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Tanabe

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[54] **HEAT EXCHANGER**

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[73] Assignee: **Sanden Corporation**, Isesaki, Japan

[21] Appl. No.: **851,455**

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[30] **Foreign Application Priority Data**

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Mar. 15, 1991 [JP] Japan ..... 3-015395[U]

[51] **Int. Cl.**[5] **F28D 1/047**
[52] **U.S. Cl.** **165/176**; 165/177
[58] **Field of Search** 165/174, 176, 177

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,746,525	7/1973	Kasuga et al.	165/176 X
4,770,240	9/1988	Dawson et al.	165/176
4,825,941	5/1989	Hoshiro et al.	165/110
4,860,823	8/1989	Noguchi	165/153

FOREIGN PATENT DOCUMENTS

3302150	7/1984	Fed. Rep. of Germany	165/176
2166862A	5/1986	United Kingdom	165/176

Primary Examiner—Allen J. Flanigan
Attorney, Agent, or Firm—Baker & Botts

[57] **ABSTRACT**

An evaporator for an automotive air conditioning refrigeration circuit includes first and second header pipes, a plurality of communicating members which comprise a substantially U-shaped communication path therein, and a corrugated fin unit fixedly disposed between the U-shaped flat pipes. The first and second header pipes are disposed parallel to each other. Each of the U-shaped flat pipes includes a pair of straight portions and a U-shaped curved portion which connects the lower ends of the straight portions. An upper end of one of the straight portions is fixedly and hermetically connected to the first header pipe, and an upper end of the other straight portion is fixedly and hermetically connected to the second header pipe. The pair of the straight portions and the U-shaped curved portion of the U-shaped flat pipe extend along a plane which is parallel to the flow direction of air passing an exterior surface of the evaporator.

2 Claims, 6 Drawing Sheets

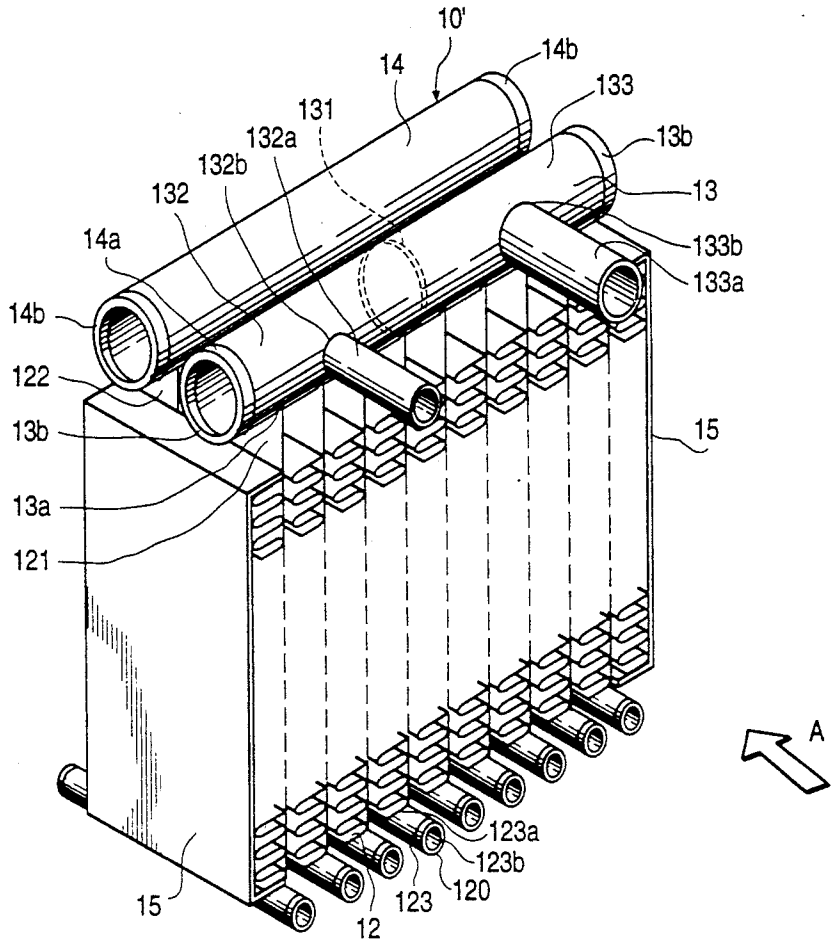


FIG. 1
PRIOR ART

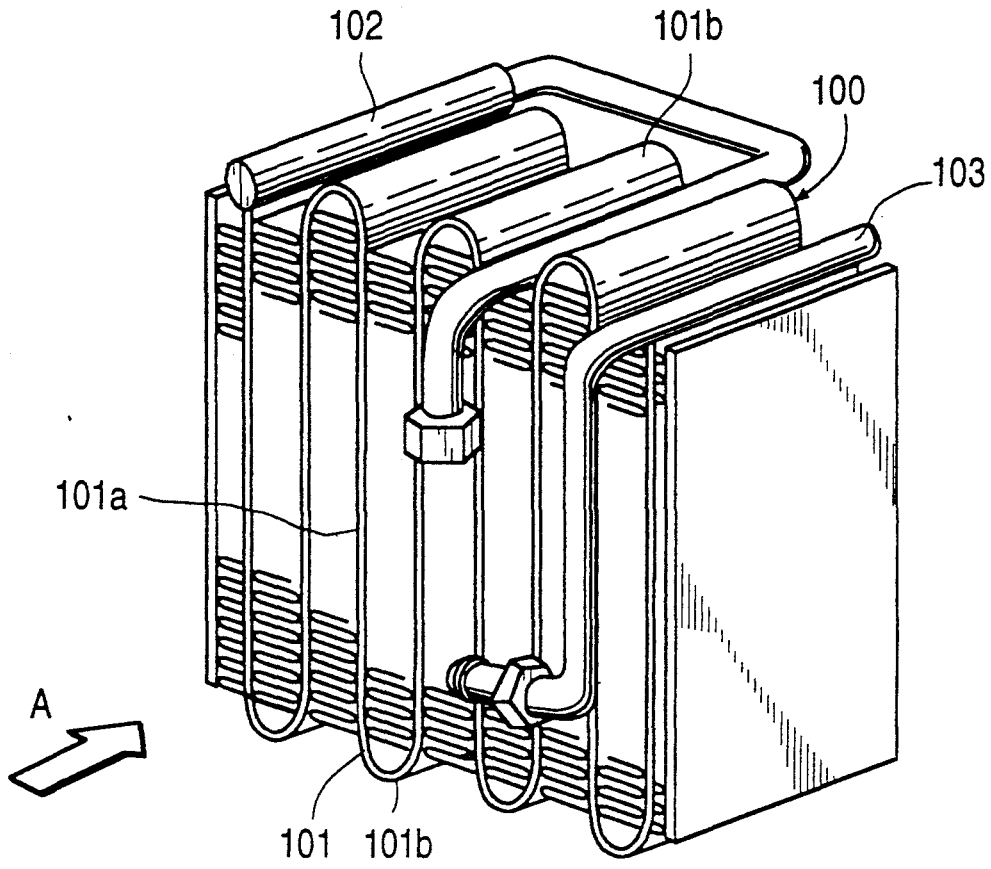


FIG. 2

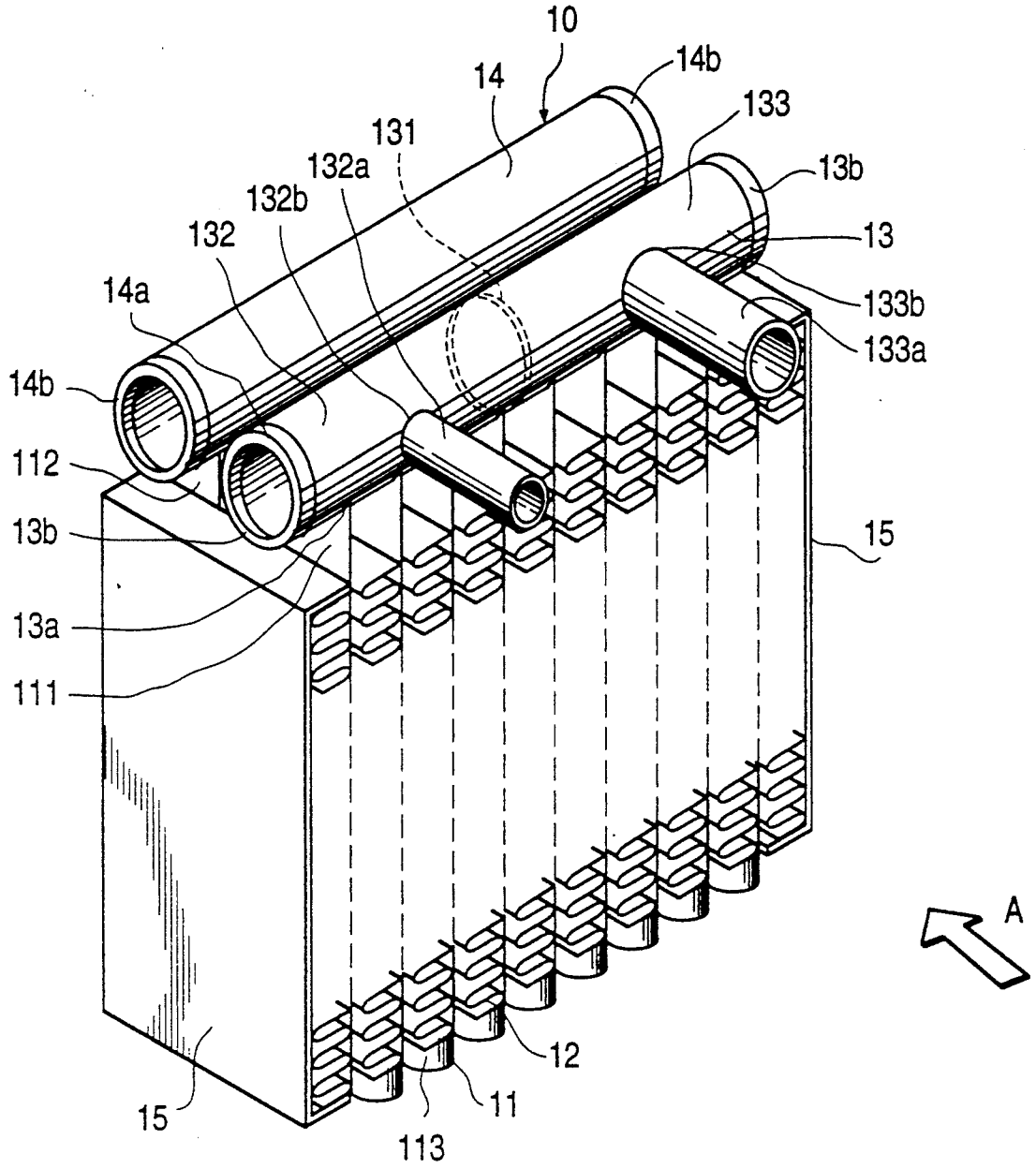

10
14
14b
133
131
132a
13b
132b
132
13
14a
133b
133a
14b
112
13b
15
13a
111
A
12
11
15
113

FIG. 3

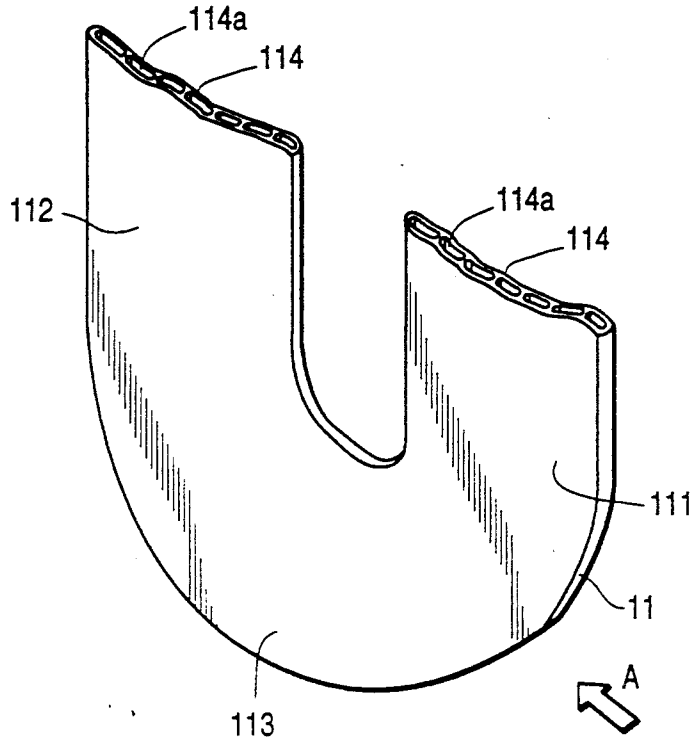


FIG. 4

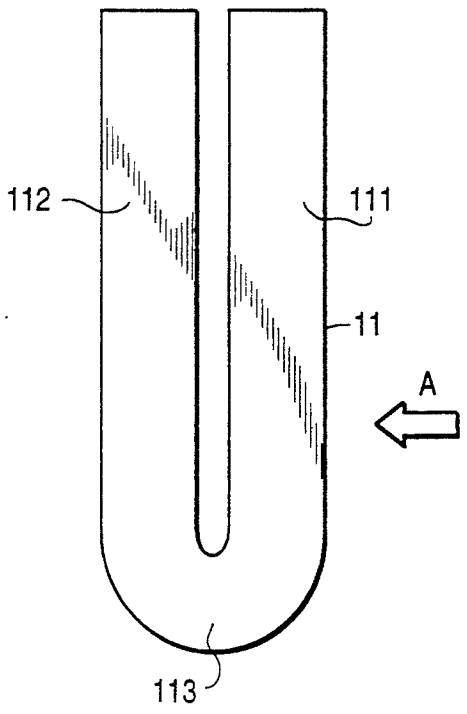


FIG. 5

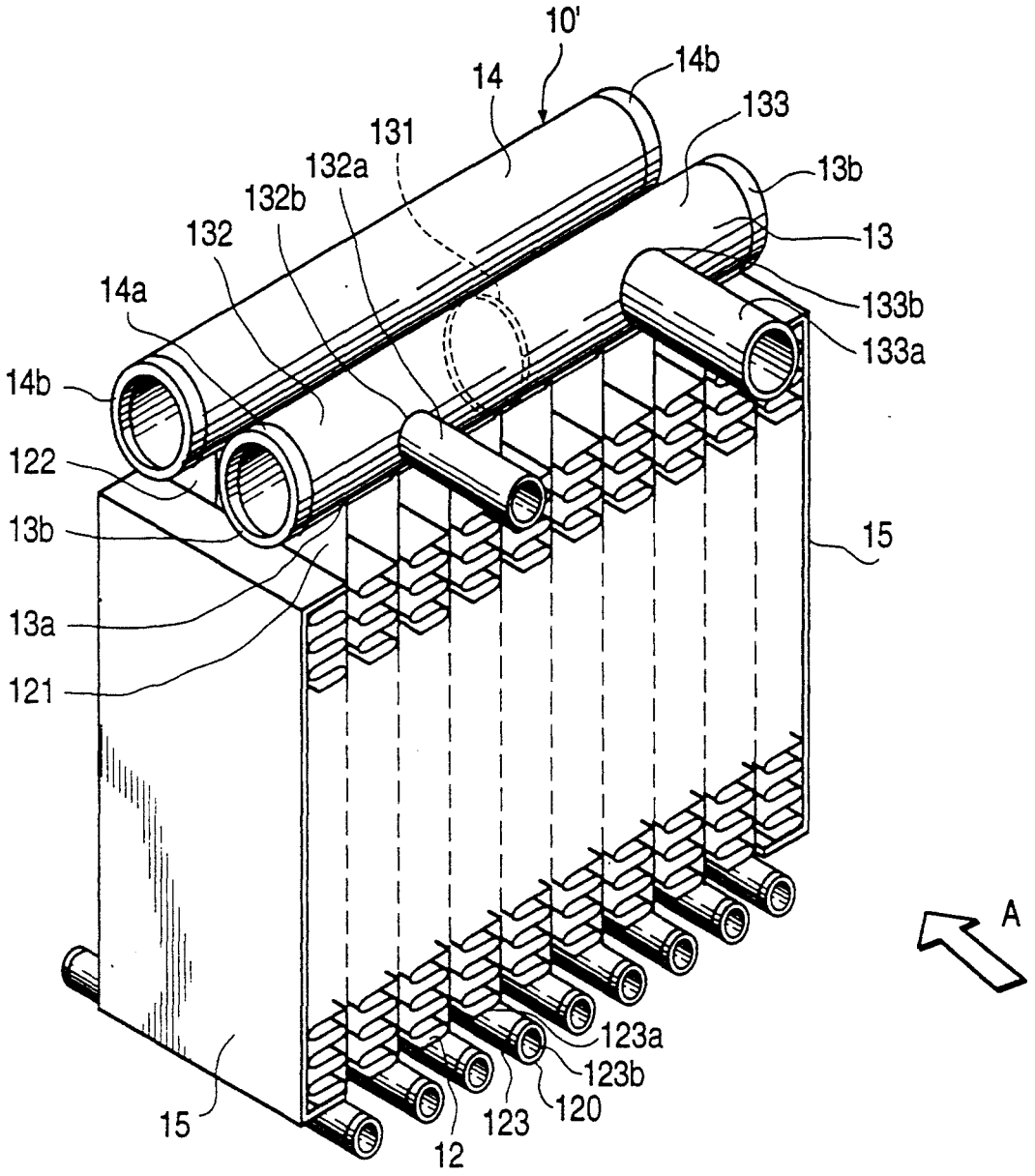

10'
14
14b
133
131
132a
13b
132b
132
13
14a
133b
133a
14b
122
13b
15
13a
121
A
123a
123b
120
123
15
12

FIG. 7

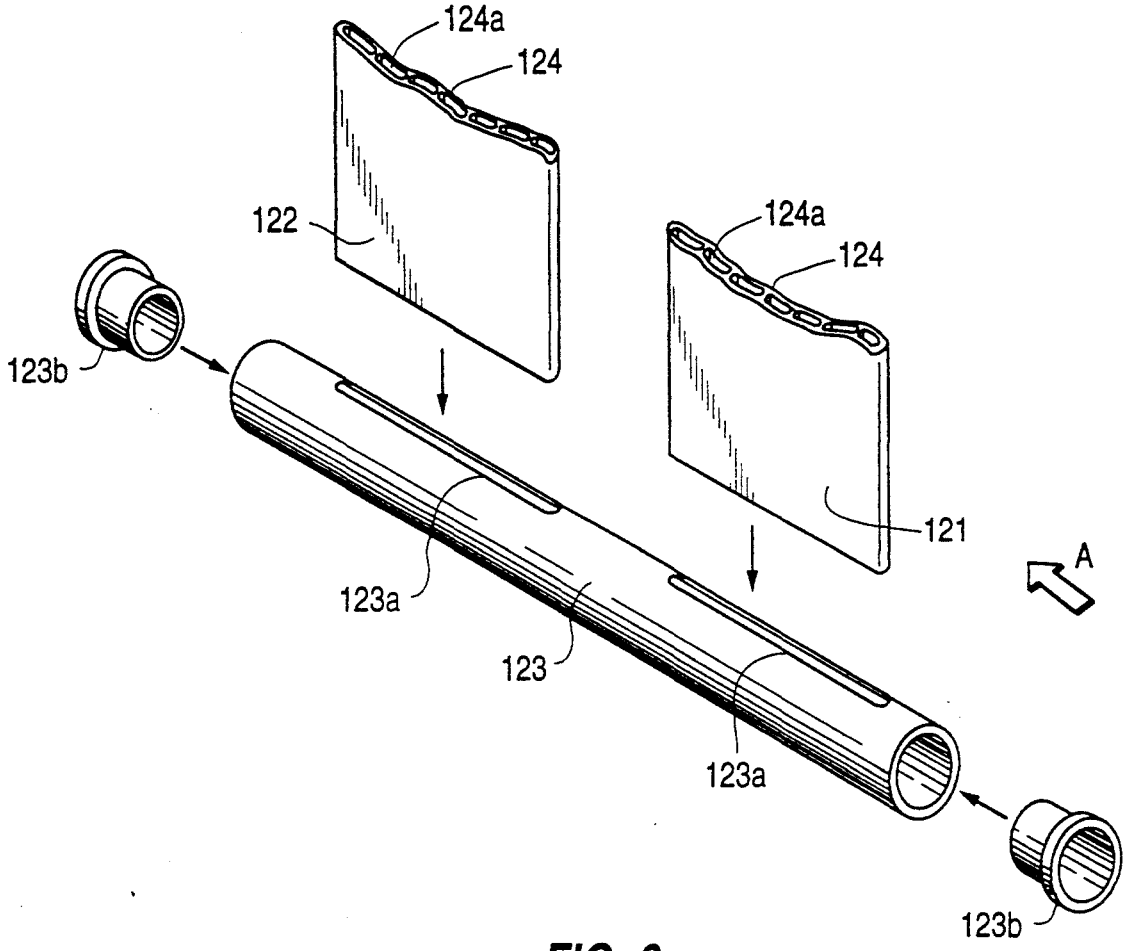

124a
124
122
124a
124
123b
121
A
123a
123
123a
123b

FIG. 6

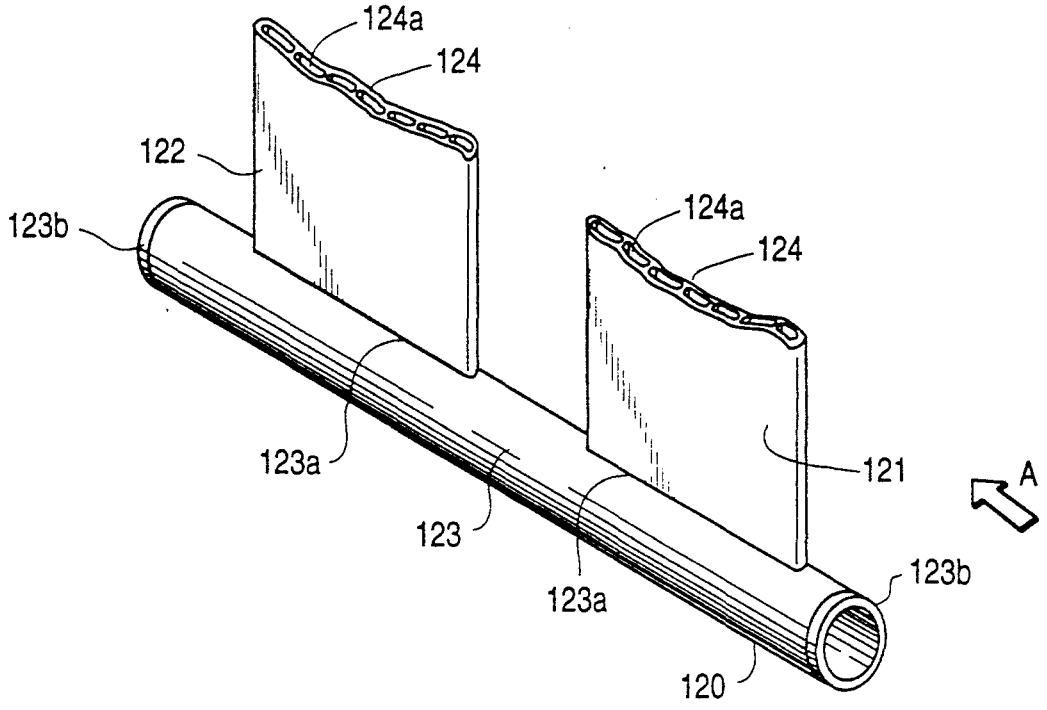
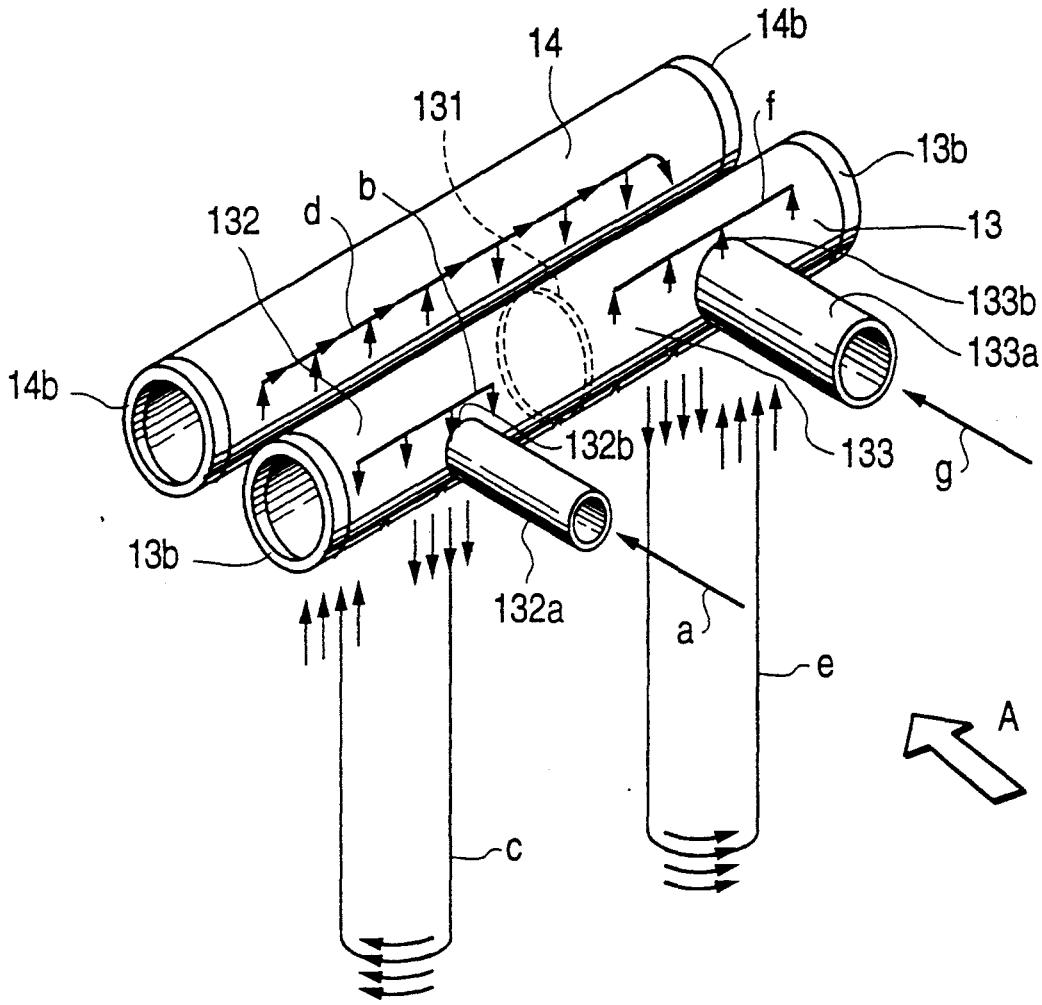

124a
124
122
123b
124a
124
121
A
123a
123
123a
123b
120

FIG. 8



HEAT EXCHANGER

BACKGROUND OF THE INVENTION

1. Technical Field

This invention relates to a heat exchanger for a refrigeration circuit and more particularly, to an evaporator for an automotive air conditioning refrigeration circuit.

2. Description of the Prior Art

Evaporators for use in automotive air conditioning refrigeration circuits are known in the art, for example, U.S. Pat. No. 4,892,143 to Ishii. With reference to FIG. **1**, a serpentine-type evaporator or heat exchanger discussed in the Ishii '143 patent is shown. Evaporator **100** includes a continuous serpentine tube **101** through which refrigeration fluid flows. Serpentine tube **101** includes a plurality of spaced, planar portions **101***a* and a corresponding plurality of curved connecting portions **101***b*. The planar portions **101***a* are parallel to one another and vertically disposed so as to be parallel to the flow direction "A" of air which passes an exterior surface of evaporator **100**. One end of serpentine tube **101** is brazed to a fluid inlet pipe **102**. The fluid inlet pipe **102** is linked to the output of a compression or an expansion means (for example, a compressor, not shown) of a refrigeration circuit. The other end of serpentine tube **101** is brazed to a fluid outlet pipe **103**. The fluid outlet pipe **103** is linked to the inlet of the compressor.

Refrigeration fluid is provided to serpentine tube **101** from the compressor via inlet pipe **102**, flows through each successive planar portion **101***a* and connecting portion **101***b* towards outlet pipe **103**, and is then returned to the compressor. Of course, the refrigeration circuit may include other elements disposed between the compressor and evaporator **100**.

The curved connecting portions of the evaporator discussed in Ishii '143 are formed by bending a straight tube. However, when the number of planar portions of the evaporator are increased in order to increase its ability to exchange heat, the radius of curvature of the curved connecting portions must be decreased. When a straight tube is bent with a small radius, the outer region of the resulting curved connecting portion becomes excessively thin. As a result, the mechanical strength and corrosion resistance of the outer regions is remarkably decreased. Therefore, the life of the evaporator decreases considerably. Accordingly, the ability of the Ishii device to exchange heat can only be increased a small amount due to the limits on the number of planar portions which can be formed.

Furthermore, since the refrigeration fluid flows through each of the planar portions and the curved connecting portions in succession from the inlet pipe to the outlet pipe, the efficiency of the heat exchange between the refrigeration fluid flowing through the serpentine tube and the air passing the exterior surface of the evaporator gradually decreases from the inlet pipe to the outlet pipe. Therefore, the air temperature leaving the exterior surface of the evaporator is not uniform across the evaporator. As a result, an improved elaborate automobile air conditioning system cannot be obtained.

Moreover, the water drops condensed on the exterior surface of the evaporator tend to be concentrated at an inner surface of each of the lower curved connecting portions. These gathered water drops may be scattered into the passenger compartment of an automobile by the air blown from an evaporator fan.

SUMMARY OF THE INVENTION

Accordingly it is an object of the present invention to provide an evaporator whose ability to exchange heat can be greatly increased without reducing the life of the evaporator.

It is another object of the present invention to provide an evaporator which at any portion thereof has a generally uniform air temperature leaving its exterior surface.

It is still another object of the present invention to provide an evaporator which effectively drains the water drops condensed at the exterior surface thereof.

An evaporator according to the present invention includes a pair of header pipes disposed substantially parallel to each other and a plurality of communicating members for providing communication between the interior space of one header pipe with the interior space of the other header pipe. Each of the communicating members includes a first portion which communicates with the interior chamber of one header pipe, a second portion which communicates with the interior space of the other header pipe, and a third portion which communicates between the first portion and the second portion. The first, second, and third portions of the communicating member extend along a plane that is parallel to the flow direction of a fluid, such as air, which passes an exterior surface of the evaporator.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a perspective view of one prior art evaporator.

FIG. **2** illustrates a perspective view of an evaporator in accordance with a first embodiment of the present invention.

FIG. **3** illustrates an enlarged partial perspective view of an U-shaped flat tube shown in FIG. **2**.

FIG. **4** illustrates a side view of the U-shaped flat tube shown in FIG. **2**.

FIG. **5** illustrates a perspective view of an evaporator in accordance with a second embodiment of the present invention.

FIG. **6** illustrates a partial perspective view of a communicating unit shown in FIG. **5**.

FIG. **7** illustrates an exploded perspective view of the communicating unit shown in FIG. **5**.

FIG. **8** illustrates a schematic perspective view of the evaporator in accordance with the first and second embodiments of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **2** illustrates a perspective view of a heat exchanger, such as an evaporator for an automotive air conditioning refrigeration circuit, in accordance with a first embodiment of the present invention. Evaporator **10** includes a plurality of U-shaped flat tubes **11** and a plurality of corrugated fins **12** which are fixedly disposed between the adjacent tubes **11**.

Referring to FIGS. **3** and **4** additionally, U-shaped flat tube **11** includes a pair of straight sections **111** and **112**. U-shaped curved section **113** connects the lower ends of straight sections **111** and **112**. Straight sections **111**, **112** and U-shaped curved section **113** are coplanar and extend along a vertical plane which is parallel to the flow direction (shown by "A" in FIGS. **2–4**) of air

which passes along the exterior surfaces of evaporator **10**. Straight section **112** is located rearwardly (to the left in FIG. **2**) of straight section **111** with respect to the direction of air passing evaporator **10**.

As shown in FIG. **3**, the interior space of tube **11** is divided by a plurality of parallel partition walls **114** into a corresponding plurality of essentially parallel passages **114***a* through which refrigeration fluid flows.

A lower end of U-shaped curved section **113** of each of tubes **11** projects downwardly from a lower end of corrugated fins **12**. An upper end of straight section **111** of each of tubes **11** upwardly projects from an upper end of adjacent corrugated fin **12**. The upper end of straight section **111** is fixedly and hermetically connected to a lower portion of first cylindrical header pipe **13** through slot **13***a* thereby enabling the interior space of cylindrical header pipe **13** to communicate with passages **114***a* defined within tube **11**. An upper end of straight section **112** of each of tubes **11** upwardly projects from an upper end of adjacent corrugated fin **12**. The upper end of straight portion **112** is fixedly and hermetically connected to a lower portion of second cylindrical header pipe **14** through slot **14***a* thereby enabling the interior space of cylindrical header pipe **14** to communicate with passages **114***a* defined within tube **11**. First and second cylindrical header pipes **13** and **14** are disposed parallel to each other.

Circular plate **131** is fixedly disposed within a mid-region of first cylindrical header pipe **13** so as to divide the interior space of cylindrical header pipe **13** into a first chamber section **132** and a second chamber section **133**. Inlet pipe **132***a* is fixedly and hermetically connected to a front portion of cylindrical header pipe **13** through opening **132***b* so as to link first chamber section **132** of cylindrical header pipe **13** to an output of a compressor which forms a part of the refrigeration circuit. Outlet pipe **133***a*, is also fixedly and hermetically connected to a front portion of cylindrical header pipe **13** through opening **133***b* so as to link second chamber section **133** of cylindrical header pipe **13** to the inlet of the compressor.

Of course, the refrigeration circuit may include other elements disposed between the compressor and evaporator **10**, such as a condenser, an accumulator and an expansion valve. A pair of cap members **13***b* are fixedly and hermetically connected to the respective open ends of first cylindrical header pipe **13**. A cap member **14***b* is fixedly and hermetically connected to each of the open ends of second cylindrical header pipe **14**. A pair of side plates **15** are fixedly connected to the opposite outer corrugated fins **12**, respectively.

Referring to FIG. **8**, when the compressor of the refrigeration circuit operates, the refrigeration fluid successively flows preferably through flow paths "a'-'-"g" as described below. Of course other flow arrangements could be used. In flow path "a", the refrigeration fluid flows from the outlet of the compressor, through the condenser, the accumulator, and the expansion valve, through the inlet pipe **132***a*, and into first chamber section **132** of first cylindrical header pipe **13**. In flow path "b", the refrigeration fluid in first chamber section **132** is distributed to straight sections **111** of the corresponding first tubes **11**. In flow path "c", the refrigeration fluid flows downwardly through each of the straight sections **111** of the first tubes, around each of the corresponding U-shaped curved sections **113**, and then upwardly through each of the corresponding straight sections **112**. Heat is exchanged as the air passing along the exterior surface of evaporator **10** vaporizes the refrigeration fluid.

In flow path "d", the refrigeration fluid in each of straight sections **112** of the first tubes **11** flows into a first half of the interior space of second cylindrical header pipe **14**. The refrigeration fluid mixes together as it flows to the second half of the interior space of cylindrical header pipe **14**. The refrigeration fluid is then is distributed to the straight sections **112** of the remaining second set of tubes **11**.

In flow path "e", the refrigeration fluid flows downwardly through each of the remaining straight sections **112**, around each of the corresponding U-shaped curved sections **113**, and then upwardly through each of the corresponding straight sections **111** which are linked to second chamber section **133** of first cylindrical header pipe **13**. Heat is exchanged as the air passing along the exterior surface of evaporator **10** vaporizes the refrigeration fluid. In flow path "f", the refrigeration fluid in each of straight sections **111** flows into second chamber section **133** of first cylindrical header pipe **13** and mixes together. In flow path "g", the refrigeration fluid in second chamber section **133** of first cylindrical header pipe **13** flows to the inlet of the compressor through outlet pipe **133***a*.

According to the evaporator of the first embodiment of the present invention, the number of the U-shaped flat tubes can be easily increased to a large value because, in contrast to the prior art discussed above, there are no curved portions connecting the tubes together. Therefore, the heat exchange tubes **11** can be spaced closer together without the concomitant concerns associated with bending the pipes with a small radius of curvature. As a result, the ability of the evaporator to exchange heat can be greatly increased without a corresponding reduction in the life of the evaporator.

Furthermore, because the refrigeration fluid flows in parallel independently through each of the U-shaped flat tubes, the efficiency of the heat exchange performed by the evaporator is generally uniform at any portion thereof. As a result, an improved elaborate air conditioning system for an automobile can be obtained.

Moreover, since the evaporator of the first embodiment does not include the lower curved connecting portions discussed in the Ishii '143 patent, water drops condensed at the exterior surface of the present evaporator can be effectively drained.

FIG. **5** illustrates a perspective view of an evaporator for an automotive air conditioning refrigeration circuit in accordance with a second embodiment of the present invention. The reference numerals of FIG. **5** which are common to FIG. **2** refer to the same elements described in connection with FIG. **2**.

Referring to FIG. **5**, evaporator **10'** includes a plurality of communicating units **120** which function in a manner substantially similar to the U-shaped flat tubes **11** of the first embodiment. Communicating unit **120** includes a pair of flat tubes **121** and **122**. Cylindrical tube **123** is fixedly and hermetically connected to the lower end of each of tubes **121**, **122** through slot **123***a* formed at a top portion of cylindrical tube **123**. Flat tubes **121**, **122** and cylindrical tube **123** are coplanar and extend along a vertical plane which is parallel to the flow direction (shown by "A" in FIG. **5**) of air which passes an exterior surface of evaporator **10'**. Flat tube **122** is located rearwardly (to the left in FIG. **5**) of flat tube **121** with respect to the direction of air passing the exterior surface of evaporator **10'**.

As shown in FIGS. **6** and **7**, the interior space of each of flat tubes **121**, **122** is divided by a plurality of parallel partition walls **124** into a corresponding plurality of essentially parallel passages **124***a* through which refrigeration fluid flows. A cap member **123***b* is fixedly and hermetically connected to each of the open ends of cylindrical tube **123**.

An upper end of each of flat tubes **121** upwardly projects from an upper end of adjacent corrugated fin **12**. The upper end of each flat tube **121** is fixedly and hermetically connected to a lower portion of first cylindrical header pipe **13** through slot **13***a* so as to enable communication between the interior space of cylindrical header pipe **13** with passages **124***a* defined within flat tube **121**. An upper end of each of flat tubes **122** upwardly projects from an upper end of adjacent corrugated fin **12**. The upper end of each flat tube **122** is fixedly and hermetically connected to a lower portion of second cylindrical header pipe **14** through slot **14***a* so as to enable communication between the interior space of cylindrical header pipe **14** with passages **124***a* defined within flat tube **122**.

The function and effects of the second embodiment are similar to that of the first embodiment. Therefore, a description of the function and effects of the second embodiment is omitted.

This invention has been described in detail in connection with preferred embodiments. These embodiments, however, are merely for explanation only and the invention is not restricted thereto. It will be easily understood by those skilled in the art that other variations and modifications can easily be made within the scope of this invention, as described by the appended claims.

I claim:

1. An evaporator for use in a refrigeration circuit comprising:

first and second header pipes disposed substantially in parallel to each other; and

a plurality of communicating members for providing communication between an interior space of the first header pipe and an interior space of the second header pipe, each of the plurality of communicating members including a first portion which communicates with the interior space of the first header pipe, a second portion which communicates with the interior space of the second header pipe, and a third portion which communicates between the first portion and the second portion,

wherein the first, second and third portions of each communicating member extend along a plane which is parallel to a flow direction of a fluid which passes an exterior surface of the evaporator, and wherein the first portion, the second portion, and the third portion of at least one of the plurality of communicating members comprise a first flat pipe, a second flat pipe, and a cylindrical pipe connected to one end of each of the first and second flat pipes, respectively.

2. A heat exchanger comprising:

first and second header pipes disposed substantially in parallel to each other; and

a plurality of communicating members for providing communication between an interior space of the first header pipe and an interior space of the second header pipe, each of the plurality of communicating members including a first portion which communicates with the interior space of the first header pipe, a second portion which communicates with the interior space of the second header pipe, and a third portion which communicates between the first portion and the second portion,

wherein the first, second and third portions of each communicating member extend along a plane which is parallel to a flow direction of a fluid which passes an exterior surface of the heat exchanger, and wherein the first portion, the second portion, and the third portion of at least one of the plurality of communicating members comprise a first flat pipe, a second flat pipe, and a cylindrical pipe connected to one end of each of the first and second flat pipes, respectively.

* * * * *