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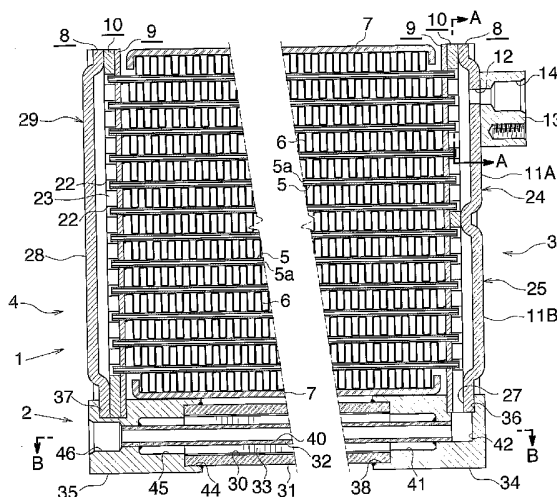
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(54) Title: INTEGRATED HEAT EXCHANGE APPARATUS



(57) Abstract: An integrated heat exchange apparatus is composed of a gas cooler 1 and an intermediate heat exchanger 2. The gas cooler 1 includes two header tanks 3, 4, and a plurality of heat exchange tubes 5. A refrigerant outlet 27 is formed on the first header tank 3. The intermediate heat exchanger 2 includes an outer tube 31 and an inner tube 32 having two refrigerant passages 30, 40, and connectors 34, 35 fixed to the opposite ends of the tubes 31, 32 and having first flow passages 41, 45 communicating with the first refrigerant passage 30 and second flow passages 42, 46 communicating with the second refrigerant passage 40. Both the connectors 34, 35 of the intermediate heat exchanger 2 are fixed to the header tanks 3, 4 of the gas cooler 1. The second flow passage 42 of one connector 34 of the intermediate heat exchanger 2 communicates with the refrigerant outlet 27 of the gas cooler 1. This integrated heat exchange apparatus can simplify the routing of piping and can make the installation space relatively small.



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DESCRIPTION

INTEGRATED HEAT EXCHANGE APPARATUS

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 dates of Provisional Application Nos. 60/613,227 and 60/662,353 filed September 28, 2004 and March 17, 2005, respectively, pursuant to 35 U.S.C. § 111(b).

TECHNICAL FIELD

The present invention relates to an integrated heat exchange apparatus, and more particularly to an integrated heat exchange apparatus suitable for use as a gas cooler and as an intermediate heat exchanger of a supercritical refrigeration cycle which includes, for example, a compressor, a gas cooler, an evaporator, a gas-liquid separator, a pressure-reducing device, and an intermediate heat exchanger for performing heat exchange between refrigerant flowing out of the gas cooler and refrigerant flowing out of the evaporator and in which a supercritical refrigerant such as CO₂ is used.

Herein and in the appended claims, the term "aluminum" encompasses aluminum alloys in addition to pure aluminum.

BACKGROUND ART

Conventionally, a refrigeration cycle which includes a compressor, a condenser, an evaporator, a gas-liquid separator, and a pressure-reducing device and which uses a fluorocarbon refrigerant has been widely used as a car air conditioner mounted on an automobile.

Incidentally, in recent years, there has been considered mounting, onto an automobile, as a car air conditioner, a supercritical refrigeration cycle which uses a supercritical refrigerant such as CO₂. The supercritical refrigerant refers to a refrigerant which becomes a supercritical state while exceeding the critical pressure at the high pressure side of the supercritical refrigeration cycle.

As shown in FIG. 12, a supercritical refrigeration cycle includes a compressor 75, a gas cooler 76, an evaporator 77, an accumulator 78 serving as a gas-liquid separator, an expansion valve 79 serving as a pressure-reducing device, and an intermediate heat exchanger 80 for performing heat exchange between refrigerant flowing out of the gas cooler 76 and refrigerant flowing out of the evaporator 77.

Incidentally, the intermediate heat exchanger 80 of the supercritical refrigeration cycle is a heat exchanger which is not used in the conventional refrigeration cycle, which uses a fluorocarbon refrigerant. The intermediate heat exchanger 80 is required to be efficiently accommodated within an engine compartment of an automobile, and presently

is considered to be disposed in the engine compartment at a portion between the gas cooler 76 and the evaporator 77.

A known intermediate heat exchanger which is used in the supercritical refrigeration cycle shown in FIG. 12 includes a heat exchange tube having a single inner fluid hole, and a plurality of outer fluid holes formed around the inner fluid hole at circumferential intervals; two connectors for the inner fluid hole which are fixed to opposite end portions of the heat exchange tube and which each have a flow passage communicating with the inner fluid hole; and two connectors for the outer fluid holes which are fixed to the heat exchange tube at locations inward of the connectors for the inner fluid hole with respect to the longitudinal direction of the heat exchange tube and which each have a flow passage communicating with the outer fluid holes (see the publication of JP-A No. 2000-2492).

Another known intermediate heat exchanger which is used in the supercritical refrigeration cycle shown in FIG. 12 includes a pair of header tanks separated from each other; and a plurality of flat heat exchange tubes which are disposed in parallel between the header tanks and whose opposite ends are connected to the corresponding header tanks (see the publication of JP-A No. 2003-121086). Each of the header tanks has a double pipe structure composed of a first header pipe and a second header pipe disposed within the first header pipe. Each of the heat exchange tubes includes a plurality of first fluid passages and a plurality of second

fluid passages formed therein, and the opposite end portions of each heat exchange tube are connected to the two header tanks such that the first fluid passages communicate with the interior of the first header pipe, and the second fluid passages communicate with the interior of the second header pipe.

However, in the case of a supercritical refrigeration cycle which uses the intermediate heat exchanger disclosed in the publications, there arise problems of a route of piping for passing refrigerant through the intermediate heat exchanger becoming complex, and requirement of a relatively large installation space. Further, in the case where the intermediate heat exchanger is disposed in the engine compartment at a portion between the gas cooler and the evaporator, the ambient temperature around the intermediate heat exchanger may become very high, and because of thermal influence from the surrounding atmosphere, the efficiency of heat exchange between refrigerant flowing out of the gas cooler and refrigerant flowing out of the evaporator drops, with a possible drop in the cooling performance of the supercritical refrigeration cycle.

An object of the present invention is to overcome the above problems and to provide an integrated heat exchange apparatus which can realize a supercritical refrigeration cycle which can simplify the routing of piping, can make the installation space relatively small, and can prevent a drop in cooling performance.

DISCLOSURE OF THE INVENTION

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

1) An integrated heat exchange apparatus comprising a first heat exchanger including first and second header tanks disposed apart from each other, and a plurality of heat exchange tubes disposed between the two header tanks at intervals along the length direction of the header tanks and each having opposite end portions connected to the respective header tanks, wherein a refrigerant outlet is formed on the first header tank; and a second heat exchanger including a heat exchange section having first and second refrigerant passages, and connectors provided at the opposite ends of the heat exchange section and each having a first flow passage for establishing communication between the first refrigerant passage and the outside of the second heat exchanger and a second flow passage for establishing communication between the second refrigerant passage and the outside of the second heat exchanger, wherein both the connectors of the second heat exchanger are fixed to the first heat exchanger, and the second flow passage of one connector of the second heat exchanger communicates with the refrigerant outlet of the first header tank of the first heat exchanger.

2) An integrated heat exchange apparatus according to par. 1), wherein one connector of the second heat exchanger is fixed to the first header tank of the first heat exchanger,

the other connector of the second heat exchanger is fixed to the second header tank of the first heat exchanger, and the second flow passage of the one connector communicates with the refrigerant outlet of the first header tank of the first heat exchanger.

3) An integrated heat exchange apparatus according to par. 2), wherein the first header tank of the first heat exchanger has a plurality of header sections arranged along the length direction thereof; the second header tank of the first heat exchanger has a header section(s) which is one fewer in number than the header sections of the first header tank; a header section at one end of the first header tank serves as a refrigerant inlet header section having a refrigerant inlet; and a header section at the other end of the first header tank serves as a refrigerant outlet header section having a refrigerant outlet, wherein refrigerant having flowed from the refrigerant inlet into the refrigerant inlet header section passes through the heat exchange tubes and the header sections, and is fed out from the refrigerant outlet of the refrigerant outlet header section.

4) An integrated heat exchange apparatus according to par. 1), wherein both the connectors of the second heat exchanger are fixed to the first header tank of the first heat exchanger, and the second flow passage of one connector communicates with the refrigerant outlet of the first header tank of the first heat exchanger.

5) An integrated heat exchange apparatus according to

par. 4), wherein the first header tank of the first heat exchanger has a plurality of header sections arranged along the length direction thereof; the second header tank of the first heat exchanger has header sections which are arranged along the length direction thereof and which are equal in number with the header sections of the first header tank; a header section at one end of the second header tank serves as a refrigerant inlet header section having a refrigerant inlet; and a header section at the other end of the first header tank serves as a refrigerant outlet header section having a refrigerant outlet, wherein a refrigerant having flowed from the refrigerant inlet into the refrigerant inlet header section passes through the heat exchange tubes and the header sections, and is fed out from the refrigerant outlet of the refrigerant outlet header section.

6) An integrated heat exchange apparatus according to par. 1), wherein each header tank of the first heat exchanger is constructed by mutually stacking and brazing a header-forming plate, a tube-connecting plate, and an intermediate plate disposed between the header-forming plate and the tube-connecting plate; a bulging portion is formed on the header-forming plate such that the bulging portion extends along the length direction thereof and its opening is closed by the intermediate plate; a plurality of tube insertion holes are formed in the tube-connecting plate in a region corresponding to the bulging portion such that the tube insertion holes penetrate the tube-connecting plate and are arranged at

intervals along the length direction of the tube-connecting plate; communication holes for establishing communication between the tube insertion holes of the tube-connecting plate and the interior of the bulging portion of the header-forming plate are formed in the intermediate plate such that the communication holes penetrate the intermediate plate; a header section is formed by a portion of the header-forming plate including the bulging portion and portions of the tube-connecting plate and the intermediate portion corresponding to the bulging portion; and the opposite end portions of the heat exchange tubes are inserted into the tube insertion holes of the tube-connecting plates of the two header tanks and are brazed to the tube-connecting plates.

7) An integrated heat exchange apparatus according to par. 6), wherein a cover wall is integrally provided along each of the opposite lateral edge portions of the tube-connecting plate so as to cover a boundary between the header-forming plate and the intermediate plate over the entire length; and the cover wall is brazed to the corresponding side surfaces of the header-forming plate and the intermediate plate.

8) An integrated heat exchange apparatus according to par. 7), wherein engagement portions which engage the outer surface of the header-forming plate are integrally provided at the end portions of the cover walls.

9) An integrated heat exchange apparatus according to par. 1), wherein the heat exchange section of the second heat

exchanger includes an outer tube and an inner tube disposed within the outer tube with a clearance formed therebetween, wherein the clearance between the outer tube and the inner tube serves as the first refrigerant passage, and the interior of the inner tube serves as the second refrigerant passage.

10) An integrated heat exchange apparatus according to par. 9), wherein fins are provided between the outer tube and the inner tube of the second heat exchanger; the opposite end portions of the inner tube project outward from the outer tube; a fin-absent portion is provided at least at an end portion of each of the outward projecting portions; and the fin-absent portions of the inner tube are inserted into end portions of the second flow passages of the corresponding connectors.

11) An integrated heat exchange apparatus according to par. 10), wherein fins are integrally formed on the outer circumferential surface of the inner tube at circumferential intervals such that the fins extend along the length direction of the inner tube.

12) An integrated heat exchange apparatus according to par. 10), wherein the entirety of each of the outward projecting portions of the inner tube projecting from the outer tube is the fin-absent portion.

13) A supercritical refrigeration cycle which comprises a compressor, a gas cooler, an evaporator, a gas-liquid separator, a pressure-reducing device, and an intermediate

heat exchanger for performing heat exchange between refrigerant flowing out of the gas cooler and refrigerant flowing out of the evaporator and in which a supercritical refrigerant is used, wherein the gas cooler is composed of the first heat exchanger of the integrated heat exchange apparatus according to any one of pars. 1) to 12), and the intermediate heat exchanger is composed of the second heat exchanger of the integrated heat exchange apparatus.

14) A supercritical refrigeration cycle according to par. 13), wherein low-pressure refrigerant flowing out of the evaporator flows through the first refrigerant passage of the intermediate heat exchanger, and high-pressure refrigerant flowing out of the gas cooler flows through the second refrigerant passage of the intermediate heat exchanger.

15) A supercritical refrigeration cycle according to par. 14), wherein the supercritical refrigerant is carbon dioxide.

16) A vehicle in which a supercritical refrigeration cycle according to par. 14) is installed as a car air conditioner.

According to the integrated heat exchange apparatus described in any one of pars. 1) to 5), both the connectors of the second heat exchanger are fixed to the first heat exchanger, and the second flow passage of one connector of the second heat exchanger communicates with the refrigerant outlet of the first header tank of the first heat exchanger. Therefore, refrigerant fed out from the first heat exchanger

via the refrigerant outlet flows directly into the second refrigerant passage via the second flow passage of the corresponding connector of the second heat exchanger, so that piping between the refrigerant outlet of the first heat exchanger and the second heat exchanger becomes unnecessary. Accordingly, in a refrigeration cycle, such as a supercritical refrigeration cycle, to which the integrated heat exchange apparatus is applied, routing of piping can be simplified, and the installation space can be made relatively small. Further, in the case where the integrated heat exchange apparatus is applied to a supercritical refrigeration cycle in such a manner that the first and second heat exchangers are used as a gas cooler and an intermediate heat exchanger, respectively, since the gas cooler is typically disposed at the frontmost portion of the engine compartment, the ambient temperature around the intermediate heat exchanger becomes relatively low, so that the intermediate heat exchanger becomes less likely to be thermally influenced from the surroundings. According, it is possible to prevent a drop in the efficiency of heat exchange between refrigerant flowing out of the gas cooler and refrigerant flowing out of the evaporator, to thereby prevent a drop in the cooling performance of the supercritical refrigeration cycle.

According to the integrated heat exchange apparatus according to any one of pars. 2) to 5), the flow direction of refrigerant in the first heat exchanger can be properly set

so as to improve the heat exchange efficiency.

According to the integrated heat exchange apparatus described in par. 6), the opposite ends of each header tank of the first heat exchanger can be closed without use of a closing part such as a cap. Accordingly, the number of parts decreases, and operation of joining a closing part such as a cap becomes unnecessary. In addition, work of separately fabricating a closing part such as a cap becomes unnecessary. Further, since the header-forming plate having a bulging portion, the tube-connecting plate having tube insertion holes, and the intermediate plate having communication holes can be formed through press working performed on a metal plate, the number of machining steps can be reduced, and the machining time can be shortened. In addition, a separate member such as a partition is not required even when a plurality of header sections are formed as in the integrated heat exchange apparatuses according to pars. 3) and 5).

According to the integrated heat exchange apparatus described in par. 7), the cover walls can prevent leakage of refrigerant from the boundary between the header-forming plate and the intermediate plate.

According to the integrated heat exchange apparatus described in par. 8), when the three plates are brazed together, the three plates can be provisionally fixed together by means of the engagement portions. Therefore, a separate jig for provisional fixing is not required.

According to the integrated heat exchange apparatus

described in par. 9), since the heat exchange section of the second heat exchanger is composed of an outer tube and an inner tube disposed within the outer tube with a clearance formed therebetween, the number of parts decreases.

According to the integrated heat exchange apparatus described in par. 10), since fins are provided between the outer tube and the inner tube of the second heat exchanger, the heat transmission area between the refrigerant flowing through the first refrigerant passage and that flowing through the second refrigerant passage increases, and the heat exchange efficiency increases.

According to the integrated heat exchange apparatus described in par. 11), the heat transmission area between the refrigerant flowing through the first refrigerant passage of the second heat exchanger and that flowing through the second refrigerant passage of the second heat exchanger increases, and the heat exchange efficiency increases. In addition, since the fins are formed integrally with the inner tube, the number of components decreases further.

According to the integrated heat exchange apparatus described in par. 12), the flow resistance against the refrigerant flowing into or flowing out of the first flow passage of each connector of the second heat exchanger can be reduced.

According to the supercritical refrigeration cycle described in any one of pars. 13) to 15), refrigerant fed out from the first heat exchanger via the refrigerant outlet

flows directly into the second refrigerant passage via the second flow passage of the corresponding connector of the second heat exchanger, so that piping between the refrigerant outlet of the first heat exchanger and the second heat exchanger becomes unnecessary. Accordingly, in the supercritical refrigeration cycle, routing of piping can be simplified, and the installation space can be made relatively small. Further, since the gas cooler is typically disposed at the frontmost portion of the engine compartment, the ambient temperature around the intermediate heat exchanger becomes relatively low, so that the intermediate heat exchanger becomes less likely to be thermally influenced from the surroundings. According, it is possible to prevent a drop in the efficiency of heat exchange between refrigerant flowing out of the gas cooler and refrigerant flowing out of the evaporator, to thereby prevent a drop in the cooling performance of the supercritical refrigeration cycle.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view showing the overall construction of an integrated heat exchange apparatus of Embodiment 1 of the present invention. FIG. 2 is a partially omitted vertical sectional view of the integrated heat exchange apparatus of FIG. 1 as viewed from the rear side toward the front side thereof. FIG. 3 is an exploded perspective view showing a first header tank of the gas cooler of the integrated heat exchange apparatus of FIG. 1.

FIG. 4 is an enlarged sectional view taken along the line A-A in FIG. 2. FIG. 5 is an exploded perspective view showing a second header tank of the gas cooler of the integrated heat exchange apparatus of FIG. 1. FIG. 6 is an enlarged sectional view taken along the line B-B in FIG. 2. FIG. 7 is an enlarged sectional view taken along the line C-C in FIG. 6. FIG. 8 is an exploded perspective view showing a connection structure for connecting a first connector of an intermediate heat exchanger and the first header tank of the gas cooler of the integrated heat exchange apparatus of FIG. 1. FIG. 9 is a diagram showing the flow of refrigerant through the integrated heat exchange apparatus of FIG. 1. FIG. 10 is a view corresponding to FIG. 2 and showing the overall construction of an integrated heat exchange apparatus of Embodiment 2 of the present invention. FIG. 11 is a diagram showing the flow of refrigerant through the integrated heat exchange apparatus of FIG. 10. FIG. 12 is a diagram showing a supercritical refrigeration cycle. FIG. 13 is a cross-sectional view showing a first modified embodiment of the heat exchange tube. FIG. 14 is a fragmentary enlarged view of FIG. 13. FIG. 15 is a set of views showing a method of manufacturing the heat exchange tube shown in FIG. 13. FIG. 16 is a cross-sectional view showing a second modified embodiment of the heat exchange tube. FIG. 17 is a cross-sectional view showing a third modified embodiment of the heat exchange tube. FIG. 18 is a fragmentary enlarged view of FIG. 17. FIG. 19 is a set of views showing a method of

manufacturing the heat exchange tube shown in FIG. 17.

BEST MODE FOR CARRYING OUT THE INVENTION

Embodiments of the present invention will be described below with reference to the drawings. In the following embodiments, an integrated heat exchange apparatus according to the present invention is applied to a gas cooler and an intermediate heat exchanger of a supercritical refrigeration cycle.

Notably, in the following description, the upper, lower, left-hand, and right-hand sides of FIGS. 1, 2, and 10 will be referred to as "upper," "lower," "left," and "right," respectively. Further, the downstream side of flow of air through an air passage clearance between each pair of adjacent heat exchange tubes (the direction indicated by arrow X in FIGS. 1 and 11; the reverse sides of the sheets of FIGS. 2 and 10) will be referred to as the "front," and the opposite side as the "rear."

Embodiment 1

This embodiment is shown in FIGS. 1 to 9.

FIGS. 1 and 2 shows the overall structure of the integrated heat exchange apparatus; FIGS. 3 to 8 show essential portions thereof; and FIG. 9 shows a flow of refrigerant within the integrated heat exchange apparatus.

With reference to FIGS. 1 and 2, the integrated heat exchange apparatus used in a supercritical refrigeration cycle in which a supercritical refrigerant, such as CO₂, is

used includes a gas cooler 1 (first exchanger) and an intermediate heat exchanger 2 (second exchanger), which are integrated together.

The gas cooler 1 comprises two header tanks 3, 4 extending vertically and separated from each other in the left-right direction, a plurality of flat heat exchange tubes 5 arranged in parallel between the two header tanks 3, 4 and separated from one another in the vertical direction, corrugated fins 6 arranged in respective air passage clearances between respective adjacent pairs of heat exchange tubes 5 and outside the heat exchange tubes 5 at the upper and lower ends of the cooler and each brazed to the adjacent pair of heat exchange tubes 5 or to the end tube 5, and side plates 7 of bare aluminum material arranged externally of and brazed to the respective fins 6 at the upper and lower ends. In this embodiment, the header tank 3 at the right will be referred to as the "first header tank," and the header tank 4 at the left as the "second header tank."

As shown in FIGS. 2 and 3, the first header tank 3 comprises a header-forming plate 8 made from a brazing sheet having a brazing material layer over opposite surfaces thereof (an aluminum brazing sheet in the present embodiment), a tube-connecting plate 9 made from a brazing sheet having a brazing material layer over opposite surfaces thereof (an aluminum brazing sheet in the present embodiment), and an intermediate plate 10 interposed between the header-forming plate 8 and the tube-connecting plate 9 and made from a bare

metal material (bare aluminum material in the present embodiment), the plates 8 to 10 being arranged in superposed layers and brazed to one another.

Formed in the header-forming plate 8 and mutually separated in the vertical direction are a plurality of (two in the present embodiment) bulging portions 11A, 11B extending vertically and being equal in bulging height, length, and width. An opening of each of the bulging portions 11A, 11B facing leftward is closed with the intermediate plate 10. A refrigerant inlet 12 is formed in the top of the upper bulging portion 11A of the plate 8; and an inlet member 13 made from a metal (bare aluminum material in the present embodiment) and having a refrigerant inflow passage 14 communicating with the refrigerant inlet 12 is brazed to the outer surface of the bulging portion 11A by use of the brazing material on the outer surface of the header-forming plate 8. The header-forming plate 8 is made by press work, from an aluminum brazing sheet having a brazing material layer over opposite surfaces thereof.

The tube-connecting plate 9 has a plurality of tube insertion holes 18 extending through the thickness thereof, elongated in the front-rear direction, and separated from one another in the vertical direction. The insertion holes 18 in the upper half of the plate 9 are provided within the vertical range of the upper bulging portion 11A of the header-forming plate 8, and the insertion holes 18 in the lower half of the plate 9 are provided within the vertical

range of the lower bulging portion 11B of the header-forming plate 8. The front-to-rear length of each tube insertion holes 18 is slightly larger than the front-to-rear width of the bulging portion 11A or 11B, and the front and rear ends of the tube insertion hole 18 project outward beyond the respective front and rear edges of the bulging portion 11A or 11B. The tube-connecting plate 9 is integrally provided at each of its front and rear side edges with a cover wall 19 projecting rightward to the outer surface of the header-forming plate 8, covering the boundary between the plate 8 and the intermediate plate 10 over the entire length thereof and brazed to the front or rear side faces of the plates 8, 10. The projecting end of the cover wall 19 is integrally provided with engaging portions 21 separated from one another in the vertical direction, engaging with the outer surface of the plate 8, and brazed to the plate 8. The tube-connecting plate 9 is made by press work, from an aluminum brazing sheet having a brazing material layer over opposite surfaces thereof.

The intermediate plate 10 has communication holes 22 extending through the thickness thereof and equal in number to the tube insertion holes 18 in the tube-connecting plate 9 for causing the holes 18 to communicate with the bulging portion 11A or 11B of the plate 8 therethrough. The communication holes 22 are substantially larger than the insertion holes 18; that is, larger in transverse cross section than the heat exchange tubes 5 (see FIG. 4). The

communication holes 22 are positioned in corresponding relation with the respective tube insertion holes 18 of the tube-connecting plate 9. The tube insertion holes 18 in the upper half of the plate 9 communicate with the interior of the upper bulging portion 11A through the communication holes 22 in the upper half of the intermediate plate 10, and the tube insertion holes 18 in the lower half of the plate 10 communicate with the interior of the lower bulging portion 11B through the communication holes 22 in the lower half of the intermediate plate 10. All the communication holes 22 communicating with the interior of the upper bulging portion 11A, as well as all the communication holes 22 communicating with the interior of the lower bulging portion 11B, are held in communication by communication portions 23 formed by cutting away the portion between each adjacent pair of holes 22 in the intermediate plate 10. The intermediate plate 10 is made from a bare aluminum material by press work.

The upper half of the header-forming plate 8 including the upper bulging portion 11A, the upper half of the tube-connecting plate 9, and the upper half of the intermediate plate 10 form a refrigerant inlet header section 24, whereas the lower half of the header-forming plate 8 including the lower bulging portion 11B, the lower half of the tube-connecting plate 9, and the lower half of the intermediate plate 10 form a refrigerant outlet header section 25. In the refrigerant inlet header section 24 and the refrigerant outlet header section 25, refrigerant flows along the length

direction of the first header tank 3 via the interiors of the bulging portions 11A, 11B and the communication portions 23.

Downward projecting portions 8a, 9a, 10a slightly narrower in width than the three plates 8, 9, 10 are formed at the respective lower ends of the plates 8, 9, 10. In the intermediate plate 10, a cut 26 is formed such that it extends from the end of the downward projecting portion 10a to the lowermost communication hole 22, whereby a refrigerant outlet 27 communicating with the refrigerant outlet header section 25 is formed in the first header tank 3 (see FIG. 2).

As shown in FIG. 5, the second header tank 4 has approximately the same construction as the first header tank 3, and like parts are designated by like reference numerals. The two header tanks 3, 4 are arranged with their tube-connecting plates 9 opposed to each other. The second header tank 4 differs from the first header tank 3 in that the header-forming plate 8 has one bulging portion 28 which is one fewer in number than the bulging portions 11A, 11B of the first header tank 3 and which extends from the upper end of the header-forming plate 8 to the lower end thereof so as to face both the bulging portions 11A, 11B of the first header tank 3; that the outer bulging portion 28 does not have the refrigerant inlet; that all tube insertion holes 18 of the tube-connecting plate 9 communicate with the interior of the bulging portion 28 through all the communication holes 22 in the intermediate plate 10; that all the communication holes 22 of the intermediate plate 10 are held in communication by

communication portions 23 formed by cutting away the portion between each adjacent pair of communication holes 22; and that no cut is formed in the downward projecting portion 10a of the intermediate plate 10. The projecting height and width of the outer bulging portion 28 are equal to those of the outer bulging portions 11A, 11B of the first header tank 3. The entireties of the three plates 8, 9, 10 form an intermediate header section 29. In the intermediate header section 29, refrigerant flows along the length direction of the second header tank 4 via the interior of the bulging portion 28 and the communication portions 23.

The header tanks 3, 4 are manufactured as shown in FIGS. 3 and 5.

First, an aluminum brazing sheet having a brazing material layer over opposite surfaces thereof is subjected to press work so as to form the header-forming plate 8 having the bulging portions 11A, 11B and the downward projecting portion 8a and the header-forming plate 8 having the bulging portion 28 and the downward projecting portion 8a. Further, an aluminum brazing sheet having a brazing material layer over opposite surfaces thereof is subjected to press work so as to form the tube-connecting plates 9 each having the tube insertion holes 18, the cover walls 19, engaging portion forming lugs 21A extending straight from each of the cover walls 19, and the downward projecting portion 9a. Moreover, a bare aluminum material is subjected to press work so as to form the intermediate plates 10 each having the communication

holes 22, the communication portions 23, and the downward projecting portion 10a. The cut 26 is formed in the intermediate plate 10 of the first header tank 3.

Subsequently, the three plates 8, 9, 10 of each header tank are assembled in a layered form; and then the lugs 21A are bent to form engaging portions 21. The engagement portions 21 are engaged with the corresponding header-forming plates 8 so as to form provisional fixed assemblies. Subsequently, utilizing the brazing material layers of the plates 8, 9, the three plates 8, 9, 10 of each assembly are then brazed to one another; the cover walls 19 are brazed to the front and rear side faces of the intermediate plate 10 and the header-forming plate 8; and the engaging portions 21 are brazed to the plate 8. In this manner, both the header tanks 3, 4 are manufactured.

Each of the heat exchange tubes 5 is made from a metal extrudate (aluminum extrudate in the present embodiment), is in the form of a flat tube having an increased width in the front-rear direction, and has inside thereof a plurality of refrigerant channels 5a extending longitudinally thereof and arranged in parallel. The heat exchange tubes 5 are brazed to the tube-connecting plates 9 of the two header tanks 3, 4 using the brazing material layers of the plates 9, with their opposite ends placed into the respective tube insertion holes 18 of the tanks 3, 4. Each end of the tube 5 is placed into the corresponding communication hole 22 of the intermediate plate 10 to an intermediate portion of the thickness thereof.

The heat exchange tubes 5 in the upper half of the cooler to be fabricated have their right ends connected to the first header tank 3 so as to communicate with the interior of the upper bulging portion 11A; i.e., the interior of the refrigerant inlet header section 24, and have their left ends connected to the second header tank 4 so as to communicate with the interior of the bulging portion 28; i.e., the interior of the intermediate header section 29. Further, the heat exchange tubes 5 in the lower half have their right ends connected to the first header tank 3 so as to communicate with the interior of the lower bulging portion 11B; i.e., the interior of the refrigerant outlet header section 25, and have their left ends connected to the second header tank 4 so as to communicate with the interior of the bulging portion 28; i.e., the interior of the intermediate header section 29.

Each of the corrugated fins 6 is made in a wavy form from a brazing sheet having a brazing material layer over , opposite surfaces thereof (aluminum brazing sheet in the present embodiment).

As shown in FIGS. 2 and 6, the intermediate heat exchanger 2 includes an outer tube 31 extending in the left-right direction; an inner tube 32 concentrically disposed within the outer tube 31 with a clearance formed therebetween and extending in the left-right direction; fins 33 provided on the outer circumferential surface of the inner tube 32; and two connectors 34, 35 fixed to the opposite ends of the tubes 31, 32. The clearance between the outer tube 31 and

the inner tube 32 serves as a first refrigerant passage 30, and the interior of the inner tube 32 serves as a second refrigerant passage 40. The outer tube 31 and the inner tube 32 form a heat exchange section. The connectors 34, 35 of the intermediate heat exchanger 2 are fixed to the header tanks 3, 4 of the gas cooler 1.

The outer tube 31 is made from a metal extrudate (aluminum extrudate in the present embodiment). The inner tube 32 is made from a metal extrudate (aluminum extrudate in the present embodiment), and the plurality of fins 33 are integrally formed on the outer circumferential surface thereof at circumferential intervals such that the fins 33 extend in the longitudinal direction of the inner tube 32. A slight clearance is present between the ends of the fins 33 and the inner circumferential surface of the outer tube 31 (see FIG. 7). The opposite ends of the inner tube 32 project outward from the outer tube 31. The fins 33 are removed from the outward projecting portions of the inner tube 32 to thereby form fin-absent portions 32a. Further, a plurality of inner fins 39 are integrally formed on the inner circumferential surface of the inner tube 32 at circumferential intervals such that the inner fins 39 extend over the entire length of the inner tube 32 (see FIG. 7).

The connectors 34, 35 are each formed of a metal block (aluminum block in the present embodiment). In the following description, the right-hand connector 34 will be referred to as a first connector, and the left-hand connector 35 will be

referred to as a second connector.

A header tank insertion hole 36 is formed in a right end portion of the upper surface of the first connector 34, and the downward projecting portions 8a, 9a, 10a of the plates 8, 9, 10 of the first header tank 3 of the gas cooler 1 are fitted into the header tank insertion hole 36 (see FIG. 8). A header tank insertion hole 37 is formed in a left end portion of the upper surface of the second connector 35, and the downward projecting portions 8a, 9a, 10a of the plates 8, 9, 10 of the second header tank 4 of the gas cooler 1 are fitted into the header tank insertion hole 37. The first header tank 3 and the first connector 34 are brazed together by use of the brazing material layers of the header-forming plate 8 and the tube-connecting plate 9 with the downward projecting portions 8a, 9a, 10a of the plates 8, 9, 10 of the first header tank 3 of the gas cooler 1 fitted into the header tank insertion hole 36 of the first connector 34. The second header tank 4 and the second connector 35 are brazed together by use of the brazing material layers of the header-forming plate 8 and the tube-connecting plate 9 with the downward projecting portions 8a, 9a, 10a of the plates 8, 9, 10 of the second header tank 4 fitted into the header tank insertion hole 37 of the second connector 35. Thus, the intermediate heat exchanger 2 is fixed to the gas cooler 1 in such a manner that the intermediate heat exchanger 2 does not close the air passage clearances between respective adjacent pairs of heat exchange tubes 5 of the gas cooler 1.

An outer tube insertion recess 38 is formed on the left-hand side surface of the first connector 34, and the right end of the outer tube 31 is fitted into the outer tube insertion recess 38. The outer circumferential surface of the outer tube 31 is joined, by means of brazing, to the left-hand side surface of the first connector 34 at a portion surrounding the circumferential edge of the opening of the outer tube insertion recess 38. A first flow passage 41 is formed in the first connector 34 such that one end of the first flow passage 41 is opened to the bottom surface of the outer tube insertion recess 38, and the other end thereof is opened to the rear surface of the first connector 34. The first flow passage 41 communicates with the first refrigerant passage 30. Further, a second flow passage 42 is formed in the first connector 34 such that one end of the second flow passage 42 is opened to the bottom surface of the header tank insertion hole 36, and the other end thereof is opened to the right end surface of a portion of the first flow passage 41 extending in the left-right direction. The second flow passage 42 communicates with the second refrigerant passage 40. A right end portion of the fin-absent portion 32a of the inner tube 32 is inserted into a portion of the second flow passage 42 extending in the left-right direction, and the outer circumferential surface of the fin-absent portion 32a of the inner tube 32 is joined, by means of brazing, to the right end surface of the left-right direction extending portion of the first flow passage 41 at a portion surrounding

the circumferential edge of the opening of the second flow passage 42. Accordingly, the second flow passage 42 of the first connector 34 communicates with the refrigerant outlet 27 of the refrigerant outlet header section 25 of the gas cooler 1, whereby the second refrigerant passage 40 of the intermediate heat exchanger 2 communicates with the refrigerant outlet 27 of the gas cooler 1 via the second flow channel 42. Further, an internally threaded hole 43 is formed on the rear surface of the first connector 34. This internally threaded hole 43 is used for connecting to the first connector 34 a piping pipe (not shown) for discharging refrigerant from the interior of the first refrigerant passage 30 via the first flow passage 41.

An outer tube insertion recess 44 is formed on the right-hand side surface of the second connector 35, and the left end of the outer tube 31 is fitted into the outer tube insertion recess 44. The outer circumferential surface of the outer tube 31 is joined, by means of brazing, to the right-hand side surface of the second connector 35 at a portion surrounding the circumferential edge of the opening of the outer tube insertion recess 44. A first flow passage 45 is formed in the second connector 35 such that one end of the first flow passage 45 is opened to the bottom surface of the outer tube insertion recess 44, and the other end thereof is opened to the rear surface of the second connector 35. The first flow passage 45 communicates with the first refrigerant passage 30. Further, a second flow passage 46 is

formed in the second connector 35 such that one end of the second flow passage 46 is opened to the left-hand side surface of the second connector 35, and the other end thereof is opened to the left end surface of a portion of the first flow passage 45 extending in the left-right direction. The second flow passage 46 communicates with the second refrigerant passage 40. A left end portion of the fin-absent portion 32a of the inner tube 32 is inserted into a right end portion of the second flow passage 46, and the outer circumferential surface of the fin-absent portion 32a of the inner tube 32 is joined, by means of brazing, to the left end surface of the left-right direction extending portion of the first flow passage 45 at a portion surrounding the circumferential edge of the right end opening of the second flow passage 46. Further, internally threaded holes 47, 48 are formed on the rear surface and left-hand side surface, respectively, of the second connector 35. The internally threaded hole 47 formed on the rear surface is used for connecting to the second connector 35 a piping pipe (not shown) for supplying refrigerant to the interior of the first refrigerant passage 30 via the first flow passage 45. The internally threaded hole 48 formed on the left-hand side surface is used for connecting to the second connector 35 a piping pipe (not shown) for discharging refrigerant from the interior of the second refrigerant passage 40 via the second flow passage 46.

The above-described integrated heat exchange apparatus

is manufactured by assembling and brazing all the components together.

When the integrated heat exchange apparatus is used for a supercritical refrigeration cycle as shown in FIG. 12, a piping pipe extending from the compressor 75 is connected to the refrigerant inlet member 13 of the gas cooler 1, and a piping pipe extending from the accumulator 78, serving as a gas-liquid separator, is connected to the second connector 35 of the intermediate heat exchanger 2 by use of the internally threaded hole 47 on the rear surface so as to establish communication with the first flow passage 45. Further, a piping pipe extending to the compressor 75 is connected to the first connector 34 by use of the internally threaded hole 43 so as to establish communication with the first flow passage 41. Moreover, a piping pipe extending to the expansion valve 79, serving as a pressure-reducing device, is connected to the second connector 35 by use of the internally threaded hole 48 on the left-hand side surface so as to establish communication with the second flow passage 46. This supercritical refrigeration cycle uses CO₂ as a supercritical refrigerant, and is mounted on a vehicle, such as an automobile, as a car air conditioner.

In the integrated heat exchange apparatus, as shown in FIG. 9, high-pressure CO₂ having passed through the compressor 75 passes through the refrigerant inflow passage 14 of the refrigerant inlet member 13, and then enters the interior of the refrigerant inlet header section 24 of the

first header tank 3 of the gas cooler 1 from the refrigerant inlet 12. The CO₂ dividedly flows into the refrigerant channels 5a of all the heat exchange tubes 5 in communication with the interior of the upper bulging portion 11A. The CO₂ in the channels 5a flows leftward through the channels 5a and enters the interior of the intermediate header section 29 of the second header tank 4, and then flows downward via the interior of the bulging portion 28 and the communication portions 23 of the intermediate plate 10. The CO₂ then dividedly flows into the channels 5a of all the heat exchange tubes 5 in communication with the interior of the intermediate header section 29 and the interior of the refrigerant outlet header section 25, thereby changing its flow direction, flows rightward through the channels 5a, and enters the refrigerant outlet header section 25 of the first header tank 3. The CO₂ having entered the refrigerant outlet header section 25 flows downward via the interior of the lower bulging portion 11B and the communication portions 23 of the intermediate plate 10, and then flows into the second refrigerant passage 40 via the refrigerant outlet 27 and the second flow passage 42 of the first connector 34 of the intermediate heat exchanger 2. The CO₂ then flows leftward within the second refrigerant passage 40, enters the piping pipe via the second flow passage 46 of the second connector 35, and is then fed to the expansion valve 79.

Meanwhile, low pressure CO₂ fed from the accumulator 78 flows from the piping pipe into the first refrigerant passage

30 via the first flow passage 45 of the second connector 35 of the intermediate heat exchanger 2. Subsequently, the CO₂ flows rightward through the first refrigerant passage 30, then flows into the piping pipe via the first flow passage 41 of the first connector 34, and is then fed to the compressor 75.

While flowing through the channels 5a of the heat exchange tubes 5 of the gas cooler 1, the CO₂ is subjected to heat exchange with the air flowing through the air passage clearances in the direction of arrow X shown in FIGS. 1 and 9, and is thereby cooled. Further, the high-pressure refrigerant having come out of the gas cooler 1 and flowing through the first refrigerant passage 30 of the second heat exchanger 2 exchanges heat with the low-pressure refrigerant having come out of the evaporator 77 and flowing through the second refrigerant passage 40.

Embodiment 2

The present embodiment is shown in FIGS. 10 and 11.

In the present embodiment, a left-hand header tank 51 of a gas cooler 50 will be referred to as a first header tank, and a right-hand header tank 52 thereof will be referred to as a second header tank.

A plurality of (two in the present embodiment) bulging portions 53A, 53B are formed on the header-forming plate 8 of the first header tank 51 of the gas cooler 50 such that they are mutually separated in the vertical direction and extend vertically. The two bulging portions 53A, 53B are equal in

bulging height and width. An opening of each of the bulging portions 53A, 53B facing rightward is closed with the intermediate plate 10. The length of the upper bulging portion 53A is greater than that of the lower bulging portion 53B. Portions of the three plates 8, 9, 10, including the upper bulging portion 53A, form a first intermediate header section 54, whereas portions of the three plates 8, 9, 10, including the lower bulging portion 53B, form a refrigerant outlet header section 55. In the first intermediate header section 54 and the refrigerant outlet header section 55, refrigerant flows along the length direction of the first header tank 51 via the interiors of the bulging portions 53A, 53B and the communication portions 23.

The tube-connecting plate 9 has tube insertion holes 18 formed in the vertical range of the upper bulging portion 53A of the header-forming plate 8, and tube insertion holes 18 formed in the vertical range of the lower bulging portion 53B of the header-forming plate 8.

Downward projecting portions 8a, 9a, 10a slightly narrower in width than the three plates 8, 9, 10 are formed at the respective lower ends of the plates 8, 9, 10. In the intermediate plate 10, a cut 56 is formed such that it extends from the end of the downward projecting portion 10a to the lowermost communication hole 22, whereby a refrigerant outlet 57 communicating with the refrigerant outlet header section 55 is formed in the first header tank section 51. Upward projecting portions 8b, 9b, 10b slightly narrower in

width than the three plates 8, 9, 10 are formed at the respective upper ends of the plates 8, 9, 10.

The remaining portions of the first header tank 51 have the same structures as those of the second header tank 4 of the gas cooler 1 of Embodiment 1.

A plurality of (two in the present embodiment) bulging portions 58A, 58B are formed on the header-forming plate 8 of the second header tank 52 of the gas cooler 50 such that they are mutually separated in the vertical direction and extend vertically. The two bulging portions 58A, 58B are equal in bulging height and width. An opening of each of the bulging portions 58A, 58B facing leftward is closed with the intermediate plate 10. The length of the upper bulging portion 58A is less than that of the lower bulging portion 58B. The upper bulging portion 53A of the first header tank 51 faces the two bulging portions 58A, 58B of the second header tank 52, whereas the lower bulging portion 58B of the second header tank 52 faces the two bulging portions 53A, 53B of the first header tank 51. Portions of the three plates 8, 9, 10, including the upper bulging portion 58A, form a refrigerant inlet header section 59, whereas portions of the three plates 8, 9, 10, including the lower bulging portion 58B, form a second intermediate header section 61. In the refrigerant inlet header section 59 and the second intermediate header section 61, refrigerant flows along the length direction of the second header tank 52 via the interiors of the bulging portions 58A, 58B and the

communication portions 23. Notably, a refrigerant inlet 12 is formed at a top portion of the upper bulging portion 58A of the second header tank 52; and a refrigerant inlet member 13 which has a refrigerant inflow passage 14 communicating with the refrigerant inlet 12 is brazed to the upper bulging portion 58A.

The tube-connecting plate 9 has tube insertion holes 18 formed in the vertical range of the upper bulging portion 58A of the header-forming plate 8, and tube insertion holes 18 formed in the vertical range of the lower bulging portion 58B of the header-forming plate 8. Downward projecting portions are not formed at the lower ends of the three plates 8, 9, 10, and needless to say, no cut is formed in the intermediate plate.

The remaining portions of the second header tank 52 have the same structures as those of the first header tank 3 of the gas cooler 1 of Embodiment 1.

The remaining portions of the gas cooler 50 have the same structure as those of the gas cooler 1 of Embodiment 1. Like components and like portions are denoted by like reference numerals.

The intermediate heat exchanger 62 includes a vertically extending outer tube 31; a vertically extending inner tube 32 concentrically disposed within the outer tube 31 with a clearance formed therebetween; fins 33 provided on the outer circumferential surface of the inner tube 32; and two connectors 63, 64 fixed to the upper and lower ends of

the tubes 31, 32. The clearance between the outer tube 31 and the inner tube 32 serves as a first refrigerant passage 30, and the interior of the inner tube 32 serves as a second refrigerant passage 40. The connectors 63, 64 of the intermediate heat exchanger 62 are fixed to the first header tank 51 of the gas cooler 50.

The outer tube 31, the inner tube 32, and the fins 33 are identical with the outer tube, inner tube, and fins of the intermediate heat exchanger 62 of Embodiment 1, but are directed vertically.

The connectors 63, 64 are each formed of a metal block (aluminum block in the present embodiment). In the following description, the lower connector 64 will be referred to as the first connector, and the upper connector 63 will be referred to as the second connector.

A header tank insertion hole 65 is formed in a right end portion of the upper surface of the first connector 64, and the downward projecting portions 8a, 9a, 10a of the plates 8, 9, 10 of the first header tank 51 of the gas cooler 50 are fitted into the header tank insertion hole 65. A header tank insertion hole 66 is formed in a right end portion of the lower surface of the second connector 63, and the upward projecting portions 8b, 9b, 10b of the plates 8, 9, 10 of the first header tank 51 of the gas cooler 50 are fitted into the header tank insertion hole 66. The first header tank 51 of the gas cooler 50 and the first connector 64 are brazed together by use of the brazing material layers

of the header-forming plate 8 and the tube-connecting plate 9 with the downward projecting portions 8a, 9a, 10a of the plates 8, 9, 10 of the first header tank 51 fitted into the header tank insertion hole 65 of the first connector 64. The first header tank 51 and the second connector 63 are brazed together by use of the brazing material layers of the header-forming plate 8 and the tube-connecting plate 9 with the upward projecting portions 8b, 9b, 10b of the plates 8, 9, 10 of the first header tank 51 fitted into the header tank insertion hole 66 of the second connector 63. Thus, the intermediate heat exchanger 62 is fixed to the gas cooler 50 in such a manner that the intermediate heat exchanger 62 does not close the air passage clearances between respective adjacent pairs of heat exchange tubes 5 of the gas cooler 50.

An outer tube insertion recess 67 is formed on a left-hand portion of the upper surface of the first connector 64, and the lower end of the outer tube 31 is fitted into the outer tube insertion recess 67. The outer circumferential surface of the outer tube 31 is joined, by means of brazing, to the upper surface of the first connector 64 at a portion surrounding the circumferential edge of the opening of the outer tube insertion recess 67. A first flow passage 68 is formed in the first connector 64 such that one end of the first flow passage 68 is opened to the bottom surface of the outer tube insertion recess 67, and the other end thereof is opened to the rear surface of the first connector 64. The first flow passage 68 communicates with the first refrigerant

passage 30. Further, a second flow passage 69 is formed in the first connector 64 such that one end of the second flow passage 69 is opened to the bottom surface of the header tank insertion hole 65, and the other end thereof is opened to the lower end surface of a vertically extending portion of the first flow passage 68. The second flow passage 69 communicates with the second refrigerant passage 40. A lower end portion of the fin-absent portion 32a of the inner tube 32 is inserted into a vertically extending portion of the second flow passage 69, and the outer circumferential surface of the fin-absent portion 32a of the inner tube 32 is joined, by means of brazing, to the lower end surface of the vertically extending portion of the first flow passage 68 at a portion surrounding the circumferential edge of the opening of the second flow passage 69. Accordingly, the second flow passage 69 of the first connector 64 communicates with the refrigerant outlet 57 of the gas cooler 50, whereby the second refrigerant passage 40 of the intermediate heat exchanger 62 communicates with the refrigerant outlet 57 of the refrigerant outlet header section 55 of the gas cooler 50 via the second flow channel 69. Although not illustrated in the drawings, an internally threaded hole is formed on the rear surface of the first connector 64. This internally threaded hole is used for connecting to the first connector 64 a piping pipe for discharging refrigerant from the interior of the first refrigerant passage 30 via the first flow passage 68.

An outer tube insertion recess 71 is formed on the left-hand end portion of the lower surface of the second connector 63, and the upper end of the outer tube 31 is fitted into the outer tube insertion recess 71. The outer circumferential surface of the outer tube 31 is joined, by means of brazing, to the lower surface of the second connector 63 at a portion surrounding the circumferential edge of the opening of the outer tube insertion recess 71. A first flow passage 72 is formed in the second connector 63 such that one end of the first flow passage 72 is opened to the bottom surface of the outer tube insertion recess 71, and the other end thereof is opened to the rear surface of the second connector 63. The first flow passage 72 communicates with the first refrigerant passage 30. Further, a second flow passage 73 is formed in the second connector 63 such that one end of the second flow passage 73 is opened to the upper surface of the second connector 63, and the other end thereof is opened to the upper end surface of a vertically extending portion of the first flow passage 72. The second flow passage 73 communicates with the second refrigerant passage 40. An upper end portion of the fin-absent portion 32a of the inner tube 32 is inserted into a lower end portion of the second flow passage 73, and the outer circumferential surface of the fin-absent portion 32a of the inner tube 32 is joined, by means of brazing, to the upper end surface of the vertically extending portion of the first flow passage 72 at a portion surrounding the circumferential edge of the opening

of the second flow passage 73. Although not illustrated in the drawings, an internally threaded hole is formed on the rear surface of the second connector 63. This internally threaded hole is used for connecting to the second connector 63 a piping pipe for supplying refrigerant to the interior of the first refrigerant passage 30 via the first flow passage 72. Further, an internally threaded hole is formed on the upper surface of the second connector 63. This internally threaded hole is used for connecting to the second connector 63 a piping pipe for discharging refrigerant from the interior of the second refrigerant passage 40 via the second flow passage 73.

The above-described integrated heat exchange apparatus is manufactured by assembling and brazing all the components together.

When the integrated heat exchange apparatus is used for a supercritical refrigeration cycle as shown in FIG. 12, a piping pipe extending from the compressor 75 is connected to the refrigerant inlet member 13 of the gas cooler 50, and a piping pipe extending from the accumulator 78, serving as a gas-liquid separator, is connected to the second connector 63 of the intermediate heat exchanger 62 by use of the internally threaded hole on the rear surface so as to establish communication with the first flow passage 72. Further, a piping pipe extending to the compressor 75 is connected to the first connector 64 by use of the internally threaded hole on the rear surface so as to establish

communication with the first flow passage 68. Moreover, a piping pipe extending to the expansion valve 79, serving as a pressure-reducing device, is connected to the second connector 63 by use of the internally threaded hole on the upper surface so as to establish communication with the second flow passage 73. This supercritical refrigeration cycle uses CO₂ as a supercritical refrigerant, and is mounted on a vehicle, such as an automobile, as a car air conditioner.

In the integrated heat exchange apparatus, as shown in FIG. 11, high-pressure CO₂ having passed through the compressor 75 passes through the refrigerant inflow passage 14 of the refrigerant inlet member 13, and then enters the interior of the refrigerant inlet header section 59 of the second header tank 52 of the gas cooler 50 from the refrigerant inlet 12. The CO₂ dividedly flows into the refrigerant channels 5a of all the heat exchange tubes 5 in communication with the interior of the upper bulging portion 58A. The CO₂ in the channels 5a flows leftward through the channels 5a and enters the interior of the first intermediate header section 54 of the first header tank 51, and then flows downward via the interior of the upper bulging portion 53A and the communication portions 23 of the intermediate plate 10. The CO₂ then dividedly flows into the channels 5a of the heat exchange tubes 5 in communication with the interiors of both the intermediate header sections 54, 61, thereby changing its flow direction, flows rightward through the channels 5a, and enters the second intermediate header

section 61 of the second header tank 52. The CO₂ having entered the second intermediate header section 61 flows downward via the interior of the lower bulging portion 58B and the communication portions 23 of the intermediate plate 10. The CO₂ then dividedly flows into the channels 5a of all the heat exchange tubes 5 in communication with the interior of the second intermediate header section 61 and the interior of the refrigerant outlet header section 55, thereby changing its flow direction, flows leftward through the channels 5a, and enters the refrigerant outlet header section 55 of the first header tank 51. The CO₂ having entered the refrigerant outlet header section 55 flows downward via the interior of the lower bulging portion 53B and the communication portions 23 of the intermediate plate 10, and then flows into the second refrigerant passage 40 via the refrigerant outlet 57 and the second flow passage 69 of the first connector 64 of the intermediate heat exchanger 62. The CO₂ then flows upward within the second refrigerant passage 40, enters the piping pipe via the second flow passage 73 of the second connector 63, and is then fed to the expansion valve 79.

Meanwhile, low pressure CO₂ fed from the accumulator 78 flows from the piping pipe into the first refrigerant passage 30 via the first flow passage 72 of the second connector 63 of the intermediate heat exchanger 62. Subsequently, the CO₂ flows downward through the first refrigerant passage 30, then flows into the piping pipe via the first flow passage 68 of the first connector 64, and is then fed to the compressor 75.

While flowing through the channels 5a of the heat exchange tubes 5 of the gas cooler 50, the CO₂ is subjected to heat exchange with the air flowing through the air passage clearances in the direction of arrow X shown in FIG. 11, and is thereby cooled. Further, the high pressure refrigerant having come out of the gas cooler 50 and flowing through the first refrigerant passage 30 of the intermediate heat exchanger 62 exchanges heat with the low pressure refrigerant having come out of the evaporator 77 and flowing through the second refrigerant passage 40.

In the above-described Embodiment 1, the two connectors 63, 64 of the intermediate heat exchanger 62 of the above-described Embodiment 2 may be fixed to the first header tank 3 such that the second flow passage 69 of the first connector 64 communicates with the refrigerant outlet 27 of the first header tank 3. That is, in an integrated heat exchange apparatus composed of an intermediate heat exchanger and a gas cooler configured such that a first header tank has a plurality of header sections arranged along the length direction thereof, a second header tank has a header section(s) which is one fewer in number than the header sections of the first header tank, a header section at one end of the first header tank serves as a refrigerant inlet header section having a refrigerant inlet, and a header section at the other end of the first header tank serves as a refrigerant outlet header section having a refrigerant outlet, the two connectors of the intermediate heat exchanger may be

fixed to the first header tank such that the second flow passage of the first connector communicates with the refrigerant outlet of the first header tank.

In the above-described Embodiment 2, the first connector 34 of the intermediate heat exchanger 2 of the above-described Embodiment 1 may be fixed to the first header tank 51 such that the second flow passage 42 communicates with the refrigerant outlet 57 of the first header tank 51, and the second connector 35 may be fixed to the second header tank 52. That is, in an integrated heat exchange apparatus composed of an intermediate heat exchanger and a gas cooler configured such that a first header tank has a plurality of header sections arranged along the length direction thereof, a second header tank has header sections whose number is the same as the number of the header sections of the first header tank, a header section at one end of the second header tank serves as a refrigerant inlet header section having a refrigerant inlet, and a header section at the other end of the first header tank serves as a refrigerant outlet header section having a refrigerant outlet, the first connector of the intermediate heat exchanger may be fixed to the first header tank of the gas cooler, and the second connector may be fixed to the second header tank of the gas cooler, such that the second flow passage of the first connector communicates with the refrigerant outlet of the first header tank.

Although CO₂ is used as a supercritical refrigerant of a

supercritical refrigeration cycle in the above-described two embodiments, the refrigerant is not limited thereto, but ethylene, ethane, nitrogen oxide, or the like is alternatively used.

FIGS. 13 to 19 show modified embodiments of a heat exchange tube for use in the above-described gas cooler 1 and evaporator 50 of the above-described two integrated heat exchange apparatuses. Notably, in the following description regarding the modified embodiments of the heat exchange tube, the upper, lower, left-hand, and right-hand sides of FIGS. 13 to 19 will be referred to as "upper," "lower," "left," and "right," respectively.

A heat exchange tube 160 shown in FIGS. 13 and 14 includes mutually opposed flat upper and lower walls 161, 162 (a pair of flat walls); left and right side walls 163, 164 that extend over left and right side ends, respectively, of the upper and lower walls 161, 162; and a plurality of reinforcement walls 165 that are provided at predetermined intervals between the left and right side walls 163, 164 and extend longitudinally and between the upper and lower walls 161, 162. By virtue of this structure, the heat exchange tube 160 internally has a plurality of refrigerant channels 166 arranged in the width direction thereof. The reinforcement walls 165 serve as partition walls between adjacent refrigerant channels 166. The width of each refrigerant channel 166 remains unchanged along the entire height of the refrigerant channel 166.

The left side wall 163 has a dual structure and includes an outer side-wall-forming elongated projection 167 that is integrally formed with the left side end of the upper wall 161 in a downward raised condition and extends along the entire height of the heat exchange tube 160; an inner side-wall-forming elongated projection 168 that is located inside the outer side-wall-forming elongated projection 167 and is integrally formed with the upper wall 161 in a downward raised condition; and an inner side-wall-forming elongated projection 169 that is integrally formed with the left side end of the lower wall 162 in an upward raised condition. The outer side-wall-forming elongated projection 167 is brazed to the two inner side-wall-forming elongated projections 168, 169 and the lower wall 162 while a lower end portion thereof is engaged with a left side edge portion of the lower surface of the lower wall 162. The two inner side-wall-forming elongated projections 168, 169 are brazed together while , butting against each other. A right side wall 164 is integrally formed with the upper and lower walls 161, 162. A projection 169a is integrally formed on the tip end face of the inner side-wall-forming projection 169 of the lower wall 162 and extends in the longitudinal direction of the inner side-wall-forming projection 169 along the entire length thereof. A groove 168a is formed on the tip end face of the inner side-wall-forming elongated projection 168 of the upper wall 161 and extends in the longitudinal direction of the inner side-wall-forming elongated projection 168 along the

entire length thereof. The projection 169a is press-fitted into the groove 168a.

Each of the reinforcement walls 165 is formed such that a reinforcement-wall-forming elongated projection 170, which is integrally formed with the upper wall 161 in a downward raised condition, and a reinforcement-wall-forming elongated projection 171, which is integrally formed with the lower wall 162 in an upward raised condition, are brazed together while butting against each other.

The heat exchange tube 160 is manufactured by use of a tube-forming metal sheet 175 as shown in FIG. 15(a). The tube-forming metal sheet 175 is formed by performing rolling on an aluminum brazing sheet having a brazing material layer over opposite surfaces thereof. The tube-forming metal sheet 175 includes a flat upper-wall-forming portion 176 (flat-wall-forming portion); a lower-wall-forming portion 177 (flat-wall-forming portion); a connection portion 178 connecting the upper-wall-forming portion 176 and the lower-wall-forming portion 177 and adapted to form the right side wall 164; the inner side-wall-forming elongated projections 168, 169, which are integrally formed with the side ends of the upper-wall-forming and lower-wall-forming portions 176, 177 opposite the connection portion 178 in an upward raised condition and which are adapted to form an inner portion of the side wall 163; an outer side-wall-forming-elongated-projection forming portion 179, which extends in the left-right direction (rightward) from the side end (right side

end) of the upper-wall-forming portion 176 opposite the connection portion 178; and a plurality of reinforcement-wall-forming elongated projections 170, 171, which are integrally formed with the upper-wall-forming and lower-wall-forming portions 176, 177 in an upward raised condition and which are arranged at predetermined intervals in the left-right direction. The reinforcement-wall-forming elongated projections 170 of the upper-wall-forming portion 176 and the reinforcement-wall-forming elongated projections 171 of the lower-wall-forming portion 177 are located symmetrically with respect to the centerline of the width direction of the tube-forming metal sheet 175. The projection 169a is formed on the tip end face of the inner side-wall-forming elongated projection 169 of the lower-wall-forming portion 177, and the groove 168a is formed on the tip end face of the inner side-wall-forming elongated projection 168 of the upper-wall-forming portion 176. The two inner side-wall-forming elongated projections 168, 169 and all the reinforcement-wall-forming elongated projections 170, 171 have the same height. The vertical thickness of the connection portion 178 is greater than the thickness of the upper-wall-forming and lower-wall-forming portions 175, 176. The top end face of the connection portion 178 is substantially flush with the top end faces of the inner side-wall-forming elongated projections 168, 169 and the reinforcement-wall-forming elongated projections 170, 171.

The inner side-wall-forming elongated projections 168,

169 and the reinforcement-wall-forming elongated projections 170, 171 are integrally formed through rolling performed on the aluminum brazing sheet whose opposite sides are clad with a brazing material. Thus, a brazing material layer (not shown) is formed on the opposite side surfaces and tip end faces of the inner side-wall-forming elongated projections 168, 169, on those of the reinforcement-wall-forming elongated projections 170, 171, and on the vertically opposite surfaces of the upper-wall-forming and lower-wall-forming portions 175, 176. In this case, the brazing material layer on the tip end faces of the inner side-wall-forming elongated projections 168, 169 and the reinforcement-wall-forming elongated projections 170, 171 become greater in thickness than the brazing material layer on other portions of the tube-forming metal sheet 175.

The tube-forming metal sheet 175 is gradually folded at left and right side edges of the connection portion 178 by a roll forming process (see FIG. 15(b)) until a hairpin form is assumed. The inner side-wall-forming elongated projections 168, 169 are caused to butt against each other; the reinforcement-wall-forming elongated projections 170, 171 are caused to butt against each other; and the projection 169a is caused to be press-fitted into the groove 168a.

Next, the outer side-wall-forming-elongated-projection forming portion 179 is folded along the outer surfaces of the inner side-wall-forming elongated projections 168, 169, and a tip end portion thereof is deformed so as to be engaged with

the lower-wall-forming portion 177, thereby yielding a folded member 180 (see FIG. 15(c)).

Subsequently, the folded member 180 is heated at a predetermined temperature so as to braze together tip end portions of the inner side-wall-forming elongated projections 168, 169; to braze together tip end portions of the reinforcement-wall-forming elongated projections 170, 171; and to braze the outer side-wall-forming-elongated-projection forming portion 179 to the inner side-wall-forming elongated projections 168, 169 and to the lower-wall-forming portion 177. Thus is manufactured the heat exchange tube 160. The heat exchange tubes 160 are manufactured in the course of manufacture of the integrated heat exchange apparatus.

In the case of a heat exchange tube 185 shown in FIG. 16, a projection 186 extending along the entire length thereof and a groove 187 extending along the entire length thereof are alternately formed on the tip end faces of all the reinforcement-wall-forming elongated projections 170 of the upper wall 161. A groove 188 into which the corresponding projection 186 of the reinforcement-wall-forming elongated projection 170 of the upper wall 161 is fitted and a projection 186 to be fitted into the corresponding groove 187 of the reinforcement-wall-forming elongated projection 170 of the upper wall 161 are alternately formed on the tip end faces of all the reinforcement-wall-forming elongated projections 171 of the lower wall 162, along the entire length thereof. Other

structural features are similar to those of the heat exchange tube 160 shown in FIGS. 13 and 14. The heat exchange tube 185 is manufactured in a manner similar to that for the heat exchange tube 160 shown in FIGS. 13 and 14.

In a heat exchange tube 190 shown in FIGS. 17 and 18, the reinforcement wall 165 formed such that a reinforcement-wall-forming elongated projection 191 formed integrally with the upper wall 161 and in a downward raised condition is brazed to the lower wall 162, and the reinforcement wall 165 formed such that a reinforcement-wall-forming elongated projection 192 formed integrally with the lower wall 162 and in an upward raised condition is brazed to the upper wall 161, are alternately provided in the left-right direction; the upper and lower walls 161, 162 have projections 193 extending along the entire length thereof and formed integrally at portions thereof that abut the corresponding reinforcement-wall-forming elongated projections 192, 191; recesses 194 are formed on the corresponding tip end faces of the projections 193 so as to allow corresponding tip end portions of the reinforcement-wall-forming elongated projections 191, 192 to be fitted thereinto; and the tip end portions of the reinforcement-wall-forming elongated projections 191, 192 are brazed to the corresponding projections 193 while being fitted into the recesses 194 of the projections 193. The thickness of the projection 193 as measured in the left-right direction is slightly greater than that of the reinforcement-wall-forming elongated projections 191, 192. Other

structural features of the heat exchange tube 190 are similar to those of the heat exchange tube 160 shown in FIGS. 13 and 14.

The heat exchange tube 190 is manufactured by use of a tube-forming metal sheet 195 as shown in FIG. 19(a). The tube-forming metal sheet 195 is formed by performing rolling on an aluminum brazing sheet having a brazing material layer over opposite surfaces thereof. The tube-forming metal sheet 195 includes a plurality of reinforcement-wall-forming elongated projections 191, 192, which are integrally formed with the upper-wall-forming and lower-wall-forming portions 176, 177 in an upward raised condition and which are arranged at predetermined intervals in the left-right direction. The reinforcement-wall-forming elongated projections 191 of the upper-wall-forming portion 176 and the reinforcement-wall-forming elongated projections 192 of the lower-wall-forming portion 177 are located asymmetrically with respect to the centerline of the width direction of the tube-forming metal sheet 195. The reinforcement-wall-forming elongated projections 191, 192 have the same height, which is about two times the height of the inner side-wall-forming elongated projections 168, 169. The projections 193 are integrally formed, in such a manner as to extend along the entire length of the upper-wall-forming and lower-wall-forming portions 176, 177, at those portions of the upper-wall-forming and lower-wall-forming portions 176, 177 which the corresponding reinforcement-wall-forming elongated projections 192, 191 of

the lower-wall-forming and upper-wall-forming portions 177, 176 abut. The recesses 194 are formed on the corresponding tip end faces of the projections 193 so as to allow corresponding tip end portions of the reinforcement-wall-forming elongated projections 192, 161 to be fitted thereinto. Other structural features of the tube-forming metal sheet 195 are similar to those of the tube-forming metal sheet 175 shown in FIG. 15.

The tube-forming metal sheet 195 is gradually folded at left and right side edges of the connection portion 178 by a roll forming process (see FIG. 19(b)) until a hairpin form is assumed. The inner side-wall-forming elongated projections 168, 169 are caused to butt against each other, and the projection 169a is caused to be press-fitted into the groove 168a. Also, tip end portions of the reinforcement-wall-forming elongated projections 191 of the upper-wall-forming portion 176 are caused to be fitted into the corresponding grooves 194 of the projections 193 of the lower-wall-forming portion 177, and tip end portions of the reinforcement-wall-forming elongated projections 192 of the lower-wall-forming portion 177 are caused to be fitted into the corresponding grooves 194 of the projections 193 of the upper-wall-forming portion 176.

Next, the outer side-wall-forming-elongated-projection forming portion 179 is folded along the outer surfaces of the inner side-wall-forming elongated projections 168, 169, and a tip end portion thereof is deformed so as to be engaged with

the lower-wall-forming portion 177, thereby yielding a folded member 196 (see FIG. 19(c)).

Subsequently, the folded member 196 is heated at a predetermined temperature so as to braze together tip end portions of the inner side-wall-forming elongated projections 168, 169; to braze tip end portions of the reinforcement-wall-forming elongated projections 191, 192 to the corresponding projections 193; and to braze the outer side-wall-forming-elongated-projection forming portion 179 to the inner side-wall-forming elongated projections 168, 169 and to the lower-wall-forming portion 177. Thus is manufactured the heat exchange tube 190. The heat exchange tubes 190 are manufactured in the course of manufacture of the integrated heat exchange apparatus.

INDUSTRIAL APPLICABILITY

The integrated heat exchange apparatus according to the present invention is preferably used as a gas cooler and an intermediate heat exchanger of a supercritical refrigeration cycle which uses a supercritical refrigerant such as CO₂.

CLAIMS

1. An integrated heat exchange apparatus comprising:

a first heat exchanger including first and second header tanks disposed apart from each other, and a plurality of heat exchange tubes disposed between the two header tanks at intervals along the length direction of the header tanks and each having opposite end portions connected to the respective header tanks, wherein a refrigerant outlet is formed on the first header tank; and

a second heat exchanger including a heat exchange section having first and second refrigerant passages, and connectors provided at the opposite ends of the heat exchange section and each having a first flow passage for establishing communication between the first refrigerant passage and the outside of the second heat exchanger and a second flow passage for establishing communication between the second refrigerant passage and the outside of the second heat exchanger,

wherein both the connectors of the second heat exchanger are fixed to the first heat exchanger, and the second flow passage of one connector of the second heat exchanger communicates with the refrigerant outlet of the first header tank of the first heat exchanger.

2. An integrated heat exchange apparatus according to claim 1, wherein one connector of the second heat exchanger is fixed to the first header tank of the first heat exchanger, the other connector of the second heat exchanger is fixed to

the second header tank of the first heat exchanger, and the second flow passage of the one connector communicates with the refrigerant outlet of the first header tank of the first heat exchanger.

3. An integrated heat exchange apparatus according to claim 2, wherein the first header tank of the first heat exchanger has a plurality of header sections arranged along the length direction thereof; the second header tank of the first heat exchanger has a header section(s) which is one fewer in number than the header sections of the first header tank; a header section at one end of the first header tank serves as a refrigerant inlet header section having a refrigerant inlet; and a header section at the other end of the first header tank serves as a refrigerant outlet header section having a refrigerant outlet, wherein refrigerant having flowed from the refrigerant inlet into the refrigerant inlet header section passes through the heat exchange tubes and the header sections, and is fed out from the refrigerant outlet of the refrigerant outlet header section.

4. An integrated heat exchange apparatus according to claim 1, wherein both the connectors of the second heat exchanger are fixed to the first header tank of the first heat exchanger, and the second flow passage of one connector communicates with the refrigerant outlet of the first header tank of the first heat exchanger.

5. An integrated heat exchange apparatus according to claim 4, wherein the first header tank of the first heat exchanger

has a plurality of header sections arranged along the length direction thereof; the second header tank of the first heat exchanger has header sections which are arranged along the length direction thereof and are equal in number with the header sections of the first header tank; a header section at one end of the second header tank serves as a refrigerant inlet header section having a refrigerant inlet; and a header section at the other end of the first header tank serves as a refrigerant outlet header section having a refrigerant outlet, wherein a refrigerant having flowed from the refrigerant inlet into the refrigerant inlet header section passes through the heat exchange tubes and the header sections, and is fed out from the refrigerant outlet of the refrigerant outlet header section.

6. An integrated heat exchange apparatus according to claim 1, wherein each header tank of the first heat exchanger is constructed by mutually stacking and brazing a header-forming plate, a tube-connecting plate, and an intermediate plate disposed between the header-forming plate and the tube-connecting plate; a bulging portion is formed on the header-forming plate such that the bulging portion extends along the length direction thereof and its opening is closed by the intermediate plate; a plurality of tube insertion holes are formed in the tube-connecting plate in a region corresponding to the bulging portion such that the tube insertion holes penetrate the tube-connecting plate and are arranged at intervals along the length direction of the tube-connecting

plate; communication holes for establishing communication between the tube insertion holes of the tube-connecting plate and the interior of the bulging portion of the header-forming plate are formed in the intermediate plate such that the communication holes penetrate the intermediate plate; a header section is formed by a portion of the header-forming plate including the bulging portion and portions of the tube-connecting plate and the intermediate portion corresponding to the bulging portion; and the opposite end portions of the heat exchange tubes are inserted into the tube insertion holes of the tube-connecting plates of the two header tanks and are brazed to the tube-connecting plates.

7. An integrated heat exchange apparatus according to claim 6, wherein a cover wall is integrally provided along each of the opposite lateral edge portions of the tube-connecting plate so as to cover a boundary between the header-forming plate and the intermediate plate over the entire length; and the cover wall is brazed to the corresponding side surfaces of the header-forming plate and the intermediate plate.

8. An integrated heat exchange apparatus according to claim 7, wherein engagement portions which engage the outer surface of the header-forming plate are integrally provided at the end portions of the cover walls.

9. An integrated heat exchange apparatus according to claim 1, wherein the heat exchange section of the second heat exchanger includes an outer tube and an inner tube disposed within the outer tube with a clearance formed therebetween,

wherein the clearance between the outer tube and the inner tube serves as the first refrigerant passage, and the interior of the inner tube serves as the second refrigerant passage.

10. An integrated heat exchange apparatus according to claim 9, wherein fins are provided between the outer tube and the inner tube of the second heat exchanger; the opposite end portions of the inner tube project outward from the outer tube; a fin-absent portion is provided at least at an end portion of each of the outward projecting portions; and the fin-absent portions of the inner tube are inserted into end portions of the second flow passages of the corresponding connectors.

11. An integrated heat exchange apparatus according to claim 10, wherein fins are integrally formed on the outer circumferential surface of the inner tube at circumferential intervals such that the fins extend along the length direction of the inner tube.

12. An integrated heat exchange apparatus according to claim 10, wherein the entirety of each of the outward projecting portions of the inner tube projecting from the outer tube is the fin-absent portion.

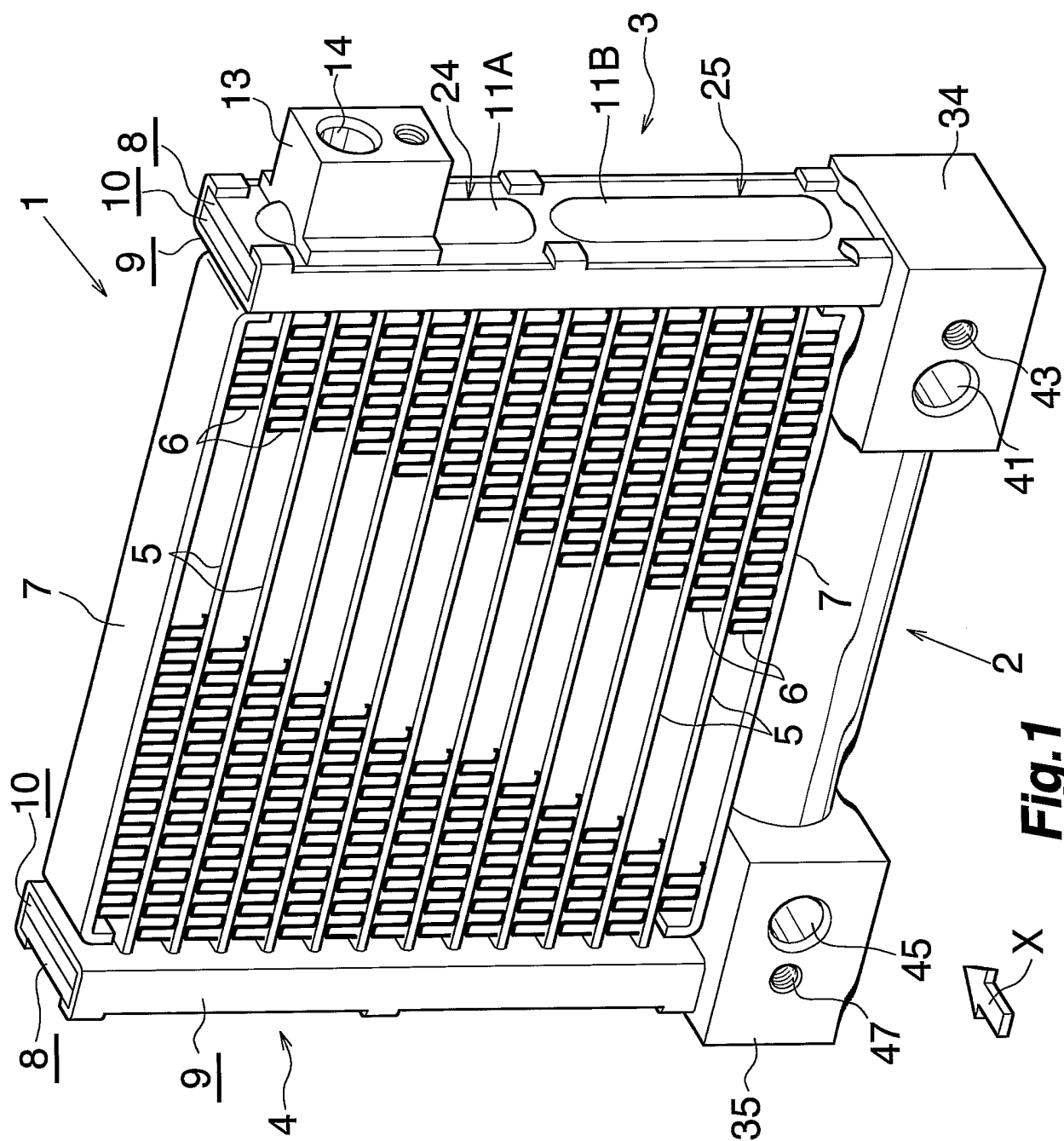
13. A supercritical refrigeration cycle which comprises a compressor, a gas cooler, an evaporator, a gas-liquid separator, a pressure-reducing device, and an intermediate heat exchanger for performing heat exchange between refrigerant flowing out of the gas cooler and refrigerant

flowing out of the evaporator and in which a supercritical refrigerant is used, wherein the gas cooler is composed of the first heat exchanger of the integrated heat exchange apparatus according to any one of claims 1 to 12, and the intermediate heat exchanger is composed of the second heat exchanger of the integrated heat exchange apparatus.

14. A supercritical refrigeration cycle according to claim 13, wherein low-pressure refrigerant flowing out of the evaporator flows through the first refrigerant passage of the intermediate heat exchanger, and high-pressure refrigerant flowing out of the gas cooler flows through the second refrigerant passage of the intermediate heat exchanger.

15. A supercritical refrigeration cycle according to claim 14, wherein the supercritical refrigerant is carbon dioxide.

16. A vehicle in which a supercritical refrigeration cycle according to claim 14 is installed as a car air conditioner.



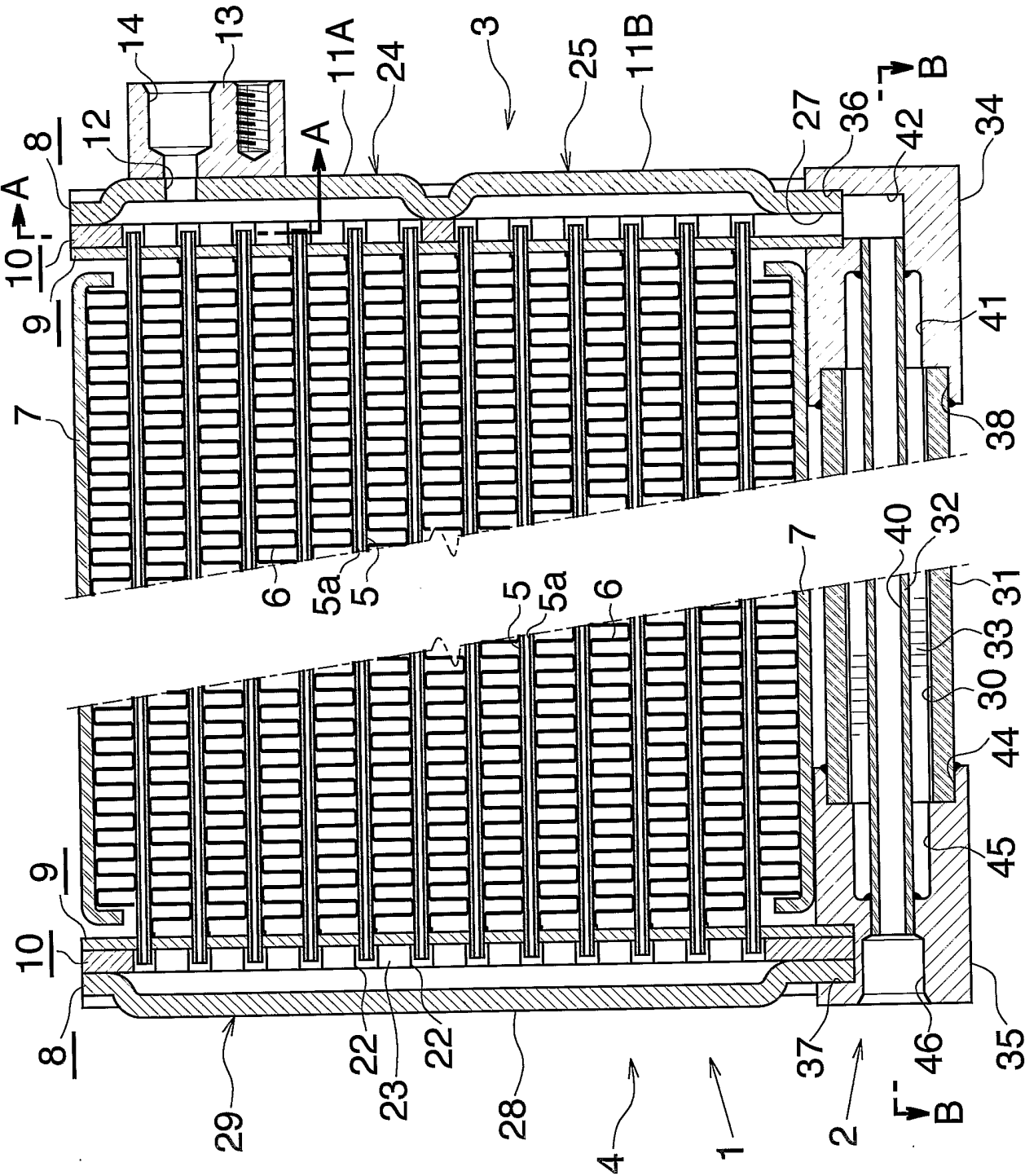


Fig. 2

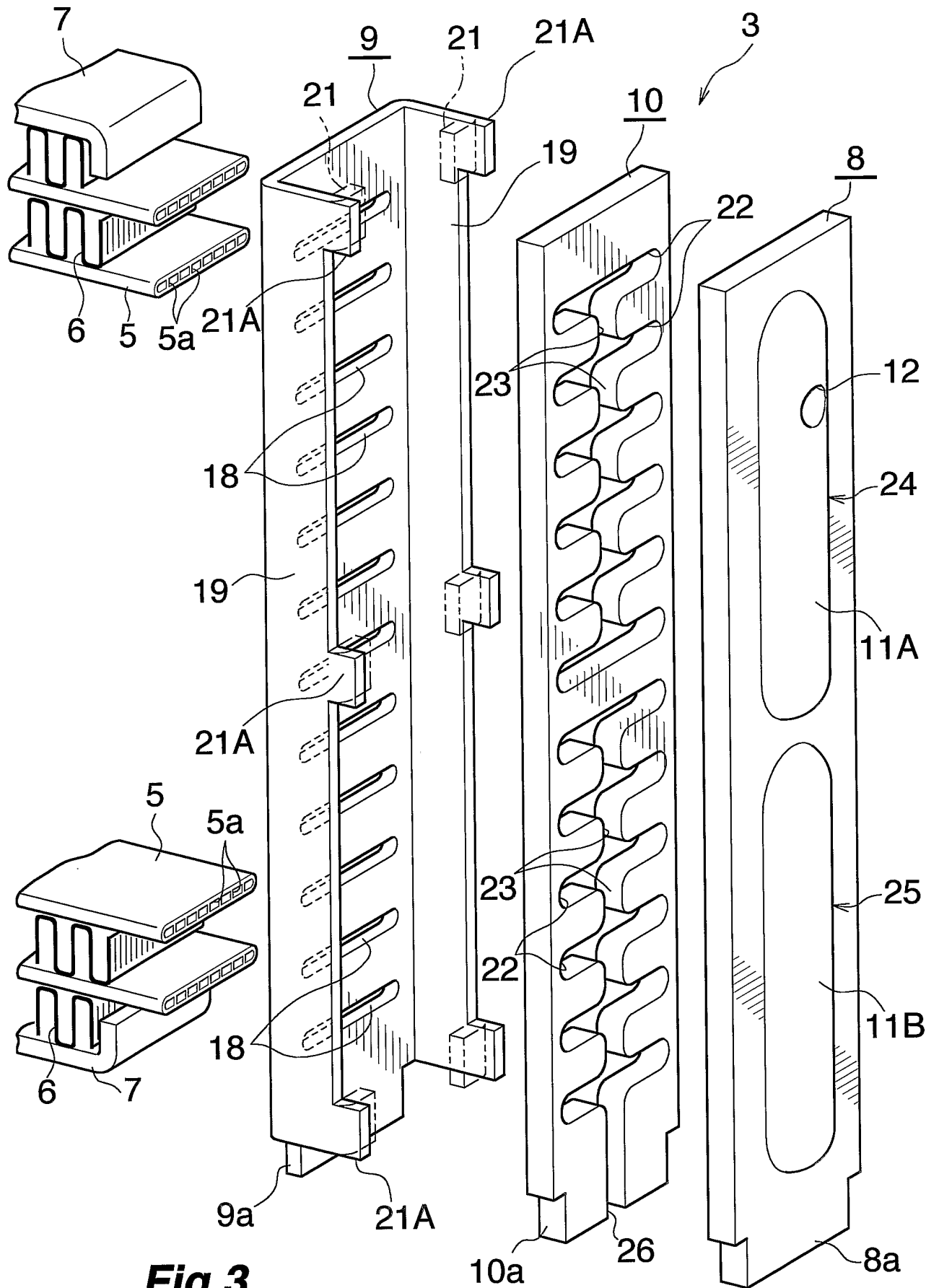


Fig.3

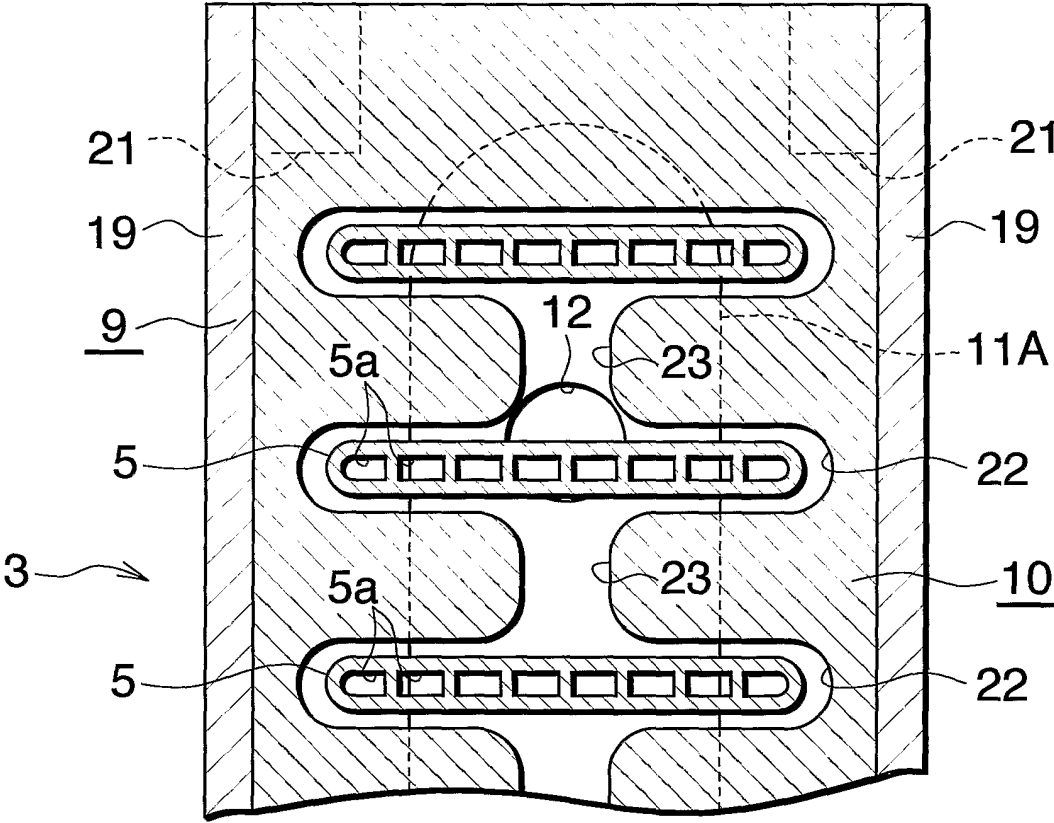
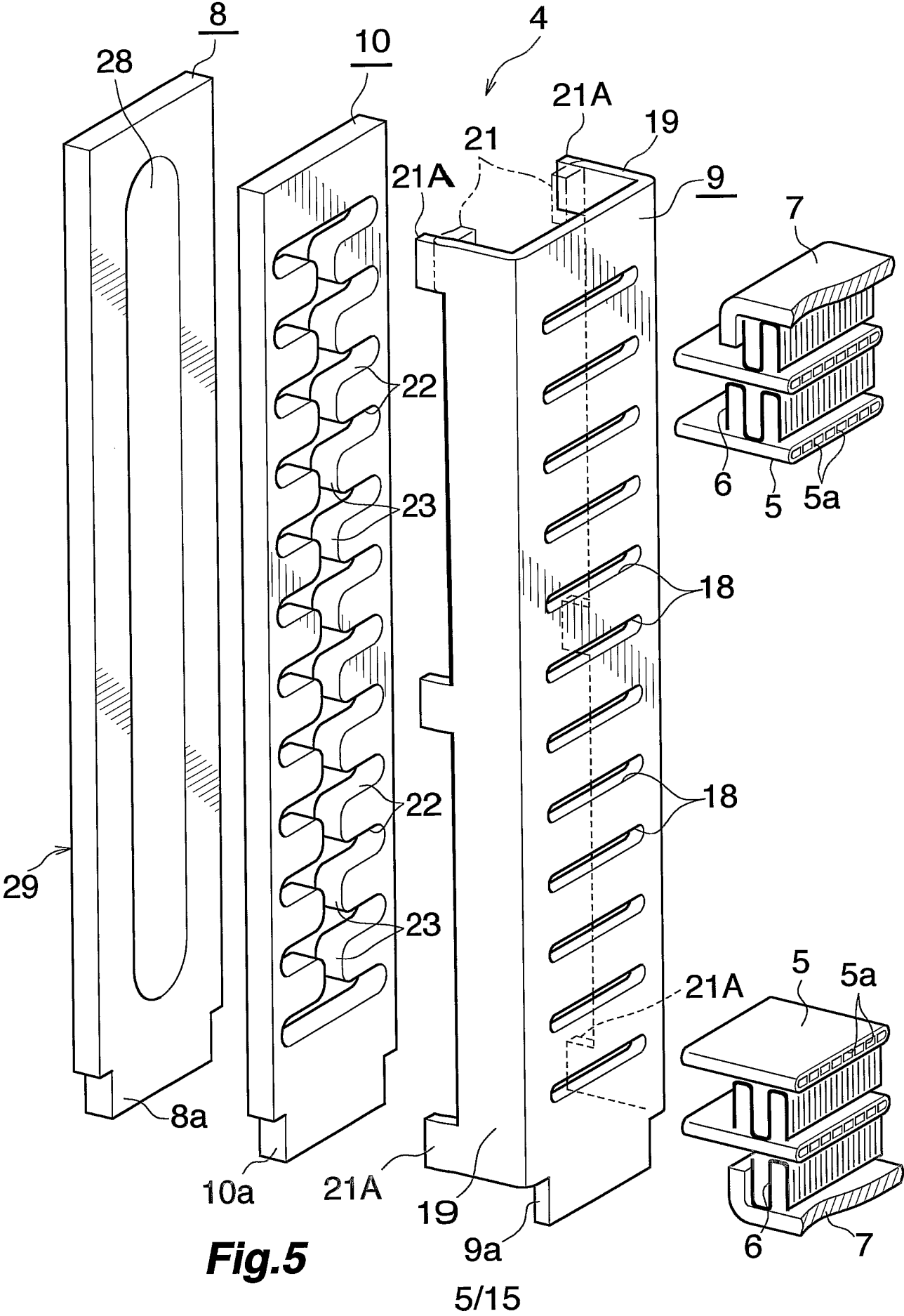


Fig.4



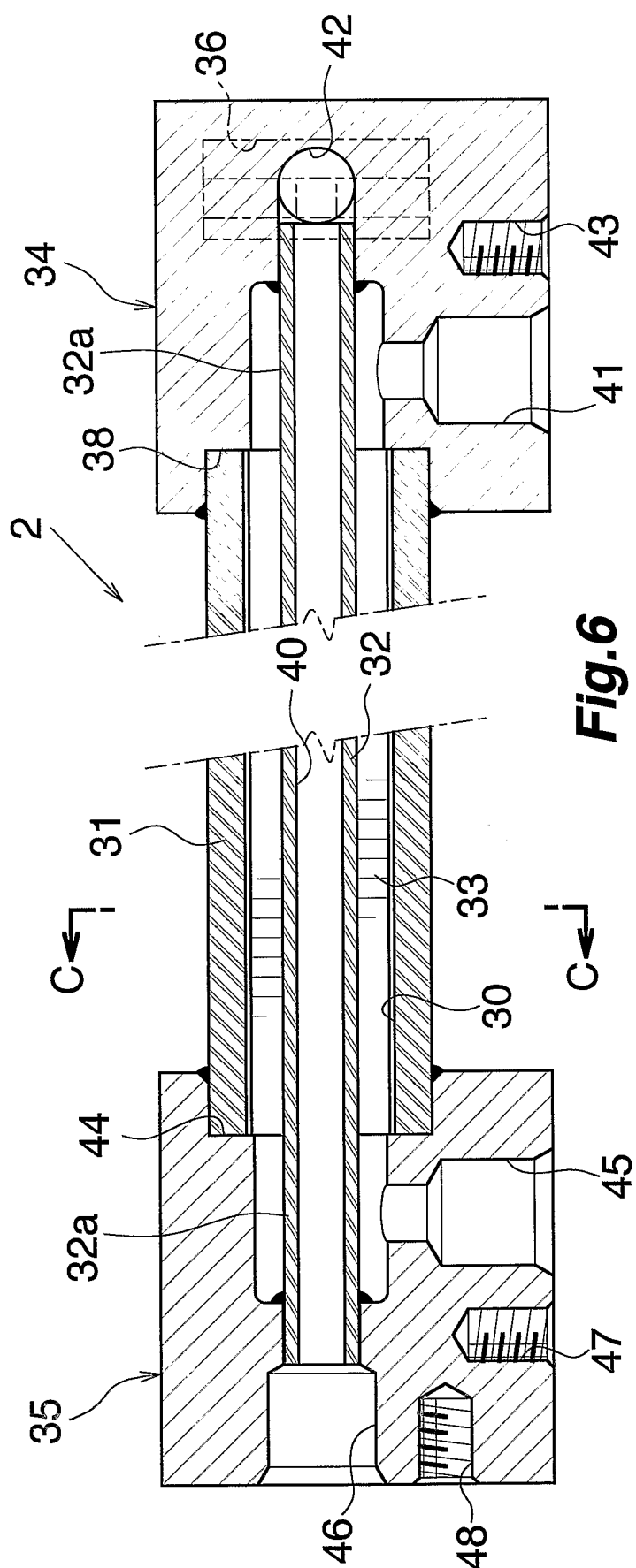


Fig. 6

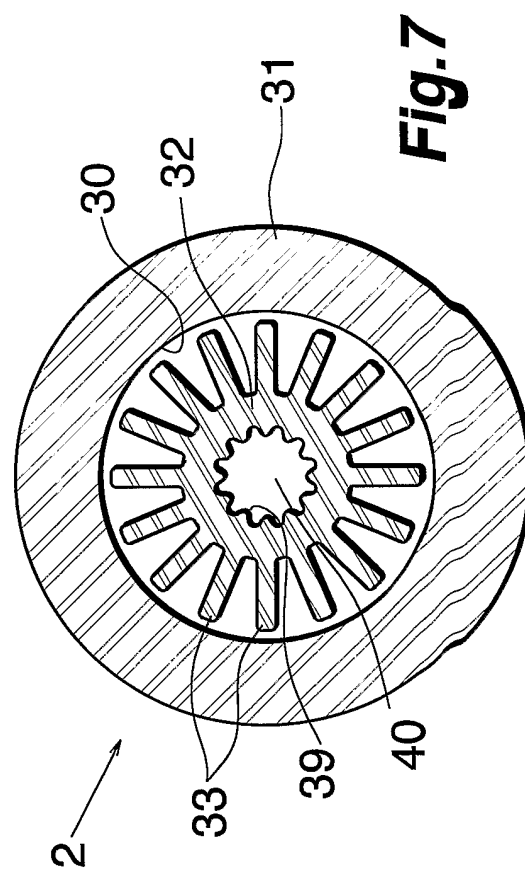


Fig. 7

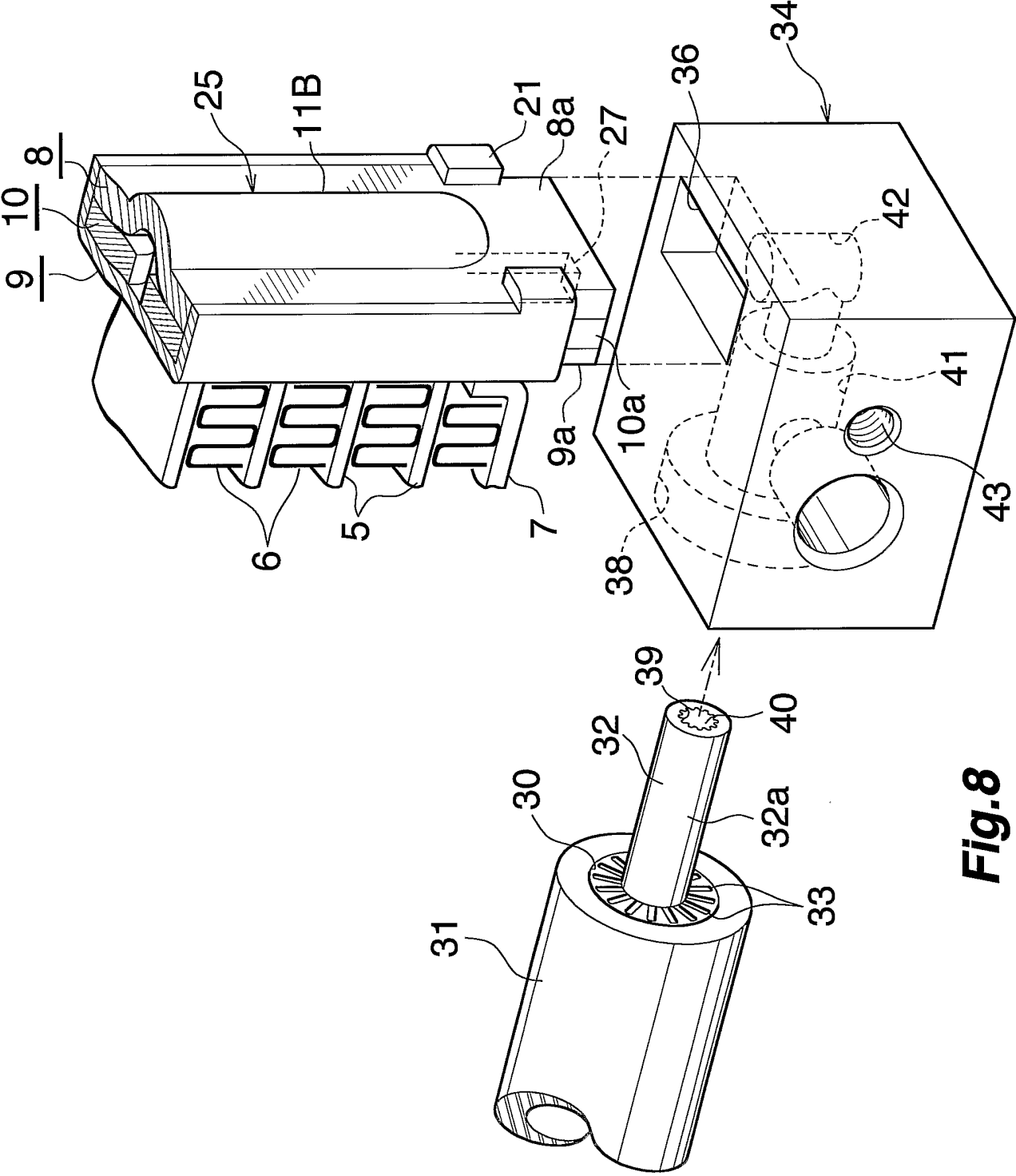


Fig.8

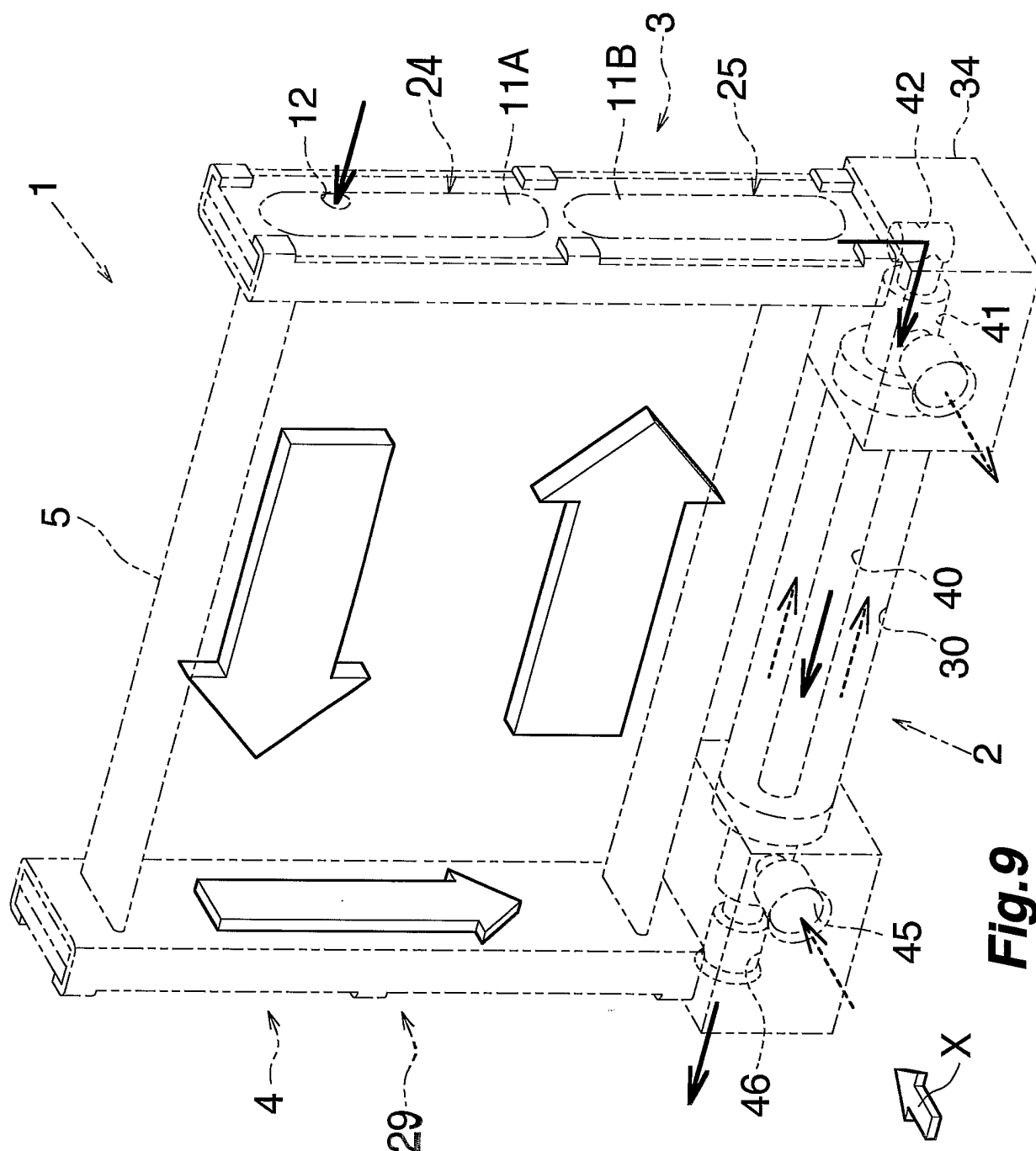
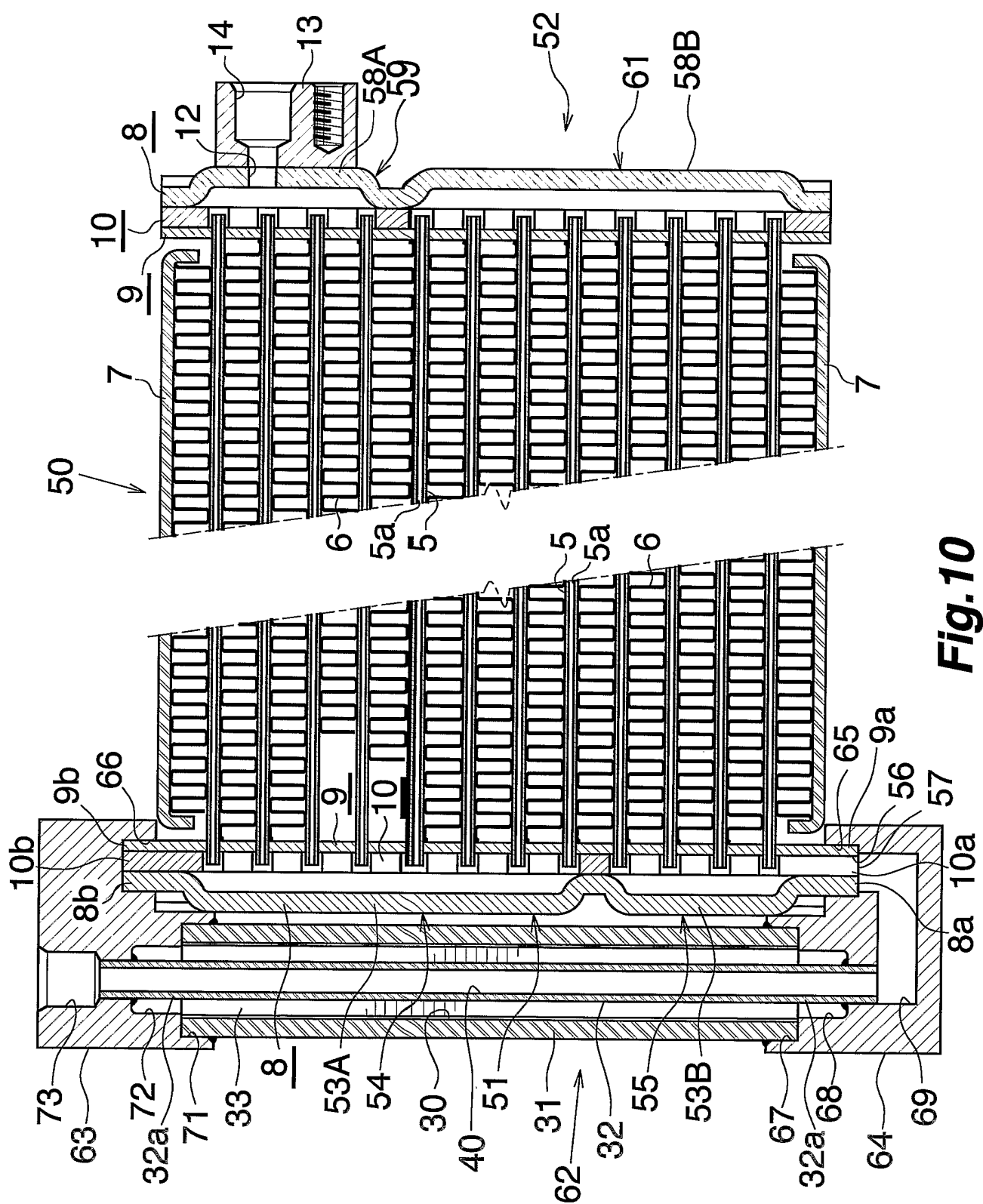


Fig. 9



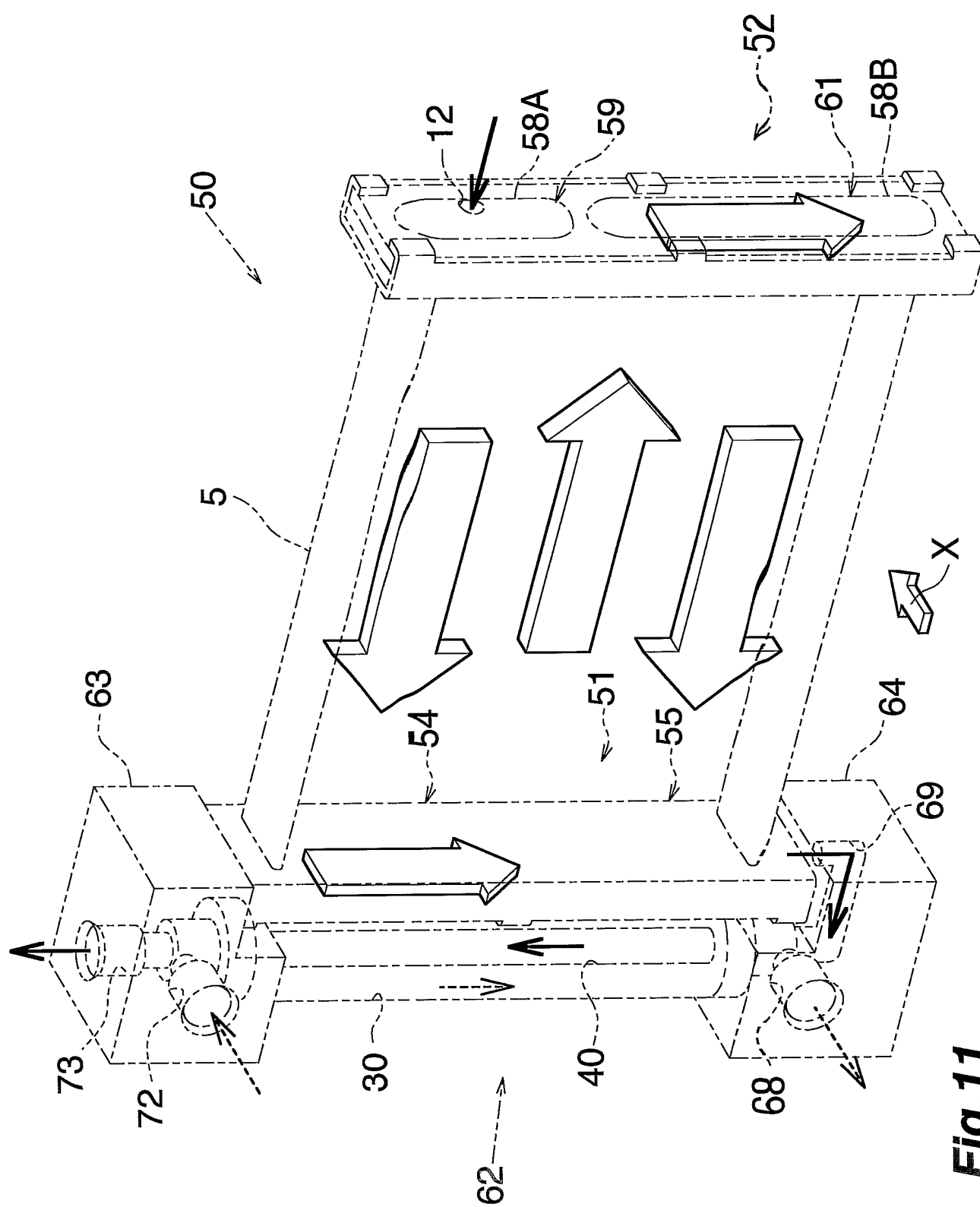
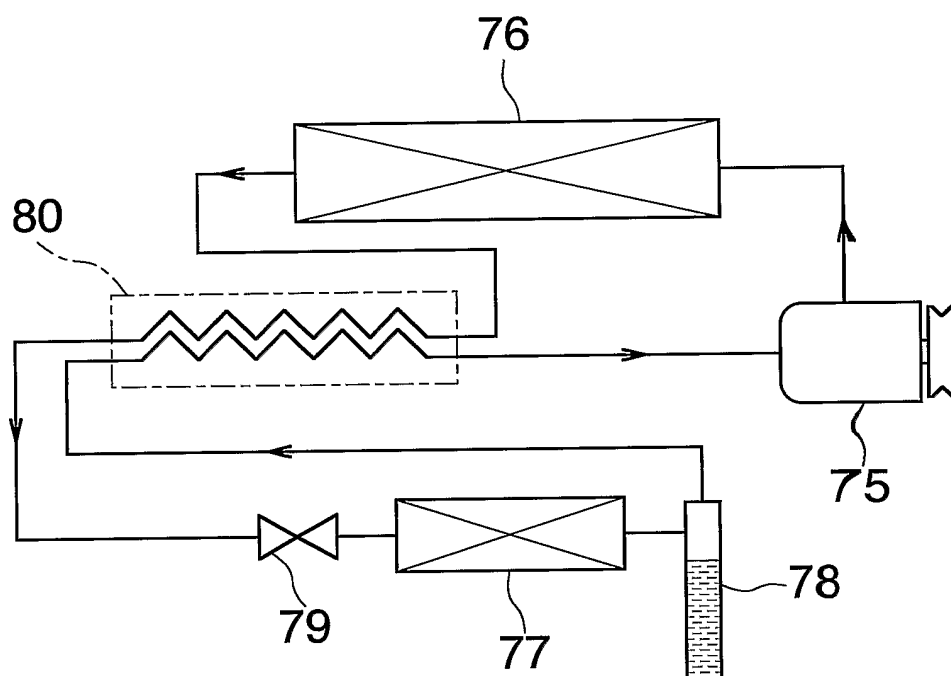
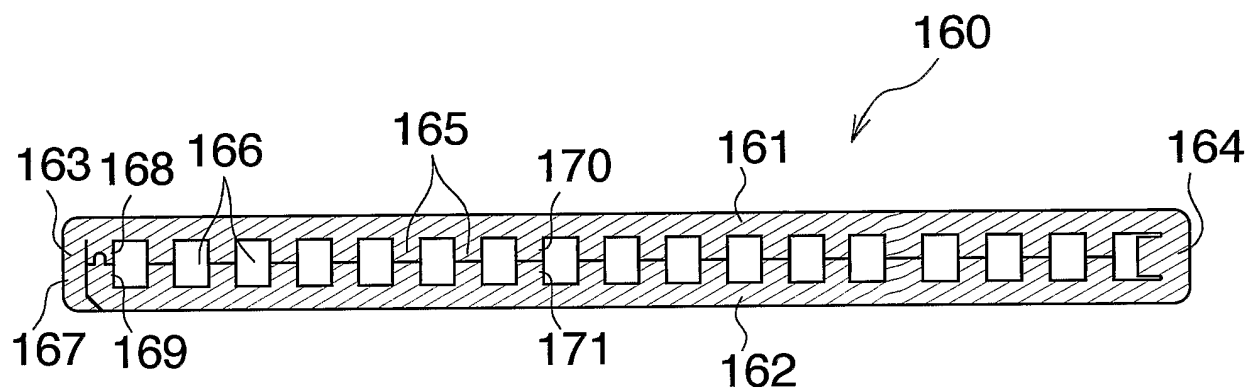
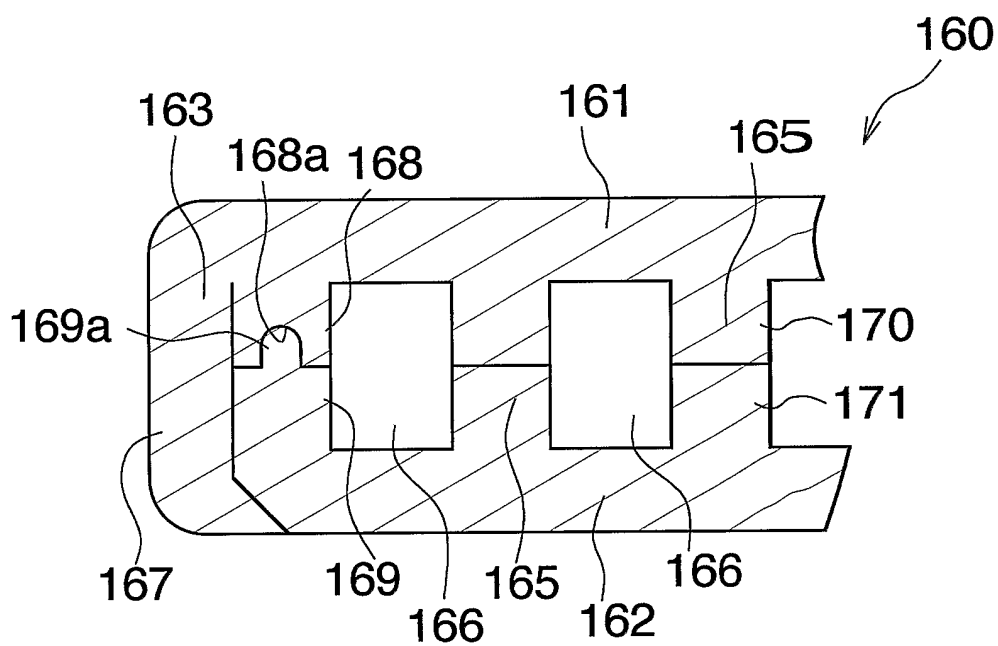
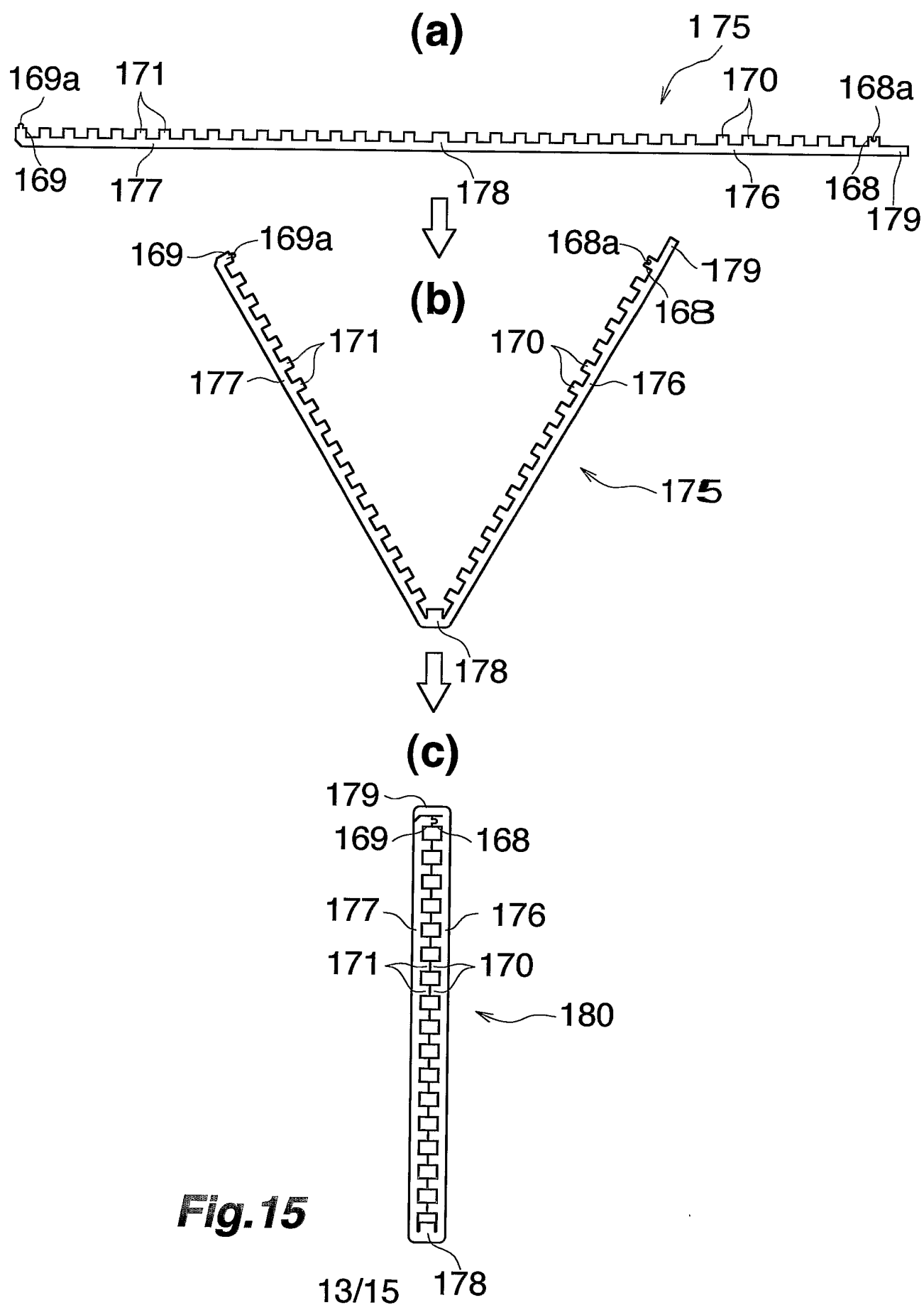
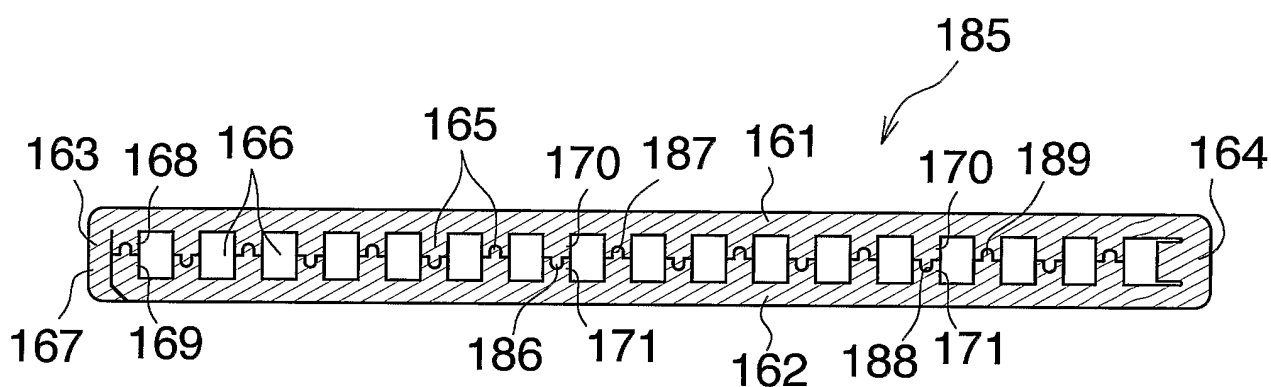
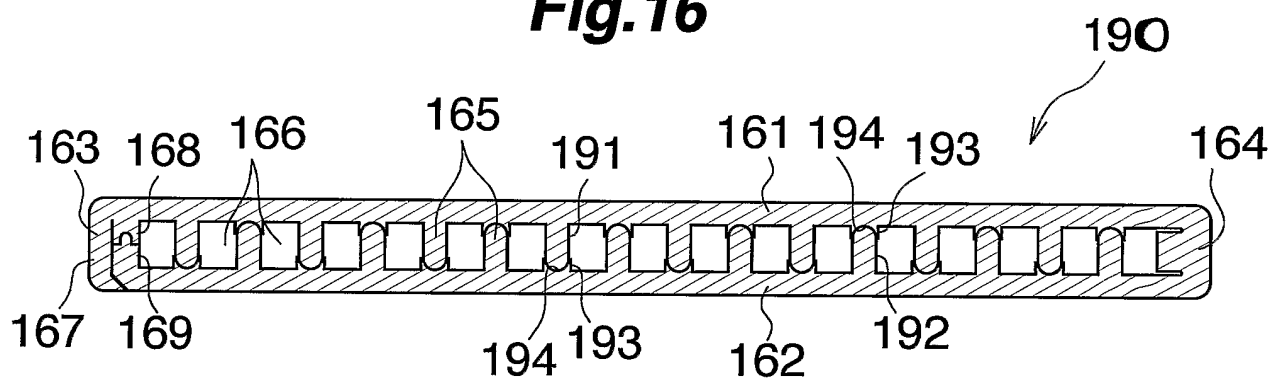
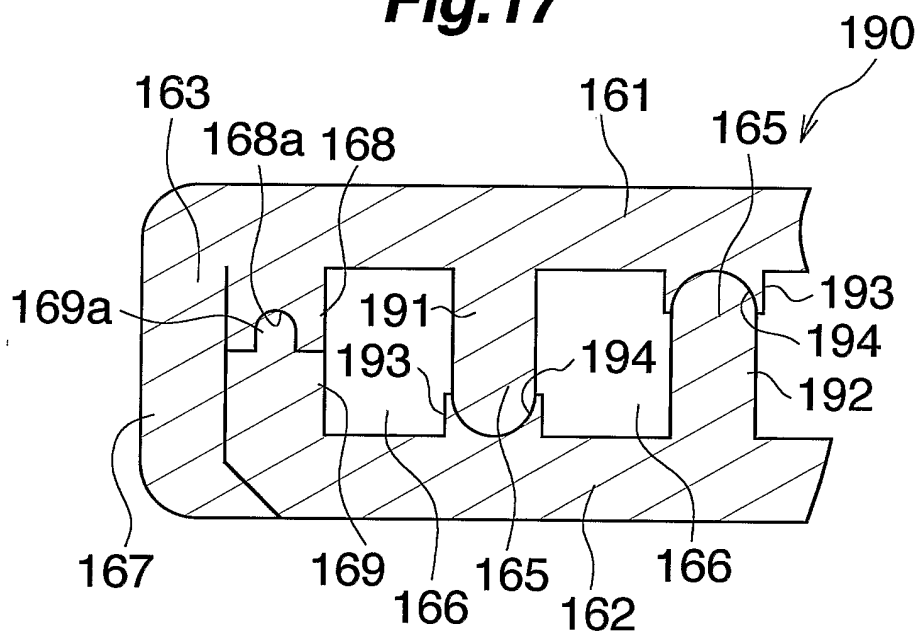


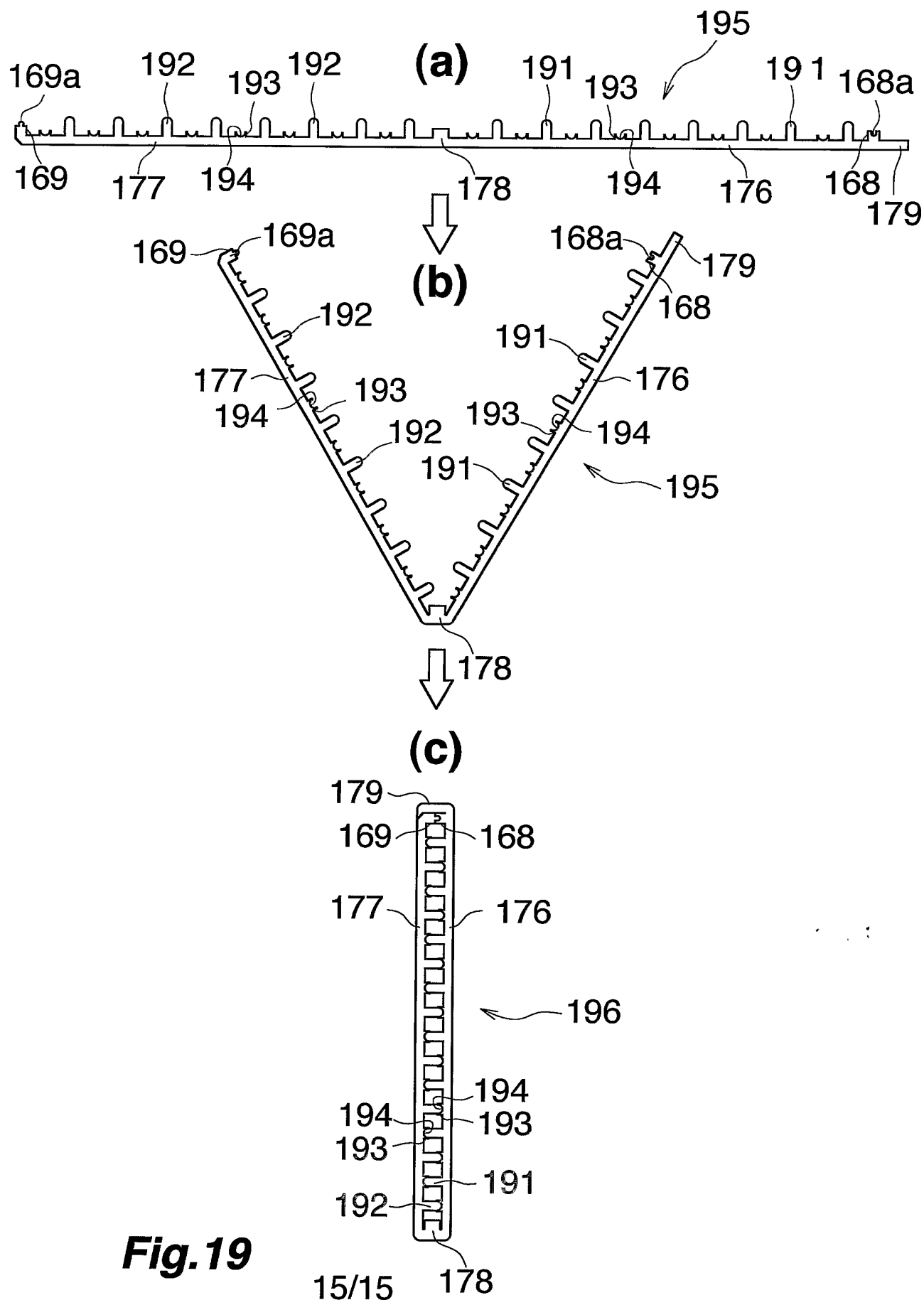
Fig. 11

**Fig.12**

**Fig. 13****Fig. 14**



**Fig. 16****Fig. 17****Fig. 18**

**Fig. 19**

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2005/017428

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. *F28F9/26* (2006.01), *F25B1/00* (2006.01), *F28D1/053* (2006.01), *F28D7/10* (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. *F25B 1/00*, *F28D 1/053*, *F28D 7/10*, *F28F 9/26*

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.
Y	JP 2004-190875 A (Denso Corporation) 2004.07.08, Line 2-5, page 7, Line 19-23, page 8, line 39-46, page 8, Figs 1-4 & US 2004/0112073 A1 & DE 10356447 A1	1-16
Y	JP 2001-272195 A (Calsonic Kansei Corporation) 2001.10.05, Line 46, Column 3, page 3 to line 43, column 4, page 4, Figs 1-4 (Family; none)	1-16
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 & EP 001192402 A1 & WO 2001-050080 A2	6-8

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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"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

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Date of the actual completion of the international search

25.01.2006

Date of mailing of the international search report

07.02.2006

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3M 3530

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2005/017428

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 05-090175 U (Nippon-Alumi Corporation) 1993.12.07, Line 21-28, page 5, Fig. 5 (Family; none)	11
Y	JP 2003-097857 A (Calsonic Kansei Corporation) 2003.04.03, Line 26-42, Column 2, page 2, Fig. 4 & US 2003/0010488 A1 & DE 10231645 A1	15, 16