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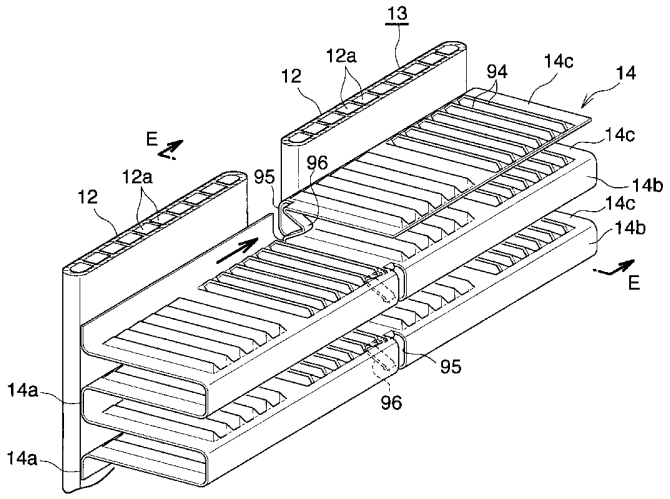


(57) **Abstract:** A corrugate fin 14 of an evaporator 1 includes wave crest portions 14a, wave trough portions 14b, and flat connection portions 14c connecting together the wave crest portions 14a and the wave trough portions 14b. Opposite end portions of a cutout 95 extend to corresponding connection portions 14c located at opposite ends of the wave crest portion 14a and the wave trough portion 14b. A projection 96 projecting inward is formed integrally with end portions of the connection portions 14c, the end portions of the connection portions 14c corresponding to opposite ends of the cutout 95. The projection 96 is formed in such a manner as to extend between the end portions of the connection portions 14c located at the opposite ends of the wave crest portion 14a and the wave trough portion 14c. The projection 96 projects inward in a shape resembling a lying letter V. The evaporator 1 exhibits excellent drainage of condensed water and enables high work efficiency in manufacture thereof.

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*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

# DESCRIPTION

## EVAPORATOR

## CROSS REFERENCE TO RELATED APPLICATIONS

This application is an application filed under 35 U.S.C. § 111(a) claiming the benefit pursuant to 35 U.S.C. § 119(e)(1) of the filing date of Provisional Application No. 60/619,009 filed October 18, 2004 pursuant to 35 U.S.C. § 111(b).

## TECHNICAL FIELD

The present invention relates to an evaporator for use in a car air conditioner, which is a refrigeration cycle to be mounted on, for example, a vehicle.

Herein and in the appended claims, the upper, lower, left-hand, and right-hand sides of FIGS. 1 and 2 will be referred to as "upper," "lower," "left," and "right," respectively. The downstream side of an air flow (a side represented by arrow X in FIG. 1, and a right-hand side in FIG. 3) is referred to as the "front," and the opposite side as the "rear."

## BACKGROUND ART

A conventionally used evaporator for use in a car air conditioner includes a plurality of refrigerant flow members arranged in parallel, and corrugate fins each disposed

between and brazed to the adjacent refrigerant flow members. Each of the corrugate fins includes wave crest portions, wave trough portions, and horizontal connection portions connecting together the wave crest portions and the wave trough portions. The wave crest portions and the wave trough portions are brazed to the refrigerant flow members. A plurality of louvers are formed in the connection portions in such a manner as to be juxtaposed in the air flow direction.

In the evaporator, a portion of condensed water on the surface of the refrigerant flow members and on the surface of the corrugate fins flows downward through openings between adjacent louvers. The residual condensed water flows, by the effect of surface tension, toward joint portions between the refrigerant flow members and the wave crest portions of the corrugate fins and toward joint portions between the refrigerant flow members and the wave trough portions of the corrugate fins. Then, the residual condensed water flows, by the effect of the flowing air, in the air flow direction and flows downward along the front ends of the refrigerant flow members. However, in the case where the quantity of condensed water is large, drainage performance may become insufficient.

An evaporator in which the above problem is solved has been proposed. In the evaporator, a corrugate fin disposed between adjacent refrigerant flow members is divided into a plurality of separate fin members, which are arranged at predetermined intervals in the air flow direction. A

clearance is formed between the adjacent separate fin members. Drain grooves for draining condensed water are formed on the outer surface of the refrigerant flow members at positions corresponding to the clearances. (Such an evaporator is proposed in, for example, Japanese Patent Application Laid-Open (*kokai*) No. 10-141805.)

However, in the evaporator described in the above-mentioned publication, each of the corrugate fins is divided into a plurality of separate fin members, which are arranged at predetermined intervals in the air flow direction, and a clearance is formed between the adjacent separate fin members. This, in manufacture of the evaporator, raises a problem that assembling together the refrigerant flow members and the separate fin members is troublesome. Also, as compared with an undivided corrugate fin, the divided corrugate fin is smaller in the area of heat transfer with air that flows through an air-passing clearance between adjacent refrigerant flow members, thus raising a problem of an impairment in heat-exchanging performance.

An object of the present invention is to solve the above problem and to provide an evaporator which exhibits excellent drainage of condensed water and enables high work efficiency in manufacture thereof.

## DISCLOSURE OF THE INVENTION

To achieve the above object, the present invention comprises the following modes.

1) An evaporator comprising a plurality of refrigerant flow members arranged in parallel in a left-right direction, and corrugate fins disposed in corresponding air-passing clearances between the adjacent refrigerant flow members, the corrugate fins each comprising wave crest portions, wave trough portions, and flat connection portions connecting together the wave crest portions and the wave trough portions, a cutout being formed in each of the wave crest portions and the wave trough portions.

2) An evaporator according to par. 1), wherein a plurality of louver groups each consisting of a plurality of louvers juxtaposed in a front-rear direction are arranged at predetermined intervals in the front-rear direction at each connection portion of each corrugate fin, whereby a plurality of louver-free portions are provided at each connection portion at the predetermined intervals in the front-rear direction; and the cutout is formed in each of the wave crest portions and the wave trough portions at least at a position corresponding to one of the louver-free portions of each connection portion.

3) An evaporator according to par. 1), wherein opposite end portions of each cutout of each corrugate fin extend to connection portions located at opposite ends of the corresponding wave crest portion or wave trough portion.

4) An evaporator according to par. 3), wherein a projection projecting inward is formed integrally with corresponding end portions of each pair of connection

portions of each corrugate fin, the end portions of the connection portions corresponding to opposite ends of one of the cutouts.

5) An evaporator according to par. 4), wherein each projection of each corrugate fin is formed in such a manner as to extend between the corresponding end portions of the connection portions located at the opposite ends of the corresponding wave crest portion or wave trough portion, the end portions of the connection portions corresponding to the opposite ends of one of the cutouts.

6) An evaporator according to par. 5), wherein the projections of the corrugate fins project inward in a shape resembling a lying letter V.

7) An evaporator according to par. 5), wherein a pair of slits spaced apart from each other in the front-rear direction is formed in each of the wave crest portions and the wave trough portions of each corrugate fin in such a manner as to extend to the connection portions located at the opposite ends of the corresponding wave crest portion or wave trough portion; and a portion sandwiched between the slits is bent inward to thereby form the cutout and the projection.

8) An evaporator according to par. 1), wherein each of the wave crest portions and the wave trough portions of each corrugate fin comprises a flat portion and round portions located at corresponding opposite ends of the flat portion and connected to the corresponding connection portions; and the round portions have a radius of curvature of 0.7 mm or

less.

9) An evaporator according to par. 1), wherein a fin height of each corrugate fin, which is a direct distance between the wave crest portions and the wave trough portions, is 7.0 mm to 10.0 mm; and a fin pitch, which is a pitch of the connection portions, is 1.3 mm to 1.8 mm.

10) An evaporator according to par. 1), wherein tube groups are arranged in a plurality of rows at predetermined intervals in the front-rear direction, each tube group consisting of a plurality of flat tubes arranged in parallel at predetermined intervals in the left-right direction; and a plurality of flat tubes arranged in tandem in the front-rear direction constitute a single refrigerant flow member.

11) An evaporator according to par. 10), wherein front end portions of the corrugate fins project frontward beyond front ends of the refrigerant flow members, and a cutout is formed in each of the front projecting portions of the corrugate fins.

12) An evaporator according to par. 10), wherein the cutouts are formed in each corrugate fin at positions corresponding to clearances between adjacent front and rear flat tubes of the refrigerant flow members.

13. An evaporator according to claim 12, wherein front end portions of the corrugate fins project frontward beyond front ends of the refrigerant flow members, and a cutout is formed in each of the front projecting portions of the corrugate fins.

13) An evaporator according to par. 12), wherein front end portions of the corrugate fins project frontward beyond front ends of the refrigerant flow members, and a cutout is formed in each of the front projecting portions of the corrugate fins.

14) An evaporator according to par. 10), further comprising a refrigerant inlet header section which is disposed on a side toward the front and on a first-end side of the refrigerant flow members and to which the flat tubes of at least a single tube group are connected; a refrigerant outlet header section which is disposed on the first-end side of the refrigerant flow members and rearward of the refrigerant inlet header section and to which the flat tubes of the remaining tube groups are connected; a first intermediate header section which is disposed on the side toward the front and on a second-end side of the refrigerant flow members and to which the flat tubes connected to the refrigerant inlet header section are connected; and a second intermediate header section which is disposed on the second-end side of the refrigerant flow members and rearward of the first intermediate header section and to which the flat tubes connected to the refrigerant outlet header section are connected; wherein the first and second intermediate header sections communicate with each other.

15) An evaporator according to par. 10), wherein a thickness of the individual flat tubes as measured in the left-right direction; i.e., a tube height, is 0.75 mm to 1.5

mm.

16) An evaporator according to par. 1), wherein each of the refrigerant flow members is formed of two metal plates whose peripheral edge portions are joined together; a bulging refrigerant flow tube portion is formed between the two metal plates, and a bulging header formation portion is connectedly formed at each of opposite ends of the bulging refrigerant flow tube portion; and a plurality of the refrigerant flow members are laminated such that their bulging header formation portions abut each other and such that air-passing clearances are formed between the bulging refrigerant flow tube portions.

17) An evaporator according to par. 16), wherein a drain groove for draining condensed water downward is formed on an outer surface of the refrigerant flow members, and the cutouts are formed in the corrugate fins at positions corresponding to the drain grooves.

18) An evaporator according to par. 16), wherein a thickness of the bulging refrigerant flow tube portion as measured in the left-right direction; i.e., a tube portion height, is 0.75 mm to 1.5 mm.

19) A refrigeration cycle comprising a compressor, a condenser, and an evaporator, and using a chlorofluorocarbon-based refrigerant, the evaporator being an evaporator according to any one of pars. 1) to 18).

20) A vehicle having installed therein a refrigeration cycle according to par. 19) as a car air conditioner.

21) A supercritical refrigeration cycle which comprises a compressor, a gas cooler, an evaporator, a pressure-reducing device, and an intermediate heat exchanger for performing heat exchange between a refrigerant from the gas cooler and a refrigerant from the evaporator and in which a supercritical refrigerant is used, the evaporator being an evaporator according to any one of pars. 1) to 18).

22) A vehicle having installed therein a refrigeration cycle according to par. 21) as a car air conditioner.

With the evaporator of any one of pars. 1) to 3), a portion of condensed water on the surface of the refrigerant flow members and on the surface of the corrugate fins flows downward through openings between adjacent louvers. The residual condensed water flows, by the effect of surface tension, toward joint portions between the refrigerant flow members and the wave crest portions and the wave trough portions of the corrugate fins, and is collected on the joint portions. The condensed water collected on the joint portions between the refrigerant flow members and the wave crest portions and the wave trough portions of the corrugate fins flows frontward by the effect of air passing through the air-passing clearances. Accordingly, the condensed water remaining rearward of the cutouts flows downward through the cutouts, and the condensed water remaining frontward of the cutouts flows downward along the front ends of the refrigerant flow members. Since the quantity of condensed water collected on the joint portions located frontward of

the cutouts and the quantity of condensed water collected on the joint portions located rearward of the cutouts become relatively small, drainage of condensed water is enhanced. This prevents splashing of condensed water from front end portions of the refrigerant flow members at the time of an abrupt change in air flow rate; a drop in cooling performance caused by an increase in air flow resistance which, in turn, is caused by surface tension causing condensed water to block openings between the louvers; and freezing of condensed water. In contrast to the corrugate fins of the evaporator described in the above-mentioned publication, each of the corrugate fins is not divided into a plurality of separate fin members in the air flow direction. This facilitates assembly of the refrigerant flow members and the corrugate fins in manufacture of the evaporator, and suppresses a reduction in the area of heat transfer between the corrugate fins and the air flowing through air-passing clearances between adjacent refrigerant flow members, thereby suppressing a drop in cooling performance of the evaporator.

The evaporator of any one of pars. 4) to 6) exhibits further-enhanced drainage of condensed water.

In manufacture of the corrugate fin of the evaporator of par. 7), through utilization of a release plate used to release a fin from a fin-forming roll, the cutouts and the projections can be formed simultaneously, thereby simplifying manufacturing work.

With the evaporator of par. 8), the quantity of

condensed water collected on the joint portions between the refrigerant flow members and the wave crest portions and on the joint portions between the refrigerant flow members and the wave trough portions tends to increase. However, even in this case, employment of the configuration of any one of pars. 1) to 6) enhances drainage of condensed water.

With the evaporator of par. 9), while an increase of air flow resistance is suppressed, heat exchange performance is enhanced, thereby establishing good balance between air flow resistance and heat exchange performance.

With the evaporator of par. 11), condensed water which is collected, by the effect of surface tension, on the joint portions between the refrigerant flow members and the wave crest portions and the wave trough portions of the corrugate fins passes through the cutouts of the front projecting portions of the corrugate fins and flows while being attracted, by the effect of surface tension, toward internal corner portions each defined by the front end surface of the front-end flat, hollow member and the front projecting portion of the corrugate fin. Subsequently, the condensed water flows downward along the internal corner portions and is then drained away. Accordingly, drainage of condensed water is enhanced, thereby preventing splashing of condensed water from front end portions of the refrigerant flow members at the time of an abrupt change in air flow rate; a drop in cooling performance caused by an increase in air flow resistance which, in turn, is caused by surface tension

causing condensed water to block openings between the louvers; and freezing of condensed water.

With the evaporator of par. 12), condensed water which is collected, by the effect of surface tension, on the joint portions between the refrigerant flow members and the wave crest portions and the wave trough portions of the corrugate fins passes through the cutouts; flows downward along the portions of the refrigerant flow members located between adjacent front and rear flat tubes of the refrigerant members; and is drained away. Accordingly, drainage of condensed water is enhanced, thereby preventing splashing of condensed water from front end portions of the refrigerant flow members at the time of an abrupt change in air flow rate; a drop in cooling performance caused by an increase in air flow resistance which, in turn, is caused by surface tension causing condensed water to block openings between the louvers; and freezing of condensed water.

With the evaporator of par. 13), condensed water collected rearward of the cutouts formed at positions corresponding to the portions located between adjacent front and rear flat tubes is drained away as in the case of the evaporator of par. 12). Also, condensed water collected rearward of the cutouts formed at the front projecting portions is drained away as in the case of the evaporator of par. 11). Accordingly, drainage of condensed water is enhanced, thereby preventing splashing of condensed water from front end portions of the refrigerant flow members at

the time of an abrupt change in air flow rate; a drop in cooling performance caused by an increase in air flow resistance which, in turn, is caused by surface tension causing condensed water to block openings between the louvers; and freezing of condensed water.

With the evaporator of par. 15), while an increase of air flow resistance is suppressed, heat exchange performance is enhanced, thereby establishing good balance between air flow resistance and heat exchange performance.

With the evaporator of par. 17), condensed water which is collected, by the effect of surface tension, on the joint portions between the refrigerant flow members and the wave crest portions and the wave trough portions of the corrugate fins enters the drain grooves via the cutouts; flows downward in the drain grooves; and is drained away. Accordingly, drainage of condensed water is enhanced, thereby preventing splashing of condensed water from front end portions of the refrigerant flow members at the time of an abrupt change in air flow rate; a drop in cooling performance caused by an increase in air flow resistance which, in turn, is caused by surface tension causing condensed water to block openings between the louvers; and freezing of condensed water.

With the evaporator of par. 18), while an increase of air flow resistance is suppressed, heat exchange performance is enhanced, thereby establishing good balance between air flow resistance and heat exchange performance.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partially cut-away perspective view showing the overall configuration of Embodiment 1 of an evaporator according to the present invention; FIG. 2 is a fragmentary view in vertical section showing the evaporator shown in FIG. 1 as it is seen from the rear, with its intermediate portion omitted; FIG. 3 is an enlarged fragmentary view in section taken along line A—A of FIG. 2; FIG. 4 is an exploded perspective view of a refrigerant inlet/outlet tank of the evaporator shown in FIG. 1; FIG. 5 is an exploded perspective view of a refrigerant turn tank of the evaporator shown in FIG. 1; FIG. 6 is an enlarged fragmentary view in section taken along line B—B of FIG. 2; FIG. 7 is an enlarged fragmentary view in section taken along line C—C of FIG. 2; FIG. 8 is a sectional view taken along line D—D of FIG. 2; FIG. 9 is an enlarged perspective view showing a refrigerant flow member and a corrugate fin; FIG. 10 is a sectional view taken along line E—E of FIG. 9; FIG. 11 is a diagram showing the flow of a refrigerant in the evaporator shown in FIG. 1; FIG. 12 is a view equivalent to FIG. 9, showing Embodiment 2 of an evaporator according to present invention; FIG. 13 is a view equivalent to FIG. 9, showing Embodiment 3 of an evaporator according to present invention; FIG. 14 is an enlarged perspective view showing a refrigerant flow member and a corrugate fin in Embodiment 4 of an evaporator according to the present invention; FIG. 15 is a sectional view taken along line F—F of FIG. 14; FIG. 16 is an exploded

perspective view showing a refrigerant flow member used in the evaporator of FIG. 14; FIG. 17 is an exploded perspective view showing a modified embodiment of a refrigerant flow member used in the evaporator of Embodiment 4; and FIG. 18 is a graph showing the test results of Experimental Examples 1 and 2 and Comparative Experimental Example.

BEST MODE FOR CARRYING OUT THE INVENTION

Embodiments of the present invention will next be described in detail with reference to the drawings. The embodiments are of an evaporator according to the present invention that is applied to a car air conditioner using a chlorofluorocarbon-based refrigerant.

In the drawings, like parts or like elements are denoted by like reference numerals, and repeated descriptions thereof are omitted.

Embodiment 1

The present embodiment is illustrated in FIGS. 1 to 10.

FIGS. 1 to 3 show the overall configuration of an evaporator, and FIGS. 4 to 10 show the configuration of essential portions of the evaporator. FIG. 11 shows how a refrigerant flows in the evaporator.

In FIGS. 1 to 3, the evaporator (1), which is used in a car air conditioner using a chlorofluorocarbon-based refrigerant, includes a refrigerant inlet/outlet tank (2) made of aluminum and a refrigerant turn tank (3) made of aluminum, the tanks (2) and (3) being vertically spaced apart

from each other, and further includes a heat exchange core section (4) provided between the tanks (2) and (3).

The refrigerant inlet/outlet tank (2) includes a refrigerant inlet header section (5) located on a side toward the front (downstream side with respect to the air flow direction) and a refrigerant outlet header section (6) located on a side toward the rear (upstream side with respect to the air flow direction). A refrigerant inlet pipe (7) made of aluminum is connected to the refrigerant inlet header section (5) of the refrigerant inlet/outlet tank (2). A refrigerant outlet pipe (8) made of aluminum is connected to the refrigerant outlet header section (6).

The refrigerant turn tank (3) includes a refrigerant inflow header section (9) located on the side toward the front and a refrigerant outflow header section (11) located on the side toward the rear. A connection section (10) connects the header sections (9) and (11) together. The header sections (9) and (11) and the connection section (10) define a drain gutter (20).

The heat exchange core section (4) includes a plurality of refrigerant flow members (13) arranged in parallel at predetermined intervals in the left-right direction; corrugate fins (14) made of aluminum, disposed within air-passing clearances between the adjacent refrigerant flow members (13) and on the outer sides of the leftmost and rightmost refrigerant flow members (13), and brazed to the refrigerant flow members (13); and side plates (15) made of

aluminum, disposed outer sides of the leftmost and rightmost corrugate fins (14), and brazed to the corresponding corrugate fins (14). Each of the refrigerant flow members (13) includes a plurality of; herein, two, flat tubes (12) made from an aluminum extrudate and disposed at predetermined intervals in the front-rear direction such that their widths extend in the front-rear direction. The upper and lower ends of the front flat tube (12) are connected to the refrigerant inlet header section (5) and the refrigerant inflow header section (9), respectively, whereas the upper and lower ends of the rear flat tube (12) are connected to the refrigerant outlet header section (6) and the refrigerant outflow header section (11), respectively.

As shown in FIGS. 2 to 4, the refrigerant inlet/outlet tank (2) is formed from an aluminum brazing sheet having a brazing material layer on each of opposite sides thereof, and includes a first member (16) having a plate-like shape and to which the flat tubes (12) are connected; a second member (17) formed from a bare aluminum extrudate and covering the upper side of the first member (16); and caps (18) and (19) formed from an aluminum brazing sheet having a brazing material layer on each of opposite sides thereof, and joined to the opposite ends of the first and second members (16) and (17) to thereby close the left and right end openings. A joint plate (21) made of aluminum and elongated in the front-rear direction is brazed to the outer surface of the right-hand cap (19) while facing the respective ends of the refrigerant

inlet header section (5) and the refrigerant outlet header section (6). The refrigerant inlet pipe (7) and the refrigerant outlet pipe (8) are connected to the joint plate (21).

The first member (16) has front and rear curved portions (22), whose central regions each have an arcuate cross section projecting downward and having a small curvature. A plurality of tube insertion holes (23), which are elongated in the front-rear direction, are formed in the curved portions (22) at predetermined intervals in the left-right direction. The tube insertion holes (23) of the front curved portion (22) and those of the rear curved portion (22) are identical in position in the left-right direction. A rising wall (22a) is formed integrally with each of the front edge of the front curved portion (22) and the rear edge of the rear curved portion (22), over the entire length of the front and rear edges. A plurality of through holes (25) are formed in a flat portion (24) located between the curved portions (22) of the first member (16), at predetermined intervals in the left-right direction.

The second member (17) includes front and rear walls (26) extending in the left-right direction and jointly forming a cross section resembling the letter m, which opens downward; a partition wall (27) provided at a central region thereof between the front and rear walls (26), extending in the left-right direction, and dividing the interior of the refrigerant inlet/outlet tank (2) into a front space and a

rear space; and two substantially arcuate connection walls (28) projecting upward and integrally connecting the upper end of the partition wall (27) and the upper ends of the front and rear walls (26). A flow-dividing resistance plate (29) integrally connects a lower end portion of the rear wall (26) of the second member (17) and a lower end portion of the partition wall (27) over the entire length thereof. A plurality of refrigerant passage holes (31A) and (31B) in a through-hole form and elongated in the left-right direction are formed in a rear region, excluding left and right end portions thereof, of the flow-dividing resistance plate (29) at predetermined intervals in the left-right direction. The lower end of the partition wall (27) projects downward beyond the lower ends of the front and rear walls (26). A plurality of projections (27a) are integrally formed on the lower end face of the partition wall (27) at predetermined intervals in the left-right direction in such a manner as to project downward, and are fitted into corresponding through holes (25) of the first member (16). The projections (27a) are formed by cutting off predetermined portions of the partition wall (27).

A leftward projecting portion (32) to be fitted into the refrigerant inlet header section (5) is formed integrally with the right-hand cap (19), on the side toward the front. An upper, leftward projecting portion (33) and a lower, leftward projecting portion (34) are formed integrally with the right-hand cap (19), on the side toward the rear, and

spaced apart from each other in the vertical direction. The upper, leftward projecting portion (33) is fitted into a space (6a) of the refrigerant outlet header section (6), the space (6a) being located above the flow-dividing resistance plate (29). The lower, leftward projecting portion (34) is fitted into a space (6b) of the refrigerant outlet header section (6), the space (6b) being located under the flow-dividing resistance plate (29). An engagement finger (35) projecting leftward is formed integrally with each of an arcuate portion extending between the front side edge and the top edge of the right-hand cap (19) and an arcuate portion extending between the rear side edge and the top edge of the right-hand cap (19). Further, an engagement finger (36) projecting leftward is formed integrally with each of a front portion and a rear portion of the lower end face of the right-hand cap (19). A refrigerant inlet (37) is formed in the bottom wall of the leftward projecting portion (32), located on the side toward the front, of the right-hand cap (19). A refrigerant outlet (38) is formed in the bottom wall of the upper, leftward projecting portion (33), located on the side toward the rear, of the right-hand cap (19). The left-hand cap (18) is a mirror image of the right-hand cap (19) and includes the following integrally formed portions: a rightward projecting portion (39) to be fitted into the refrigerant inlet header section (5); an upper, rightward projecting portion (41) to be fitted into the space (6a) of the refrigerant outlet header section (6), the space (6a)

being located above the flow-dividing resistance plate (29); a lower, rightward projecting portion (42) to be fitted into the space (6b) of the refrigerant outlet header section (6), the space (6b) being located under the flow-dividing resistance plate (29); and upper and lower engagement fingers (43) and (44) projecting rightward. No opening is formed in the bottom walls of the rightward projecting portion (39) and the upper, rightward projecting portion (41). The upper edge of the cap (18) and the upper edge of the cap (19) each assume a shape such that two substantially arcuate portions are integrally connected together at a central position in the front-rear direction, so as to coincide with the corresponding left and right ends of the upper surface of the second member (17) of the refrigerant inlet/outlet tank (2). The lower edge of the cap (18) and the lower edge of the cap (19) each assume a shape such that two substantially arcuate portions are integrally connected together via a flat portion located centrally in the front-rear direction, so as to coincide with the corresponding left and right ends of the lower surface of the first member (16) of the refrigerant inlet/outlet tank (2).

The joint plate (21) includes a short, cylindrical refrigerant inflow port (45) communicating with the refrigerant inlet (37) of the right-hand cap (19), and a short, cylindrical refrigerant outflow port (46) communicating with the refrigerant outlet (38) of the right-hand cap (19). A bent portion (47) projecting leftward is

formed at a portion of each of the upper and lower edge portions of the joint plate (21) located between the refrigerant inflow port (45) and the refrigerant outflow port (46). The upper bent portion (47) is fitted between two substantially arcuate portions of the upper edge of the right-hand cap (19) and between the two connection walls (28) of the second member (17). The lower bent portion (47) is fitted to the above-mentioned flat portion formed between two substantially arcuate portions of the lower edge of the right-hand cap (19) and to the flat portion (24) of the first member (16). An engagement finger (48) projecting leftward is formed integrally with each of front and rear end portions of the lower edge of the joint plate (21). The engagement fingers (48) are fitted to the lower edge of the right-hand cap (19). A diameter-reduced portion formed at one end portion of the refrigerant inlet pipe (7) is inserted into and brazed to the refrigerant inflow port (45) of the joint plate (21). Similarly, a diameter-reduced portion formed at one end portion of the refrigerant outlet pipe (8) is inserted into and brazed to the refrigerant outflow port (46) of the joint plate (21). Although unillustrated, an expansion valve attachment member is joined to the other end portions of the refrigerant inlet and outlet pipes (7) and (8) while facing the ends of the pipes (7) and (8).

The first and second members (16) and (17) of the refrigerant inlet/outlet tank (2), the caps (18) and (19), and the joint plate (21) are brazed together as follows. In

assembly of the first and second members (16) and (17), the projections (27a) of the second member (17) are inserted into the corresponding through holes (25) of the first member (16), followed by crimping. As a result, upper end portions of the front and rear rising walls (22a) of the first member (16) are fitted to corresponding lower end portions of the front and rear walls (26) of the second member (17). In the thus-established condition, the first and second members (16) and (17) are brazed together by utilization of the brazing material layers of the first member (16). In attachment of the caps (18) and (19), the front projecting portions (39) and (32) are fitted into the space defined by the first and second members (16) and (17) and located frontward of the partition wall (27); the rear, upper projecting portions (41) and (33) are fitted into the space defined by the first and second members (16) and (17) and located rearward of the partition wall (27) and above the flow-dividing resistance plate (29); the rear, lower projecting portions (42) and (34) are fitted into the space defined by the first and second members (16) and (17) and located rearward of the partition wall (17) and under the flow-dividing resistance plate (29); the upper engagement fingers (43) and (35) are fitted to the connection walls (28) of the second member (17); and the lower engagement fingers (44) and (36) are fitted to the curved portions (22) of the first member (16). In the thus-established condition, the caps (18) and (19) are brazed to the first and second members (17) and (17) by utilization of

the brazing material layers thereof. In attachment of the joint plate (21), the bent portions (47) are fitted to the right-hand cap (19) and the second member (17), and the engagement fingers (48) are fitted to the right-hand cap (19). In the thus-established condition, the joint plate (21) is brazed to the right-hand cap (19) by utilization of the brazing material layers of the right-hand cap (19).

The refrigerant inlet/outlet tank (2) is thus formed. A portion of the refrigerant inlet/outlet tank (2) located frontward of the partition wall (27) of the second member (17) serves as the refrigerant inlet header section (5), and a portion of the refrigerant inlet/outlet tank (2) located rearward of the partition wall (27) serves as the refrigerant outlet header section (6). The flow-dividing resistance plate (29) divides the interior of the refrigerant outlet header section (6) into the upper and lower spaces (6a) and (6b). The spaces (6a) and (6b) communicate with each other through the refrigerant passage holes (31A) and (31B). The refrigerant outlet (38) of the right-hand cap (19) communicates with the upper space (6a) of the refrigerant outlet header section (6). The refrigerant inflow port (45) of the joint plate (21) communicates with the refrigerant inlet (37), and the refrigerant outflow port (46) communicates with the refrigerant outlet (38).

As shown in FIGS. 2, 3, and 5 to 8, the refrigerant turn tank (3) is formed from an aluminum brazing sheet having a brazing material layer on each of opposite sides thereof

and includes a first member (50) having a plate-like shape and to which the flat tubes (12) are connected; a second member (51) formed from a bare aluminum extrudate and covering the lower side of the first member (50); caps (52) and (53) formed from an aluminum brazing sheet having a brazing material layer on each of opposite sides thereof, and closing the left and right end openings of the first and second members (50) and (51); an auxiliary drain plate (54) formed from an aluminum bare material, elongated in the left-right direction, and joined to the connection section (10); and a communication member (55) formed from an aluminum bare material, elongated in the front-rear direction, and brazed to the outer surface of the left-hand cap (52) in such a manner as to face the ends of the refrigerant inflow header section (9) and the refrigerant outflow header section (11). The refrigerant inflow header section (9) and the refrigerant outflow header section (11) communicate with each other at their left end portions via the communication member (55).

Each of the refrigerant inflow header section (9) and the refrigerant outflow header section (11) has a top face, a front side face, a rear side face, and a bottom face. The top faces, excluding their inside and outside portions with respect to the front-rear direction, of the header sections (9) and (11) serve as horizontal flat faces (9a) and (11a), respectively. The inside portions with respect to the front-rear direction of the top faces of the header sections (9) and (11) serve as first low portions (9b) and (11b),

respectively, which are of faces inclined linearly downward and toward the inside with respect to the front-rear direction. The first low portions (9b) and (11b) serve as front and rear side surfaces of the drain gutter (20). The front and rear side surfaces of the drain gutter (20) fan out upward and in the front-rear direction. Preferably, the first low portions (9b) and (11b) are inclined downward at an angle of 45 degrees or greater with respect to a horizontal plane. The front and rear side surfaces of the drain gutter (20); i.e., the first low portions (9b) and (11b) of the header sections (9) and (11), are not necessarily inclined linearly, but may be curved, so long as they fan out upward and in the front-rear direction. Outside portions with respect to the front-rear direction of the top faces of the header sections (9) and (11) serve as second low portions (9c) and (11c), respectively, which are of faces inclined linearly downward and toward the outside with respect to the front-rear direction. Preferably, the second low portions (9c) and (11c) are inclined downward at an angle of 45 degrees or greater with respect to a horizontal plane. The front and rear outside surfaces of the header sections (9) and (11) are connected to the corresponding second low portions (9c) and (11c) of the top faces.

The first member (50) includes a first header formation portion (56), which forms an upper portion of the refrigerant inflow header section (9); a second header formation portion (57), which forms an upper portion of the refrigerant outflow

header section (11); and a connection wall (58), which connects the header formation portions (56) and (57) and forms the connection section (10). The first header formation portion (56) includes a horizontal flat top wall (56a); a first inclined wall (56b), which is formed integrally with the rear edge of the top wall (56a) over the entire length thereof and inclined rearward and downward; a second inclined wall (56c), which is formed integrally with the front edge of the top wall (56a) over the entire length thereof and inclined frontward and downward; and a vertical wall (56d), which is formed integrally with the front edge of the second inclined wall (56c) over the entire length thereof. The second header formation portion (57) includes a horizontal flat top wall (57a); a first inclined wall (57b), which is formed integrally with the front edge of the top wall (57a) over the entire length thereof and inclined frontward and downward; a second inclined wall (57c), which is formed integrally with the rear edge of the top wall (57a) over the entire length thereof and inclined rearward and downward; and a vertical wall (57d), which is formed integrally with the rear edge of the second inclined wall (57c) over the entire length thereof. The connection wall (58) integrally connects the lower edge of the first inclined wall (56b) of the first header formation portion (56) and the lower edge of the first inclined wall (57b) of the second header formation portion (57). The bottom end faces of the vertical walls (56d) and (57d) of the header formation

portions (56) and (57), respectively, are inclined downward, and inward with respect to the front-rear direction. An outside portion of each of the bottom faces partially forms a stepped portion (69), which will be described later. The upper surface of the top wall (56a) of the first header formation portion (56) serves as the top face of the refrigerant inflow header section (9); i.e., as the horizontal flat face (9a); the upper surfaces of the inclined walls (56b) and (56c) serve as the low portions (9b) and (9c); and the outer surface of the vertical wall (56c) serves as an upper portion of the front surface of refrigerant inflow header section (9). The upper surface of the top wall (57a) of the second header formation portion (57) serves as the top face of the refrigerant outflow header section (11); i.e., as the horizontal flat face (11a); the upper surfaces of the inclined walls (57b) and (57c) serve as the low portions (11b) and (11c); and the outer surface of the vertical wall (57d) serves as an upper portion of the rear surface of the refrigerant outflow header section (11).

A plurality of tube insertion holes (59) elongated in the front-rear direction are formed in the header formation portions (56) and (57) of the first member (50) at predetermined intervals in the left-right direction. The tube insertion holes (59) of the header formation portion (56) and those of the header formation portion (57) are identical in position in the left-right direction. End portions, located on a side toward the connection section

(10), of the tube insertion holes (59); i.e., rear end portions of the tube insertion holes (59) of the first header formation portion (56) and front end portions of the tube insertion holes (59) of the second header formation portion (57), are located in the first inclined walls (56b) and (57b), respectively. Thus, the end portions, located on the side toward the connection section (10), of the tube insertion holes (59) are located in the side surfaces of the drain gutter (20). Outer end portions, with respect to the front-rear direction, of the tube insertion holes (59); i.e., front end portions of the tube insertion holes (59) of the first header formation portion (56) and rear end portions of the tube insertion holes (59) of the second header formation portion (57), are located in the second inclined walls (56c) and (57c), respectively. Thus, the front and rear end portions of the tube insertion holes (59) are located in the second low portions (9c) and (11c) of the top faces of the header sections (9) and (11).

In the top walls (56a) and (57a) and the inclined walls (56b), (56c), (57b), and (57c) of the header formation portions (56) and (57) of the first member (50), their portions located on the left and right sides of each tube insertion hole (59) serve as inclined portions (61) that are inclined downward and toward the tube insertion hole (59). The inclined portions (61) located on the left and right sides of each tube insertion hole (59) define a recess (62). Drain grooves (63) for draining condensed water downward of

the refrigerant turn tank (3) are formed, in connection with the front and rear end portions of the corresponding tube insertion holes (59), on the upper surfaces of the second inclined walls (56c) and (57c) and the outer surfaces of the vertical walls (56d) and (57d) of the header formation portions (56) and (57) of the first member (50). The bottom of each drain groove (63) extends downward as the distance from the corresponding tube insertion hole (59) increases. The bottom of a portion of each drain groove (63) located on the second inclined wall (56c) or (57c); i.e., on the second low portion (9c) or (11c), is linearly inclined, with respect to a horizontal plane, downward and toward the front or the rear. Preferably, the bottom of the portion of each drain groove (63) located on the second low portion (9c) or (11c) is inclined at an angle of 45 degrees or greater with respect to the horizontal plane. The lower end of a portion of each drain groove (63) located on the vertical wall (56d) or (57d) opens at the bottom end face of the vertical wall (56d) or (57d) (see FIG. 6).

A plurality of drain through-holes (64) elongated in the left-right direction are formed in the connection wall (58) of the first member (50) at predetermined intervals in the left-right direction. Also, a plurality of fixation though-holes (65) are formed in the connection wall (58) of the first member (50) at predetermined intervals in the left-right direction while being shifted from the drain through-holes (64).

The first member (50) is formed, by press work, from an aluminum brazing sheet in such a manner as to form the header formation portions (56) and (57); i.e., the top walls (56a) and (57a), the inclined walls (56b), (56c), (57b), and (57c), the vertical walls (56d) and (57d), the connection wall (58), the tube insertion holes (59), the inclined portions (61), and the drain grooves (63), and to form the drain through-holes (64) and the fixation through-holes (65) in the connection wall (58).

The second member (51) includes a first header formation portion (66), which forms a lower portion of the refrigerant inflow header section (9); a second header formation portion (67), which forms a lower portion of the refrigerant outflow header section (11); and a connection wall (68), which connects together the header formation portions (66) and (67) and is brazed to the connection wall (58) of the first member (50) to thereby form the connection section (10). The first header formation portion (66) includes vertical front and rear walls (66a), and a bottom wall (66b) integrally connecting the bottom ends of the front and rear walls (66a), projecting downward, and having a substantially arcuate cross section. The second header formation portion (67) includes vertical front and rear walls (67a); a bottom wall (67b) integrally connecting the bottom ends of the front and rear walls (67a), projecting downward, and having a substantially arcuate cross section; and a horizontal flow-dividing control wall (67c) integrally

connecting upper end portions of the front and rear walls (67a). The connection wall (68) integrally connects an upper end portion of the rear wall (66a) of the first header formation portion (66) and an upper end portion of the front wall (67a) of the second header formation portion (67). The outer surface of the front wall (66a) of the first header formation portion (66) and the outer surface of the rear wall (67a) of the second header formation portion (67) are located inward, with respect to the front-rear direction, of the outer surface of the vertical wall (56d) of the first header formation portion (56) and the outer surface of the vertical wall (57d) of the second header formation portion (57), respectively, of the first member (50). Thus, the stepped portion (69) is provided at each of joint portions between the vertical walls (56d) and (57d) of the first member (50) and the front and rear walls (66a) and (67a) of the second member (51); the outer surfaces of the vertical walls (56d) and (57d) are located outward, with respect to the front-rear direction, of the outer surfaces of the front and rear walls (66a) and (67a), respectively, via the corresponding stepped portions (69); and the entire bottom end of each drain groove (63) opens at the corresponding stepped portion (69) (see FIGS. 6 and 7). The outer surface of an upper edge portion of the front wall (66a) of the first header formation portion (66) is flush with the bottom surface of a portion of the drain groove (63) located on the vertical wall (56d), and the outer surface of an upper edge portion of the rear wall (67a)

of the second header formation portion (67) is flush with the bottom surface of a portion of the drain groove (63) located on the vertical wall (57d). The outer surface of the front wall (66a) of the first header formation portion (66) serves as a lower portion of the front surface of the refrigerant inflow header section (9). The outer surface of the rear wall (67a) of the second header formation portion (67) serves as a lower portion of the rear surface of the refrigerant outflow header section (11).

A plurality of circular refrigerant passage holes (71) in a through-hole form are formed in a rear region of the flow-dividing control wall (67c) of the second header formation portion (67) of the second member (51) at predetermined intervals in the left-right direction. The distance between the two adjacent circular refrigerant passage holes (71) increases gradually as the distance from the left end of the flow-dividing control wall (67c) increases. Thus, the number of circular refrigerant passage holes (71) per unit length of the flow-dividing control wall (67c) reduces toward the right. Notably, the distance between the two adjacent circular refrigerant passage holes (71) may be constant. A plurality of through holes (72) elongated in the left-right direction are formed in the connection wall (68) of the second member (51), in alignment with the corresponding drain through-holes (64) of the first member (50). Also, a plurality of fixation through-holes (73) are formed in the connection wall (68), in alignment

with the corresponding fixation through-holes (65) of the first member (50).

The second member (51) is formed as follows. First, the front and rear walls (66a) and (67a) and the bottom walls (66b) and (67b) of the header formation portions (66) and (67), the flow-dividing control wall (67c) of the second header formation portion (67), and the connection wall (68) are integrally formed by extrusion. Subsequently, the resultant extrudate is subjected to press work so as to form the refrigerant passage holes (71) in the flow-dividing control wall (67c), and the drain through-holes (72) and the fixation through-holes (73) in the connection wall (68).

Cutouts (74) are formed in the auxiliary drain plate (54) in such a manner as to extend from its upper edge and to correspond to the drain through-holes (64) and (72) of the first and second members (50) and (51). The width of an open portion of the cutout (74) as measured in the left-right direction is equal to the length of the drain through-holes (64) and (72) as measured in the left-right direction. Auxiliary drain grooves (75) are formed on the front and rear surfaces of the auxiliary drain plate (54) as follows: the auxiliary drain grooves (75) extend vertically and are connected to the corresponding lower end portions of the cutouts (74); and their lower end portions are open at the bottom face of the auxiliary drain plate (54). Projections (76) are formed at the top edge of the auxiliary drain plate (54) in such a manner as to align with the corresponding

fixation through-holes (65) and (73) of the first and second members (50) and (51) and to project upward so as to be inserted into the corresponding fixation through-holes (65) and (73). The auxiliary drain plate (54) is formed, by press work, from an aluminum bare material in such a manner as to form the cutouts (74), the auxiliary drain grooves (75), and the projections (76).

The caps (52) and (53) assume a plate-like form and are formed, by press work, from an aluminum brazing sheet having a brazing material layer on each of opposite sides thereof. A rightward projecting portion (77) to be fitted into the refrigerant inflow header section (9) is formed integrally with the left-hand cap (52), on the side toward the front. An upper, rightward projecting portion (78) and a lower, rightward projecting portion (79) are formed integrally with the left-hand cap (52), on the side toward the rear, and spaced apart from each other in the vertical direction. The upper, rightward projecting portion (78) is fitted into a space (11A) of the refrigerant outflow header section (11), the space (11A) being located above the flow-dividing control wall (67c). The lower, rightward projecting portion (79) is fitted into a space (11B) of the refrigerant outflow header section (11), the space (11B) being located under the flow-dividing control wall (67c). In the left-hand cap (52), an engagement finger (81) projecting rightward is formed integrally with each of an arcuate portion extending between the front side edge and the bottom edge and an arcuate

portion extending between the rear side edge and the bottom edge, and is also formed integrally with the top edge at front and rear positions; and further, an engagement finger (82) projecting leftward is formed on each of the upper and lower edges at a central position with respect to the front-rear direction. Through holes (83) and (84) are formed in the bottom wall of the front, rightward projecting portion (77) and the bottom wall of the rear, lower, rightward projecting portion (79), respectively, of the left-hand cap (52). The front through hole (83) establishes communication between the interior and the exterior of the refrigerant inflow header section (9). The rear through hole (84) establishes communication between the interior and the exterior of the space (11B), located under the flow-dividing control wall (67c), of the refrigerant outflow header section (11).

A leftward projecting portion (85) to be fitted into the refrigerant inflow header section (9) is formed integrally with the right-hand cap (53), on the side toward the front. An upper, leftward projecting portion (86) and a lower, leftward projecting portion (87) are formed integrally with the right-hand cap (53), on the side toward the rear, and spaced apart from each other in the vertical direction. The upper, leftward projecting portion (86) is fitted into the space (11A) of the refrigerant outflow header section (11), the space (11A) being located above the flow-dividing control wall (67c). The lower, leftward projecting portion

(87) is fitted into the space (11B) of the refrigerant outflow header section (11), the space (11B) being located under the flow-dividing control wall (67c). In the right-hand cap (53), an engagement finger (88) projecting leftward is formed integrally with each of an arcuate portion extending between the front side edge and the bottom edge, and an arcuate portion extending between the rear side edge and the bottom edge, and is also formed integrally with the top edge at front and rear positions. No through hole is formed in the bottom walls of the leftward projecting portion (85) and the lower, leftward projecting portion (87).

The communication member (55) is formed, by press work, from an aluminum bear material and assumes, as viewed from the left, a plate-like form identical with that of the left-hand cap (52). A peripheral edge portion of the communication member (55) is brazed to the outer surface of the left-hand cap (52). An outward bulging portion (89) is formed on the communication member (55) so as to establish communication between the two through holes (83) and (84) of the left-hand cap (52). The interior of the outward bulging portion (89) serves as a communication channel (91) for establishing communication between the through holes (83) and (84) of the left-hand cap (52). A cutout (92) is formed on each of the upper and lower edges of the communication member (55) at a central position with respect to the front-rear direction. The engagement fingers of the left-hand cap (52) are fitted into the corresponding cutouts (92).

In assembly of the refrigerant turn tank (3), the first and second members (50) and (51), the auxiliary drain plate (54), the caps (52) and (53), and the communication member (55) are brazed together as follows. In assembly of the first member (50) and the second member (51), the connection walls (58) and (68) are brought in contact with each other such that the drain through-holes (64) and (72) are aligned with each other and such that the fixation through-holes (65) and (73) are aligned with each other; the bottom ends of the vertical walls (56d) and (57d) of the header formation portions (56) and (57) are engaged with the corresponding top ends of the front wall (66a) of the first header formation portion (66) and the rear wall (67a) of the second header formation portion (67); and the projections (76) of the auxiliary drain plate (54) are inserted from underneath into the fixation through-holes (73) and (65) of the members (50) and (51) and then crimped, thereby tacking the members (56) and (57) together. In the thus-established condition, these members are brazed together by utilization of the brazing material layers of the first member (50). The auxiliary drain plate (54) is brazed to the connection walls (58) and (68) of the members (50) and (51) by utilization of the brazing material layers of the first member (50). In attachment of the caps (52) and (53), the front projecting portions (77) and (85) are fitted into the space defined by the first header formation portions (56) and (66) of the members (50) and (51); the rear, upper projecting portions

(78) and (86) are fitted into the upper space defined by the second header formation portions (57) and (67) of the members (50) and (51) and located above the flow-dividing control wall (67c); the rear, lower projecting portions (79) and (87) are fitted into the lower space defined by the second header formation portions (57) and (67) of the members (50) and (51) and located under the flow-dividing control wall (67c); the upper engagement fingers (81) are fitted to the first member (50); and the lower engagement fingers (81) and (88) are fitted to the second member (51). In the thus-established condition, the caps (52) and (53) are brazed to the first and second members (50) and (51) by utilization of the brazing material layers thereof. In attachment of the communication member (55), the communication member (55) is engaged with the left-hand cap (52) such that the engagement fingers (82) are fitted into the corresponding cutouts (92). In the thus-established condition, the communication member (55) is brazed to the left-hand cap (52) by utilization of the brazing material layers of the left-hand cap (52).

The refrigerant turn tank (3) is thus formed. The first header formation portions (56) and (66) of the members (50) and (51) define the refrigerant inflow header section (9). The second header formation portions (57) and (67) define the refrigerant outflow header section (11). The flow-dividing control wall (67c) divides the interior of the refrigerant outflow header section (11) into the upper and lower spaces (11A) and (11B). The spaces (11A) and (11B) communicate with

each other through the circular refrigerant passage holes (71). The rear through hole (84) of left-hand cap (52) communicates with the lower space (11B) of the refrigerant outflow header section (11). The interior of the refrigerant inflow header section (9) and the lower space (11B) of the refrigerant outflow header section (11) communicate with each other via the through holes (83) and (84) of the left-hand cap (52) and the communication channel (91) in the outward bulging portion (89) of the communication member (55). The connection walls (58) and (68) of the members (50) and (51) define the connection section (10). The first low portion (9b) of the refrigerant inflow header section (9), the first low portion (11b) of the refrigerant outflow header section (11), and the connection section (10) define the drain gutter (20). The drain through-holes (64) and (72) of the connection walls (58) and (68) of the members (50) and (51) define the drain holes (93) of the connection section (10).

Each of the flat tubes (12) is formed from a bare aluminum extrudate and assumes a flat form having a wide width in the front-rear direction. In the flat tube (12), a plurality of refrigerant channels (12a) extending in the longitudinal direction thereof are formed in parallel therein. The front flat tubes (12) and the rear flat tubes (12) are arranged in such a manner as to be identical in position in the left-right direction. Upper end portions of the flat tubes (12) are inserted into the corresponding tube insertion holes (23) of the first member (16) of the refrigerant

input/output tank (2) and brazed to the first member (16) by utilization of the brazing material layers of the first member (16). Lower end portions of the flat tubes (12) are inserted into the corresponding tube insertion holes (59) of the first member (50) of the refrigerant turn tank (3) and brazed to the first member (50) by utilization of the brazing material layers of the first member (50). The front flat tubes (12) communicate with the refrigerant inlet header section (5) and the refrigerant inflow header section (9). The rear flat tubes (12) communicate with the refrigerant outlet header section (6) and the refrigerant outflow header section (11).

Preferably, the thickness of the flat tube (12) as measured in the left-right direction; i.e., a tube height (h), is 0.75 mm to 1.5 mm (see FIG. 10); the width of the flat tube (12) as measured in the front-rear direction is 12 mm to 18 mm; the wall thickness of the flat tube (12) is 0.175 mm to 0.275 mm; the thickness of a partition wall separating the refrigerant channels (12a) from each other is 0.175 mm to 0.275 mm; the pitch of the partition walls is 0.5 mm to 3.0 mm; and the front and rear end walls each have a radius of curvature of 0.35 mm to 0.75 mm as measured on the outer surface thereof.

In place of use of the flat tube (12) formed from an aluminum extrudate, a flat tube to be used may be formed such that an inner fin is inserted into a seam welded pipe of aluminum so as to form a plurality of refrigerant channels

therein. Alternatively, a flat tube to be used may be formed as follows. An aluminum brazing sheet having a brazing material layer on each of opposite sides thereof is subjected to a rolling process so as to form a plate that includes two flat-wall-forming portions connected together via a connection portion; side-wall-forming portions, which are formed, in a bulging condition, integrally with the corresponding flat-wall-forming portions at their side edges located in opposition to the connection portion; and a plurality of partition-wall-forming portions, which are formed integrally with the flat-wall-forming portions in such a manner as to project from the flat-wall-forming portions, and to be arranged at predetermined intervals in the width direction of the flat-wall-forming portions. The thus-prepared plate is bent at the connection portion into a hairpin form such that the side-wall-forming portions abut each other, followed by brazing. The partition-wall-forming portions become partition walls. In this case, corrugate fins formed from a bare material are used.

As shown in FIGS. 9 and 10, each of the corrugated fins (14) is made in a wavy form from an aluminum brazing sheet having a brazing material layer over opposite surfaces thereof. The corrugate fin (14) includes wave crest portions (14a), wave trough portions (14b), and horizontal flat connection portions each connecting together the wave crest portion (14a) and the wave trough portion (14b). A plurality of louvers (94) are formed at the connection portions (14c)

in such a manner as to be juxtaposed in the front-rear direction. The front and rear flat tubes (12) that constitute the refrigerant flow member (13) share the corrugate fin (14). The width of the corrugate fin (14) as measured in the front-rear direction is slightly greater than the span between the front end of the front flat tube (12) and the rear end of the rear flat tube (12), and a front end portion of the corrugate fin (14) projects frontward beyond the front end of the front flat tube (12). The wave crest portions (14a) and the wave trough portions (14b) of the corrugate fin (14) are brazed to the front and rear flat tubes (12) that constitute the refrigerant flow member (13). Preferably, a fin height (H) of the corrugate fin (14); i.e., a direct distance between the wave crest portion (14a) and the wave trough portion (14b), is 7.0 mm to 10.0 mm; and a fin pitch (P); i.e., the pitch of the connection portions (14c), is 1.3 mm to 1.8 mm. Each of the wave crest portion (14a) and the wave trough portion (14b) of the corrugate fin (14) includes a flat portion, which is brazed in a surface contact condition to the flat tubes (12), and round portions, which are located at corresponding opposite ends of the flat portion and connected to the corresponding connection portions (14c). Preferably, the round portions have a radius (R) of curvature of 0.7 mm or less.

The louver (94) is not formed on the connection portions (14c) of the corrugate fin (14) at positions corresponding to the clearance between the adjacent front and

rear flat tubes (12). A vertically extending cutout (95) is formed at each of the wave crest portions (14a) and the wave trough portions (14b) at positions corresponding to the clearance between the adjacent front and rear flat tubes (12). Opposite end portions of each cutout (95) extend to the corresponding connection portions (14c) located at vertically opposite ends of each of the wave crest portions (14a) and the wave trough portions (14b). An inward projection (96) having a shape resembling a lying letter V as viewed from the front is formed integrally with respective end portions of the connection portions (14c) located at vertically opposite ends of each of the wave crest portions (14a) and the wave trough portions (14b), the respective end portions of the connection portions (14c) corresponding to the opposite ends of the cutout (95). Each of the inward projections (96) is formed as follows: a pair of slits is formed at each of the wave crest portions (14a) and the wave trough portions (14b) in such a manner as to extend to the connection portions (14c) located at the opposite ends of each of the wave crest portions (14a) and the wave trough portions (14b); and a portion sandwiched between the paired slits is bent inward. For example, in manufacture of the corrugate fin (14) for use in an evaporator, through utilization of a release plate used to release the fin (14) from a fin-forming roll, the cutouts (95) and the inward projections (96) can be formed simultaneously.

In manufacture of the evaporator (1), component members

thereof excluding the refrigerant inlet pipe (7) and the refrigerant outlet pipe (8) are assembled and tacked together, and the resultant assembly is subjected to batch brazing.

The evaporator (1), together with a compressor, a condenser, and a pressure-reducing device, constitutes a refrigeration cycle that uses a chlorofluorocarbon-based refrigerant. The refrigeration cycle is installed in a vehicle, for example, an automobile, as a car air conditioner.

In the evaporator (1) described above, as shown in FIG. 11, two-phase refrigerant of vapor-liquid phase having passed through a compressor, a condenser, and an expansion valve enters the refrigerant inlet header section (5) of the refrigerant inlet/outlet tank (2) from the refrigerant inlet pipe (7) through the refrigerant inflow port (45) of the joint plate (21) and the refrigerant inlet (37) of the right-hand cap (19). Then, the refrigerant dividedly flows into the refrigerant channels (12a) of all of the front flat tubes (12).

The refrigerant having entered the refrigerant channels (12a) of all the front flat tubes (12) flows downward through the refrigerant channels (12a) and enters the refrigerant inflow header section (9) of the refrigerant turn tank (3). The refrigerant having entered the refrigerant inflow header section (9) flows leftward and then flows through the front through hole (83) of the left-hand cap (52), the communication channel (91) in the outward bulging portion (89) of the communication member (55), and the rear through

hole (84) of the left-hand cap (52), thereby turning its flow direction and entering the lower space (11B) of the refrigerant outflow header (11).

Even when the distribution of temperature (dryness of refrigerant) of the refrigerant flowing through the front flat tubes (12) becomes nonuniform due to a failure in the refrigerant flowing from the refrigerant inlet header section (5) to the front flat tubes (12) in a uniformly divided condition, the refrigerant is mixed up when the refrigerant outflowing from the refrigerant inflow header section (9) turns its flow direction and flows into the lower space (11B) of the refrigerant outflow header section (11), so that its temperature becomes uniform.

The refrigerant having entered the lower space (11B) of the refrigerant outflow header section (11) flows rightward; enters the upper space (11A) through the circular refrigerant passage holes (71) of the flow-dividing control wall (67c); and dividedly flows into the refrigerant channels (12a) of all of the rear flat tubes (12).

The refrigerant having flown into the refrigerant channels (12) of the flat tubes (12) flows upward, in opposition to the previous flow direction; enters the lower space (6b) of the refrigerant outlet header section (6); and enters the upper space (6a) through the elongated refrigerant passage holes (31A) and (31B) of the flow-dividing resistance plate (29). Since the flow-dividing control walls (67c) and (29) impart resistance to the flow of the refrigerant, the

divided flow from the upper space (11A) of the refrigerant outflow header section (11) to the rear flat tubes (12) becomes uniform, and the divided flow from the refrigerant inlet header section (5) to the front flat tubes (12) becomes uniform to a greater extent. As a result, the refrigerant flow rate becomes uniform among all the flat tubes (12), so that the temperature distribution throughout the heat exchange core section (4) becomes uniform.

Next, the refrigerant having entered the upper space (6a) of the refrigerant outlet header section (6) flows out to the refrigerant outlet pipe (8) through the refrigerant outlet (38) of the right-hand cap (19) and the refrigerant outflow port (46) of the joint plate (21). While flowing through the refrigerant channels (12a) of the front flat tubes (12) and through the refrigerant channels (12a) of the rear flat tubes (12), the refrigerant is subjected to heat exchange with the air flowing through the air-passing clearances in the direction of arrow X shown in FIGS. 1 and 11 and flows out from the evaporator (1) in a vapor phase.

During the heat exchange, condensed water is generated on the surface of the corrugate fins (14). A portion of the condensed water flows downward through openings between the louvers (94). Also, the condensed water flows, by the effect of surface tension, toward joint portions between the flat tubes (12) and the wave crest portions (14a) and the wave trough portions (14b) of the corrugate fins (14), and is collected on the joint portions. The condensed water

collected on the joint portions between the flat tubes (12) and the wave crest portions (14a) and the wave trough portions (14b) of the corrugate fins (14) flows frontward by the effect of air passing through the air-passing clearances. Accordingly, the condensed water remaining rearward of the cutouts (95) flows downward, through the cutouts (95), along the clearances between the front and rear flat tubes (12) of the refrigerant flow members (13), and the condensed water remaining frontward of the cutouts (95) flows downward along the front end faces of the front flat tubes (12). When condensed water flows downward through the cutouts (95), the inward projections (96) function to suppress remaining of condensed water on the corrugate fins (14). In the regions between the wave crest portions (14a) and the wave trough portions (14b), condensed water flows downward through the openings between the louvers (94).

Accordingly, drainage of condensed water is enhanced, thereby preventing splashing of condensed water from end portions located downward with respect to the air flow direction at the time of an abrupt change in air flow rate; a drop in cooling performance caused by an increase in air flow resistance which, in turn, is caused by surface tension causing condensed water to block openings between the louvers; and freezing of condensed water.

Condensed water drained from the corrugate fins (14) flows down onto the refrigerant inflow header section (9) and the refrigerant outflow header section (11) of the

refrigerant turn tank (3). A portion of the condensed water having flown down onto the refrigerant turn tank (3) enters the drain gutter (20). When the condensed water collected in the drain gutter (20) reaches a certain amount, the condensed water flows down the connection section (10) through the drain holes (93); flows along side edge portions of the cutouts (74) of the auxiliary drain plate (54); enters the auxiliary drain grooves (75); flows down in the auxiliary drain grooves (75); and drops downward below the refrigerant turn tank (3) from the bottom end openings of the auxiliary drain grooves (75). The remaining condensed water enters the drain grooves (63); flows in the drain grooves (63); and drops downward below the refrigerant turn tank (3) from the bottom end openings of the drain grooves (63); i.e., from the openings of the stepped portions (69).

The above mechanism prevents freezing of condensed water which could otherwise result from stagnation of condensed water in a large amount in the regions between the bottom ends of the corrugate fins (14) and the horizontal flat faces (9a) and (11a) of the header sections (9) and (11) of the refrigerant turn tank (3). As a result, a drop in performance of the evaporator (1) is prevented.

Embodiment 2

The present embodiment is illustrated in FIG. 12.

In the corrugate fins (14) of the evaporator of Embodiment 2, in addition to the cutouts (95) and the inward projections (96) provided at positions corresponding to

clearances between the adjacent front and rear flat tubes (12), the cutouts (95) and the inward projections (96) are formed at front projecting portions (140) of the corrugate fins (14) projecting frontward beyond the front ends of the front flat tubes (12).

Other configurational features are similar to those of the evaporator (1) of Embodiment 1.

In the evaporator of Embodiment 2, when condensed water is generated on the surface of the corrugate fins (14), a portion of the condensed water flows downward through openings between the louvers (94). Also, the condensed water flows, by the effect of surface tension, toward joint portions between the flat tubes (12) and the wave crest portions (14a) and the wave trough portions (14b) of the corrugate fins (14), and is collected on the joint portions. The condensed water collected on the joint portions between the flat tubes (12) and the wave crest portions (14a) and the wave trough portions (14b) of the corrugate fins (14) flows frontward by the effect of air passing through the air-passing clearances. Accordingly, the condensed water remaining rearward of the cutouts (95) located at the position corresponding to the clearance between the adjacent front and rear flat tubes (12) flows downward, through the cutouts (95), along the clearances between the front and rear flat tubes (12) of the refrigerant flow members (13). The condensed water remaining rearward of the cutouts (95) of the front projection portions (140) passes through the cutouts

(95) of the front projecting portions (140) and flows while being attracted, by the effect of surface tension, toward internal corner portions each defined by the front end surface of the front flat tube (12) and the front projecting portion (140) of the corrugate fin (14). Subsequently, the condensed water flows downward along the internal corner portions.

Embodiment 3

The present embodiment is illustrated in FIG. 13.

In the corrugate fins (14) of the evaporator of Embodiment 3, in place to the cutouts (95) and the inward projections (96) provided at positions corresponding to clearances between the adjacent front and rear flat tubes (12), the cutouts (95) and the inward projections (96) are formed at the front projecting portions (140) of the corrugate fins (14) projecting frontward beyond the front ends of the front flat tubes (12).

Other configurational features are similar to those of the evaporator (1) of Embodiment 1.

In the evaporator of Embodiment 3, when condensed water is generated on the surface of the corrugate fins (14), a portion of the condensed water flows downward through openings between the louvers (94). Also, the condensed water flows, by the effect of surface tension, toward joint portions between the flat tubes (12) and the wave crest portions (14a) and the wave trough portions (14b) of the corrugate fins (14), and is collected on the joint portions.

The condensed water collected on the joint portions between the flat tubes (12) and the wave crest portions (14a) and the wave trough portions (14b) of the corrugate fins (14) flows frontward by the effect of air passing through the air-passing clearances. Then, the condensed water passes through the cutouts (95) and flows while being attracted, by the effect of surface tension, toward internal corner portions each defined by the front end surface of the front flat tube (12) and the front projecting portion (140) of the corrugate fin (14). Subsequently, the condensed water flows downward along the internal corner portions.

Embodiment 4

The present embodiment is illustrated in FIGS. 14 to 16.

In the present embodiment, the evaporator is configured such that a plurality of refrigerant flow members (100) each having a vertically elongated rectangular shape are arranged in a laminated condition in the left-right direction and joined together while their widths extend in the front-rear direction (air flow direction).

Each of the refrigerant flow members (100) includes two vertically extending rectangular aluminum plates (101) whose peripheral edge portions are brazed together. Each of the aluminum plates (101) is formed from an aluminum brazing sheet having a brazing material layer on each of opposite sides thereof. Two (front and rear) vertically extending, bulging refrigerant flow tube portions (102) and (103), and bulging header formation portions (104) and (105) are

provided between the two aluminum plates (101), which partially constitute the refrigerant flow member (100). The bulging header formation portions (104) and (105) are connected to corresponding upper and lower end portions of the refrigerant flow tube portions (102) and (103). An aluminum corrugate inner fin (106) is disposed in each of the refrigerant flow members (100) in such a manner as to extend across the front and rear refrigerant flow tube portions (102) and (103). The corrugate inner fin (106) is brazed to the aluminum plates (101). Notably, two aluminum corrugate inner fins may be disposed separately in the corresponding refrigerant flow tube portions (102) and (103). A drain groove (107) extending vertically and adapted to drain condensed water is formed in a portion of the outer surface of the refrigerant flow member (100), the portion being sandwiched between the front and rear refrigerant flow tube portions (102) and (103).

The right-hand aluminum plate (101) used to partially constitute the refrigerant flow member (100) includes two (front and rear) vertically extending, rightward bulging, tube-portion-forming bulging portions (108) and four rightward bulging, header-forming bulging portions (109) connected to the corresponding upper and lower ends of the tube-portion-forming bulging portions (108) and having a bulging height greater than that of the tube-portion-forming bulging portions (108). A portion of the right-hand side surface of the right-hand aluminum plate (101) sandwiched

between the two tube-portion-forming bulging portions (108) serves as the drain groove (107). The top wall of each of the header-forming bulging portions (109) is punched out to thereby form a through-hole (111). The left-hand aluminum plate (101) used to partially constitute the refrigerant flow member (100) is a mirror image of the right-hand aluminum plate (101). The header formation portions (104) and (105) of the two refrigerant flow members (100) are respectively joined together in a communicating condition such that slightly size-reduced end portions of the header-forming bulging portions (109) of one refrigerant flow member (100) are press-fitted into and brazed to the corresponding through-holes (111) of the header-forming bulging portions (109) of the other refrigerant flow member (100).

In the refrigerant flow members (100), the height of the header formation portions (104) and (105) in the left-right direction is greater than that of the refrigerant flow tube portions (102) and (103). Clearances between the refrigerant flow tube portions (102) and clearances between the refrigerant flow tube portions (103) of the adjacent refrigerant flow members (100) serve as air-passing clearances. The corrugate fins (14) similar to those of Embodiment 1 are disposed in the corresponding air-passing clearances in such a manner as to be shared between the refrigerant flow tube portions (102) and (103). The wave crest portions (14a) and the wave trough portions (14b) of each corrugate fin (14) are brazed to the outer surfaces of

the refrigerant flow tube portions (102) and (103). The cutouts (95) of the corrugate fins (14) are located at positions corresponding to the drain grooves (107) of the refrigerant flow members (100).

Preferably, the thickness of the refrigerant flow tube portions (102) and (103) of the refrigerant flow member (100) as measured in the left-right direction; i.e., a tube height (h1), is 0.75 mm to 1.5 mm (see FIG. 15); the width of the refrigerant flow member (100) as measured in the front-rear direction is 12 mm to 18 mm; and the wall thickness of the aluminum plate (101) is 0.175 mm to 0.275 mm.

In manufacture of the evaporator, component members thereof are assembled and tacked together, and the resultant assembly is subjected to batch brazing.

In the evaporator of the present embodiment, the flow of refrigerant is optimized by means of blocking communication via the through-hole (111) between two predetermined adjacent refrigerant flow members (100).

In the evaporator of the present embodiment, when condensed water is generated on the surface of the corrugate fins (14), the condensed water is drained as in the case of the evaporator of Embodiment 1. However, the condensed water remaining rearward of the cutouts (95) enters the drain grooves (107) via the cutouts (95) and flows downward in the drain grooves (107), thereby enhancing drainage of condensed water.

In the evaporator of Embodiment 4, in addition to or in

place of the cutouts (95) and the inward projections (96) provided in a central region in the front-rear direction, the cutouts (95) and the inward projections (96) may be formed at front end portions of the corrugate fins (14).

FIG. 17 shows a modified embodiment of the refrigerant flow member used in the evaporator of Embodiment 4. In FIG. 17, a hairpin refrigerant flow tube portion (116) and two bulging header formation portions (119) and (120) are provided between the two aluminum plates (130), which partially constitute a refrigerant flow member (115). The hairpin refrigerant flow tube portion (116) includes two (front and rear) vertically extending, bulging linear portions (117) and a bulging communication portion (118) for establishing communication between the two bulging linear portions (117) at upper end portions thereof. The two bulging header formation portions (119) and (120) are connected to corresponding lower end portions of the two bulging linear portions (117) of the refrigerant flow tube portion (116). Each of the two aluminum plates (130) is formed from an aluminum brazing sheet having a brazing material layer on each of opposite sides thereof. An aluminum corrugate inner fin (106) is disposed in each of the refrigerant flow members (115) in such a manner as to extend across the two bulging linear portions (117) of the refrigerant flow tube portion (116). The corrugate inner fin (106) is brazed to the two aluminum plates (130). A drain groove (121) extending vertically and adapted to drain

condensed water is formed in a portion of the outer surface of the refrigerant flow member (115), the portion being sandwiched between the front and rear bulging linear portions (117) of the refrigerant flow tube portion (116).

The right-hand aluminum plate (130) used to partially constitute the refrigerant flow member (115) includes two (front and rear) vertically extending, rightward bulging, linear-portion-forming bulging portions (122); a rightward bulging, communication-portion-forming bulging portion (123) adapted to establish communication between upper end portions of the linear-portion-forming bulging portions (122) and having a bulging height equal to that of the linear-portion-forming bulging portions (122); and two (front and rear) rightward bulging, header-forming bulging portions (124) connected to the corresponding lower ends of the linear-portion-forming bulging portions (122) and having a bulging height greater than that of the linear-portion-forming and communication-portion-forming bulging portions (122) and (123). A plurality of inward projecting arcuate ribs (125) are formed at certain intervals on the top wall of the communication-portion-forming bulging portion (123) by means of concaving the corresponding portions of the top wall. The ribs (125) have a bulging height equal to that of the linear-portion-forming bulging portions (122). The top wall of each of the header-forming bulging portions (124) is punched out to thereby form a through-hole (126). The left-hand aluminum plate (130) used to partially constitute the refrigerant flow

member (115) is a mirror image of the right-hand aluminum plate (130).

In the refrigerant flow members (115), the height of the header formation portions (119) and (120) in the left-right direction is greater than that of the refrigerant flow tube portions (116). Clearances between the refrigerant flow tube portions (116) of the adjacent refrigerant flow members (115) serve as air-passing clearances. The corrugate fins (14) similar to those of Embodiment 1 are disposed in the corresponding air-passing clearances in such a manner as to be shared between the bulging linear portions (117). The wave crest portions (14a) and the wave trough portions (14b) of each corrugate fin (14) are brazed to the outer surfaces of the bulging linear portions (117). The cutouts (95) of the corrugate fin (14) are located at positions corresponding to the drain grooves (121) of the refrigerant flow members (115).

In the evaporator using the refrigerant flow members (115) shown in FIG. 17, the flow of refrigerant is optimized by means of blocking communication via the through-hole (126) between two predetermined adjacent refrigerant flow members (115).

The above four embodiments are described while mentioning the evaporator applied to an evaporator of a car air conditioner that uses a chlorofluorocarbon-based refrigerant. However, the present invention is not limited thereto. The evaporator of the present invention may be used

as an evaporator of a car air conditioner used in a vehicle, for example, an automobile, the car air conditioner including a compressor, a gas cooler, an evaporator, a pressure-reducing device, and an intermediate heat exchanger for performing heat exchange between a refrigerant from the gas cooler and a refrigerant from the evaporator, and using a supercritical refrigerant such as a $CO_2$ refrigerant.

Next will be described Experimental Examples regarding tests that were conducted for evaluating drainage of condensed water of corrugate fins.

Experimental Example 1

An evaporator having the configuration of Embodiment 1 and in a condition before connection of a refrigerant inlet pipe and a refrigerant outlet pipe thereto was prepared. The tube height (h) of the flat tube was 1.4 mm; the fin height (H) of the corrugate fin (14) was am; the fin pitch (P) was 1.5 mm; and the radius (R) of curvature of round portions of the wave crest portion (14a) and the wave trough portion (14b) connected to the connection portion (14c) was 0.6 mm. The refrigerant inflow port and the refrigerant outflow port of the joint plate were closed. The evaporator was immersed in water contained in a water tank so as to remove remaining air from spaces between the flat tubes and spaces around the corrugate fins and then allowed to stand for 30 minutes. Then, the evaporator was lifted out of water in a vertical condition and measured for weight for 1,800 seconds so as to evaluate drainage performance.

Experimental Example 2

An evaporator prepared had a configuration similar to that of Experimental Example 1 except that the corrugate fins had cutouts formed therein, but had no inward projections formed therein. The evaporator was evaluated for drainage performance in a manner similar to that of Experimental Example 1.

Comparative Experimental Example 1.

An evaporator prepared had a configuration similar to that of Experimental Example 1 except that the corrugate fins had no cutouts and inward projections formed therein. The evaporator was evaluated for drainage performance in a manner similar to that of Experimental Example 1.

FIG. 18 shows the test results of Experimental Examples 1 and 2 and Comparative Experimental Example 1. In FIG. 18, the term "water-retained weight" represents the percentage of evaporator weight to an evaporator weight that is measured immediately after the evaporator is lifted out of water in a vertical condition and taken as 100%. A reduction in water-retained weight means an increase in the amount of drained water, indicating an enhancement in drainage performance.

The test results shown in FIG. 18 reveal that, even when only cutouts are formed in the corrugate fins, drainage performance is enhanced in contrast to the case where no cutouts and inward projections are formed. The test results also reveal that, when cutouts and inward projections are formed in the corrugate fins, drainage performance is further

enhanced as compared with the case where only cutouts are formed in the corrugate fins.

## INDUSTRIAL APPLICABILITY

The evaporator of the present invention is favorably used as an evaporator for use in a car air conditioner, which is a refrigeration cycle of, for example, an automobile.

CLAIMS

1. An evaporator comprising a plurality of refrigerant flow members arranged in parallel in a left-right direction, and corrugate fins disposed in corresponding air-passing clearances between the adjacent refrigerant flow members, the corrugate fins each comprising wave crest portions, wave trough portions, and flat connection portions connecting together the wave crest portions and the wave trough portions, a cutout being formed in each of the wave crest portions and the wave trough portions.

2. An evaporator according to claim 1, wherein a plurality of louver groups each consisting of a plurality of louvers juxtaposed in a front-rear direction are arranged at predetermined intervals in the front-rear direction at each connection portion of each corrugate fin, whereby a plurality of louver-free portions are provided at each connection portion at the predetermined intervals in the front-rear direction; and the cutout is formed in each of the wave crest portions and the wave trough portions at least at a position corresponding to one of the louver-free portions of each connection portion.

3. An evaporator according to claim 1, wherein opposite end portions of each cutout of each corrugate fin extend to connection portions located at opposite ends of the corresponding wave crest portion or wave trough portion.

4. An evaporator according to claim 3, wherein a projection

projecting inward is formed integrally with corresponding end portions of each pair of connection portions of each corrugate fin, the end portions of the connection portions corresponding to opposite ends of one of the cutouts.

5. An evaporator according to claim 4, wherein each projection of each corrugate fin is formed in such a manner as to extend between the corresponding end portions of the connection portions located at the opposite ends of the corresponding wave crest portion or wave trough portion, the end portions of the connection portions corresponding to the opposite ends of one of the cutouts.

6. An evaporator according to claim 5, wherein the projections of the corrugate fins project inward in a shape resembling a lying letter V.

7. An evaporator according to claim 5, wherein a pair of slits spaced apart from each other in the front-rear direction is formed in each of the wave crest portions and the wave trough portions of each corrugate fin in such a manner as to extend to the connection portions located at the opposite ends of the corresponding wave crest portion or wave trough portion; and a portion sandwiched between the slits is bent inward to thereby form the cutout and the projection.

8. An evaporator according to claim 1, wherein each of the wave crest portions and the wave trough portions of each corrugate fin comprises a flat portion and round portions located at corresponding opposite ends of the flat portion and connected to the corresponding connection portions; and

the round portions have a radius of curvature of 0.7 mm or less.

9. An evaporator according to claim 1, wherein a fin height of each corrugate fin, which is a direct distance between the wave crest portions and the wave trough portions, is 7.0 mm to 10.0 mm; and a fin pitch, which is a pitch of the connection portions, is 1.3 mm to 1.8 mm.

10. An evaporator according to claim 1, wherein tube groups are arranged in a plurality of rows at predetermined intervals in the front-rear direction, each tube group consisting of a plurality of flat tubes arranged in parallel at predetermined intervals in the left-right direction; and a plurality of flat tubes arranged in tandem in the front-rear direction constitute a single refrigerant flow member.

11. An evaporator according to claim 10, wherein front end portions of the corrugate fins project frontward beyond front ends of the refrigerant flow members, and a cutout is formed in each of the front projecting portions of the corrugate fins.

12. An evaporator according to claim 10, wherein the cutouts are formed in each corrugate fin at positions corresponding to clearances between adjacent front and rear flat tubes of the refrigerant flow members.

13. An evaporator according to claim 12, wherein front end portions of the corrugate fins project frontward beyond front ends of the refrigerant flow members, and a cutout is formed in each of the front projecting portions of the corrugate

fins.

14. An evaporator according to claim 10, further comprising a refrigerant inlet header section which is disposed on a side toward the front and on a first-end side of the refrigerant flow members and to which the flat tubes of at least a single tube group are connected; a refrigerant outlet header section which is disposed on the first-end side of the refrigerant flow members and rearward of the refrigerant inlet header section and to which the flat tubes of the remaining tube groups are connected; a first intermediate header section which is disposed on the side toward the front and on a second-end side of the refrigerant flow members and to which the flat tubes connected to the refrigerant inlet header section are connected; and a second intermediate header section which is disposed on the second-end side of the refrigerant flow members and rearward of the first intermediate header section and to which the flat tubes connected to the refrigerant outlet header section are connected; wherein the first and second intermediate header sections communicate with each other.

15. An evaporator according to claim 10, wherein a tube height, which is a thickness of the individual flat tubes as measured in the left-right direction, is 0.75 mm to 1.5 mm.

16. An evaporator according to claim 1, wherein each of the refrigerant flow members is formed of two metal plates whose peripheral edge portions are joined together; a bulging refrigerant flow tube portion is formed between the two metal

plates, and a bulging header formation portion is connectedly formed at each of opposite ends of the bulging refrigerant flow tube portion; and a plurality of the refrigerant flow members are laminated such that their bulging header formation portions abut each other and such that air-passing clearances are formed between the bulging refrigerant flow tube portions.

17. An evaporator according to claim 16, wherein a drain groove for draining condensed water downward is formed on an outer surface of the refrigerant flow members, and the cutouts are formed in the corrugate fins at positions corresponding to the drain grooves.

18. An evaporator according to claim 16, wherein a tube portion height, which is a thickness of the bulging refrigerant flow tube portion as measured in the left-right direction, is 0.75 mm to 1.5 mm.

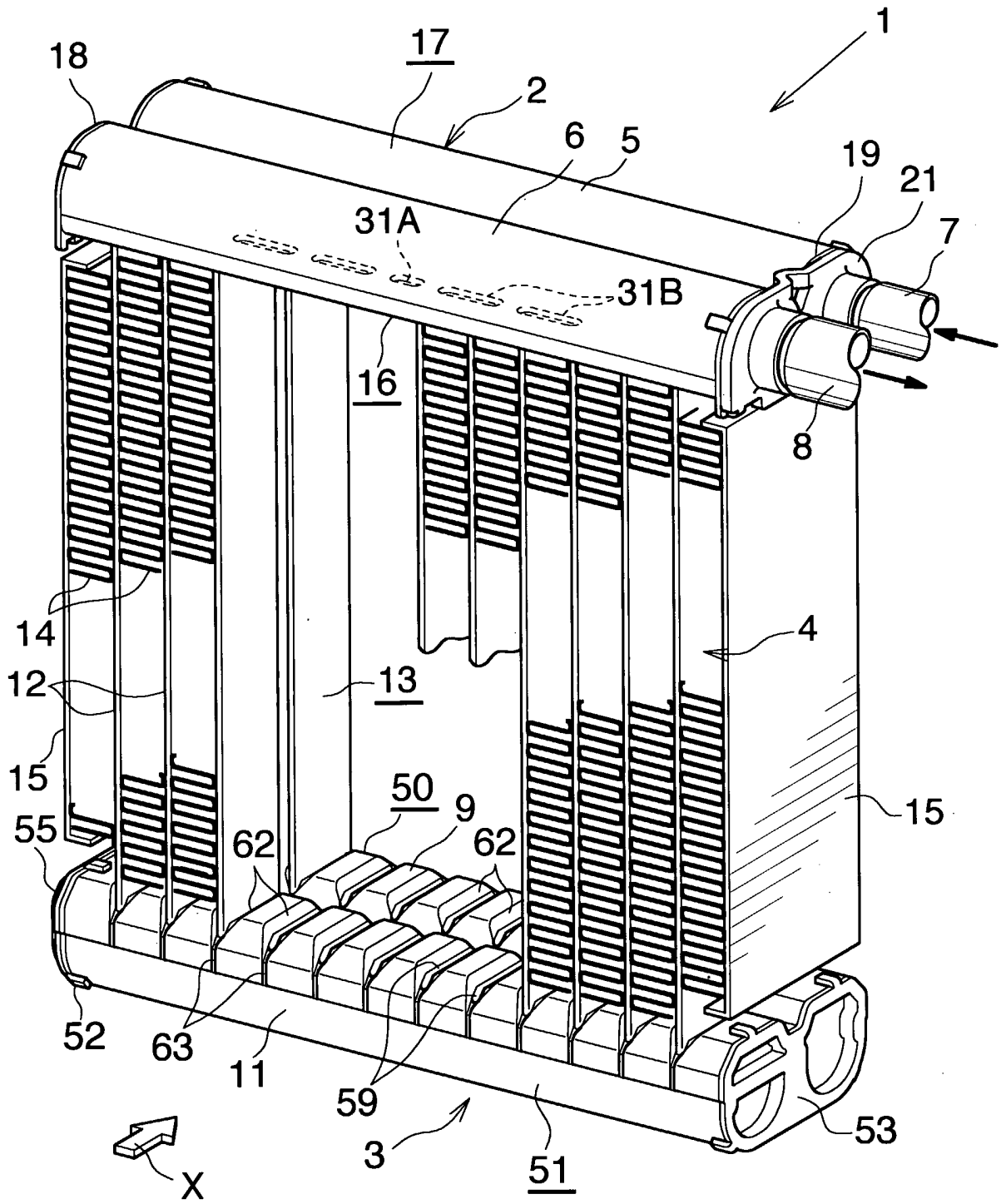
19. A refrigeration cycle comprising a compressor, a condenser, and an evaporator, and using a chlorofluorocarbon-based refrigerant, the evaporator being an evaporator according to any one of claims 1 to 18.

20. A vehicle having installed therein a refrigeration cycle according to claim 19 as a car air conditioner.

21. A supercritical refrigeration cycle which comprises a compressor, a gas cooler, an evaporator, a pressure-reducing device, and an intermediate heat exchanger for performing heat exchange between a refrigerant from the gas cooler and a refrigerant from the evaporator and in which a supercritical

refrigerant is used, the evaporator being an evaporator according to any one of claims 1 to 18.

22. A vehicle having installed therein a refrigeration cycle according to claim 21 as a car air conditioner.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18
17
2
6
5
19
21
7
31A
31B
16
8
14
4
12
13
15
50
9
62
62
55
15
52
63
11
59
3
51
53
X

*Fig.1*

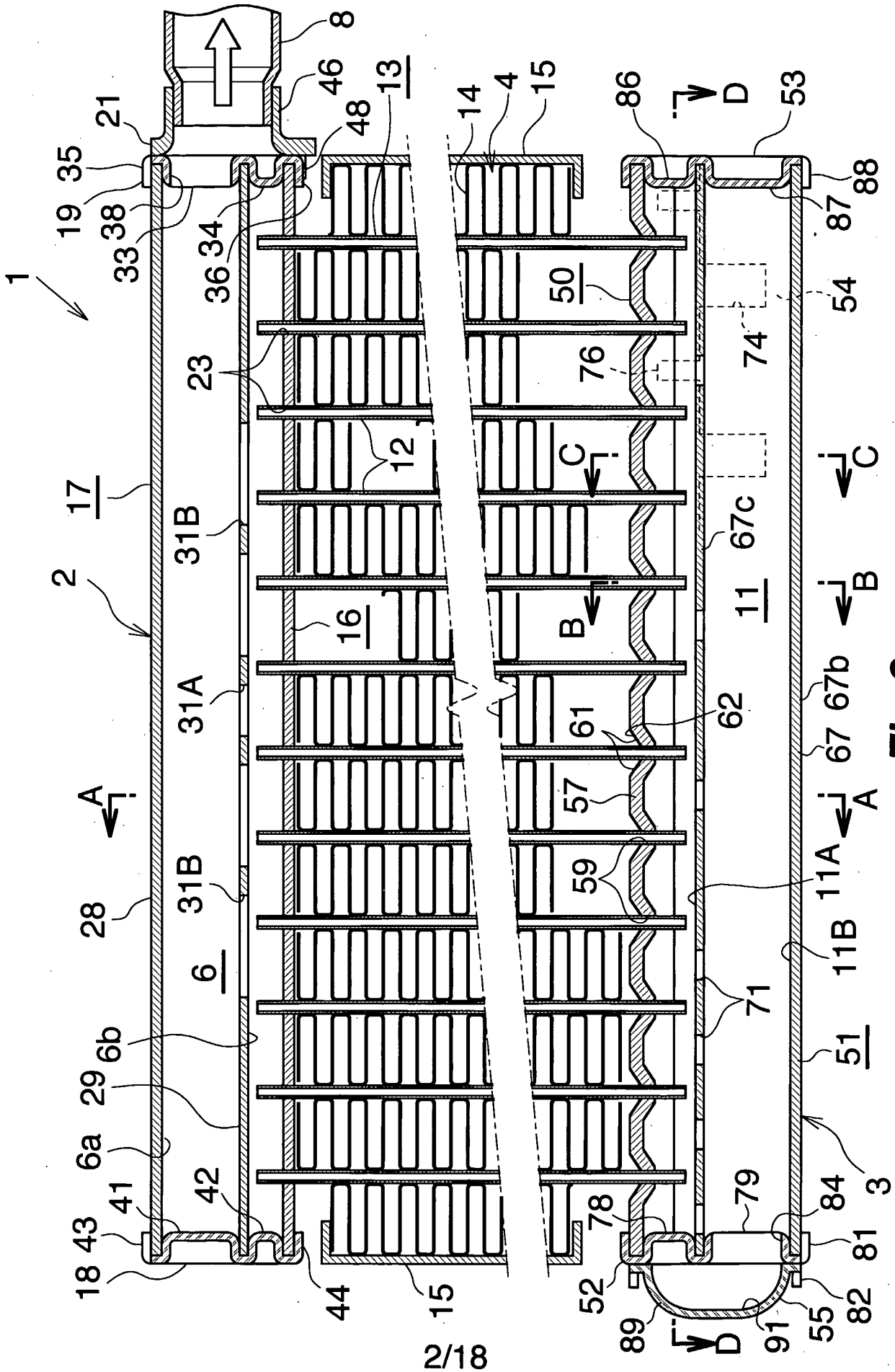

1
2
3
4
6
6a
6b
8
11
11A
11B
12
13
14
15
16
17
18
19
21
23
28
29
31A
31B
33
34
35
36
38
41
42
43
44
46
48
50
51
52
53
54
55
57
59
61
62
67
67b
67c
71
74
76
78
79
81
82
84
86
87
88
89
91
A
B
C
D
E
F

Fig.2

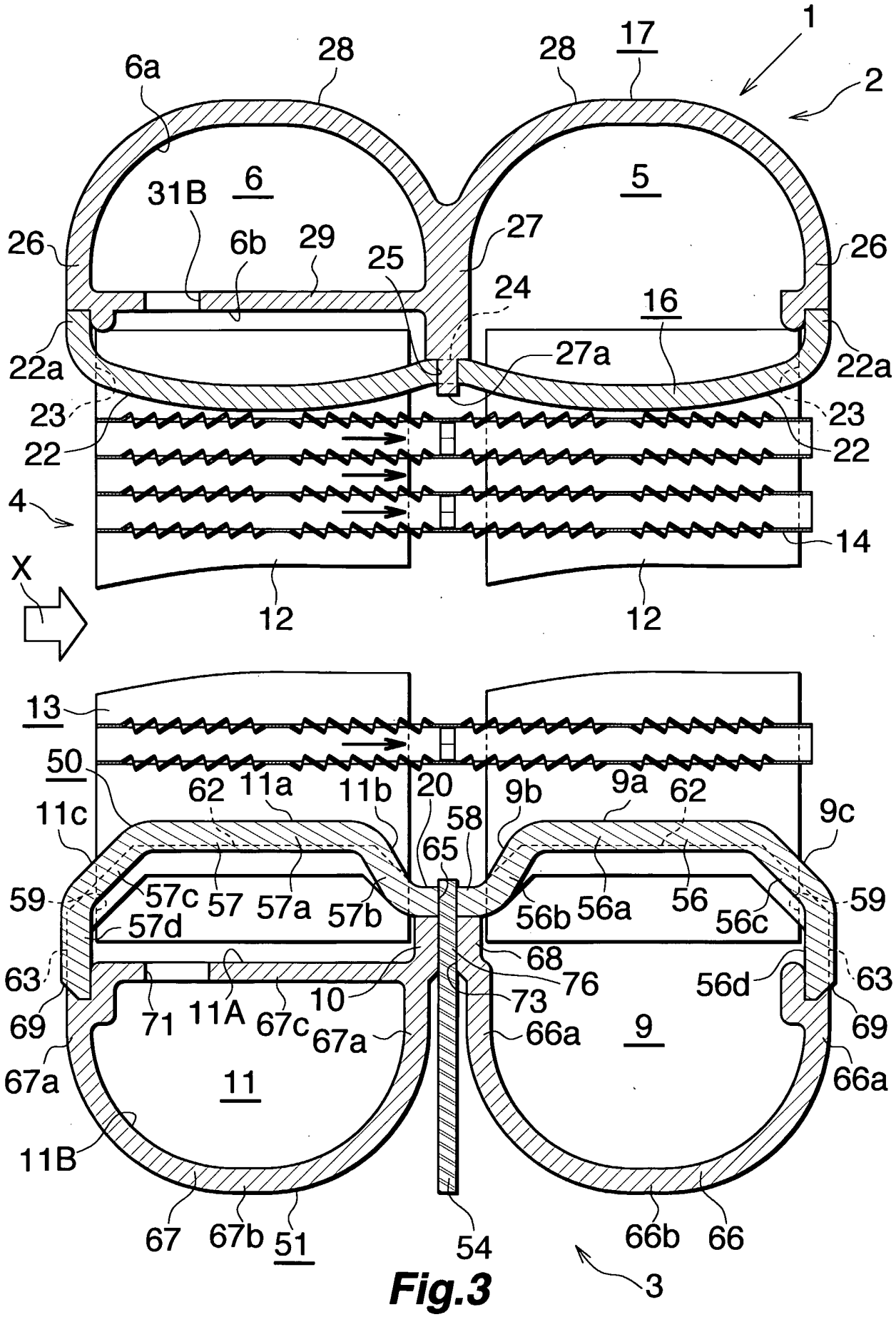
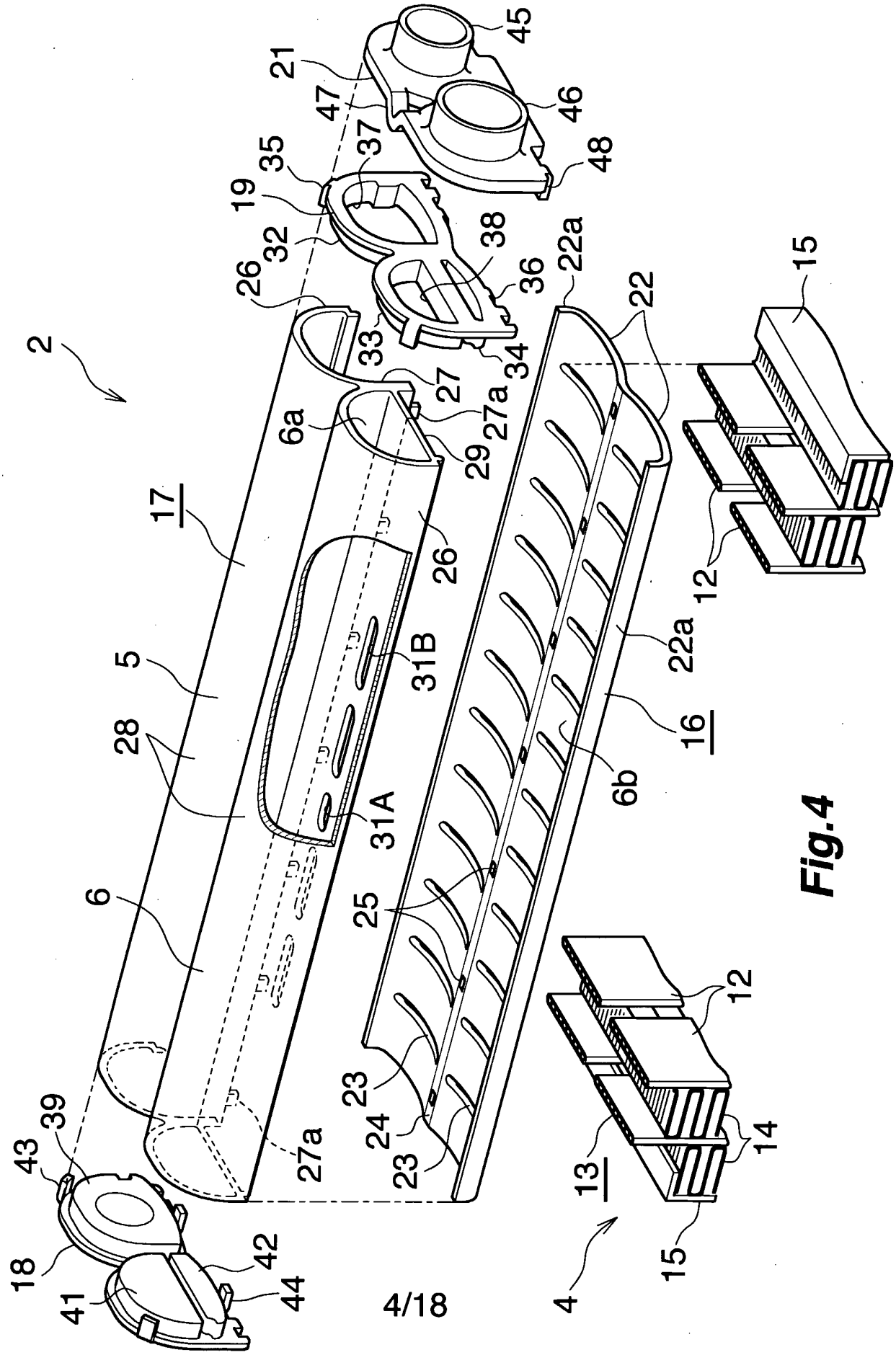

1
2
17
28
28
6a
6
31B
6b
29
25
27
5
26
26
24
16
22a
27a
22a
23
23
22
22
4
14
X
12
12
13
50
62
11a
11b
20
9b
9a
62
9c
11c
58
65
59
57c
57
57a
57b
56b
56a
56
56c
59
57d
63
68
76
56d
63
69
71
11A
67c
10
73
67a
66a
9
69
67a
11
66a
11B
67
67b
51
54
66b
66
3

***Fig.3***


2
4
5
6
6a
6b
12
13
14
15
16
17
18
19
21
22
22a
23
24
25
26
27
27a
28
29
31A
31B
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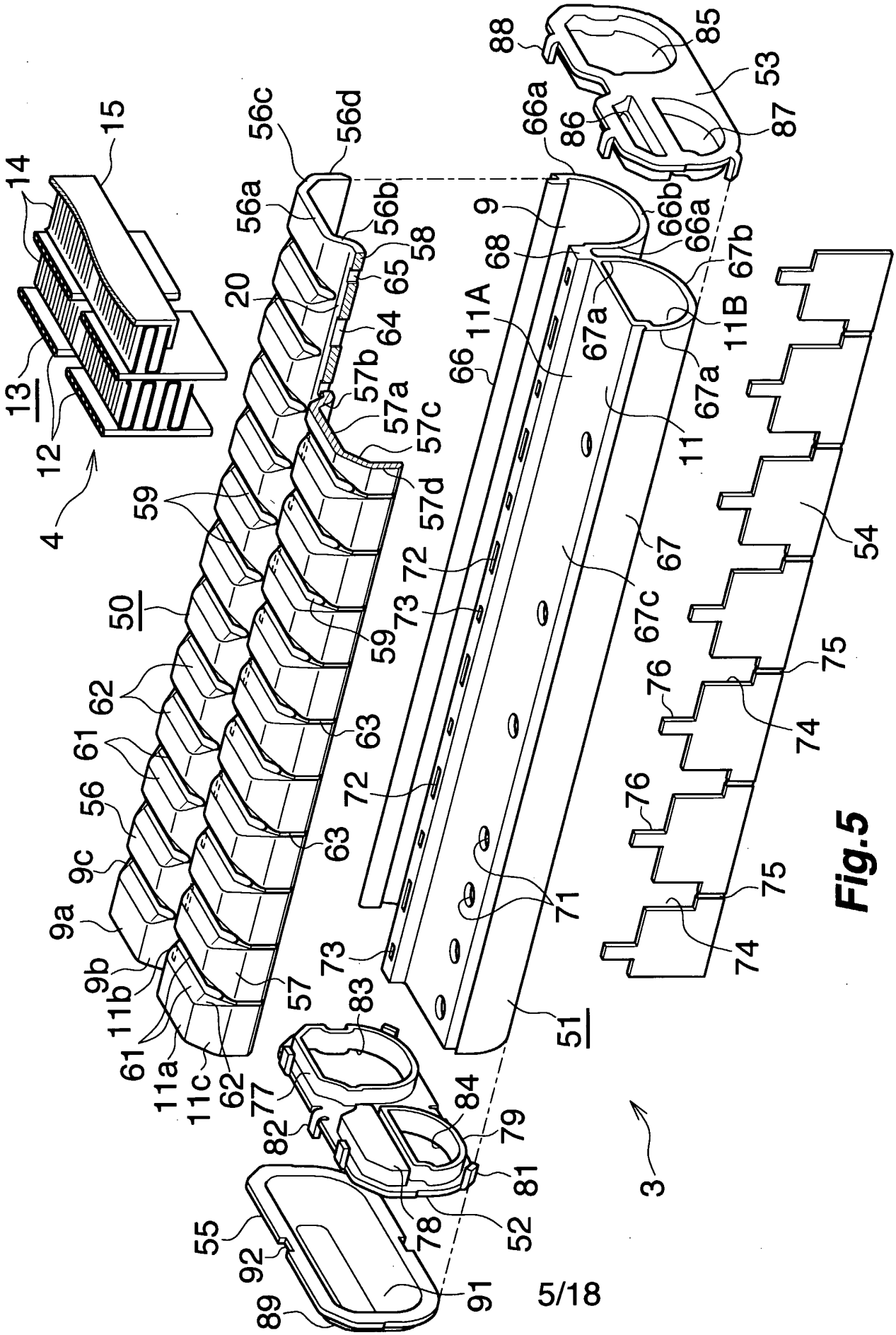
48

Fig.4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4
56c
56d
56a
56b
58
20
65
64
57b
57a
57c
57d
59
50
62
61
56
9c
9a
9b
11b
11a
11c
61
62
63
57
83
77
82
84
79
81
78
52
55
92
89
91
88
85
53
87
66a
86
9
66b
66a
68
67b
11A
66
67a
11B
67a
11
67
54
72
73
59
67c
75
76
74
76
75
74
71
73
51
3

Fig.5

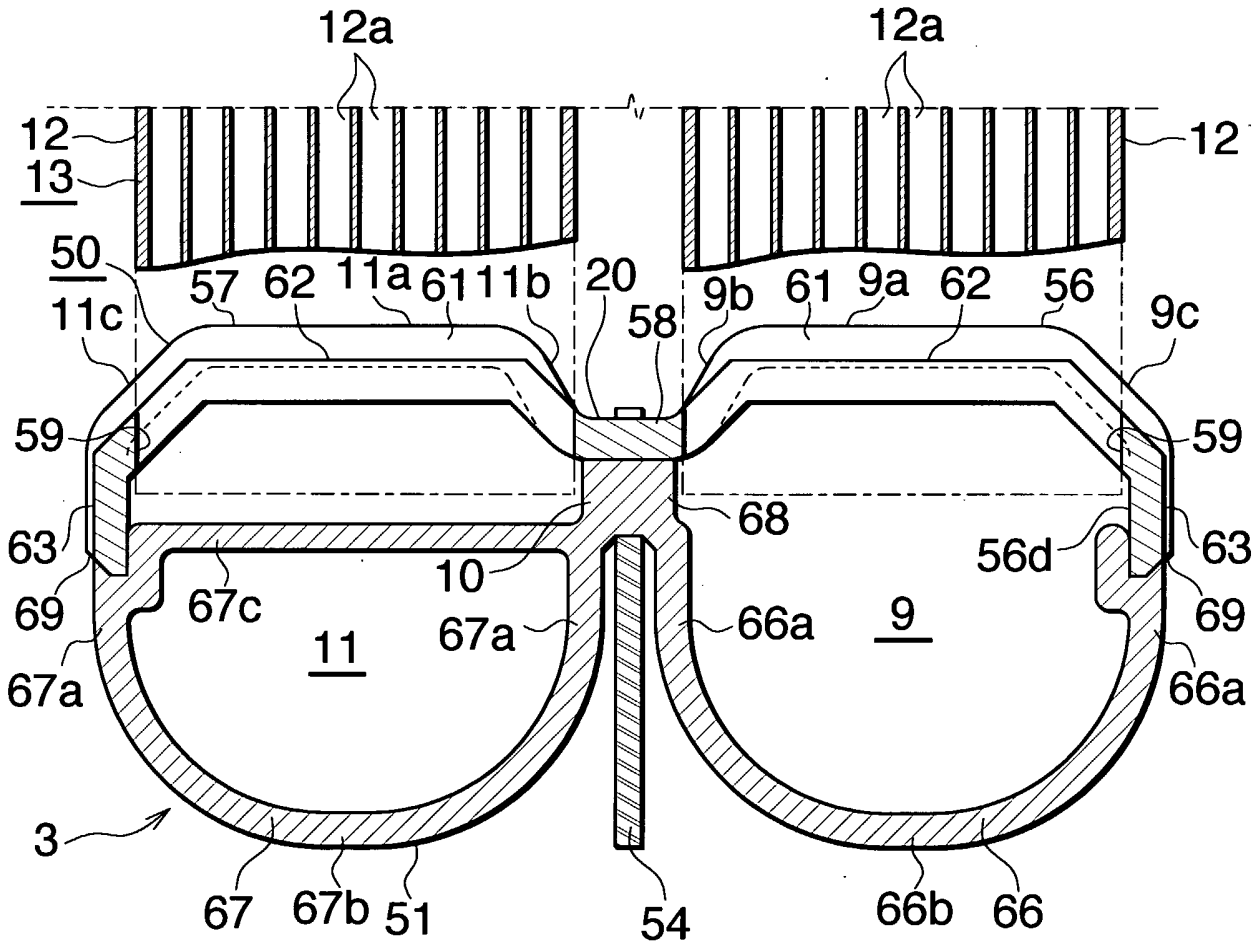
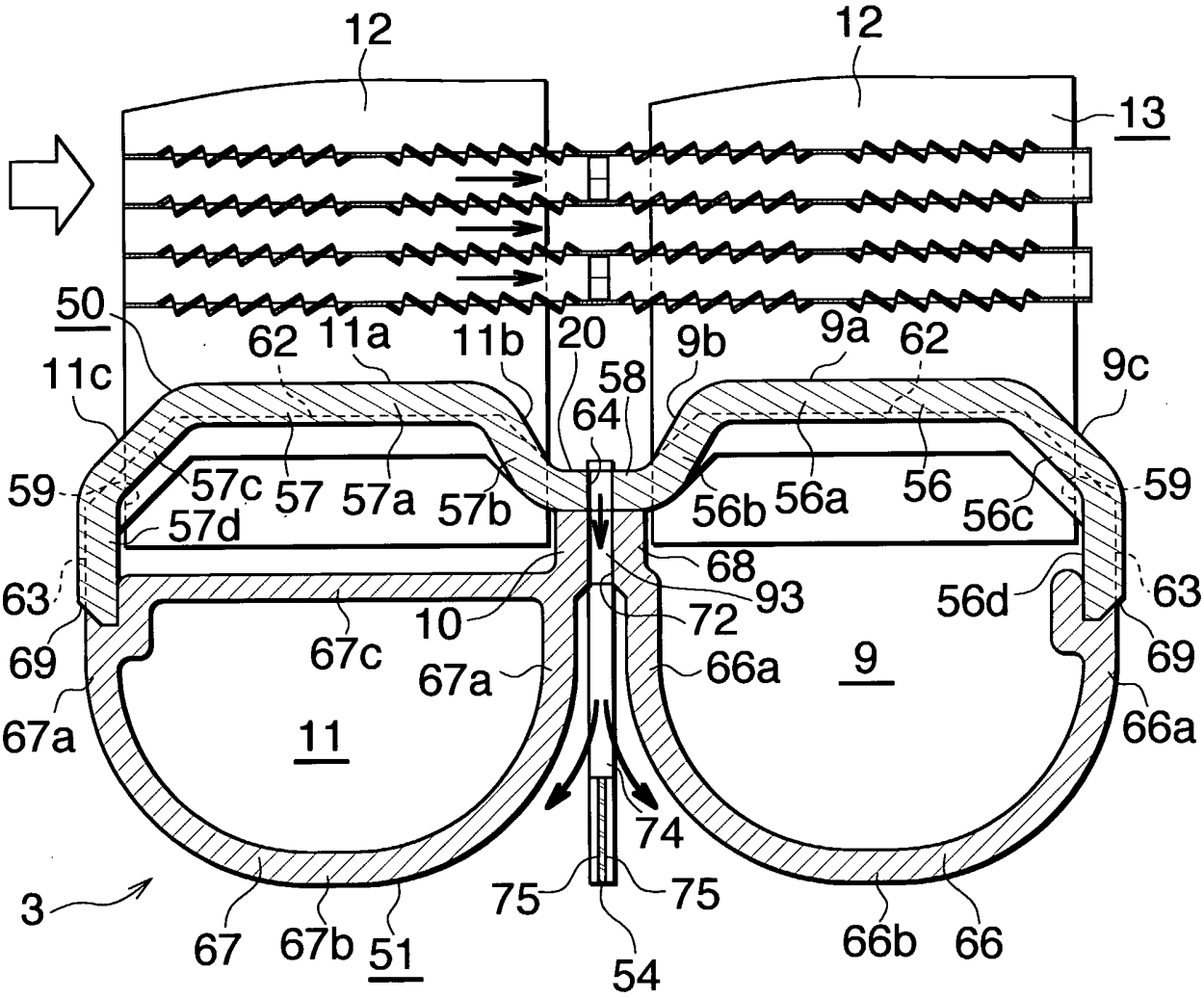

12a
12a
12
13
12
50
11c
57
62
11a
61
11b
20
58
9b
61
9a
62
56
9c
59
59
63
68
56d
63
69
67c
10
66a
9
69
67a
11
67a
66a
3
67
67b
51
54
66b
66

***Fig.6***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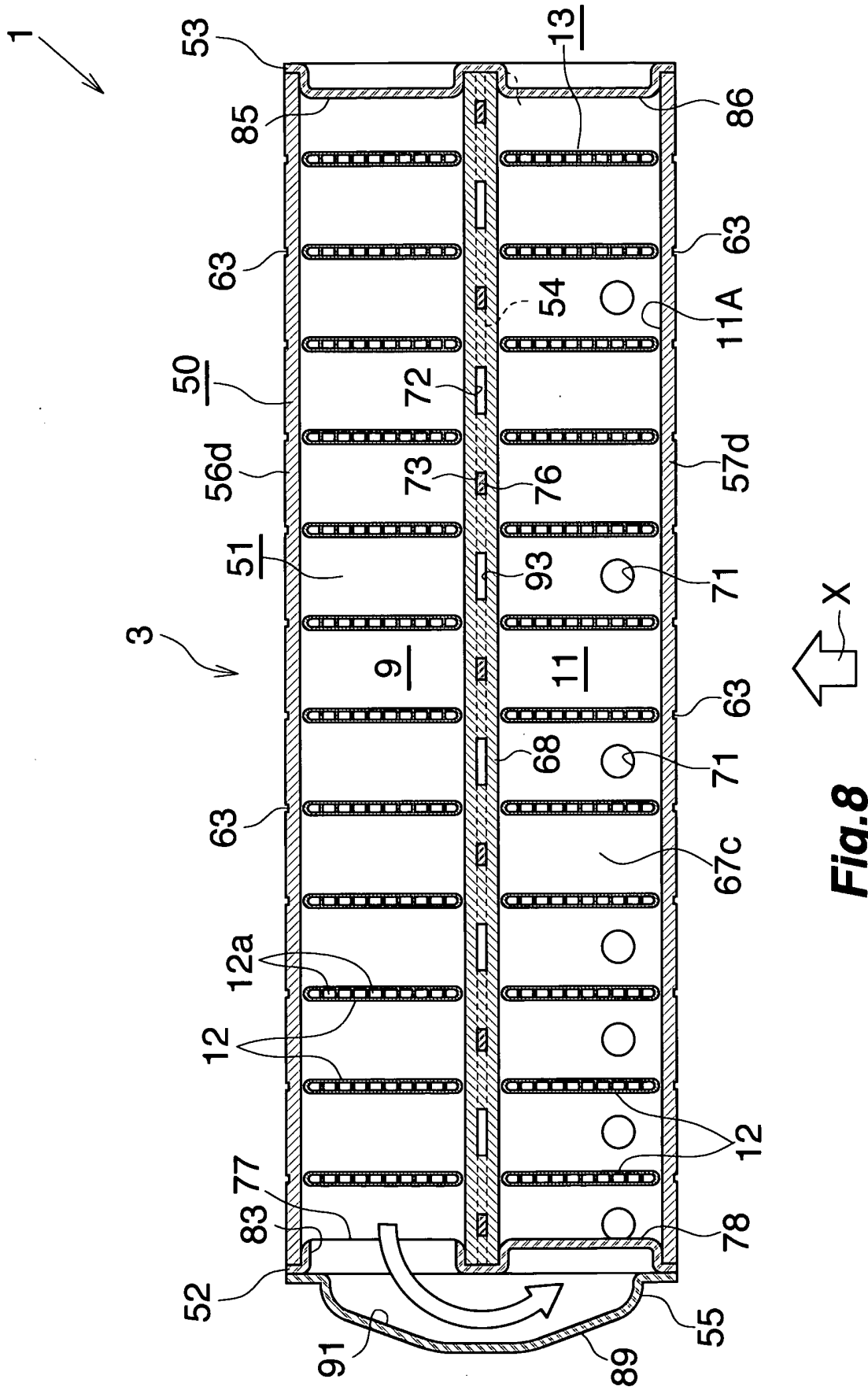
13
50
62
11a
11b
20
9b
9a
62
11c
58
64
9c
59
57c
57
57a
57b
56b
56a
56
56c
59
57d
68
63
93
56d
63
10
72
69
67c
67a
66a
9
69
67a
11
66a
74
3
75
75
67
67b
51
54
66b
66

*Fig.7*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13
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63
54
11A
50
72
56d
73
76
57d
51
93
71
3
9
11
63
68
71
63
67c
12a
12
12
77
83
78
52
55
91
89
X

Fig.8

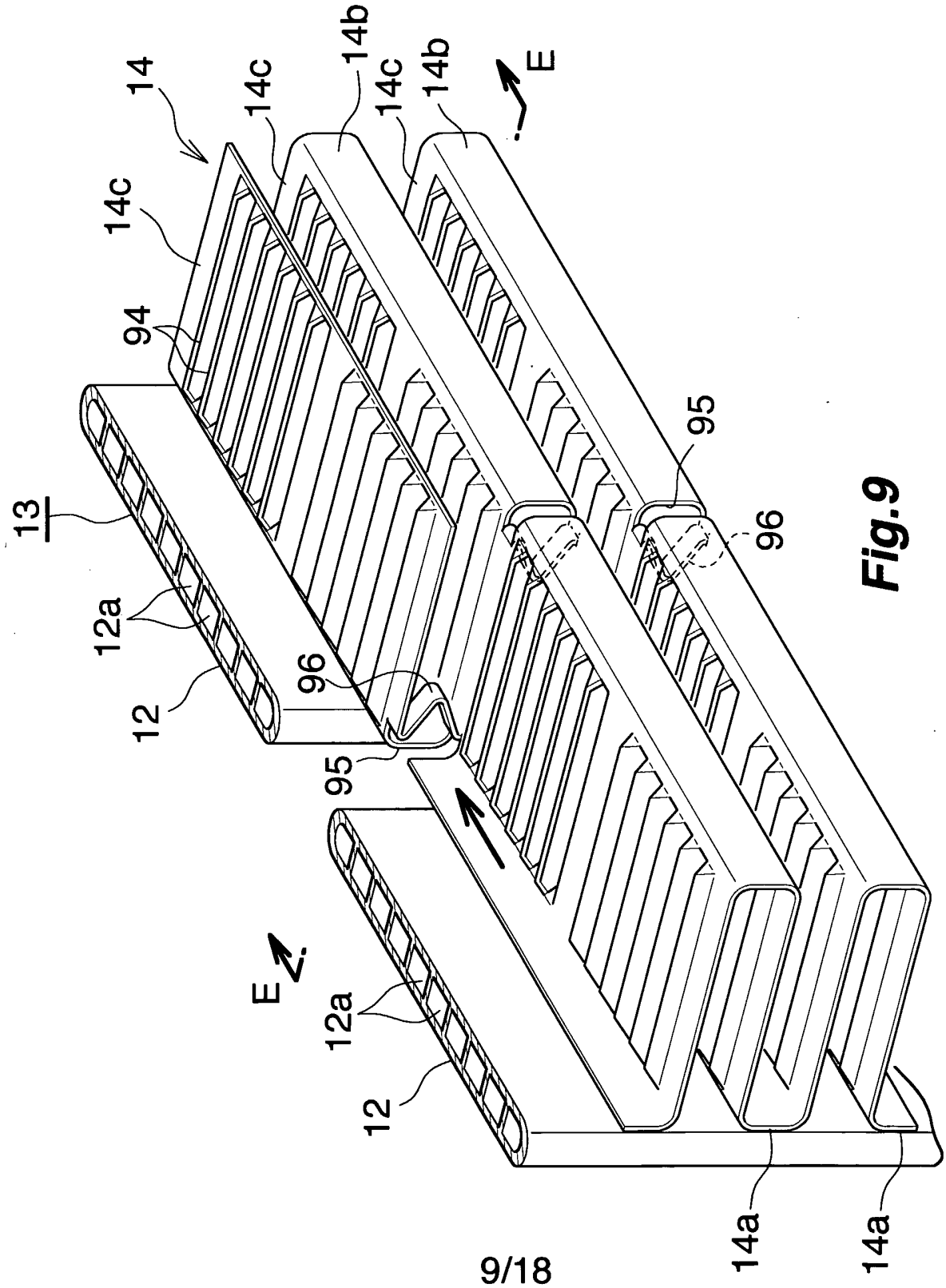



Fig.9

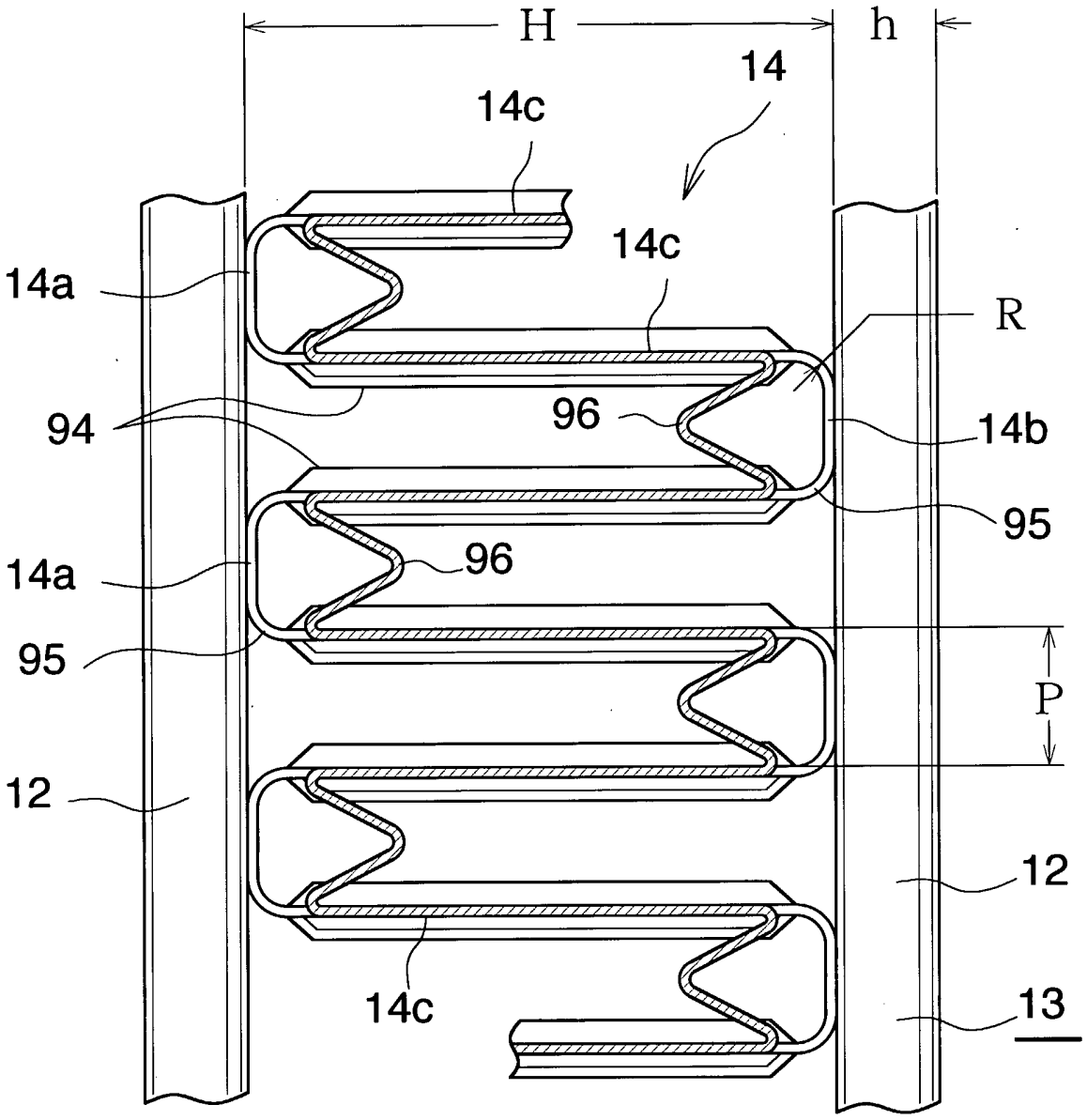



*Fig.10*

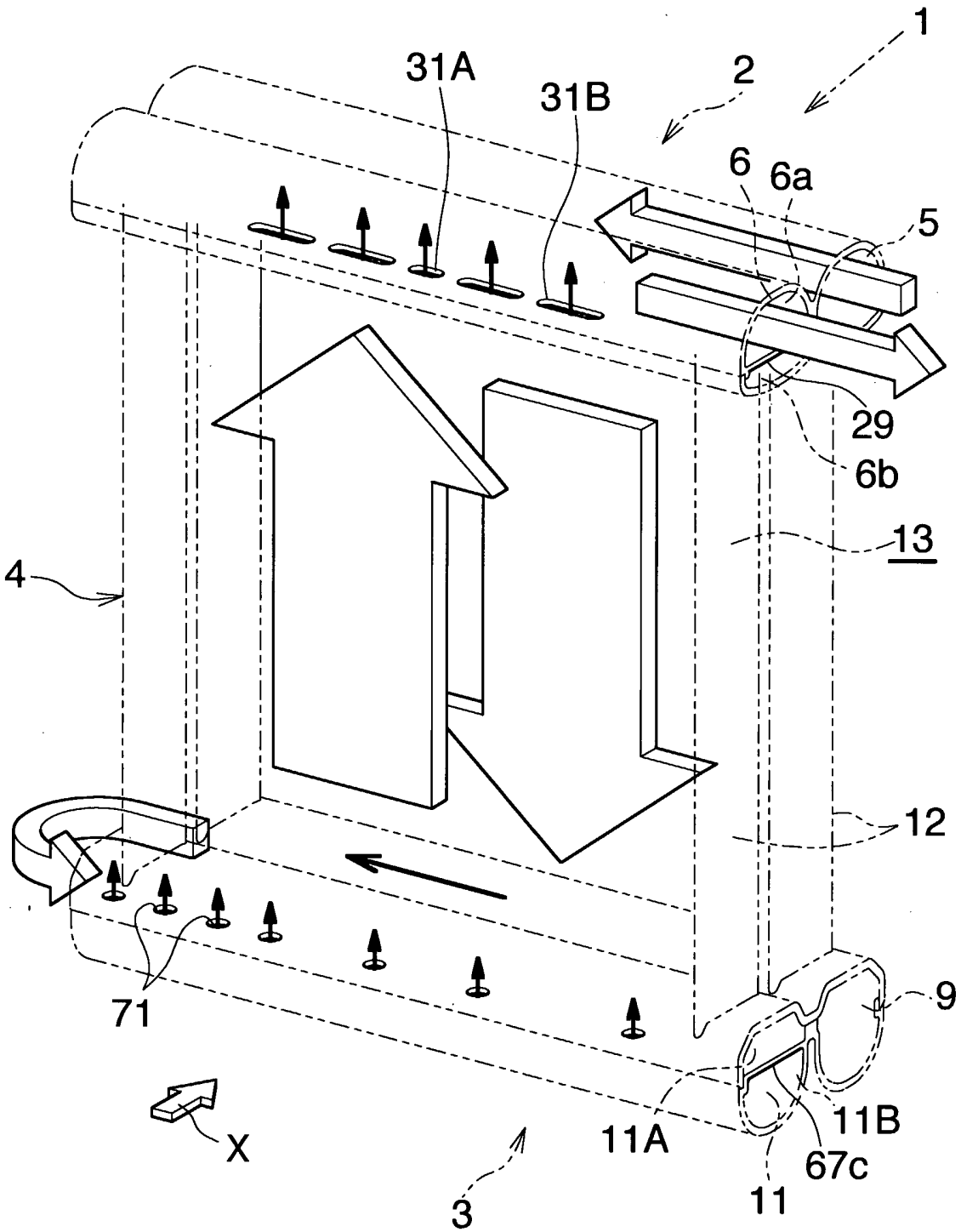
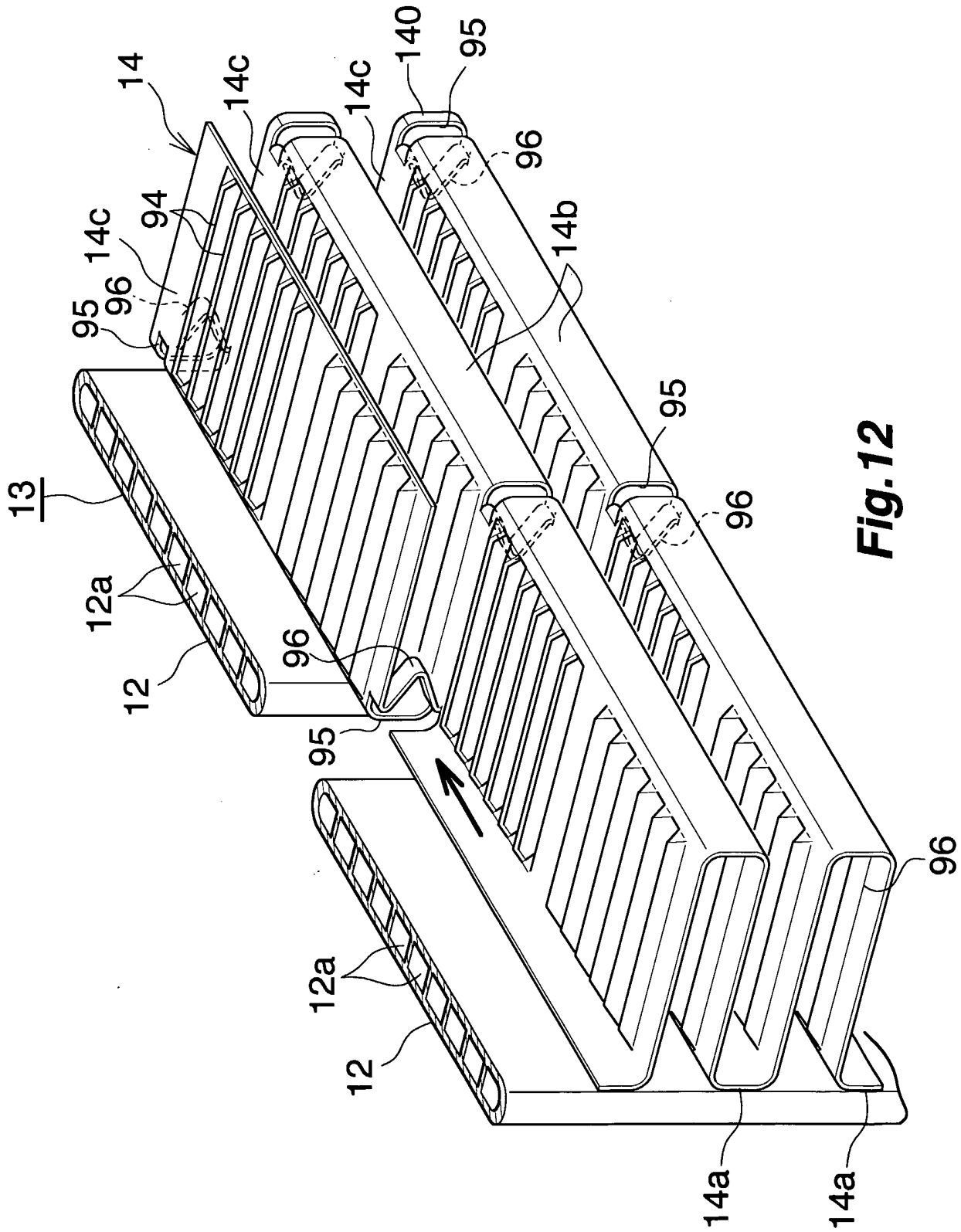



*Fig.11*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14c
14c
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96
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14c
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14b
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12a
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12a
12
14a
14a
96

Fig.12

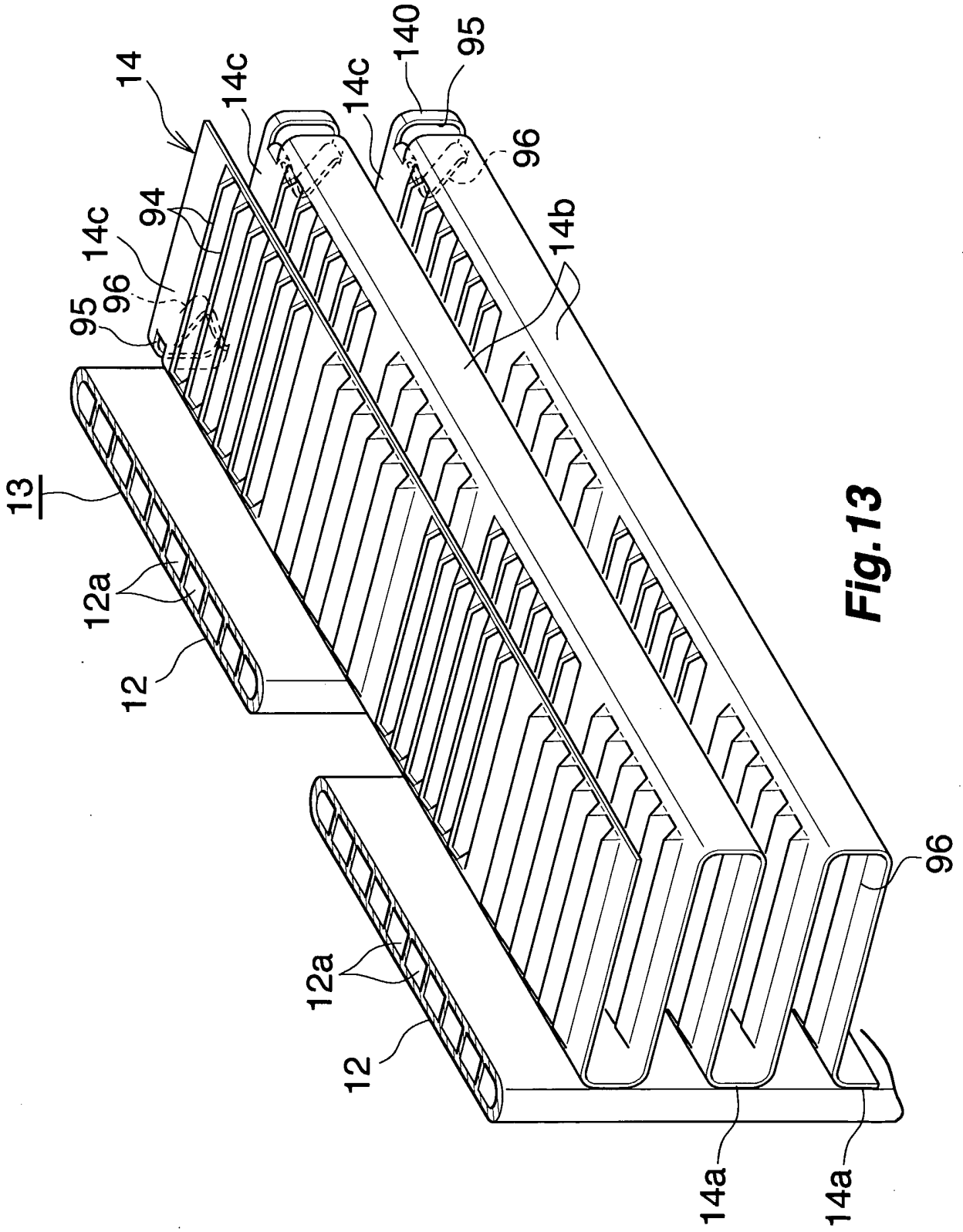



Fig.13

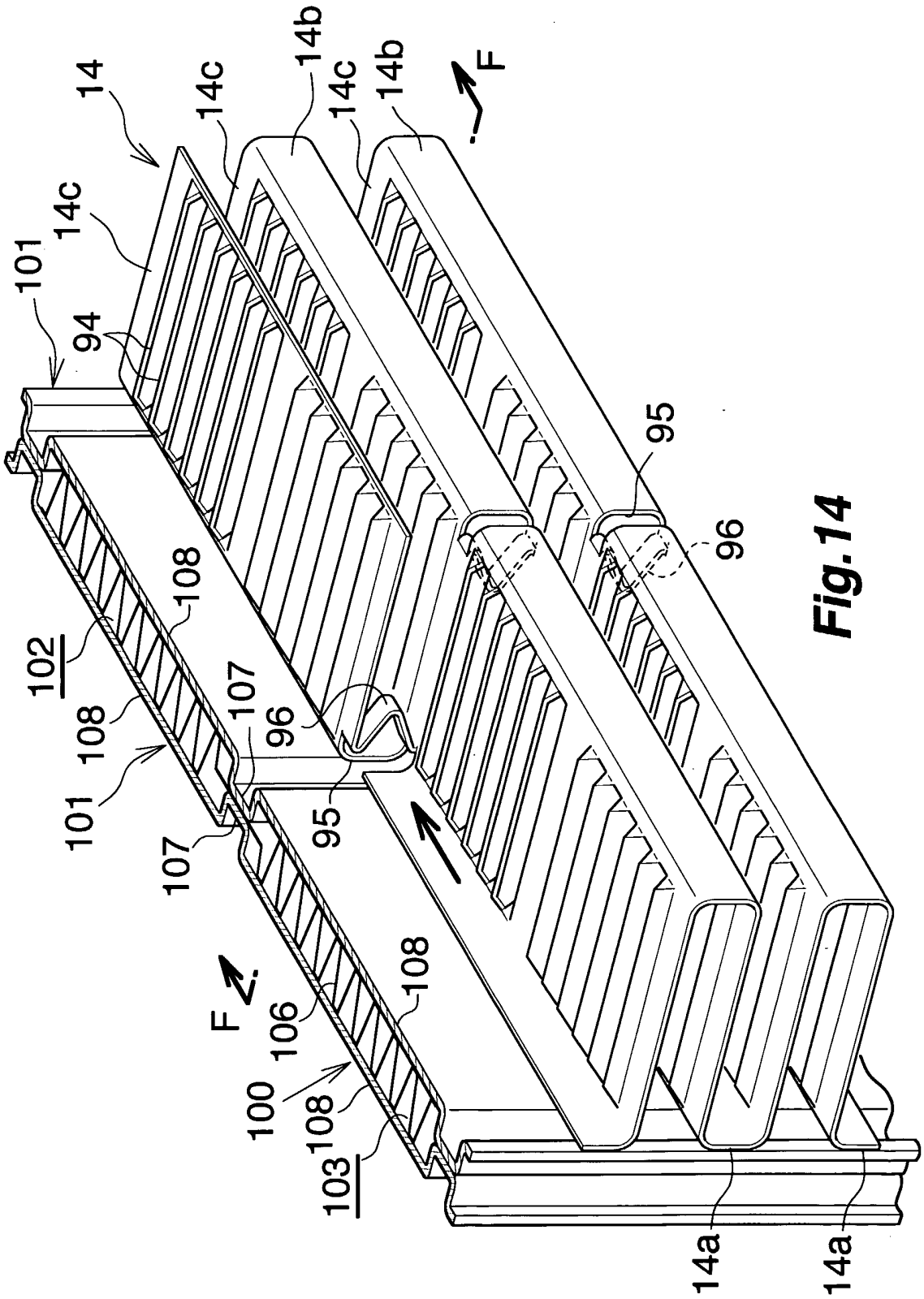
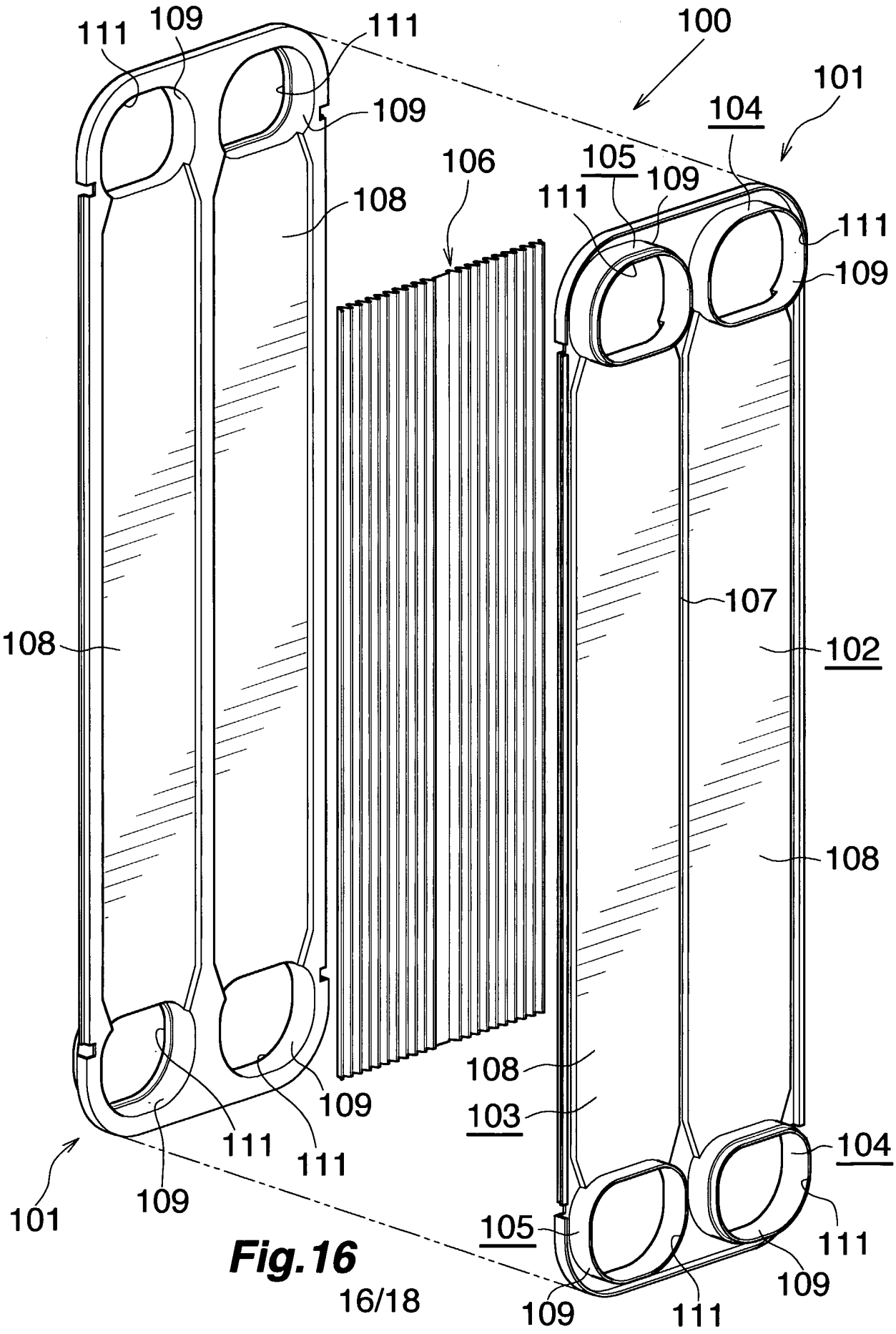

14
14c
14b
14c
14b
F
14c
101
94
95
96
108
102
108
107
96
101
95
107
F
108
106
100
108
103
14a
14a

Fig.14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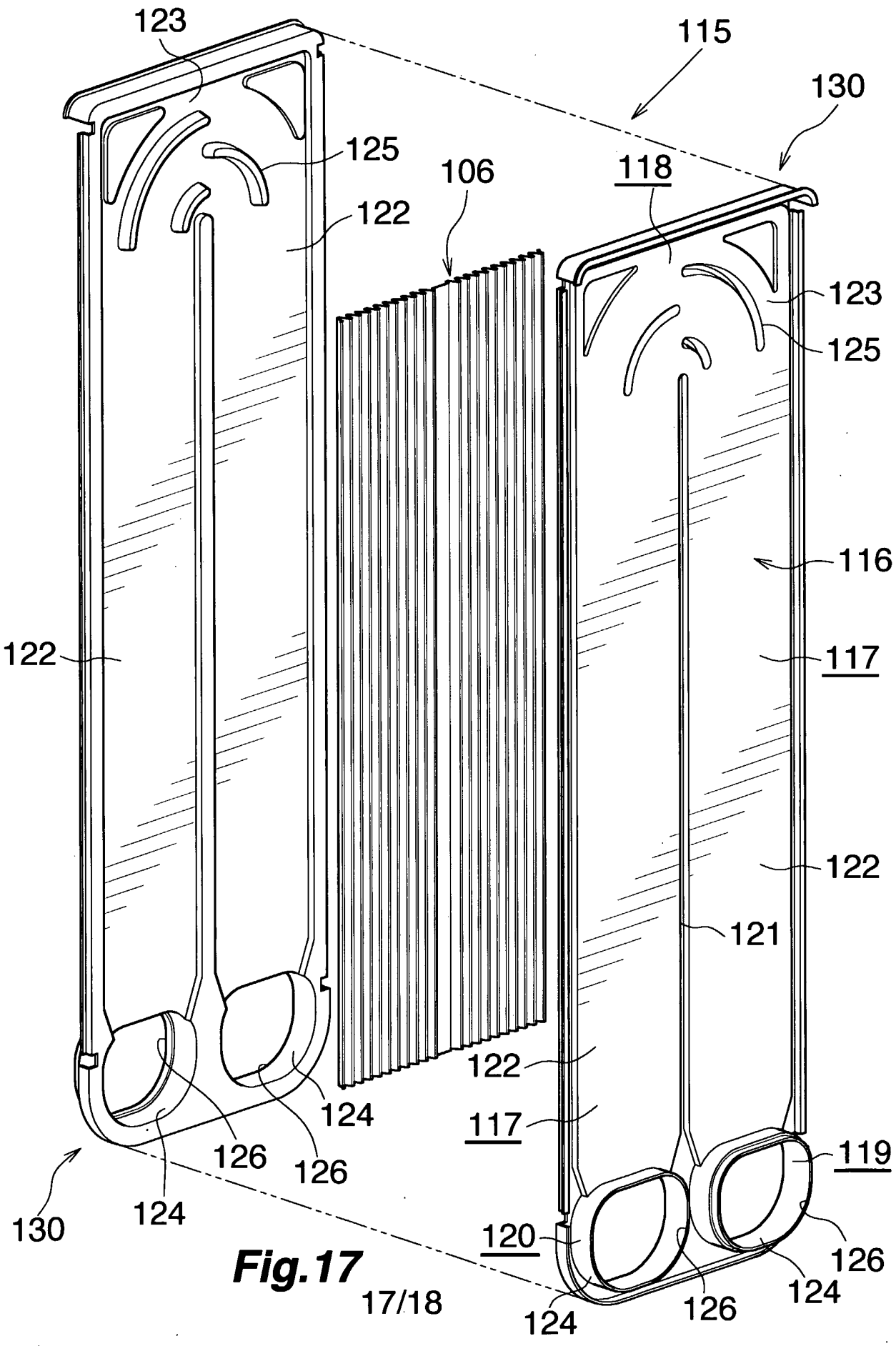
111

Fig.16


123
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124

Fig.17

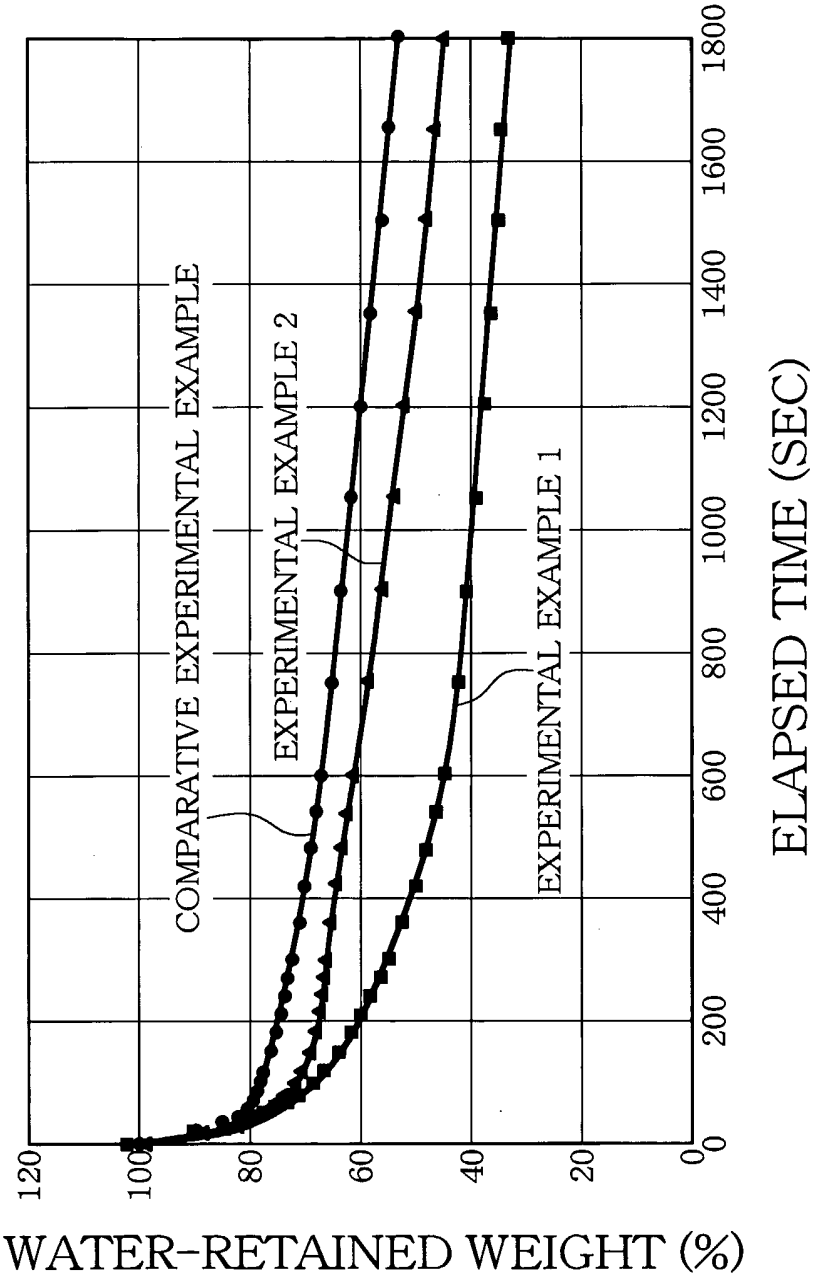
COMPARATIVE EXPERIMENTAL EXAMPLE
EXPERIMENTAL EXAMPLE 2
EXPERIMENTAL EXAMPLE 1
WATER-RETAINED WEIGHT (%)
120
100
80
60
40
20
0
0
200
400
600
800
1000
1200
1400
1600
1800
ELAPSED TIME (SEC)

Fig.18

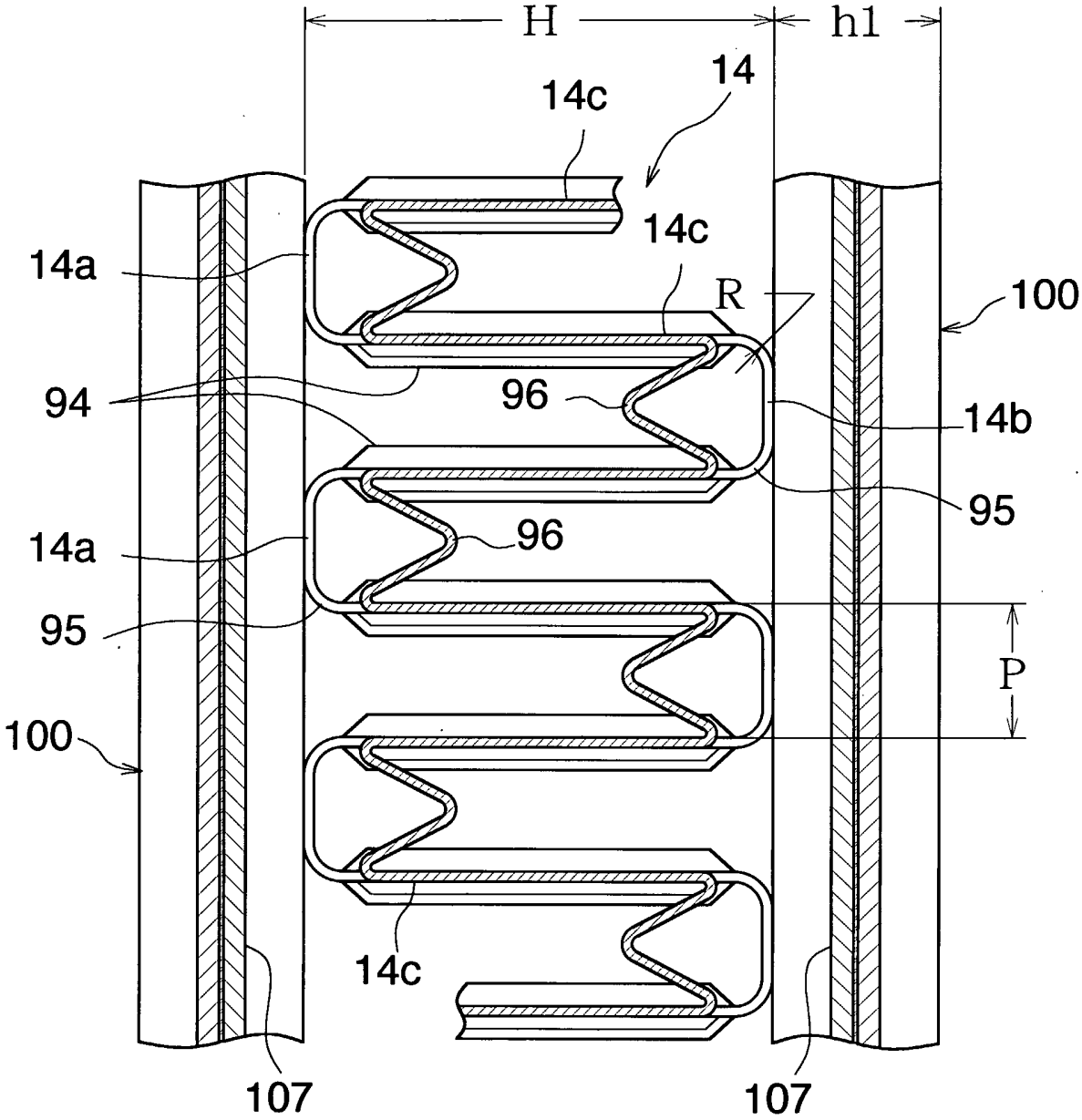


*Fig.15*

# INTERNATIONALSEARCHREPORT

International application No.
PCT/JP2005/019255

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. ***F28F1/30*** (2006.01), ***F25B39/02*** (2006.01), ***F28D1/053*** (2006.01)

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)

Int.Cl. F28F 1/30, F25B 39/02, F28D 1/053

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2006
Registered utility model specifications of Japan 1996-2006
Published registered utility model applications of Japan 1994-2006

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X<br>Y | JP 2001-059690 A (ZEXEL VALEO CLIMATE CONTROL CORPORATION) 2001.03.06, paragraph 0014-0015, 0021-0022, Figs 1-6 (Family; none) | 1-9, 16-22<br>10-15 |
| Y | JP 55-006701 U (NIHON RADIATOR) 1980.01.17, line 4-16, page 4, Figs 1-7 (Family; none) | 10-15 |
| Y | JP 2003-519356 A (VALEO CLIMATISATION) 2003.06.17, line 13,page 9 to line 14,page 13,Figs 1-4 & US 2002-0134538 A1 & EP001192402 A1 & WO 2001/050080 A2 | 14 |

☐ 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 |
|---|---|
| 14.02.2006 | 28.02.2006 |
| Name and mailing address of the ISA/JP<br>**Japan Patent Office**<br>3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan | Authorized officer<br>SHOJI Hidefumi<br>Telephone No. +81-3-3581-1101 Ext. 3377 |

3M 3530

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