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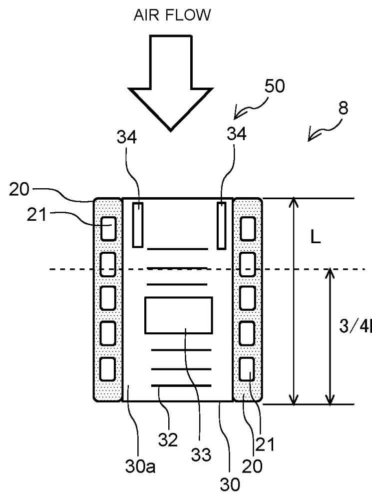
(54) HEAT EXCHANGER AND AIR CONDITIONER

(57) A heat exchanger includes a plurality of flat tubes in which refrigerant flows and a plurality of fins provided between the plurality of flat tubes and configured to transfer heat of refrigerant flowing in the plurality of flat tubes. An upstream end portion of each of the plurality of flat tubes in an air flow direction is located at the same position as an upstream end portion of each of the plurality of fins or protrudes farther than the upstream end portion of each of the plurality of fins, and an opening port is formed at the upstream end portion of each of the plurality of flat tubes or at the upstream end portion of each of the plurality of fins.

FIG. 3



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Description

Technical Field

[0001] The present disclosure relates to a heat exchanger including flat tubes and fins, and also relates to an air-conditioning apparatus.

Background Art

[0002] Some heat exchanger has been known that includes flat tubes and fins. Patent Literature 1 discloses a heat exchanger including a plurality of flat tubes, and corrugated fins provided with a plurality of louvers. In Patent Literature 1, the fins each protrude at its upstream end portion in the air flow direction as an extended portion farther than the upstream end portion of each of the flat tubes. In general, heating energy or cooling energy is transferred away from air having exchanged heat at the upstream portion of each of the fins by the amount of heat exchanged. This reduces the heat exchange amount at the downstream portion accordingly. In Patent Literature 1, the fins each protrude at its upstream end portion farther than the upstream end portion of each of the flat tubes, and a contact area between the fins and the flat tubes is thus small at the upstream portions. With this configuration, Patent Literature 1 is intended to decrease the heat exchange amount at the upstream portion to reduce a reduction in the heat exchange amount at the downstream portion to thereby maintain the balance of the heat exchange amount between the upstream portion and the downstream portion.

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Patent No. 5563162

Summary of Invention

Technical Problem

[0004] However, in the heat exchanger disclosed in Patent Literature 1, the fins each protrude at its upstream end portion farther than the upstream end portion of each of the flat tubes, and a strength of the fins is thus reduced.

[0005] The present disclosure has been achieved to solve the above problem, and it is an object of the present disclosure to provide a heat exchanger that ensures a sufficient strength of fins, while maintaining the balance of the heat exchange amount between the upstream portion and the downstream portion, and to also provide an air-conditioning apparatus.

Solution to Problem

[0006] A heat exchanger according to an embodiment of the present disclosure includes a plurality of flat tubes in which refrigerant flows and a plurality of fins provided between the plurality of flat tubes and configured to transfer heat of refrigerant flowing in the plurality of flat tubes. An upstream end portion of each of the plurality of flat tubes in an air flow direction is located at the same position as an upstream end portion of each of the plurality of fins or protrudes farther than the upstream end portion of each of the plurality of fins, and an opening port is formed at the upstream end portion of each of the plurality of flat tubes or at the upstream end portion of each of the plurality of fins. Advantageous Effects of Invention

[0007] According to an embodiment of the present disclosure, the upstream end portion of each of the flat tubes in the air flow direction is located at the same position as the upstream end portion of each of the fins or protrudes farther than the upstream end portion of each of the fins. This can ensure a sufficient strength of the fins. The opening port is formed at the upstream end portion of each of the flat tubes or at the upstream end portion of each of the fins. This helps maintain the balance of the heat exchange amount between the upstream portion and the downstream portion of each of the fins. That is, the heat exchanger according to an embodiment of the present disclosure can ensure a sufficient strength of the fins, while maintaining the balance of the heat exchange amount between the upstream portion and the downstream portion of each of the fins.

Brief Description of Drawings

[0008]

[Fig. 1] Fig. 1 is a circuit diagram illustrating an air-conditioning apparatus according to Embodiment 1.

[Fig. 2] Fig. 2 is a front view illustrating the heat exchanger according to Embodiment 1.

[Fig. 3] Fig. 3 is a cross-sectional view illustrating flat tubes and a fin according to Embodiment 1.

[Fig. 4] Fig. 4 is a cross-sectional view illustrating flat tubes and a fin according to Embodiment 2.

[Fig. 5] Fig. 5 is a cross-sectional view illustrating flat tubes and a fin according to Embodiment 3.

[Fig. 6] Fig. 6 is a cross-sectional view illustrating the flat tubes and the fin according to Embodiment 3.

[Fig. 7] Fig. 7 is a cross-sectional view illustrating flat tubes and a fin according to a modification of Embodiment 3.

[Fig. 8] Fig. 8 is a cross-sectional view illustrating flat tubes and fins according to Embodiment 4.

[Fig. 9] Fig. 9 is a front view illustrating a heat exchanger according to Embodiment 5.

[Fig. 10] Fig. 10 is a cross-sectional view illustrating flat tubes and a fin according to Embodiment 5.

[Fig. 11] Fig. 11 is a cross-sectional view illustrating flat tubes and a fin according to a modification of Embodiment 5.

[Fig. 12] Fig. 12 is a cross-sectional view illustrating flat tubes and a fin according to Embodiment 6.

Description of Embodiments

[0009] Embodiments of a heat exchanger and an air-conditioning apparatus of the present disclosure will be described hereinafter with reference to the drawings. Note that the present disclosure is not limited by the embodiments described below. In addition, the relationship of sizes of the components in the drawings described below including Fig. 1 may differ from that of actual ones. In the descriptions below, terms that represent directions are appropriately used for the sake of easily understanding the present disclosure. However, these terms are used merely for description purposes, and the present disclosure is not limited by these terms. Examples of the terms that represent directions include "upper," "lower," "right," "left," "front," and "rear." Note that in some of the drawings, cross-section hatching is partially omitted.

Embodiment 1

[0010] Fig. 1 is a circuit diagram illustrating an air-conditioning apparatus 1 according to Embodiment 1. As illustrated in Fig. 1, the air-conditioning apparatus 1 is a device that conditions air in a room space, and includes an outdoor unit 2 and an indoor unit 3 connected to the outdoor unit 2. The outdoor unit 2 is provided with a compressor 6, a flow switching device 7, a heat exchanger 8, an outdoor fan 9, and an expansion unit 10. The indoor unit 3 is provided with an indoor heat exchanger 11 and an indoor fan 12.

[0011] The compressor 6, the flow switching device 7, the heat exchanger 8, the expansion unit 10, and the indoor heat exchanger 11 are connected by a refrigerant pipe 5 to form a refrigerant circuit 4 in which refrigerant flows as working gas. The compressor 6 sucks refrigerant in a low-temperature and low-pressure state, compresses the sucked refrigerant into a high-temperature and high-pressure state, and discharges the compressed refrigerant. The flow switching device 7 changes the flow direction of refrigerant in the refrigerant circuit 4, and is, for example, a four-way valve. For example, the heat exchanger 8 exchanges heat between outside air and refrigerant. The heat exchanger 8 serves as a condenser during cooling operation, and serves as an evaporator during heating operation.

[0012] The outdoor fan 9 is a device to deliver outside air to the heat exchanger 8. The expansion unit 10 is a pressure reducing valve or an expansion valve to reduce the pressure of refrigerant and expand the refrigerant. The expansion unit 10 is, for example, an electronic expansion valve whose opening degree is adjusted. For example, the indoor heat exchanger 11 exchanges heat between room air and refrigerant. The indoor heat exchanger 11 serves as an evaporator during cooling operation, and serves as a condenser during heating operation. The indoor fan 12 is a device to deliver room air to the indoor heat exchanger 11.

(Operating mode, cooling operation)

[0013] Next, the operating modes of the air-conditioning apparatus 1 are described. First, cooling operation is described. During cooling operation, refrigerant sucked into the compressor 6 is compressed by the compressor 6 into a high-temperature and high-pressure gas state and then discharged. The refrigerant in high-temperature and high-pressure gas state discharged from the compressor 6 passes through the flow switching device 7, and flows into the heat exchanger 8, which serves as a condenser. In the heat exchanger 8, the refrigerant exchanges heat with outside air delivered by the outdoor fan 9, and condenses into liquid. The refrigerant having condensed into a liquid state flows into the expansion unit 10, and is expanded and reduced in pressure in the expansion unit 10, so that the refrigerant is brought into a low-temperature and low-pressure two-phase gas-liquid state. The refrigerant in the two-phase gas-liquid state flows into the indoor heat exchanger 11, which serves as an evaporator. In the indoor heat exchanger 11, the refrigerant exchanges heat with room air delivered by the indoor fan 12, and evaporates into gas. At this time, the room air is cooled and thus cooling is performed in the room. The refrigerant having evaporated into a low-temperature and low-pressure gas state passes through the flow switching device 7 and is sucked into the compressor 6.

(Operating mode, heating operation)

[0014] Next, heating operation is described. During heating operation, refrigerant sucked into the compressor 6 is compressed by the compressor 6 into a high-temperature and high-pressure gas state and then discharged. The refrigerant in a high-temperature and high-pressure gas state discharged from the compressor 6 passes through the flow switching device 7 and flows into the indoor heat exchanger 11, which serves as a condenser. In the indoor heat exchanger 11, the refrigerant exchanges heat with room air delivered by the indoor fan 12, and condenses into liquid. At this time, the room air is heated and thus heating is performed in the room. The refrigerant having condensed into a liquid state flows into the expansion unit 10, and is expanded and reduced in pressure in the expansion unit 10, so that the refrigerant is brought into a low-temperature and low-pressure two-phase gas-liquid state. The refrigerant in the two-phase gas-liquid state flows into the heat exchanger 8, which serves as an evaporator. In the heat exchanger 8, the refrigerant exchanges heat with outside air delivered by the outdoor fan 9, and evaporates into gas. The refrigerant having evaporated into a low-temperature and low-pressure gas state passes through the flow switching device 7 and is sucked into the compressor 6.

[0015] Fig. 2 is a front view illustrating the heat exchanger 8 according to Embodiment 1. Next, the heat exchanger 8 is described in detail. As illustrated in Fig. 2, the heat exchanger 8 is, for example, a parallel-flow heat exchanger 8. Note that the heat exchanger 8 may be a fin-and-tube heat exchanger. The heat exchanger 8 includes flat tubes 20, fins 30, and headers 40. A plurality of the flat tubes 20 are arranged side by side, in each of which refrigerant flows. The flat tubes 20 are made of aluminum or aluminum alloy. The flat tubes 20 may also be formed by using an aluminum core cladding material. In each of the flat tubes 20, for example, a plurality of flow passages 21 (see Fig. 3) are formed in line, through which refrigerant flows.

[0016] Each of the fins 30 is a heat transferring part to transfer heat of the refrigerant flowing in the flat tubes 20. For example, the fin 30 is a corrugated fin having regular folds and located between the flat tubes 20. The fin 30 includes an inclined face 30a that is inclined from the horizontal direction (see Fig. 3). The fin 30 is folded into alternating ridges and grooves. A space defined by the fin 30 and the corresponding flat tubes 20 serves as an airflow passage 31 through which air flows. The fin 30 is made of, for example, aluminum. Note that the fin 30 may be a plate fin. In the headers 40, refrigerant flows. The headers 40 distribute the refrigerant to a plurality of the flat tubes 20 connected to the headers 40. The headers 40 are made of, for example, aluminum. The fins 30 may be formed by using the same materials as the flat tubes 20 as described above, or using different materials from materials of the flat tubes 20.

[0017] The headers 40 include a header 40 connected to one end portion of each of the plurality of flat tubes 20, and another header 40 connected to the other end portion of each of the plurality of flat tubes 20. Note that in the header 40, the flow passages 21 through which refrigerant flows may be partitioned by one partition or a plurality of partitions. One of the headers 40, to which the refrigerant pipe 5 is connected, is connected to the flow switching device 7 by the refrigerant pipe 5. The other header 40, to which the refrigerant pipe 5 is connected, is connected to the expansion unit 10 by the refrigerant pipe 5. The headers 40 may be formed by using the same materials as the flat tubes 20.

[0018] Fig. 3 is a cross-sectional view illustrating the flat tubes 20 and the fin 30 according to Embodiment 1. Fig. 3 illustrates a portion of the cross-section taken along the A-A line in Fig. 2. In Fig. 3, air flows downward from the top. As illustrated in Fig. 3, the fin 30 is provided between the flat tubes 20, and has a plurality of louvers 32 provided in the inclined face 30a. The upstream portion of the fin 30 does not have the louvers 32 and has a larger flat portion than a flat portion of the downstream portion. A rectangular slit 33 is formed in between ones of the plurality of louvers 32.

[0019] On the upstream end portion of the fin 30, two holes 34 are provided as an opening port 50. The holes 34 each have a rectangular shape extending in the longitudinal direction of the fin 30. Specifically, the holes 34 are provided in the upstream portion located within one-fourth of the entire length L of the fin 30 in the longitudinal direction from the upstream end. With this configuration, the upstream end portion of the fin 30 in the air flow direction has a smaller heat-transfer area than does the downstream end portion of the fin 30. The downstream end portion of the fin 30 is located on the same plane as the downstream end portion of each of the flat tubes 20. Note that the downstream end portion of the fin 30 may be located upstream of the downstream end portion of each of the flat tubes 20. The upstream end portion of each of the flat tubes 20 is located at the same position as the upstream end portion of the fin 30.

[0020] In the present Embodiment 1, the upstream end portion of each of the flat tubes 20 in the air flow direction is located at the same position as the upstream end portion of the fin 30. The fin 30 does not protrude farther than the flat tubes 20, and the fin 30 is thus prevented from being bent during production or transport. This can ensure a sufficient strength of the fin 30. The opening port 50 is formed at the upstream end portion of the fin 30. This helps maintain the balance of the heat exchange amount between the upstream portion and the downstream portion of the fin 30. That is, the present Embodiment 1 can ensure a sufficient strength of the fin 30, while maintaining the balance of the heat exchange amount between the upstream portion and the downstream portion of the fin 30.

[0021] The holes 34 serving as the opening port 50 are provided at the upstream end portion of the fin 30. In general, heating energy or cooling energy is transferred away from air having exchanged heat at the upstream portion of the fin 30 by the amount of heat exchanged. This reduces the heat exchange amount at the downstream portion accordingly. In the present Embodiment 1, the holes 34 serving as the opening port 50 are provided at the upstream end portion of the fin 30, and the fin 30 thus has a smaller heat-transfer area at its upstream end portion in the air flow direction than at its downstream end portion. Therefore, the balance of the heat exchange amount between the upstream portion and the downstream portion of the fin 30 can be maintained. As described above, the present Embodiment 1 can ensure a sufficient strength of the fin 30, while maintaining the balance of the heat exchange amount between the upstream portion and the downstream portion of the fin 30.

[0022] A technique for some heat exchanger has been known, in which the fins each protrude at its upstream end portion in the air flow direction as an extended portion farther than the upstream end portion of each of the flat tubes. In this case, there is a possibility that the protruding portion of each of the fins may be bent during production or transport, and thus heat-transfer performance may be degraded. In a case where a drainage slit is formed in the fin, the strength of the fin is thus further reduced, and the fin has an increased probability of being bent. If the extended portion of the fin is eliminated, the heat transfer area at the upstream portion of the fin will be increased, and accordingly frost is more likely to be formed at the upstream portion of the fin. This results in a reduction in resistance to frost formation.

[0023] In contrast to this, in the present Embodiment 1, the upstream end portion of each of the flat tubes 20 is located at the same position as the upstream end portion of the fin 30, and in addition, the holes 34 serving as the opening port 50 are provided at the upstream end portion of the fin 30. This can ensure a sufficient strength of the fin 30, while maintaining the balance of the heat exchange amount between the upstream portion and the downstream portion of the fin 30.

[0024] The holes 34 serving as the opening port 50 are provided at the upstream end portion of each of the fins 30, and heat transfer at the upstream portion of each of the fins 30 is thus reduced to reduce uneven frost formation. With this configuration, the airflow passage 31 through which air flows can be prevented from being clogged with frost. Condensed water adhering to the fin 30 passes through the holes 34, and water drainage performance thus can be improved.

Embodiment 2

[0025] Fig. 4 is a cross-sectional view illustrating the flat tubes 20 and a fin 130 according to Embodiment 2. A heat exchanger 108 in the present Embodiment 2 is different from the heat exchanger 8 in Embodiment 1 in that the opening port 50 is made up of gaps 134 defined between the upstream end portion of the fin 130 and the flat tubes 20. In the present Embodiment 2, the components in common with those in Embodiment 1 are denoted by the same reference signs, and thus descriptions of the components are omitted. The differences from Embodiment 1 are mainly described below.

[0026] As illustrated in Fig. 4, the fin 130 has a smaller width at its upstream end portion than the width at its downstream end portion. With this configuration, the gaps 134 are defined between the upstream end portion of the fin 130 and the flat tubes 20. The upstream end portion of each of the flat tubes 20 is located at the same position as the upstream end portion of the fin 130 similarly to Embodiment 1.

[0027] In the present Embodiment 2, the upstream end portion of each of the flat tubes 20 is located at the same position as the upstream end portion of the fin 130. The fin 130 does not protrude farther than the flat tubes 20, and the fin 130 is thus prevented from being bent during production or transport. That is, a sufficient strength of the fin 130 can be ensured. The gaps 134 are defined between the upstream end portion of the fin 130 and the flat tubes 20, and the fin 130 thus has a smaller heat-transfer area at its upstream end portion in the air flow direction than at its downstream end portion. Therefore, the balance of the heat exchange amount between the upstream portion and the downstream portion of the fin 130 can be maintained. As described above, the present Embodiment 2 can ensure a sufficient strength of the fin 130, while maintaining the balance of the heat exchange amount between the upstream portion and the downstream portion of the fin 130.

[0028] The gaps 134 are defined between the upstream end portion of the fin 130 and the flat tubes 20, and heat transfer at the upstream portion of the fin 130 is thus reduced to reduce uneven frost formation. With this configuration, the airflow passage 31 through which air flows can be prevented from being clogged with frost. Condensed water adhering to the fin 130 passes through the gaps 134, and water drainage performance thus can be improved.

Embodiment 3

[0029] Fig. 5 is a cross-sectional view illustrating flat tubes 220 and a fin 230 according to Embodiment 3. A heat exchanger 208 in the present Embodiment 3 is different from the heat exchanger 8 in Embodiment 1 in that the opening port 50 is made up of gaps 234 defined between the upstream end portion of the fin 230 and the flat tubes 220. In the present Embodiment 3, the components in common with those in Embodiments 1 and 2 are denoted by the same reference signs, and thus descriptions of the components are omitted. The differences from Embodiments 1 and 2 are mainly described below.

[0030] As illustrated in Fig. 5, the flat tubes 220 each have a smaller width at its upstream end portion than the width at its downstream end portion. Each of the flat tubes 220 has a tapered tip end shaped into a curve at the upstream portion. With this configuration, the gaps 234 are defined between the upstream end portion of the fin 230 and the flat tubes 220. The flat tubes 220 each protrude at its upstream end portion farther than the upstream end portion of the fin 230.

[0031] In the present Embodiment 3, the flat tubes 220 each protrude at its upstream end portion farther than the upstream end portion of the fin 230. The fin 230 does not protrude farther than the flat tubes 220, and the fin 230 is thus prevented from being bent during production or transport. That is, a sufficient strength of the fin 230 can be ensured. The gaps 234 are defined between the upstream end portion of the fin 230 and the flat tubes

220, and the fin 230 thus has a smaller heat-transfer area at its upstream end portion in the air flow direction than at its downstream end portion. Therefore, the balance of the heat exchange amount between the upstream portion and the downstream portion of the fin 230 can be maintained. As described above, the present Embodiment 3 can ensure a sufficient strength of the fin 230, while maintaining the balance of the heat exchange amount between the upstream portion and the downstream portion of the fin 230.

[0032] The gaps 234 are defined between the upstream end portion of the fin 230 and the flat tubes 220, and heat transfer at the upstream portion of the fin 230 is thus reduced to reduce uneven frost formation. With this configuration, the airflow passage 31 through which air flows can be prevented from being clogged with frost. Condensed water adhering to the fin 230 passes through the gaps 234, and water drainage performance thus can be improved. Furthermore, each of the flat tubes 220 has a tip end shaped into a curve, and an airflow resistance is thus reduced.

[0033] Fig. 6 is a cross-sectional view illustrating the flat tubes 220 and the fin 230 according to Embodiment 3. In Embodiment 3, an example case is illustrated in which the flat tubes 220 are aligned in two rows in a direction parallel to the air flowing direction. In this case, as illustrated in Fig. 6, the flat tubes 220 located upstream each have a tapered tip end, while the flat tubes 220 located downstream do not each have a tapered tip end. The reason for this is that a sufficient amount of heat is transferred to the fin 230 at the downstream end portion of each of the flat tubes 220 located upstream, and it is thus unnecessary for the flat tubes 220 located downstream to each have a tapered tip end.

(Modification)

[0034] Fig. 7 is a cross-sectional view illustrating flat tubes 220a and a fin 230a according to a modification of Embodiment 3. As illustrated in Fig. 7, in a heat exchanger 208a in the modification, each of the flat tubes 220a is provided with a gap 234a defined by notching one corner of the upstream end portion of the flat tube 220a that is adjacent to the corresponding one of fins 230a. Also in the modification, the gap 234a is defined between the upstream end portion of the fin 230a and the flat tube 220a, and the fin 230a thus has a smaller heat-transfer area at its upstream end portion in the air flow direction than at its downstream end portion. Therefore, the modification can maintain the balance of the heat exchange amount between the upstream portion and the downstream portion of the fin 230a.

Embodiment 4

[0035] Fig. 8 is a cross-sectional view illustrating the flat tubes 20 and fins 330 according to Embodiment 4. A heat exchanger 308 in the present Embodiment 4 is different from the heat exchangers in Embodiments 1 to 3 in that the heat exchanger 308 includes reinforcement portions 360 to reinforce the fins 330. In the present Embodiment 4, the components in common with those in Embodiments 1 to 3 are denoted by the same reference signs, and thus descriptions of the components are omitted. The differences from Embodiments 1 to 3 are mainly described below.

[0036] As illustrated in Fig. 8, the fins 330 each protrude at its upstream end portion farther than the upstream end portion of each of the flat tubes 20. The reinforcement portions 360 are provided between the portions of the fins 330 protruding farther than the flat tubes 20. The reinforcement portions 360 are made of, for example, resin with a relatively high thermal resistance.

[0037] In the present Embodiment 4, although the fins 330 protrude farther than the flat tubes 20, the reinforcement portions 360 are provided between the portions of the fins 330 protruding farther than the flat tubes 20, and the fins 330 are thus prevented from being bent during production or transport. That is, a sufficient strength of the fins 330 can be ensured. The upstream end portion of each of the fins 330 is not in contact with the flat tubes 20, and the fins 330 thus each have a smaller heat-transfer area at its upstream end portion in the air flow direction than at its downstream end portion. Therefore, the balance of the heat exchange amount between the upstream portion and the downstream portion of each of the fins 330 can be maintained. As described above, the present Embodiment 4 can ensure a sufficient strength of the fins 330, while maintaining the balance of the heat exchange amount between the upstream portion and the downstream portion of each of the fins 330.

[0038] The upstream end portion of each of the fins 330 is not in contact with the flat tubes 20, and heat transfer at the upstream portion of each of the fins 330 is thus reduced to reduce uneven frost formation. With this configuration, the airflow passage 31 through which air flows can be prevented from being clogged with frost. Condensed water adhering to the fins 330 flows on the reinforcement portions 360, which is resin, and water drainage performance thus can be improved.

Embodiment 5

[0039] Fig. 9 is a front view illustrating a heat exchanger 408 according to Embodiment 5. Fig. 10 is a cross-sectional view illustrating the flat tubes 20 and a fin 430 according to Embodiment 5. The present Embodiment 5 is different from Embodiments 1 to 4 in that reinforcement portions 434 are formed in the fin 430. In the present Embodiment 5, the components in common with those in Embodiments 1 to 4 are denoted by the same reference signs, and thus descriptions of the components are omitted. The differences from Embodiments 1 to 4 are mainly described below.

[0040] As illustrated in Figs. 9 and 10, the plurality of reinforcement portions 434 are formed in the inclined face 30a of the fin 430 at its upstream end portion. The reinforcement portions 434 reinforce the fin 430. The reinforcement portions 434 are formed by bending the fin 430 into a shape with a series of rectangular projections and recesses. The fin 430 protrudes at its upstream end portion farther than the upstream end portion of each of the flat tubes 20.

[0041] In the present Embodiment 5, although the fin 430 protrudes farther than the flat tubes 20, the reinforcement portions 434 are formed at the upstream end portion of the fin 430, and the fin 430 is thus prevented from being bent during production or transport. That is, a sufficient strength of the fin 430 can be ensured. The upstream end portion of the fin 430 is not in contact with the flat tubes 20, and the fin 430 thus has a smaller heat-transfer area at its upstream end portion in the air flow direction than at its downstream end portion. Therefore, the balance of the heat exchange amount between the upstream portion and the downstream portion of the fin 430 can be maintained. As described above, the present Embodiment 5 can ensure a sufficient strength of the fin 430, while maintaining the balance of the heat exchange amount between the upstream portion and the downstream portion of the fin 430.

[0042] The upstream end portion of the fin 430 is not in contact with the flat tubes 20, and heat transfer at the upstream portion of the fin 430 is thus reduced to reduce uneven frost formation. With this configuration, the airflow passage 31 through which air flows can be prevented from being clogged with frost. Condensed water adhering to the fin 430 flows on the reinforcement portions 434, which is resin, and water drainage performance thus can be improved.

(Modification)

[0043] Fig. 11 is a cross-sectional view illustrating the flat tubes 20 and a fin 430a according to a modification of Embodiment 5. As illustrated in Fig. 11, in a heat exchanger 408a in the modification, the fin 430a protrudes farther than the flat tubes 20 by a greater amount compared with the fin 430 in Embodiment 5. Reinforcement portions 434a are larger in size than the reinforcement portions 434 in Embodiment 5. With this configuration, although the fin 430a protrudes farther than the flat tubes 20 by a greater amount, the reinforcement portions 434a are formed larger in size at the upstream end portion of the fin 430a, and the fin 430a is thus prevented from being bent during production or transport. A relatively large area of the upstream end portion of the fin 430a is not in contact with the flat tubes 20, and the fin 430a thus has a smaller heat-transfer area at its upstream end portion in the air flow direction than at its downstream end portion. Therefore, the balance of the heat exchange amount between the upstream portion and the downstream portion of the fin 430a can be maintained. As described above, the modification can ensure a sufficient strength of the fin 430a, while maintaining the balance of the heat exchange amount between the upstream portion and the downstream portion of the fin 430a.

Embodiment 6

[0044] Fig. 12 is a cross-sectional view illustrating the flat tubes 20 and a fin 530 according to Embodiment 6. A heat exchanger 508 in the present Embodiment 6 is different from the heat exchangers in Embodiments 1 to 5 in that the opening port 50 is provided with an opening-closing louver 535. In the present Embodiment 6, the components in common with those in Embodiments 1 to 5 are denoted by the same reference signs, and thus descriptions of the components are omitted. The differences from Embodiments 1 to 5 are mainly described below.

[0045] As illustrated in Fig. 12, the fin 530 has the opening-closing louver 535 provided at the opening port 50 to open and close the opening port 50. The upstream end portion of each of the flat tubes 20 is located at the same position as the upstream end portion of the fin 530 similarly to Embodiment 1.

[0046] In the present Embodiment 6, the upstream end portion of each of the flat tubes 20 is located at the same position as the upstream end portion of the fin 530. The fin 530 does not protrude farther than the flat tubes 20, and the fin 530 is thus prevented from being bent during production or transport. That is, a sufficient strength of the fin 530 can be ensured. The opening port 50 that is opened and closed by the opening-closing louver 535 is formed at the upstream end portion of the fin 530, and the fin 530 thus has a smaller heat-transfer area at its upstream end portion in the air flow direction than at its downstream end portion. Therefore, the balance of the heat exchange amount between the upstream portion and the downstream portion of the fin 530 can be maintained. As described above, the present Embodiment 6 can ensure a sufficient strength of the fin 530, while maintaining the balance of the heat exchange amount between the upstream portion and the downstream portion of the fin 530.

[0047] The opening port 50 that is opened and closed by the opening-closing louver 535 is formed at the upstream end portion of the fin 530, and heat transfer at the upstream portion of the fin 530 is thus reduced to reduce uneven frost formation. With this configuration, the airflow passage 31 through which air flows can be prevented from being clogged with frost. Condensed water adhering to the fin 530 passes through the opening port 50, and water drainage performance thus can be improved.

Reference Signs List

[0048] 1: air-conditioning apparatus, 2: outdoor unit, 3: indoor unit, 4: refrigerant circuit, 5: refrigerant pipe, 6: compressor, 7: flow switching device, 8: heat exchanger, 9: outdoor fan, 10: expansion unit, 11: indoor heat exchanger, 12: indoor fan, 20: flat tube, 21: flow passage, 30: fin, 30a: inclined face, 31: airflow passage, 32: louver, 33: slit, 34: hole, 40: header, 50: opening port, 108: heat exchanger, 130: fin, 134: gap, 208, 208a: heat exchanger, 220, 220a: flat tube, 230: fin, 234, 234a: gap, 308: heat exchanger, 330: fin, 360: reinforcement portion, 408, 408a: heat exchanger, 430, 430a: fin, 434, 434a: reinforcement portion, 508: heat exchanger, 530: fin, 535: opening-closing louver

Claims

1. A heat exchanger comprising:

a plurality of flat tubes in which refrigerant flows; and
a plurality of fins provided between the plurality of flat tubes and configured to transfer heat of refrigerant flowing in the plurality of flat tubes,
an upstream end portion of each of the plurality of flat tubes in an air flow direction being located at the same position as an upstream end portion of each of the plurality of fins or protruding farther than the upstream end portion of each of the plurality of fins,
an opening port being formed at the upstream end portion of each of the plurality of flat tubes or at the upstream end portion of each of the plurality of fins.

2. The heat exchanger of claim 1, wherein the opening port is a hole provided in the upstream end portion of each of the plurality of fins.

3. The heat exchanger of claim 1 or 2, wherein the opening port is a gap defined between the upstream end portion of each of the plurality of fins and a corresponding one of the plurality of flat tubes.

4. The heat exchanger of claim 3, wherein the plurality of fins each have a smaller width at the upstream end portion than a width at a downstream end portion of the fin.

5. The heat exchanger of claim 3 or 4, wherein the plurality of flat tubes each have a smaller width at the upstream end portion than a width at a downstream end portion of the flat tube.

6. The heat exchanger of any one of claims 1 to 5, wherein each of the plurality of fins has an opening-closing louver provided at the opening port and configured to open and close the opening port.

7. A heat exchanger comprising:

a plurality of flat tubes in which refrigerant flows;
a plurality of fins provided between the plurality of flat tubes and configured to transfer heat of refrigerant flowing in the plurality of flat tubes, the plurality of fins each protruding at an upstream end portion in an air flow direction farther than an upstream end portion of each of the plurality of flat tubes; and
a reinforcement portion provided between portions of the plurality of fins each protruding farther than the plurality of flat tubes and configured to reinforce the plurality of fins.

8. A heat exchanger comprising:

a plurality of flat tubes in which refrigerant flows; and
a plurality of fins provided between the plurality of flat tubes and configured to transfer heat of refrigerant flowing in the plurality of flat tubes, the plurality of fins each protruding at an upstream end portion in an air flow direction farther than an upstream end portion of each of the plurality of flat tubes,
a reinforcement portion being formed at the upstream end portion of each of the plurality of fins, the reinforcement portion being shaped into a projection and a recess and configured to reinforce the plurality of fins.

9. An air-conditioning apparatus comprising the heat exchanger of any one of claims 1 to 8.

FIG. 1

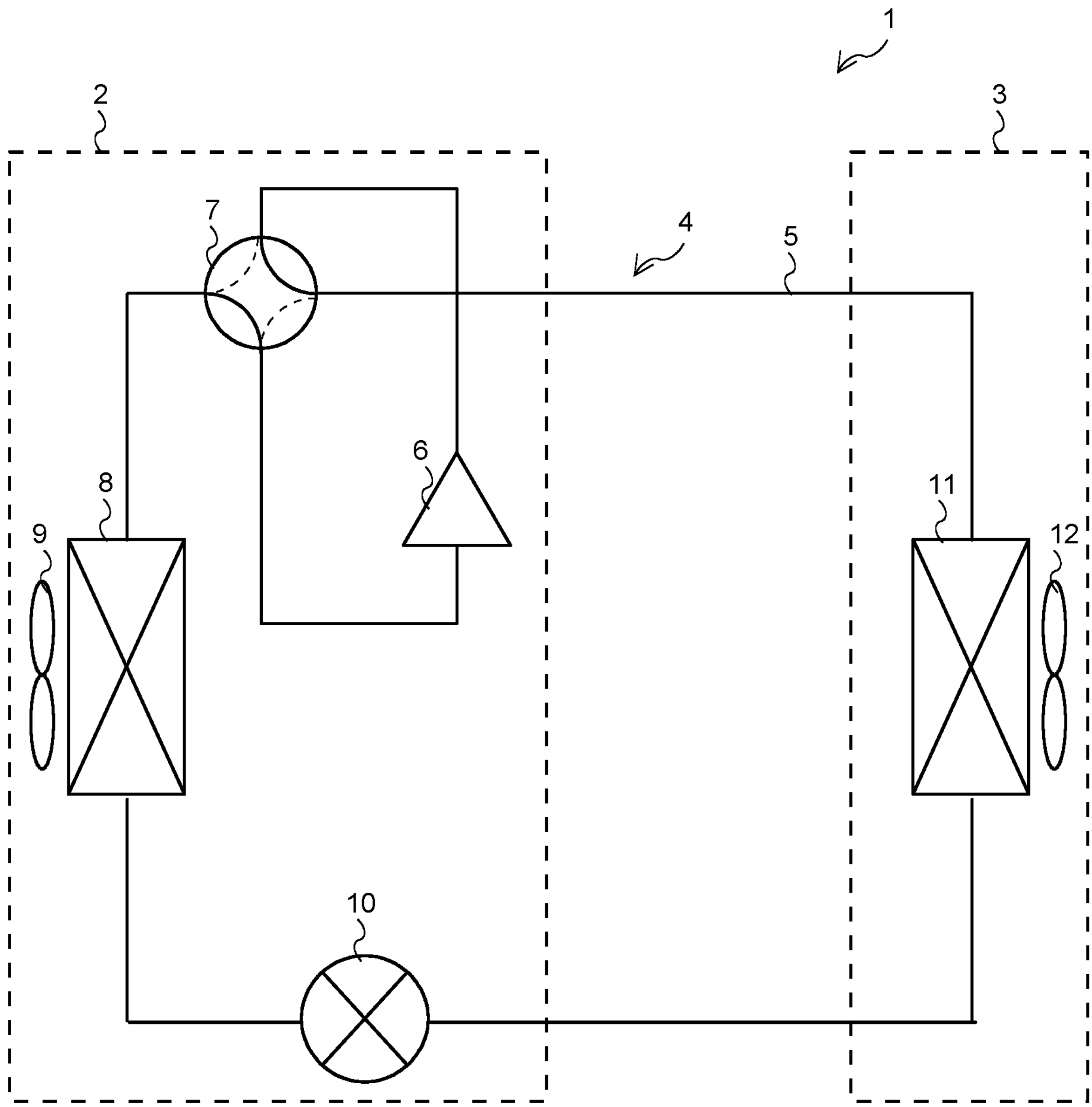


FIG. 2

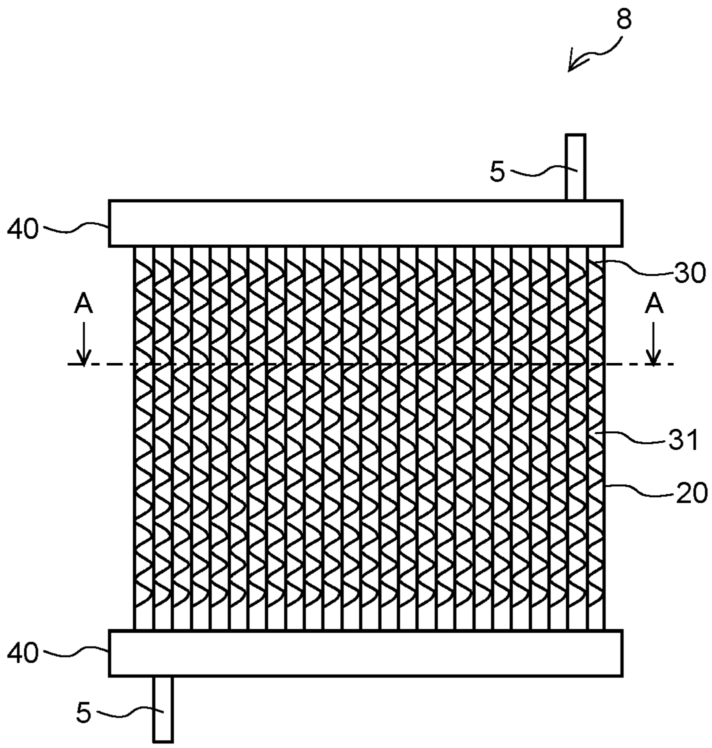


FIG. 3

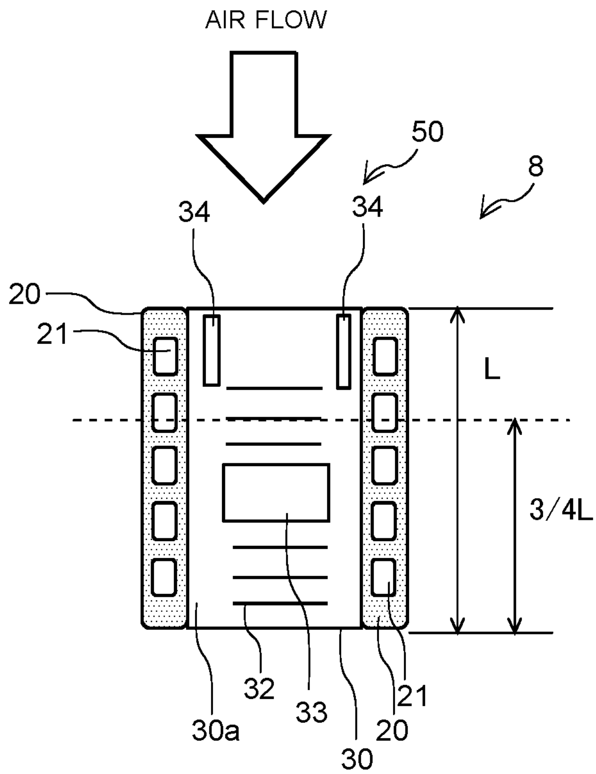


FIG. 4

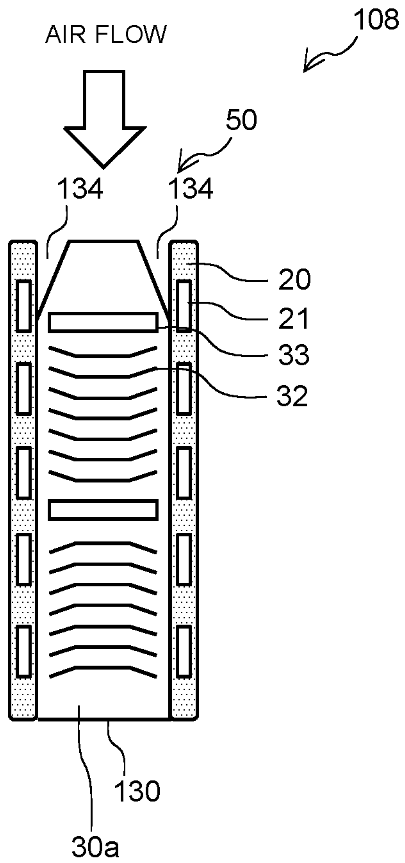


FIG. 5

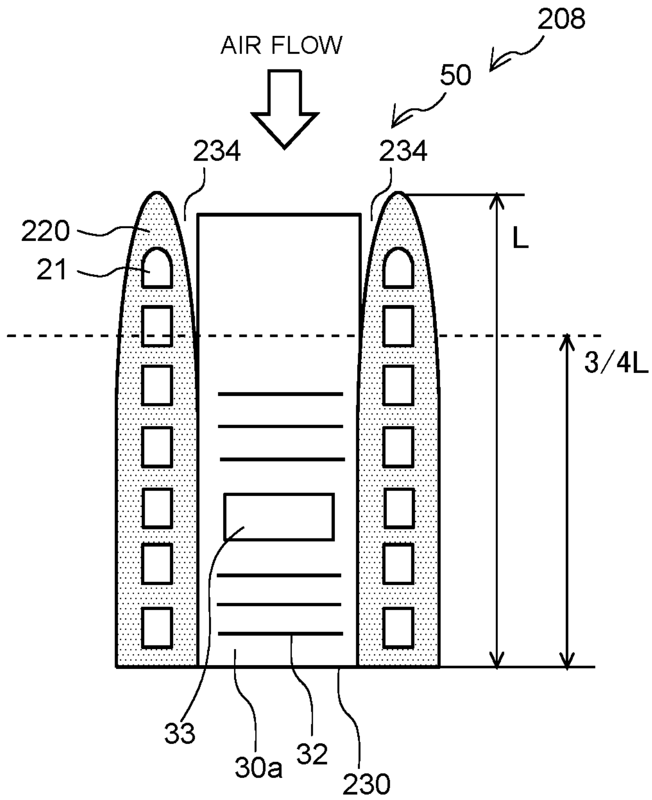


FIG. 6

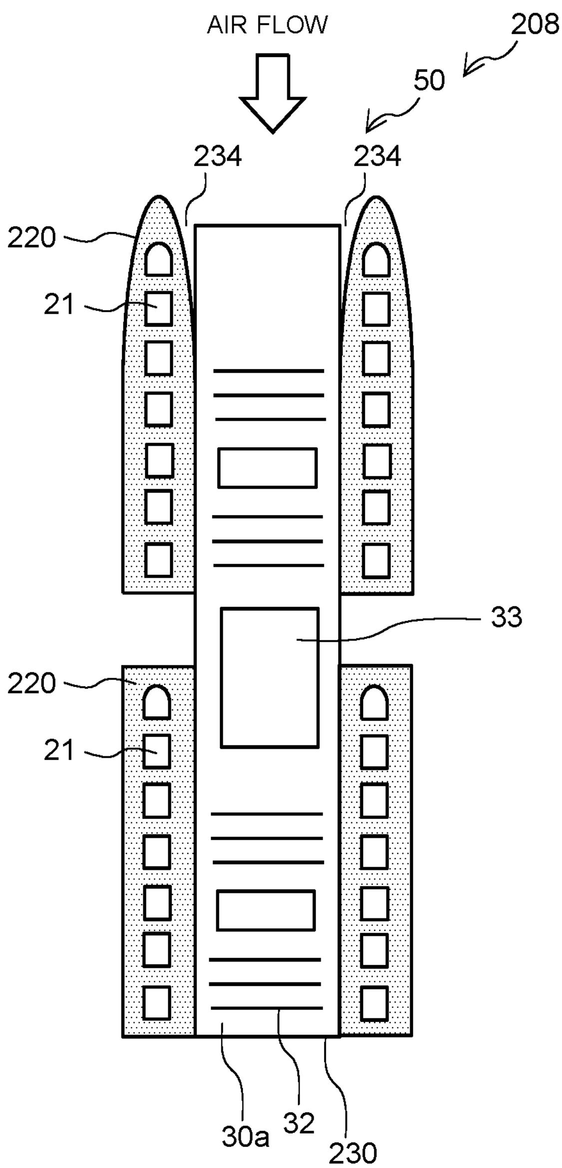


FIG. 7

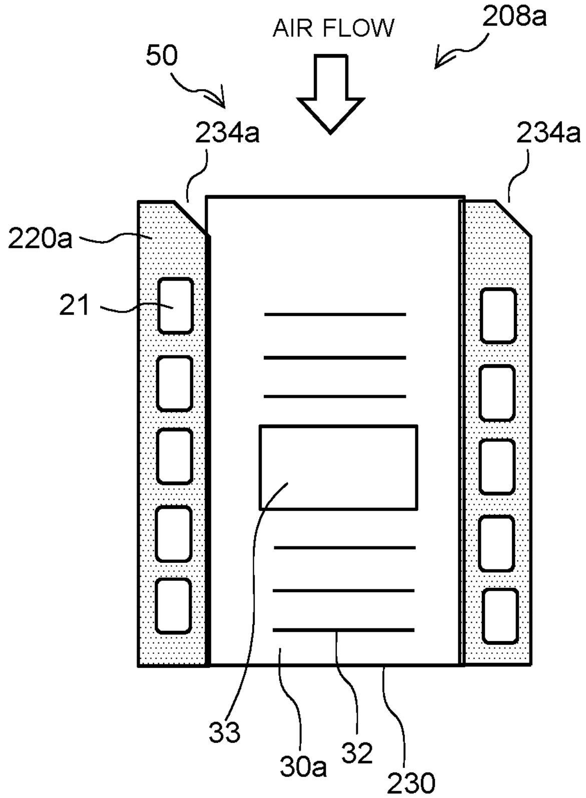
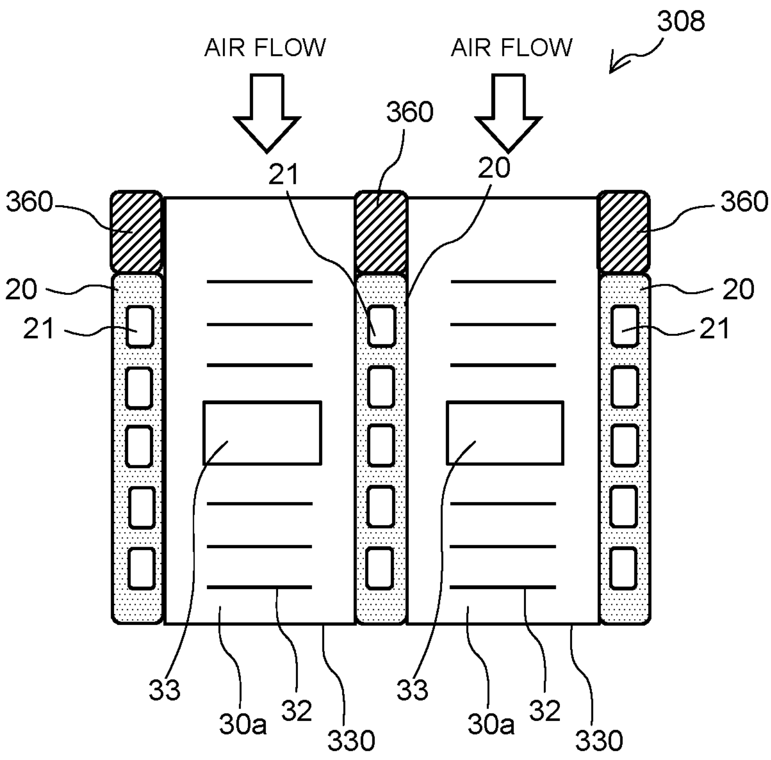


FIG. 8


AIR FLOW
AIR FLOW
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360
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20
21
21
33
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32
330
33
30a
32
330

FIG. 9

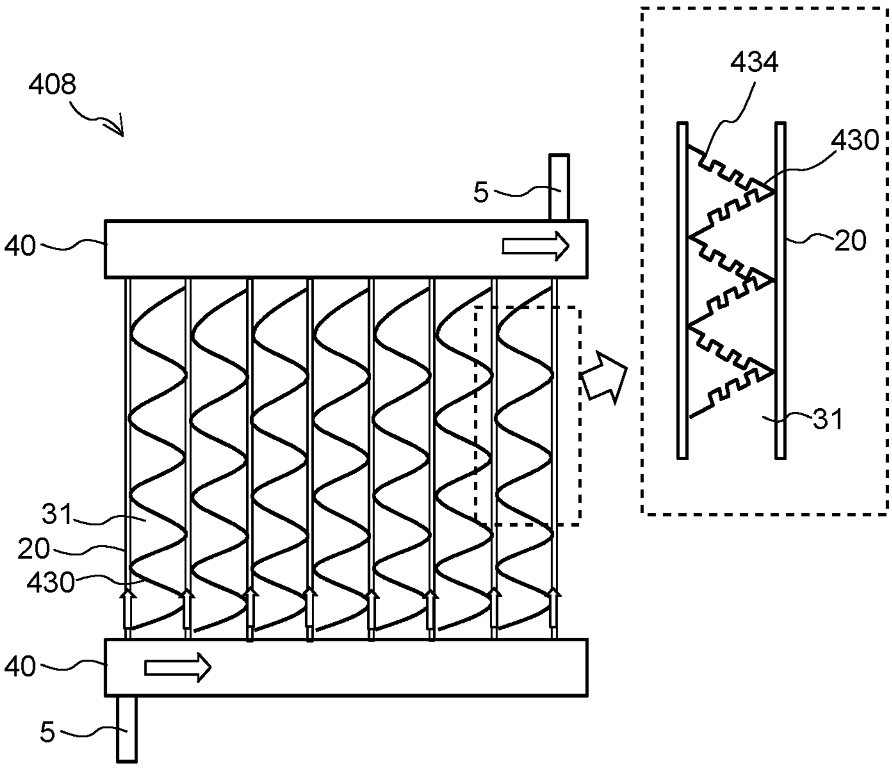


FIG. 10

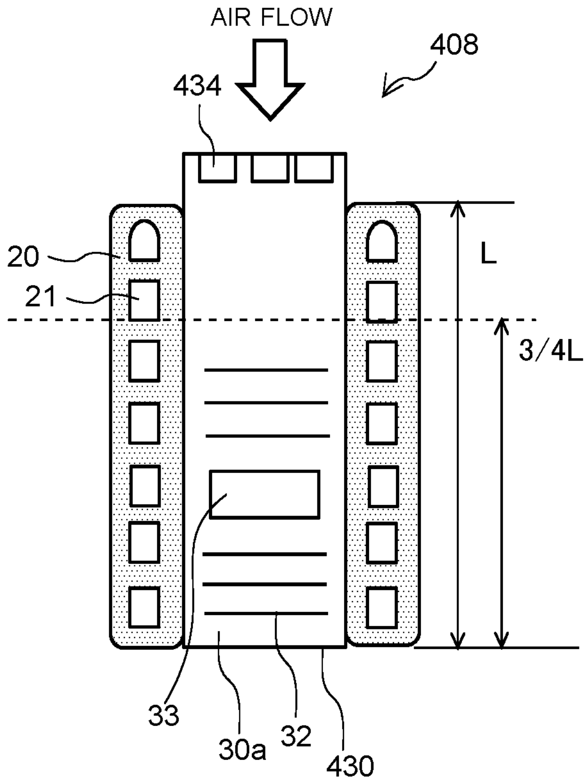


FIG. 11

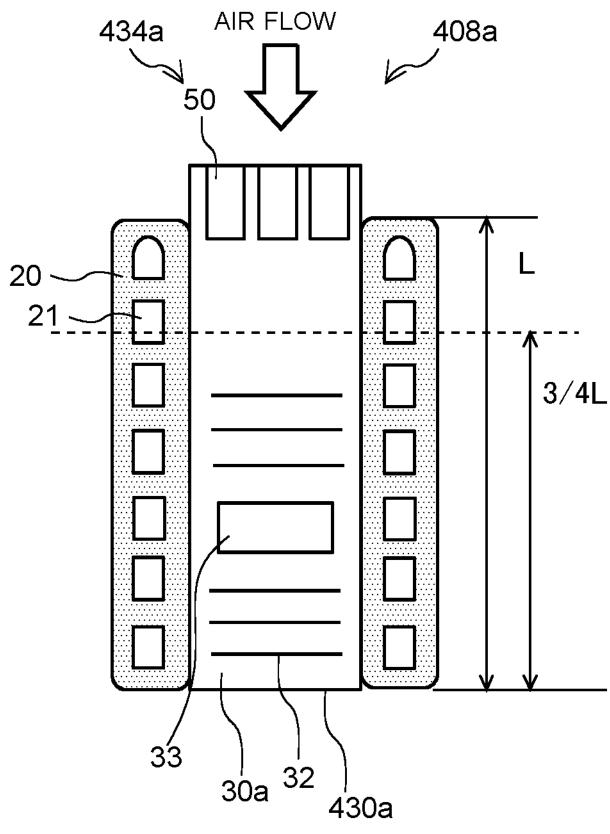
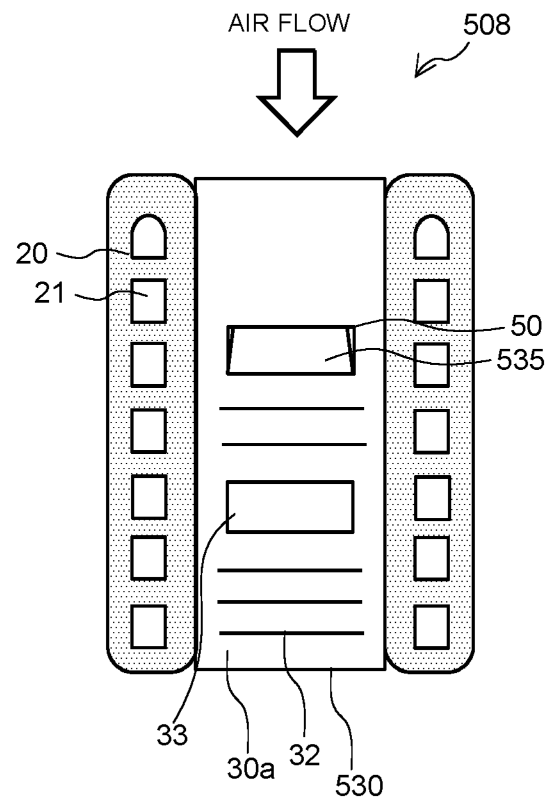


FIG. 12



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/020357

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. F28F1/32(2006.01)i, F28F1/02(2006.01)i, F28D1/053(2006.01)i
FI: F28F1/32 N, F28F1/32 R, F28F1/02 A, F28D1/053 A

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int. Cl. F28F1/32, F28F1/02, F28D1/053

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

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2020
Registered utility model specifications of Japan	1996-2020
Published registered utility model applications of Japan	1994-2020

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2018/235215 A1 (MITSUBISHI ELECTRIC CORP.) 27 December 2018, paragraphs [0039]-[0041], [0063], fig. 10	1-2, 6, 9
X	JP 2018-9743 A (HITACHI JOHNSON CONTROLS AIR CONDITIONING INC.) 18 January 2018, paragraphs [0016], [0051]-[0055], fig. 8	1, 3-4, 9
X	WO 2018/100738 A1 (MITSUBISHI ELECTRIC CORP.) 07 June 2018, paragraphs [0037]-[0046], fig. 5, 8	7, 9
X	JP 2012-67971 A (MITSUBISHI ELECTRIC CORP.) 05 April 2012, paragraphs [0009]-[0012], [0018], fig. 3	7, 9

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

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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

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

Date of the actual completion of the international search	Date of mailing of the international search report
14.07.2020	21.07.2020

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/020357

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2013/160950 A1 (MITSUBISHI ELECTRIC CORP.) 31 October 2013, paragraphs [0017], [0025]-[0028], fig. 7	8-9
Y	JP 2012-2402 A (MITSUBISHI ELECTRIC CORP.) 05 January 2012, paragraphs [0001], [0015]-[0024], fig. 4	1, 5, 9
Y	WO 2017/221303 A1 (MITSUBISHI ELECTRIC CORP.) 28 December 2017, paragraph [0082], fig. 12	1, 5, 9

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2020/020357

Patent Documents referred to in the Report	Publication Date	Patent Family	Publication Date
WO 2018/235215 A1	27.12.2018	CN 110741216 A	
JP 2018-9743 A	18.01.2018	(Family: none)	
WO 2018/100738 A1	07.06.2018	EP 3550247 A1 paragraphs [0037]-[0046], fig. 5, 8	
JP 2012-67971 A	05.04.2012	(Family: none)	
WO 2013/160950 A1	31.10.2013	US 2015/0068244 A1 paragraphs [0037]-[0044], [0064]-[0077], fig. 7 EP 2857785 A1 CN 104285119 A	
JP 2012-2402 A	05.01.2012	(Family: none)	
WO 2017/221303 A1	28.12.2017	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

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Patent documents cited in the description

- JP 5563162 B **[0003]**