of the plurality of heat transfer tubes that are adjacent to the other one of the plurality of heat transfer tubes that are adjacent and slope relative to the fin portion. The plurality of heat transfer promoters include a first heat transfer promoter disposed most upstream in the air flow direction. A first drain space is provided between the first heat transfer promoter and an air upstream part of the fin portion that is located closest to and upstream of the first heat transfer promoter in the air flow direction. A second drain space is provided between the heat transfer promoters that are adjacent. The first drain space has a larger area than the second drain space when viewed in a direction perpendicular to the fin portion.

Advantageous Effects of Invention

[0007] According to the embodiment of the present disclosure, the area of the first drain space is larger than that of the second drain space when viewed in the direction perpendicular to the fin portion. The first drain space located between the air upstream part of the fin portion and the heat transfer promoter has a relatively large area. This can increase the amount of water drained through the first drain space. The heat exchanger according to the embodiment of the present disclosure can reduce accumulation of condensate water, resulting in enhanced drainage performance. The second drain space located between the adjacent heat transfer promoters has a relatively small area. This can reduce a decrease in heat transfer area of the corrugated fin, thus reducing a decrease in heat transfer performance.

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## Description

BRIEF DESCRIPTION OF DRAWINGS
[0008] FIG. **1** is a diagram illustrating the configuration of a heat exchanger according to Embodiment 1.
[0009] FIG. **2** is a schematic perspective view of flat heat transfer tubes and a corrugated fin in Embodiment 1.
[0010] FIG. **3** is a schematic top view illustrating a fin portion of the corrugated fin in Embodiment 1.
[0011] FIG. **4** is a schematic longitudinal sectional view of the fin portion of the corrugated fin in Embodiment 1.
[0012] FIG. **5** is a schematic top view illustrating a fin portion of a corrugated fin having a first drain space and a third drain space in Modification of Embodiment 1.
[0013] FIG. **6** is a schematic top view illustrating a corrugated fin in Embodiment 2.
[0014] FIG. **7** is a sectional side view of a fin portion of a corrugated fin in Embodiment 3.
[0015] FIG. **8** is a sectional side view of a fin portion of a corrugated fin in Embodiment 4.
[0016] FIG. **9** is a schematic top view illustrating the fin portion of the corrugated fin in Embodiment 4.
[0017] FIG. **10** is a sectional side view of a fin portion of a corrugated fin in Modification of Embodiment 4.
[0018] FIG. **11** is a schematic top view illustrating the fin portion of the corrugated fin in Modification of Embodiment 4.
[0019] FIG. **12** is a sectional side view of a fin portion of a corrugated fin in Embodiment 5.
[0020] FIG. **13** is a diagram illustrating the configuration of an air-conditioning apparatus according to Embodiment 6.
DESCRIPTION OF EMBODIMENTS
[0021] An air-conditioning apparatus according to one or more embodiments will be described below with reference to the drawings. Note that the same component is described with the same reference sign in the figures and duplicate explanations are given only when necessary. The present disclosure may encompass all possible combinations of combinable configurations among the configurations described in the following embodiments. Furthermore, note that the relationship between the sizes of components in the figures may differ from that of actual ones. Additionally, note that the forms of components described herein are intended to be illustrative only and the forms of the components are not intended to be limited to those described herein. In particular, combinations of the components are not intended to be limited only to those in the embodiments. A component in one embodiment can be used in another embodiment.
Embodiment 1
[0022] FIG. **1** is a diagram illustrating the configuration of a heat exchanger **10** according to Embodiment 1.
[0023] As illustrated in FIG. **1**, the heat exchanger **10** according to Embodiment 1 is a corrugated-fin and tube heat exchanger **10** of a parallel-pipe type. The heat exchanger **10** includes multiple flat heat transfer tubes **1**, multiple corrugated fins **2**, a lower header **3**A, and an upper header **3**B. In the following description, an up-down direction in the drawing sheet of FIG. **1** is referred to as a height

direction of the heat exchanger **10**. In addition, a side-to-side direction in the drawing sheet of FIG. **1** is referred to as a horizontal direction. Furthermore, a front-rear direction in the drawing sheet of FIG. **1** is referred to as a depth direction of the heat exchanger **10**.

[0024] The lower header **3**A is connected to another device included in an air-conditioning apparatus by a pipe. The lower header **3**A is a tube into or out of which refrigerant, which is a fluid as a heat exchange medium, flows and through which the refrigerant is divided into streams or through which the refrigerant streams join together. The upper header **3**B is connected to another device included in the air-conditioning apparatus by a pipe. The upper header **3**B is a tube into or out of which the refrigerant, which is a fluid as a heat exchange medium, flows and through which the refrigerant is divided into streams or through which the refrigerant streams join together.

[0025] The multiple flat heat transfer tubes **1** are disposed parallel to each other between the lower header **3**A and the upper header **3**B such that the tubes are perpendicular to the lower header **3**A and the upper header **3**B. The lower header **3**A and the upper header **3**B are vertically and separately disposed in the height direction. The lower header **3**A allows liquid refrigerant to pass therethrough. The upper header **3**B allows gaseous refrigerant to pass therethrough.

[0026] The flat heat transfer tubes **1** are arranged at regular intervals in the horizontal direction such that the flat heat transfer tubes **1** that are adjacent have spacing therebetween. In fabricating the heat exchanger **10** according to Embodiment 1, each flat heat transfer tube **1** is inserted into an insertion hole (not illustrated) in each of the lower header **3**A and the upper header **3**B and is then brazed and joined to the header. For a brazing filler metal, for example, a filler metal containing aluminum is used.

[0027] While the heat exchanger **10** is used as a condenser or radiator, high-temperature, high-pressure refrigerant flows through refrigerant passages in the flat heat transfer tubes **1**. While the heat exchanger **10** is used as an evaporator or cooler, low-temperature, low-pressure refrigerant flows through the refrigerant passages in the flat heat transfer tubes **1**. In FIG. **1**, arrows represent a refrigerant flow direction in an operation of the heat exchanger **10** as an evaporator or cooler. The refrigerant flows into either the lower header **3**A or the upper header **3**B through the pipe (not illustrated) through which the refrigerant is supplied from an external device (not illustrated) to the heat exchanger **10**. Once in one of the lower header **3**A and the upper header **3**B, the refrigerant is distributed to the flat heat transfer tubes **1** and flows through each of the flat heat transfer tubes **1**. The flat heat transfer tube **1** exchanges heat between the refrigerant flowing inside the tube and outdoor air, serving as a fluid flowing outside the tube. At this time, the refrigerant transfers heat to or removes heat from the air while flowing through the flat heat transfer tube **1**. When the refrigerant has a higher temperature than the air, the refrigerant transfers its heat to the air. When the refrigerant has a lower temperature than the air, the refrigerant removes heat from the air. The refrigerant subjected to heat exchange through the flat heat transfer tube **1** flows into the other one of the lower header **3**A and the upper header **3**B, and joins the refrigerant that has passed through the other flat heat transfer tubes **1**. Then, the refrigerant is recirculated to an external device (not illustrated) through the pipe (not illustrated) connected to the other one of the lower header **3**A and the upper header **3**B.

[0028] The corrugated fins **2** are disposed between the arranged flat heat transfer tubes **1** such that each corrugated fin is located between flat surfaces of the tubes facing each other. Each of the corrugated fins **2** is disposed to increase the area of heat transfer between the refrigerant and the air. The corrugated fin **2** is formed by corrugating a plate. Specifically, the plate is folded into alternating ridges and troughs and is thus formed into an undulating shape or corrugations. The ridges and the troughs of the undulating shape form folds defining top portions **2**A of the undulating shape. The corrugated fin **2** includes fin portions **21** (refer to FIG. **2**) each defining a flat surface and the top portions **2**A each defining a curved surface between the fin portions **21**. In Embodiment 1, the top portions **2**A of the corrugated fin **2** are arranged in the height direction.

[0029] FIG. **2** is a schematic perspective view of the flat heat transfer tubes **1** and the corrugated fin

**2** in Embodiment 1. FIG. **3** is a schematic top view illustrating the fin portion **21** of the corrugated fin **2** in Embodiment 1. FIG. **3** illustrates a center line D-D that passes through the middle of the fin portion **21** in the depth direction.

[0030] The flat heat transfer tubes **1** each have a flat shape in cross-section. A longitudinal direction of the flat shape is parallel to the depth direction as an air flow direction. The flat heat transfer tubes **1** have flat outer surfaces in the depth direction. The heat transfer tubes have curved outer surfaces in a lateral direction of the flat shape that is orthogonal to the longitudinal direction.

[0031] The flat heat transfer tubes **1** are multi-hole flat heat transfer tubes each having therein multiple holes, serving as refrigerant passages. In Embodiment 1, the holes of the flat heat transfer tubes **1** serve as refrigerant passages between the lower header **3**A and the upper header **3**B in FIG. **1** and extend in the height direction.

[0032] Each flat heat transfer tube **1** is apart from the next flat heat transfer tube **1** such that the outer surfaces of the tubes in the longitudinal direction of the flat shape face each other.

[0033] Each corrugated fin **2** includes an end portion **2**B protruding upstream in the air flow direction between the flat heat transfer tubes **1** facing each other. Except for the top portions **2**A in the end portion **2**B, the top portions **2**A of the undulating shape of the corrugated fin **2** are in surface contact with the flat surfaces of the flat heat transfer tubes **1**. Contact portions are brazed and joined together with a filler metal. The plate for the corrugated fin **2** is made of, for example, aluminum alloy. The plate is clad with a filler metal layer. The filler metal layer is made of, for example, a filler metal containing aluminum such as an aluminum-silicon alloy. The plate has a thickness of from approximately 30 to approximately 200 μm.

[0034] The fin portions **21** are flat surfaces of ridge sides between the top portions **2**A of the corrugated fin **2**, or portions between the top portions **2**A arranged in the height direction. The fin portions **21** each include louver parts **22**, each projecting upward and serving as a heat transfer promoter, and first drain spaces **23**D_**1**.

[0035] The louver parts **22** are narrow slats. The louver parts **22** are spaced in the depth direction, which is the air flow direction, in each of the fin portions **21**. In other words, the multiple louver parts **22** are arranged along an air flow.

[0036] FIG. **2** illustrates condensate water **4** generated on the fin portion **21** and being drained to the first drain spaces **23**D_**1**.

[0037] As illustrated in FIGS. **2** and **3**, the fin portion **21** includes a first heat transfer promoter group **25**A and a second heat transfer promoter group **25**B.

[0038] The first heat transfer promoter group **25**A is located in a region upstream of the center line D-D of the fin portion **21** in the air flow direction. In FIG. **3**, the first heat transfer promoter group **25**A includes two louver parts **22**, the first drain space **23**D_**1**, a second drain space **23**D_**2**, and a third drain space **23**D_**3**. Although FIG. **3** illustrates the two louver parts **22**, three louver parts **22** may be provided as illustrated in FIG. **2**. Alternatively, four or more louver parts **22** may be provided.

[0039] The multiple louver parts **22** include a first louver part **22_1** located most upstream in the air flow direction and a second louver part **22_2** located most downstream in the air flow direction.

[0040] The first drain space **23**D_**1** is provided between the first louver part **22_1** and an air upstream part of the fin portion **21** that is located closest to and upstream of the first louver part **22_1** in the air flow direction. The first drain space **23**D_**1** is an opening extending through the fin portion **21** and has a rectangular shape as viewed from above in a direction perpendicular to the flat surface of the fin portion **21**.

[0041] The second drain space **23**D_**2** is provided between the louver parts **22** that are adjacent. The louver parts **22** in Embodiment 1 are formed by cutting the plate forming the fin portion **21** and raising cut parts. The second drain space **23**D_**2** is a space between the raised cut parts of the fin portion **21**.

[0042] The third drain space **23**D_**3** is provided between the second louver part **22_2** and a downstream part of the fin portion **21** that is located closest to and downstream of the second louver part **22_2** in the air flow direction. The third drain space **23**D_**3** is an opening extending through the fin portion **21** and has a rectangular shape as viewed from above in the direction perpendicular to the flat surface of the fin portion **21**.

[0043] The first drain space **23**D_**1** has an area larger than that of the second drain space **23**D_**2** when viewed in the direction perpendicular to the fin portion **21**. Furthermore, in Embodiment 1, the third drain space **23**D_**3** has an area larger than that of the second drain space **23**D_**2** when viewed in the direction perpendicular to the fin portion **21**.

[0044] The second heat transfer promoter group **25**B is located in a region downstream of the center line D-D of the fin portion **21** in the air flow direction. In FIG. **3**, the second heat transfer promoter group **25**B includes two louver parts **22**, the first drain space **23**D_**1**, the second drain space **23**D_**2**, and the third drain space **23**D_**3**. Although FIG. **3** illustrates the two louver parts **22**, three louver parts **22** may be provided as illustrated in FIG. **2**. Alternatively, four or more louver parts **22** may be provided.

[0045] The multiple louver parts **22** include the first louver part **22_1** located most upstream in the air flow direction and the second louver part **22_2** located most downstream in the air flow direction.

[0046] The first drain space **23**D_**1** is provided between the first louver part **22_1** and an air upstream part of the fin portion **21** that is located closest to and upstream of the first louver part **22_1** in the air flow direction. The first drain space **23**D_**1** is an opening extending through the fin portion **21** and has a rectangular shape as viewed from above in the direction perpendicular to the flat surface of the fin portion **21**.

[0047] The second drain space **23**D_**2** is provided between the louver parts **22** that are adjacent.

[0048] The third drain space **23**D_**3** is provided between the second louver part **22_2** and a downstream part of the fin portion **21** that is located closest to and downstream of the second louver part **22_2** in the air flow direction. The third drain space **23**D_**3** is an opening extending through the fin portion **21** and has a rectangular shape as viewed from above in the direction perpendicular to the flat surface of the fin portion **21**.

[0049] The first drain space **23**D_**1** has an area larger than that of the second drain space **23**D_**2** when viewed in the direction perpendicular to the fin portion **21**. Furthermore, in Embodiment 1, the third drain space **23**D_**3** has an area larger than that of the second drain space **23**D_**2** when viewed in the direction perpendicular to the fin portion **21**.

[0050] FIG. **4** is a schematic longitudinal sectional view of the fin portion **21** of the corrugated fin **2** in Embodiment 1. FIG. **4** illustrates an example of the first heat transfer promoter group **25**A including three louver parts **22** arranged in the air flow direction and further illustrates an example of the second heat transfer promoter group **25**B including three louver parts **22** arranged in the air flow direction.

[0051] FIG. **4** illustrates the following reference signs and parameters.

[0052] A-A: An imaginary line representing a slope of the louver part **22** of the first heat transfer promoter group **25**A relative to the fin portion **21**

[0053] B-B: An imaginary line representing a slope of the louver part **22** of the second heat transfer promoter group **25**B relative to the fin portion **21**

[0054] L.sub.L denotes a distance between the louver parts **22** that are adjacent in a plane along the fin portion **21**. In the example of FIG. **4**, L.sub.L denotes a distance between a lower end of one of the adjacent louver parts **22** and an upper end of the other louver part **22** in a direction along the fin portion **21**.

[0055] L.sub.P denotes a distance between the centers of the adjacent louver parts **22** in the plane along the fin portion **21**.

[0056] L.sub.s denotes a distance of a gap between the adjacent louver parts **22**.

[0057] θ denotes an inclination angle of the louver part **22** relative to the fin portion **21**.

[0058] L.sub.L is equal to L.sub.P.
[0059] S.sub.L in an upstream region of the first heat transfer promoter group **25**A in the air flow direction denotes a distance between the first louver part **22_1** and the air upstream part of the fin portion **21** located closest to and upstream of the first louver part **22_1** in the air flow direction. In other words, S.sub.L in the upstream region of the first heat transfer promoter group **25**A in the air flow direction denotes a dimension of the first drain space **23**D_**1** when viewed in the direction perpendicular to the flat surface of the fin portion **21**.
[0060] S.sub.L in a downstream region of the first heat transfer promoter group **25**A in the air flow direction denotes a distance between the second louver part **22_2** and the downstream part of the fin portion **21** located closest to and downstream of the second louver part **22_2**. In other words, S.sub.L in the downstream region of the first heat transfer promoter group **25**A in the air flow direction denotes a dimension of the third drain space **23**D_**3** when viewed in the direction perpendicular to the flat surface of the fin portion **21**.
[0061] L.sub.L in the first heat transfer promoter group **25**A denotes a distance between the adjacent louver parts **22** in the first heat transfer promoter group **25**A. In other words, L.sub.L in the first heat transfer promoter group **25**A denotes a dimension of the second drain space **23**D_**2** in the air flow direction when viewed in the direction perpendicular to the fin portion **21**.
[0062] The dimension S.sub.L in the downstream region of the first heat transfer promoter group **25**A in the air flow direction is longer than the dimension L.sub.L in the first heat transfer promoter group **25**A.
[0063] S.sub.L in an upstream region of the second heat transfer promoter group **25**B in the air flow direction denotes a distance between the first louver part **22_1** and the air upstream part of the fin portion **21** located closest to and upstream of the first louver part **22_1**. In other words, S.sub.L in the upstream region of the first heat transfer promoter group **25**A in the air flow direction denotes a dimension of the first drain space **23**D_**1** when viewed in the direction perpendicular to the flat surface of the fin portion **21**. S.sub.L in a downstream region of the second heat transfer promoter group **25**B in the air flow direction denotes a distance between the second louver part **22_2** and the downstream part of the fin portion **21** located closest to and downstream of the second louver part **22_2** in the air flow direction. In other words, S.sub.L in the downstream region of the first heat transfer promoter group **25**A in the air flow direction denotes a dimension of the third drain space **23**D_**3** when viewed in the direction perpendicular to the flat surface of the fin portion **21**.
[0064] L.sub.L in the second heat transfer promoter group **25**B denotes a distance between the adjacent louver parts **22** in the second heat transfer promoter group **25**B. In other words, L.sub.L in the second heat transfer promoter group **25**B denotes a dimension of the second drain space **23**D_**2** in the air flow direction when viewed in the direction perpendicular to the fin portion **21**.
[0065] The dimension S.sub.L in the downstream region of the second heat transfer promoter group **25**B in the air flow direction is longer than the dimension L.sub.L in the second heat transfer promoter group **25**B.
[0066] In the heat exchanger **10** according to Embodiment 1, each of the first drain space **23**D_**1** and the third drain space **23**D_**3**, which are larger than the second drain space **23**D_**2** between the adjacent louver parts **22**, is located between a part of the fin portion **21** and the louver part **22** adjacent to the part of the fin portion **21**. Therefore, the relationship of S.sub.L>L.sub.L holds.
[0067] In the first heat transfer promoter group **25**A in FIG. **4**, the three louver parts **22** are spaced and arranged parallel to each other. In the first heat transfer promoter group **25**A, a gap formed outside each outermost louver part **22** is larger than the gap between the louver parts **22** in the first heat transfer promoter group **25**A. In the second heat transfer promoter group **25**B, a gap formed outside each outermost louver part **22** is larger than the gap between the louver parts **22** in the second heat transfer promoter group **25**B.
[0068] A part of the perimeter of the first drain space **23**D_**1** is defined by an edge of the first

louver part **22_1** at the most upstream location. In other words, the first louver part **22_1** and the first drain space **23**D_**1** adjoin each other without any part or space therebetween. A part of the perimeter of the third drain space **23**D_**3** is defined by an edge of the second louver part **22_2** at the most downstream location. In other words, the second louver part **22_2** and the third drain space **23**D_**3** adjoin each other without any part or space therebetween.

[0069] In the above description, the first drain space **23**D_**1** and the third drain space **23**D_**3** each have a rectangular shape when viewed from above, as illustrated in FIG. **3**. The first drain space **23**D_**1** and the third drain space **23**D_**3** may have any shape other than a rectangle.

[0070] FIG. **5** is a schematic top view illustrating a fin portion **21** of a corrugated fin **2** having a first drain space **23**D_**1** and a third drain space **23**D_**3** in Modification of Embodiment 1. As illustrated in FIG. **5**, the first drain space **23**D_**1** and the third drain space **23**D_**3** each have a shape including a curve when viewed in the direction perpendicular to the fin portion **21**. In the example of FIG. **5**, the first drain space **23**D_**1** and the third drain space **23**D_**3** are D-shaped in outline. The louver part **22** defining the first drain space **23**D_**1** has a curved edge extending from one flat heat transfer tube **1** to the other flat heat transfer tube **1**. This causes the shape of the first drain space **23**D_**1** to include a curve. In addition, a part of the fin portion **21** defining the third drain space **23**D_**3** has a curved edge extending from one flat heat transfer tube **1** to the other flat heat transfer tube **1**. This causes the shape of the third drain space **23**D_**3** to include a curve. The curve of each of the first drain space **23**D_**1** and the third drain space **23**D_**3** is a curve having a top portion **2**A located at the midpoint between the flat heat transfer tubes **1** and protruding in the air flow direction. The first drain space **23**D_**1** and the third drain space **23**D_**3** each have an opening area that increases toward the midpoint between the flat heat transfer tubes **1**. Although FIG. **5** illustrates the example in which the curve of each of the first drain space **23**D_**1** and the third drain space **23**D_**3** protrudes in the air flow direction, the curve may protrude in a direction opposite to the air flow direction.

[0071] In a related-art heat exchanger, condensate water **4** on the corrugated fin **2** flows downward through a drain space (second drain space **23**D_**2** in Embodiment 1) between the louver parts **22**. In a path through which the condensate water **4** flows on the corrugated fin **2**, the amount of condensate water **4** flowing to the louver part **22** from a part of the fin portion **21** that is adjacent to the louver part **22** in the air flow direction is larger than the amount of condensate water **4** flowing on the louver part **22**.

[0072] In the heat exchanger **10** according to Embodiment 1, the first drain space **23**D_**1** is provided between the first louver part **22_1** and the air upstream part of the fin portion **21** located closest to and upstream of the first louver part **22_1** in the air flow direction, and the second drain space **23**D_**2** is provided between the louver parts **22** that are adjacent. The area of the first drain space **23**D_**1** is larger than that of the second drain space **23**D_**2** when viewed in the direction perpendicular to the fin portion **21**.

[0073] The condensate water **4** on the flat fin portion **21** of the corrugated fin **2** is pressed by an air flow and thus flows from upstream to downstream on the fin portion **21**. Then, the condensate water **4** reaches the first drain space **23**D_**1** located between the first louver part **22_1**, serving as a heat transfer promoter located upstream in the air flow direction, and the fin portion **21** and flows downward through the first drain space **23**D_**1**. Since the first drain space **23**D_**1** has a relatively large area as described in Embodiment 1, most of the condensate water **4** flows downward through the first drain space **23**D_**1**. This results in enhanced drainage of the condensate water **4** on the fin portion **21** of the corrugated fin **2**. The term “drainage” as used herein refers to the amount of water drained from the heat exchanger **10** per unit time. Such a relatively large area of the first drain space **23**D_**1** between the first louver part **22_1** and the adjacent part of the fin portion **21** allows a reduction in accumulation of the condensate water **4** in the first drain space **23**D_**1**, or a bridge of the condensate water **4** between the first louver part **22_1** and the fin portion **21**.

[0074] Experiments and analysis by the inventors demonstrate that while condensate water **4** drains or flows downward through the gaps between the louver parts **22**, a large amount of condensate water **4** is guided from the fin portion **21**. This result reveals that the first drain space **23**D_**1** larger than the second drain space **23**D_**2** can effectively enhance the drainage. The area of the second drain space **23**D_**2** located between the louver parts **22** of the corrugated fin **2** is smaller than the area of the first drain space **23**D_**1**. This reduces a decrease in heat transfer area of the corrugated fin **2**, thus reducing a decrease in heat transfer performance.

[0075] The first drain space **23**D_**1** is provided in a region that is located upstream in an air flow and in which the air contains a large amount of moisture when the heat exchanger **10** is used under frosting conditions. This increases a frost retention region. In other words, more frost forms around the first drain space **23**D_**1** and is retained there. Thus, the time it takes for growing frost to block an air passage between the fin portions **21** arranged vertically can be prolonged, resulting in improved resistance to frost.

[0076] In the heat exchanger **10** according to Embodiment 1, the multiple louver parts **22** include the second louver part **22**_**2** located most downstream in the air flow direction.

[0077] The third drain space **23**D_**3** is provided between the second louver part **22**_**2** and the downstream part of the fin portion **21** located closest to and downstream of the second louver part **22**_**2** in the air flow direction. The area of the third drain space **23**D_**3** is larger than that of the second drain space **23**D_**2** when viewed in the direction perpendicular to the fin portion **21**.

[0078] The condensate water **4** on the flat fin portion **21** of the corrugated fin **2** is pressed by an air flow and thus flows from upstream to downstream on the fin portion **21**. Then, the condensate water **4** reaches the third drain space **23**D_**3** located between the second louver part **22**_**2**, serving as a heat transfer promoter located downstream in the air flow direction, and the fin portion **21** and flows downward through the third drain space **23**D_**3**. Since the third drain space **23**D_**3** has a relatively large area as described in Embodiment 1, most of the condensate water **4** flows downward through the third drain space **23**D_**3**. This results in enhanced drainage of the condensate water **4** on the fin portion **21** of the corrugated fin **2**. Such a relatively large area of the third drain space **23**D_**3** between the second louver part **22**_**2** and the adjacent part of the fin portion **21** allows a reduction in accumulation of the condensate water **4** in the third drain space **23**D_**3**, or a bridge of the condensate water **4** between the second louver part **22**_**2** and the fin portion **21**.

[0079] As illustrated in FIG. **5**, when each of the first drain space **23**D_**1** and the third drain space **23**D_**3** is shaped such that a middle portion of the opening area has a large curvature, such a shape can further enhance the drainage while minimizing a decrease in heat transfer performance of parts of the fin portion **21** that have low fin efficiency. If each of the first drain space **23**D_**1** and the third drain space **23**D_**3** is shaped such that the middle portion of the opening area has a larger opening space, such a shape can further enhance the drainage while minimizing a decrease in heat transfer performance.

Embodiment 2

[0080] FIG. **6** is a schematic top view illustrating a corrugated fin **2** in Embodiment 2. The same elements as those in FIG. **3** are assigned the same reference signs. The following description will focus on a difference from FIG. **3**.

[0081] In Embodiment 2, as illustrated in FIG. **6**, the first drain space **23**D_**1** in the first heat transfer promoter group **25**A has an opening area larger than that of the third drain space **23**D_**3** in the first heat transfer promoter group **25**A.

[0082] The sum of opening areas defined by the multiple louver parts **22** in the first heat transfer promoter group **25**A is greater than the sum of opening areas defined by the multiple louver parts **22** in the second heat transfer promoter group **25**B. The relationship is expressed by A.sub.1>B.sub.1 where A.sub.1 is the sum of the opening areas defined by the multiple louver parts **22** in the first heat transfer promoter group **25**A and B.sub.1 is the sum of the opening areas defined by the multiple louver parts **22** in the second heat transfer promoter group **25**B. The sum of the opening areas includes the opening areas of the first drain space **23**D_**1**, the second drain space **23**D_**2**, and the third drain space **23**D_**3**.

[0083] The heat exchanger **10** provides a large amount of heat exchange in a part of the fin portion **21** that is located upstream in the air flow direction and that has a large difference in temperature between the air and the refrigerant flowing through the flat heat transfer tubes **1**. Therefore, more condensate water **4** can be generated upstream in the air flow direction.

[0084] In the heat exchanger **10** according to Embodiment 2, the sum of the opening areas of the drain spaces in the first heat transfer promoter group **25**A located upstream of the center line D-D of the fin portion **21** in the air flow direction is greater than the sum of the opening areas of the drain spaces in the second heat transfer promoter group **25**B located downstream in the air flow direction. Therefore, the heat exchanger **10** according to Embodiment 2 exhibits higher drainage than the heat exchanger **10** according to Embodiment 1.

[0085] Furthermore, as illustrated in the first heat transfer promoter group **25**A in FIG. **6**, the first drain space **23**D_**1** located upstream in the air flow direction has an opening area larger than that of the third drain space **23**D_**3** located downstream in the air flow direction. This results in further enhanced drainage.

Embodiment 3

[0086] FIG. **7** is a sectional side view of a fin portion **21** of a corrugated fin **2** in Embodiment 3. The same elements as those in FIG. **4** are assigned the same reference signs. The following description will focus on differences from FIG. **4**.

[0087] As illustrated in FIG. **7**, the multiple louver parts **22** in the first heat transfer promoter group **25**A slope relative to the fin portion **21**. An air upstream part of the fin portion **21** that is located closest to and upstream of the first louver part **22_1** in the air flow direction includes a first sloping part **26_1** that slopes parallel to a sloping direction of the first louver part **22_1**. A downstream part of the fin portion **21** that is located closest to and downstream of the second louver part **22_2** in the air flow direction includes a second sloping part **26_2** that slopes parallel to a sloping direction of the second louver part **22_2**.

[0088] The first sloping part **26_1** of the air upstream part of the fin portion **21** located closest to and upstream of the first louver part **22_1** in the air flow direction in the first heat transfer promoter group **25**A protrudes to a lower surface of the fin portion **21**.

[0089] The second sloping part **26_2** of the downstream part of the fin portion **21** located closest to and downstream of the first louver part **22_1** in the air flow direction in the first heat transfer promoter group **25**A protrudes to an upper surface of the fin portion **21**.

[0090] When viewed in the direction perpendicular to the fin portion **21**, the first drain space **23**D_**1** provided between the first sloping part **26_1** and the first louver part **22_1** in the first heat transfer promoter group **25**A has an area larger than that of the second drain space **23**D_**2** provided between the adjacent louver parts **22**.

[0091] When viewed in the direction perpendicular to the fin portion **21**, the third drain space **23**D_**3** provided between the second sloping part **26_2** and the second louver part **22_2** in the first heat transfer promoter group **25**A has an area larger than that of the second drain space **23**D_**2** provided between the adjacent louver parts **22**.

[0092] The multiple louver parts **22** in the second heat transfer promoter group **25**B slope relative to the fin portion **21**. An air upstream part of the fin portion **21** that is located closest to and upstream of the first louver part **22_1** in the air flow direction includes a first sloping part **26_1** that slopes parallel to a sloping direction of the first louver part **22_1**. A downstream part of the fin portion **21** that is located closest to and downstream of the second louver part **22_2** in the air flow direction includes a second sloping part **26_2** that slopes parallel to a sloping direction of the second louver part **22_2**.

[0093] The first sloping part **26_1** of the air upstream part of the fin portion **21** located closest to and upstream of the first louver part **22_1** in the air flow direction in the second heat transfer

promoter group **25**B protrudes to the upper surface of the fin portion **21**.
[0094] The second sloping part **26_2** of the fin portion **21** located closest to and downstream of the first louver part **22_1** in the air flow direction in the second heat transfer promoter group **25**B protrudes to the lower surface of the fin portion **21**.
[0095] The first drain space **23**D**_1** provided between the first sloping part **26_1** and the first louver part **22_1** in the second heat transfer promoter group **25**B is larger than the second drain space **23**D**_2** provided between the adjacent louver parts **22**.
[0096] The third drain space **23**D**_3** provided between the second sloping part **26_2** and the second louver part **22_2** in the second heat transfer promoter group **25**B is larger than the second drain space **23**D**_2** provided between the adjacent louver parts **22**.
[0097] In a heat exchanger **10** according to Embodiment 3, the first sloping parts **26_1** and the second sloping parts **26_2** increase an area that contributes to heat exchange in the corrugated fin **2**, thus improving the heat transfer performance of the corrugated fin **2**.
[0098] The first drain space **23**D**_1** in the first heat transfer promoter group **25**A extending along the slope (in the direction of a thick broken-line arrow in FIG. **7**) of the louver parts **22** defines a passage along the slope between the first sloping part **26_1** and the first louver part **22_1**. The passage between the first sloping part **26_1** and the first louver part **22_1** serves as a drain path for condensate water **4**. This allows enhanced drainage from the corrugated fin **2** as well as improved heat transfer performance, as compared with the configuration without the first sloping part **26_1**.
[0099] The third drain space **23**D**_3** extending along the slope (in the direction of a thick broken-line arrow in FIG. **7**) of the louver parts **22** defines a large opening with the second sloping part **26_2**, as compared with the configuration without the second sloping part **26_2**. This allows enhanced drainage from the corrugated fin **2**.
Embodiment 4
[0100] FIG. **8** is a sectional side view of a fin portion **21** of a corrugated fin **2** in Embodiment 4. The same elements as those in FIG. **4** are assigned the same reference signs. The following description will focus on a difference from FIG. **4**.
[0101] A heat exchanger **10** according to Embodiment 4 includes a flat drain slit **27** that is located at substantially the middle of the fin portion **21** in the air flow direction and that serves as a fourth drain space to drain condensate water **4**. The flat drain slit **27** is provided between the first heat transfer promoter group **25**A and the second heat transfer promoter group **25**B.
[0102] Although not illustrated in FIG. **8**, the multiple fin portions **21** are arranged vertically as seen from FIGS. **1** and **2**. The flat drain slits **27** of the respective fin portions **21** are also arranged vertically.
[0103] As illustrated in FIG. **8**, the louver parts **22** are directed so that the condensate water **4** (not illustrated) can be gathered to the flat drain slit **27** of the fin portion **21** at a lower level than the fin portion **21** including these louver parts **22**. In FIG. **8**, broken-line arrows each represent the direction of drainage of the condensate water **4**. As represented by the broken-line arrows, the condensate water **4** flowing along the surfaces of the louver parts **22** falls toward the flat drain slit **27** of the fin portion **21** at a lower level than these louver parts **22** and then falls downward through the flat drain slit **27**. Directing the louver parts **22** in the above-described manner can enhance the drainage of condensate water **4**.
[0104] Furthermore, the sloping direction of the multiple louver parts **22** in the first heat transfer promoter group **25**A relative to the fin portion **21** is opposite, with respect to the flat drain slit **27**, to the sloping direction of the multiple louver parts **22** in the second heat transfer promoter group **25**B relative to the fin portion **21**. This allows the condensate water **4** falling from the first heat transfer promoter group **25**A and the condensate water **4** falling from the second heat transfer promoter group **25**B to flow toward one flat drain slit **27**.
[0105] FIG. **9** is a schematic top view illustrating the fin portion **21** of the corrugated fin **2** in Embodiment 4. The same elements as those in FIG. **3** are assigned the same reference signs. The

following description will focus on a difference from FIG. **3**.

[0106] As illustrated in FIG. **9**, the flat drain slit **27** has an opening area greater than a total opening area of the first heat transfer promoter group **25**A. The total opening area of the first heat transfer promoter group **25**A is the sum of the opening areas of the first drain space **23**D_**1**, the second drain space **23**D_**2**, and the third drain space **23**D_**3**. The flat drain slit **27** has a dimension Ss in the air flow direction.

<Modification>

[0107] Although FIGS. **8** and **9** illustrate an example in which the flat drain slit **27** is a single rectangular opening, the flat drain slit **27** may include multiple openings.

[0108] FIG. **10** is a sectional side view of a fin portion **21** of a corrugated fin **2** in Modification of Embodiment 4. The same elements as those in FIG. **4** are assigned the same reference signs. The following description will focus on a difference from FIG. **4**. FIG. **11** is a schematic top view illustrating the fin portion **21** of the corrugated fin **2** in Modification of Embodiment 4. The same elements as those in FIG. **3** are assigned the same reference signs. The following description will focus on a difference from FIG. **3**.

[0109] FIGS. **10** and **11** illustrate the flat drain slit **27** including two openings located at substantially the middle of the fin portion **21** in the air flow direction.

[0110] The flat drain slit **27** as an opening may have any shape other than a rectangle. Multiple flat drain slits **27** are provided such that a thin part of the fin portion **21** is located between the slits that are adjacent. In such a configuration, condensate water **4** can be guided by the thin part of the fin portion **21** and be drained. This results in enhanced drainage.

[0111] In the heat exchanger **10** according to Embodiment 4, the opening area of the flat drain slit **27** is greater than the total opening area of the first heat transfer promoter group **25**A. The corrugated fin **2** includes the fin portions **21** arranged vertically. In the corrugated fin **2**, therefore, the condensate water **4** guided from the first heat transfer promoter group **25**A and the second heat transfer promoter group **25**B of an upper fin portion **21** can be drained through the flat drain slit **27** of a lower fin portion **21**. This results in enhanced drainage from the heat exchanger **10**.

Embodiment 5

[0112] FIG. **12** is a sectional side view of a fin portion **21** of a corrugated fin **2** in Embodiment 5. The same elements as those in FIG. **4** are assigned the same reference signs. The following description will focus on differences from FIG. **4**.

[0113] In a heat exchanger **10** according to Embodiment 5, an inclination angle θ of a louver part **22** relative to the flat surface of the fin portion **21** differs from an inclination angle θ of the next louver part **22** in the air flow direction. In FIG. **12**, let θ**1** denote a an inclination angle of the louver part **22** relative to the first louver part **22_1**, let θ**2** denote an inclination angle relative to the louver part **22**, and let θ**3** denote an inclination angle of the second louver part **22_2**. In Embodiment 5, θ**1**<θ**2**<θ**3** holds.

[0114] Specifically, the inclination angle θ**1**, the inclination angle θ**2**, and the inclination angle θ**3** in the first heat transfer promoter group **25**A differ from each other. The slope θ**3** of the second louver part **22_2** in the first heat transfer promoter group **25**A is larger than the inclination angle θ**1** of the first louver part **22_1**.

[0115] A slope θ**1**, an inclination angle θ**2**, and an inclination angle θ**3** in the second heat transfer promoter group **25**B differ from each other. The slope θ**3** of the second louver part **22_2** in the second heat transfer promoter group **25**B is larger than the inclination angle θ**1** of the first louver part **22_1**.

[0116] In the heat exchanger **10** according to Embodiment 5, the inclination angle θ**2** of the second louver part **22_2** located downstream in the air flow direction is larger than the inclination angle θ**1** of the first louver part **22_1** located upstream in the air flow direction. This reduces in heat transfer coefficient in an upstream region, where a large amount of frost can be formed, in the air flow direction. This results in improved resistance to frost.

Embodiment 6

[0117] FIG. **13** is a diagram illustrating the configuration of an air-conditioning apparatus A according to Embodiment 6. In Embodiment 6, the air-conditioning apparatus A will be described as an exemplary refrigeration cycle apparatus. In the air-conditioning apparatus A of FIG. **13**, the heat exchanger **10** is used as an outdoor heat exchanger **230**. The use of the heat exchanger **10** is not limited to this example. The heat exchanger **10** may be used as an indoor heat exchanger **110**. The heat exchanger **10** may be used as each of the outdoor heat exchanger **230** and the indoor heat exchanger **110**.

[0118] As illustrated in FIG. **13**, the air-conditioning apparatus A includes an outdoor unit **200** and an indoor unit **100**, which are connected by a gaseous refrigerant pipe **300** and a liquid refrigerant pipe **400** to form a refrigerant circuit. The outdoor unit **200** includes a compressor **210**, a four-way valve **220**, the outdoor heat exchanger **230**, and an outdoor fan **240**. The air-conditioning apparatus A according to Embodiment 1 includes the single outdoor unit **200** and the single indoor unit **100** connected by the pipes.

[0119] The compressor **210** sucks, compresses, and discharges the refrigerant. The compressor **210** is, but not particularly limited to, a compressor whose capacity can be varied by changing its operating frequency to any value through, for example, an inverter circuit. The four-way valve **220** is a valve that switches the flow of refrigerant between, for example, a cooling operation and a heating operation.

[0120] The outdoor heat exchanger **230** exchanges heat between the refrigerant and outdoor air. For example, in the heating operation, the outdoor heat exchanger **230** operates as an evaporator to evaporate and gasify the refrigerant. In the cooling operation, the outdoor heat exchanger **230** operates as a condenser to condense and liquify the refrigerant. The outdoor fan **240** sends the outdoor air to the outdoor heat exchanger **230** to promote heat exchange in the outdoor heat exchanger **230**.

[0121] The indoor heat exchanger **110** exchanges heat between the refrigerant and air in, for example, a room to be air-conditioned. In the heating operation, the indoor heat exchanger **110** operates as a condenser to condense and liquify the refrigerant. In the cooling operation, the indoor heat exchanger **110** operates as an evaporator to evaporate and gasify the refrigerant.

[0122] The indoor unit **100** includes the indoor heat exchanger **110**, an expansion valve **120**, and an indoor fan **130**. The expansion valve **120**, such as an expansion device, reduces the pressure of the refrigerant to expand the refrigerant. Assuming that the expansion valve **120** is, for example, an electronic expansion valve, its opening degree is adjusted based on an instruction from a controller (not illustrated), for example. The indoor heat exchanger **110** exchanges heat between the refrigerant and the air in the room, which is an air-conditioned space. For example, in the heating operation, the indoor heat exchanger **110** operates as a condenser to condense and liquify the refrigerant. In the cooling operation, the indoor heat exchanger **110** operates as an evaporator to evaporate and gasify the refrigerant. The indoor fan **130** causes the air in the room to pass through the indoor heat exchanger **110**, and supplies the air that has passed through the indoor heat exchanger **110** to the room.

[0123] Operations of the devices included in the air-conditioning apparatus A will now be described based on the flow of refrigerant. The operations of the devices in the refrigerant circuit in the heating operation will first be described based on the flow of refrigerant. High-temperature, high-pressure gaseous refrigerant compressed and discharged by the compressor **210** passes through the four-way valve **220** and then flows into the indoor heat exchanger **110**. While passing through the indoor heat exchanger **110**, the gaseous refrigerant exchanges heat with, for example, the air in the air-conditioned space, and thus condenses and liquifies. The refrigerant that has condensed and liquified passes through the expansion valve **120**. The refrigerant is reduced in pressure when passing through the expansion valve **120**. The refrigerant, reduced in pressure by the expansion valve **120**, in a two-phase gas-liquid state passes through the outdoor heat exchanger

**230**. In the outdoor heat exchanger **230**, the refrigerant exchanges heat with outdoor air sent from the outdoor fan **240** and thus evaporates and gasifies. The refrigerant then passes through the four-way valve **220** and is sucked into the compressor **210** again. The refrigerant is circulated through the air-conditioning apparatus A in the above-described manner, thus performing air-conditioning for heating.

[0124] The cooling operation will now be described. High-temperature, high-pressure gaseous refrigerant compressed and discharged by the compressor **210** passes through the four-way valve **220** and then flows into the outdoor heat exchanger **230**. The refrigerant passes through the outdoor heat exchanger **230** and exchanges heat with outdoor air supplied by the outdoor fan **240** and thus condenses and liquifies. The refrigerant then passes through the expansion valve **120**. The refrigerant is reduced in pressure when passing through the expansion valve **120**. The refrigerant, reduced in pressure by the expansion valve **120**, in a two-phase gas-liquid state passes through the indoor heat exchanger **110**. In the indoor heat exchanger **110**, the refrigerant exchanges heat with, for example, air in the air-conditioned space and thus evaporates and gasifies. The refrigerant then passes through the four-way valve **220** and is sucked into the compressor **210** again. The refrigerant is circulated through the air-conditioning apparatus A in the above-described manner, thus performing air-conditioning for cooling.

[0125] As described above, in the heat exchanger **10** operating as an evaporator, the surfaces of the flat heat transfer tubes **1** and the corrugated fins **2** are at a temperature lower than that of the air passing through the heat exchanger **10**. Therefore, moisture in the air is converted to water droplets on the surfaces of the flat heat transfer tubes **1** and the corrugated fins **2**, thus causing deposition of condensate water **4**. When the air has a lower temperature, the temperatures of the surfaces of the fins drop to or below the freezing point of water, so that the condensate water **4** on the surfaces of the fins freezes into frost. The frost grows to block air flows, causing an increase in air passage resistance. This reduces the amount of air flowing through the heat exchanger **10**, resulting in lower performance of the heat exchanger **10**.

[0126] The air-conditioning apparatus A according to Embodiment 6 includes the heat exchanger **10** according to any of Embodiment 1, Embodiment 2, Embodiment 3, Embodiment 4, and Embodiment 5. Therefore, the heat exchanger **10** can reduce accumulation of the condensate water **4** and thus exhibit enhanced drainage performance. In addition, the first drain spaces **23**D_**1** and the third drain spaces **23**D_**3** increase a frost retention region. This can prolong the time it takes for frost to block an air flow between the fin portions **21**, resulting in improved resistance to frost. Thus, the heat exchanger **10** of the air-conditioning apparatus A according to Embodiment 6 can reduce a decrease in heat transfer area of the corrugated fins **2** under frost formation conditions, thus reducing a decrease in heat transfer performance.

[0127] In Embodiment 1, Embodiment 2, Embodiment 3, Embodiment 4, Embodiment 5, and Embodiment 6, the louver part **22** is also referred to as a heat transfer promoter, and the flat drain slit **27** is also referred to as a fourth drain space.

REFERENCE SIGNS LIST

[0128] **1**: flat heat transfer tube, **2**: corrugated fin, **2**A: top portion, **2**B: end portion, **3**A: lower header, **3**B: upper header, **4**: condensate water, **10**: heat exchanger, **21**: fin portion, **22**: louver part, **22_1**: first louver part, **22_2**: second louver part, **23**D_**1**: first drain space, **23**D_**2**: second drain space, **23**D_**3**: third drain space, **25**A: first heat transfer promoter group, **25**B: second heat transfer promoter group, **26_1**: first sloping part, **26_2**: second sloping part, **27**: flat drain slit, **100**: indoor unit, **110**: indoor heat exchanger, **120**: expansion valve, **130**: indoor fan, **200**: outdoor unit, **210**: compressor, **220**: four-way valve, **230**: outdoor heat exchanger, **240**: outdoor fan, **300**: gaseous refrigerant pipe, **400**: liquid refrigerant pipe, A: air-conditioning apparatus, S.sub.L: drain-space dimension, Ss: dimension of the flat drain slit, L.sub.L: distance between a lower end, located on a lower surface of the fin portion, of one of adjacent louver parts and an upper end, located on an upper surface of the fin portion, of the other louver part in a direction along the fin portion, L.sub.s:

distance of a gap between the louver parts **22**, A.sub.1: opening areas defined by multiple louver parts in the first heat transfer promoter group, B.sub.1: opening areas defined by multiple louver parts in the second heat transfer promoter group, θ: inclination angle

## Claims

**1**. A heat exchanger comprising: a plurality of heat transfer tubes spaced in a direction orthogonal to an air flow direction; and a corrugated fin disposed between the plurality of heat transfer tubes, the corrugated fin including a fin portion defining a flat surface and one or more heat transfer promoter groups each including a plurality of louver parts, the plurality of louver parts extending from one of the plurality of heat transfer tubes that are adjacent to an other one of the plurality of heat transfer tubes that are adjacent and sloping relative to the fin portion, wherein the plurality of louver parts include a first louver part disposed most upstream in the air flow direction, a first drain space having a shape in which a part of a perimeter thereof is defined by an edge of the first louver part and is open at upstream side of the first louver part in the air flow direction when viewed in a direction perpendicular to the fin portion is provided between the first louver part and an air upstream part of the fin portion that is located closest to and upstream of the first louver part in the air flow direction, a second drain space is provided between adjacent ones of the louver parts, and the first drain space has a larger area than the second drain space when viewed in a direction perpendicular to the fin portion.
**2**. The heat exchanger of claim 1, wherein the plurality of louver parts include a second louver part disposed most downstream in the air flow direction, a third drain space, having a shape in which a part of a perimeter thereof is defined by an edge of the second louver part and is open at upstream in the air of the first louver part when viewed in the direction perpendicular to the fin portion is provided between the second louver part and a downstream part of the fin portion that is located closest to and downstream of the second louver part in the air flow direction, and the third drain space has a larger area than the second drain space when viewed in the direction perpendicular to the fin portion.
**3**. The heat exchanger of claim 2, wherein a distance between the first louver part and the air upstream part of the fin portion located closest to and upstream of the first louver part in the air flow direction is longer than a distance between the louver parts that are adjacent, and a distance between the second louver part and the downstream part of the fin portion located closest to and downstream of the second louver part in the air flow direction is longer than the distance between the louver parts that are adjacent.
**4**. The heat exchanger of claim 2, wherein the area of the first drain space is larger than the area of the third drain space when viewed in the direction perpendicular to the fin portion.
**5**. The heat exchanger of claim 4, wherein the one or more heat transfer promoter groups include a first heat transfer promoter group and a second heat transfer promoter group located downstream of the first heat transfer promoter group in the air flow direction, and a sum of the areas of the first drain space, second drain space, and third drain space in the first heat transfer promoter group is greater than a sum of the areas of the first, second, and third drain spaces in the second heat transfer promoter group when viewed in the direction perpendicular to the fin portion.
**6**. The heat exchanger of claim 2, wherein between the air upstream part of the fin portion located closest to and upstream of the first louver part in the air flow direction and the first louver parts is provided a first sloping part sloping parallel to a sloping direction of the first heat transfer promoter and protruding from a flat surface of the fin, and between the downstream part of the fin portion located closest to and downstream of the second louver part in the air flow direction and the second louver part is provided a second sloping part sloping parallel to the sloping direction of the first heat transfer promoter and protruding to a flat surface of the fin.
**7**. The heat exchanger of claim 5, wherein a fourth drain space extending through the fin portion is

provided in a part of the fin portion that is located between the first heat transfer promoter group and the second heat transfer promoter group.

**8**. The heat exchanger of claim 7, wherein the fourth drain space has an opening area greater than the sum of the areas of the first drain space, second drain space, and third drain space in the first heat transfer promoter group when viewed in the direction perpendicular to the fin portion.

**9**. The heat exchanger of claim 7, wherein the fourth drain space comprises a plurality of openings arranged in the air flow direction.

**10**. The heat exchanger of claim 5, wherein the plurality of louver parts in the first heat transfer promoter group slope relative to the fin portion in a direction opposite to a direction in which the plurality of louver parts in the second heat transfer promoter group slope relative to the fin portion.

**11**. The heat exchanger of claim 2, wherein an inclination angle of the second louver part relative to the fin portion is larger than an inclination angle of the first louver part relative to the fin portion.

**12**. The heat exchanger of claim 1, wherein an edge of the fin portion or the louver part that defines the first drain space includes a curve, and the curve includes a top portion at a midpoint between the plurality of heat transfer tubes that are adjacent and protrudes in the air flow direction or a direction opposite to the air flow direction.

**13**. The heat exchanger of claim 1, wherein the corrugated fin includes a plurality of fin portions including the fin portion and a curved top portion located between the plurality of fin portions that are adjacent, and has an undulating shape as a whole such that the plurality of fin portions are arranged in a direction along axes of the plurality of heat transfer tubes.

**14**. An air-conditioning apparatus comprising: the heat exchanger of claim 1.