US005211222A

# United States Patent [19]

Shinmura

[11] Patent Number: 5,211,222

[45] Date of Patent: May 18, 1993

[54] HEAT EXCHANGER

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

[21] Appl. No.: **791,255**

[22] Filed: **Nov. 13, 1991**

[30] **Foreign Application Priority Data**

Nov. 13, 1990 [JP] Japan .................................. 2-306649

[51] **Int. Cl.**[5] .................................................. **F28D 1/03**

[52] **U.S. Cl.** ............................... **165/176**; 29/890.043; 165/153

[58] **Field of Search** ........................ 165/153, 175, 176; 29/890.043, 890.039

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*Primary Examiner*—Allen J. Flanigan

*Attorney, Agent, or Firm*—Baker & Botts

[57] **ABSTRACT**

A laminated type evaporator for an automotive air conditioning refrigerant circuit is disclosed. The evaporator includes a plurality of tube units having a pair of tray-shaped plates. A pair of conduits for distributing the refrigerant to the interior region of each of the tube units and for receiving the refrigerant from the interior region of each of the tube units are connected to the top surface of the tube units. Communication between the plurality of tube units is obtained through separately formed conduits, thereby obviating the need to form an internal passageway during the formation of the tray-shaped plates and thus simplifying the manufacturing process of the evaporator.

**14 Claims, 12 Drawing Sheets**

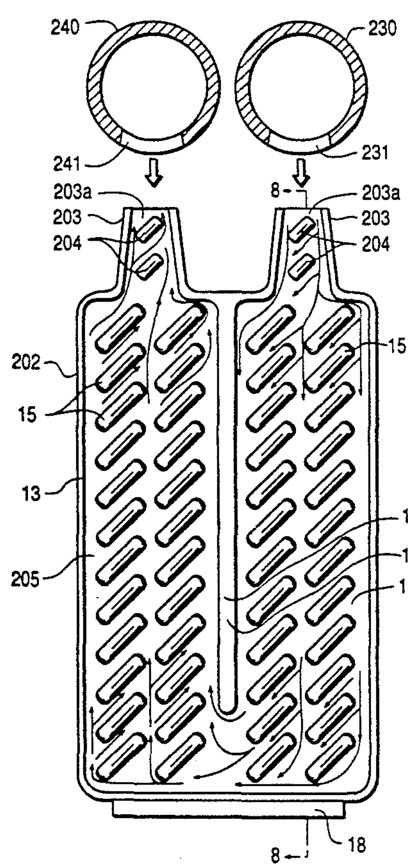


FIG. 1
PRIOR ART

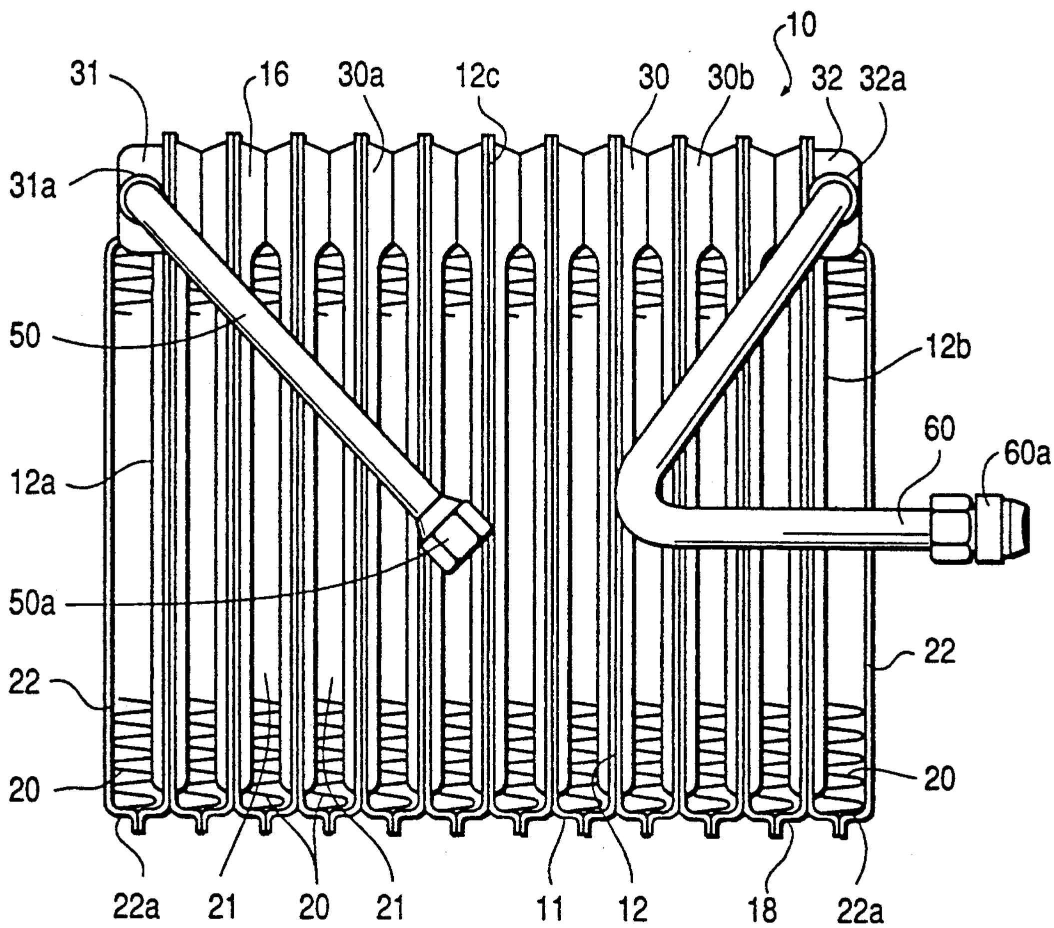


FIG. 2
PRIOR ART

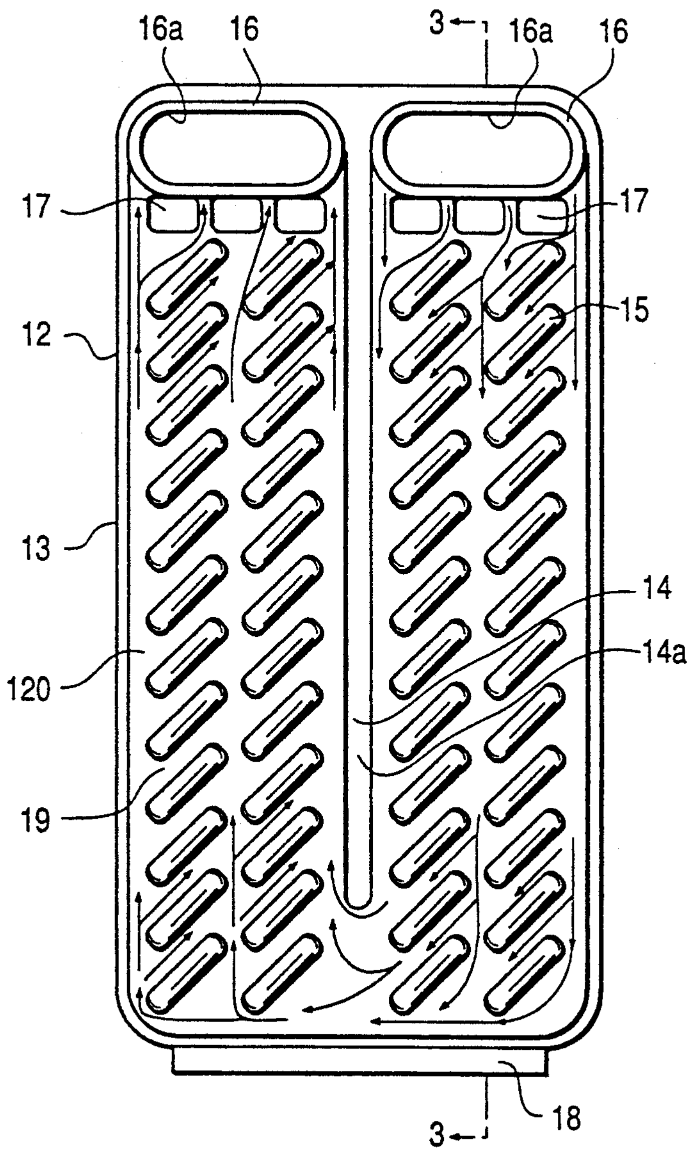



FIG. 3
PRIOR ART

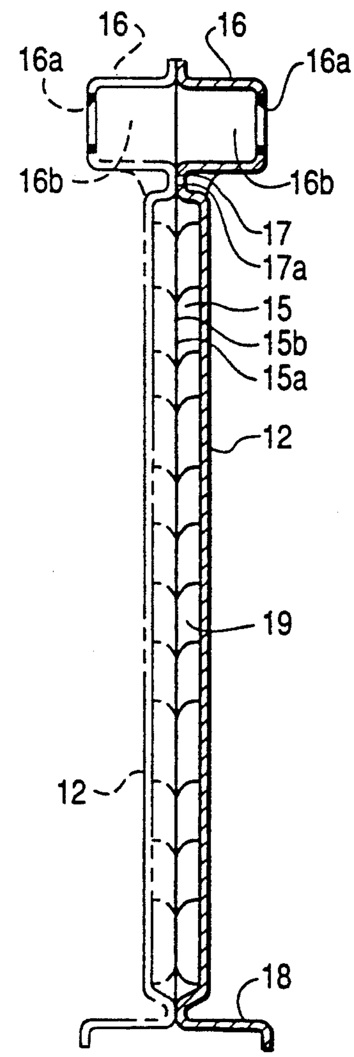


*FIG. 4*
*PRIOR ART*

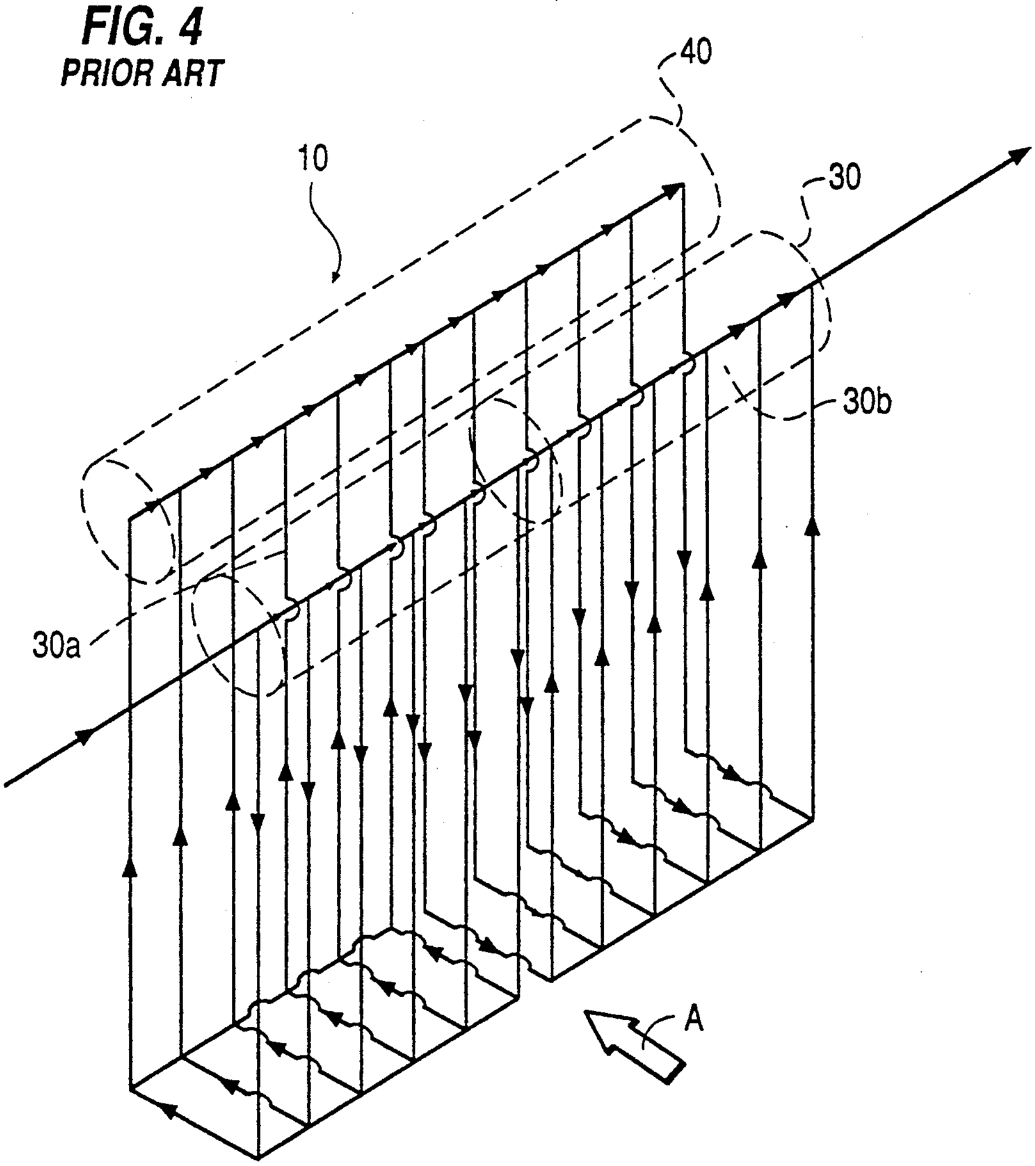
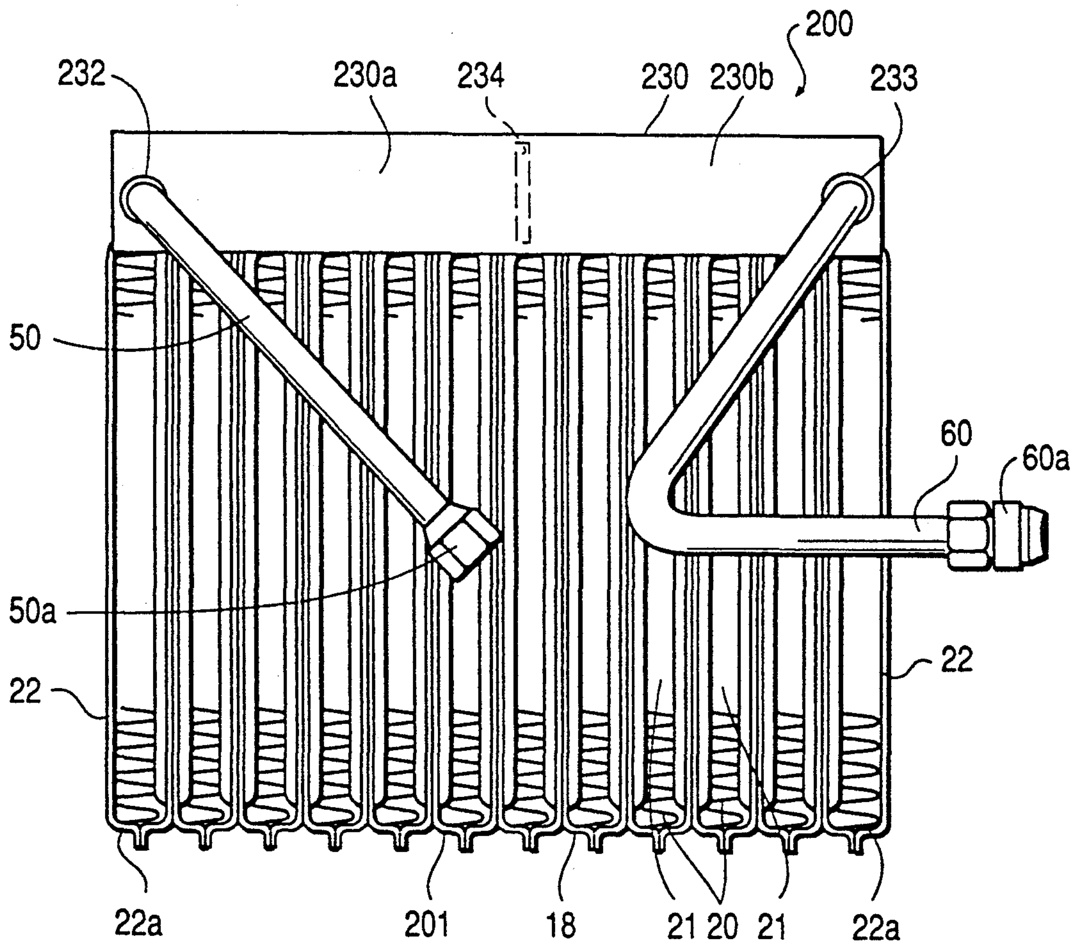
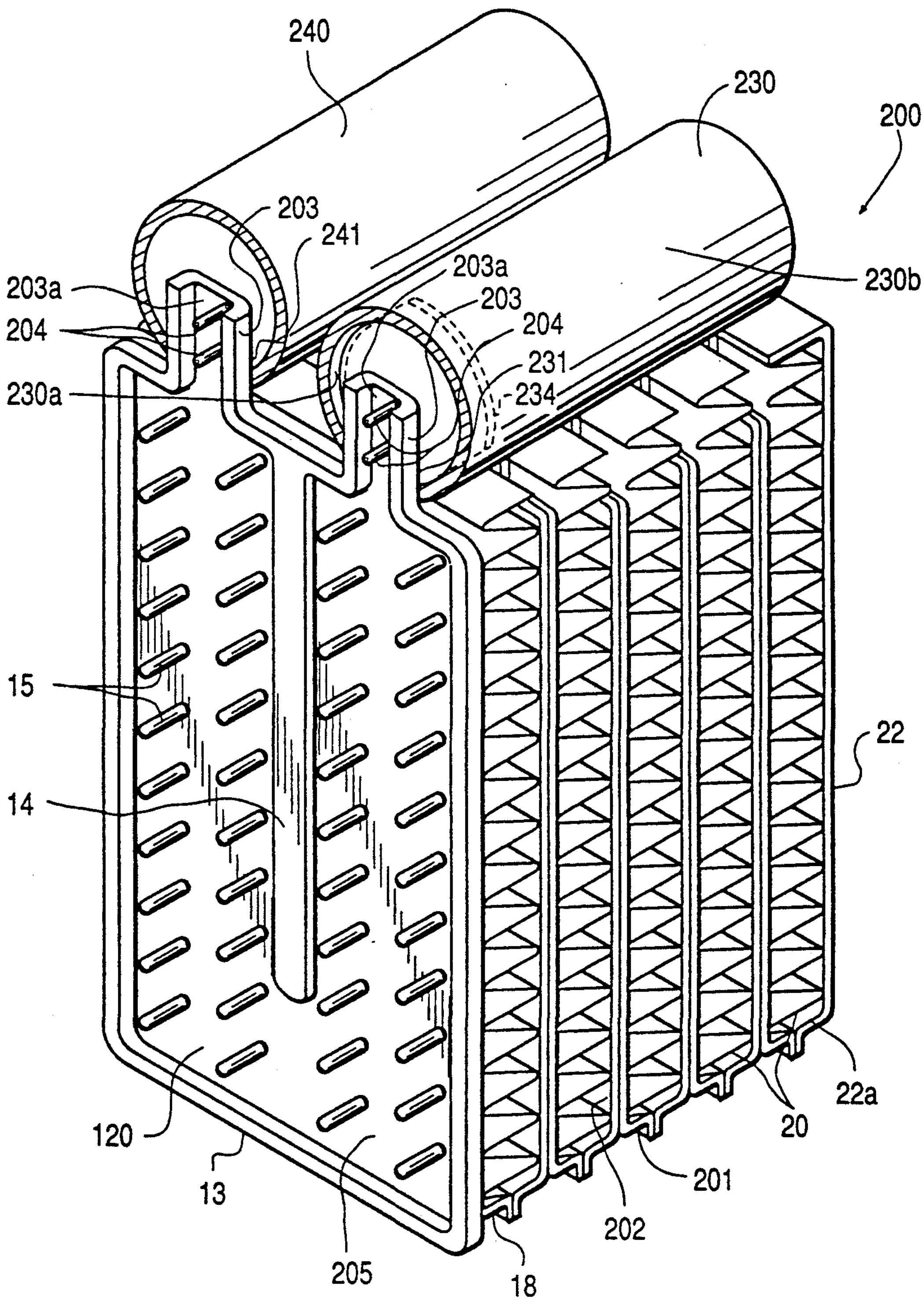


FIG. 5



200
232
230a
234
230
230b
233
50
60
60a
50a
22
22
22a
201
18
21
20
21
22a

FIG. 6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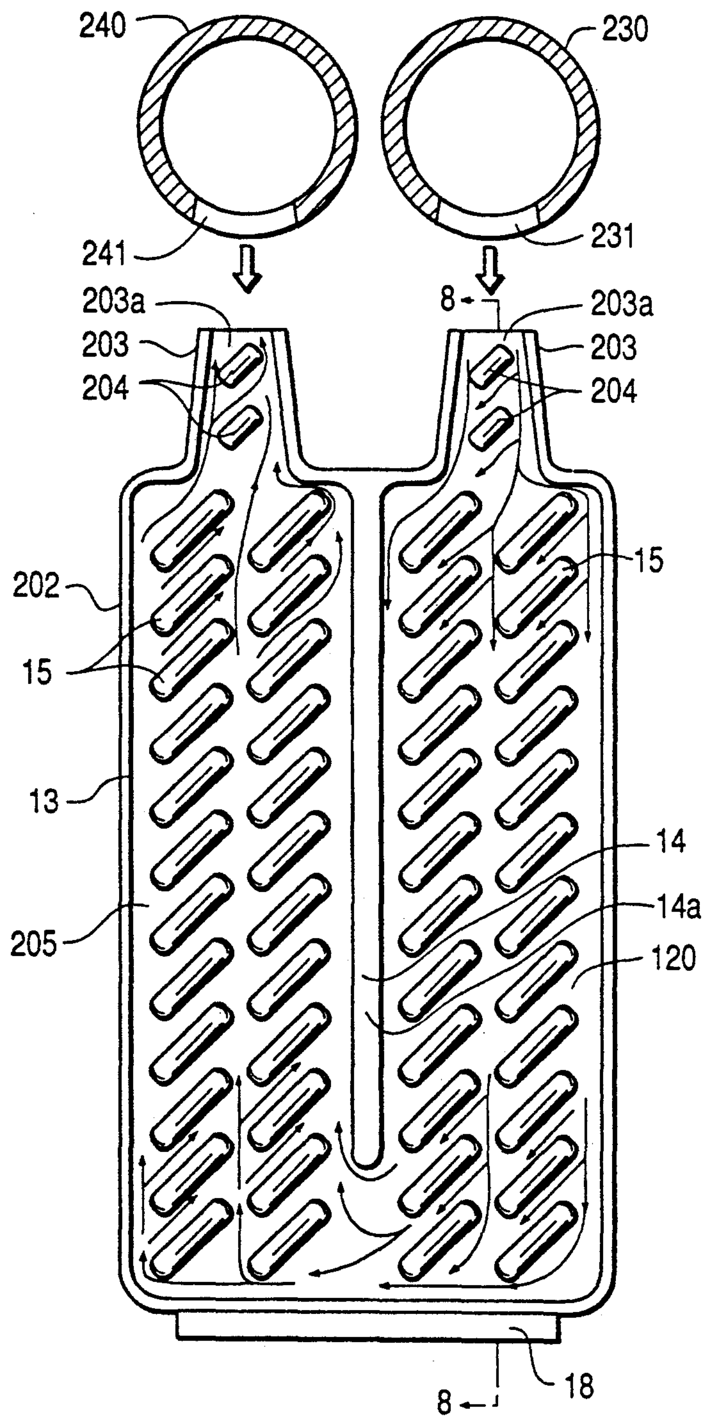
230
200
203
241
203a
203a
230b
203
204
204
231
230a
234
15
22
14
22a
20
120
201
13
202
205
18

FIG. 7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230
241
231
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203a
203a
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203
204
204
202
15
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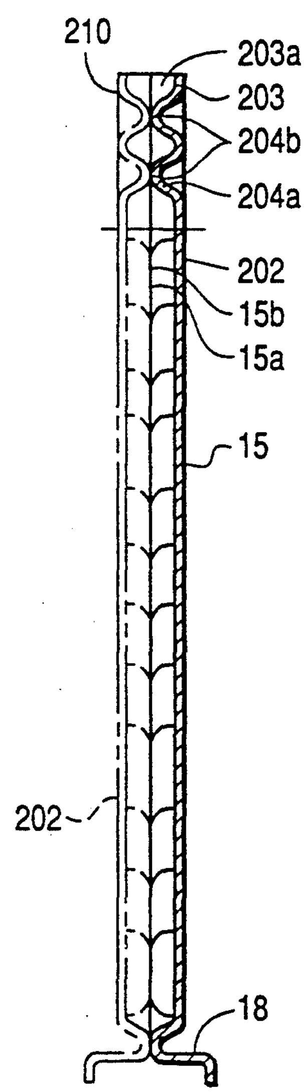
13
14
14a
205
120
18
8

FIG. 8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203a
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204b
204a
202
15b
15a
15
202
18

FIG. 9

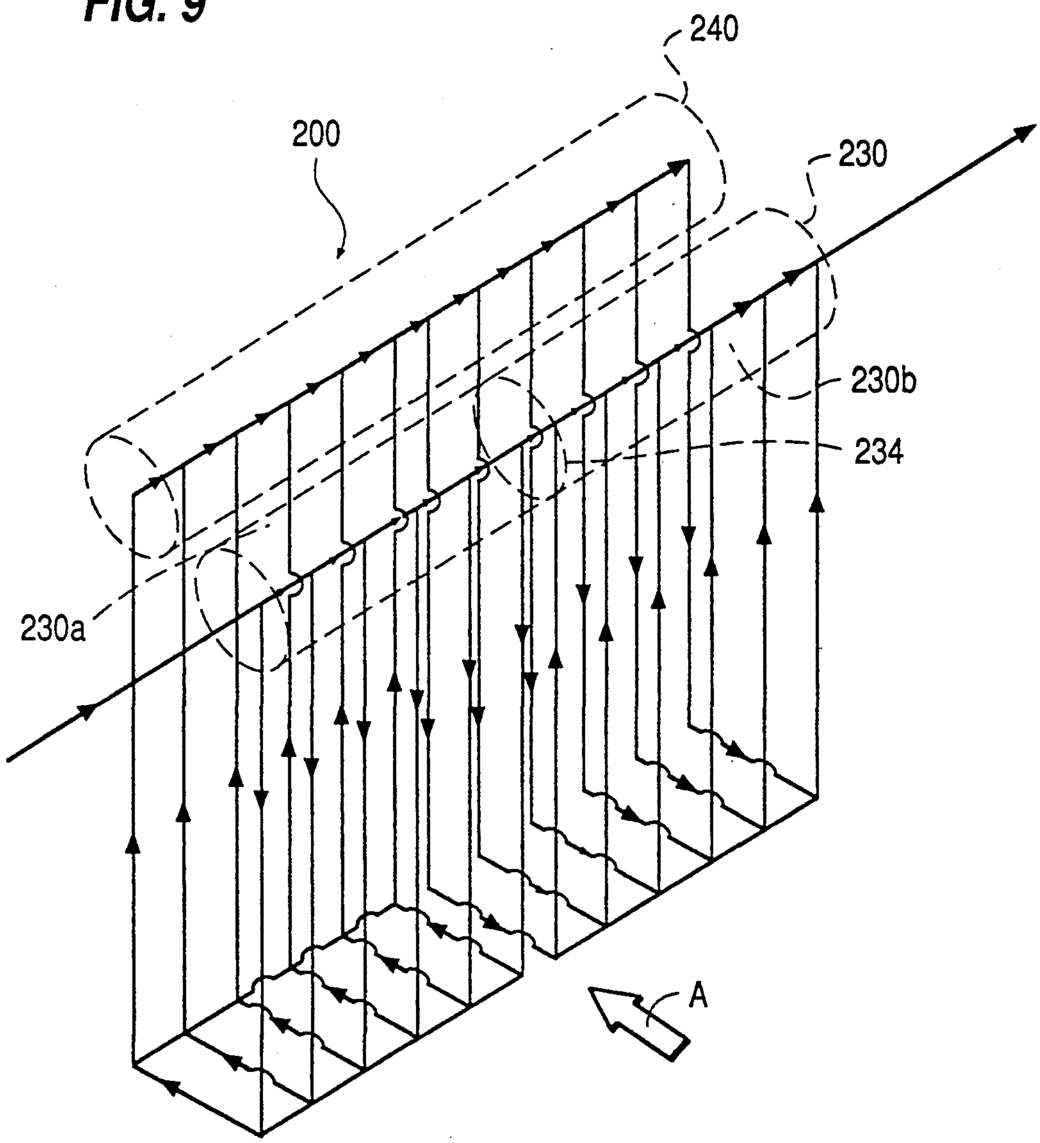
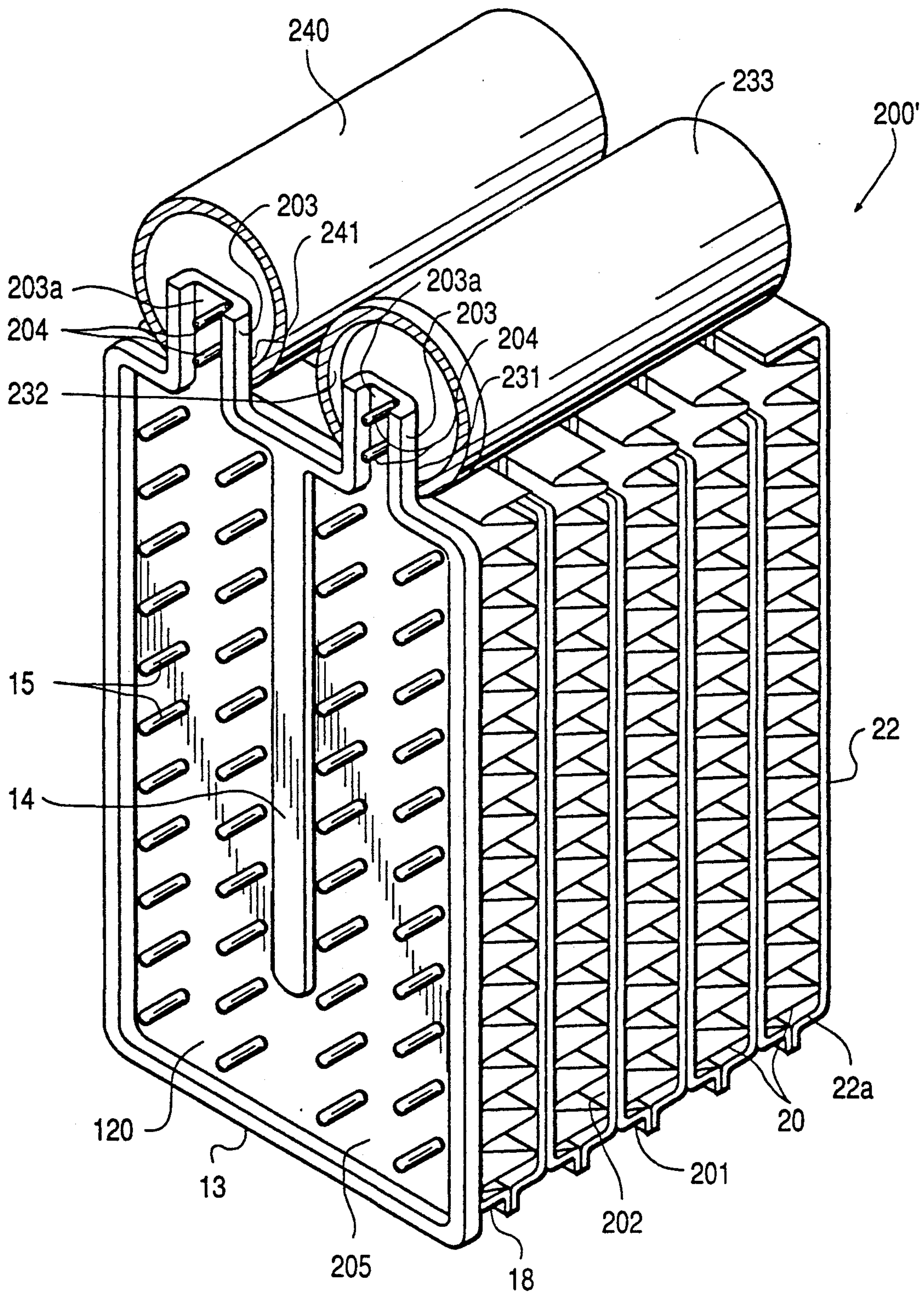


FIG. 10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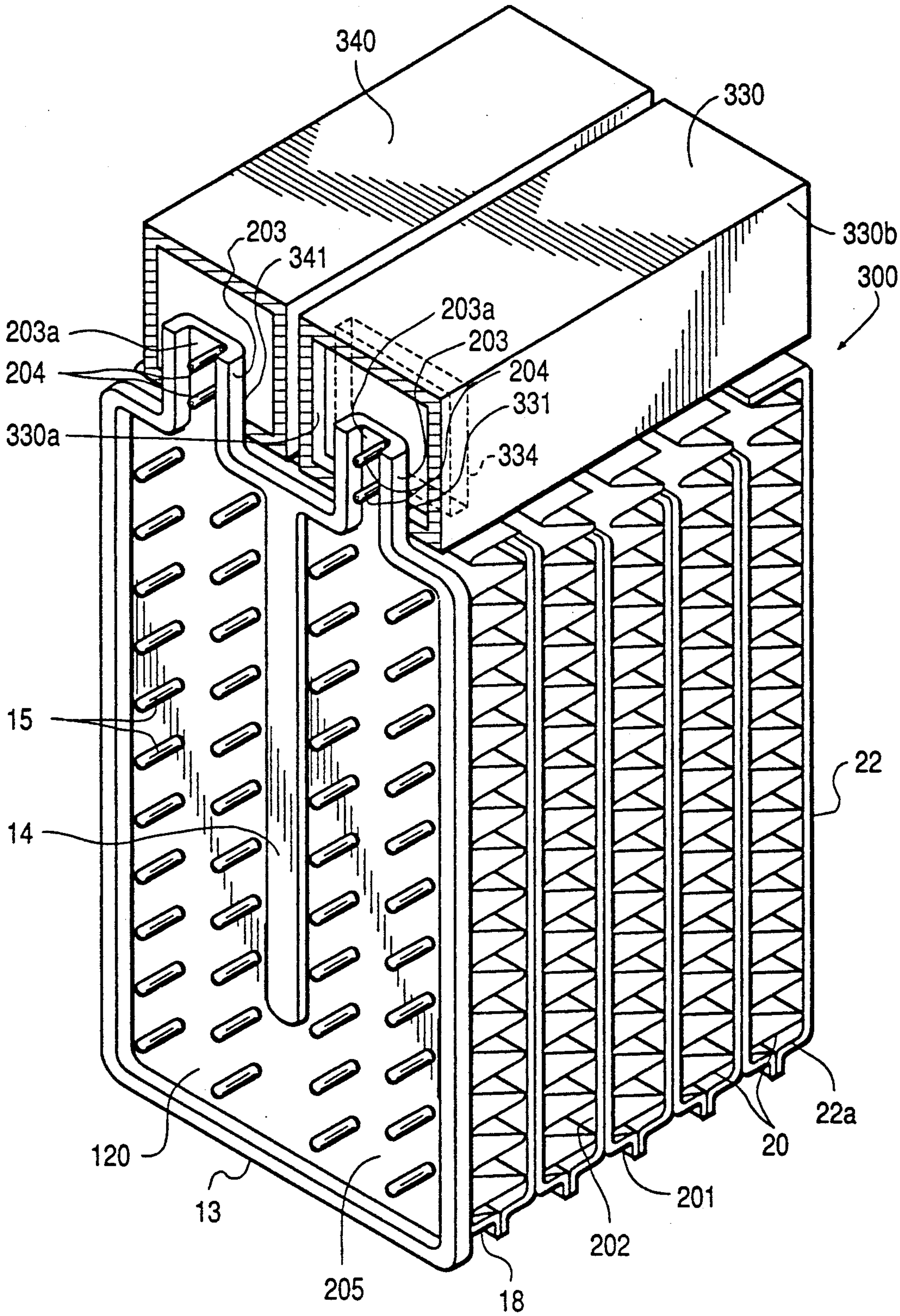
233
200'
203
241
203a
204
203a
203
204
232
231
15
22
14
22a
20
120
201
13
202
205
18

FIG. 11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330
330b
300
203
341
203a
204
330a
203a
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204
331
334
15
14
22
120
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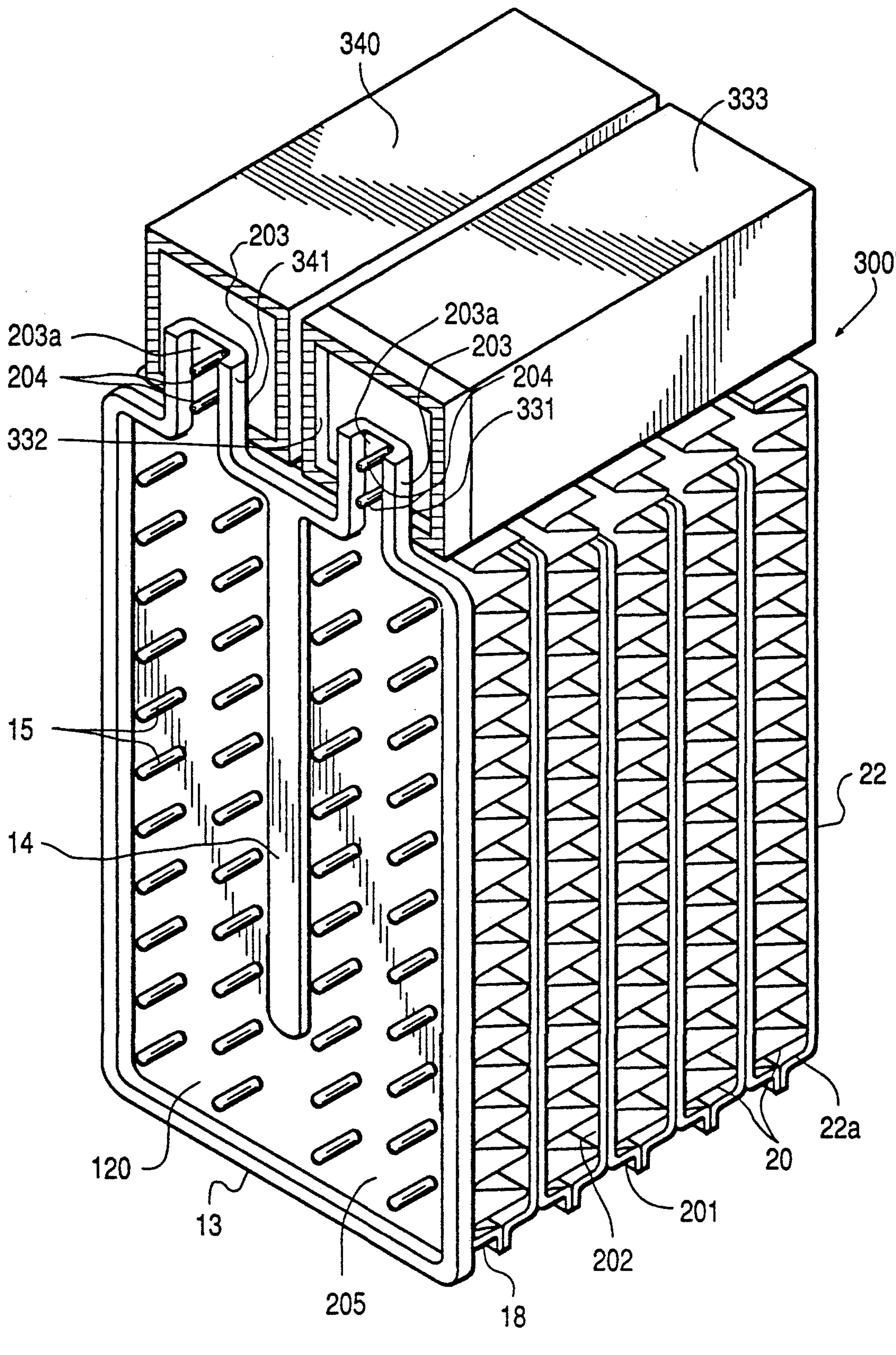
205
18
202
201
20
22a

FIG. 12


340
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203
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300'
203a
203a
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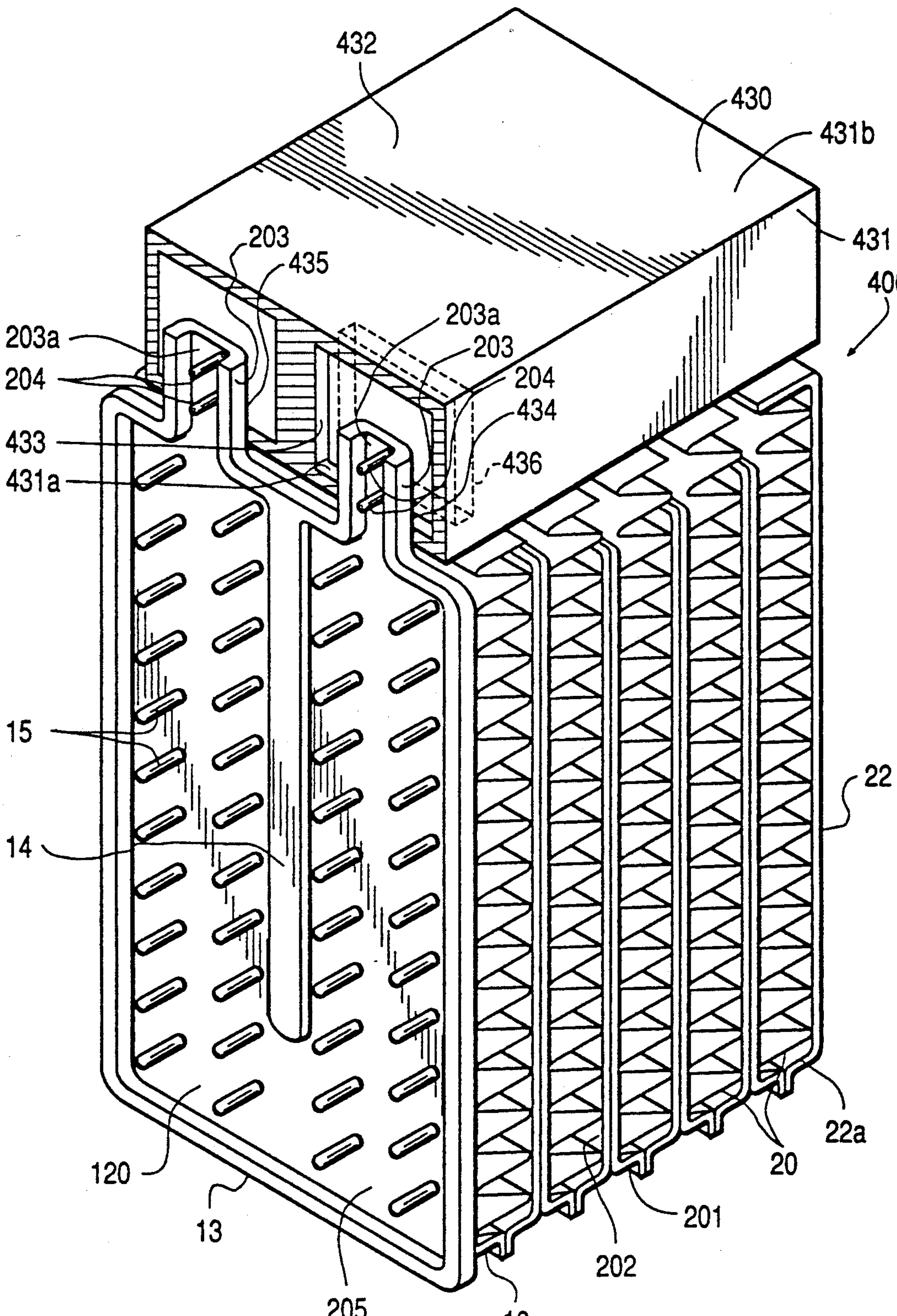
204
204
331
332
15
14
22
120
13
205
18
202
201
20
22a

FIG. 13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431b
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400
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203a
203a
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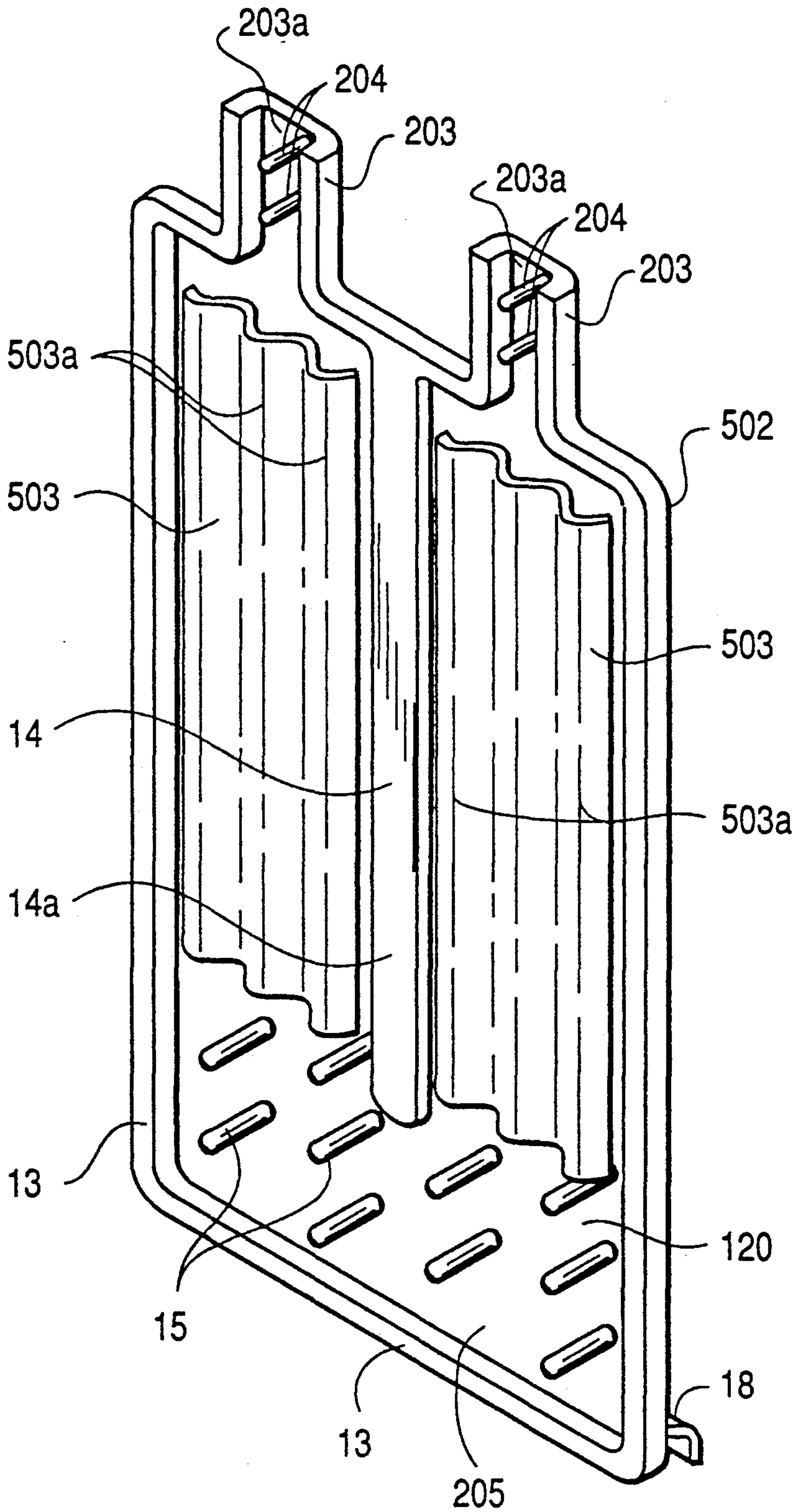
434
433
436
431a
15
22
14
22a
20
120
201
13
202
205
18

FIG. 14



203a
204
203
203a
204
203
503a
502
503
503
14
503a
14a
13
120
15
18
13
205

## HEAT EXCHANGER

### BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to heat exchangers for refrigerant circuits and, more particularly, to a laminated type evaporator for an automotive air conditioning refrigerant circuit.

2. Description of the Prior Art

A laminated type evaporator is known in the prior art, as for example, Japanese Patent Application Publication No. 62-5097 which discloses an evaporator as shown in FIGS. 1–3. The evaporator **10** includes a plurality of tube units **11** of aluminum alloy each of which includes a pair of tray-shaped plates **12**. Tray-shaped plates **12** include a shallow depression **120** defined therein, a flange **13** formed around the periphery thereof, and a narrow wall **14** formed in the central region thereof. Narrow wall **14** extends downwardly from an upper end of plate **12** and terminates approximately one-eighth the length of plate **12** away from the lower end thereof. Narrow wall **14** includes a flat top surface **14***a*. A plurality of diagonally disposed semicylindrical projections **15** project from the inner bottom surface of shallow depression **120**. Semicylindrical projections **15** are aligned with one another in each of a plurality of, for example, four rows. As shown in FIG. **2**, there are two rows of semicylindrical projections **15** located in shallow depression **120** on the right side of narrow wall **14** and two rows located on the left side thereof. Semicylindrical projections **15** also include a ridge **15***a* and are utilized in order to reinforce the mechanical strength of plate **12**. A pair of cylindroid-shaped bulged portions **16** are formed in the upper region of plate **12** and project oppositely to semicylindrical projections **15** such that a hollow space **16***b* is defined by each bulged portion **16**. An oval opening **16***a* is formed in the bottom surface of each bulged portion **16**. A plurality of rectangular parallelepiped projections **17** project from the inner bottom surface of shallow depression **120** adjacent to the interior surface of each bulged portion **16**. Each of the three rectangular parallelepiped projections **17** shown includes a flat top surface **17***a*. A rectangular flange **18** projects from the lower end of plate **12** in a direction opposite to semicylindrical projections **15**, and is bent downwardly in a generally right angle at the terminal end thereof.

The levels of flat top surface **14***a* of narrow wall **14**, ridge **15***a* of semicylindrical projections **15**, and flat top surface **17***a* of parallelepiped projections **17** are even with the surface of flange **13**. Therefore, when the pair of tray-shaped plates **12** are joined together by flanges **13** so as to form a passage **19** therebetween, narrow walls **14** of each plate **12** contact one another at the flat top surfaces **14***a*, parallelepiped projections **17** of each plate **12** contact one another at their flat top surfaces **17***a*, and semicylindrical projections **15** of plates **12** contact one another at the intersections **15***b* along ridges **15***a*. Flanges **13** of plates **12** are fixedly attached to each other by, for example, brazing or any other conventional manner, and flat top surfaces **14***a* of narrow walls **14** in plates **12** are also fixedly attached to each other by brazing, or on a like manner.

Evaporator **10** is formed by laminating together a plurality of tube units **11** and inserting corrugated fins **20** within the intervening space **21** between the adjacent tube units **11**. Tube unit **11**, located on the far left side of evaporator **10** shown in FIG. **1**, includes a tray-shaped plate **12***a* having no bulged portion **16**. Plate **12***a* is provided with a cylindroid-shaped tank **31** which is fixedly attached to the upper end thereof. The interior region of tank **31** is linked to hollow space **16***b* in the adjacent front side bulged portion **16** of plate **12** through an opening (not shown) formed in the upper end of plate **12***a*. Tube unit **11**, located on the far right side of evaporator **10**, also includes a tray-shaped plate **12***b* having no bulged portion **16**. Plate **12***b* is provided with a cylindroid-shaped tank **32** which is fixedly attached to the upper end thereof. The interior region of tank **32** is similarly linked to hollow space **16***b* in the adjacent front side bulged portion **16** of plate **12** through an opening (not shown) formed in the upper end of plate **12***b*. Tank **31** is provided with a circular opening **31***a* formed in the front surface thereof. Tank **32** is provided with a circular opening **32***a* also formed in the front surface thereof. One end of an inlet pipe **50** is connected to opening **31***a* of tank **31** and one end of an outlet pipe **60** is connected to opening **32***a* of tank **32**. Inlet pipe **50** is provided with a union joint **50***a* at the other end thereof and outlet pipe **60** is similarly provided with a union joint **60***a* at the other end thereof. A pair of side plates **22** are attached to the left side of plate **12***a* and to the right side of plate **12***b*, respectively, and corrugated fins **20** are disposed between side plate **22** and plate **12***a*, and between side plate **22** and plate **12***b*, respectively. The lower end of side plate **22** includes a rectangular flange **22***a* projecting inwardly and then bent downwardly in a generally right angle at the terminal end thereof. Respective tube units **11**, corrugated fins **20**, and side plates **22** are fixedly attached to one another by any conventional manner, such as brazing, for example. Although corrugated fins **20** are only illustrated in FIG. **1** at the upper and lower ends of intervening spaces **21**, it should be understood that corrugated fins **20** continuously extend along the entire length of intervening spaces **21**. In addition, although tray-shaped plate **12***c* located in the central region of evaporator **10** includes a pair of bulged portions **16**, it should be noted that bulged portion **16** located on the front side of the evaporator does not have an oval opening **16***a*.

Latitudinally adjacent hollow spaces **16***b* of a pair of bulged portions **16** are linked to one another through oval openings **16***a*, thereby forming a pair of parallel conduits **30** and **40**. Conduit **30** is located on the front side of evaporator **10** and conduit **40** is located on the rear side of evaporator **10**. Conduit **30** is divided into left and right side sections **30***a* and **30***b* by plate **12***c* as shown in FIG. **1**.

Referring also to FIG. **4**, in the above-mentioned construction of the evaporator, when an automotive air conditioning refrigerant circuit operates, the refrigerant flows from the condenser (not shown) of the refrigerant circuit via a throttling device, such as an expansion valve, into the interior region of tank **31** through inlet pipe **50**. The refrigerant in the interior region of tank **31** flows through left side section **30***a* of conduit **30** from the left side to the right side and concurrently flows into the upper right region of passage **19** of each of tube units **11**. As shown in FIG. **2**, the refrigerant in the upper right region of passage **19** then flows downwardly to the lower right region of passageway **19** in a complex flow path substantially formed from both diagonal and straight flow paths, as shown by the solid arrows in FIG. **2**, while also exchanging heat with the air passing along corrugated fins **20**. This complex flow path of the refrigerant enhances the heat exchangeability between the air and the refrigerant. The air passes through evaporator **10** from the front to the rear, as shown by the large narrow "A" in FIG. **4**. The refrigerant located in the lower right region of passage **19** is turned at the terminal end of narrow wall **14** and directed to flow from the right side to the left side of passage **19** as shown by the solid arrows in FIG. **2**. That is, the refrigerant flows from the front to the rear of passage **19**, then flows upwardly to the upper left region of passage **19** in the complex flow path mentioned above while further exchanging heat with the air passing along corrugated fins **20**, and finally, flows out of passage **19** of each of tube units **11**. The refrigerant flowing out of passage **19** of each of tube units **11** combines together in conduit **40** and flows through conduit **40** from the left side to the right side thereof.

The refrigerant flowing through conduit **40**, after passing through plate **12***c*, concurrently flows into the upper left region of passage **19** of each of tube units **11**. The refrigerant in the upper left region of passage **19** then flows downwardly to the lower left region of passageway **19** in a complex flow path, like the aforementioned flow path, while exchanging heat with the air passing along corrugated fins **20**. The refrigerant located in the lower left region of passage **19** is directed, at the terminal end of narrow wall **14**, from the left side to the right side of passage **19**. That is, the refrigerant flows from the rear to the front of passage **19**, then flows upwardly to the upper right region of passage **19** in a complex flow path while further exchanging heat with the air passing along corrugated fins **20**, and finally flows out of passage **19** of each of tube units **11**. The refrigerant flowing out of passage **19** of each of tube units **11** combines together in the right side section **30***b* of conduit **30**, and flows through the right side section **30***b* of conduit **30** from the left side to the right side thereof. The gaseous phase refrigerant located in the far right side of right side section **30***b* of conduit **30** flows into the interior region of tank **32** and then through outlet pipe **60** to the suction chamber of the compressor (not shown) of the refrigerant circuit.

In this prior art evaporator, the manufacturing process for plate **12** includes a drawing process for forming shallow depression **120**, semicylindrical projections **15**, parallelepiped projections **17** and bulged portions **16** from a rectangular sheet of aluminum alloy, and a punching process for punching out oval opening **16***a* from the bottom surface of each bulged portion **16**. In the drawing process, shallow depression **120**, semicylindrical projections **15**, parallelepiped projections **17** and bulged portions **16** are formed by a plurality of drawing steps. The number of drawing steps required to form bulged portions **16** is greater than the number of drawing steps for forming the other above-mentioned elements because bulged portions **16** are more deeply and sharply depressed than the other elements. Therefore, the manufacturing of plate **12** becomes a complicated process. Furthermore, the large number of drawing steps necessary to form bulged portions **16** decreases the thickness of the aluminum alloy sheet at that point such that bulged portions **16** may be easily cracked in the drawing process. The cracking of bulged portions **16** must then be prevented by increasing the thickness of the rectangular sheet. However, this in turn unnecessarily increases the weight of plate **12**, thus causing an unnecessary increase in the weight of evaporator **10**, and unnecessarily decreasing the heat exchangeability of evaporator **10**.

## SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a heat exchanger which can be simply manufactured without increasing the weight thereof.

The heat exchanger includes a plurality of laminated tube units each comprising a pair of plates which define a fluid passage therebetween, and a pair of conduits for distributing a heat medium to the fluid passage of each of the tube units or receiving the heat medium from the fluid passage of each of the tube units. The pair of conduits is separately provided from the tube units.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates an overall front view of a laminated type evaporator in accordance with a prior art embodiment.

FIG. **2** illustrates a side view of a tube unit of the evaporator shown in FIG. **1**.

FIG. **3** illustrates a cross section taken along line **3—3** of FIG. **2**.

FIG. **4** is a schematic view showing the flow path of the refrigerant flowing through the interior of the laminated type evaporator shown in FIG. **1**.

FIG. **5** illustrates an overall front view of a laminated type evaporator in accordance with a first embodiment of the present invention.

FIG. **6** illustrates a perspective cut-away view of the laminated type evaporator shown in FIG. **5**.

FIG. **7** illustrates a side view of a tube unit of the evaporator shown in FIG. **6**.

FIG. **8** illustrates a cross section taken along line **8—8** of FIG. **7**.

FIG. **9** is a schematic view showing the flow path of the refrigerant flowing through the interior of the laminated type evaporator shown in FIG. **5**.

FIG. **10** illustrates a perspective cut-away view of a laminated type evaporator in accordance with a second embodiment of the present invention.

FIG. **11** illustrates a perspective cut-away view of a laminated type evaporator in accordance with a third embodiment of the present invention.

FIG. **12** illustrates a perspective cut-away view of a laminated type evaporator in accordance with a fourth embodiment of the present invention.

FIG. **13** illustrates a perspective cut-away view of a laminated type evaporator in accordance with a fifth embodiment of the present invention.

FIG. **14** illustrates a perspective view of a tube unit of a laminated type evaporator in accordance with a sixth embodiment of the present invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. **5–8** illustrate a first embodiment of the present invention, and FIGS. **10–14** illustrate the second through sixth embodiments of the present invention, respectively. In the drawings, like reference numerals are used to denote elements corresponding to those shown in FIGS. **1–3** and a detailed explanation thereof is therefore omitted. Furthermore, the general function and effect of the second through sixth embodiments of the present invention are similar to the first embodiment of the present invention such that a detailed explanation thereof is likewise omitted.

The construction of a laminated type evaporator in accordance with a first embodiment of the present invention is shown in FIGS. 5–8. The laminated type evaporator **200** includes a plurality of tube units **201** of aluminum alloy each of which comprises a pair of tray-shaped plates **202**.

Each of tray-shaped plates **202** includes a tapered connecting tongue **203** projecting upwardly from the upper end thereof. One of the tongues **203** is disposed to the right of narrow wall **14**, and the other tongues **203** is disposed to the left thereof. A depression **203***a* is formed in the central region of tongue **203**, longitudinally extends from the upper end to the lower end thereof, and is linked to shallow depression **120** of plate **202**. The bottom surface of depression **203***a* is formed even with the plane of the inner bottom surface of shallow depression **120**. A pair of diagonally disposed semicylindrical projections **204** are formed on the bottom surface of depression **203***a*. Semicylindrical projections **204** reinforce the mechanical strength of tongues **203**. Semicylindrical projections **204** are longitudinally aligned with each other and are offset from the two rows of semicylindrical projections **15** formed in shallow depression **120**.

The flat top end surface of each of truncated semicylindroids **203** is formed even with the plane of flange **13**. The pair of tray-shaped plates **202** are joined together at flanges **13** and the top end surfaces of tongues **203**, so as to enclose therebetween a passage **205**. Opposing semicylindrical projections **204** on the pair of tray-shaped plates **202** contact one another at intersections **204***b* formed between their ridges **204***a*. The flat top end surfaces of tongues **203** are fixedly attached to one another by, for example, brazing, thereby forming a pair of tapered hollow connecting portions **210**.

Laminated type evaporator **200** further includes a pair of parallel closed ended cylindrical pipes **230** and **240** situated above the upper surface of laminated tube units **201**. As illustrated in FIG. **6**, cylindrical pipe **230** is positioned in front of cylindrical pipe **240**. A plurality of generally oval-shaped slots **231** are formed along the lower curved surface of cylindrical pipe **230** at equal intervals. A plurality of generally oval-shaped slots **241** are also formed along the lower curved surface of cylindrical pipe **240** at equal intervals. Generally, oval-shaped slots **231** of pipe **230** are aligned with generally oval-shaped slots **241** of pipe **240** so as to receive the pair of hollow connecting portions **210** of tube units **201**. The pair of annular hollow connecting portions **210** of tube units **201** are inserted into slots **231** and **241** until the lower end portion of connecting portions **210** contacts the inner peripheral surface of slots **231** and **241**, respectively. The pair of annular hollow connecting portions **210** are fixedly attached to slots **231** and **241**, respectively, by brazing or other conventional methods. A pair of circular openings **232** and **233** are formed at the left end and right end of cylindrical pipe **230**, respectively, on the front curved surface thereof. Opening **233** is omitted in FIG. **6**. One end of inlet pipe **50** is fixedly connected to opening **232** of cylindrical pipe **230** and one end of outlet pipe **60** is fixedly connected to opening **233** of cylindrical pipe **230**.

Circular plate **234** is fixedly disposed at an intermediate location within the interior region of cylindrical pipe **230** so as to divide the cylindrical pipe **230** into a left side section **230***a* and a right side section **230***b*, as shown in FIG. **5**.

With reference to FIG. **9** additionally, in the above-described construction of the evaporator, when the automotive air conditioning refrigerant circuit operates the refrigerant flows from a condenser (not shown) of the refrigerant circuit via a throttling device, such as an expansion valve, through inlet pipe **50** into left side section **230***a* of the interior region of cylindrical pipe **230**, and through left side section **230***a* in a left to right direction. The refrigerant flowing through left side section **230***a* of the interior region of pipe **230** concurrently flows through the interior region of hollow connecting portions **210** and into the upper right region of passage **205** in each of tube units **201**. The refrigerant in the upper right region of passage **205** then flows downwardly to the lower right region of passageway **205** in a complex flow path, which includes diagonal and straight flow paths as shown by the solid arrows in FIG. **7**, while also exchanging heat with the air passing along corrugated fins **20**. The air passes through evaporator **200** from the front to the rear thereof, as shown by the large arrow "A" in FIG. **9**. The refrigerant located in the lower right region of passage **205** is turned at the terminal end of narrow wall **14** and directed from the right side to the left side of passage **205**, as shown by the solid arrows in FIG. **7**. That is, the refrigerant flows from the front to the rear of passage **205**, then flows upwardly to the upper left region of passage **205** in a complex flow path while further exchanging heat with the air passing along corrugated fins **20**, and then finally flows out of passage **205** in each of tube units **201** through the interior hollow connecting portion **210**. The refrigerant flowing out of passage **205** from each of tube units **201** combines in the interior region of cylindrical pipe **240** and flows therethrough in a direction from the left side to the right side thereof.

The refrigerant flowing through the interior region of the right side of cylindrical pipe **240** concurrently flows into the upper left region of passage **205** in each of tube units **201** through the interior hollow connecting portion **210**. The refrigerant in the upper left region of passage **205** flows downwardly to the lower left region of passageway **205** in a complex flow path and exchanges heat with the air passing along corrugated fins **20**. The refrigerant located in the lower left region of passage **205** is turned at the terminal end of narrow wall **14** and directed from the left side to the right side of passage **205**. That is, the refrigerant flows from the rear to the front of passage **205**, then flows upwardly to the upper right region of passage **205** in a complex flow path while further exchanging heat with the air passing along corrugated fins **20**, and finally flows out of passage **205** from each of tube units **201** through the interior hollow connecting portions **210**. The refrigerant flowing from passage **205** in each of tube units **201** combines in the right side section **230***b* of the interior region of cylindrical pipe **230** and flows therethrough in a direction from the left side to the right side thereof. The gaseous phase refrigerant located in the far right side of right side section **230***b* in the interior region of cylindrical pipe **230** flows through outlet pipe **60** to a suction chamber of a compressor (not shown) in the refrigerant circuit.

In the present invention, cylindrical pipes **230** and **240** function to distribute the refrigerant to each of the tube units or to receive the refrigerant from each of the tube units, and are separately provided from the tube units. Therefore, in contrast to the prior art discussed above, it is not required to form the bulged portions in the tube units in order to obtain the desired distribution of the refrigerant. Accordingly, the number of drawing steps involved in forming the tray-shaped plate of the tube unit can be limited to a value which avoids causing any portion of the tray-shaped plate to crack. Thus, the tray-shaped plate of the present invention can be made by a simple forming process. Furthermore, the unnecessary increase in the weight of the evaporator, which in turn caused the unnecessary decrease in the heat exchangeability of the prior art evaporator, is eliminated because in the present invention it is not necessary to thicken the aluminum alloy sheet to prevent cracking.

FIG. 10 illustrates a second embodiment of the present invention. In the second embodiment, a pair of closed ended cylindrical pipes **232** and **233** are positioned in series along the upper end of the laminated tube units **201** in place of cylindrical pipe **230** of the first embodiment. Cylindrical pipe **232** is located on the left side of evaporator **200'** and cylindrical pipe **233** is located on the right side of evaporator **200'**. The right closed end of cylindrical pipe **232** and the left closed end of cylindrical pipe **233** can either be fixedly connected to one another or left apart.

FIG. 11 illustrates a third embodiment of the present invention. In the third embodiment, a pair of closed ended rectangular parallelepipeds **330** and **340** are located along the upper end of the laminated tube units **201** in place of the pair of cylindrical pipes **230** and **240** of the first embodiment. Rectangular plate **334** is fixedly disposed at an intermediate location within rectangular parallelepiped **330** so as to divide the interior region thereof into a left side section **330*a*** and a right side section **330*b***. A plurality of generally ovalshaped slots **331** are formed in the lower end surface of rectangular parallelepiped **330** at equal intervals and a plurality of generally ovalshaped slots **341** are also formed in the lower end surface of rectangular parallelepiped **340** at equal intervals. The lower end portions of tapered hollow connecting portions **210** of tube units **201** are fixedly connected to an inner peripheral surface of oval-shaped slots **331** and **341**. Oval-shaped slots **331** and **341** are more easily formed in the lower end surfaces of rectangular parallelepipeds **331** and **341**, in comparison to the formation of oval-shaped slots **231** and **241** in the cylindrical pipes of the first and second embodiments, due to the lower end surfaces of rectangular parallelepipeds **331** and **341** being planar.

FIG. 12 illustrates a fourth embodiment of the present invention. In the fourth embodiment, a pair of closed ended rectangular parallelepipeds **332** and **333** are positioned in series along the upper end of the laminated tube units **201** in place of rectangular parallelepiped **330** of the third embodiment. Rectangular parallelepiped **332** is located at the left side of evaporator **300** and rectangular parallelepiped **333** is located at the right side of evaporator **300'**. The right closed end of rectangular parallelepiped **332** and the left closed end of rectangular parallelepiped **333** can either be fixedly connected to each other or left unconnected.

FIG. 13 illustrates a fifth embodiment of the present invention. In the fifth embodiment, a closed ended rectangular parallelepiped **430** is located along the upper end of the laminated tube units **201** in place of the pair of rectangular parallelepipeds **330** and **340** of the third embodiment. The interior region of rectangular parallelepiped **430** is divided into front and rear sections **431** and **432** by a rectangular wall **433** formed at an intermediate location. A plurality of generally oval-shaped slots



**434** are formed in the lower end surface of front section **431** of rectangular parallelepiped **430** at equal intervals and a plurality of generally oval-shaped slots **435** are also formed in the lower end surface of rear section **432** of rectangular parallelepiped **430** at equal intervals. Rectangular plate **436** is fixedly disposed at an intermediate location in front section **431** so as to divide front section **431** into a left side sub-section **431*a*** and a right side sub-section **431*b***.

FIG. 14 illustrates a sixth embodiment of the present invention. Tray-shaped plate **502** is provided with a pair of corrugated plates **503** fixedly disposed on the bottom surface of shallow depression **120** in place of semicylindrical projections **15**. Corrugated plates **503** extend from the upper end of shallow depression **120** to a point approximately even with the terminal end of narrow wall **14**. Corrugated plate **503** includes a plurality of axial ridges **503*a*** extending along the length thereof.

One of the pair of corrugated plates **503** is located on the right side of shallow depression **120**, with respect to narrow wall **14**, and the other corrugated plate **503** is located on the left side of shallow depression **120**. The level of ridges **503*a*** is even with the level of flange **13**. Therefore, when the pair of tray-shaped plates **502** are joined together by flanges **13**, ridges **503*a*** of corrugated plates **503** are also brought into contact with one another.

It should be apparent to one skilled in the art that tray-shaped plate **502** could be substituted for tray-shaped plate **202** that was provided for tube unit **201** of the first through fifth embodiments.

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

I claim:

**1**. A heat exchanger comprising:

a plurality of laminated tube units, each of said tube units including a pair of plates joined together to define therebetween a fluid passageway and at least one generally tubular opening projecting upwards from a top surface of said pair of plates and linked in fluid communication with said fluid passageway; and

at least one conduit separately formed and disposed on an upper surface of said plurality of laminated tube units, said at least one conduit including a plurality of equiinterval slots in the bottom surface thereof;

wherein said at least one conduit is positioned on said plurality of tube units such that said at least one generally tubular opening is received in one of said equiinterval slots and fluid communication between said plurality of tube units is thereby obtained through said at least one conduit; and

wherein each of said pair of plates includes a shallow depression defined therein, a flange extending about the periphery thereof, and a wall disposed at an intermediate location therein and extending a majority of the length of said plate, said wall thereby defining a left side and a right side of said plate.

**2**. The heat exchanger of claim **1** wherein each of said pair of plates further includes a plurality of projections extending from the bottom surface of said depression.

3. The heat exchanger of claim **1** wherein each of said pair of plates further includes with the depression a corrogated sheet having a plurality of axial ridges disposed on the bottom surface of said depression.

4. The heat exchanger of claim **1** wherein said at least one conduit comprises a pair of generally rectangular pipes having two closed ends.

5. The heat exchanger of claim **4** wherein one of said pair of generally rectangular pipes includes a dividing plate disposed therein to thereby divide said conduit into a left side section and a right side section.

6. A heat exchanger comprising:

a plurality of laminated tube units, each of said tube units including a pair of plates joined together to define therebetween a fluid passageway and at least one tapered hollow connecting portion projecting upwards from a top surface of said pair of plates and linked in fluid communication with said fluid passageway; and

at least one conduit separately formed and disposed on an upper surface of said plurality of laminated tube units, said at least one conduit including a plurality of equiinterval slots in the bottom surface thereof;

wherein said at least one conduit is positioned on said plurality of tube units such that said hollow connecting portion is received in one of said equiinterval slots and fluid communication between said plurality of tube units is thereby obtained through said at least one conduit.

7. A heat exchanger comprising:

a plurality of laminated tube units, each of said tube units including a pair of plates joined together to define therebetween a fluid passageway and at least one tapered hollow connecting portion projecting upwards from a top surface of said pair of plates and linked in fluid communication with said passageway; and

a pair of cylindrical pipes having two closed ends and disposed on an upper surface of said plurality of laminated tube units, said cylindrical pipes each including a plurality of equiinterval slots in the bottom surface thereof, each of said pipes having two closed ends and positioned in series on the upper surface of said plurality of laminated tube units;

wherein said pipes are positioned on said plurality of tube units such that said hollow connecting portion is received in one of said equiinterval slots and fluid communication between said plurality of tube units is thereby obtained through said pipes.

8. A heat exchanger comprising:

a plurality of laminated tube units, each of said tube units including a pair of plates joined together to define therebetween a fluid passageway and at least one tapered hollow connecting portion projecting upwards from a top surface of said pair of plates and linked in fluid communication with said fluid passageway; and

a pair of generally rectangular pipes having two closed ends separately formed and disposed on an upper surface of said plurality of laminated tube units, said pair of generally rectangular pipes including a plurality of equiinterval slots in the bottom surface thereof;

wherein said pipes are positioned on said plurality of tube units such that said at least one connecting portion is received in one of said equiinterval slots and fluid communication between said plurality of tube units is thereby obtained through said pipes.

9. A heat exchanger comprising:

a plurality of laminated tube units, each of said tube units including a pair of plates joined together to define therebetween a fluid passageway and at least one tapered hollow connecting portion projecting upwards from the top surface of said pair of plates and linked in fluid communication with said fluid passageway; and

a generally rectangular structure having an interior region that is divided into a first rectangular passage and a second rectangular passage by a dividing wall extending the length thereof separately formed and disposed on an upper surface of said plurality of said laminated tube units, said rectangular structure including a plurality of equiinterval slots in the bottom surface thereof;

wherein said rectangular structure is positioned on said plurality of tube units such that said at least one hollow connecting portion is received in one of said equiinterval slots and fluid communication between said plurality of tube units is thereby obtained through said rectangular structure.

10. The heat exchanger of claim **9** wherein one of said first rectangular passage and said second rectangular passage includes a dividing plate disposed therein, thereby further dividing said passage into a left side and a right side.

11. A method for manufacturing a heat exchanger comprising the steps of:

forming a pair of conduits;

forming spaced openings in one side of each said conduit;

forming a plurality of relatively shallow tray shaped plates having a depression therein, each having a pair of spaced, tapered, dished tongue portions at one end thereof;

joining a pair of said tray shaped plates to form a plurality of tube members having a pair of spaced, hollow connecting portions at one end;

arranging said conduits in side by side relation;

inserting said hollow connecting portions into each of said spaced openings; and

connecting said tubes to said conduits with said connecting portions extending into said holes.

12. The method of claim **11** and also including the step of forming a plurality of projections in each said plate extending into said depression.

13. The method of claim **12** wherein said projections are formed in an arrangement wherein like projections formed in connected plates are in contact when said plates are connected.

14. The method of claim **13** wherein said step of connecting said tubes to said conduits includes brazing.

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