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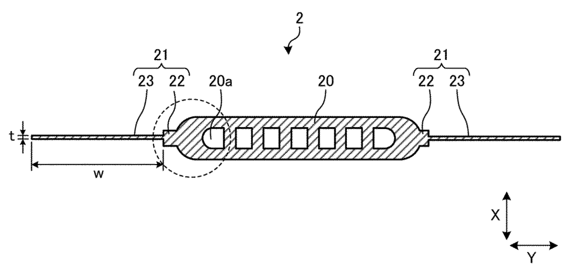
(54) HEAT EXCHANGER, REFRIGERATION CYCLE DEVICE, AND METHOD FOR MANUFACTURING HEAT EXCHANGER

(57) A heat exchanger includes a heat transfer part that has a heat transfer tube that has a refrigerant flow passage inside the heat transfer tube, and a fin that has a plate shape that extends along a direction of a tube axis of the heat transfer tube and that is integrated with the heat transfer tube. The fin has an integrated portion and a fin portion, the integrated portion being a portion at which the fin is integrated with the heat transfer tube, the fin portion being a portion of the fin that is other than the integrated portion. The fin portion has a plate thickness that is smaller than a plate thickness of the integrated portion.

FIG. 3



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Description

Technical Field

[0001] The present disclosure relates to a heat exchanger including a heat transfer part that has a heat transfer tube and a fin that extends along a direction of the tube axis of the heat transfer tube, and also relates to a refrigeration cycle apparatus and a method of manufacturing a heat exchanger.

Background Art

[0002] A heat transfer part for this type of heat exchanger includes a fin that has an elongated plate shape and a recessed portion extending in the longitudinal direction of the fin at the central portion in its short-side direction to braze a heat transfer tube to this recessed portion (see, for example, Patent Literature 1).

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2018-155479

Summary of Invention

Technical Problem

[0004] In Patent Literature 1, since the fin and the heat transfer tube are formed as separate pieces, both the fin and the heat transfer tube need to be brazed together during the production process. Thus, heat generated because of the brazing causes the fin and the heat transfer tube to be thermally deformed. There is thus a problem in that the occurrence of such thermal deformation results in degradation in the heat exchange performance of the heat exchanger.

[0005] From the viewpoint of improvement in heat exchange efficiency, heat exchangers are required to improve heat conductivity of the heat transfer part.

[0006] The present disclosure has been made in view of the above problems, and it is an object of the present disclosure to provide a heat exchanger that improves heat exchange performance by employing a structure that eliminates the need for joining a fin and a heat transfer tube together, and that makes it possible to improve heat conductivity of a heat transfer part, and also to provide a refrigeration cycle apparatus and a method of manufacturing a heat exchanger.

Solution to Problem

[0007] A heat exchanger according to one embodiment of the present disclosure includes a heat transfer part that has a heat transfer tube that has a refrigerant flow passage inside the heat transfer tube, and a fin that has a plate shape that extends along a direction of a tube axis of the heat transfer tube and that is integrated with the heat transfer tube, the fin having an integrated portion and a fin portion, the integrated portion being a portion at which the fin is integrated with the heat transfer tube, the fin portion being a portion of the fin that is other than the integrated portion, the fin portion having a plate thickness that is smaller than a plate thickness of the integrated portion.

[0008] A refrigeration cycle apparatus according to another embodiment of the present disclosure includes the heat exchanger described above.

[0009] A method of manufacturing a heat exchanger according to still another embodiment of the present disclosure is a method of manufacturing a heat exchanger provided with a heat transfer part that has a heat transfer tube that has a refrigerant flow passage inside the heat transfer tube and a fin that has a plate shape that extends along a direction of a tube axis of the heat transfer tube, the method including an extrusion process for forming the heat transfer tube and the fin through extrusion, and a rolling process for extending the fin through application of pressure. Advantageous Effects of Invention

[0010] According to an embodiment of the present disclosure, a structure is employed in which the heat transfer tube and the fin are integrated with each other. Thus, this makes it possible to avoid thermal deformation during the production process due to heat generated in a case where the heat transfer tube and the fin are joined together, and to consequently improve the heat exchange performance. The fin portion that is a portion of the fin other than the integrated portion that is integrated with the heat transfer tube is formed to have a plate thickness smaller than the plate thickness of the integrated portion. Accordingly, heat conductivity of the heat transfer part can be improved.

Brief Description of Drawings

[0011]

[Fig. 1] Fig. 1 is a perspective view schematically illustrating the configuration of a heat exchanger according to Embodiment 1.

[Fig. 2] Fig. 2 is a side view of a heat transfer part of the heat exchanger according to Embodiment 1.

[Fig. 3] Fig. 3 is a cross-sectional view of the heat transfer part taken along the A-A line in Fig. 2.

[Fig. 4] Fig. 4 is a partially-enlarged cross-sectional view of Fig. 3.

[Figs. 5] Figs. 5 are explanatory diagrams illustrating a method of manufacturing the heat transfer part of the heat exchanger according to Embodiment 1.

[Fig. 6] Fig. 6 is an end view of the heat transfer tube in cross-section taken along the A-A line in step S6 in Fig. 5(c).

[Figs. 7] Figs. 7 are explanatory diagrams illustrating a modification of the method of manufacturing the heat transfer part of the heat exchanger according to Embodiment 1.

[Figs. 8] Figs. 8 illustrate pattern 1 in Modification 1 of the heat transfer part of the heat exchanger according to Embodiment 1.

[Figs. 9] Figs. 9 illustrate pattern 2 in Modification 1 of the heat transfer part of the heat exchanger according to Embodiment 1.

[Figs. 10] Figs. 10 illustrate pattern 3 in Modification 1 of the heat transfer part of the heat exchanger according to Embodiment 1.

[Fig. 11] Fig. 11 illustrates Modification 2 of the heat transfer part of the heat exchanger according to Embodiment 1.

[Fig. 12] Fig. 12 illustrates Modification 3 of the heat transfer part of the heat exchanger according to Embodiment 1.

[Fig. 13] Fig. 13 illustrates Modification 4 of the heat transfer part of the heat exchanger according to Embodiment 1.

[Fig. 14] Fig. 14 illustrates Modification 5 of the heat transfer part of the heat exchanger according to Embodiment 1.

[Fig. 15] Fig. 15 illustrates Modification 6 of the heat transfer part of the heat exchanger according to Embodiment 1.

[Fig. 16] Fig. 16 is a refrigerant circuit diagram of a refrigeration cycle apparatus according to Embodiment 2.

Description of Embodiments

[0012] Embodiments of the present disclosure will be described hereinafter with reference to the drawings. Note that the relative relationship of sizes, the shapes, and other properties of components in the drawings below including Fig. 1 may differ from those of actual ones. In addition, in the drawings below, the same reference signs denote the same or equivalent components, which are common throughout the entire specification. The shape, size, location, and other properties of the components described in each of the drawings may be appropriately changed within the scope of the present disclosure.

Embodiment 1

[0013] Fig. 1 is a perspective view schematically illustrating the configuration of a heat exchanger according to Embodiment 1. Fig. 2 is a side view of a heat transfer part of the heat exchanger according to Embodiment 1. Fig. 3 is a cross-sectional view of the heat transfer part taken along the A-A line in Fig. 2. Fig. 4 is a partially-enlarged cross-sectional view of Fig. 3. With reference to Figs. 1 to 4, a heat exchanger 1 according to Embodiment 1 is described below.

[0014] As illustrated in Fig. 1, the heat exchanger 1 includes a plurality of heat transfer parts 2, a first header 3, and a second header 4. The plurality of heat transfer parts 2 are spaced from each other in the X-direction, such that air flows in the Y-direction perpendicular to the X-direction between the heat transfer parts 2. The plurality of heat transfer parts 2 are each formed into an elongated shape extending in the Z-direction perpendicular to the X-direction and the Y-direction. Opposite ends of the heat transfer parts 2 in the Z-direction are connected to the first header 3 and the second header 4.

[0015] Each of the heat transfer parts 2 includes a heat transfer tube 20 in which refrigerant flows, and fins 21. The heat transfer part 2 is of an integrated structure in which the heat transfer tube 20 and the fins 21 are integrated with each other. The heat transfer part 2 is made of metal material with heat conductivity. Examples of the metal material to be used include aluminum, aluminum alloy, copper, and copper alloy.

[0016] As illustrated in Fig. 3, the heat transfer tube 20 is a flat tube formed into a flat shape in cross-section having the major axis and the minor axis. The flat tube has a plurality of refrigerant flow passages 20a made up of through holes. The major axis extends in the Y-direction. The minor axis extends in the X-direction. Note that the heat transfer tube 20 is not limited to the flat tube, but may be a circular tube. Note that the configuration is described in this example in which the plurality of heat transfer parts 2 are provided. However, any number of heat transfer parts 2 may be provided. One or more heat transfer parts 2 are only required.

[0017] Each of the fins 21 is made up of an elongated planar plate that extends along the direction of the tube axis of the heat transfer tube 20. The longitudinal direction of the fin 21 corresponds to the Z-direction, while the short-side direction of the fin 21 corresponds to the Y-direction. At least two fins 21 are located at positions opposite to each other with the heat transfer tube 20 interposed between the two fins 21. Specifically, the fins 21 are provided at opposite end portions of the heat transfer tube 20 in the Y-direction, and at the middle portion of the heat transfer tube 20 in the X-direction. Each of the fins 21 includes an integrated portion 22 at which the fin 21 is integrated with the heat transfer tube 20, and a fin portion 23 that is smaller than the integrated portion 22. As described above, the fin portion 23 is formed to have a plate thickness "t" that is smaller than a plate thickness "p" of the integrated portion 22. This makes it possible to improve the heat conductivity of the fin 21 compared to the configuration in which the fin 21 is formed in its entirety with a plate thickness equal to that of the integrated portion 22.

[0018] As illustrated in Fig. 2, opposite end portions of the fins 21 in the Z-direction are located further inside than opposite end portions of the heat transfer tube 20 in the Z-direction. The opposite end portions of the heat transfer tube 20 protrude further outside than the opposite end portions of the fins 21. Portions of the heat transfer tube 20 that protrude further outside than the fins 21 are denoted as insertion portions 20b to be inserted into the first header 3 and the second header 4.

[0019] As illustrated in Fig. 3, the fin portion 23 is formed to have dimensions such that t/w is equal to 0.1 or smaller, where the plate thickness of the fin portion 23 is represented as "t" and the width of the fin portion 23 is represented as "w." Because of these dimensions, the weight of the fin 21 can be reduced compared to the case where the fin portion 23 has a plate thickness equal to that of the integrated portion 22. As the plate thickness of the fin portion 23 is reduced, the heat resistance inside the fin material is decreased. Accordingly, heat exchange efficiency between refrigerant and air improves.

[0020] The first header 3 and the second header 4 are hollow containers extending in the X-direction. In Fig. 1, the first header 3 and the second header 4 are each formed into a cuboid shape. However, the shape of the first header 3 and the second header 4 is not particularly limited, but may be a cylindrical or other shape. The first header 3 and the second header 4 are formed to have a plurality of insertion holes (not illustrated). In each of the insertion holes of the first header 3, one of the insertion portions 20b of the corresponding one of the heat transfer tubes 20 is inserted. The inserted end portions of the plurality of heat transfer tubes 20 communicate with each other inside the first header 3. In each of the insertion holes of the second header 4, the other insertion portion 20b of the corresponding one of the heat transfer tubes 20 is inserted. The other inserted end portions of the plurality of heat transfer tubes 20 communicate with each other inside the first header 3. A refrigerant inlet-outlet pipe 5 is connected to the first header 3. A refrigerant inlet-outlet pipe 6 is connected to the second header 4.

[0021] In the heat exchanger 1 having the configuration as described above, refrigerant flows into the first header 3 from the refrigerant inlet-outlet pipe 5. The refrigerant having flowed into the first header 3 is distributed from the first header 3 to the heat transfer tubes 20 of the heat transfer parts 2, and then flows through the heat transfer tubes 20 toward the second header 4. The refrigerant flowing through the heat transfer tubes 20 exchanges heat with air flowing in the Y-direction, and subsequently joins together in the second header 4 and flows out of the second header 4 from the refrigerant inlet-outlet pipe 6. Note that in this example, refrigerant flows into the first header 3 from the refrigerant inlet-outlet pipe 5 connected to the first header 3, and then flows out of the second header 4 from the refrigerant inlet-outlet pipe 6 connected to the second header 4, however, refrigerant may flow in the reverse direction. That is, refrigerant may flow into the second header 4 from the refrigerant inlet-outlet pipe 6 connected to the second header 4, and then flows out of the first header 3 from the refrigerant inlet-outlet pipe 5 connected to the first header 3.

[0022] During heat exchange between air and refrigerant flowing through the heat transfer tubes 20, heat of the refrigerant flowing through the heat transfer tubes 20 is transferred to the fins 21, so that the heat is exchanged between air and the heat transfer parts 2 in their entirety. The fin portion 23 of the fin 21 is formed to have a plate thickness that is smaller than that of the integrated portion 22 as described above. Because of this configuration, the heat conductivity of the fin 21 improves compared to the configuration in which the fin 21 is formed in its entirety with a thickness equal to that of the integrated portion 22. Therefore, heat of the refrigerant is transmitted from the heat transfer tubes 20 efficiently to the fins 21 in their entirety, so that the heat exchange efficiency between the heat transfer parts 2 and air is increased.

[0023] Next, a method of manufacturing the heat transfer part 2 is described.

[0024] Figs. 5 are explanatory diagrams illustrating the method of manufacturing the heat transfer part of the heat exchanger according to Embodiment 1. Fig. 5(a) is a flowchart of the method of manufacturing the heat transfer part. Fig. 5(b) is a cross-sectional view of the heat transfer part in each step taken along the X-Y plane. Fig. 5(c) is a side view of the heat transfer part in each step when viewed from the X-direction. As illustrated in Fig. 5(a), the method of manufacturing the heat transfer part includes processes in steps S1 to S6. Fig. 5(b) illustrates cross-sectional views corresponding to the respective steps. Fig. 5(c) illustrates side views corresponding to the respective steps. In Fig. 5(c), the fin portions are shown by dots. Fig. 6 is an end view of the heat transfer tube in cross-section taken along the A-A line in step S6 in Fig. 5(c).

[0025] In manufacturing the heat transfer part 2, extrusion is first performed in which heated metal material is extruded from a die hole to form a heat-transfer-part base 100 having a cross-sectional shape in step S1 in Fig. 5(b) (extrusion process (step S1)). The heat-transfer-part base 100 has the heat transfer tube 20 and the two fins 21 formed at opposite end portions of the heat transfer tube 20 in the Y-direction. Next, the dimensions of the heat transfer tube 20 are corrected to suit the dimensions of the insertion holes provided in the first header 3 and the second header 4 (resizing process (step S2)). This resizing process is performed by applying pressure to the fins 21 from opposite end portions of the heat-transfer-part base 100 in the Y-direction. The resizing process is performed before the rolling process is performed next, that is, before the plate thickness of the fins 21 is reduced, so that even when the heat transfer tube 20 is applied with a force, the fins 21 can still be prevented from bending.

[0026] Subsequently, the two fins 21 are extended through application of pressure (rolling process (step S3)). In the rolling process, the fins 21 are extended through application of pressure into a set plate thickness. Through this rolling process, the fin portion 23, that is a portion of the fin 21 other than the integrated portion 22 that is integrated with the heat transfer tube 20, is formed to have a set plate thickness. In this state, if the integrated portion 22 is also extended through application of pressure into a set plate thickness, there may be a possibility that the heat transfer tube 20 can be deformed. In view of the above, the fin portion 23 of the fin 21, other than the integrated portion 22, is only extended through application of pressure. The rolling process is performed at a temperature exceeding the recrystallization temperature for the material of the heat transfer part 2. The reason for this is that when the rolling process is performed at a temperature equal to or below the recrystallization temperature for the material of the heat transfer part 2, the material is hardened, which makes it difficult to form the material into a set plate thickness, and the machining accuracy is thus degraded.

[0027] The heat-transfer-part base 100 having undergone the above processes is cooled (cooling process (step S4)). Subsequently, the end portion of each fin 21 in the Y-direction is cut (cutting process (step S5)). After the rolling process is performed, the end portions of the fins 21 are twisted in Fig. 5(b). Thus, in the cutting process, the twisted end portions are cut to shape the fins 21. Then, opposite end portions of each fin 21 in the Z-direction are cut (end portion machining process (step S6)). In the end portion machining process, along with the fins 21, opposite end portions of the heat transfer tube 20 in the Y-direction are also cut as illustrated in Fig. 6. Through this end portion machining process, the heat transfer tube 20 protrudes further outside than opposite end portions of the fins 21 in the Z-direction, and the insertion portions 20b are thus formed, which are to be inserted into the first header 3 and the second header 4, as illustrated in step S6 in Fig. 5(c). Through the processes described above, manufacturing of the heat transfer part 2 is completed.

<Modification of manufacturing method>

[0028] The method of manufacturing the heat transfer part 2 is not limited to the manufacturing method illustrated in Figs. 5, but may be modified without departing from the scope of Embodiment 1, for example, in the manner as described below.

(Modification)

[0029] Figs. 7 are explanatory diagrams illustrating a modification of the method of manufacturing the heat transfer part of the heat exchanger according to Embodiment 1. The manufacturing method in Figs. 7 is described below through explanation of the differences from the manufacturing method illustrated in Figs. 5.

[0030] In the manufacturing method illustrated in Figs. 5, both two fins 21 are extended through application of pressure simultaneously in the rolling process. In contrast, in this modification, two fins 21 are extended through application of pressure at different timings. That is, as illustrated in Figs. 7, one of the two fins 21 is extended through application of pressure (first rolling process (step S3a)), and subsequently the other of the two fins 21 is extended through application of pressure (second rolling process (step S3b)). When both two fins 21 positioned opposite to each other with the heat transfer tube 20 interposed between the two fins 21 are extended through application of pressure simultaneously, there may be a possibility that the heat transfer tube 20 may be stretched and deformed. For this reason, in the modification, the two fins 21 are extended through application of pressure one by one at different timings. This can reduce deformation of the heat transfer tube 20.

<Modification of heat transfer part 2>

[0031] The heat transfer part 2 is not limited to the configuration of the basic embodiment illustrated in Figs. 1 to 4, but may be modified without departing from the scope of Embodiment 1, for example, in the manner as described below.

(Modification 1)

[0032] Figs. 8 illustrate pattern 1 in Modification 1 of the heat transfer part of the heat exchanger according to Embodiment 1. Figs. 9 illustrate pattern 2 in Modification 1 of the heat transfer part of the heat exchanger according to Embodiment 1. Figs. 10 illustrate pattern 3 in Modification 1 of the heat transfer part of the heat exchanger according to Embodiment 1. Figs. 8(a), 9(a), and 10(a) are cross-sectional views of the heat transfer part. Figs. 8(b), 9(b), and 10(b) are side views of the heat transfer part.

[0033] In Modification 1, the fin portions 23 are each formed into a wavy shape. The fin portions 23 may have a wavy shape in which wave displacement in the X-direction continues along the Y-direction as illustrated in Figs. 8. The fin portions 23 may have a wavy shape in which wave displacement in the X-direction continues along the Z-direction as illustrated in Figs. 9. The fin portions 23 may have a wavy shape in which wave displacement in the X-direction continues along both the Y-direction and the Z-direction as illustrated in Figs. 10. Such a wavy shape of the fin portions 23 as described above can increase the surface area of the fin portions 23, and consequently improve the heat conductivity to air. Such a wavy shape of the fin portions 23 as described above may be formed simultaneously with the rolling process, or may be formed after the rolling process.

(Modification 2)

[0034] Fig. 11 illustrates Modification 2 of the heat transfer part of the heat exchanger according to Embodiment 1.

[0035] In Modification 2, each of the fin portions 23 has an uneven shape 24 on its surface. The fin portion 23 has the uneven shape 24 on its surface as described above, so that a flow of air on the surface of the fin portion 23 is turbulent, and the heat conductivity to air can be improved accordingly. The uneven shape 24 as described above may be formed simultaneously with the rolling process, or may be formed after the rolling process.

(Modification 3)

[0036] Fig. 12 illustrates Modification 3 of the heat transfer part of the heat exchanger according to Embodiment 1.

[0037] In the above basic embodiment, the integrated portion 22 of the fin 21 that is integrated with the heat transfer tube 20 is positioned at the central portion of the heat transfer tube 20 in the X-direction. However, in Modification 3, the integrated portion 22 is positioned at the end portion of the heat transfer tube 20 in the X-direction. With this configuration, an extension roller used for extending the fins 21 through application of pressure can be simplified.

(Modification 4)

[0038] Fig. 13 illustrates Modification 4 of the heat transfer part of the heat exchanger according to Embodiment 1.

[0039] In Modification 4, the fin 21 is provided only at one end of the heat transfer tube 20.

(Modification 5)

[0040] Fig. 14 illustrates Modification 5 of the heat transfer part of the heat exchanger according to Embodiment 1.

[0041] In Modification 5, the heat transfer tube 20 included in the heat transfer part 2 includes a plurality of heat transfer tubes 20. The heat transfer tubes 20 are connected to each other by the fin 21. Note that Fig. 14 omits illustrations of the integrated portion 22.

(Modification 6)

[0042] Fig. 15 illustrates Modification 6 of the heat transfer part of the heat exchanger according to Embodiment 1.

[0043] In Modification 6, each of the heat transfer tubes 20 is a circular tube. In Modification 6, an example is shown in which each of the heat transfer tubes 20 of the heat transfer part 2 in the modification in Fig. 14 is made up of a circular tube. However, the heat transfer tube 20 in any of the basic embodiment and Modifications 1 to 5 described above may be a circular tube. Note that Fig. 15 omits illustrations of the integrated portion 22.

(Modification 7)

[0044] The above modifications may be appropriately combined. For example, Modification 1 and Modification 2 may be combined such that the uneven shape 24 is provided on the surface of the fin portion 23 with a wavy shape.

[0045] As described above, the heat exchanger 1 according to Embodiment 1 includes the heat transfer part 2 that has the heat transfer tube 20 in which refrigerant flows, and the fin 21 that has an elongated plate shape that extends along a direction of the tube axis of the heat transfer tube 20 and that is integrated with the heat transfer tube 20. In the fin 21 of the heat transfer part 2, the fin portion 23 other than the integrated portion 22 that is integrated with the heat transfer tube 20 is formed to have a plate thickness that is smaller than the plate thickness of the integrated portion 22. In this manner, a structure is employed that the heat transfer tube 20 and the fin 21 are integrated with each other and thus the fin 21 and the heat transfer tube 20 do not need to be joined together. Therefore, this makes it possible to avoid the fin 21 and the heat transfer tube 20 from being deformed because of heat generated by the joining, and to improve the heat exchange performance. The fin portion 23 is formed to have a plate thickness that is smaller than the plate thickness of the integrated portion 22. This can improve the heat conductivity of the fin 21 compared to the configuration in which the fin 21 is formed in its entirety with a plate thickness equal to that of the integrated portion 22.

[0046] The fin portion 23 may be formed into a wavy shape, or the uneven shape 24 may be formed on the surface of the fin portion 23. The fin portion 23 is formed in this manner, so that the heat conductivity to air can be improved.

[0047] In the fin 21, where the plate thickness of the fin portion 23 is represented as "t" and the width of the fin portion 23 in its short-side direction is represented as "w," t/w is equal to or smaller than 0.1. Because of these dimensions, the weight of the heat transfer part 2 can be reduced compared to the case where the fin portion 23 has a plate thickness equal to the plate thickness of the integrated portion 22.

[0048] The heat transfer tube 20 included in heat transfer part 2 may include a plurality of heat transfer tubes 20 that are connected to each other by the fin 21. Each of the heat transfer tubes 20 may be a flat tube or a circular tube.

[0049] The method of manufacturing the heat exchanger 1 in Embodiment 1 includes an extrusion process for forming the heat transfer tube 20 and the fin 21 through extrusion, and a rolling process for extending the fin 21 through application of pressure. The heat transfer tube 20 and the fin 21 are integrated with each other in the manner as described above, so that the need for the joining process can be eliminated, and consequently heat exchange performance can be improved. The fin 21 is extended through application of pressure, so that the plate thickness of the fin 21 can be reduced, and the heat conductivity of the heat transfer part 2 can be improved accordingly.

[0050] In the rolling process, the fin 21 is extended through application of pressure, except for the integrated portion 22 that is integrated with the heat transfer tube 20. This can reduce deformation of the heat transfer tube 20 during the rolling process.

[0051] The rolling process is performed at a temperature exceeding the recrystallization temperature for the material of the heat transfer part 2. In this temperature state, the fin 21 can be extended through application of pressure with high machining accuracy.

[0052] A resizing process is performed in between the extrusion process and the rolling process. The resizing process corrects the dimensions of the heat transfer tube 20 while the fin 21 is applied with pressure. As described above, the resizing process is performed before the fin 21 is extended through application of pressure, so that even when the heat transfer tube 20 is applied with a force, the fin 21 can still be prevented from bending.

[0053] The fin 21 includes two fins located at positions opposite to each other with the heat transfer tube 20 interposed between the fins 21. The rolling process includes a first process for extending one of the fins 21 through application of pressure, and a second process for extending the other fin 21 through application of pressure, and these first and second processes are performed at different timings. This can reduce deformation of the heat transfer tube 20.

[0054] Embodiment 1 includes a cutting process for cutting the end portion of the fin 21 in the short-side direction after the fin 21 is extended through application of pressure in the rolling process. Because of this cutting process, the twisted portion of the fin 21 after the fin 21 has been extended through application of pressure can be cut to shape the fin 21.

Embodiment 2

[0055] Embodiment 2 relates to a refrigeration cycle apparatus including the heat exchanger 1 of Embodiment 1 described above.

[0056] Fig. 16 is a refrigerant circuit diagram of the refrigeration cycle apparatus according to Embodiment 2.

[0057] The refrigeration cycle apparatus 200 includes a compressor 201, a condenser 202, a pressure reducing device 203 that is an expansion valve or other valve, and an evaporator 204. The heat exchanger 1 of Embodiment 1 is used in one or both of the condenser 202 and the evaporator 204.

[0058] The refrigeration cycle apparatus 200 having the configuration as described above operates in the manner as described below.

[0059] Refrigerant compressed in the compressor 201 flows into the condenser 202. The refrigerant having flowed into the condenser 202 exchanges heat with air passing through the condenser 202, is then cooled, and flows into the pressure reducing device 203. The refrigerant having flowed into the pressure reducing device 203 is reduced in the pressure, and flows into the evaporator 204. The refrigerant having flowed into the evaporator 204 exchanges heat with air passing through the evaporator 204, is thus heated, and then suctioned into the compressor 201 again.

[0060] Since the refrigeration cycle apparatus 200 of Embodiment 2 includes the heat exchanger 1 of Embodiment 1, the refrigeration cycle apparatus 200 with improved heat exchange performance can be formed.

[0061] Note that the refrigeration cycle apparatus 200 is applicable to air-conditioning apparatuses, refrigerators, refrigerating machines, or other machines.

Reference Signs List

[0062] 1: heat exchanger, 2: heat transfer part, 3: first header, 4: second header, 5: refrigerant inlet-outlet pipe, 6: refrigerant inlet-outlet pipe, 20: heat transfer tube, 20a: refrigerant flow passage, 20b: insertion portion, 21: fin, 22: integrated portion, 23: fin portion, 24: uneven shape, 100: heat-transfer-part base, 200: refrigeration cycle apparatus, 201: compressor, 202: condenser, 203: pressure reducing device, 204: evaporator

Claims

1. A heat exchanger, comprising

a heat transfer part that has

a heat transfer tube that has a refrigerant flow passage inside the heat transfer tube, and
a fin that has a plate shape that extends along a direction of a tube axis of the heat transfer tube and that is integrated with the heat transfer tube,

the fin having an integrated portion and a fin portion, the integrated portion being a portion at which the fin is integrated with the heat transfer tube, the fin portion being a portion of the fin that is other than the integrated portion,
the fin portion having a plate thickness that is smaller than a plate thickness of the integrated portion.

2. The heat exchanger of claim 1, wherein the fin is formed into a wavy shape.

3. The heat exchanger of claim 1 or 2, wherein an uneven shape is formed on a surface of the fin.

4. The heat exchanger of any one of claims 1 to 3, wherein the heat transfer tube included in the heat transfer part comprises a plurality of heat transfer tubes, the plurality of heat transfer tubes being connected to each other by the fin.

5. The heat exchanger of any one of claims 1 to 4, wherein the heat transfer tube is a flat tube.

6. The heat exchanger of any one of claims 1 to 4, wherein the heat transfer tube is a circular tube.

7. A refrigeration cycle apparatus comprising the heat exchanger of any one of claims 1 to 6.

8. A method of manufacturing a heat exchanger provided with a heat transfer part that has a heat transfer tube that has a refrigerant flow passage inside the heat transfer tube and a fin that has a plate shape that extends along a direction of a tube axis of the heat transfer tube, the method comprising:

an extrusion process for forming the heat transfer tube and the fin through extrusion; and
a rolling process for extending the fin through application of pressure, the rolling process being performed after the extrusion process is performed.

9. The method of manufacturing the heat exchanger of claim 8, wherein in the rolling process, the fin is extended through application of pressure, except for an integrated portion of the fin, the integrated portion being integrated with the heat transfer tube.

10. The method of manufacturing the heat exchanger of claim 8 or 9, wherein the rolling process is performed at a temperature exceeding a recrystallization temperature for material of the heat transfer part.

11. The method of manufacturing the heat exchanger of any one of claims 8 to 10, further comprising a resizing process for correcting a dimension of the heat transfer tube while the fin is applied with pressure, the resizing process being performed in between the extrusion process and the rolling process.

12. The method of manufacturing the heat exchanger of any one of claims 8 to 11, wherein the fin comprises two fins located at positions opposite to each other with the heat transfer tube interposed between the two fins, and the rolling process includes a first process for extending one of the two fins through application of pressure, and a second process for extending an other of the two fins through application of pressure, the first and second processes being performed at different timings.

13. The method of manufacturing the heat exchanger of any one of claims 8 to 12, further comprising a cutting process for cutting an end portion of the fin in a short-side direction of the fin after the fin is extended through application of pressure in the rolling process.

FIG. 1

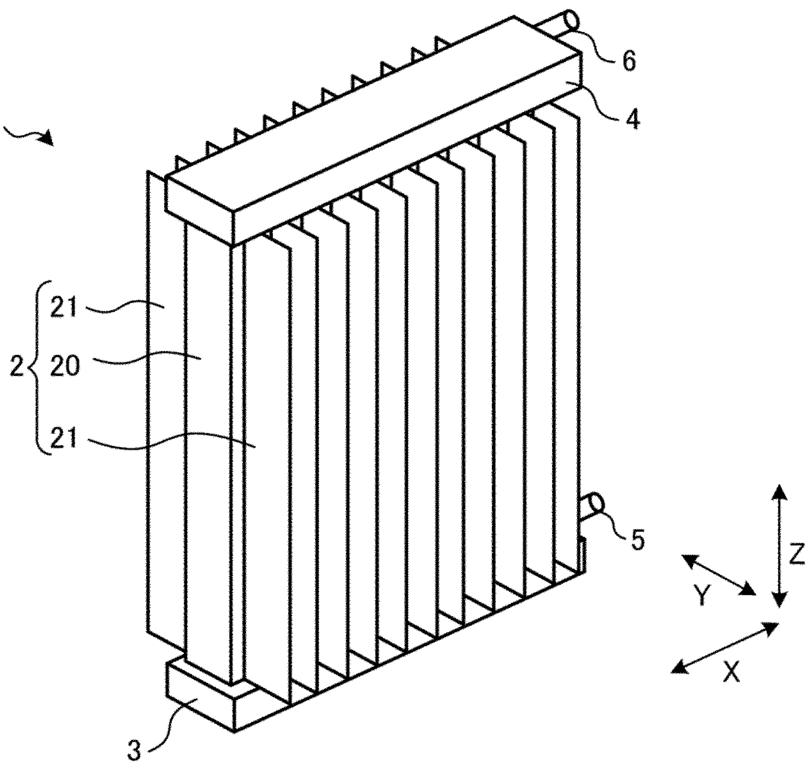


FIG. 2

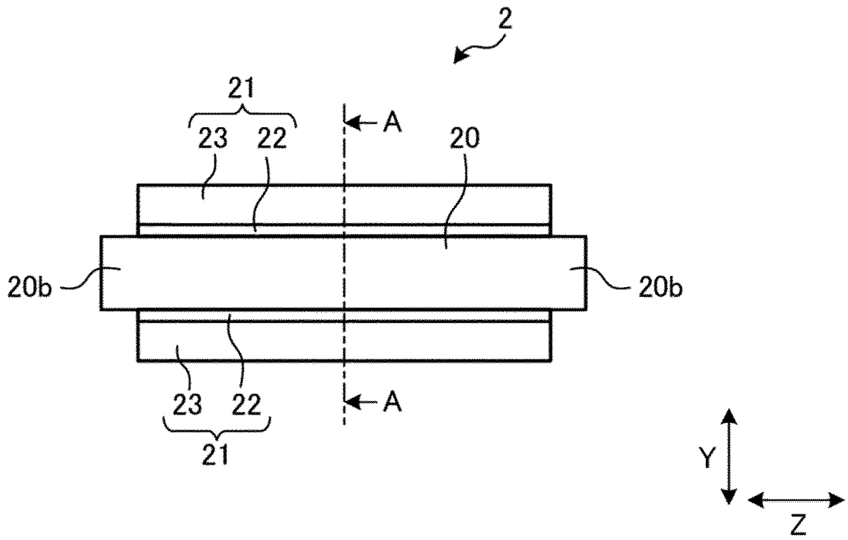


FIG. 3

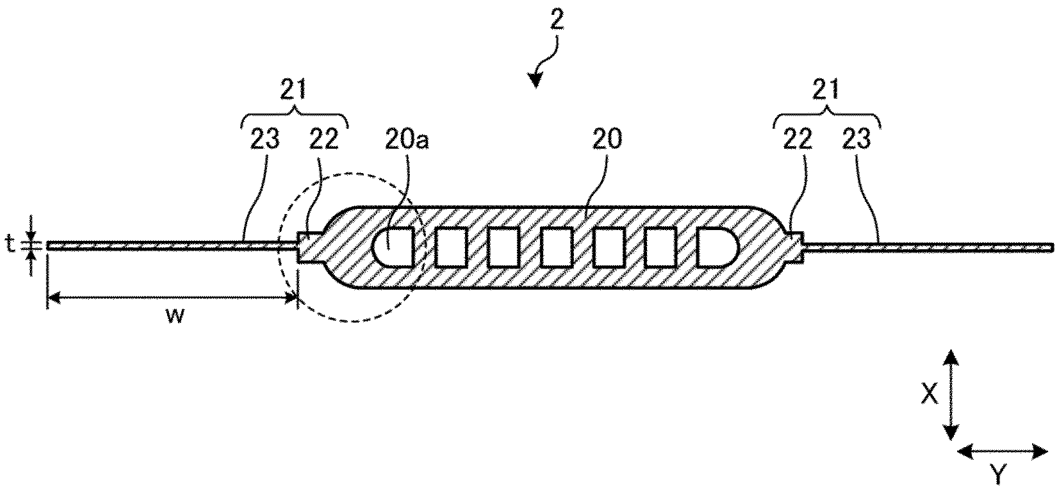


FIG. 4

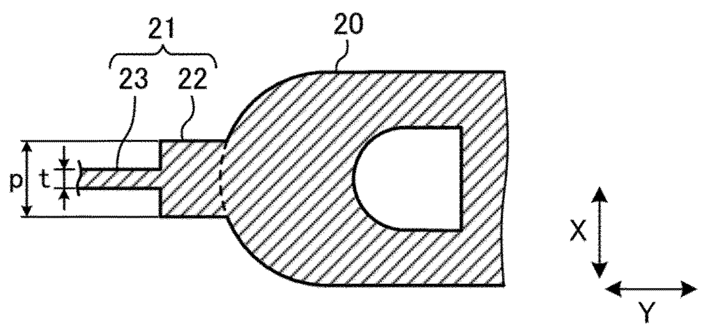


FIG. 5

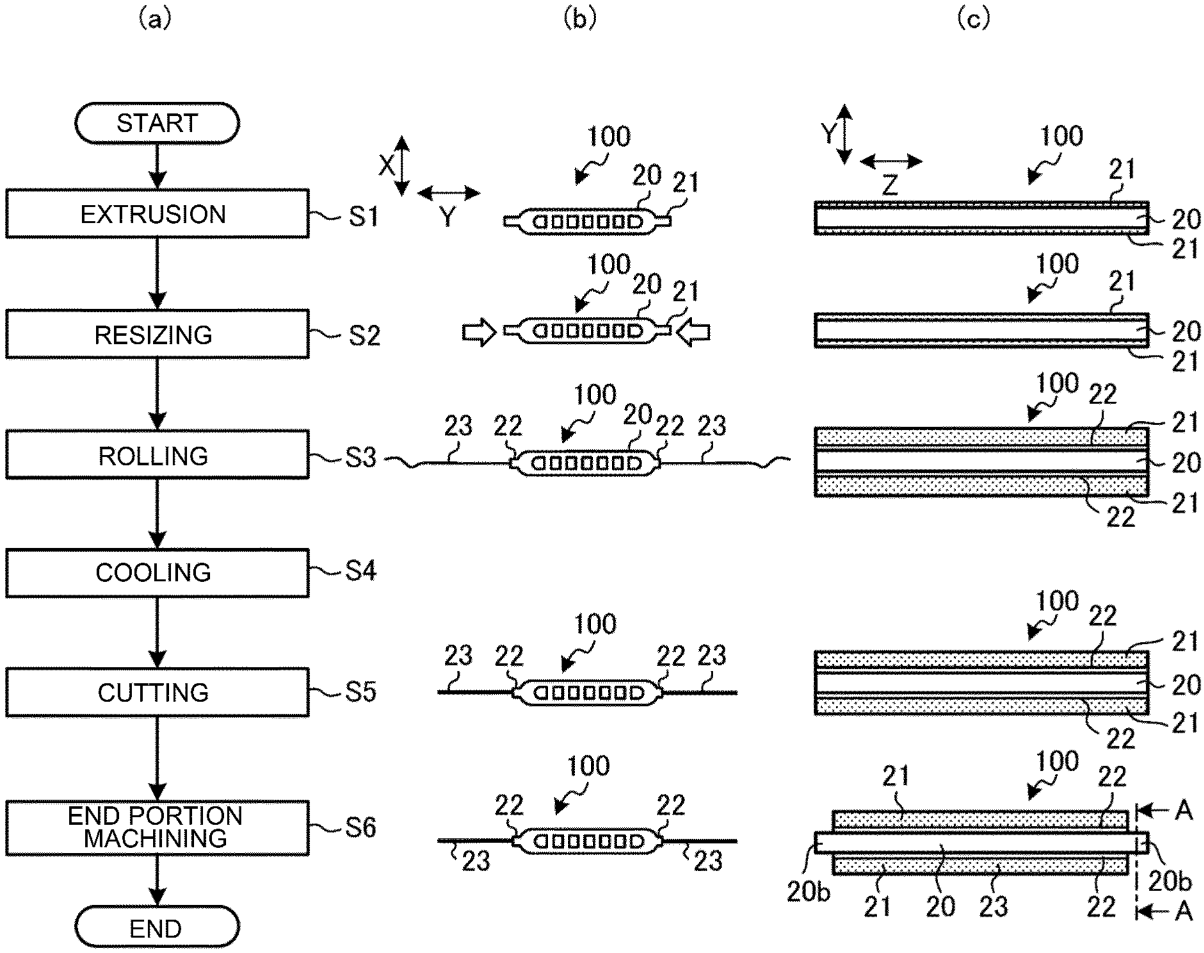

(a)
(b)
(c)
START
EXTRUSION
S1
RESIZING
S2
ROLLING
S3
COOLING
S4
CUTTING
S5
END PORTION MACHINING
S6
END
X
Y
Z
100
20
21
22
23
20b
A

FIG. 6

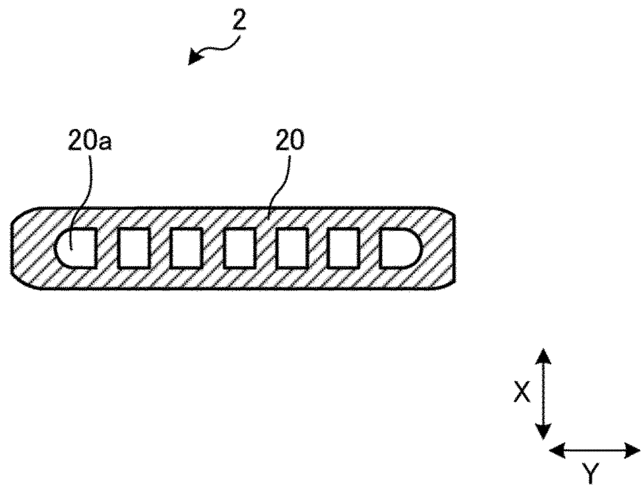


FIG. 7

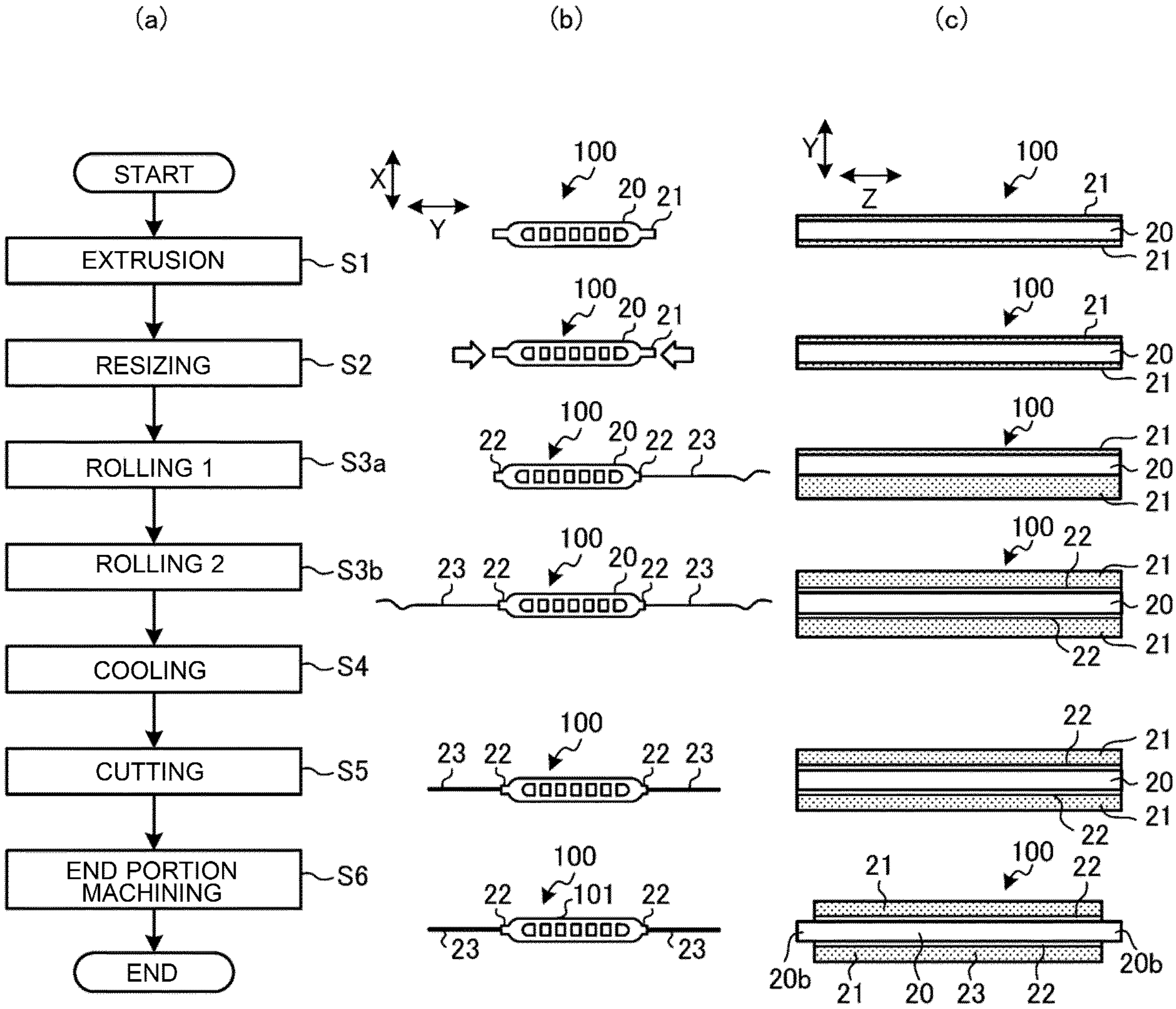

(a)
(b)
(c)
START
EXTRUSION
S1
RESIZING
S2
ROLLING 1
S3a
ROLLING 2
S3b
COOLING
S4
CUTTING
S5
END PORTION MACHINING
S6
END
X
Y
Z
100
101
20
20b
21
22
23

FIG. 8

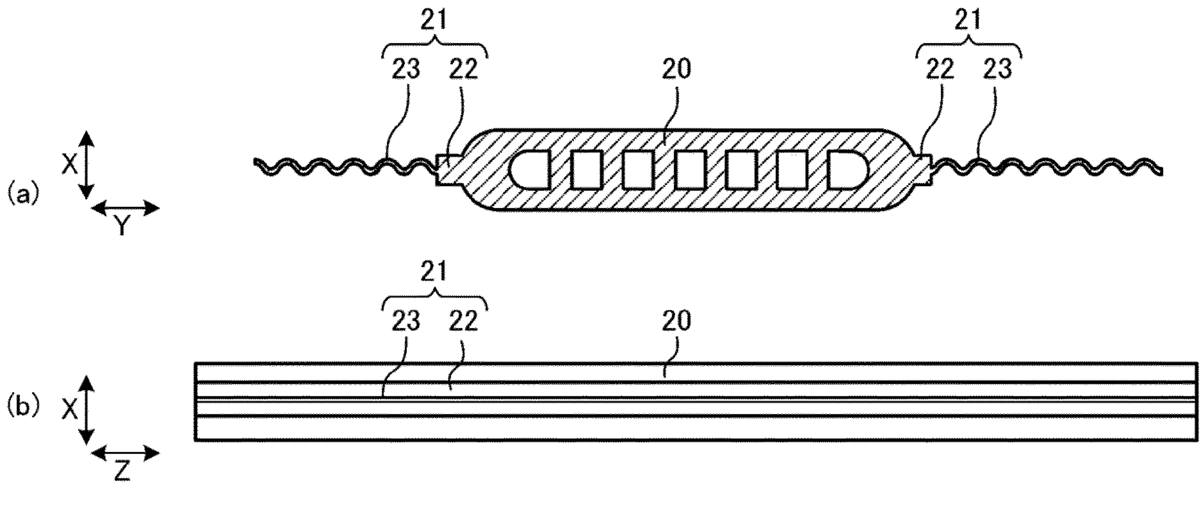


FIG. 9

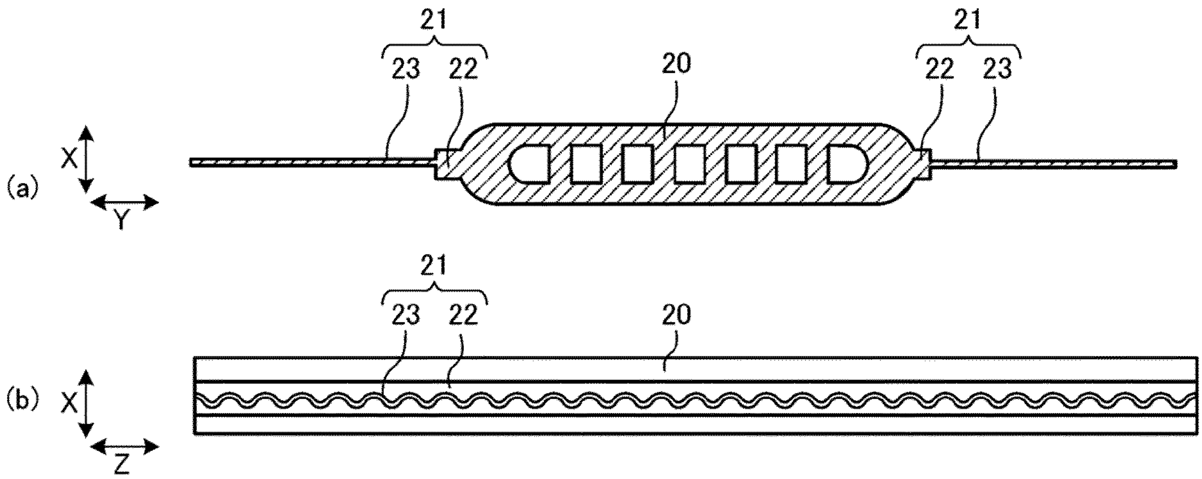


FIG. 10

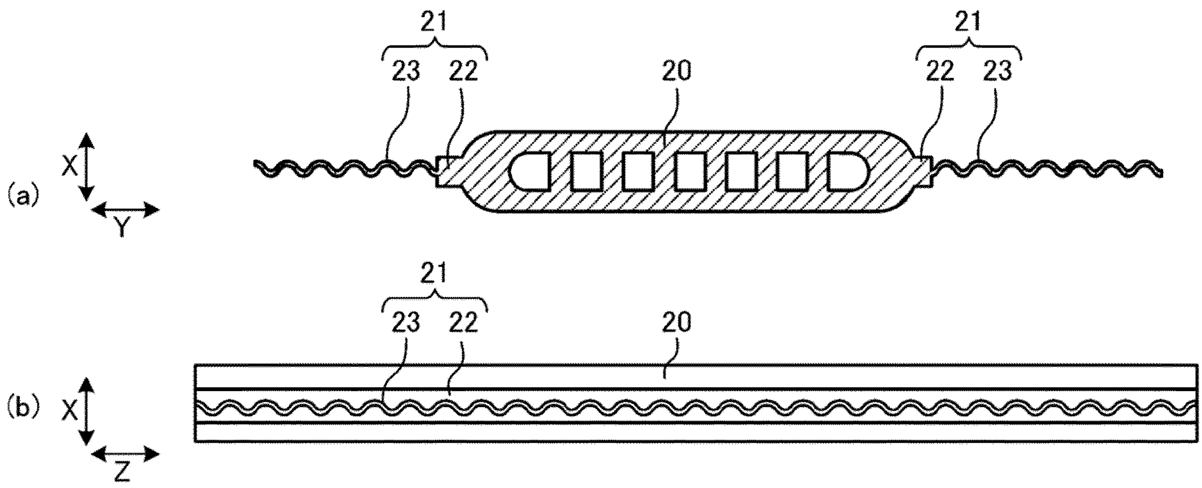


FIG. 11

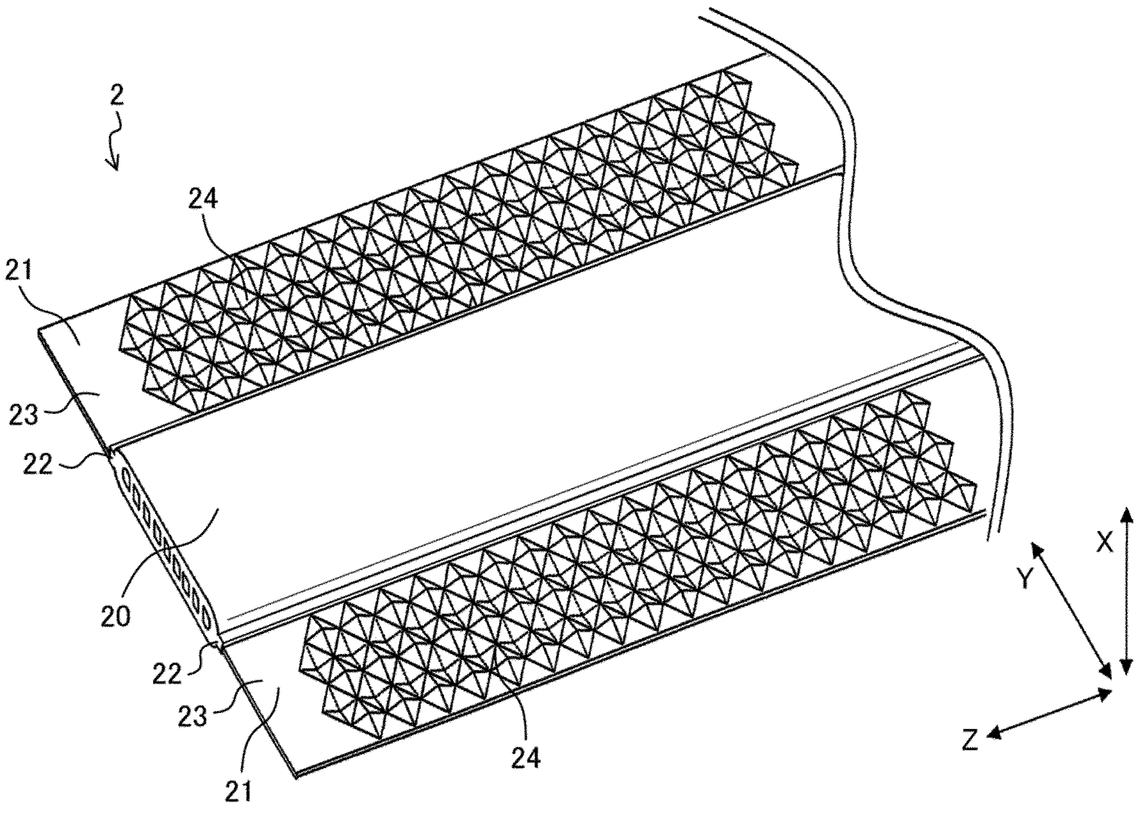


FIG. 12

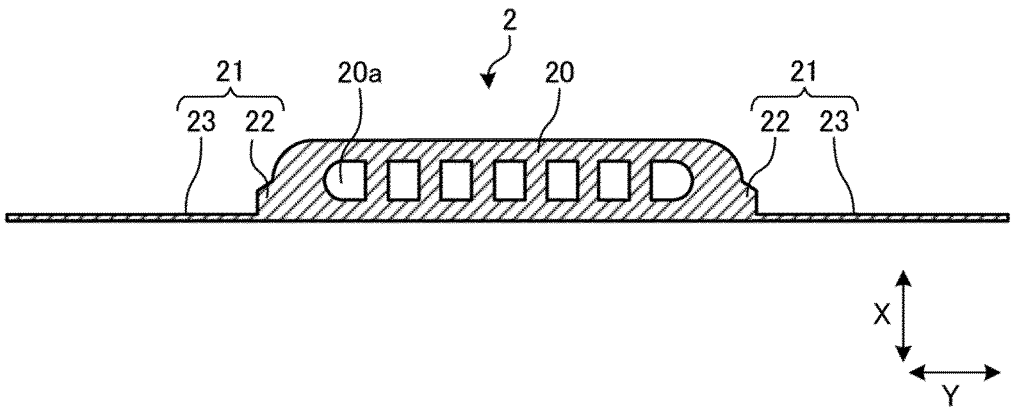


FIG. 13

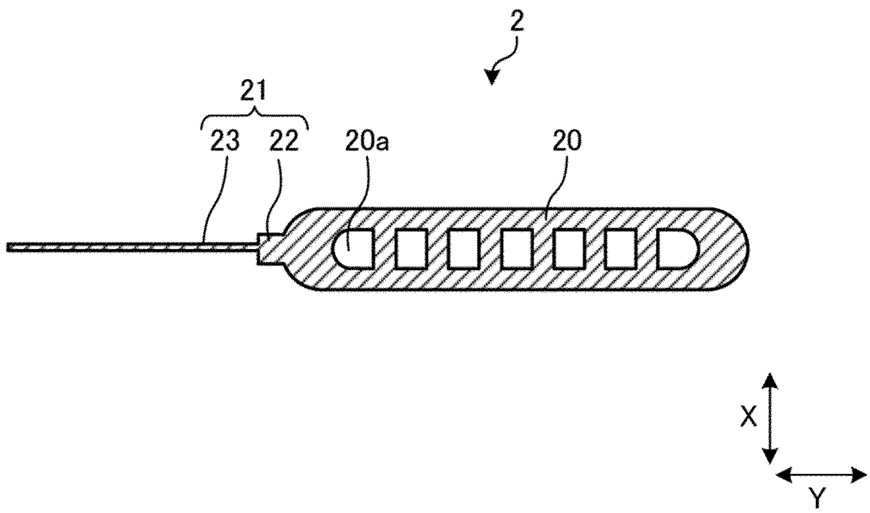


FIG. 14

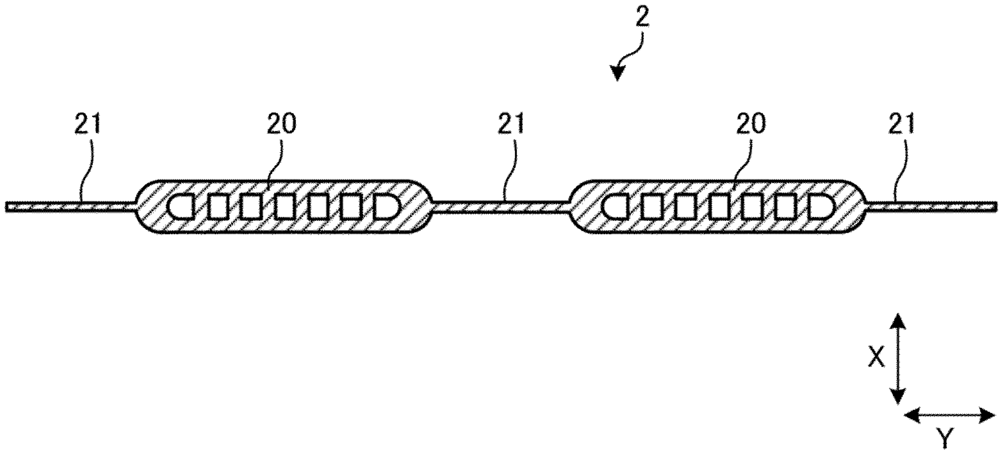


FIG. 15

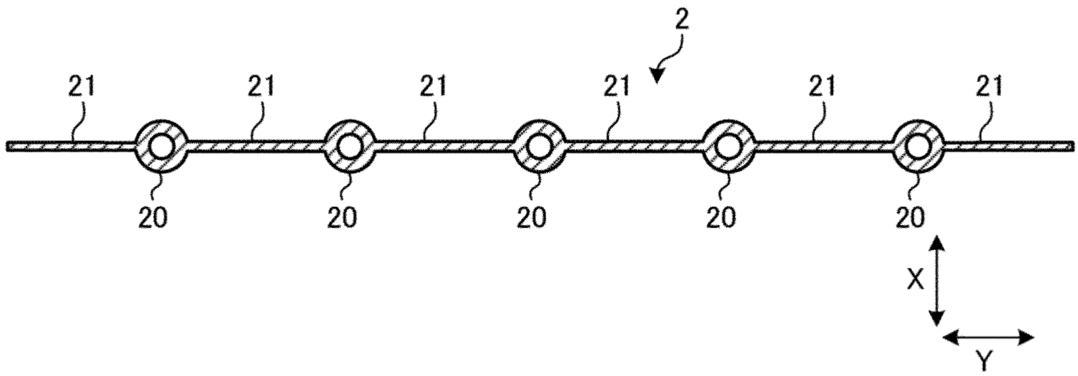
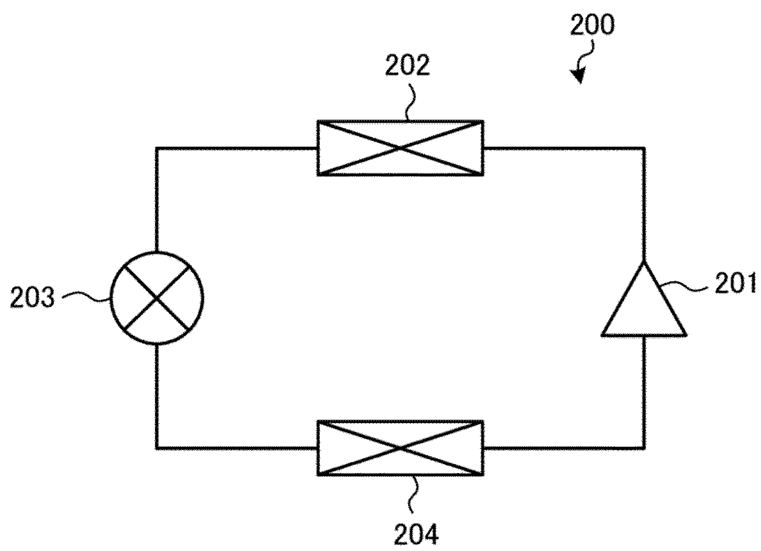


FIG. 16



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/013884

A. CLASSIFICATION OF SUBJECT MATTER

F28F 1/16(2006.01)i; B21C 23/10(2006.01)i; B21C 37/22(2006.01)i; B21D 53/06(2006.01)i; F28D 1/053(2006.01)i; F28F 1/02(2006.01)i
FI: F28F1/16 A; F28F1/02 B; F28D1/053 A; B21C23/10; B21C37/22; B21D53/06 E

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F28F1/00-1/44; B21C23/00-99/00; B21D3/00-3/16; B21D47/00-55/00; F28D1/00-13/00

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 Y A	JP 41-1218 B 1 (SHOWA ALUMINUM CORP.) 31 January 1966 (1966-01-31) entire text, all drawings	1, 8-9 2-7, 10, 13 11-12
Y	JP 49-38256 A (UNION CARBIDE CORPORATION) 09 April 1974 (1974-04-09) fig. 6-8	2-7
Y	US 2347957 A (MCCULLOUGH, William E.) 02 May 1944 (1944-05-02) fig. 12	4-7
Y	JP 2000-119782 A (KOBE STEEL, LTD.) 25 April 2000 (2000-04-25) paragraphs [0001], [0022]-[0023]	10, 13
A	JP 2-117728 A (SUMITOMO METAL INDUSTRIES, LTD.) 02 May 1990 (1990-05-02) entire text, all drawings	11-12

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

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05 June 2020 (05.06.2020)	16 June 2020 (16.06.2020)

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

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT	International application No. PCT/JP2020/013884

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
See extra sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2020/013884

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
JP 41-1218 B1	31 Jan. 1966	(Family: none)	
JP 49-38256 A	09 Apr. 1974	(Family: none)	
US 2347957 A	02 May 1944	(Family: none)	
JP 2000-119782 A	25 Apr. 2000	(Family: none)	
JP 2-117728 A	02 May 1990	(Family: none)	

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/013884

<Continuation of Box No. III>

Document 1: JP 41-1218 B 1 (SHOWA ALUMINUM CORP.) 31 January 1966 (1966-01-31) entire text, all drawings (Family: none)

Claims are classified into the following two inventions.

(Invention 1) Claims 1-7

Document 1 discloses a "heat exchanger in which a thickness of a fin portion is smaller than a thickness of a coupling portion," and claim 1 lacks novelty in light of document 1. Therefore, claim 1 does not have a special technical feature.

However, claim 2 dependent on claim 1 has the special technical feature, and claims 3-7 also have the special technical feature identical to claim 2.

Therefore, claims 1-7 are classified as invention 1.

(Invention 2) Claims 8-13

It cannot be said that claims 8-13 have the special technical feature identical or corresponding to claim 2 classified as invention 1. Also, claims 8-13 are not dependent on claim 1. Further, claims 8-13 are not substantially identical or equivalent to any of the claims classified as invention 1.

Accordingly, claims 8-13 cannot be classified as invention 1.

Claims 8-13 have the special technical feature of "including an extruding step for forming a heat transfer tube and a fin by an extrusion forming and a rolling step for rolling the fin after the extruding step", and thus are classified as invention 2.

Form PCT/ISA/210 (extra sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2018155479 A **[0003]**