



(11)

EP 2 843 346 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:

26.12.2018 Bulletin 2018/52

(51) Int Cl.:

F28F 1/32 (2006.01) **F25B 39/02** (2006.01)
F28D 1/047 (2006.01) **F28F 1/30** (2006.01)
F28D 21/00 (2006.01) **F28F 17/00** (2006.01)

(21) Application number: **13781866.2**

(86) International application number:

PCT/JP2013/002710

(22) Date of filing: **22.04.2013**

(87) International publication number:

WO 2013/161263 (31.10.2013 Gazette 2013/44)

(54) **FIN-TUBE HEAT EXCHANGER AND METHOD OF MANUFACTURING THE SAME**

WÄRMETAUSCHER MIT GERIPPTEN RÖHREN UND HERSTELLUNGSVERFAHREN DAFÜR

ÉCHANGEUR DE CHALEUR À TUBE À AILETTES ET SON PROCÉDÉ DE FABRICATION

(84) Designated Contracting States:

**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**

- **OHTSUBO, Shuhei**
Osaka-shi, Osaka 540-6207 (JP)
- **YOKOYAMA, Shoichi**
Osaka-shi, Osaka 540-6207 (JP)
- **HIROTA, Masanobu**
Osaka-shi, Osaka 540-6207 (JP)

(30) Priority: **23.04.2012 JP 2012097380**

(43) Date of publication of application:

04.03.2015 Bulletin 2015/10

(74) Representative: **Eisenführ Speiser**
Patentanwälte Rechtsanwälte PartGmbB
Postfach 31 02 60
80102 München (DE)

(73) Proprietor: **Panasonic Corporation**
Kadoma-shi, Osaka 571-8501 (JP)

(72) Inventors:

- **SUKAWA, Toru**
Osaka-shi, Osaka 540-6207 (JP)
- **OKAICHI, Atsuo**
Osaka-shi, Osaka 540-6207 (JP)
- **NAGOSHI, Kenji**
Osaka-shi, Osaka 540-6207 (JP)
- **HONMA, Masaya**
Osaka-shi, Osaka 540-6207 (JP)

(56) References cited:

EP-A1- 1 498 681 EP-A1- 2 072 939
EP-A2- 0 789 216 JP-A- H0 886 584
JP-A- H05 322 470 JP-A- H08 144 067
JP-A- H08 178 573 JP-A- H10 281 674
JP-A- 2000 193 389 JP-A- 2002 318 088
JP-A- 2003 314 980 JP-A- 2006 138 504
JP-A- 2006 336 904 JP-A- 2008 249 320
US-A- 5 203 403 US-A1- 2003 000 686

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Description

Patent Document(s)

Technical Field

Non-Patent Document(s)

[0001] The present invention relates to a fin-tube heat exchanger for exchanging heat with a gas and to a method of manufacturing the same.

5 **[0008]** Document 1: "Surface Treatment Technology for a Precoated aluminum fin material" written by Hideki-mi Hirasawa, Surface Technology, Vol. 57(2006), No. 2, p127

Background Art

10 Patent Document(s)

[0002] Conventionally, a fin-tube heat exchanger of this kind includes a plurality of fins arrayed at predetermined intervals and a heat-transfer tube extending through the plurality of fins. Air (a gas) flows between the fins to exchange heat with a fluid in the heat-transfer tube.

[0009]

Document 2: No. JP-A-2010-175131

15 Document 3: No. JP-UM-64-22186

[0003] In applications where such a fin-tube heat exchanger is used as an evaporator, if the surface temperature of the fins drops below the dew point of heat-exchanging air, moisture in the air condenses and water droplets (condensed water) adhere to fin surfaces. In this way, if the condensed water adheres to the fin surfaces, a bridge of moisture is generated, for example, between adjacent fins and an airflow path between the fins is blocked by the condensed water, thus giving rise to an increase in airflow resistance.

[0010] From EP-A-0789216 a fin-tube heat exchanger according to the preamble of claim 1 is disclosed.

20 Summary of the Invention

Problems to be solved by the Invention

[0004] As a result, a device such as, for example, an air conditioner or a water heater employing such a fin-tube heat exchanger is confronted with problems of increasing the power consumption and reducing the energy efficiency. Accordingly, it is preferred that the condensed water be quickly removed from the fin surfaces.

25 **[0011]** However, the technique as disclosed in Document 1 poses a problem that the drainage property of the condensed water is not sufficient if a bridge of the condensed water is generated particularly between the fins stacked at predetermined intervals.

[0005] To this end, a hydrophilic film layer is formed on each fin surface to enhance the drainage property by reducing a contact angle with respect to the water adhering to the fin surface, thereby preventing the condensed water so generated from blocking the airflow path between the fins (see, for example, Document 1).

30 **[0012]** Also, the technique as disclosed in Document 2 poses a problem that in applications where fine asperities are formed on the fin surface, an expensive working process such as, for example, plasma irradiation is required, which leads to a considerable increase in manufacturing cost.

[0006] In another solution, the hydrophilic film layer on the fin surface is irradiated with plasma to thereby form fine asperities to enhance the drainage property (see, for example, Document 2).

35 **[0013]** Further, in the technique as disclosed in Document 3, a drainage slit is formed in a flat fin and, as shown in Figs. 2 and 5 of Document 3, this technique poses a problem that a difficulty is encountered in preventing a bridge from being generated between the adjacent fins and it is accordingly insufficient to smoothly guide the condensed water downwardly of the fins.

[0007] In a further solution, each fin is formed with a drainage slit to enhance the drainage property of the condensed water (see, for example, Document 3). Fig. 10 depicts a configuration of a fin-tube heat exchanger as disclosed in Document 3. As shown in Fig. 10, a fin 131 has a drainage slit 116 defined therein so as to extend obliquely downwardly from a drain (condensed water 113) retention area positioned below a heat-transfer tube 121 along the surface of the fin 131. The drainage slit 116 is intended to quickly discharge the condensed water 113 that accumulates in the drain retention area below the heat-transfer tube 121.

40 **[0014]** The present invention has been developed in view of the problems referred to above and is intended to provide a fin-tube heat exchanger that can enhance the drainage performance of the condensed water adhering to the fin surfaces using an inexpensive working process and is superior in energy efficiency. The present invention is also intended to provide a method of manufacturing such a fin-tube exchanger.

50 Means to Solve the Problems

[0015] In accomplishing the above objective, the present invention is directed to a fin-tube heat exchanger comprising: a plurality of fins arrayed parallel to one another to form flow paths of a gas therebetween; and a heat-transfer tube extending through the plurality of fins to allow a fluid to flow through the heat-transfer tube for

heat exchange with the gas; each of the fins comprising; a plurality of first inclined portions that incline with respect to a direction of airflow so as to form at least one ridge portion; a plurality of tube-surrounding portions located around the heat-transfer tube that extends through each of the fins at a first position and a second position spaced away from each other in a direction of gravitational force; and a plurality of second inclined portions that incline with respect to the direction of airflow, the second inclined portions connecting the tube-surrounding portions and the first inclined portions together, wherein each of the first inclined portions includes a groove portion defined in a surface thereof to connect the second inclined portion at the first position to the second inclined portion at the second position.

Effects of the Invention

[0016] The present invention can provide a fin-tube heat exchanger that can enhance the drainage performance of the condensed water adhering to the fin surfaces using an inexpensive working process and is superior in energy efficiency.

Brief Description of the Drawings

[0017]

Fig. 1 is a perspective view of a fin-tube heat exchanger according to a first embodiment of the present invention.

Fig. 2A is a top plan view of a corrugated fin of the fin-tube heat exchanger according to the first embodiment.

Fig. 2B is a cross-sectional view of the corrugated fin of Fig. 2A taken along a line A-A.

Fig. 2C is a cross-sectional view of the corrugated fin of Fig. 2A taken along a line B-B.

Fig. 3 is a cross-sectional view depicting a configuration of a fin material employed in the fin-tube heat exchanger according to the first embodiment.

Fig. 4 is an explanatory view depicting a state where condensed water accumulates in a corrugated fin of a fin-tube heat exchanger according to a comparative example of the first embodiment.

Fig. 5 is an explanatory view depicting a condensed water drainage action that takes place in the corrugated fin of the fin-tube heat exchanger according to the first embodiment.

Fig. 6 is a cross-sectional view depicting a detailed configuration of a groove portion defined in the fin-tube heat exchanger according to the first embodiment.

Fig. 7 is a cross-sectional view depicting another detailed configuration of the groove portion defined in the fin-tube heat exchanger according to the first embodiment.

Fig. 8 is a top plan view of a corrugated fin of a fin-

tube heat exchanger according to a second embodiment of the present invention.

Fig. 9A is a top plan view of a corrugated fin of a fin-tube heat exchanger according to a third embodiment of the present invention.

Fig. 9B is a cross-sectional view of the corrugated fin of Fig. 9A taken along a line A-A.

Fig. 9C is a cross-sectional view of the corrugated fin of Fig. 9A taken along a line B-B.

Fig. 10 is a top plan view of a fin of a conventional fin-tube heat exchanger.

Embodiment(s) for Carrying out the Invention

[0018] A first aspect of the invention is directed to a fin-tube heat exchanger comprising: a plurality of fins arrayed parallel to one another to form flow paths of a gas therebetween; and a heat-transfer tube extending through the plurality of fins to allow a fluid to flow through the heat-transfer tube for heat exchange with the gas; each of the fins comprising; a plurality of first inclined portions that incline with respect to a direction of airflow so as to form at least one ridge portion; a plurality of tube-surrounding portions located around the heat-transfer tube that extends through each of the fins at a first position and a second position spaced away from each other in a direction of gravitational force; and a plurality of second inclined portions that incline with respect to the direction of airflow, the second inclined portions connecting the tube-surrounding portions and the first inclined portions together, wherein each of the first inclined portions includes a groove portion defined in a surface thereof to connect the second inclined portion at the first position to the second inclined portion at the second position.

[0019] This configuration can efficiently introduce condensed water downwardly in the direction of gravitational force through the groove portion from the second inclined portion where the condensed water mainly accumulates (or from the tube-surrounding portion through the second inclined portion). That is, the condensed water accumulating on the second inclined portion at the first position can be efficiently introduced to another second inclined portion at the second position, which is positioned downwardly of the first position in the direction of gravitational force, through the groove portion. Accordingly, a fin-tube heat exchanger can be provided that can enhance the drainage performance of the condensed water adhering to the fin surfaces and restrain a bridge from being generated between adjacent fins and is superior in energy efficiency. Also, the groove portion can be formed through a comparatively simple working process, thus making it possible to restrain an increase in manufacturing cost associated with the formation of the groove portion.

[0020] A second aspect of the invention is directed to a fin-tube heat exchanger according to the first aspect, wherein the groove portion has an opening of a width dimension of 2 mm or less.

[0021] This configuration creates the effect of the capillary action between the groove portion and the condensed water to thereby further efficiently discharge the condensed water.

[0022] A third aspect of the invention is directed to a fin-tube heat exchanger according to the first or second aspect, wherein in each of the fins, the ridge portion defined by the first inclined portions has a ridge line extending in the direction of gravitational force, and the groove portion extends in the direction of gravitational force.

[0023] This configuration can efficiently discharge the condensed water, which has entered the groove portion, downwardly in the direction of gravitational force.

[0024] A fourth aspect of the invention is directed to a fin-tube heat exchanger according to any one of the first to third aspects, wherein each of the fins comprises a base material and a coating formed on a surface of the base material, and the coating comprises a hydrophilic layer.

[0025] In the presence of the hydrophilic layer, the condensed water accumulating on the tube-surrounding portion or the second inclined portion spreads flatly along the fin surface, thereby making it possible to further restrain the generation of the bridge and easily introduce the condensed water to the groove portion.

[0026] A fifth aspect of the invention is directed to a method of manufacturing the fin-tube heat exchanger according to fourth aspect, comprising: forming the hydrophilic layer on the base material; and subsequently shaping each of the fins by shaping the first inclined portions, the second inclined portions and the groove portion at the same time using the base material.

[0027] In this method, the first inclined portions, the second inclined portions and the groove portion of each fin are shaped at the same time, thus making it possible to provide a fin-tube heat exchanger that is superior in energy efficiency while restraining the manufacturing cost without addition of a new working process.

[0028] Embodiments of the present invention are described hereinafter with reference to the drawings, but the present invention is not limited by the embodiments.

(Embodiment 1)

[0029] Fig. 1 depicts a perspective view of a fin-tube heat exchanger according to a first embodiment of the present invention. As shown in Fig. 1, the fin-tube heat exchanger 100 according to the first embodiment includes a plurality of fins 1 arrayed parallel to one another at predetermined intervals to form flow paths of air A (a gas) and a heat-transfer tube 21 extending through these fins 1. The fin-tube heat exchanger is configured to exchange heat between a medium B flowing through the heat-transfer tube 21 and the air A flowing along surfaces of the fins 1.

[0030] A refrigerant such as, for example, carbon dioxide or hydrofluorocarbon is employed as the medium B. The heat-transfer tube 21 may be made up of only one

tube or branched into a plurality of tubes.

[0031] Figs. 2A, 2B and 2C depict a detailed configuration of each fin 1 according to the first embodiment. As shown in Fig. 2A, the fin 1 is formed with at least one ridge portion 3 that appears with respect to a direction of airflow S. Specifically, the fin 1 has two ridge portions 3 with respect to the direction of airflow S and, as shown in a cross-sectional view of Fig. 2B, the fin 1 is formed as a corrugated fin having a cross-sectional shape generally in the form of an M.

[0032] Also, as shown in Figs. 2B and 2C, the fin 1 is provided with a plurality of tube-surrounding portions 5, a plurality of first inclined portions 6 that incline with respect to the direction of airflow S so as to form the ridge portions 3, and a plurality of second inclined portions 7 that connect the tube-surrounding portions 5 and the first inclined portions 6 together.

[0033] As shown in Fig. 2B, the two ridge portions 3 and a hollow portion 4 positioned therebetween are formed by alternately connecting the first inclined portions 6 having different inclined angles with respect to the direction of airflow S. In the fin 1 according to the first embodiment, ridge lines of the ridge portions 3 and the hollow portion 4 are formed so as to extend along the direction of gravitational force.

[0034] Each tube-surrounding portion 5 is an annular portion disposed so as to surround an associated heat-transfer tube 21 at a location where the heat-transfer tube 21 penetrates the fin 1. As shown in Fig. 2C, in the first embodiment, the tube-surrounding portion 5 is formed as a plane or planar surface extending along the direction of airflow S. Also, as shown in Fig. 2A, the heat-transfer tube 21 penetrates each fin 1 at a plurality of locations spaced away from one another in the direction of gravitational force. The tube-surrounding portions 5 are provided at the locations where the heat-transfer tube 21 penetrates the fin 1.

[0035] Each second inclined portion 7 is a portion provided around one of the tube-surrounding portions 5. As shown in Fig. 2C, each planar tube-surrounding portion 5 and each first inclined portion 6 having an inclined surface are connected to each other by one of the second inclined portions 7 having an inclined surface. Accordingly, as shown in Fig. 2C, a hollowed region surrounded by the inclined surfaces of the second inclined portions 7 is formed around the location where the heat-transfer tube 21 penetrates the fin 1. The hollowed region is a region where condensed water is apt to accumulate.

[0036] The fin 1 according to the first embodiment has a plurality of recessed groove portions 8 defined therein to discharge condensed water that has accumulated on the second inclined portions 7. Specifically, the recessed groove portions 8 are formed in the surfaces of a pair of first inclined portions 6, which form the hollow portion 4, so as to extend in the direction of gravitational force. Each of the groove portions 8 is formed in the vicinity of the hollow portion 4 along an associated one of the ridge portions 3 and the hollow portion 4.

[0037] Also, as shown in Fig. 2A, two adjacent hollow regions (second inclined portions 7) formed around the heat-transfer tube 21, which extends through the fin 1 at a first position P1 and at a second position P2 spaced away from each other in the direction of gravitational force, are connected to each other by the plurality of groove portions 8. That is, each groove portion 8 is formed so as to extend in the direction of gravitational force to connect the hollow regions that are adjacent to each other in the direction of gravitational force and each surrounded by the second inclined portion 7. Preferably, the groove portion 8 is such that at least a portion of a hollow cross-sectional surface thereof is open into the second inclined portion 7 at a connecting portion with the second inclined portion 7.

[0038] When it comes to the surface material of the fin 1, it is preferred that a metal having a water contact angle of 30 degrees or less be used. Also, an oxide layer or corrosion product is formed on the metal if the metal is exposed to air or moisture and, accordingly, in a surface treatment of a base material of the fin 1, a hydrophilic coating is preferably formed on respective surfaces of the base material.

[0039] In this case, as shown in Fig. 3, a base material 9 having a coating 10 on respective surfaces thereof is used. The coating 10 is made up of a corrosion-resistant layer 10a, a hydrophilic layer 10b laminated on the corrosion-resistant layer 10a, and a lubricant layer 10c laminated on the hydrophilic layer 10b. A ferrous material, a copper material or an aluminum material can be used for the base material 9.

[0040] The corrosion-resistant layer 10a is formed through a chromate-phosphate treatment, while an inorganic (liquid glass-based or boehmite-based) layer, an organic resin-based layer, or an organic-inorganic composite layer can be used as the hydrophilic layer 10b. In the first embodiment, a silica/resin-based composite layer that is an organic-inorganic composite layer and has been formed through a chemical conversion treatment is used as the hydrophilic layer 10b.

[0041] Also, the lubricant layer 10c is intended to enhance the lubricating property when the fin material is pressed into the fin 1. If a water-soluble layer is used as the lubricant layer 10c, it readily disappears in the presence of condensed water generated on the fin 1. Accordingly, the hydrophilic property of the hydrophilic layer 10b is not lowered by the lubricant layer 10c formed thereon.

[0042] If at least one of the plurality of layers of the coating 10 is made up of the hydrophilic layer 10b in the above-described manner, the condensed water spreads flatly along the fin surfaces, thus making it possible to restrain a bridge from being generated between adjacent fins and to readily lead the condensed water to the groove portions 8 in a manner explained later.

[0043] In the fin-tube heat exchanger 100 of the above-described construction according to the first embodiment, the action and operation of discharging the condensed water adhering to the fins 1 are explained here-

inafter.

[0044] Fig. 4 is a top plan view of a fin 1 having no groove portions 8 in a fin-tube heat exchanger according to a comparative example of the first embodiment. The same component parts other than the groove portions 8 as those in the fin 1 according to the first embodiment are designated by the same reference numbers and explanation thereof is omitted.

[0045] As shown in Fig. 4, in the fin-tube heat exchanger with no groove portions 8 according to the comparative example, condensed water 13 generated particularly around the heat-transfer tube 21 flows gradually downwardly along the surface of the fin 1 in the direction of gravitational force. This condensed water cannot climb over the ridge portion 3 positioned at the boundary with the first inclined portion 6 and gradually accumulates on the tube-surrounding portion 5 and the second inclined portion 7.

[0046] Upon further generation of the condensed water 13, the amount of accumulated condensed water increases and a bridge is generated between adjacent fins 1 to block a space between them. As a result, the airflow resistance increases and the heat-transfer area of the fin to be utilized for heat exchange with air reduces, thereby giving rise to a reduction in energy efficiency.

[0047] An operation of discharging the condensed water in the fin 1 according to the first embodiment is explained hereinafter with reference to Fig. 5. In Fig. 5, (a), (b), (c) and (d) are shown in order of time from the left. Firstly, as shown in Fig. 5(a), when the condensed water 13 begins accumulating on the second inclined portions 7 at the first position P1, as shown in Fig. 5(b), the accumulated condensed water is introduced into and passes through the groove portions 8, which are respectively connected to lower portions of the second inclined portions 7 in the direction of gravitational force, and is then introduced to the second inclined portions 7 at the second position P2 adjacent to the first position P1 in the direction of gravitational force. Such a condensed water-introducing action of the groove portions 8 conveys the condensed water 13 from the tube-surrounding portion 5 and the second inclined portions 7 both positioned at an upper portion (position P1) in the direction of gravitational force to the next tube-surrounding portion 5 and the next second inclined portions 7 both positioned at a lower portion (position P2) in the direction of gravitational force (Fig. 5(c)). The condensed water-introducing action of the groove portions 8 is repeatedly conducted to thereby convey the condensed water 13 further downwardly (Fig. 5(d)).

[0048] In this way, the condensed water-introducing action of the groove portions 8 can rapidly discharge the condensed water 13 accumulating on the tube-surrounding portion 5 and the second inclined portions 7, thus making it possible to dramatically enhance the drainage performance of the fin 1.

[0049] Although in this first embodiment the groove portions 8 have been described as being formed so as

to connect the second inclined portions 7 adjacent to each other in the direction of gravitational force, the groove portions 8 may be at least held in contact with the second inclined portions 7 formed at a lower portion of the heat-transfer tube 21 in the direction of gravitational force to introduce the condensed water accumulating on the second inclined portions 7 downwardly in the direction of gravitational force.

[0050] Although in the first embodiment two parallel groove portions 8 are formed along the ridge lines of the ridge portions 3 formed by the first inclined portions 6, one or more than three groove portions may be formed. Also, in the first embodiment, the groove portions 8 are formed to avoid the ridge lines of the ridge portions 3 or the hollow portions 4 formed by the first inclined portions 6, but the groove portions may be formed on the ridge lines by further hollowing the ridge portions 3 or the hollow portions 4.

[0051] As shown in Fig. 6, a width dimension L of an opening of each groove portion 8 is preferably 2 mm or less to make use of the capillary action and, in order to further enhance the effect of the capillary action, the width dimension L is preferably 0.5 mm or less. By employing such an opening width dimension, the action of the groove portions 8 for introducing the condensed water 13 can be significantly enhanced.

[0052] Although the shape of each groove portion 8 as shown in Fig. 6 has inclined side surfaces 8a in consideration of a reduction in airflow resistance of air passing between the fins 1, as shown in Fig. 7, the groove portion 8 may have vertically extending side surfaces 8a. Alternatively, the groove portion 8 may be sharpened downwardly (in the form of a V) so as to have opposite side surfaces 8a that meet at a bottom portion 8b.

[0053] In manufacturing the fins 1 of the above-described configuration according to the first embodiment, the first inclined portions 6, the second inclined portions 7 and the groove portions 8 can be shaped at the same time by pressing a base material having coatings formed thereon. Accordingly, an inexpensive fin-tube heat exchanger that is superior in drainage property can be manufactured without addition of a new working process.

(Embodiment 2)

[0054] Fig. 8 is a top plan view of a fin of a fin-tube heat exchanger according to a second embodiment of the present invention. In the second embodiment, the same component parts as those in the first embodiment referred to above are designated by the same reference numbers and explanation thereof is omitted.

[0055] The second embodiment differs from the first embodiment in that the groove portions 8 are provided in the vicinity of the ridge portions 3 of each fin 1.

[0056] As shown in Fig. 8, each groove portion 8 is formed so as to connect two second inclined portions 7 adjacent to each other in the direction of gravitational force along one of the ridge portions 3 of the fin 1.

[0057] In this configuration, because a lower end of each second inclined portion 7 in the direction of gravitational force is held in contact with an upper end of the groove portion 8, condensed water 13 accumulating on the second inclined portion 7 can be smoothly introduced downwardly.

(Embodiment 3)

[0058] Fig. 9A is a top plan view of a corrugated fin of a fin-tube heat exchanger according to a third embodiment of the present invention. Figs. 9B and 9C are cross-sectional views of the corrugated fin. In the third embodiment, the same component parts as those in the first embodiment referred to above are designated by the same reference numbers and explanation thereof is omitted.

[0059] The third embodiment differs from the first embodiment in that, as shown in Figs. 9B and 9C, each fin 15 is formed as a corrugated fin having a cross-sectional shape generally in the form of an inverted V (that is, the fin 15 has only one ridge portion 3 formed thereon).

[0060] As shown in Fig. 9A, each groove portion 8 is formed so as to connect two second inclined portions 7 adjacent to each other in the direction of gravitational force along the ridge portion 3 of the fin 15.

[0061] In general, a V-shaped corrugated fin can be formed so as to have a larger surface area than that of an M-shaped corrugated fin and is accordingly likely to have an increased heat exchanging performance.

[0062] On the other hand, the V-shaped corrugated fin is provided with the flat tube-surrounding portions 5 and the second inclined portions 7 both having larger areas as those of the M-shaped corrugated fin and, accordingly, the area where the condensed water 13 accumulates becomes large, thus posing a problem that the condensed water 13 is likely to accumulate.

[0063] Therefore, the condensed water 13 can be smoothly introduced downwardly in the direction of gravitational force by providing the groove portions 8 in the manner as set forth in the third embodiment, thus making it possible to realize a V-shaped corrugate fin that has an enhanced heat exchanging performance and is superior in drainage performance.

[0064] Although in the above explanation the groove portions 8 have been described as extending in the direction of gravitational force, it is sufficient if the groove portions continuously have components directed downwardly in the direction of gravitational force. By way of example, the groove portions may be inclined or curved with respect to the direction of gravitational force.

[0065] Although in the above explanation the groove portions formed in the fin surfaces have been also described as being able to enhance the drainage property of the condensed water adhering to the fin surfaces, the groove portions can enhance the drainage property of a liquid adhering to the fin surfaces as well as the condensed water.

[0066] Although in the above explanation an example is taken in which a heat medium exchanges heat with air passing through a fin-tube heat exchanger, the heat medium may exchange heat with a gas passing through the fin-tube heat exchanger as well as the air.

[0067] Although the present invention has been fully described by way of preferred embodiments with reference to the accompanying drawings, it is to be noted here that various changes and modifications will be apparent to those skilled in the art. Therefore, unless such changes and modifications otherwise depart from the scope of the present invention as set forth in the appended claims, they should be construed as being included therein.

Industrial Applicability

[0068] As described above, because the fin-tube heat exchanger according to the present invention has the groove portions formed in the fin surfaces to enhance the drainage property, the fin-tube heat exchanger according to the present invention can be utilized as a heat exchanger for use in an air conditioner, a water heater, a heating appliance or the like.

Explanation of reference numerals

[0069]

- 1, 15 fin (corrugated fin)
- 3 ridge portion
- 4 hollow portion
- 5 tube-surrounding portion
- 6 first inclined portion
- 7 second inclined portion
- 8 groove portion
- 9 base material
- 10 coating
- 10a corrosion-resistant layer
- 10b hydrophilic layer
- 10c lubricant layer
- 13 condensed water
- 21 heat-transfer tube
- 100 fin-tube heat exchanger
- P1 first position
- P2 second position
- S direction of airflow
- L width dimension of opening

Claims

1. A fin-tube heat exchanger (100) comprising:

a plurality of fins (1; 15) arrayed parallel to one another to form flow paths of a gas there between; and

a heat-transfer tube (21) extending through the plurality of fins (1; 15) to allow a fluid to flow

through the heat-transfer tube (21) for heat exchange with the gas;

each of the fins (1;15) comprising;

a plurality of first inclined portions (6) that incline with respect to a direction of airflow so as to form at least one ridge portion (3); a plurality of tube-surrounding portions (5) located around the heat-transfer tube (21) that extends through each of the fins (1; 15) at a first position (P1) and a second position (P2) spaced away from each other in a direction of gravitational force; and a plurality of second inclined portions (7) that incline with respect to the direction of airflow, the second inclined (7) portions connecting the tube-surrounding portions (5) and the first inclined (6) portions together,

characterized in that each of the first inclined portions (6) includes a groove portion (8) defined in a surface thereof to connect the second inclined portion (7) at the first position (P1) to the second inclined portion (7) at the second position (P2).

2. The fin-tube heat exchanger according to claim 1, wherein the groove portion (8) has an opening of a width dimension of 2 mm or less.
3. The fin-tube heat exchanger according to claim 1 or 2, wherein in each of the fins (1; 15), the ridge portion (3) defined by the first inclined portions (6) has a ridge line extending in the direction of gravitational force, and the groove portion (8) extends in the direction of gravitational force.
4. The fin-tube heat exchanger according to any one of claims 1 to 3, wherein each of the fins (1; 15) comprises a base material (9) and a coating (10) formed on a surface of the base material (9), and the coating (10) comprises a hydrophilic layer (10b).
5. A method of manufacturing the fin-tube heat exchanger according to claim 4, comprising:

forming the hydrophilic layer on the base material; and

subsequently shaping each of the fins by shaping the first inclined portions, the second inclined portions and the groove portion at the same time using the base material.

Patentansprüche

1. Rippenrohrwärmetauscher (100), enthaltend: eine Vielzahl an Rippen (1;15), welche parallel zu-

einander angeordnet sind, um Strömungspfade für ein Gas dazwischen zu bilden, und

ein Wärmeübertragungsrohr (21), welches sich durch die Vielzahl an Rippen (1; 15) hindurch erstreckt, um einem das Wärmeübertragungsrohr (21) durchströmenden Fluid den Wärmehaustausch mit dem Gas zu ermöglichen; jede der Rippen (1;15) enthaltend:

eine Vielzahl an ersten geneigten Abschnitten (6), welche relativ zur Strömungsrichtung des Gases geneigt sind, um mindestens ein Scheiteltammabschnitt (3) zu bilden; eine Vielzahl an rohrumgebenden Abschnitten (5), welche um das Wärmeübertragungsrohr (21) angeordnet sind, das sich durch jede der Rippen (1, 15) in einer ersten Position (P1) und einer zweiten Position (P2), die in Schwerkraftichtung zueinander beabstandet sind, hindurch erstreckt; und eine Vielzahl an zweiten geneigten Abschnitten (7), welche relativ zur Strömungsrichtung des Gases geneigt sind, wobei die zweiten geneigten Abschnitte (7) die rohrumgebenden Abschnitte (5) mit den ersten geneigten Abschnitten (6) verbinden,

dadurch gekennzeichnet, dass jeder der ersten geneigten Abschnitte (6) einen in seiner Oberfläche ausgebildeten Rinnenabschnitt (8) aufweist, um den zweiten geneigten Abschnitt (7) an der ersten Position (P1) mit dem zweiten geneigten Abschnitt (7) an der zweiten Position (P2) zu verbinden.

2. Rippenrohrwärmetauscher nach Anspruch 1, wobei der Rinnenabschnitt (8) eine Öffnung mit einer Breitenabmessung von 2 mm oder weniger aufweist.
3. Rippenrohrwärmetauscher nach Anspruch 1 oder 2, wobei in jeder der Rippen (1; 15), der Scheiteltammabschnitt (3), welcher durch die ersten geneigten Abschnitte (6) gebildet ist, eine sich in Richtung der Schwerkraft erstreckende Scheiteltammlinie aufweist, und sich der Rinnenabschnitt (8) entlang der Schwerkraftichtung erstreckt.
4. Rippenrohrwärmetauscher nach einem der Ansprüche 1 bis 3, wobei jede der Rippen (1; 15) ein Grundmaterial (9) und eine Beschichtung (10), die auf dem Grundmaterial (9) gebildet ist, aufweist, und die Beschichtung (10) eine hydrophile Schicht (10b) enthält.
5. Fertigungsverfahren für den Rippenrohrwärmetauscher nach Anspruch 4, enthaltend:

Bilden der hydrophilen Schicht (10b) auf dem Grundmaterial (9); und anschließendes Formen jeder der Rippen durch zeitgleiches Formen der ersten geneigten Abschnitte (6), der zweiten geneigten Abschnitte (7) und des Rinnenabschnitts (8) unter Verwendung des Grundmaterials (9).

10 Revendications

1. Échangeur de chaleur à tube à ailettes (100) comprenant :

une pluralité d'ailettes (1 ; 15) disposées parallèlement les unes aux autres pour former des trajets d'écoulement d'un gaz entre celles-ci ; et un tube de transfert de chaleur (21) s'étendant à travers la pluralité d'ailettes (1 ; 15) pour permettre à un fluide de s'écouler à travers le tube de transfert de chaleur (21) pour un échange de chaleur avec le gaz ; chacune des ailettes (1 ; 15) comprenant ;

une pluralité de premières parties inclinées (6) qui s'inclinent par rapport à une direction d'écoulement d'air de façon à former au moins une partie de crête (3) ;

une pluralité de parties entourant le tube (5) situées autour du tube de transfert de chaleur (21) qui s'étend à travers chacune des ailettes (1 ; 15) à une première position (P1) et une seconde position (P2) espacées l'une de l'autre dans une direction de force de gravitation ; et

une pluralité de secondes parties inclinées (7) qui s'inclinent par rapport à la direction d'écoulement d'air, les secondes parties inclinées (7) reliant les parties entourant le tube (5) et les premières parties inclinées (6) ensemble,

caractérisé en ce que chacune des premières parties inclinées (6) comprend une partie de rainure (8) définie dans une surface de celle-ci pour relier la seconde partie inclinée (7) au niveau de la première position (P1) à la seconde partie inclinée (7) au niveau de la seconde position (P2).

2. Échangeur de chaleur à tube à ailettes selon la revendication 1, dans lequel la partie de rainure (8) a une ouverture d'une dimension de 2 mm ou moins de large.
3. Échangeur de chaleur à tube à ailettes selon la revendication 1 ou 2, dans lequel, chacune des ailettes (1 ; 15), la partie de crête (3) définie par les premières parties inclinées (6) présente une ligne de crête

s'étendant dans la direction de force de gravitation, et la partie de rainure (8) s'étend dans la direction de force de gravitation.

4. Échangeur de chaleur à tube à ailettes selon l'une quelconque des revendications 1 à 3, dans lequel chacune des ailettes (1 ; 15) comprend un matériau de base (9) et un revêtement (10) formé sur une surface du matériau de base (9), et le revêtement (10) comprend une couche hydrophile (10b). 5 10

5. Procédé de fabrication de l'échangeur de chaleur à tube à ailettes selon la revendication 4, comprenant :

la formation de la couche hydrophile sur le matériau de base ; et 15
par la suite, la mise en forme de chacune des ailettes par mise en forme des premières parties inclinées, des secondes parties inclinées et de la partie de rainure en même temps à l'aide du 20
matériau de base.

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Fig. 1

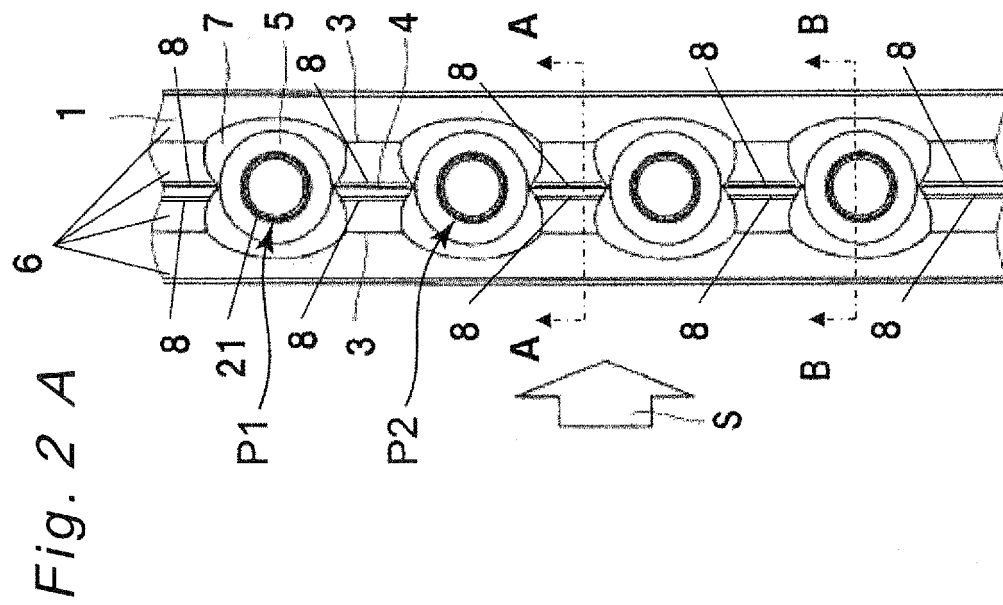
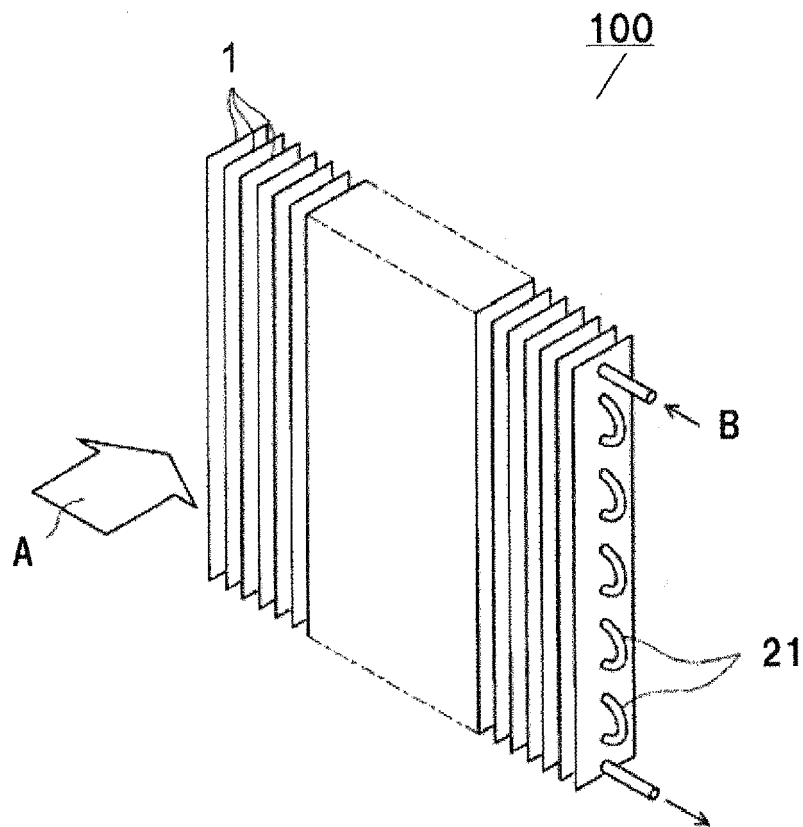


Fig. 2 B

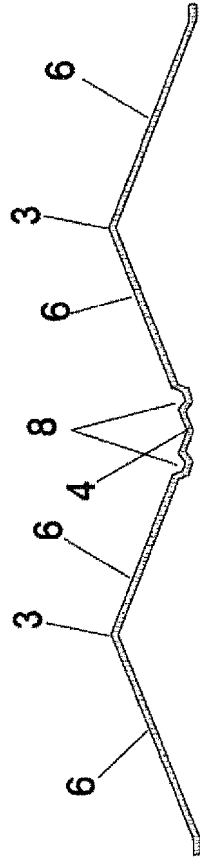


Fig. 2 C

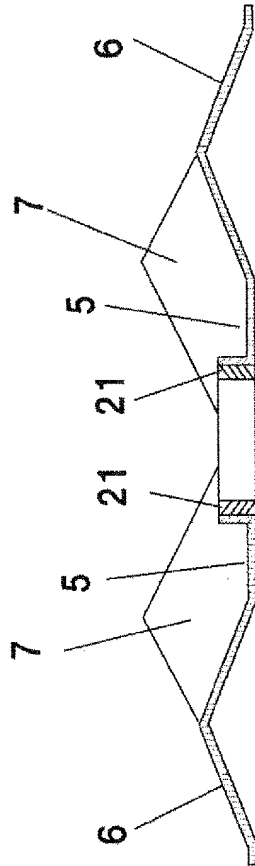


Fig. 3

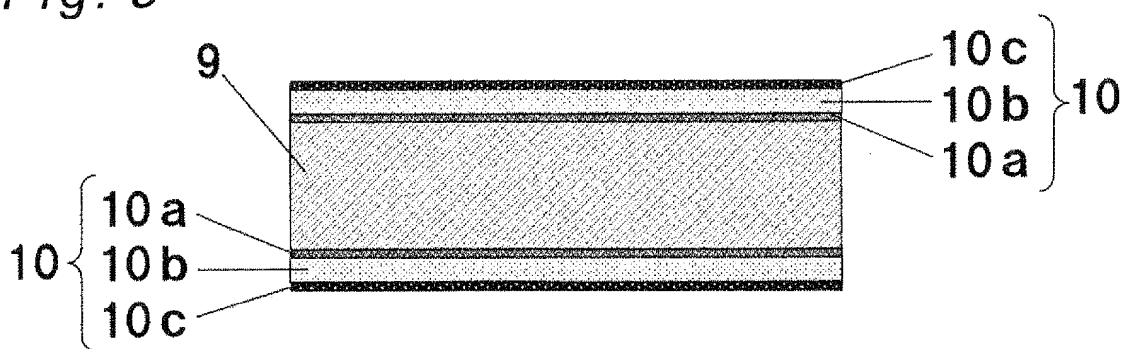


Fig. 4

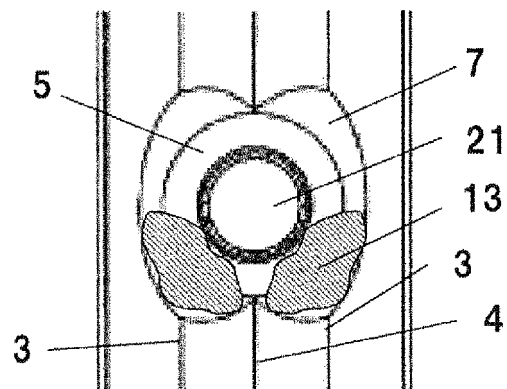


Fig. 5

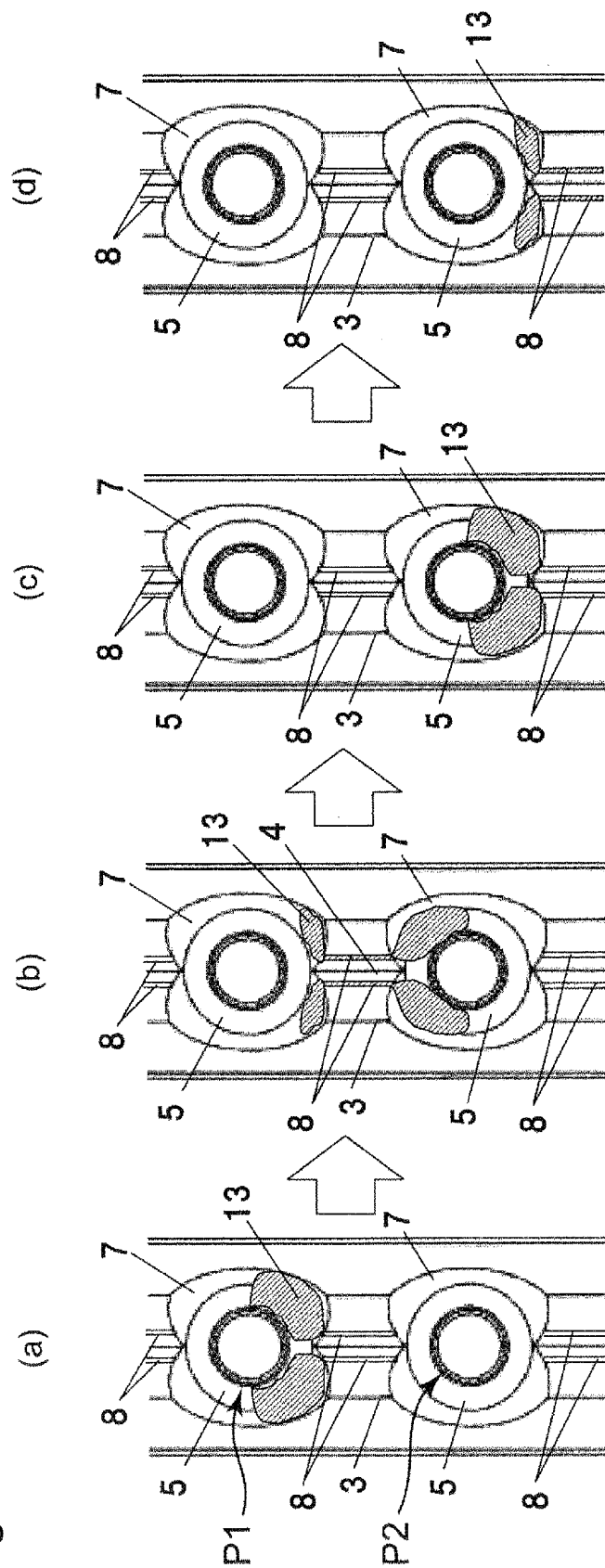


Fig. 6

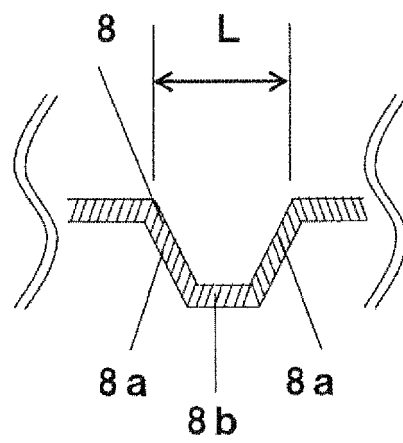


Fig. 7

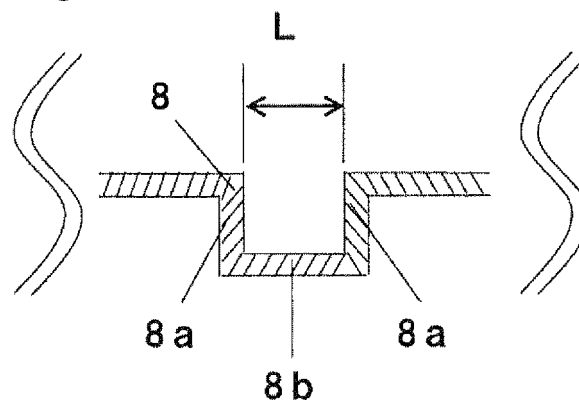


Fig. 8

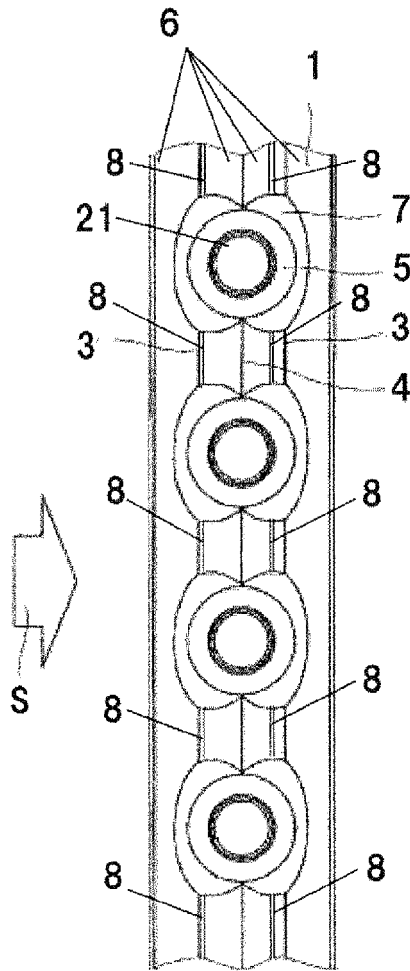


Fig. 9 A

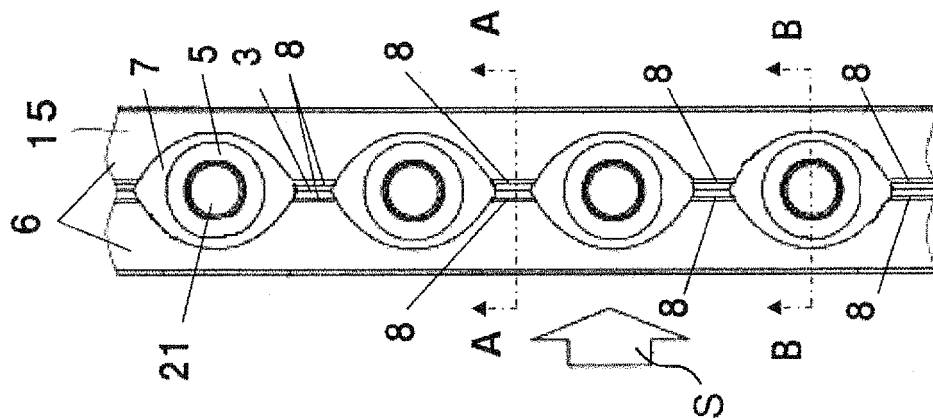


Fig. 9 B

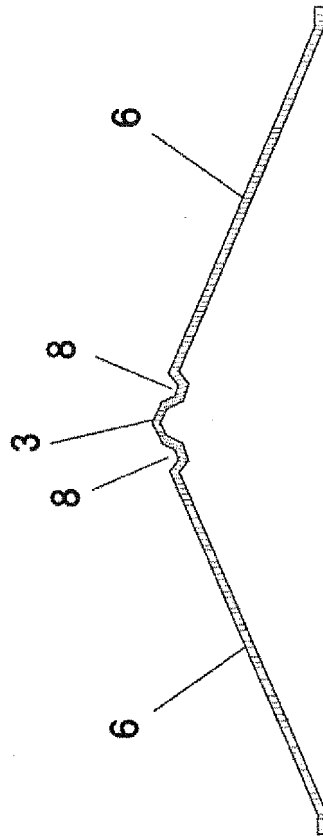


Fig. 9 C

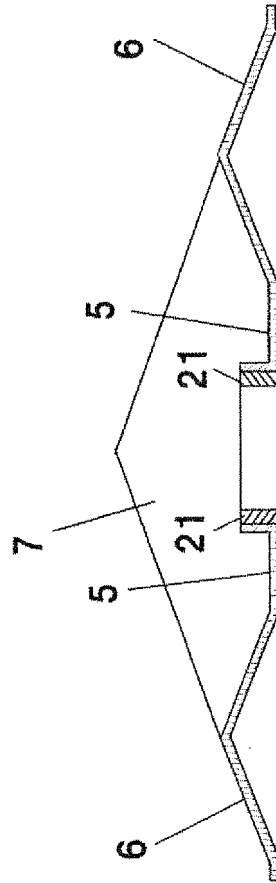
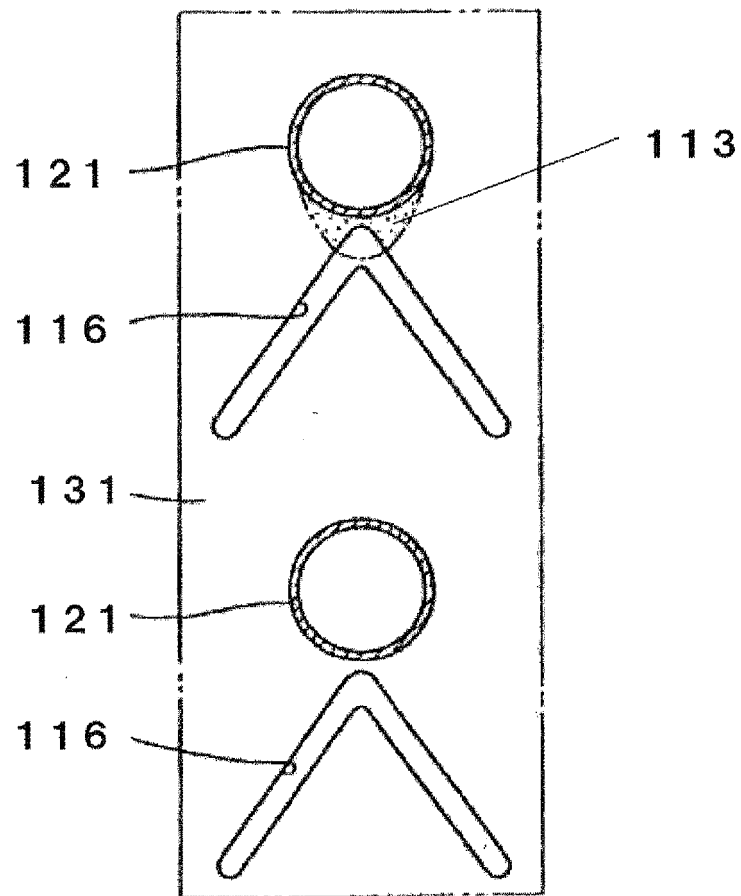


Fig. 1 0



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2010175131 A [0009]
- JP 6422186 B [0009]
- EP 0789216 A [0010]

Non-patent literature cited in the description

- **HIDEKIMI HIRASAWA.** Surface Treatment Technology for a Precoated aluminum fin material. *Surface Technology*, 2006, vol. 57 (2), 127 [0008]