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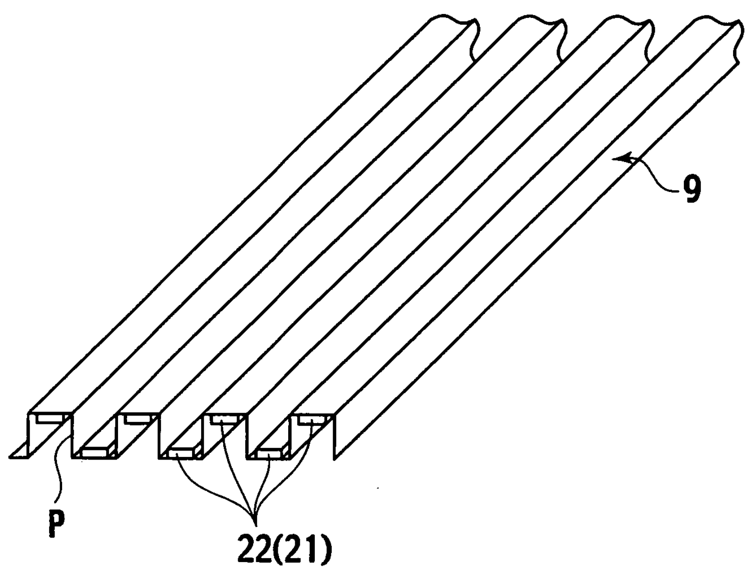
(54) EVAPORATOR

(57) An evaporator (1) having: a plurality of vertical tubes (2) having a refrigerant path (7, 8) therein; an upper tank (10, 11) communicating upper ends of the refrigerant paths (7, 8) in the plural tubes (2); a lower tank (12, 13) communicating lower ends of the refrigerant paths (7, 8) in the plural tubes (2); and a resistance generators (21) provided in vicinity of inlets of the refrigerant paths (7, 8) and applying resistance to refrigerant flowing from the upper tank (10, 11) or the lower tank (12, 13) into the refrigerant paths (7, 8).

FIG. 11



Description

TECHNICAL FIELD

[0001] The present invention relates to an evaporator.

BACKGROUND ART

[0002] A conventional evaporator includes plural tubes which are stacked and have a refrigerant path therein, an upper tank communicating upper ends of the refrigerant paths in the plural tubes one another, and a lower tank communicating lower ends of the refrigerant paths in the plural tubes one another.

DISCLOSURE OF THE INVENTION

[0003] When such an evaporator is made thinner, the ratio between the cross-section area of the tanks and cross-section area of the refrigerant paths in the tubes are changed. When the tank cross-section areas are made smaller, refrigerant in the tanks flows faster and the refrigerant is easily separated into gas-phase refrigerant and liquid phase refrigerant in those tanks. More concretely, it is likely that more liquid phase refrigerant flows in the distal side (opposite side of the refrigerant introducing side) of the tank in a longitudinal direction and accordingly, less liquid phase refrigerant and more gas-phase refrigerant flow in the proximal side (the refrigerant introducing side) of the tank in the longitudinal direction.

[0004] In such a case, more gas-phase refrigerant flows in a group of tubes connected to the proximal side of the tank in a longitudinal direction and, on the other hand, more liquid phase refrigerant flows in a group of tubes connected to the distal side of the tank in a longitudinal direction. This causes non-uniformity of the temperature distribution in a core section (a heat exchange section) of the evaporator.

[0005] Particularly, as shown in Fig. 17, it is obvious that liquid phase refrigerant and gas phase refrigerant tend to be separated in a lower tank 112. As shown in Figs. 17 and 18, non-uniformity of the temperature distribution is remarkable in a core section 100A composed of a group of upflow-type tubes 102, which connect the lower tank 112 and an upper tank 110 to flow refrigerant upward from the lower tank 112 to the upper tank 110.

[0006] It is assumed that such non-uniformity of liquid phase refrigerant can be reduced when the cross-section area of the refrigerant path of the tube is made smaller. However, since oil contained in the refrigerant is adhered to an inner surface of the tube (wall surface of the refrigerant path), the cross-section area of the refrigerant path of the tube is made smaller and contact area between the inner surface of the tube (wall surface of the refrigerant path) and the refrigerant is reduced. This can lower a heat exchange rate of the evaporator.

[0007] For example, when a square-shaped path section Pa, shown in Fig. 19(a), defined by a tube 2 and an inner fin 9 is changed to a rectangular-shaped path section Pb shown in Fig. 19(b), the contact area between the inner wall surface of the path section Pb and refrigerant R increases. Further, when the square-shaped path section Pa shown in Fig. 19(a) is changed to a triangular shaped path section Pc shown in Fig. 19(c), the amount of oil L adhered to the inner wall surface of the path section Pc increases and the contact area decreases. In other words, the relation can be defined as: the contact area between the path section Pb and refrigerant R > the contact area between the path section Pa and refrigerant R > the contact area between the path section Pc and refrigerant R. Also, the relation can be defined as: the flow resistance of the path section Pb < the flow resistance of the path section Pb < the flow resistance of the path section Pc. Further, the relation can be defined as: the tensile strength of the path section Pa > the tensile strength of the path section Pc > the tensile strength of the path section Pb.

[0008] An evaporator described in Japanese Patent Application Laid-Open No. 2003-75024 (paragraphs 0112 and 0117, Figs. 2 and 3) includes a distributing resistance plate disposed in an inlet side tank and a resistance plate disposed in an outlet side tank for preventing a non-uniform flow.

[0009] In this evaporator, the resistance plate in the inlet side tank can uniform the amounts of refrigerant frown from the tank to the respective tubes. However, this conventional art requires a flow-branching resistance plate and this caused an increased number of parts and accordingly the cost and weight of the evaporator increases.

[0010] The present invention has been made in view of this conventional art and has an object to provide an evaporator capable of reducing the non-uniformity of refrigerant amounts flown from a tank into tubes while preventing a reduction in heat exchange rate.

[0011] An aspect of the present invention is an evaporator having: a plurality of vertical tubes having a refrigerant path therein; an upper tank communicating upper ends of the refrigerant paths in the plural tubes; a lower tank communicating lower ends of the refrigerant paths in the plural tubes; and resistance generators provided in vicinity of inlets of the refrigerant paths and applying resistance to refrigerant flowing from the tank into the refrigerant paths.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

Fig. 1 is a perspective view of an evaporator according to a first embodiment of the present invention;
Fig. 2 is an exploded perspective view of the evaporator shown in Fig. 1;
Fig. 3 is a plan view of a tube of the evaporator shown in Fig. 1;

Fig. 4 is a sectional view along the line IV-IV shown in Fig. 3;

Fig. 5 is a sectional view along the line V-V shown in Fig. 3;

Fig. 6 is a side view showing an area around a joint of a refrigerant path of the tube and a lower tank;

Fig. 7 is a sectional view along the line VII-VII shown in Fig. 6;

Fig. 8 is a plan view showing an inner fin of the evaporator of the first embodiment;

Fig. 9 is a sectional view along the line IX-IX shown in Fig. 8;

Fig. 10 is a side view of the inner fin shown in Fig. 8;

Fig. 11 is a perspective view of the inner fin shown in Fig. 8;

Fig. 12 is a perspective view of an inner fin of an evaporator according to a second embodiment of the present invention;

Fig. 13 is a side view of the inner fin shown in Fig. 12;

Fig. 14 is a side view of an area around a resistance generator of an evaporator according to a third embodiment of the present invention;

Fig. 15 is a sectional view along the line XV-XV shown in Fig. 14;

Fig. 16 is a perspective view showing an evaporator composed of a combination of tubes and tanks which are separately provided;

Fig. 17 is a sectional view showing a refrigerant flow state near a joint of a tank and tubes in a conventional evaporator;

Fig. 18 is a view showing a temperature distribution state of an entire core section of the conventional evaporator; and

Figs. 19(a) to 19(c) are sectional views showing path sections of refrigerant paths defined by a tube and an inner fin.

DETAILED DESCRIPTION OF THE INVENTION

[0013] An evaporator of embodiments of the present invention will be described with reference to the drawings.

(First Embodiment)

[0014] As shown in Figs. 1 and 2, an evaporator 1 of a first embodiment includes tubes 2 and cooling fins 3, which are alternatively stacked. A pair of reinforcing side plates 4 is provided at ends, in the stack direction, of the multi-layered body of the tubes 2 and cooling fins 3.

[0015] As shown in Fig. 2, the tubes 2 are plate-to-plate type tubes, which are formed by combining a pair of flat tube sheets 5, 6 (tube members). In the tube 2, a first refrigerant path 7 and a second refrigerant path 8, which extend parallel in a longitudinal direction of the tube 2, are formed. Inner fins 9 are accommodated in the respective refrigerant paths 7, 8 of the tube 2.

[0016] At one end of the tube 2, cylindrical tank forming portions 10a, 11a are formed. The tank forming portions 10a, 11a are projected in the stack direction of the tubes 2 and communicate with the ends of the refrigerant paths 7, 8. The tank forming portions 10a, 11a are adjacent to each other. At the other end of the tube 2, cylindrical tank forming portions 12a, 13a are formed. The tank forming portions 12a, 13a are projected in the stack direction of the tubes 2 and communicate with the other ends of the refrigerant path 7, 8. The tank forming portions 12a, 13a are adjacent to each other.

[0017] In other words, the tube sheets 5, 6 constituting the tube 2 are formed with concave portions to communicate with the first refrigerant paths 7 and concave portions to communicate with the second refrigerant paths 8, which extend parallel in a longitudinal direction of the tube sheet 5, 6. At one ends of the tube sheets 5, 6, the cylindrical tank forming portions 10a, 11a, which are projected in the stack direction of the tubes 2 and communicate with one ends of the refrigerant paths 7, 8, are formed. At the other ends of the tube sheets 5, 6, the cylindrical tank forming portions 12a, 13a, which are projected in the stack direction of the tubes 2 and communicate with the other ends of the refrigerant paths 7, 8, are formed.

[0018] With such a structure, refrigerant flows into and out of the first refrigerant path 7 via the tank forming portions 10a, 12a and, similarly, refrigerant flows into and out of the second refrigerant path 8 via the tank forming portions 11a, 13a.

[0019] The inner fin 9 is a thin plate in a waveform shape, as shown in Figs. 8 and 9. The inner fin 9 of the present embodiment has a shape of a thin plate having equally spaced folds at right angle. The inner fin 9 thus partitions the refrigerant paths 7, 8 into plural square path sections P when the inner fin 9 is accommodated in the refrigerant paths 7, 8 of the tube 2, as shown in Fig. 7.

[0020] In an assembly of the evaporator 1, pairs of tube sheets 5, 6 are combined as accommodating the inner fins 9 therein to form the tubes 2, and then, the tubes 2 and the cooling fins 3 are alternatively stacked. As a result, the evaporator 1 is obtained. When the tubes are stacked, the tank forming portions 10a, 11a, 12a, 13a of adjacent tubes 2 are connected to each other and tanks 10, 11, 12, 13 are formed. The assembled evaporator 1 is positioned to have the refrigerant paths 7, 8 extending in a vertical direction. According to the present embodiment, as shown in Fig. 1, the tanks 10, 11 are disposed in an upper side and the other tanks 12, 13 are disposed in a lower side.

[0021] When refrigerant is introduced in this evaporator 1, the refrigerant flows as follows. When refrigerant is introduced into the upper tank 11 via an inlet pipe (not shown), the refrigerant flows in the upper tank 11 toward the right side in Fig. 1 and is distributed to the second refrigerant paths 8 of the respective tubes 2. The distributed refrigerant passing through the second refrigerant paths 8 of the tubes 2 moves down to the lower tank 13. The refrigerant, which is converged in the lower tank 13 via the second refrigerant paths 8, is introduced into the other lower tank 12 from the lower tank 13 via a communicating pipe (not shown). The refrigerant introduced in the lower tank 12 flows in the lower tank 12 toward the left side in Fig. 1 and is distributed to the first refrigerant paths 7 of the respective tubes 2. The refrigerant passing through the first refrigerant paths 7 of the tubes 2 moves up to the upper tank 10 and is converged in the upper tank 10. The refrigerant, which is converged in the upper tank 10, is discharged from the upper tank 10 to the outside the evaporator 1 via an outlet pipe (not shown).

[0022] Heat exchange is performed between the refrigerant flown in the evaporator 1 as described above and air passing through the evaporator. According to the present embodiment, air is sent in the direction indicated by the arrow in Fig. 1, so when air passes through between the tubes 2 and cooling fins 3, heat exchange is firstly performed between the air and refrigerant flowing in the first refrigerant path 7, which is in windward side, and then, heat exchange is performed between the air and refrigerant flowing in the second refrigerant path 8, which is in leeward side.

[0023] In the evaporator 1 of the present embodiment, resistance generators 21 are provided at inlets of the refrigerant paths 7 to apply resistance to refrigerant flown from the tank 12 into the refrigerant paths 7 of the tubes 2. The resistance generators 21 are not provided to the downflow-type refrigerant paths 8 but to the upflow-type refrigerant paths 7. The resistance generators 21 are formed as claws 22 provided at ends of the inner fins 9 in a longitudinal direction. The claws 22 project into the inlet of the respective path section P and apply resistance to refrigerant flown into the path sections P in order to generate a pressure loss. In other words, the claws 22 serve as a throttle for decreasing the cross-section area of the path section P at the inlet of the respective path sections P in view of its configuration and as a resistor for applying resistance to refrigerant flow in view of its function.

[0024] According to the first embodiment, when refrigerant moves up from the tank 12 to the refrigerant paths 7 of the tubes 2, the claws 22 apply resistance to refrigerant flow and the refrigerant flow into the respective tubes 2 is restricted, so that the flow amount difference in liquid phase refrigerant among the respective tubes 2 is reduced. Further, the cross-section area of the refrigerant path 7 other than the inlet area is not reduced although the cross-section area of the inlet of the refrigerant path 7 is reduced by the claws 22. Thus, the oil adhesion rate on the refrigerant path 7 is not increased. In other words, it is possible to prevent a reduction of a contact area between the refrigerant and the inner surface of the refrigerant path 7.

[0025] According to the first embodiment having such a structure, even if the non-uniformity is generated in the distribution of liquid phase refrigerant in the tank 12 due to a separation into liquid phase refrigerant and gasphase refrigerant in the tank 12, when the refrigerant is flown from the tank 12 into the refrigerant path 7, refrigerant receives resistance by the claws 22 placed at the inlet of the refrigerant path 7 so that non-uniformity of the liquid phase refrigerant flow amounts in the respective refrigerant paths 7 is reduced. With this structure, the temperature distribution is homogenized in the core section composed of the tubes 2 and cooling fins 3 and the temperature variation can be reduced. Further, since the wide contact area between the refrigerant and the inner surface of the refrigerant path 7 of each tube 2 is maintained, an effective heat transfer in the evaporator 1 can be maintained. Further, since the cross-section area of the refrigerant path 7 is not reduced except for the inlet area, an increased flow path resistance in the evaporator 1 can be suppressed.

[0026] Generally, uneven distribution of liquid phase refrigerant can often occur in the lower tank 12 when refrigerant flows from the lower tank 12 to the upper tank 10. In the present embodiment, the resistance generator 21 is provided at the inlet of the upflow-type refrigerant path 7 and this is more effective compared to a case that resistance generator is provided at the inlet of the downflow-type refrigerant path 8.

[0027] The claws 22 as the resistance generator 21 are integrally formed with the inner fin 9 so that another member is not required so that an inexpensive, lightweight evaporator is obtained.

(Second Embodiment)

[0028] Fig. 12 is a perspective view showing an inner fin of an evaporator according to a second embodiment of the present invention and Fig. 13 is a side view of the inner fin shown in Fig. 12. In the second embodiment, the same reference numerals and symbols are used to designate the same elements as the elements described in the first embodiment, and redundant description thereof will be omitted.

[0029] As shown in Figs. 12 and 13, the evaporator 1 of the second embodiment has the inner fin 9 having a different configuration from that of the first embodiment but other elements are same as those of the first embodiment. More concretely, the configuration of the resistance generator 21 in the second embodiment differs from that of the first embodiment. The inner fin 9 of the second embodiment is composed of a waveform shaped general portion 9a and an offset portion 9b, which is provided at one longitudinal end of the general portion 9a and has waveforms offset to the waveforms of the general portion 9a. The waveforms of the offset portion 9b are placed half wavelength off from those of the general portion 9a. The offset portion 9b serves as the resistance generator 21 for applying resistance to refrigerant flows by reducing the cross-section area of the inlet of the refrigerant path 7.

[0030] According to the second embodiment, the same operation and effect as the first embodiment can be achieved by providing the offset portion 9b as the resistance generator 21. Further, since the offset portion 9b is integrally formed with the inner fin 9, any separate member is not required.

(Third Embodiment)

[0031] Fig. 14 is a side view showing an area around a resistance generator of an evaporator according to a third embodiment of the present invention and Fig. 15 is a sectional view along the line XV-XV in Fig. 14. In the third embodiment, the same reference numerals and symbols are used to designate the same elements as the elements described in the first embodiment, and redundant description thereof will be omitted.

[0032] As shown in Figs. 14 and 15, in the evaporator 1 of the third embodiment, the resistance generator 21 is not provided to the inner fin 9 but provided to the tube 2 and this is the difference from the first embodiment. The resistance generator 21 of the present embodiment is composed of beads 25, 26, which are provided at a boundary between the refrigerant path 7 and the tank 12 in a manner of projecting inwardly. The beads 25, 26 reduce the cross-section area of the inlet of the refrigerant path 7. The beads 25, 26 are integrally formed with the tube sheets 5, 6 constituting the tube 2.

[0033] According to the third embodiment, the same operations and effects as the first embodiment can be achieved by proving the beads 25, 26 as the resistance generator 21. Further, since the beads 25, 26 are integrally formed with the tube 2, it is not required to provide a separate member unlike the conventional art, and thus, an inexpensive, lightweight evaporator can be obtained.

[0034] According to the first to third embodiments, the evaporator having plate-to-plate-type tubes 2, which are formed by combining a pair of tube sheets 5, 6 integrally formed with tank forming portions 10a, 11a, 12a, 13a, have been described as an example. However, the present invention should not be limited to those embodiments and can be applied to evaporators having different configurations, such as an evaporator 200 in which separately provided tubes 202 and tanks 210, 212 are jointed, as shown in Fig. 16.

[0035] Further, according to the first to third embodiments, structures having a resistance generator at the inlets of the upflow-type refrigerant paths have been described; however, the present invention should not be limited to those embodiments and the resistance generator can be provided at inlets of the downflow-type refrigerant paths, according to need.

Industrial Applicability

[0036] The present invention can be widely applied as evaporators for vehicular air conditioners and evaporators for air conditioners in general machineries or industrial machineries. This is because the present invention uniforms a temperature distribution of an entire core section of an evaporator to reduce its temperature variation, maintains high heat transfer efficiency of the evaporator, and provides an inexpensive and lightweight evaporator.

Claims

1. An evaporator comprising:

a plurality of vertical tubes having.a refrigerant path therein;
an upper tank communicating upper ends of the refrigerant paths in the plural tubes;
a lower tank communicating lower ends of the refrigerant paths in the plural tubes; and
resistance generators provided in vicinity of inlets of the refrigerant paths and applying resistance to refrigerant flowing from the tank into the refrigerant paths.

2. The evaporator according to claim 1, wherein
the plurality of tubes include upflow-type tubes in which refrigerant flows upward from the lower tank to the upper tank, and
the resistance generators are provided in vicinity of the inlets of the refrigerant paths in the upflow-type tubes.

3. The evaporator according to claim 1, wherein
the tubes are formed with the resistance generators on their inlet side.

4. The evaporator according to claim 1, further comprising
inner fins provided in the tubes,
wherein the resistance generators are formed on the inner fins at their inlet side.

5. The evaporator according to claim 1, wherein
each of the tubes is a plate-to-plate type tube formed by combining a pair of plate-like tube members.

FIG. 1

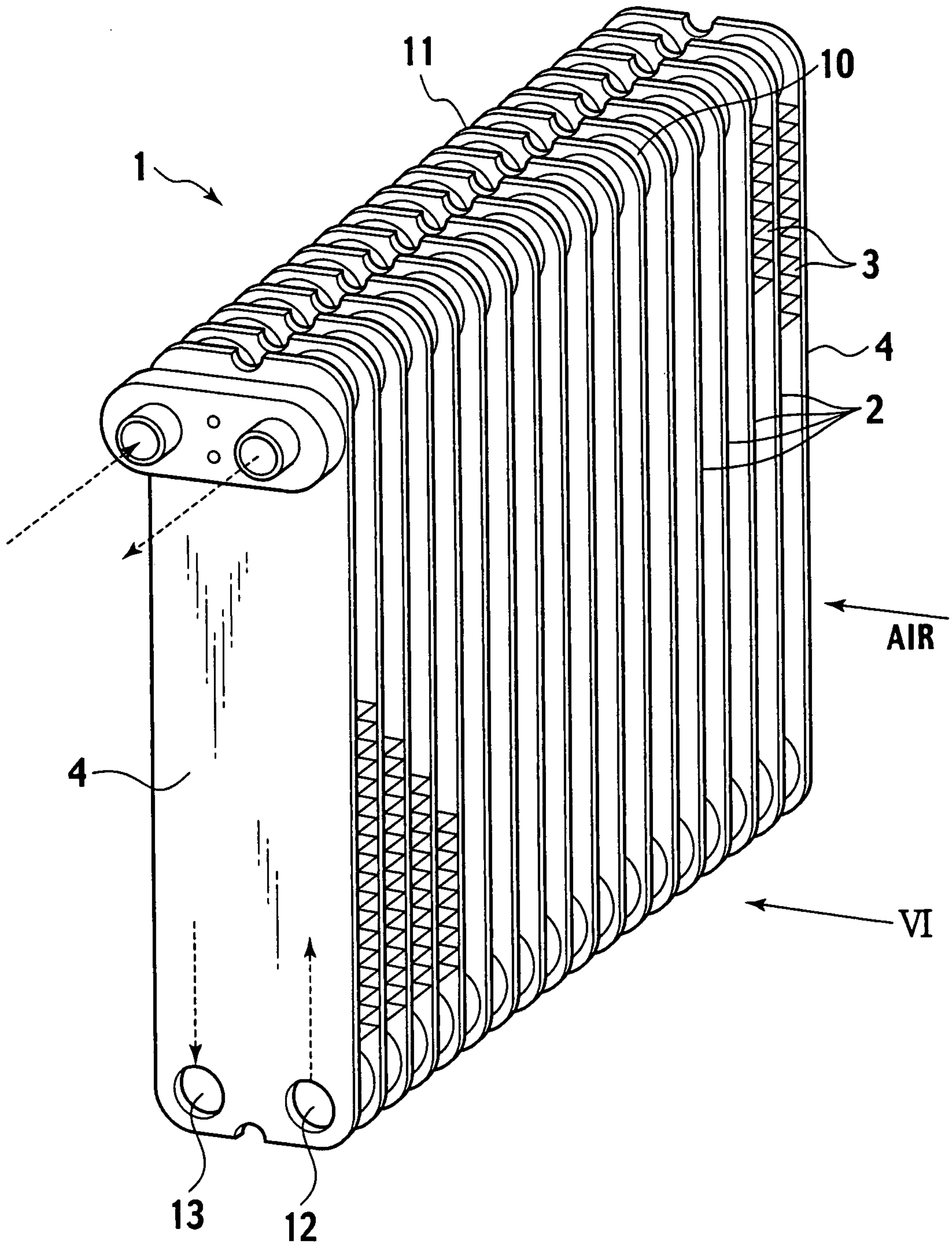


FIG. 2

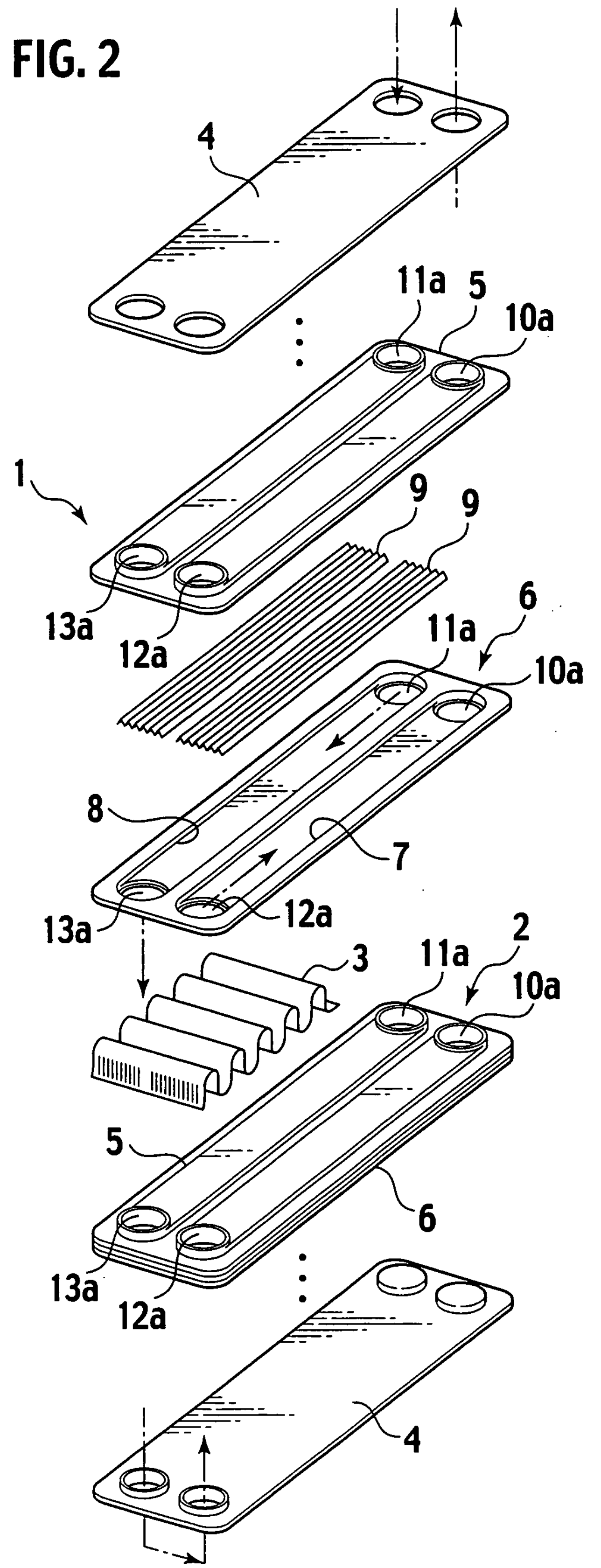


FIG. 3

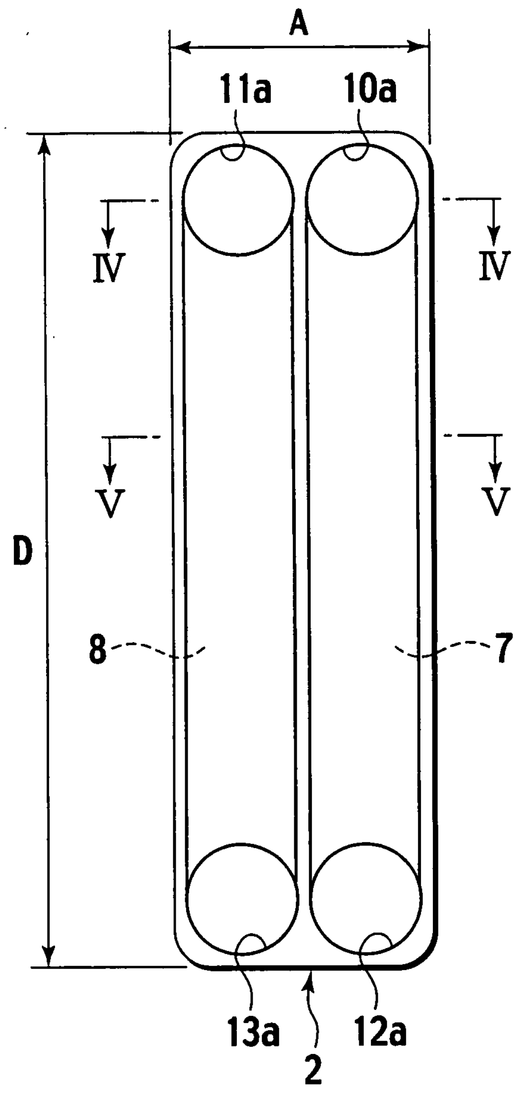


FIG. 4

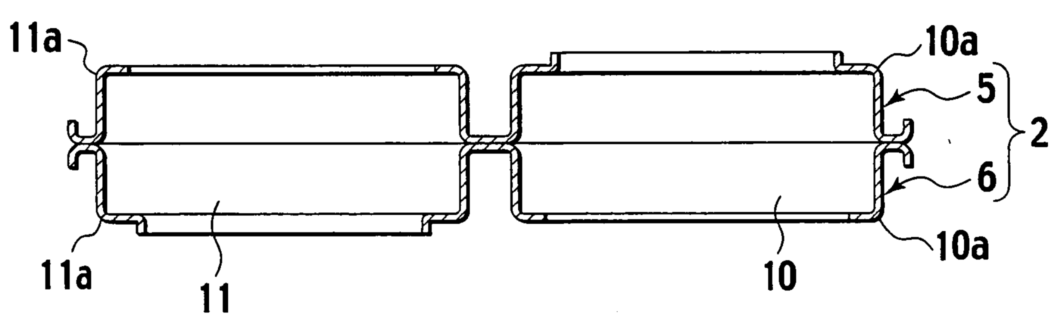


FIG. 5

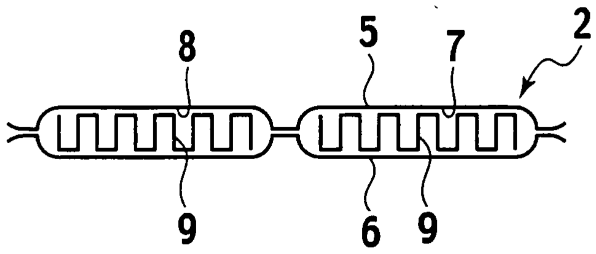


FIG. 6

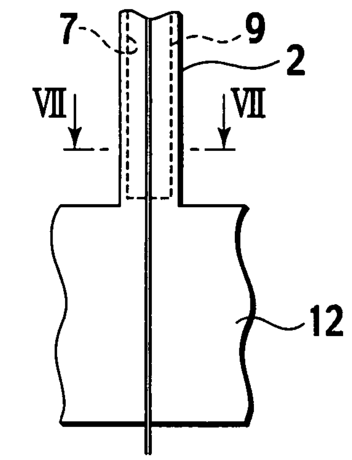


FIG. 7

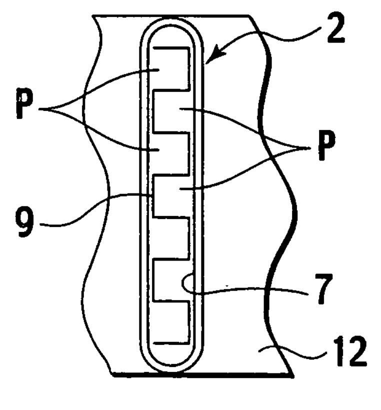


FIG. 8

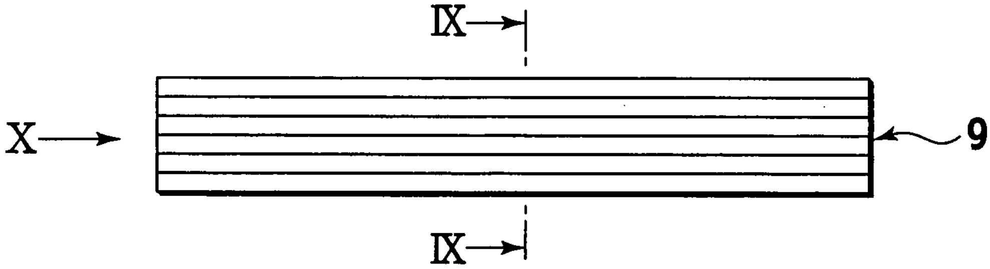


FIG. 9

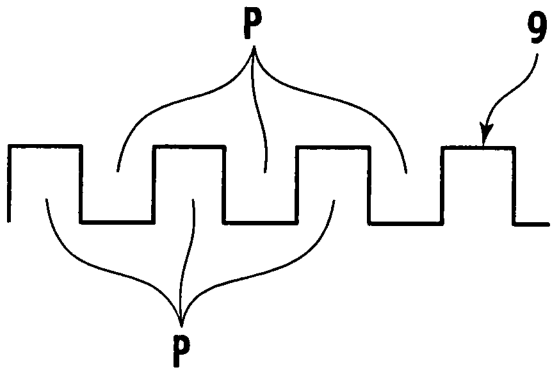


FIG. 10

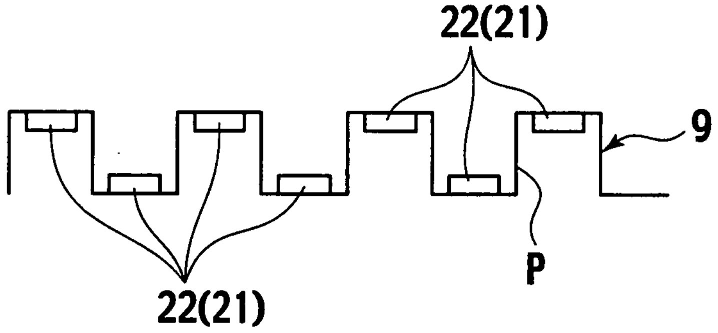


FIG. 11

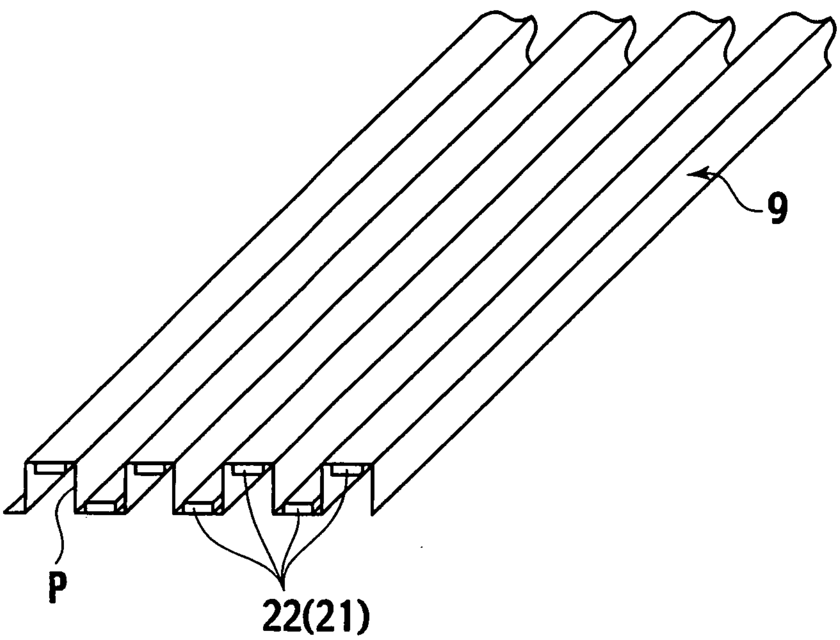


FIG. 12

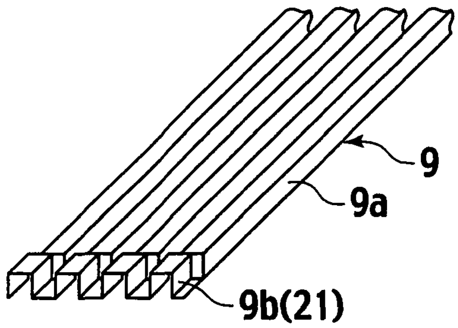


FIG. 13

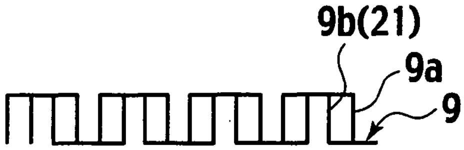


FIG. 14

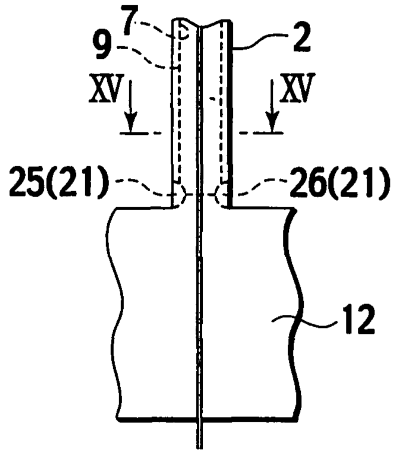


FIG. 15

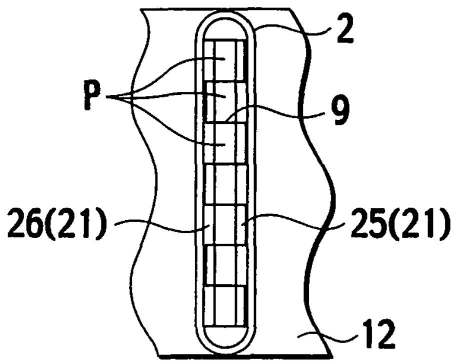


FIG. 16

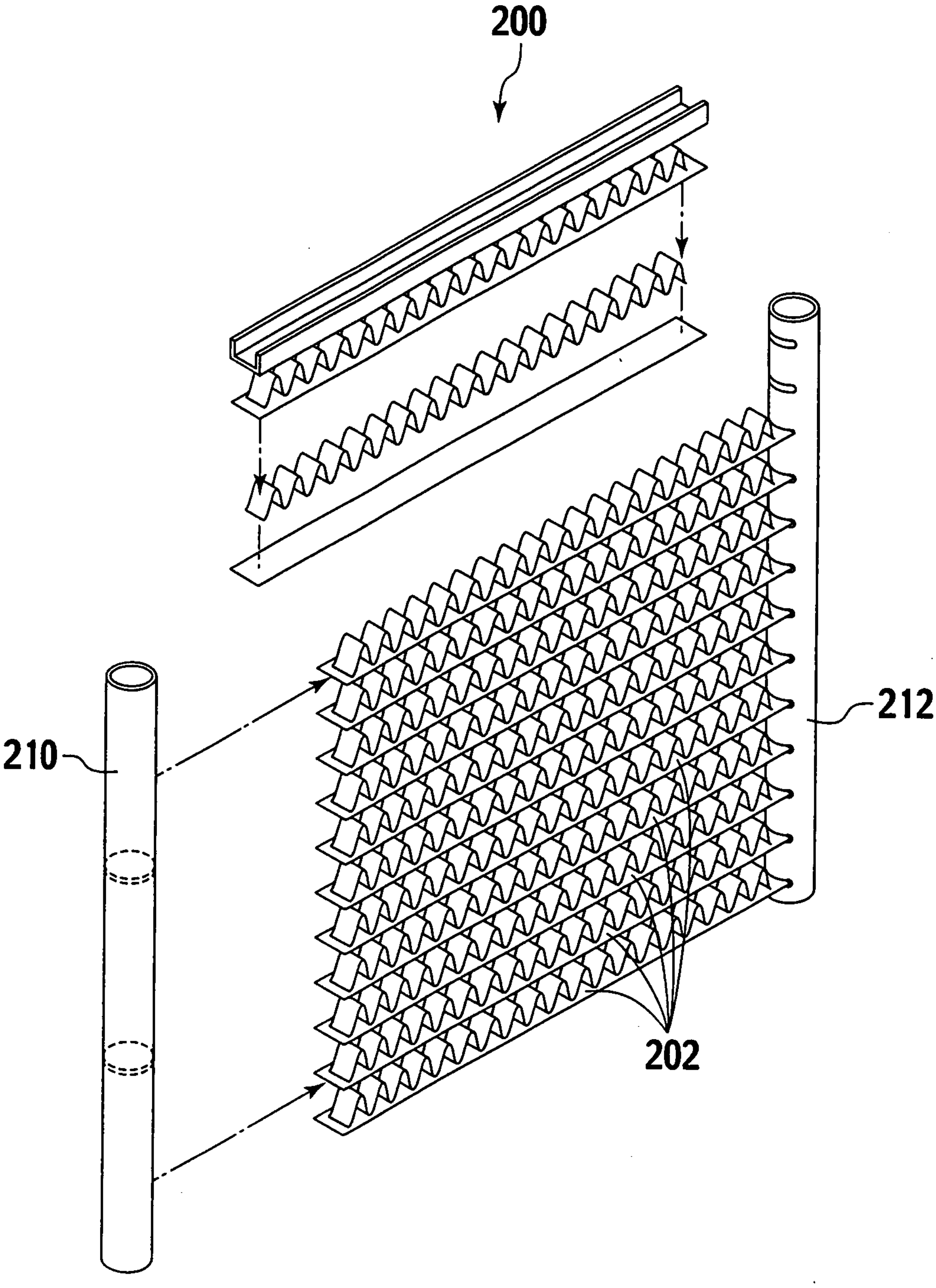


FIG. 17

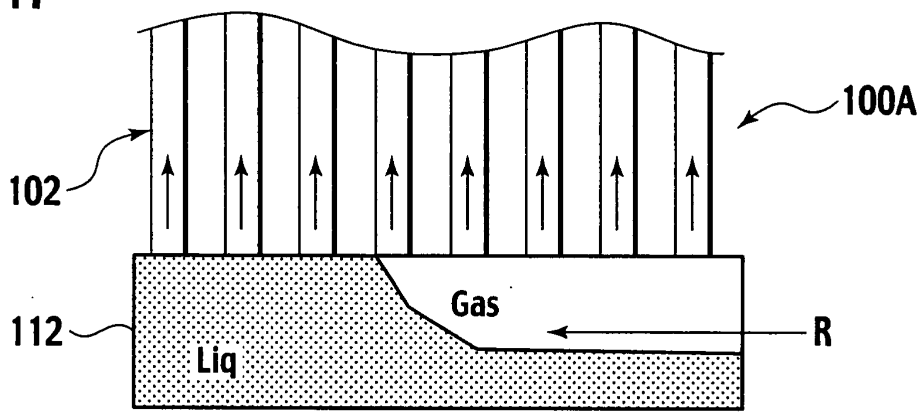


FIG. 18

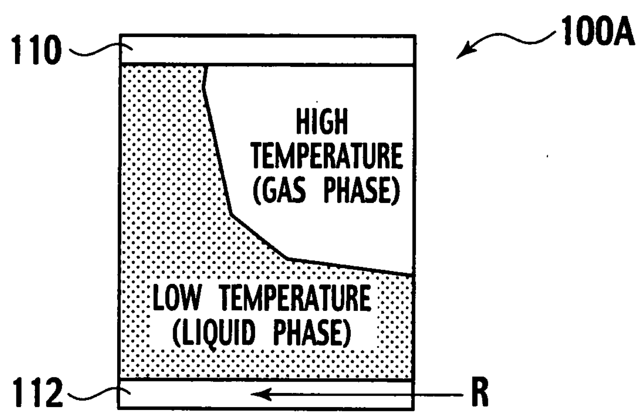
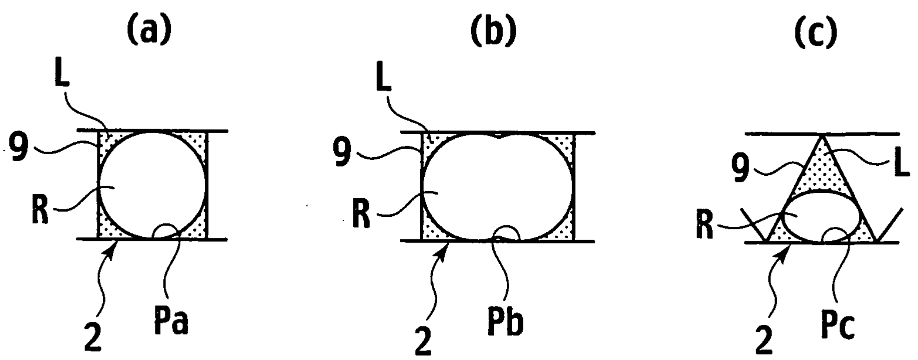


FIG. 19



INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2006/320619

A. CLASSIFICATION OF SUBJECT MATTER
F28F1/40(2006.01)i, *F25B39/02*(2006.01)i, *F28F9/24*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F28F1/40, F25B39/02, F28F9/24

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2006
Kokai Jitsuyo Shinan Koho	1971-2006	Toroku Jitsuyo Shinan Koho	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 2001-116485 A (Showa Aluminum Corp.), 27 April, 2001 (27.04.01), Par. No. [0011]; Figs. 1, 3, 7, 20 (Family: none)	1-3,5
Y	JP 4-324078 A (Hitachi, Ltd.), 13 November, 1992 (13.11.92), Par. Nos. [0035], [0036]; Figs. 18 to 20 (Family: none)	1-3,5

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"&" document member of the same patent family

Date of the actual completion of the international search 07 November, 2006 (07.11.06)	Date of mailing of the international search report 14 November, 2006 (14.11.06)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2003075024 A **[0008]**