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(54) **Stacking-type, multi-flow, heat exchangers and methods for manufacturing such heat exhangers**

(57) A stacking-type, multi-flow, heat exchanger (1) includes heat transfer tubes (2) and outer fins (3) stacked alternatively. Each heat transfer tube (2) is formed by connecting a pair of tube plates (30), and each heat transfer tube includes a raised portion (45,46) fixing the pair of tube plates (30) to each other. The raised portions (45,46) are formed by elongating or raising a portion of the pair of tube plates (30) substantially simultaneously at a position at which a pair of holes (41), each of which is formed through one tube plate (30) beforehand, are aligned. Complicated steps, such as inserting a raised portion into a hole, are not necessary. The number of types of tube plates (30) also may be reduced. Moreover, the efficiency of assembling a heat transfer tube when fixing a pair of tube plates to each other may be significantly increased.

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Description

[0001] The present invention relates to stacking-type, multi-flow, heat exchangers. Each heat exchanger comprises a plurality of heat transfer tubes and outer fins, which are stacked alternatively. Each such tube is formed by a pair of tube plates. The present invention also relates to methods for manufacturing such heat exchangers.

[0002] Recently, in the field of air conditioning systems for vehicles, a requirement for making air conditioners smaller has become more restrictive due to the narrower space available for installing air conditioner in smaller vehicles. In particular, in the field of evaporators, a requirement for decreasing a dimension in a depth direction (i.e., an air flow direction) has become more restrictive. In order to satisfy such requirements, an evaporator, in which each heat transfer tube is formed by a pair of tube plates and in which an inner fin is provided in a fluid passage formed in the heat transfer tube, is known.

[0003] Tube plate 11 is formed, for example, as depicted in **Fig. 3**. Cup portions 12, 13, 14, and 15 protrude outward and are formed on the longitudinal end portions of tube plate 11. Communication holes 16, 17, 18, and 19 are formed through in cup portions 12, 13, 14, and 15, respectively. Further, protruded portions 20 and 21 extend in the longitudinal direction of tube plate 11 and are configured to form fluid passages in heat transfer tube 2. Heat transfer tube 2 is formed by connecting (e.g., brazing) a pair of such tube plates 11 to each other after temporarily fixing them to each other.

[0004] More particularly, each heat transfer tube 2 is formed, for example, as follows. After a flux is applied to the inside of a pair of tube plates 11, an inner fin (not shown) is inserted into a fluid passage is formed by protruded portions 20 and 21. As depicted in **Figs**. **8A** and **8B,** after a raised portion 27 formed on a first tube plate 11, raised potion 27 is inserted into a hole 28 formed through a second tube plate 11', both tube plates 11 and 11' are fixed to each other by expanding the diameter of the tip portion of raised portion 27 by a punch 29.

[0005] When such a fixing method is employed, in order to form a predetermined fluid passage in heat exchanger 1, tube plates, such as those depicted in **Figs. 4 - 7,** are required. In these particular figures, a total of four kinds of tube plates are depicted. A tube plate 22 is depicted in **Fig. 4,** in which cup portions 12 and 14 communicate with each other, and in which hole 28 is provided at a first side of the communication portion (i.e., a communication plate). A tube plate 23 is depicted in **Fig. 5,** in which cup portions 12 and 14 communicate with each other, and in which raised portion 27 is formed at the first side of the communication portion (i.e., a communication plate). A tube plate 24 is depicted in **Fig. 6**, in which communication passages are not provided between the cup portions (i.e., a partition plate). A tube plate 25 is depicted in **Fig. 7**, in which respective cup portions are independent from each other. By appropriately combining these tube plates 22, 23, 24, and 25, a predetermined fluid passage may be formed in a stacking-type, multi-flow, heat exchanger.

[0006] In this case, in order to fix the same kind of tube plates 25 to each other, a complicated process is required wherein tube plates 25 formed by pressing are rotated alternatively by an angle of 180 degrees. Tube plates 25 then are combined as a pair of tube plates, raised portion 27 of one tube plate 25 is inserted into hole 28 of the other tube plate 25, and the diameter of the tip portion of the inserted raised portion 27 is expanded. Further, with respect to the communication plates, two kinds of tube plates, tube plates 22 and 23, which differ from each other in the positions of raised portion 27 and hole 28, are required.

[0007] To solve such problems, a method for combining a pair of tube plates, forming raised portions on both tube plates simultaneously in a single step, and fixing the pair of tube plates to each other by the formed raised portions is disclosed in Japanese Utility Model Laid-Open No. 55-126580. Nevertheless, because the diameters of a raised portion and a hole or passage formed through the central portion of the raised portion are substantially different from each other, it is difficult to accurately form both the raised portions and the central holes or passages simultaneously or in a single step.

[0008] Accordingly, a need has arisen to provide stacking-type, multi-flow, heat exchangers, which may reduce the number of kinds of tube plates used for forming heat transfer tubes, and which may improve significantly the efficiency of assembling the heat transfer tubes, in particular, when fixing a pair of tube plates to each other. A need also has arisen for methods for manufacturing such heat exchangers.

[0009] To satisfy the foregoing needs and to achieve other objects, a stacking-type, multi-flow, heat exchanger, according to the present invention, is provided. The stacking-type, multi-flow, heat exchanger comprises a plurality of heat transfer tubes and a plurality of outer fins, which are stacked alternatively. Each heat transfer tube comprises a pair of tube plates connected together to form a fluid passage in each heat transfer tube. Each heat transfer tube comprises raised portions fixing the pair of tube plates to each other. The raised portions are further formed by elongating or raising a portion of the pair of tube plates substantially simultaneously at a position at which a pair of holes, each of which is formed through one of the pair of tube plates, are aligned.

[0010] In the heat exchanger, it is preferred that an enlarged diameter is provided at a tip portion of each of the barred portions. In such a structure, the tube plates may be fixed to each other more securely.

[0011] Further, in the heat exchanger, an inner fin may be disposed in the fluid passage in each heat transfer tube, and the inner fin may extend in a longitudinal direction of each heat transfer tube. The inner fin may be a waved fin.

[0012] According to the present invention, a method for manufacturing a stacking-type, multi-flow, heat exchanger comprising a plurality of heat transfer tubes and a plurality of outer fins, which are stacked alternatively, also is provided. Each heat transfer tube is formed by connecting a pair of tube plates to form a fluid passage in each heat transfer tube. The method comprises the steps of forming a hole through each of the pair of tube plates, positioning the pair of tube plates, so that the holes of the pair of tube plates are aligned, and elongating or raising a portion of the pair of tube plates substantially simultaneously at a position at which the holes are aligned for fixing the pair of tube plates to each other.

[0013] In the method, it is preferred that diameters of tip portions of raised portions, formed by the step of elongating, are enlarged.

[0014] In the stacking-type, multi-flow, heat exchangers and the methods for manufacturing the same, according to the present invention, after tube plates, through each of which a hole has been formed, are assembled, so that the holes of both tube plates are aligned, a raised portion is formed by elongating or raising a portion of the plates at a position at which the holes are aligned, for example, by fit-inserting a punch into the holes. The raised portions are formed on both tube plates substantially simultaneously, as a part of each tube plate at the position at which the holes are aligned. Therefore, complicated steps, such as inserting a raised portion into a hole, are not necessary. Further, because it is not necessary to prepare two kinds of tube plates which are different from each other in the positions of a raised portion and a hole (i.e., the aforementioned communication plates), the number of types of tube plates may be reduced. Moreover, the efficiency of assembling a heat transfer tube when fixing a pair of tube plates to each other may be significantly increased.

[0015] Further objects, features, and advantages of the present invention will be understood from the following detailed description of preferred embodiments of the present invention with reference to the accompanying figures.

[0016] Embodiments of the invention now are described with reference to the accompanying figures, which are given by way of example only and are not intended to limit the present invention.

Fig. 1 is a plan view of a stacking-type, multi-flow, heat exchanger, according to an embodiment of the present invention.

Fig. 2 is an overhead or top view of the heat exchanger depicted in **Fig. 1**, as viewed along Line II-II of Fig. 1.

Fig. 3 is a perspective view of a tube plate for use in a known heat exchanger.

Fig. 4 is a plan view of a tube plate for use in a known heat exchanger.

Fig. 5 is a plan view of another tube plate for use in a known heat exchanger.

Fig. 6 is a plan view of still another tube plate for use in a known heat exchanger.

Fig. 7 is a plan view of yet another tube plate for use in a known heat exchanger.

Figs. 8A and **8B** are partial, cross-sectional views of a heat transfer tube, showing steps for fixing a pair of tube plates to each other in a method for manufacturing a known heat exchanger.

Fig. 9 is a plan view of a tube plate, which functions as a communication plate of a heat transfer tube, for use in a heat exchanger according to an embodiment of the present invention.

Fig. 10 is a plan view of a tube plate, which functions as a partition plate of a heat transfer tube, for use in a heat exchanger according to an embodiment of the present invention.

Fig. 11 is a plan view of a tube plate, which functions as an independent cup portion-type plate of a heat transfer tube, for use in a heat exchanger according to an embodiment of the present invention.

Figs. 12A-12C are partial, cross-sectional views of a heat transfer tube, showing steps for fixing a pair of tube plates to each other in a method for manufacturing a heat exchanger according to an embodiment of the present invention.

Figs. 13A-13C are partial, cross-sectional views of a heat transfer tube, showing further steps to expand the diameter of an opening at a tip portion of a raised portion after fixing a pair of tube plates to each other in a method for manufacturing a heat exchanger according to an embodiment of the present invention.

Fig. 14 is a partial, cross-sectional view of the heat transfer tube as depicted in **Fig. 12A.**

Fig. 15 is a partial, cross-sectional view of the heat transfer tube as depicted in **Fig**. **13C.**

[0017] In such evaporators, a stacking-type, multi-flow, heat exchanger, as depicted in **Figs. 1** and **2**, is known, wherein heat transfer tubes and outer fins are stacked alternatively. In these figures, a stacking-type, multi-flow, heat exchanger 1 comprises a core portion 4 in which heat transfer tubes 2 and outer fins 3 are stacked alternatively. End plates 5 and 6 are provided at outermost positions of core portion 4 in the stacking direction. Tanks 7 and 8 are formed on both tube end portions of core portion 4 by cup portions which are formed by tube plates described later.

[0018] Inlet pipe 9 for introducing a heat exchanging fluid (e.g., a refrigerant) into heat exchanger 1 is connected to tank portion 7a of tank 7. Outlet pipe 10 for discharging fluid from heat exchanger 1 is connected to tank portion 7b of tank 7. The fluid flows in a predetermined fluid passage formed in heat exchanger 1, and the heat is exchanged between the flowing fluid and outside air passing through heat exchanger 1. A stacking-type, multi-flow, heat exchanger, according to the present invention, is suitable as an evaporator for use in an air conditioning system for vehicles.

[0019] Referring to **Figs. 9-11**, tube plates are depicted for a heat transfer tube used in a stacking-type, multi-flow, heat exchanger, according to an embodiment of the present invention. A brazing material may be clad beforehand on front and back surfaces of tube plates depicted in **Figs. 9-11**, and a flux for brazing may be applied uniformly on the front and back surfaces of the tube plates. Therefore, by assembling respective members of stacking-type, multi-flow, heat exchanger 1 and brazing them together in a furnace, a pair of tube plates and other members may be brazed to each other substantially at the same time.

[0020] In a tube plate 30 (e.g., a communication plate) depicted in **Fig. 9**, cup portions 31, 32, 33, and 34 protrude outward from plate 30 and are formed on the end portions in the longitudinal direction of the tube plate. Communication holes 35, 36, 37, and 38 are provided through portions 31, 32, 33, and 34. A communication path 55 is formed between cup portions 31 and 33, and cup portions 31 and 33 communicate with each other through communication path 55. Protruded portions 39 and 40 extend in the longitudinal direction of tube plate 30 and are formed on the tube plate 30 to form fluid passages in heat transfer tube 2. Heat transfer tube 2 may be formed by fixing a pair of such tube plates 30 to each other and fixing (e.g., brazing) them to each other.

[0021] A pair of such tube plates 30 may be fixed to each other as follows. Holes 41 are formed through both end portions of respective tube plates 30, and a pair of tube plates 30 are positioned and temporarily assembled, so that corresponding holes 41 are aligned, as depicted in **Fig. 12A**. In an embodiment, such holes 41 may be formed simultaneously at the time of pressing each tube plate 30. Further, when a pair of tube plates 30 are temporarily assembled, an inner fin, formed, for example, as a waved fin (not shown), may be inserted into a space (e.g., a fluid passage) formed between and within protruded portions 39 and 40. The end portions of a pair of temporarily assembled, tube plates 30 are depicted in **Fig. 14**.

[0022] Next, while confirming that corresponding holes 41 are aligned, the assembly is fixed by a die 43, and a punch 44 is inserted into aligned holes 41, as depicted in **Fig. 12B**. By inserting punch 44 at a position 56 on the pair of tube plates 30 at which holes 41 are aligned, raised portions 45 and 46 of the respective tube plates 30 are formed substantially simultaneously as a part of each tube plate 30, as depicted in **Fig. 12C**.

[0023] Further, the diameters of the tip portions of raised portions 45 and 46 may be enlarged or expanded in order to secure a pair of tube plates 30 more strongly. For example, as depicted in **Figs. 13A** and **13B**, a punch 47 for enlarging the diameter of or extending the tip portion of a raised portion is inserted into raised portions 45 and 46, and the diameters of the tip portions of raised portions 45 and 46 are enlarged by punch 47. By such diameter-enlarged or extended, tip portions of raised portions 45 and 46, tube plates 30 may be secured to each other more strongly. The condition of the end portions of the pair of tube plates 30, with the diameter-enlarged or extended, tip portions of raised portions 45 and 46, is depicted in **Fig. 15.**

[0024] For tube plate 50 (e.g., a partition plate) depicted in **Fig. 10** and tube plate 52 (e.g., a cup portion, independent-type plate) depicted in **Fig. 11,** a pair of respective tube plates also may be fixed to each other in a similar manner to that described above.

[0025] In the above-described stacking-type, multi-flow, heat exchangers, and methods for manufacturing such heat exchangers, because holes are formed through each tube plate and subsequently the holes of a pair of tube plates are aligned, the elongating or raising step is carried out at the location of the aligned holes. As a result, the raised portions of both tube plates may be accurately and readily formed substantially simultaneously. Therefore, complicated steps, such as inserting a raised portion into a hole, are not necessary. Further, because it is not necessary to prepare two kinds of tube plates, which are different from each other in the positions of the raised portion and the hole, the number of types of tube plates is reduced. Moreover, the efficiency of assembling the tube plates, in particular, of fixing a pair of tube plates to each other, may be significantly increased.

[0026] The characteristics of stacking-type, multi-flow, heat exchangers, and the methods for manufacturing such heat exchangers, according to the present invention, may be applied to any type of stacking-type, multi-flow, heat exchangers, wherein heat transfer tubes comprising a pair of tube plates and outer fins are stacked alternatively. In particular, the present invention may be applied to stacking-type, multi-flow, heat exchangers used as evaporators in air conditioning systems for vehicles.

Claims

1. A stacking-type, multi-flow, heat exchanger comprising a plurality of heat transfer tubes and a plurality of outer fins, which are stacked alternatively, each of said heat transfer tubes comprising a pair of tube plates connected together to form a fluid passage in each of said heat transfer tubes, each of said heat transfer tubes further comprising:

    raised portions fixing said pair of tube plates to each other, said raised portions being formed by elongating said pair of tube plates substantially simultaneously at a position at which a pair of holes, each of which is formed through one of said pair of tube plates, are aligned.

2. The stacking-type, multi-flow, heat exchanger of claim 1, wherein each of said raised portions com-

prises a tip portion having an enlarged diameter.

3. The stacking-type, multi-flow, heat exchanger of claim 1 or 2, wherein an inner fin is disposed in said fluid passage in each of said heat transfer tubes, said inner fin extending in a longitudinal direction of each of said heat transfer tubes.

4. The stacking-type, multi-flow, heat exchanger of claim 3, wherein said inner fin is a waved fin.

5. A method for manufacturing a stacking-type, multi-flow, heat exchanger comprising a plurality of heat transfer tubes and a plurality of outer fins, which are stacked alternatively, each of said heat transfer tubes being formed by connecting a pair of tube plates to form a fluid passage in each of said heat transfer tubes, said method comprising the steps of:

forming a hole through each of said pair of tube plates;
positioning said pair of tube plates, so that said holes of said pair of tube plates are aligned; and
elongating said pair of tube plates substantially simultaneously at a position at which said holes are aligned for fixing said pair of tube plates to each other.

6. The method of claim 5, further comprising the steps of enlarging diameters of tip portions of raised portions, formed by said step of elongating.

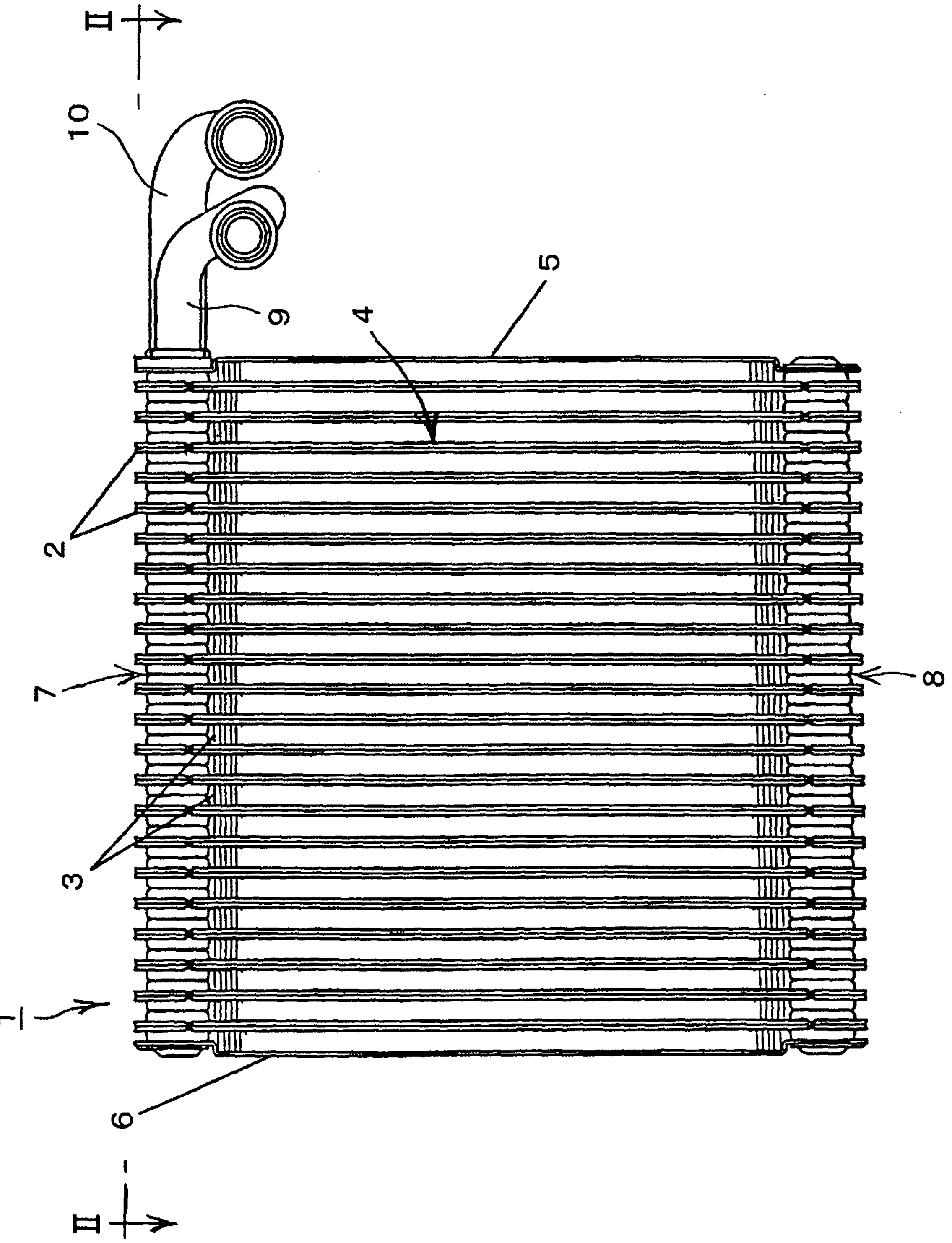


FIG. 1

FIG. 2

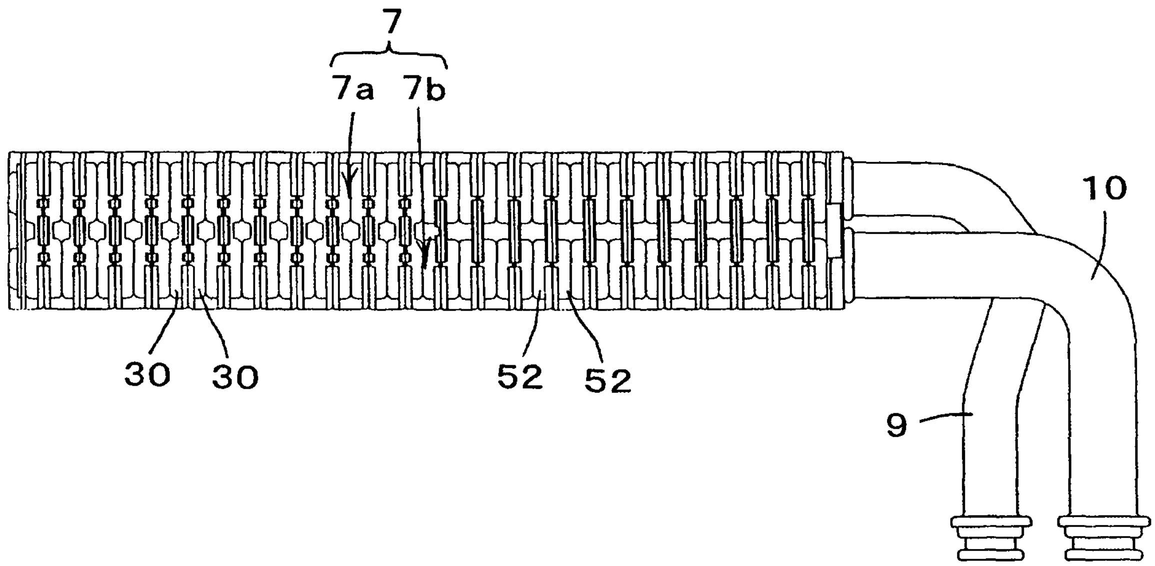


FIG. 3
PRIOR ART

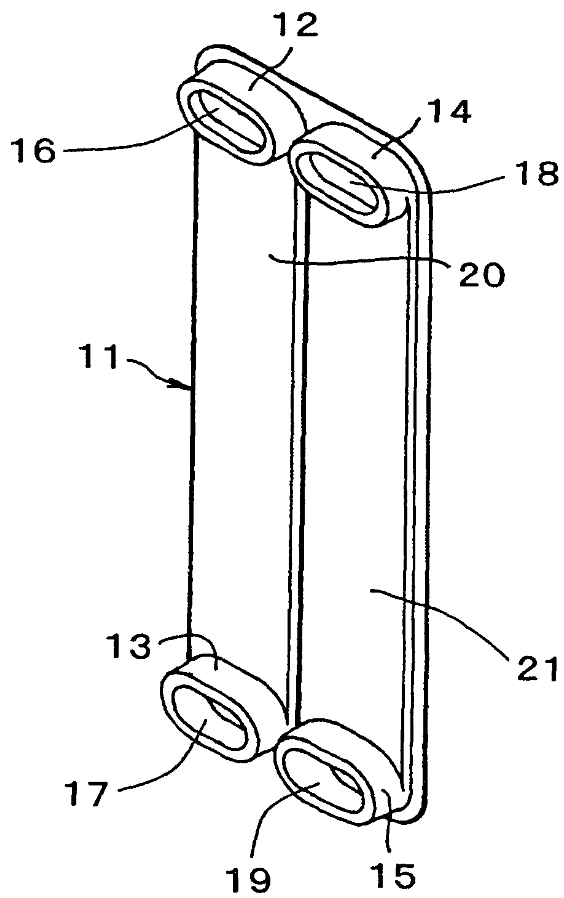


FIG. 4
PRIOR ART

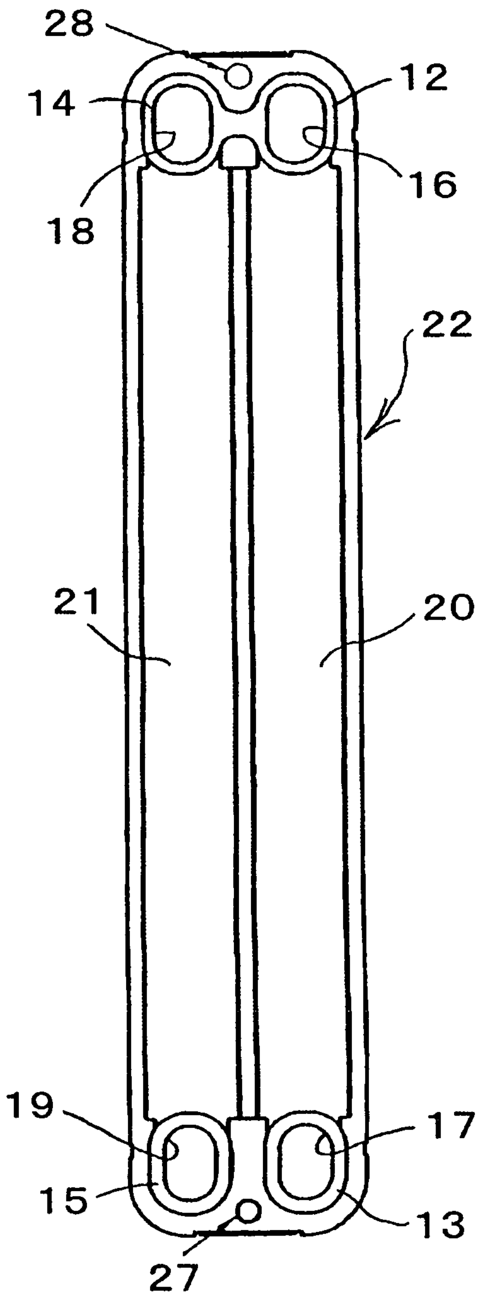


FIG. 5
PRIOR ART

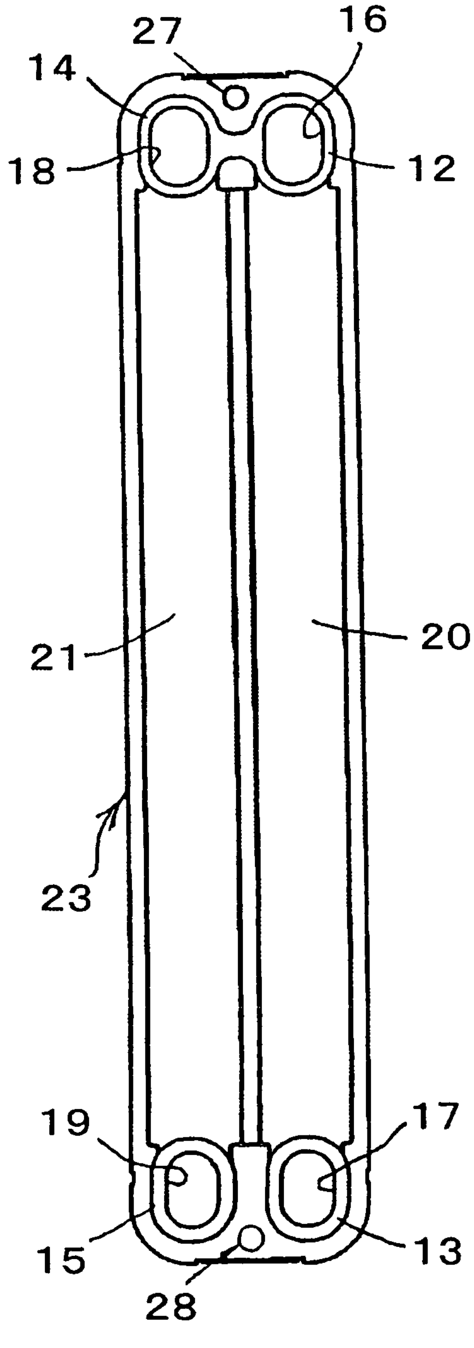


FIG. 6
PRIOR ART

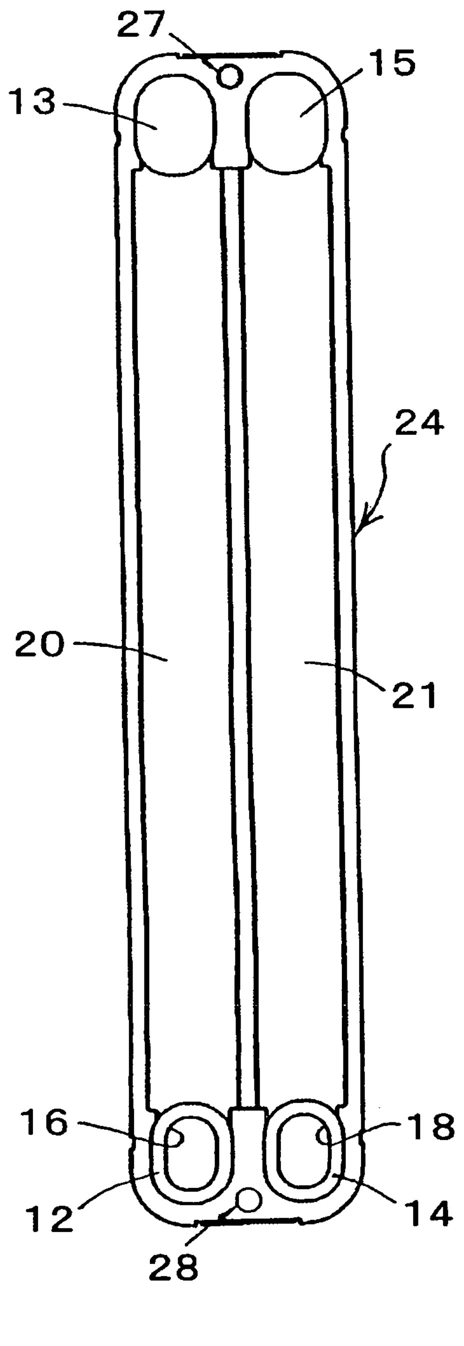
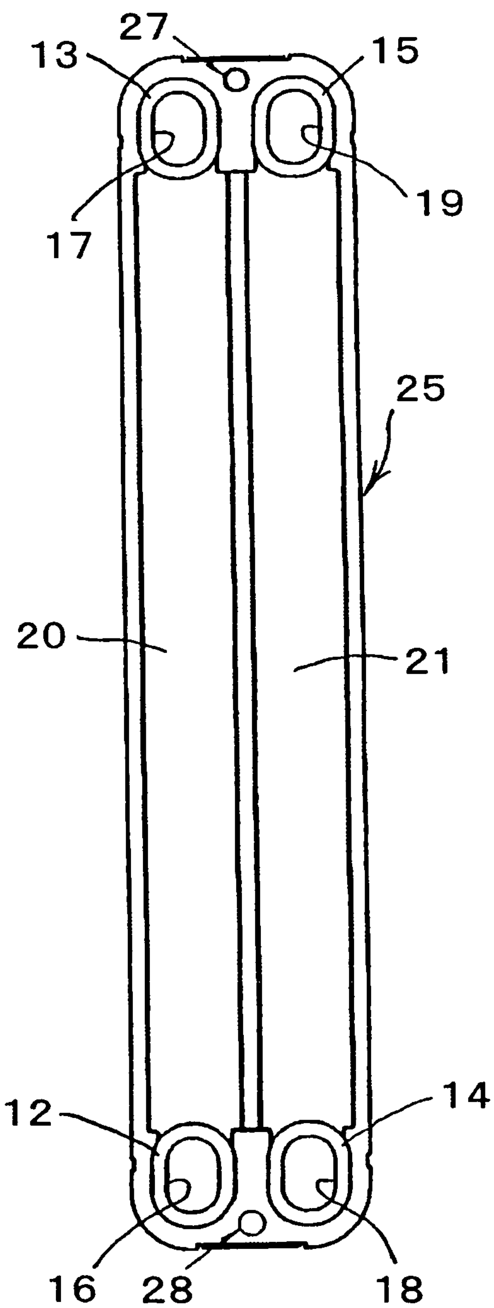


FIG. 7
PRIOR ART



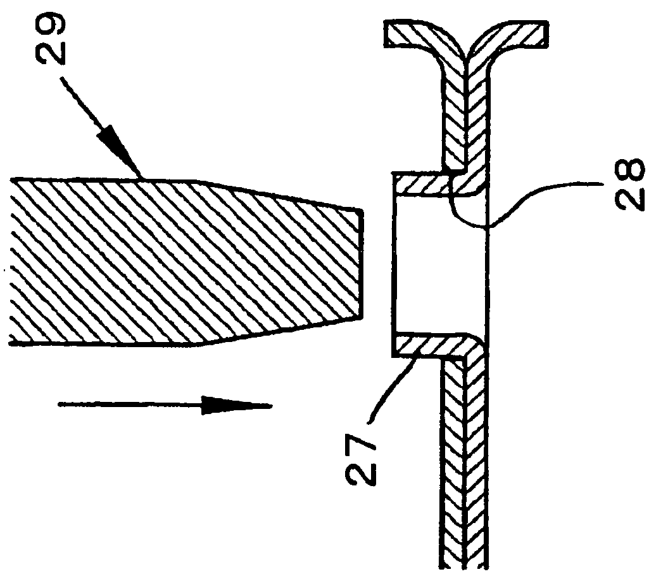


FIG. 8A
PRIOR ART

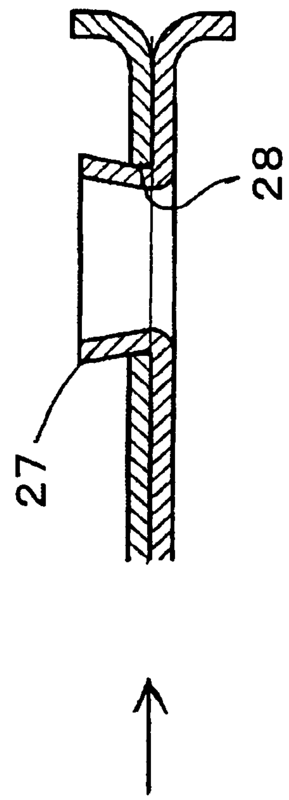


FIG. 8B
PRIOR ART

FIG. 9

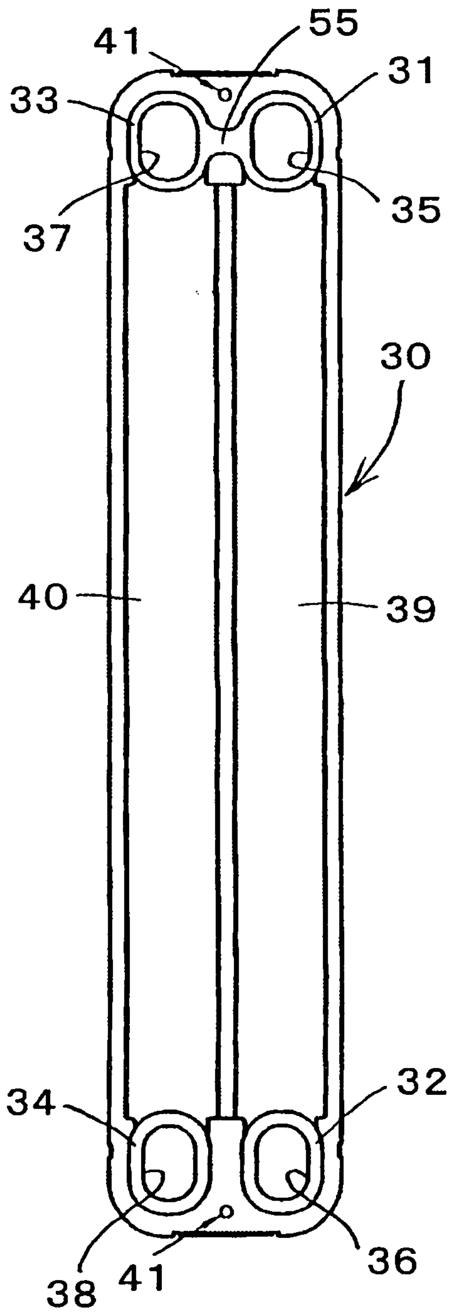


FIG. 10

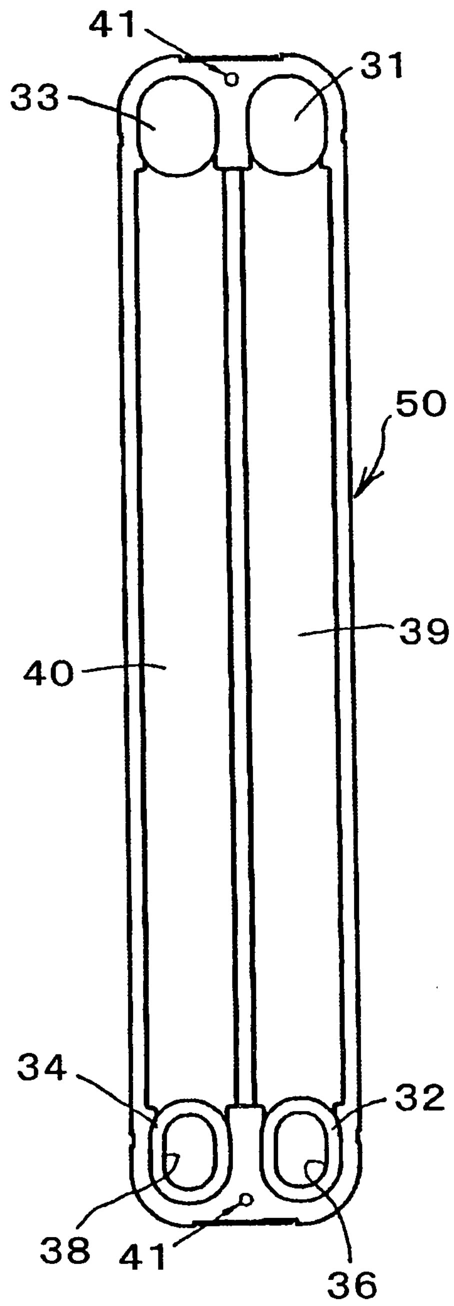
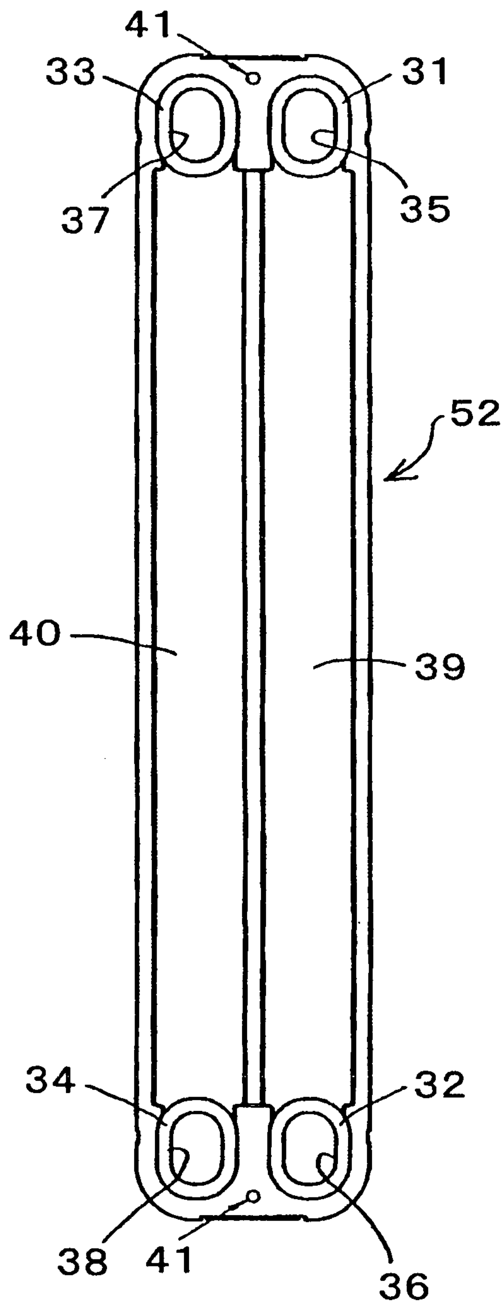


FIG. 11



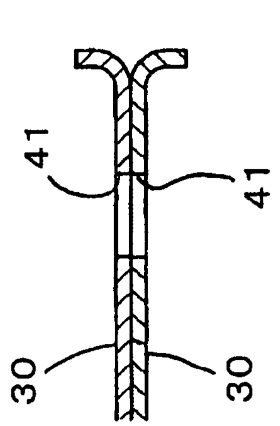


FIG. 12A

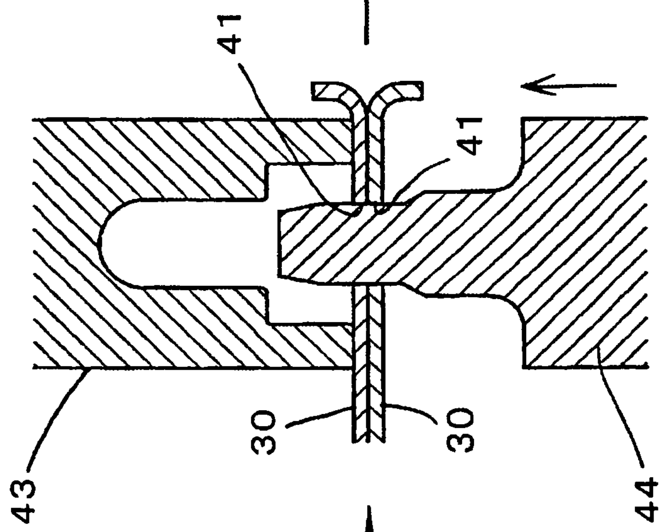


FIG. 12B

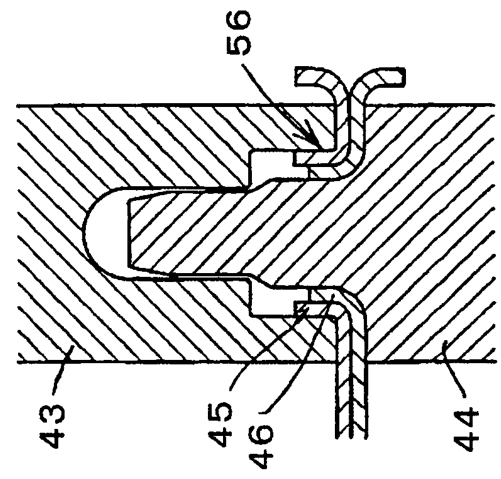


FIG. 12C

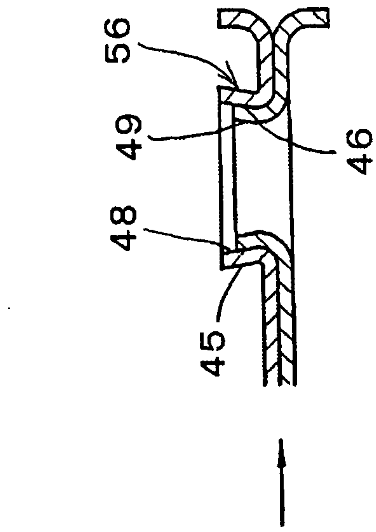


FIG. 13C

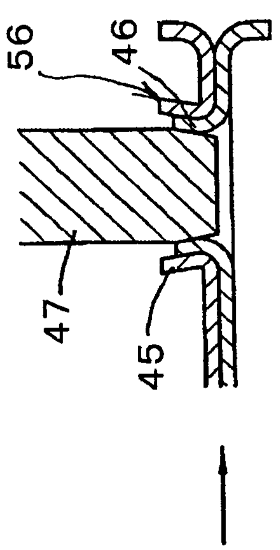


FIG. 13B

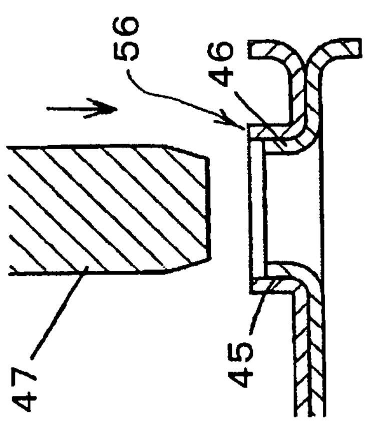


FIG. 13A

FIG. 14

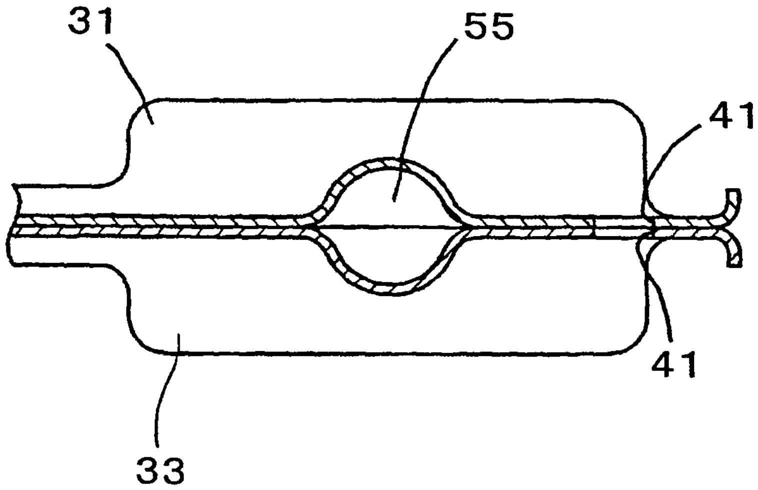


FIG. 15