(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 863 161 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
22.04.2015 Bulletin 2015/17

(21) Application number: **12875231.8**

(22) Date of filing: **26.04.2012**

(51) Int Cl.:
F28F 9/26 *(2006.01)*

(86) International application number:
PCT/JP2012/061232

(87) International publication number:
WO 2013/161038 (31.10.2013 Gazette 2013/44)

(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
Designated Extension States:
BA ME

(71) Applicant: **Mitsubishi Electric Corporation**
Tokyo 100-8310 (JP)

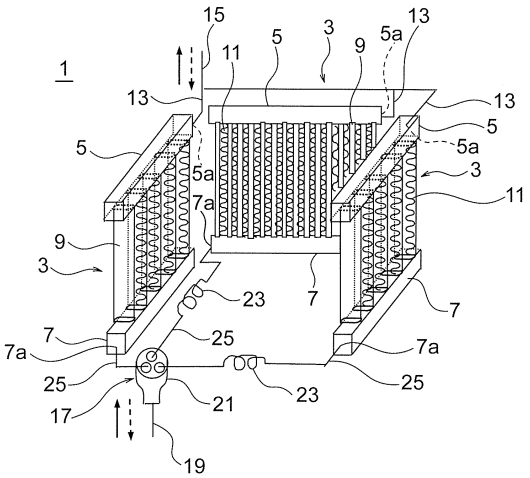
(72) Inventors:
- **OKAZAKI, Takashi**
  Tokyo 100-8310 (JP)
- **ISHIBASHI, Akira**
  Tokyo 100-8310 (JP)
- **LEE, Sangmu**
  Tokyo 100-8310 (JP)
- **MATSUDA, Takuya**
  Tokyo 100-8310 (JP)

(74) Representative: **Pfenning, Meinig & Partner GbR**
Patent- und Rechtsanwälte
Theresienhöhe 11a
80339 München (DE)

(54) HEAT EXCHANGER AND HEAT EXCHANGE METHOD

(57) Even with a plurality of heat exchange function surface units, a heat exchanger (1) can suppress an influence of the gravity exerted on refrigerant and suppress reduction of heat exchange performance in each of the surfaces. The heat exchanger (1) has the plurality of heat exchange function surface units (3), and includes an upper header pipe (5), a lower header pipe (7), and a plurality of heat exchange pipes (9) provided between the pair of upper and lower header pipes in each of the heat exchange function surface units. The plurality of heat exchange function surface units have a parallel connection relationship, and a plurality of the lower header pipes are connected to a lower collection pipe (19) through a branch current adjusting section (17).

FIG. 1



EP 2 863 161 A1

Description

Technical Field

[0001] The present invention relates to a heat exchanger and a heat exchange method.

Background Art

[0002] As one type of the heat exchanger, a parallel flow type heat exchanger is given. This heat exchanger includes a pair of header pipes, and a plurality of flat pipes provided between those header pipes. This heat exchanger is configured so that after a fluid, which has flowed into one of the headers, flows through the plurality of flat pipes, the fluid flows out to the other of the header pipes.

[0003] In this parallel flow type heat exchanger, when the pair of header pipes is arranged in a vertical up-and-down direction, due to an influence of the gravity, liquid refrigerant in gas-liquid two phase refrigerant is liable to flow into flat pipes positioned on a relatively lower side, thereby being difficult to equally distribute the refrigerant to the plurality of flat pipes.

[0004] Therefore, the parallel flow type heat exchanger may have such a structure that the pair of header pipes is horizontally arranged, to thereby suppress the influence of the gravity mutually between the plurality of flat pipes.

[0005] On the other hand, an existing outdoor unit of an air conditioner may have such a structure that heat exchange surfaces are arranged in a plurality of surfaces of a housing of the outdoor unit. When the above-mentioned parallel flow type heat exchanger having the pair of header pipes horizontally arranged is caused to exert its function in the plurality of surfaces of the housing of the outdoor unit, it is necessary to curve each of the header pipes along the plurality of surfaces. However, when the header pipe is curved into, for example, an L-shape or a U-shape, significant loads are applied, and hence there arise problems in that the apparatus is upsized and cost is increased.

[0006] To address those problems, for example, a heat exchanger disclosed in Patent Literature 1 is given. In the heat exchanger disclosed in Patent Literature 1, a pair of header pipes has been prepared separately for each of a plurality of surfaces.

Citation List

Patent Literature

[0007] [PTL 1] JP 2010-107103 A

Summary of Invention

Technical Problem

[0008] However, the above-mentioned heat exchanger disclosed in Patent Literature 1 has employed such a mode that after the refrigerant, which has flowed through a plurality of flat pipes in certain one surface (first surface), is collected to the header pipe on the outflow side of the one surface (first surface), the refrigerant is guided from this header pipe to the header pipe on the inflow side of the next surface (second surface) and distributed through a plurality of flat pipes of the next surface (second surface), and subsequently, the refrigerant is likewise guided to the next surface in sequence depending on the number of surfaces.

[0009] For this reason, an upstream/downstream relationship is generated among a plurality of heat exchange function surface units, and heat exchange efficiency is more reduced in the surface of the downstream side. In addition, the branch to a plurality of flat pipes and the collection following the branch are repeated, and hence there is a fear in that in the second and subsequent surfaces, the refrigerant after the heat exchange cannot be suitably branched to the plurality of flat pipes again.

[0010] The present invention has been made in view of the foregoing, and it is therefore an object of the present invention to provide a heat exchanger and the like, each of which is capable of suppressing, even with a plurality of heat exchange function surface units, an influence of the gravity exerted on refrigerant, and suppressing reduction of heat exchange performance in each of the surfaces.

Solution to Problem

[0011] In order to achieve the above-mentioned object, according to one embodiment of the present invention, there is provided a heat exchanger comprising: a plurality of heat exchange function surface units; each of the plurality of heat exchange function surface units having an upper header pipe, a lower header pipe, and a plurality of heat exchange pipes provided between a pair of the upper header pipe and the lower header pipe; the plurality of heat exchange function surface units having a parallel connection relationship; a plurality of the lower header pipes being connected to a lower collection pipe through a branch current adjusting section.

[0012] Further, in order to achieve the same object, according to another embodiment of the present invention, there is provided a heat exchange method of carrying out heat exchange in a plurality of surfaces, the heat exchange method including: preparing an upper header pipe, a lower header pipe, and a plurality of heat exchange pipes provided between a pair of the upper header pipe and the lower header pipe in each of a plurality of heat exchange function surface units; connecting the plurality of heat exchange function surface units in par-

allel, and connecting a plurality of the lower header pipes to a lower collection pipe through a branch current adjusting section; and branching, by the branch current adjusting section, refrigerant inside the lower collection pipe in parallel to the plurality of heat exchange function surface units, subjecting the refrigerant to the heat exchange in the each of the plurality of heat exchange function surface units, and causing the refrigerant to flow out from a plurality of the upper header pipes so as to be joined together to an upper side collection pipe.

Advantageous Effects of Invention

[0013] According to one embodiment of the present invention, it is possible to suppress, even with the plurality of heat exchange function surface units, the influence of the gravity exerted on the refrigerant, and suppress the reduction of the heat exchange performance in each of the surfaces.

Brief Description of Drawings

[0014]

FIG. 1 is a view illustrating a structure of a heat exchanger according to a first embodiment of the present invention.
FIG. 2 is a perspective view of a lower header pipe, for illustrating a perforated pipe.
FIG. 3 is a diagram illustrating liquid distribution characteristics of a lower header pipe as an example for comparing.
FIG. 4 is a diagram illustrating liquid distribution characteristics of a perforated pipe built-in type lower header pipe according to the first embodiment of the present invention.
FIG. 5 is a view illustrating an external appearance and plan view of a multi-air conditioner outdoor unit for a building according to the first embodiment of the present invention.
FIG 6 is a view illustrating an external appearance and plan view of a package air conditioner outdoor unit according to a second embodiment of the present invention.

Description of Embodiments

[0015] Now, a heat exchanger and a heat exchange method according to embodiments of the present invention are described with reference to the accompanying drawings. Note that, in the drawings, the same reference symbols represent the same or corresponding parts.

First Embodiment

[0016] FIG. 1 is a view illustrating a structure of a heat exchanger according to a first embodiment of the present invention. The heat exchanger of this embodiment functions as an outdoor unit of an air conditioner that is installed in a space of intended use, and carries out heating and cooling. Therefore, the heat exchanger is a parallel flow type heat exchanger in which when the heat exchanger operates as a condenser in a phase of the cooling, refrigerant flows from the top to the bottom as indicated by dotted line arrows in FIG. 1, and when the heat exchanger operates as an evaporator in a phase of the heating, the refrigerant flows from the bottom to the top as indicated by solid line arrows in FIG. 1.

[0017] A heat exchanger 1 has a plurality of heat exchange function surface units 3. Note that, FIG. 1 illustrates an example in which three heat exchange function surface units 3 are provided. In addition, in the example of FIG. 1, the adjacent heat exchange function surface units 3 are structured so as to be directed orthogonal to each other.

[0018] An upper header pipe 5, a lower header pipe 7, and a plurality of heat exchange pipes 9 provided between the pair of upper and lower header pipes 5, 7 are provided in each of the heat exchange function surface units 3. Specifically, a flat pipe is used as the heat exchange pipe 9. A fin 11 (specifically, a corrugated fin) is provided between the heat exchange pipes 9.

[0019] One end of an upper communication pipe 13 is connected to each of the upper header pipes 5. The other end side of the upper communication pipe 13 is connected to an upper collection pipe 15. Each of the lower header pipes 7 is connected to a lower collection pipe 19 through a branch current adjusting section 17 described later. In such a manner, the plurality of heat exchange function surface units 3 are arranged in a parallel connection relationship between the upper collection pipe 15 and the lower collection pipe 19. Note that, although an illustration is omitted, it is assumed that a pair of the adjacent heat exchange function surface units 3 is covered with a blocking member such as a metallic plate so that the fluid to be subjected to the heat exchange is not bypassed.

[0020] The branch current adjusting section 17 serves to adjust a dryness and a flow rate of the refrigerant to be supplied to the plurality of lower header pipes 7. Note that, as an example, this embodiment is described in the form of a configuration in which when the refrigerant flows from the bottom to the top in the phase of the heating, gas-liquid two phase refrigerant is supplied to the plurality of heat exchange function surface units 3 with the equal dryness and flow rate.

[0021] As an example of a configuration for realizing the equalization of such a dryness and a flow rate, the branch current adjusting section 17 includes a distributer 21 and at least one (two in the illustration) flow rate adjusting section 23. One end side of the distributer 21 is connected to the lower collection pipe 19, and a plurality of connection ports on the other end side thereof are connected to ends on one side of corresponding lower communication pipes 25. In addition, ends on the other side of the lower communication pipes 25 are connected

to collection side inlet and outlet ports 7a of the corresponding lower header pipes 7, respectively. The distributer 21 connected in such a manner supplies the refrigerant to the plurality of lower communication pipes 25 with the equal dryness.

[0022] In the illustrated example, a capillary is used as the flow rate adjusting section 23. Although the flow rate adjusting section 23 is provided between the distributer 21 and the corresponding lower header pipe 7, that is, in the lower communication pipe 25, the flow rate adjusting section 23 is not necessarily arranged in all the lower communication pipes 25.

[0023] In each of the heat exchange function surface units 3, the collection side inlet and outlet port 7a of the lower header pipe 7 and a collection side inlet and outlet port 5a of the upper header pipe 5 are positioned mutually opposite to each other in a direction in which the header pipe extends. In other words, the collection side inlet and outlet port 7a of the lower header pipe 7 is provided on one end side of the lower header pipe 7, and the collection side inlet and outlet port 5a of the upper header pipe 5 is provided on the other end side of the upper header pipe 5. That is, refrigerant distribution paths between the collection side inlet and outlet port 5a and the collection side inlet and outlet port 7a are designed so as to be approximately equal in flow path length even via any of the heat exchange pipes 9.

[0024] As illustrated in FIG. 2, a perforated pipe 27 is provided inside each of the lower header pipes 7. FIG. 2 is a perspective view of the lower header pipe, for illustrating the perforated pipe. The plurality of heat exchange pipes 9 and communication holes with the plurality of heat exchange pipes 9, which are supposed to be positioned above the lower header pipe 7, are omitted in illustration thereof.

[0025] The perforated pipe 27 is a block-shaped or pipe-shaped member, and is provided approximately in the vicinity of the center of the space inside the lower header pipe 7 in a state in which the perforated pipe 27 is floated from an inner surface of the lower header pipe 7. In addition, a large number of distribution holes 29 are formed in the perforated pipe 27. As an example, the distribution holes 29 are arranged approximately in the lower section of the perforated pipe 27.

[0026] A double pipe structure is obtained by a combination of such a perforated pipe 27 and the lower header pipe 7. Therefore, for example, in the phase of the heating, after the refrigerant, which flows through the lower communication pipe 25, temporarily flows into the perforated pipe 27, the refrigerant equally flows out from the large number of distribution holes 29 to the outside of the perforated pipe 27 in a depth direction (in a horizontal direction of the drawing sheet of FIG. 2). Further, the refrigerant is equally dispersed inside the lower header pipe 7 to be equally supplied from the communication holes (not shown) of the upper surf ace of the lower header pipe 7 to the plurality of heat exchange pipes 9.

[0027] Next, a description is made of the effects of the perforated pipe described above. FIG. 3 is a diagram illustrating liquid distribution characteristics of a lower header pipe as an example for comparing, which is horizontally arranged and does not have the perforated pipe. FIG. 4 is a diagram illustrating liquid distribution characteristics of a perforated pipe built-in type lower header pipe according to this embodiment, which is horizontally arranged.

[0028] In addition, in graph parts of FIG. 3 and FIG. 4, an axis of abscissa represents a path number, that is, numbers of flow paths of the heat exchange pipes arranged in the depth direction of the lower header pipe (flow paths of 28 flat pipes vertically inserted into the upper surface of the lower header pipe). An axis of ordinate represents a liquid distribution ratio for each path number. In addition, experimental results of three cases 1, 2, and 3 are shown, in which a refrigerant flow rate Gr [kg/hour] and an inlet port dryness X are changed with respect to the lower header pipes of the example for comparing and this embodiment.

[0029] First, in the example for comparing illustrated in FIG. 3, in the cases 1 and 3 in which the refrigerant flow rates Gr are each 90 [kg/hour] and the inlet port drynesses X are different from each other, the effect is not exhibited that the refrigerant is held in contact with the inside of a lower header pipe 7', and hence does not bounce off the inside of the lower header pipe 7'. Therefore, it is understood that the refrigerant directly flows into the heat exchange pipes 9, and hence the liquid distribution ratio is larger in the downstream region (the path numbers of No. 23 to 28). In addition, in the case 2 exhibiting the flow rate of 180 [kg/hour], which is more than that of each of the case 1 and the case 3, due to the presence of the liquid refrigerant that is abundantly supplied, the effect that the liquid refrigerant bounces off the inside of the lower header pipe 7', or the flow is disturbed provides the tendency to relax imbalance characteristics of the liquid to a certain extent. However, any of the cases is out of an example of an equal distribution line indicated in parallel with the axis of abscissa.

[0030] On the other hand, in the perforated pipe built-in type lower header pipe of this embodiment illustrated in FIG. 4, it is understood that the satisfactory liquid distribution characteristics shown approximately along the equal distribution line are obtained in the three cases 1, 2, and 3 irrespective of the refrigerant flow rate and the inlet port dryness. This results from the following fact. That is, the perforated pipe 27 is inserted into the lower header pipe 7, and the distribution holes 29 of the perforated pipe 27 are arranged in a downward direction of the perforated pipe 27. In this way, an operation for stirring a liquid film of the refrigerant, which exists in an annular region surrounded by an inner surface of the lower header pipe 7, and an outer surface of the perforated pipe 27, by bubbles ejected from the bottom of the perforated pipe 27 is desirably obtained irrespective of the inlet port dryness and the flow rate. As a result, the equal distribution of the refrigerant is realized.

[0031] Subsequently, a description is made of a specific application example of the above-mentioned heat exchanger illustrated in FIG. 1. Although this embodiment exemplifies such a mode that the refrigerant dryness and the refrigerant flow rate are equally adjusted for the plurality of heat exchange function surface units 3, an application to a multi-air conditioner outdoor unit for a building is given as the specific application example. FIG. 5 is a view illustrating an outer appearance and plan view of the multi-air conditioner outdoor unit for a building. The multi-air conditioner outdoor unit for a building is employed as a high-performance apparatus that is larger in size than an outdoor unit for general home use.

[0032] As illustrated in FIG. 5, in a multi-air conditioner outdoor unit 101 for a building, the heat exchange function surface units 3 are allocated to three surfaces of a housing 103, respectively. In plan view, a propeller fan 105 is arranged at the center of these heat exchange function surface units 3. In addition, as indicated by arrows 107, air is drawn into the housing 103 from three side surfaces of the housing 103 and is subjected to the heat exchange in the heat exchange function surface units 3. Then, as indicated by arrows 111, the air is ejected from an air outlet formed in a fan guard 109 provided on an upper surface of the housing 103 (top-flow type).

[0033] Next, a description is made of an operation of the heat exchanger constructed in such a manner and the heat exchange method according to this embodiment. In the phase of the heating operation, the heat exchanger 1 serving as the outdoor unit operates as an evaporator. The gas-liquid two phase refrigerant, which has entered the distributer 21, becomes a uniform mist flow when passing through an orifice (not shown) to be supplied to each of the lower communication pipes 25. Then, the uniform mist flow is adjusted in flow rate thereof in each of the flow rate adjusting sections 23 to flow into the lower header pipe 7 of the corresponding heat exchange function surface unit 3. The refrigerant, which has flowed into the lower header pipe 7 through the collection side inlet and outlet port 7a of the lower header pipe 7, is ejected from the distribution holes 29 of the perforated pipe 27 to be equally distributed to the heat exchange pipes 9. In the perforated pipe 27, when the dryness is large, minute droplets are ejected from the small holes. When the dryness is small, the bubbles are ejected to the liquid part collected in the annular section. Therefore, the equal distribution is realized independently of the dryness and the flow rate. After the refrigerant is subjected to the heat exchange with the air (not shown) when having passed through the heat exchange pipes 9, the refrigerant flows into the upper header pipe 5 and then flows out through the collection side inlet and outlet port 5a on the opposite side to the collection side inlet and outlet port 7a of the lower header pipe 7. The refrigerant, which has flowed out through each of the collection side inlet and outlet ports 5a, passes through the corresponding upper communication pipe 13 to join another refrigerant in the upper collection pipe 15. Note that, in the phase of the cooling operation, the heat exchanger 1 operates as the condenser, and hence the flow of the refrigerant is reversed.

[0034] As has been described so far, according to the heat exchanger and the heat exchange method using the heat exchanger of the present invention, the following advantages are obtained. First, in the heat exchange function surface units, the header pipes are directed in the horizontal direction, and hence the influence of the gravity can be suppressed for the refrigerant distribution, and the refrigerant can be equally distributed to the plurality of heat exchange pipes. In addition, although the header pipes are horizontally arranged in such a manner, a plurality of surfaces can be controlled to exhibit the heat exchange function without being impeded by the actual situation that the curve of the header pipe is difficult to form. Moreover, although the heat exchange is carried out in a plurality of surfaces, the refrigerant is branched in distribution thereof in parallel to the plurality of heat exchange function surface units. Therefore, the upstream/downstream relationship is not generated mutually among the plurality of heat exchange function surface units, and hence the satisfactory heat exchange efficiency can be maintained in each of the heat exchange function surface units. In particular, in this embodiment, after the dryness and the flow rate of the refrigerant have been desirably adjusted depending on the conditions of the heat exchange function surface units through the distributor and the flow rate adjusting section, the refrigerant is supplied to the heat exchange function surface units in a distributive manner. Therefore, the very satisfactory heat exchange performance can be obtained in all the heat exchange function surface units. In addition, the entire heat exchanger does not have such a flow path that the refrigerant, which has been subjected to the heat exchange in the plurality of heat exchange pipes, is collected once, and is branched to the plurality of heat exchange pipes again. Therefore, there is no such problem that the refrigerant cannot be equally supplied to the plurality of heat exchange pipes. In such a manner, according to the heat exchanger and the heat exchange method of this embodiment, even with the plurality of heat exchange function surface units, the influence of the gravity exerted on the refrigerant can be suppressed, and the reduction of the heat exchange performance in each of the surfaces can be suppressed.

[0035] In addition, in each of the heat exchange function surface units, the inlet and outlet port of the lower header pipe and the inlet and outlet port of the upper header pipe are arranged on opposite sides to each other. Therefore, even when the refrigerant passes through any of the heat exchange pipes, the pressure losses become approximately equal to each other, that is, the equal distribution of the gas-liquid two phase flow can be realized. In addition, the perforated pipe is provided inside the lower header pipe, with the result that the minute droplets or the bubbles are ejected from the distribution holes to the annular section of the double structure, to

thereby also promote the equal distribution of the gas-liquid two phase refrigerant. Moreover, in this embodiment, the number of distributions to the heat exchange pipes is increased, and the number of times of the distribution is suppressed low (in the example described above, the number of times of the distribution is only one). Therefore, although innumerable heat exchange pipes are used in order to prepare the plurality of heat exchange function surface units, the refrigerant pressure loss can be suppressed low relative to the number of heat exchange pipes. Therefore, in particular, low-pressure refrigerant (such as refrigerant exhibiting a large refrigerant pressure loss), for example, HFO1234yf, HFO1234ze, or R134a can also be effectively utilized.

Second Embodiment

[0036] A description is made of a second embodiment of the present invention with reference to FIG. 6. The first embodiment described above exemplifies such a mode that the refrigerant dryness is equally adjusted for the plurality of heat exchange function surface units, and the refrigerant flow rate is changed depending on the heat loads (mainly depend on the passing air velocity in the heat exchange section), which are different from one another in the heat exchange function surface units. However, the present invention is not limitedtothatmode. That is, the present invention also encompasses such a mode that the refrigerant drynesses and/or the refrigerant flow rates are adjusted so as to be different from one another in the plurality of heat exchange function surface units. As a specific application example, an application to a package air conditioner outdoor unit is given. FIG. 6 illustrates an external appearance and plan view of the application to the package air conditioner outdoor unit.

[0037] As illustrated in FIG. 6, in a package air conditioner outdoor unit 201, the heat exchange function surface units 3 are allocated to a side surface and a back surface of a housing 203, respectively. By rotation of a propeller fan 205, as indicated by arrows 207, the air is drawn into the housing 203 from the side surface and the back surface of the housing 203, and is subjected to the heat exchange in the heat exchange function surface units 3. Then, as indicated by arrows 211, the air is ejected from an air outlet provided in the front surface of the housing 203.

[0038] According to the second embodiment as well, similarly to the first embodiment, even with the plurality of heat exchange function surface units, the influence of the gravity exerted on the refrigerant can be suppressed, and the reduction of the heat exchange performance in each of the surfaces can be suppressed.

[0039] The details of the present invention have been described above specifically with reference to the preferred embodiments, but it is apparent that a person skilled in the art may employ various modifications based on the basic technical thoughts and teachings of the present invention.

[0040] For example, although in the perforated pipe described above, the large number of distribution holes have been described as being provided in the downward direction, the mode of formation of the distribution holes isnot limited thereto, and the orientation, the number, and the hole shape of the distribution holes may be suitably changed. In addition, the structure of the branch current adjusting section described above is also merely an example, and hence may be suitably changed. For example, there may also be used a branch current adjusting section having such a mode that height positions of a plurality of outlet port side branching pipes such as Y-shaped branching pipes or low-pressure loss distributers are made different from one another, a rate of a branch current of a liquid phase is changed by an influence of the gravity, and the dryness and the flow rate are simultaneously adjusted.

Reference Signs List

[0041]

heat exchanger, 3 heat exchange function surface unit, 5 upper header pipe, 7 lower header pipe, 5a, 7a collection side inlet and outlet port, 9 heat exchange pipe, 17 branch current adjusting section, 19 lower collection pipe, 21 distributer, 23 flow rate adjusting section, 25 lower communication pipe, 27 perforated pipe, 29 distribution hole.

Claims

1. A heat exchanger comprising:

a plurality of heat exchange function surface units;
each of the plurality of heat exchange function surface units having an upper header pipe, a lower header pipe, and a plurality of heat exchange pipes provided between a pair of the upper header pipe and the lower header pipe;
the plurality of heat exchange function surface units having a parallel connection relationship;
a plurality of the lower header pipes being connected to a lower collection pipe through a branch current adjusting section.

2. A heat exchanger according to claim 1,
wherein the branch current adjusting section comprises a distributer and at least one flow rate adjusting section,
wherein the distributer is provided between the lower collection pipe and the plurality of the lower header pipes, and equalizes a dryness of refrigerant to be supplied to the plurality of the lower header pipes, and
wherein the at least one flow rate adjusting section

is arranged between the distributer and a corresponding one of the plurality of the lower header pipes.

3. A heat exchanger according to claim 1 or 2, wherein each of the plurality of the lower header pipes comprises a perforated pipe arranged thereinside.

4. A heat exchanger according to any one of claims 1 to 3, wherein in the each of the plurality of heat exchange function surface units, a collection side inlet and outlet port of the lower header pipe is provided on one end side of the lower header pipe, and a collection side inlet and outlet port of the upper header pipe is provided on another end side of the upper header pipe.

5. A heat exchanger according to any one of claims 1 to 4, wherein the refrigerant to be used comprises HFO1234yf, HFO1234ze, or R134a as low-pressure refrigerant.

6. A heat exchange method of carrying out heat exchange in a plurality of surfaces, the heat exchange method comprising:

preparing an upper header pipe, a lower header pipe, and a plurality of heat exchange pipes provided between a pair of the upper header pipe and the lower header pipe in each of a plurality of heat exchange function surface units;
connecting the plurality of heat exchange function surface units in parallel, and connecting a plurality of the lower header pipes to a lower collection pipe through a branch current adjusting section; and
branching, by the branch current adjusting section, refrigerant inside the lower collection pipe in parallel to the plurality of heat exchange function surface units, subjecting the refrigerant to the heat exchange in the each of the plurality of heat exchange function surface units, and causing the refrigerant to flow out from a plurality of the upper header pipes so as to be joined together to an upper side collection pipe.

7. A heat exchange method according to claim 7, wherein the refrigerant to be used comprises HFO1234yf, HFO1234ze, or R134a as low-pressure refrigerant.

FIG. 1

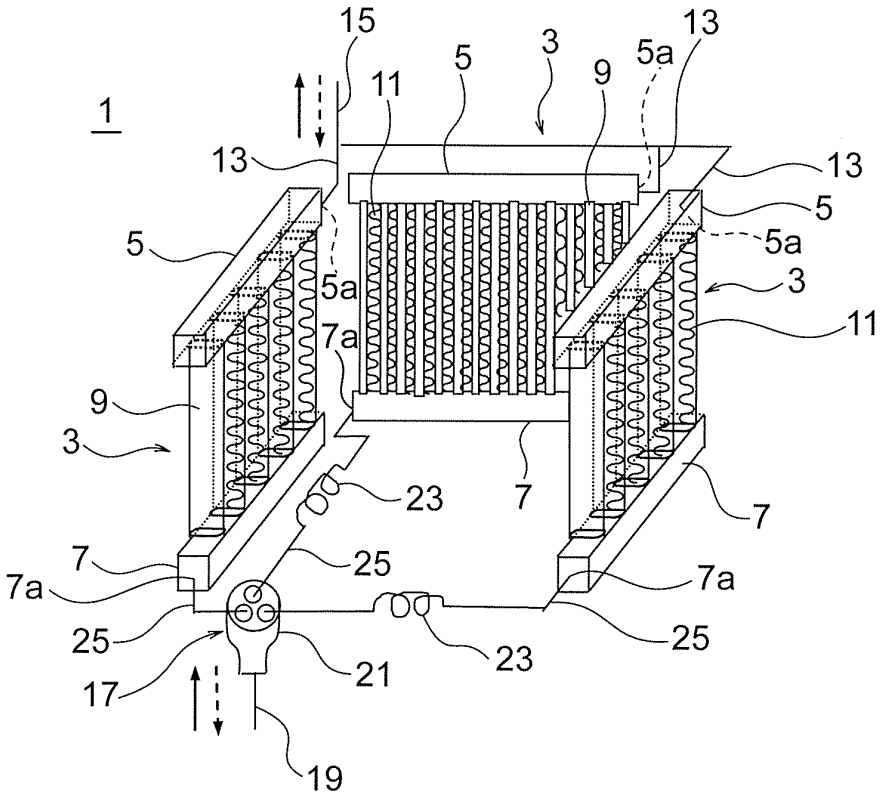

15
13
5
3
5a
13
11
9
1
13
13
5
5
5a
5a
3
11
7a
9
3
23
7
7
7
25
7a
7a
25
25
23
21
17
19

FIG. 2

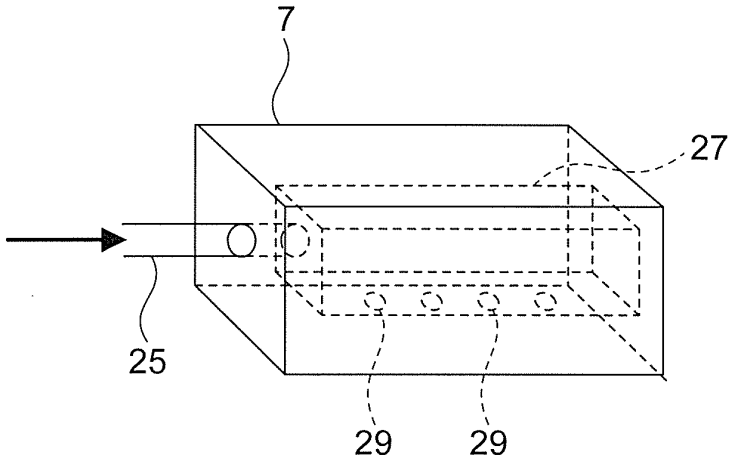
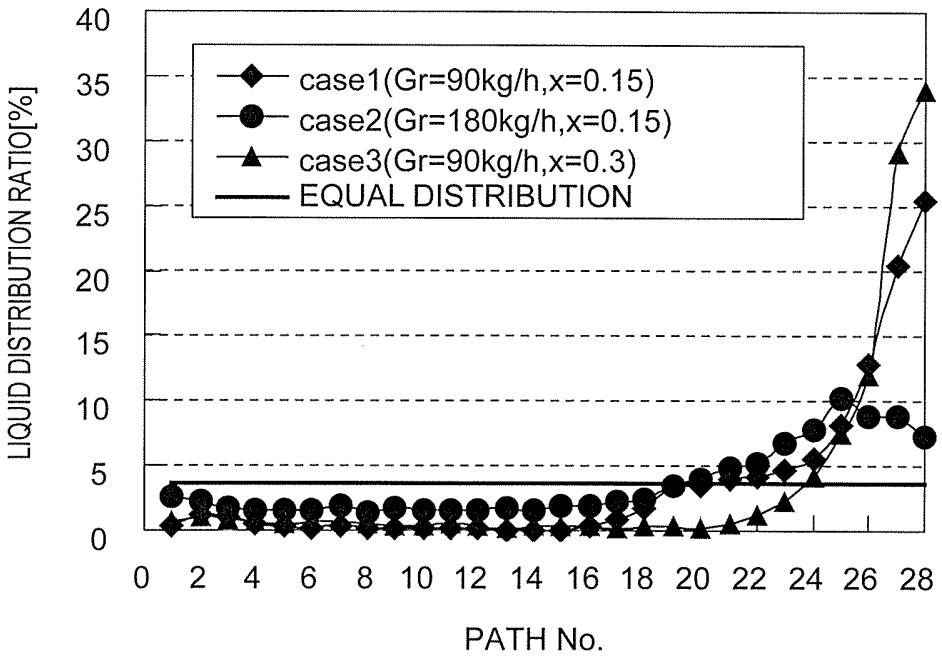

7
27
25
29
29

FIG. 3


LIQUID DISTRIBUTION RATIO[%]
40
35
30
25
20
15
10
5
0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28
PATH No.
case1(Gr=90kg/h,x=0.15)
case2(Gr=180kg/h,x=0.15)
case3(Gr=90kg/h,x=0.3)
EQUAL DISTRIBUTION

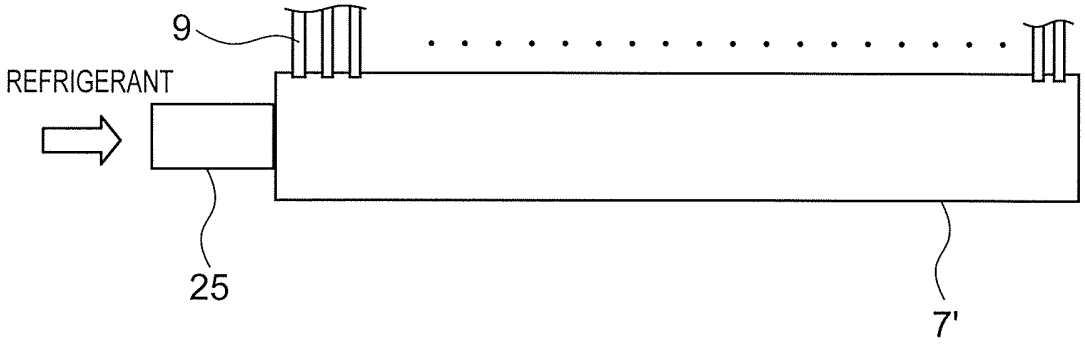
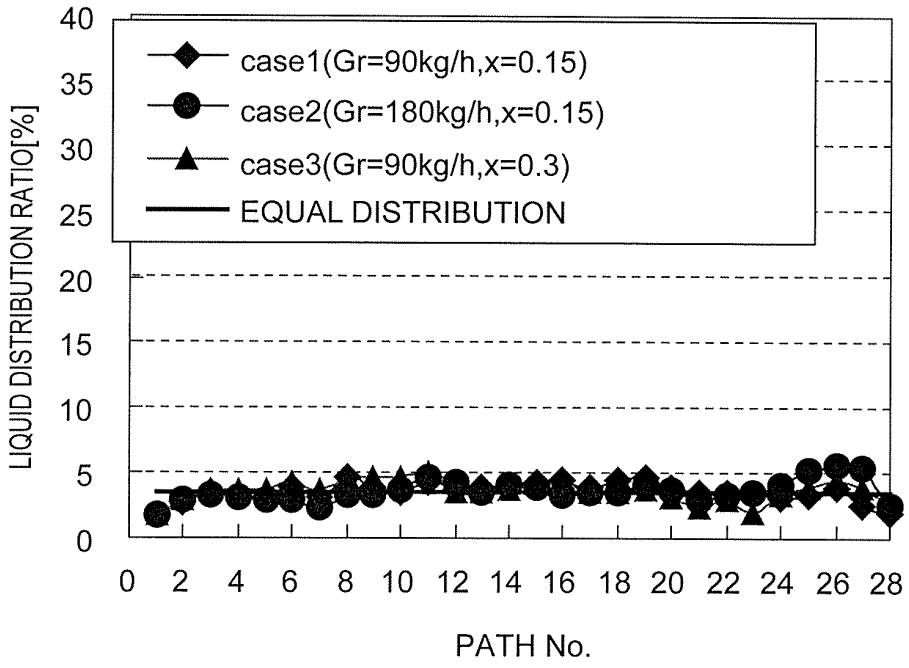

9
REFRIGERANT
25
7'

FIG. 4


40
35
30
25
20
15
10
5
0
LIQUID DISTRIBUTION RATIO[%]
case1(Gr=90kg/h,x=0.15)
case2(Gr=180kg/h,x=0.15)
case3(Gr=90kg/h,x=0.3)
EQUAL DISTRIBUTION
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28
PATH No.

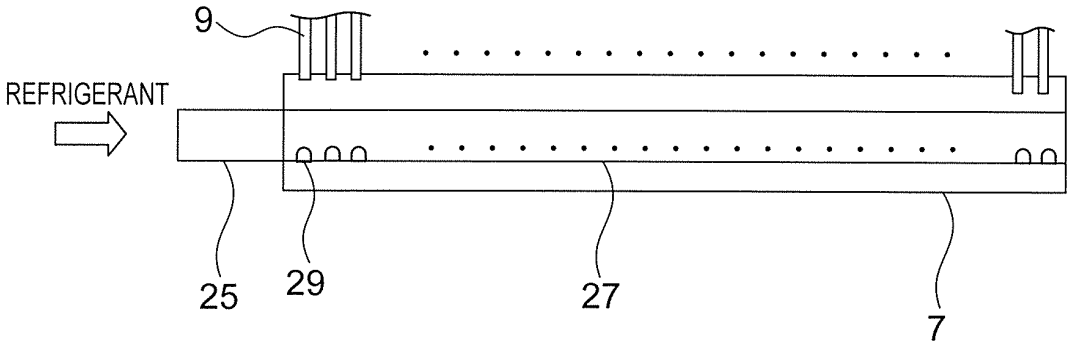
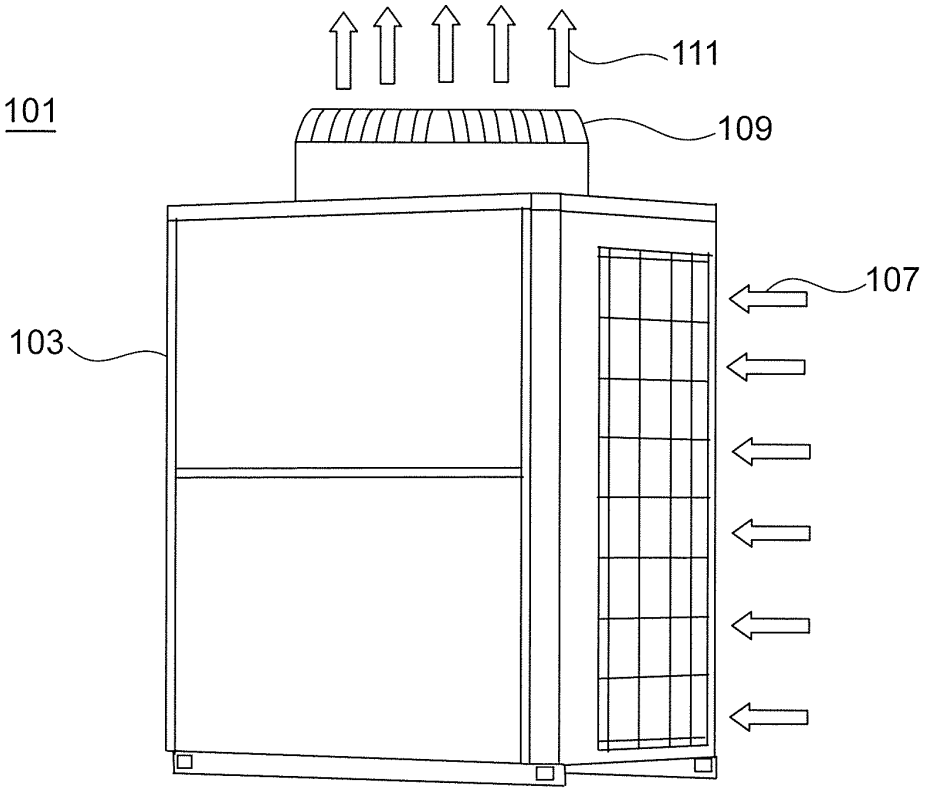

9
REFRIGERANT
25
29
27
7

FIG. 5



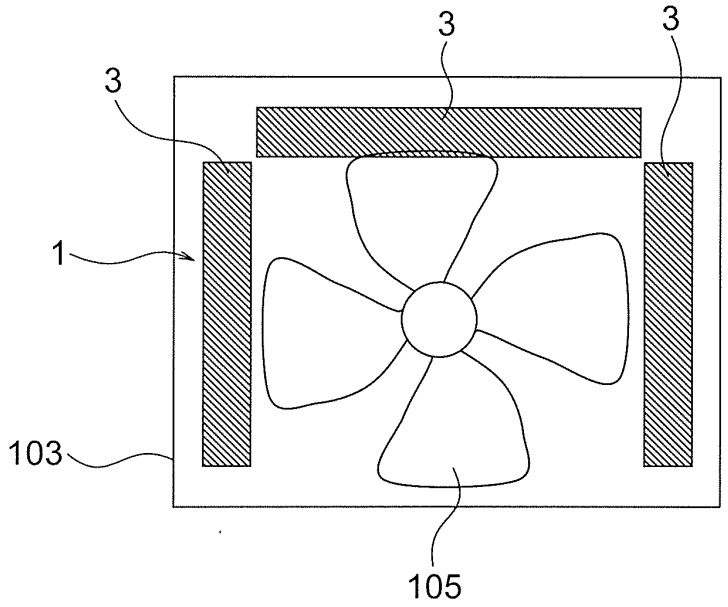
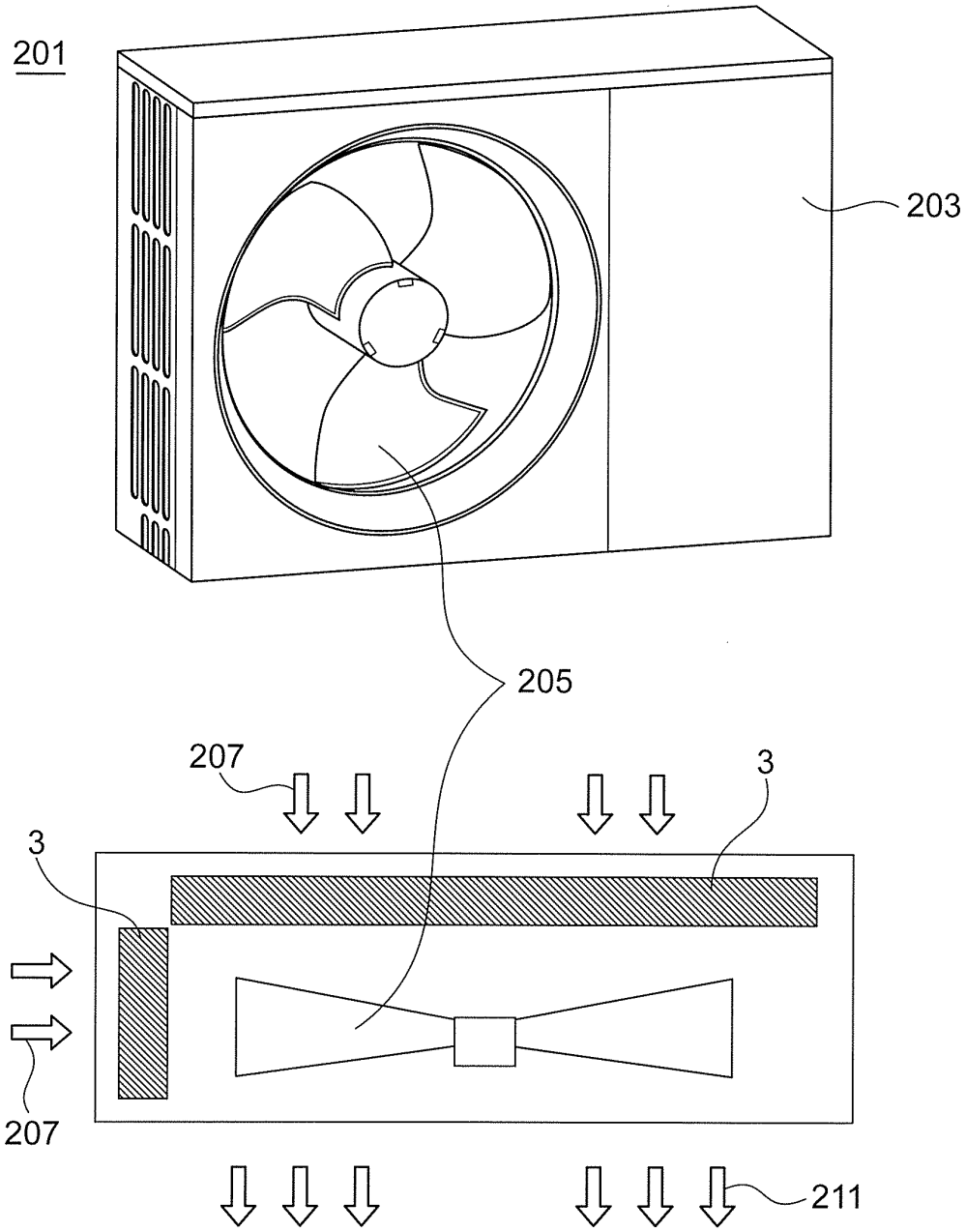


FIG. 6



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/061232

A. CLASSIFICATION OF SUBJECT MATTER
F28F9/26(2006.01)i

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)
F28F9/26

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2012
Kokai Jitsuyo Shinan Koho 1971-2012 Toroku Jitsuyo Shinan Koho 1994-2012

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.
Y	JP 10-160382 A (Toyo Radiator Co., Ltd.), 16 June 1998 (16.06.1998), paragraphs [0005] to [0010]; fig. 1, 5 (Family: none)	1-7
Y	JP 10-185358 A (Showa Aluminum Corp.), 14 July 1998 (14.07.1998), paragraphs [0017] to [0018], [0027], [0033]; fig. 1, 6, 10 & EP 838641 A2	1-7
Y	JP 6-159840 A (Nippondenso Co., Ltd.), 07 June 1994 (07.06.1994), paragraphs [0004] to [0006]; fig. 8, 9 (Family: none)	1-7

☒ 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
11 July, 2012 (11.07.12)	24 July, 2012 (24.07.12)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/061232

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 9-42743 A (Hitachi, Ltd.), 14 February 1997 (14.02.1997), paragraph [0012]; fig. 1 (Family: none)	1-7
Y	JP 6-26783 A (Kobe Steel, Ltd.), 04 February 1994 (04.02.1994), paragraph [0011]; fig. 1, 2 (Family: none)	3-5
Y	JP 2010-38439 A (Sharp Corp.), 18 February 2010 (18.02.2010), fig. 1, 4, 7 (Family: none)	4,5
Y	JP 2012-52676 A (Hitachi Appliances, Inc.), 15 March 2012 (15.03.2012), paragraph [0040]; fig. 5, 7 (Family: none)	5,7

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

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 2010107103 A **[0007]**