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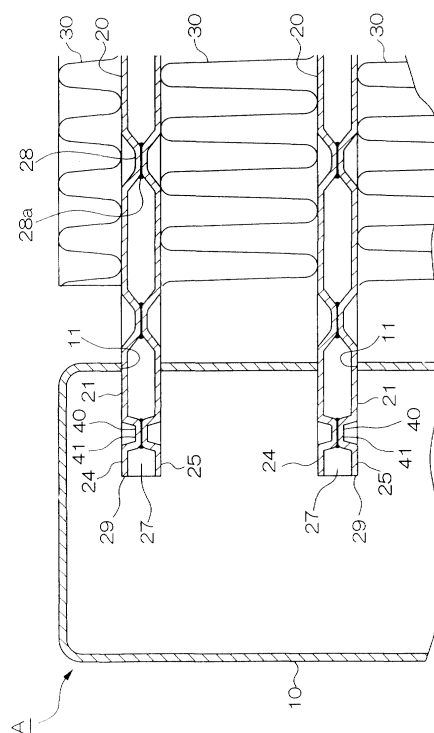
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(54) **Heat exchanger**

(57) A heat exchanger comprises: a pair of headers (10, 10) which are provided in parallel facing each other through a predetermined distance and a pathway of the fluid is respectively provided therein; and a plurality of flat heat-exchange tubes (20,20...) which are provided between the headers in parallel, both ends thereof are fastened to the headers, and a pathway of the refrigerant for connecting the pathways of both headers is respectively provided therein. In this heat exchanger, the heat-exchange tubes and the headers are air-tightly and liquid-tightly fastened by inserting end portions (21,21...) of the heat-exchange tubes into insertion holes (11,11...) which are bored on the headers. Furthermore, in the vicinity of opening ends (29) of both end portions of the flat heat-exchange tubes, shape-holding portions (41) for preventing deformation of the opening ends are provided.

FIG. 1



## Description

### BACKGROUND OF THE INVENTION

#### Field of the Invention

**[0001]** The present invention relates to a heat exchanger which is suitable for used as a heat exchanger of a refrigerant and constitutes a condenser and an evaporator of an air conditioner.

#### Description of the Related Art

**[0002]** In a cooling apparatus such as an air conditioner, a refrigerant (fluid) which has been transformed into a compressed gas having high temperature and pressure, is liquefied in a condenser, and the liquefied refrigerant is vaporized by removing heat of evaporation in an evaporator. A heat exchanger which equips a plurality of heat-exchange tubes for flowing the refrigerant in the inside thereof is used in the condenser and evaporator. In this heat exchanger, the refrigerant which flows through the heat-exchange tubes radiates or absorbs heat through the walls of the heat-exchange tubes.

**[0003]** Conventionally, the heat exchanger as shown in Figs. 23 to 26 is known as this type of heat exchanger. The heat exchanger comprises: a pair of headers 10, 10 which are provided in parallel facing each other through a predetermined distance, and a pathway of the refrigerant (fluid) is respectively provided therein; a plurality of flat heat-exchange tubes 20, 20... which are provided in parallel between the headers 10, 10, and both ends thereof are fastened to the headers 10, 10 and a pathway of the refrigerant for connecting the pathways of both headers 10, 10 is respectively provided therein; and a plurality of fins 30, 30... which are provided between the adjacent heat-exchange tubes 20, 20... to contact the outer surfaces of the heat-exchange tubes 20, 20... which face each other. Furthermore, an inlet 13 of the refrigerant is provided on one end of one of the headers 10, and an outlet 14 of the refrigerant which is approximately located at the farthest position from the inlet 13 on a diagonal line toward the inlet 13, is provided on the other header 10.

**[0004]** In addition, connecting structures between the headers 10, 10 and the heat-exchange tubes 20, 20... are provided by inserting end portions 21, 21... of the heat-exchange tubes 20, 20... into insertion holes 11, 11... which are bored on the headers 10, 10, and air-tightly and liquid-tightly fastening the headers 10, 10 and the heat-exchange tubes 20, 20....

**[0005]** Each heat-exchange tube 20 is constructed by bending a belt shaped metal plate 22 in which solder is clad on both surfaces thereof at a folding portion 23 provided along the longitudinal direction of the metal plate 22, and by forming a passage for the refrigerant between wall portions 24, 25 which are located on one and

the other sides of the bent metal plate 22 by attaching connecting end portions 26, 26 which are formed at the ends of the wall portions 24, 25 along the longitudinal direction of the bent metal plate 22. Here, in the heat-exchange tube 20, to reduce the length of the time of heat transmission, the radius of curvature of the folding portion 23 is smaller than the widths of the wall portions 24, 25, and therefore, the heat-exchange tube 20 forms a flat shape in which the distance between the wall portions 24, 25 is shortened to the widths thereof.

**[0006]** Furthermore, to stir the refrigerant which flows in the heat-exchange tubes 20, 20... in order to unify the temperature of the refrigerant, a plurality of bulging members 28, 28... project from the wall portions 24, 25 toward the opposing wall portions. Each of these bulging members 28, 28... has a truncated-cone shape, and a flat connecting portion 28a is provided on the connecting end thereof. The connecting portions 28a, 28a... of the opposing bulging members 28, 28... contact each other.

**[0007]** In addition, a notch 16 is provided on the connecting end portions 26, 26 of each end portion 21 so as to unify the inserted length of the end portion 21 by attaching the notch 16 to the edge of the insertion hole 11 when the end portion 21 is inserted into the insertion hole 11.

**[0008]** The heat exchanger is assembled by the following steps: producing the heat-exchange tubes 20, 20... by forming a metal tube by press molding or roll molding and cutting both ends of the metal tube; inserting the end portions 21, 21... of the heat-exchange tubes 20, 20... into the insertion holes 11, 11... of the headers 10, 10...; providing fins 30, 30... between the adjacent heat-exchange tubes 20, 20... by contacting the fins 30, 30... to both of the opposing outer surfaces of the adjacent heat-exchange tubes 20, 20... in order to prevent the separation of the connecting end portions 26, 26 of each heat-exchange tube 20 by a spring-back force, and retaining these heat-exchange tubes 20, 20... and the fins 30, 30... which form multilayers, by sandwiching them between a pair of holding plates 15, 15 from the outside.

**[0009]** The heat exchanger is temporarily assembled by using jigs, and braze-welded by heating in a furnace. That is, joints between the insertion holes 11, 11... and the heat-exchange tubes 20, 20... , and a joint between the opposing connecting end portions 26, 26 are each air-tightly and liquid-tightly fastened by braze-welding. Furthermore, the connecting portions 28a, 28a... of the opposing bulging members 28, 28... are also fastened by braze-welding.

**[0010]** In the above-mentioned conventional heat exchanger, the refrigerant flows into a header 10 from the inlet 13, branches off and passes through each heat-exchange tube 20, flows into the opposite header 10, and flows out from the outlet 14. The refrigerant exchanges heat toward an outer part through the wall surfaces of the heat-exchange tubes 20, 20....

**[0011]** Furthermore, the heat-exchange tubes 20,

20... in which the high pressure refrigerant flows, have a structure for improving the resistance against the pressure force which is exerted on the wall portions 24, 25 of the flat heat-exchange tubes 20, 20.... That is, the wall portions 24, 25 which are positioned on the top and bottom facing each other, are connected by welding the connecting portions 28a, 28a... of the opposing bulging members 28, 28... which are used to stir the refrigerant.

**[0012]** However, the above-mentioned conventional heat exchanger has the following problems.

**[0013]** No bulging members are provided around the opening ends which provide the inlet/outlet portion for the refrigerant at both ends of the heat-exchange tubes 20, 20..., in order to prevent problems such as pressure losses of the refrigerant caused by sudden expansion/contraction of the refrigerant. However, when forming the opening ends by cutting both ends of the roll-molded heat-exchange tube, the formed opening ends tend to be easily deformed along the cutting direction of the tube because the bulging members which support the opposing wall portions are not provided. The opening ends, which have deformations such as bending or twisting, are difficult to insert into the insertion holes of the header. Moreover, even if corrections of the deformations are performed, the deformations still remain in the end portions of the tube which is easily deformed since the bulging members are not provided. Therefore, there are problems in that spaces arise between the end portions and the insertion holes, and sufficient braze-welding cannot be performed.

**[0014]** In addition, in the heat-exchange tube formed by bending a metal plate, a force, which deforms the tube along the opening direction of the tube and which separates the upper and lower wall portions which face each other, is produced by a spring back force. The deformation is hindered by the fins which are provided between the adjacent tubes and which hold the tubes from the outside along almost the entire portion of the heat exchanger. However, in the vicinity of the end portions of the heat-exchange tube, since the fins cannot be provided by constructive restriction, there are problems that spaces arise between the opposing connecting portions or bulging members due to separation of the opposing wall portions because the end portions are not supported by the fins, and sufficient braze-welding cannot be performed.

**[0015]** As described above, in the conventional heat exchanger, there are problems in that the sealing performance and resistance against the pressure of the heat exchanger are degraded due to insufficient braze-welding. The present invention is achieved in consideration of the above circumstances, and an object thereof is to provide a heat exchanger in which braze-welding can be performed more properly and which possesses superior sealing performance and resistance against the pressure.

## SUMMARY OF THE INVENTION

**[0016]** A first aspect of the heat exchanger of the present invention comprises: a pair of headers which are provided in parallel facing each other through a pre-determined distance and a pathway of the fluid is respectively provided therein; a plurality of flat heat-exchange tubes which are provided between the headers in parallel, both ends thereof are fastened to the headers and a pathway of the refrigerant for connecting the pathways of both headers is respectively provided therein; wherein connecting structures between the headers and the heat-exchange tubes are provided by inserting the end portions of the heat-exchange tubes into insertion holes which are bored on the header, and air-tightly and liquid-tightly fastening the header and the heat-exchange tubes; and shape-holding portions for preventing the deformation of the opening ends of the heat-exchange tube which are provided in the vicinity of the opening ends of each heat-exchange tube.

**[0017]** In the heat exchanger, it is preferable that the shape-holding portions are provided by reinforcement members which project from at least one of the opposing wall portions of the heat-exchange tube toward the other opposing wall portion, and the connecting ends of the opposing reinforcement members contact each other.

**[0018]** A second aspect of the heat exchanger of the present invention comprises: a pair of headers which are provided in parallel facing each other through a pre-determined distance and a pathway of the fluid is respectively provided therein; a plurality of flat heat-exchange tubes which are provided between the headers in parallel, both ends thereof are fastened to the headers, and a pathway of the refrigerant for connecting the pathways of both headers is respectively provided therein, wherein connecting structures between the headers and the heat-exchange tubes are provided by inserting end portions of the heat-exchange tubes into insertion holes which are bored on the header, and air-tightly and liquid-tightly fastening the header and the heat-exchange tubes; and an insertion end portion, in which the width thereof between opposing side walls of the heat-exchange tube becomes narrower as it approaches an opening end of the heat-exchange tube, which is provided on each end portion of the heat-exchange tubes.

**[0019]** In the heat exchanger, it is preferable that each insertion hole has a shape corresponding to the shape of the insertion end portion.

**[0020]** It is further preferable that the insertion end portion has a contacting portion which is inwardly or outwardly projecting from the outer surface thereof, and each insertion hole has a shape corresponding to the shape of the insertion end portion in which the contacting portion is provided.

**[0021]** A third aspect of the heat exchanger of the present invention comprises: a pair of headers which are provided in parallel facing each other through a pre-

determined distance, and a pathway of the fluid is respectively provided therein; a plurality of flat heat-exchange tubes which are provided between the headers in parallel, both ends thereof are fastened to the headers, and a pathway of the refrigerant for connecting the pathways of both headers is respectively provided therein, wherein connecting structures between the headers and the heat-exchange tubes are provided by inserting end portions of the heat-exchange tubes into insertion holes which are bored on the header, and air-tightly and liquid-tightly fastening the header and the heat-exchange tubes; and a corner of an opening end of each heat-exchange tube which is partly cut off.

**[0022]** A fourth aspect of the heat exchanger of the present invention comprises: a pair of headers which are provided in parallel to facing each other through a predetermined distance, and a pathway of the fluid is respectively provided therein; a plurality of flat heat-exchange tubes which are provided between the headers in parallel, both ends thereof are fastened to the headers and a pathway of the refrigerant for connecting the pathways of both headers is respectively provided therein, wherein connecting structures between the headers and the heat-exchange tubes are provided by inserting end portions of the heat-exchange tubes into insertion holes which are bored on the header, and air-tightly and liquid-tightly fastening the header and the heat-exchange tubes; and a removal prevention member which is fastened to opposing wall portions of each heat-exchange tube for preventing the deformation of the heat-exchange tube caused by removal of the wall portions, and which is provided on at least one of the wall portions.

**[0023]** In the heat exchanger, it is preferable that the removal prevention member is provided by bulging members which project from respective wall portions toward the opposing wall portions, and the connecting ends of the opposing bulging members contact each other and are welded by laser.

**[0024]** In the heat exchanger, it is also preferable that the removal prevention member is provided with projections which project from respective wall portions toward the opposing wall portions, a hole which is provided on one of the projections, a pipe member which is provided on the other projection and passes through the hole, and a caulked portion which is provided on the ends of the projections for fastening the projections by being turning downward and caulking the end of the pipe member.

**[0025]** In the heat exchanger, it is also preferable that the removal prevention member is provided by extending a part of one of the opposing wall portions from each opening end of the heat-exchange tubes and bending toward the other wall portion so as to be fastened to the other wall portion.

#### BRIEF EXPLANATION OF THE DRAWINGS

**[0026]** Fig. 1 is an enlarged cross-sectional view of the main part of the heat exchanger according to the first

embodiment of the present invention.

**[0027]** Fig. 2 is an enlarged perspective view of the main part of the heat-exchange tube according to the first embodiment of the present invention.

**[0028]** Fig. 3 is an enlarged perspective view of the main part of the heat-exchange tube according to the second embodiment of the present invention.

**[0029]** Fig. 4 is an enlarged front view of the main part of the header which has an insertion hole according to the second embodiment of the present invention.

**[0030]** Fig. 5 is an enlarged perspective view of the main part of a variation of the heat-exchange tube according to the second embodiment of the present invention.

**[0031]** Fig. 6 is an enlarged front view of the main part of a variation of the header which has an insertion hole according to the second embodiment of the present invention.

**[0032]** Fig. 7 is an enlarged perspective view of the main part of another variation of the heat-exchange tube according to the second embodiment of the present invention.

**[0033]** Fig. 8 is an enlarged front view of the main part of another variation of the header which has an insertion hole according to the second embodiment of the present invention.

**[0034]** Fig. 9 is an enlarged perspective view of the main part of another variation of the heat-exchange tube according to the second embodiment of the present invention.

**[0035]** Fig. 10 is an enlarged front view of the main part of another variation of the header which has an insertion hole according to the second embodiment of the present invention.

**[0036]** Fig. 11 is an enlarged cross-sectional view of the main part of another variation of the heat exchanger according to the second embodiment of the present invention.

**[0037]** Fig. 12 is an enlarged perspective view of the main part of another variation of the heat-exchange tube according to the second embodiment of the present invention.

**[0038]** Fig. 13 is an enlarged front view of the main part of another variation of the header which has an insertion hole according to the second embodiment of the present invention.

**[0039]** Fig. 14 is an enlarged cross-sectional view of the main part of another variation of the heat exchanger according to the second embodiment of the present invention.

**[0040]** Fig. 15 is an enlarged perspective view of the main part of the heat-exchange tube according to the third embodiment of the present invention.

**[0041]** Fig. 16 is an enlarged plan view of the main part of the heat exchanger according to the third embodiment of the present invention.

**[0042]** Fig. 17 is an enlarged perspective view of the main part of the heat-exchange tube according to the

fourth embodiment of the present invention.

**[0043]** Fig. 18 is an enlarged cross-sectional view of the main part of the heat exchanger according to the fourth embodiment of the present invention.

**[0044]** Fig. 19 is an enlarged perspective view of the main part of the heat-exchange tube according to the fifth embodiment of the present invention.

**[0045]** Fig. 20 is an enlarged cross-sectional view of the main part of the heat exchanger according to the fifth embodiment of the present invention.

**[0046]** Fig. 21 is an enlarged perspective view of the main part of the heat-exchange tube according to the sixth embodiment of the present invention.

**[0047]** Fig. 22 is an enlarged cross-sectional view of the main part of the heat exchanger according to the sixth embodiment of the present invention.

**[0048]** Fig. 23 is a front view of a conventional heat exchanger.

**[0049]** Fig. 24 is an enlarged perspective view of the main part of the heat exchanger shown in Fig. 23.

**[0050]** Fig. 25 is an enlarged plan view of the main part of the heat exchanger shown in Fig. 23.

**[0051]** Fig. 26 is a cross-sectional view along the line A-A shown in Fig. 25.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0052]** The preferred embodiments of the present invention will be explained in the following with reference to the figures.

##### [First Embodiment]

**[0053]** Figs. 1 and 2 show a first embodiment of the heat exchanger of the present invention. A heat exchanger denoted by the symbol "A" has a similar structure to the conventional heat exchanger, which is disclosed in Fig. 23, and comprises: a pair of headers 10, 10 which are provided in parallel facing each other through a predetermined distance, and a pathway of the refrigerant (fluid) is respectively provided therein; a plurality of flat heat-exchange tubes 20, 20... which are provided in parallel between the headers 10, 10, both ends thereof are fastened to the headers 10, 10 and a pathway of the refrigerant for connecting the pathways of both headers is respectively provided therein; and a plurality of fins 30, 30... which are provided between the adjacent heat-exchange tubes 20, 20... to contact the outer surfaces of the heat-exchange tubes 20, 20... which face each other.

**[0054]** In the connecting structure between the headers 10, 10 and the heat-exchange tubes 20, 20..., end portions 21, 21... of the heat-exchange tubes 20, 20... are inserted into insertion holes 11, 11... which are bored on the header 10, 10, and air-tightly and liquid-tightly fastened to the header 10, 10.

**[0055]** Each heat-exchange tube 20 is constructed by

bending a belt-shaped metal plate 22 on which solder is clad on both surfaces thereof at a folding portion 23 provided along the longitudinal direction of the metal plate 22, and by forming a passage 27 for the refrigerant by attaching connecting end portions 26, 26 to the ends of the wall portions 24, 25 which are formed by bending and which extend along the longitudinal direction of the metal plate 22.

**[0056]** Furthermore, to stir the refrigerant which flows in the heat-exchange tubes 20, 20... in order to unify the temperature of the refrigerant, a plurality of bulging members 28, 28... project from the wall portions 24, 25 toward the opposing wall portions. Each of these bulging members 28, 28... has a truncated-cone shape, and a flat connecting portion 28a is provided on the connecting end thereof. The connecting portions 28a, 28a... of the opposing bulging members 28, 28... contact each other.

**[0057]** In addition, a notch 16 is provided on the connecting end portions 26, 26 of each end portion 21 so as to unify the inserted length of the end portion 21 by attaching the notch 16 to the edge of the insertion hole 11 when the end portion 21 is inserted into the insertion hole 11.

**[0058]** Furthermore, in the vicinity of opening ends 29 of both end portions 21 of the flat heat-exchange tube 20, reinforcement members 40, 40..., which project from the wall portions 24, 25 toward the opposing wall portions, are formed. The connecting ends of opposed reinforcement members 40, 40... contact each other and shape-holding portions 41 for preventing the deformation of the opening ends 29 are provided by these contacted reinforcement members 40, 40...

**[0059]** In the heat exchanger A which has the above-described structure, when the end portions 21 of the flat heat-exchange tubes 20 are cut along the surface which is perpendicular to the wall portions 24, 25 to form the opening ends 29, the reinforcement members 40, 40..., which project from the wall portions 24, 25 and which contact each other, support the wall portions 24, 25 along the cutting direction, and therefore, deformation of the wall portions 24, 25 is prevented by the shape-holding portions 41. Furthermore, the shapes of the opening ends 29 are maintained by preventing the deformation of the wall portions 24, 25, since the opening ends 29 are formed at the cutting surface of the end portions 21, and therefore, the end portions 21 are smoothly inserted and closely connected with the insertion holes 11.

**[0060]** Furthermore, the reinforcement members 40, 40... are composed of projections which are smaller than the bulging members 28, 28... because they are not designed for stirring the refrigerant which flows in the heat-exchange tube 20, and therefore, problems caused by sudden expansion/contraction of the refrigerant can be prevented if the reinforcement members 40, 40... are provided adjacent to the opening ends 29.

**[0061]** In the heat exchanger A shown in Figs. 1 and 2, deformation of the opening ends 29 can be prevented,

and therefore, the end portions 21 can be connected with the insertion holes 11, braze-welding between the end portions 21 and the insertion holes 11 can be performed more properly, and the sealing performance of the heat exchanger can be improved.

[Second Embodiment]

**[0062]** Figs. 3 and 4 show a second embodiment of the heat exchanger of the present invention. A heat-exchange tube 20 constitutes a main part of the heat exchanger denoted by the symbol "B" (refer to Fig. 11, for example) and comprises a pair of belt-shaped plates 22a, 22b which extend along the longitudinal direction of the heat-exchange tube 20. A passage 27 for the refrigerant is provided between the plates 22a, 22b, by attaching connecting end portions 26a, 26b which project from both ends of plates 22a, 22b and extend along the longitudinal direction of the plates 22a, 22b. Furthermore, an insertion end portion 50, in which the width thereof between the opposing connecting end portions 26a, 26b (the width between the opposing side walls of the heat-exchange tube 20) becomes narrower as it approaches the opening end 29, is provided on each end portion 21 of the heat-exchange tube 20.

**[0063]** In addition, a contacting portion 60 is provided on wall portions 24, 25 of the insertion end portion 50. The contacting portion 60 is constructed of a pair of grooves 61, 62 which extends along the longitudinal direction of the heat-exchange tube 20. These grooves 61, 62 bulge toward the opposing wall portions 24, 25 at reference positions 24a, 25a on the wall portions 24, 25, and return to the reference positions 24a, 25a in roughly V-shaped sections. Here, the heights of the grooves 61, 62 are set to about one-fourth of the distance between the opposing wall portions 24, 25, and the width of the grooves 61, 62 are set to about one-tenth of the width between the opposing connecting end portions 26a, 26b. Furthermore, the increased amount of the length along the perimeter of each end portion 21 resulting from the formation of the contacting portion 60 is about one-tenth of the original length along the perimeter of the end portion 21.

**[0064]** In addition, an insertion hole 11 in which the heat-exchange tube 20 is connected has a shape corresponding to the shape of the insertion end portion 50 in which the contacting portion 60 is provided. That is, the insertion hole 11 has the same shape as the sectional shape of the insertion end portion 50 when the insertion end portion 50 is cut along a surface which is parallel to the opening end 29 at a predetermined position. A pair of notches 11a, 11b, in which the connecting end portions 26a, 26b are connected, is formed at both ends of the flat insertion hole 11, and a pair of chevron-shaped projections 111, 112, in which the grooves 61, 62 are connected, is formed on the top and bottom of the flat insertion hole 11.

**[0065]** In Figs. 3 and 4, other parts which correspond

to the parts in Figs. 1 and 2 are given the same reference numbers, and an explanation is omitted.

**[0066]** In the heat exchanger B which has the above-described structure, the opening ends 29 are smaller than the insertion holes 11. Therefore, when the end portions 21 of the flat heat-exchange tubes 20 are cut along the surface which is perpendicular to the wall portions 24, 25 to form the opening ends 29, the end portions 21 are smoothly inserted into the insertion holes 11 even if the opening ends 29 are deformed along the cutting direction thereof. These deformations not only arise in the opening ends 29, but also in the end portions 21 in the vicinity of the opening ends 29; however, the deformed end portions 21 can be entirely inserted into the insertion holes 11 by including the entire deformed end portions 21 in the insertion end portions 50, and therefore, the end portions 21 are closely connected with the insertion holes 11 at the predetermined position.

**[0067]** The insertion holes 11 are larger than the opening ends 29 and smaller than the cross-sectional shape of the heat-exchange tubes 20, since the insertion holes 11 are formed in compliance with the insertion end portions 50. Therefore, the heat-exchange tubes 20 make contact with the insertion holes 11 at the insertion end portions 50, and the insertion end portions 50 are closely connected with the insertion holes 11. Furthermore, since the width between the opposing walls of each insertion end portion 50 enlarges as the distance from the opening end 29 increases, when a force is applied on each heat-exchange tube 20 in order to insert the heat-exchange tube 20 into the insertion hole more deeply, the insertion end portion 50 and the insertion hole 11 are elastically deformed, and the contact area between the insertion end portion 50 and the insertion hole 11 is increased. In addition, the insertion end portion 50, which presses against the insertion hole 11 in the enlarging direction, receives a reaction force which tightens the insertion end portion 50 in the insertion hole 11.

**[0068]** Furthermore, even when each insertion end portion 50 is not completely connected with the insertion hole 11 by reasons concerning their processing accuracy, for example, when complicated deformations such as a warp or distortion of the insertion end portion 50 which is not restricted a regular deformation in a certain direction or a defect of the insertion hole 11 which is caused by uneven cutting, exist, a point(s) at which the insertion end portion 50 and the insertion hole 11 is definitely contacted can be ensured on the contacting portion 60. For example, even when the insertion end portion 50 contacts adjacent to the corner of the insertion hole 11 on a roughly diagonal line thereof, since the grooves 61, 62 of the contacting portion 60 which bulge to form V-shaped sections have inclined surfaces, the grooves 61, 62 definitely contact the chevron-shaped projections 111, 112 of the insertion hole 11 at the inclined surface. On the other hand, the increased amount of the length along the perimeter of the insertion end

portion 50 by the formation of the contacting portion 60 is about one-tenth of the original length along the perimeter of the insertion end portion 50. Therefore, the amount of contact between the insertion end portion 50 and the insertion hole 11 is definitely increased due to the formation of the contacting portion 60.

**[0069]** In the heat exchanger B shown in Figs. 3 and 4, the opening end 29 and end portion 21 adjacent to the opening end 29 which are deformed as a result of cutting, are smaller than the insertion hole 11, and therefore, the deformed end portion can be entirely inserted into the insertion hole 11. As a result, the end portion 21 can be connected with the insertion hole 11 at the insertion end portion 50, and therefore, braze-welding between the insertion end portion 50 and the insertion hole 11 can be performed more properly, and the sealing performance of the heat exchanger B can be improved.

**[0070]** Furthermore, the numbers of contact points and the amount of contact between the insertion end portion 50 and the insertion hole 11 can be increased through the formation of the contacting portion 60. Therefore, braze-welding between the insertion end portion 50 and the insertion hole 11 can be performed more properly, and the sealing performance of the heat exchanger B can be improved.

**[0071]** Furthermore, since the width between the opposing walls of each insertion end portion 50 is enlarged as the distance from the opening end 29 increases, the insertion end portion 50, which presses against the insertion hole 11 in the enlarging direction, receives a reaction force which tightens the insertion end portion 50 in the insertion hole 11, and therefore, the deformation caused by the spring back force which acts to separate the wall portions 24, 25 which are positioned on the top and bottom facing each other, can be prevented. Consequently, braze-welding between each of the connecting portions 26a, 26a, 26b, 26b, and the opposing bulging members 28, 28... projecting from the end portion 21 of the heat-exchange tube 20 in which the fins 30 cannot be provided, can be performed more properly, and the sealing performance and resistance against the pressure of the heat exchanger B can be improved.

**[0072]** In addition, in the above-described embodiment, the grooves 61, 62 which bulge inwardly from the wall portions 24, 25 of each insertion end portion 50 are provided as the contacting portion 60; however, as shown in Figs. 5 and 6, bulging portions 63, 64 which bulge outwardly from the wall portions 24, 25 may be provided on the outer surface of each insertion end portion 50 as the contacting portion 60. The bulging portions 63, 64 have roughly semicircular-shaped sections and sizes roughly the same as that of the grooves 61, 62 in their lengths, heights, and widths. In this case, a pair of semicircular-shaped grooves 113, 114 in which the bulging portions 63, 64 are connected, is formed at the top and bottom of each insertion hole 11.

**[0073]** Furthermore, as shown in Figs. 7 and 8, in the heat exchanger B, bulging portions 65, 66 which bulge

outwardly from the wall portions 24, 25, may also be provided on the outer surface of each insertion end portion 50 as the contacting portion 60. The bulging portions 65, 66 have wide top or bottom end surface and heights roughly the same as that of the bulging portions 63, 64. In this case, a pair of notches 115, 116, which have shapes so as to connect with the bulging portions 65, 66, is formed at the top and bottom of each insertion hole 11.

**[0074]** Furthermore, as shown in Figs. 9, 10 and 11, in the heat exchanger B, curved portions 67, 68 which have curved surfaces curved inwardly toward the center portions of wall portions 24, 25 and which have heights roughly the same as that of the grooves 61, 62 may also be provided on the tip portion of each insertion end portion 50 as the contacting portion 60. In this case, a pair of curved edges 117, 118, which have shapes so as to connect with the curved portions 67, 68, are formed at the top and bottom of each insertion hole 11.

**[0075]** Furthermore, as shown in Figs. 12, 13 and 14, in the heat exchanger B, an oval portion 69 which has a curved surface bulging outwardly from the outer surface of the wall portions 24, 25 along the perimeter thereof, may also be provided on the base portion of the insertion end portion 50, that is, the position at which the width of the insertion end portion 50 becomes equal to that of the heat-exchange tube 20, of each insertion end portion 50 as the contacting portion 60. In this case, each insertion hole 11 forms an oval hole 119 in order to connect with the heat-exchange tube 20 closely at the point at which the oval portions 69 are formed.

**[0076]** In these example, since the contacting portion 60 as described above is provided at the outer surface of each insertion end portion 50, even when complicated deformations such as a warp or distortion of the insertion end portion 50 which is not restricted a regular deformation in a certain direction or a defect of the insertion hole 11 which is caused by uneven cutting exist, a connection between the insertion end portion 50 and the insertion hole 11 can be performed more certainly. Furthermore, the increased amounts of the lengths along the perimeter of the insertion end portions 50 by the formation of the contacting portions 60 are about one tenth of the original lengths along the perimeter of the insertion end portions 50. Therefore, the amount of contact between each insertion end portion 50 and the insertion hole 11 is definitely increased through the formation of the contacting portion 60, braze-welding can be performed more properly, and the sealing performance of the heat exchanger B can be improved..

**[0077]** Furthermore, when the oval portion 69 is employed as the contacting portion 60, since each insertion end portion 50 makes contact with the oval hole 119 on the oval portion 69 of the curved surface which faces the opening end 29, when the oval portion 69 is inserted into the oval hole 119, contact points between the oval portion 69 and the oval hole 119 are increased by the elastic deformation thereof as the insertion force of the

oval portion 69 is increased as well as the reaction force from the oval hole 119 which tighten the oval portion 69, and therefore, the deformation due to a spring back force which separates the wall portions 24, 25 which are positioned on the top and bottom facing each other, can be prevented.

[Third Embodiment]

**[0078]** Figs. 15 and 16 show a third embodiment of the heat exchanger of the present invention. In a heat-exchange tube 20 constituting a main part of the heat exchanger denoted by the symbol "C" shown in Figs. 15 and 16, a corner 29a of the opening end 29 is partly cut off. Furthermore, one of the connecting portions 26, 26 is outwardly extended and bent to form a U-shaped fastening plate 26c which fastens the connecting portions 26, 26.

**[0079]** In Figs. 15 and 16, other parts which correspond to the parts in Figs. 1 to 14 are given the same reference numbers, and an explanation is omitted.

**[0080]** When cutting the end portion 21 along the surface which is perpendicular to the opposing wall portions 24, 25 of the flat heat-exchange tube 20 in order to produce the opening ends 29, even if the opening end 29 is deformed along the cutting direction thereof and the width of the opening end 29 is extended, the width of an end of the opening end 29 becomes narrower than the insertion hole 11 because the corner 29a of the opening end 29 is cut off, and therefore, the end portion 21 is smoothly inserted into the insertion hole 11. Here, the cut-off of the corner 29a beginning from the opening end 29 in order to prevent additional deformation of the wall portions 24, 25. In actuality, deformations not only arise in the opening end 29, but also in the end portion 21 in the vicinity of the opening end 29, and the width of the end portion is also extended in the vicinity of the opening end 29, however, since the deformation of the end portion 21 decreases with the distance from the opening end 29, the deformed end portion 21 is entirely inserted into the insertion hole 11 by including the entire deformed end portion 21 in the insertion hole 11, and therefore, the end portion 21 is closely connected with the insertion hole 11 at the predetermined position in which the deformation does not arise.

**[0081]** In the heat exchanger C shown in Figs. 15 and 16, the end of the opening end 29 which is deformed by cutting can be smoothly inserted into the insertion hole 11 because the width of the opening end 29 becomes narrower than the insertion hole 11 by cut-off of the corner 29a of the opening end 29. Then, the end portion 21 can be closely connected with the insertion holes 11, and therefore, braze-welding between the end portion 21 and the insertion hole 11 can be performed more properly, and the sealing performance of the heat exchanger C can be improved.

**[0082]** Furthermore, as the result of clipping the corner 29a, the area of the end portion 21 which is inserted

into the header 10 through the insertion hole 1 and the amount of the inserted area in the pathway of the refrigerant when the header 10 along the longitudinal direction are decreased, and the loss of the refrigerant can be reduced in comparison with that of when the corner 29a is not cut off.

**[0083]** In addition, the corner 29a of the opening end 29 is cut off in a straight line in this embodiment; however, a larger area can be cut off as long as the corner 29a is included. Furthermore, it is not necessary to cut off the opening end 29 in a straight line. As a result of these improvements, the opening end 29 which is deformed can be more smoothly inserted into the insertion hole 11 because the width of an end of the opening end 29 becomes more narrow, and the loss of the refrigerant can be reduced more.

[Fourth Embodiment]

**[0084]** Figs. 17 and 18 show a fourth embodiment of the heat exchanger of the present invention. In heat-exchange tubes 20 constituting the main parts of the heat exchanger denoted by the symbol "D" shown in Figs. 17 and 18, the contact ends of the opposing bulging members 28, 28... projecting from the end portions 21 of the heat-exchange tubes 20 in which the fins 30, 30... cannot be provided, are welded by laser, and these laser-welded bulging members 28, 28... provide a removal prevention member 70.

**[0085]** In Figs. 17 and 18, other parts which correspond to the parts in Figs. 1 to 16 are given the same reference numbers, and an explanation is omitted.

**[0086]** In the heat-exchange tubes 20 formed by bending a metal plate, forces which deform the tubes along the opening direction of the tubes and which separate the upper and lower wall portions 24, 25 which face each other, is produced by a spring back force. However, the deformations caused by the spring back force are prevented as a result of the connection of the wall portions 24, 25 by the laser-welding of the contact ends of the opposing bulging members 28, 28....

**[0087]** In the heat exchanger D shown in Figs. 17 and 18, the deformations of the wall portions 24, 25 of the flat heat-exchange tubes 20 caused by the spring back force can be prevented by the connection of the wall portions 24, 25 by the laser-welding of the contact ends of the opposing bulging members 28, 28. Therefore, braze-welding between the connecting portions 28a, 28a..., which contact each other, and the opposing bulging members 28, 28..., can be performed more properly, and resistance against the pressure of the heat exchanger D can be improved; as braze-welding between the connecting end portions 26, 26 can be performed more properly as well, and the sealing performance and resistance against the pressure of the heat exchanger D can be improved.

## [Fifth Embodiment]

**[0088]** Figs. 19 and 20 show a fifth embodiment of the heat exchanger of the present invention. In heat-exchange tubes 20 constituting the main parts of the heat exchanger denoted by the symbol "E" shown in Figs. 19 and 20, a pair of projections which face each other are provided on the wall portions 24, 25 at the end portions 21 nearby. Each upper projection has a hole 71 and each lower projection has a pipe member 72. The end of the pipe member 72 which passes through the hole 71 is turned downward and caulked, and therefore, a caulked portion 73 is provided on the ends of the projections and the projections are fastened by this caulked portion 73. Namely, in this embodiment, the projections which are fastened by the caulked portion 73 provide a removal prevention member 70.

**[0089]** In Figs. 19 and 20, other parts which correspond to the parts in Figs. 1 to 18 are given the same reference numbers, and an explanation is omitted.

**[0090]** In the heat-exchange tubes 20 formed by bending a metal plate, forces which deform the tubes along the opening direction of the tubes and which separate the upper and lower wall portions 24, 25 which face each other, are produced by a spring back force. However, the deformations by the spring back force are prevented as a result of the connection of the wall portions 24, 25 by the caulked portion 73.

**[0091]** In the heat exchanger E shown in Figs. 19 and 20, the deformations of the wall portions 24, 25 of the flat heat-exchange tubes 20 by the spring back force can be prevented by the connection of the wall portions 24, 25 by the caulked portion 73. Therefore, braze-welding between the connecting portions 28a, 28a... which contact each other, of the opposing bulging members 28, 28..., can be performed more properly, and resistance against the pressure of the heat exchanger E can be improved; as braze-welding between the connecting end portions 26, 26 can be performed more properly as well, and the sealing performance and resistance against the pressure of the heat exchanger E can be improved.

**[0092]** In addition, in this embodiment, the projections of the wall portions 24, 25 are fastened by caulking the ends thereof; however, the projections may be also fastened by welding or by using a rivet, a stapler, or the like.

## [Sixth Embodiment]

**[0093]** Figs. 21 and 22 show a sixth embodiment of the heat exchanger of the present invention. In heat-exchange tubes 20 constituting the main parts of the heat exchanger denoted by the symbol "F" shown in Figs. 21 and 22, a part of each lower wall portion 25 is extended from the opening end 29. This extended part bends upward and toward the upper wall portion 24, and forms a fastening clip 74 which is fastened to the wall portion 24. Namely, in this embodiment, the fastening clip 74, which

is formed at the opening end 29, provides a removal prevention member 70. Furthermore, an opening which has a shape corresponding to the fastening clip 74 is provided at the upper end of each insertion hole 11 so as to engage with the fastening clip 74.

**[0094]** In Figs. 21 and 22, other parts which correspond to the parts in Figs. 1 to 20 are given the same reference numbers, and an explanation is omitted.

**[0095]** In the heat-exchange tubes 20 formed by bending a metal plate, forces which deform the tubes along the opening direction of the tubes and which separate the upper and lower wall portions 24, 25 which face each other, are produced by a spring back force. However, the deformations by the spring back force are prevented as a result of the connection of the wall portions 24, 25 by the fastening clip 74.

**[0096]** In the heat exchanger F shown in Figs. 21 and 22, the deformations of the wall portions 24, 25 of the flat heat-exchange tubes 20 by the spring back force can be prevented by the connection of the wall portions 24, 25 by the fastening clip 74. Therefore, braze-welding between the connecting portions 28a, 28a... which contact each other, of the opposing bulging members 28, 28..., can be performed more properly, and resistance against the pressure of the heat exchanger F can be improved; as braze-welding between the connecting end portions 26, 26 can be performed more properly as well, and the sealing performance and resistance against the pressure of the heat exchanger F can be improved.

**[0097]** In addition, in the above-described embodiments, in order to achieve a high braze-welding property of the heat exchanger for improving its sealing performance and resistance against the pressure, one of the shape-holding portions 41, the insertion end portions 50 having contacting portions 60, the opening ends 29 in which the comers 29a are partly cut off, or the removal prevention members 70, is provided, however, these means can be simultaneously provided within the same heat exchanger.

## Claims

## 1. A heat exchanger comprising:

a pair of headers (10, 10) which are provided in parallel to face through a predetermined distance and a pathway of the fluid is respectively provided therein; a plurality of flat heat-exchange tubes (20, 20...) which are provided between said headers in parallel, both ends thereof are fastened to said headers and a pathway of the refrigerant for connecting the pathways of both headers is respectively provided therein, wherein connecting structures between said headers and heat-exchange tubes are provided by inserting end portions (21, 21...) of said heat-ex-

change tubes into insertion holes (11, 11...) which are bored on said headers, and air-tightly and liquid-tightly fastening said headers and heat-exchange tubes; and  
 shape-holding portions (41) for preventing the deformation of opening ends (29) of said heat-exchange tubes are provided in the vicinity of the opening ends of each heat-exchange tube.

2. A heat exchanger according to claim 1, wherein said shape-holding portions are provided by reinforcement members (40, 40...) which project from at least one of opposing wall portion (24, 25) of said heat-exchange tube toward the opposing wall portion, and the connecting ends of opposing reinforcement members are in contact with each other.
3. A heat exchanger comprising:

a pair of headers (10, 10) which are provided in parallel facing each other through a predetermined distance and a pathway of the fluid is respectively provided therein; a plurality of flat heat-exchange tubes (20, 20...) which are provided between said headers in parallel, both ends thereof are fastened to said headers, and a pathway of the refrigerant for connecting the pathways of both headers is respectively provided therein, wherein  
 connecting structures between said headers and heat-exchange tubes are provided by inserting end portions (21, 21...) of said heat-exchange tubes into insertion holes (11, 11...) which are bored on said headers, and air-tightly and liquid-tightly fastening said headers and heat-exchange tubes; and  
 an insertion end portion (50), in which the width thereof between opposing side walls of said heat-exchange tubes becomes narrower as it approaches an opening end (29) of said heat-exchange tubes, which is provided on each end portion of said heat-exchange tubes.

4. A heat exchanger according to claim 3, wherein each of said insertion holes has a shape corresponding to the shape of said insertion end portion.
5. A heat exchanger according to claim 4, wherein said insertion end portion has a contacting portion (60) which inwardly or outwardly projects from the outer surface thereof, and each insertion hole has a shape corresponding to the shape of said insertion end portion in which said contacting portion is provided.
6. A heat exchanger comprising:

a pair of headers (10, 10) which are provided

in parallel facing each other through a predetermined distance and a pathway of the fluid is respectively provided therein; a plurality of flat heat-exchange tubes (20, 20...) which are provided between said headers in parallel, both ends thereof are fastened to said headers, and a pathway of the refrigerant for connecting the pathways of both headers is respectively provided therein, wherein

connecting structures between said headers and heat-exchange tubes are provided by inserting end portions (21, 21...) of said heat-exchange tubes into insertion holes (11, 11...) which are bored on the header, and air-tightly and liquid-tightly fastening said header and heat-exchange tubes; and  
 a corner (29a) of an opening end (29) of each heat-exchange tube is partly cut off.

7. A heat exchanger comprising:

a pair of headers (10, 10) which are provided in parallel facing each other through a predetermined distance and a pathway of the fluid is respectively provided therein; a plurality of flat heat-exchange tubes (20, 20...) which are provided between said headers in parallel, both ends thereof are fastened to said headers, and a pathway of the refrigerant for connecting the pathways of both headers is respectively provided therein, wherein  
 connecting structures between said headers and heat-exchange tubes are provided by inserting end portions (21, 21...) of said heat-exchange tubes into insertion holes (11, 11...) which are bored on the header, and air-tightly and liquid-tightly fastening said header and heat-exchange tubes; and  
 a removal prevention member (70) which is fastened to opposing wall portions (24, 25) of each heat-exchange tube for preventing the deformation of said heat-exchange tube caused by the removal of said wall portions, an which is provided on at least one of said wall portions.

8. A heat exchanger according to claim 7, wherein said removal prevention member is provided by bulging members (28, 28...) which project from respective wall portions toward the opposing wall portions, and the connecting ends of said opposing bulging members contact each other and are welded by laser.
9. A heat exchanger according to claim 7, wherein said removal prevention member is provided by projections which project from respective wall portions toward the opposing wall portions, a hole (71) which is provided on one of the projections, a pipe

member (72) which is provided on the other projection and passes through the hole, and a caulked portion (73) which is provided on the ends of said projections for fastening said projections by turned downward and caulking the end of said pipe member. 5

10. A heat exchanger according to claim 7, wherein said removal prevention member is provided by extending a part of one of the opposing wall portions 10 from each opening end (29) of said heat-exchange tubes and bending toward the other wall portion so as to be fastened to the other wall portion.

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FIG. 1

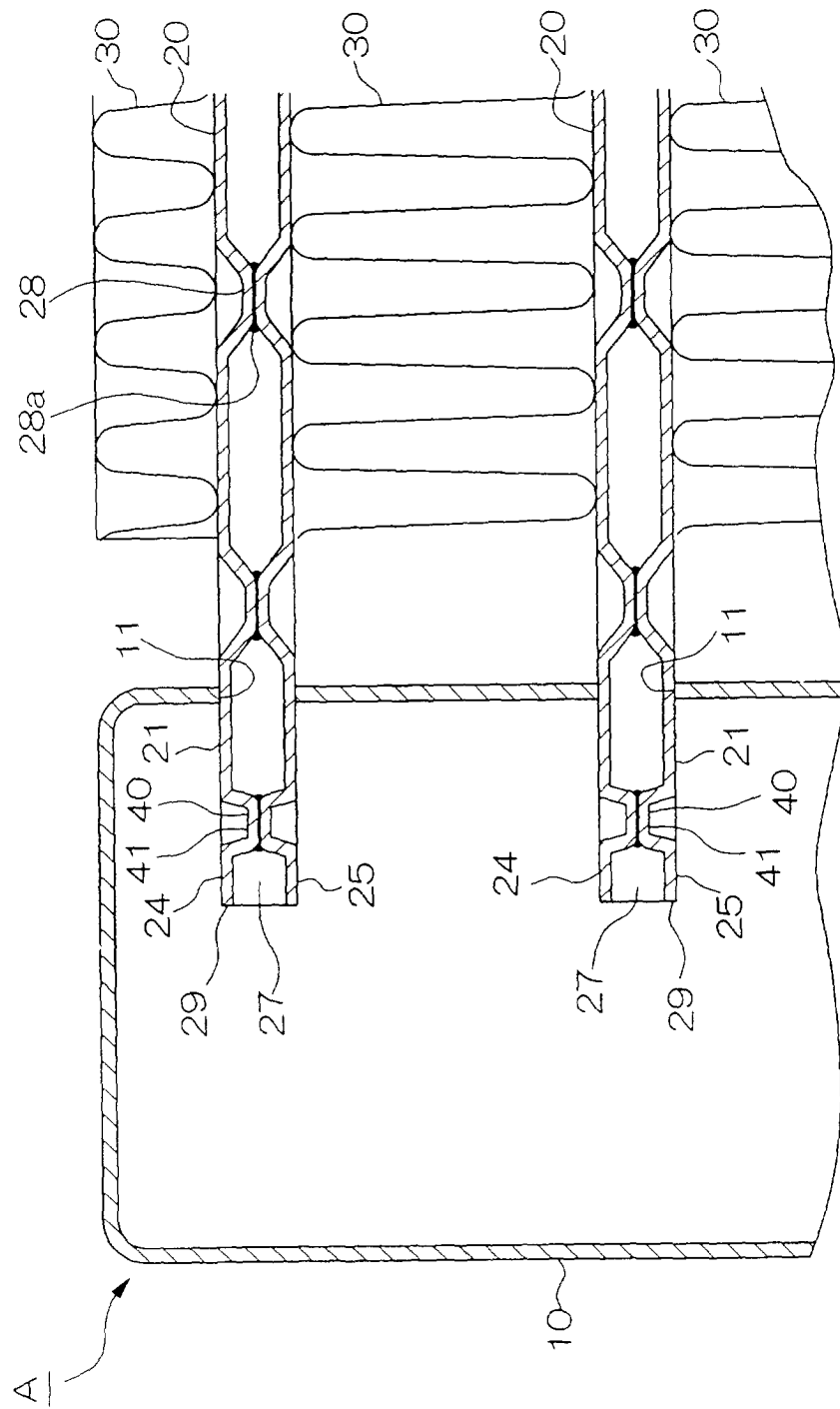


FIG. 2

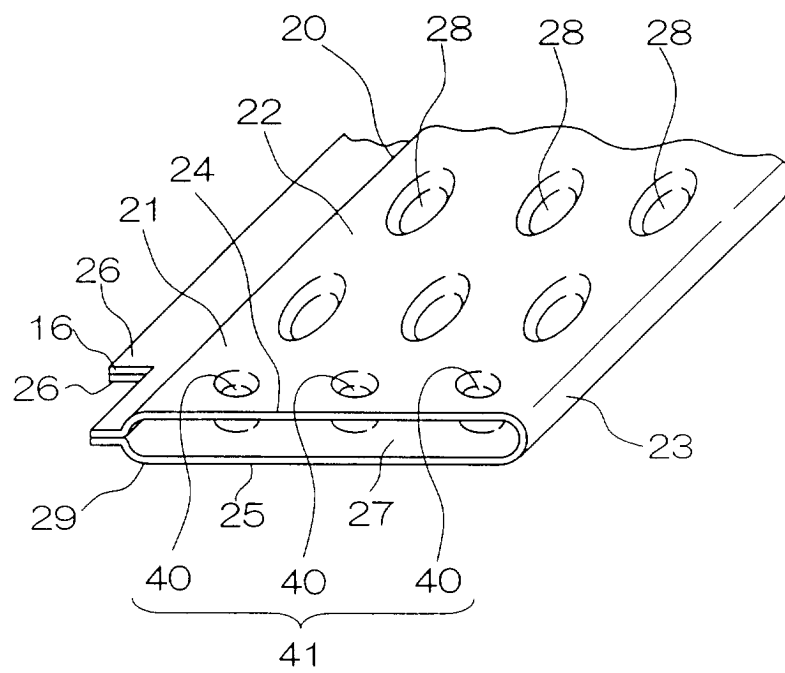


FIG. 3

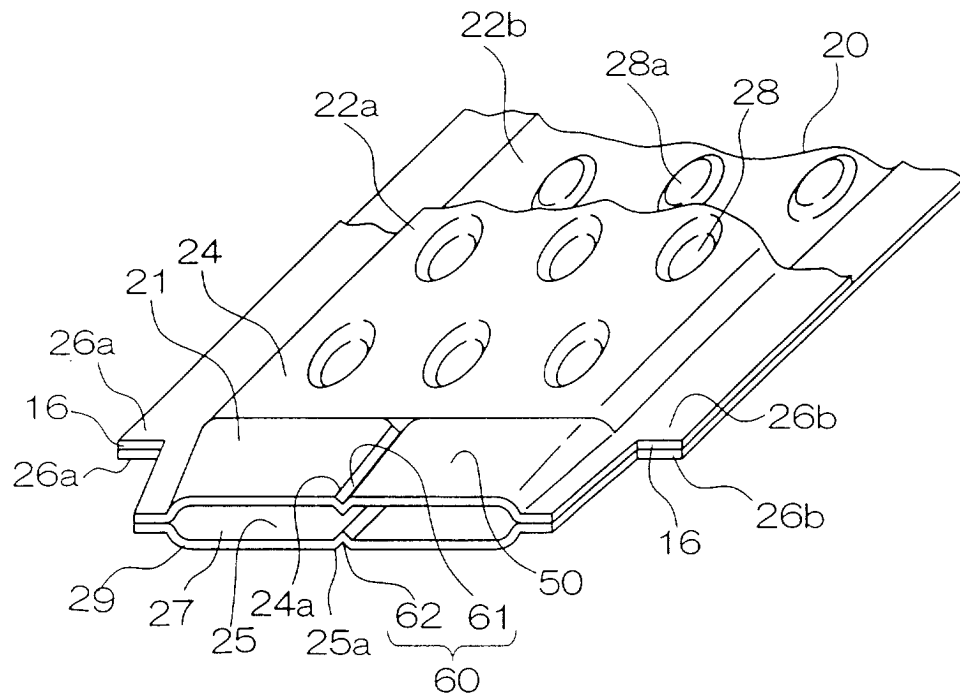


FIG. 4

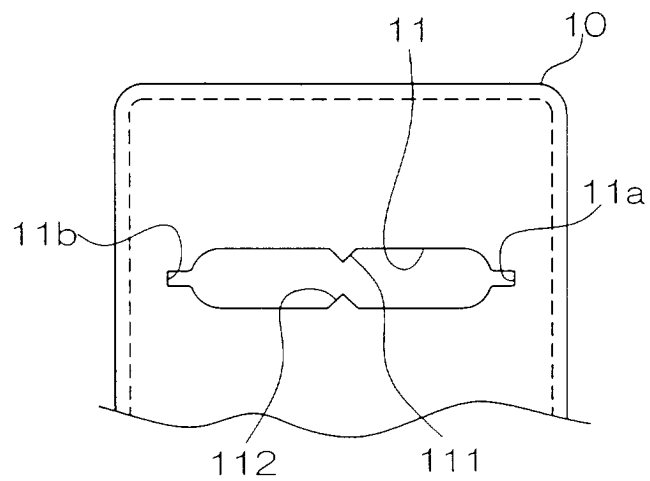


FIG. 5

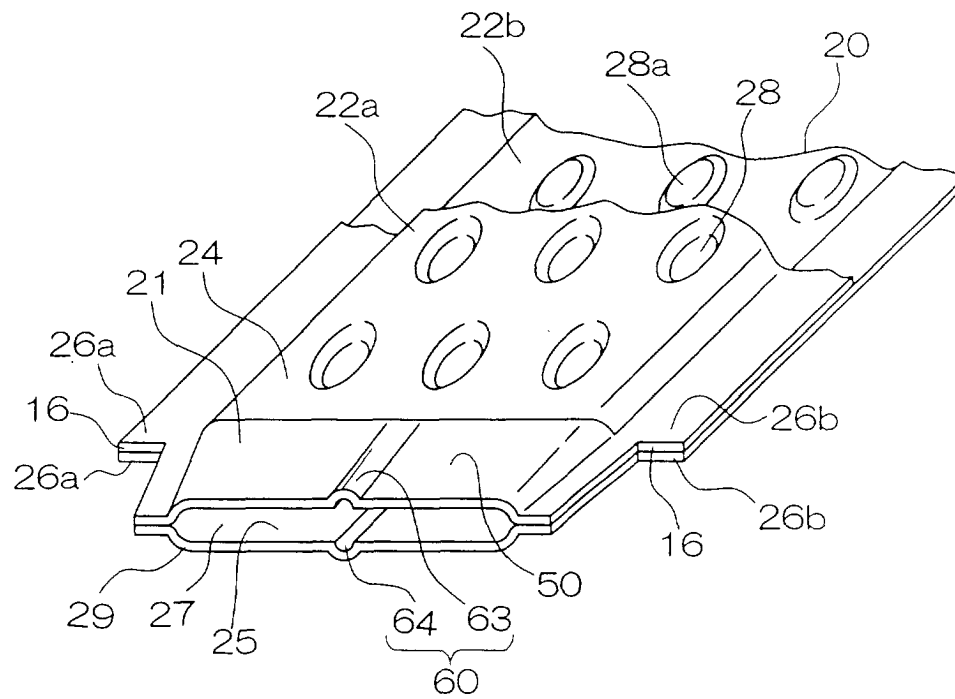


FIG. 6

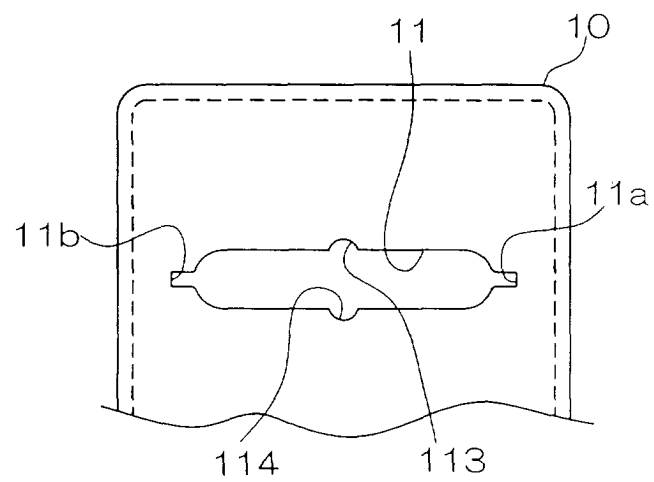


FIG. 7

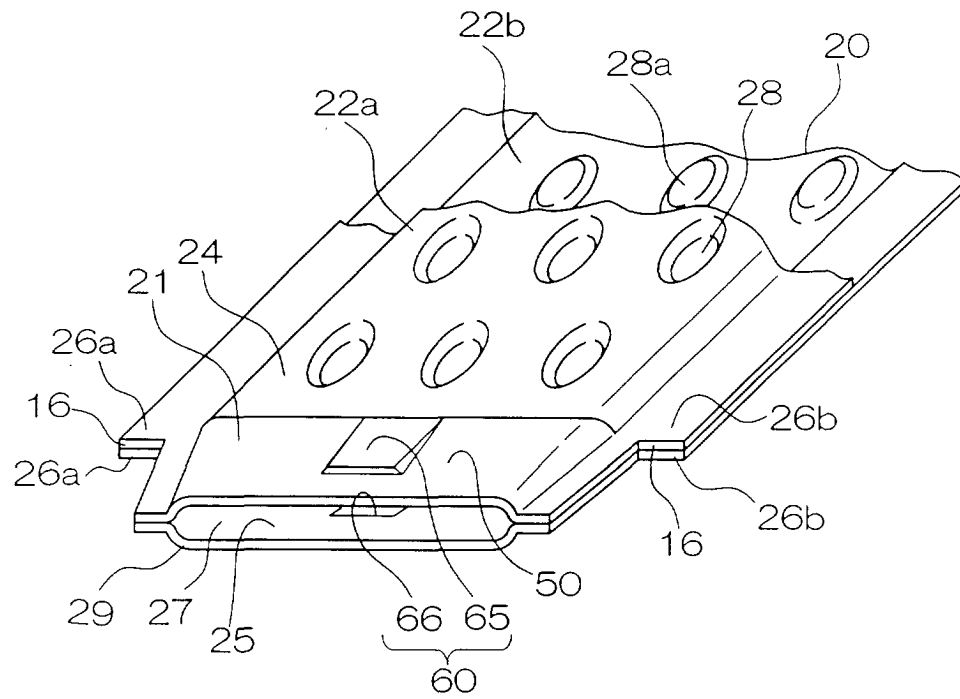


FIG. 8

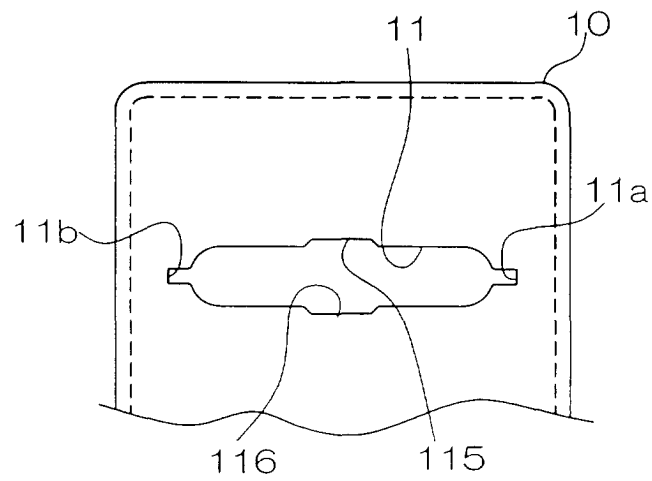


FIG. 9

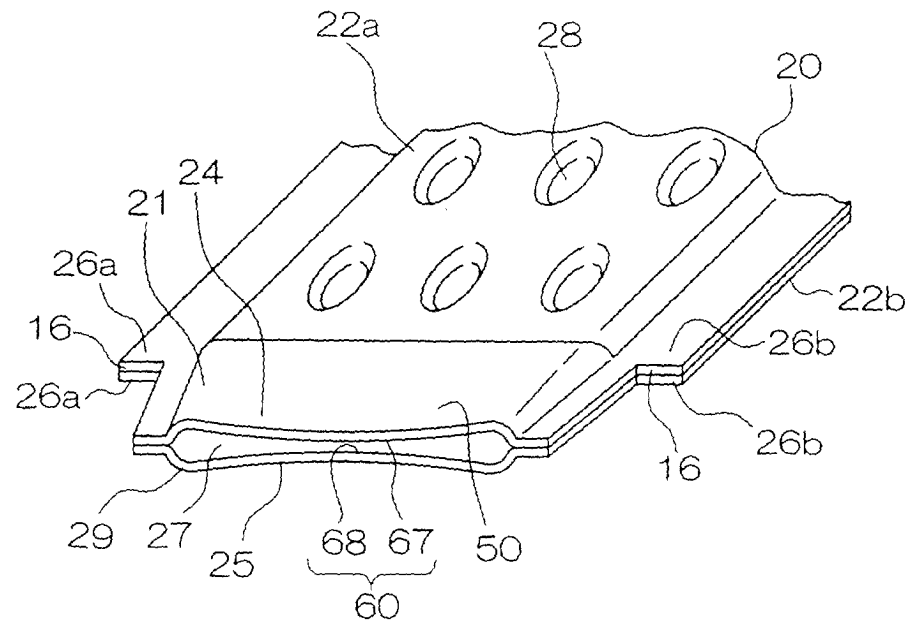


FIG. 10

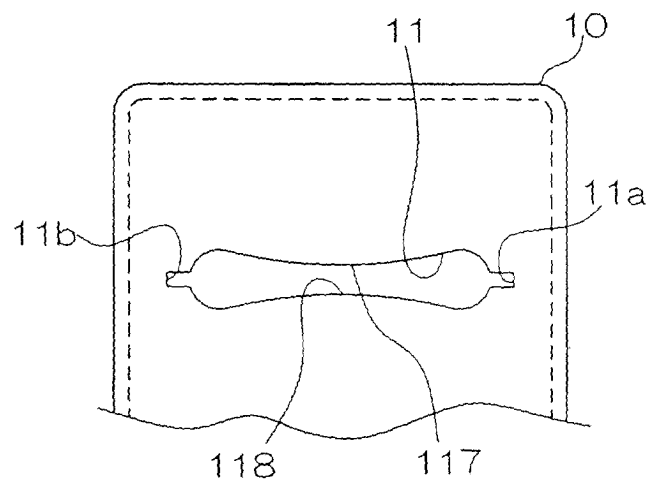


FIG. 11

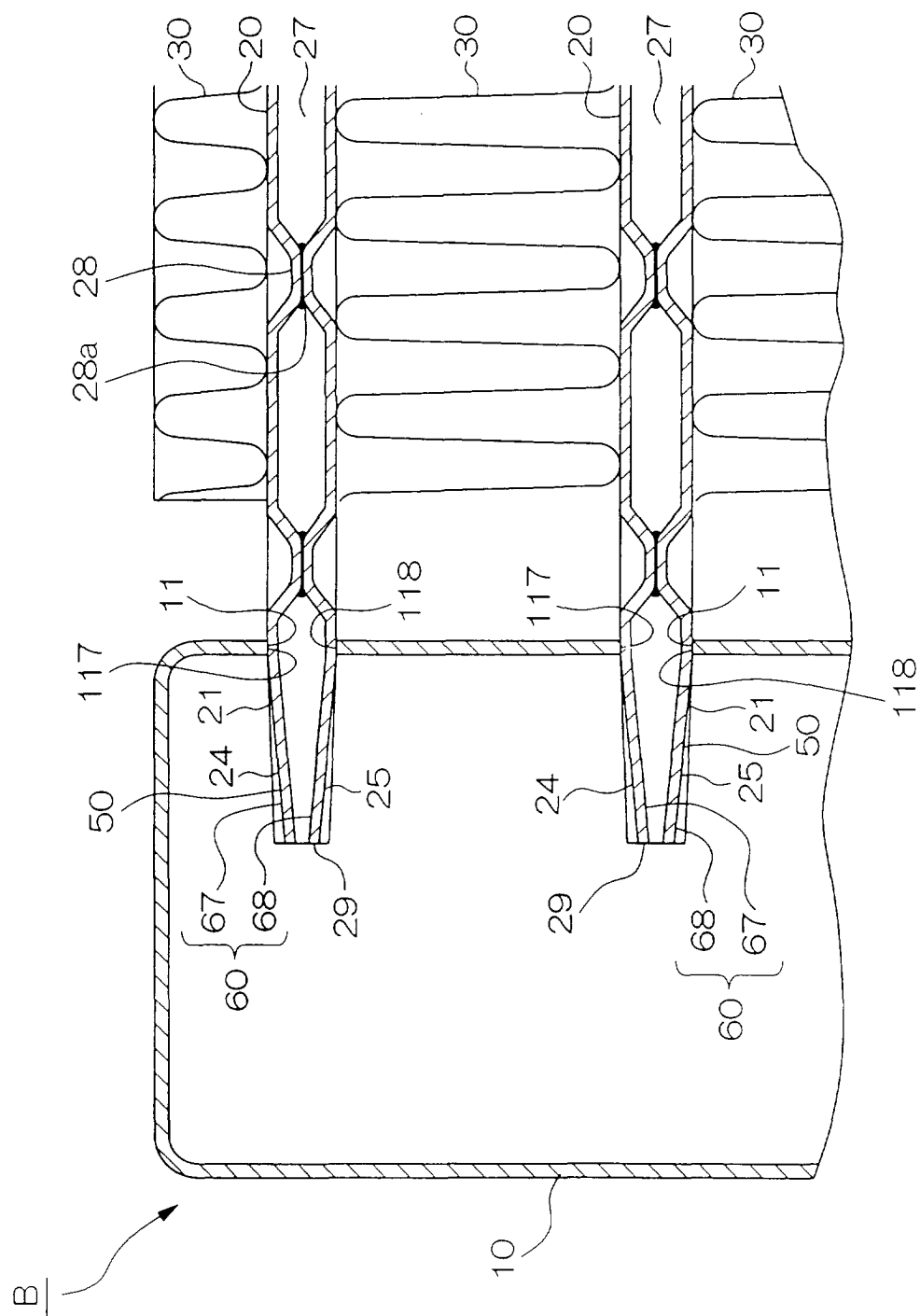


FIG. 12

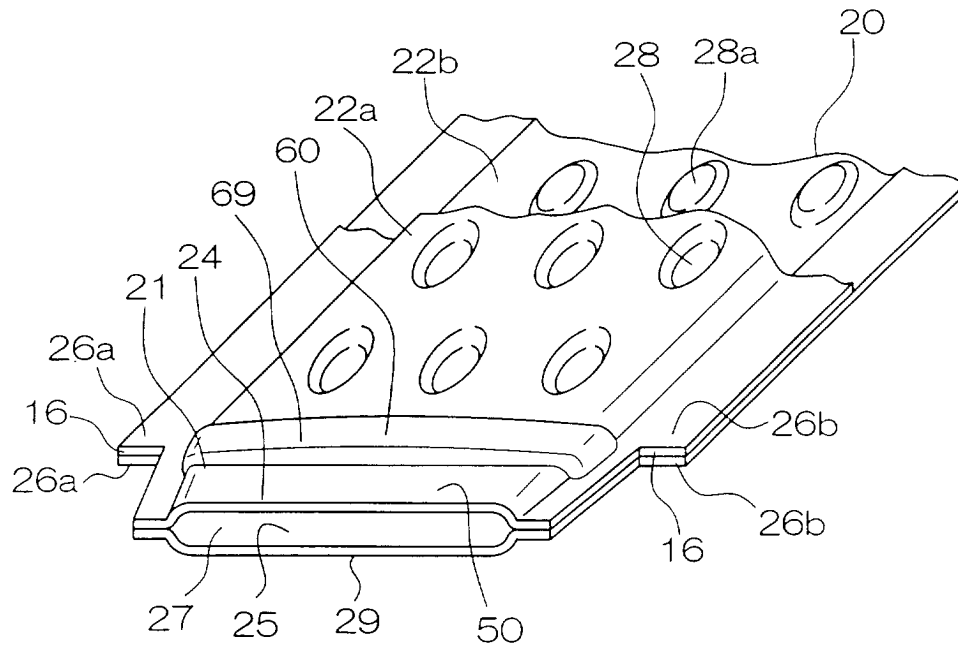


FIG. 13

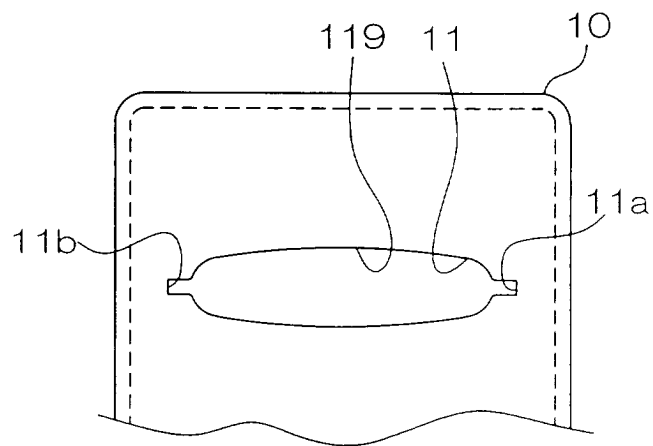


FIG. 14

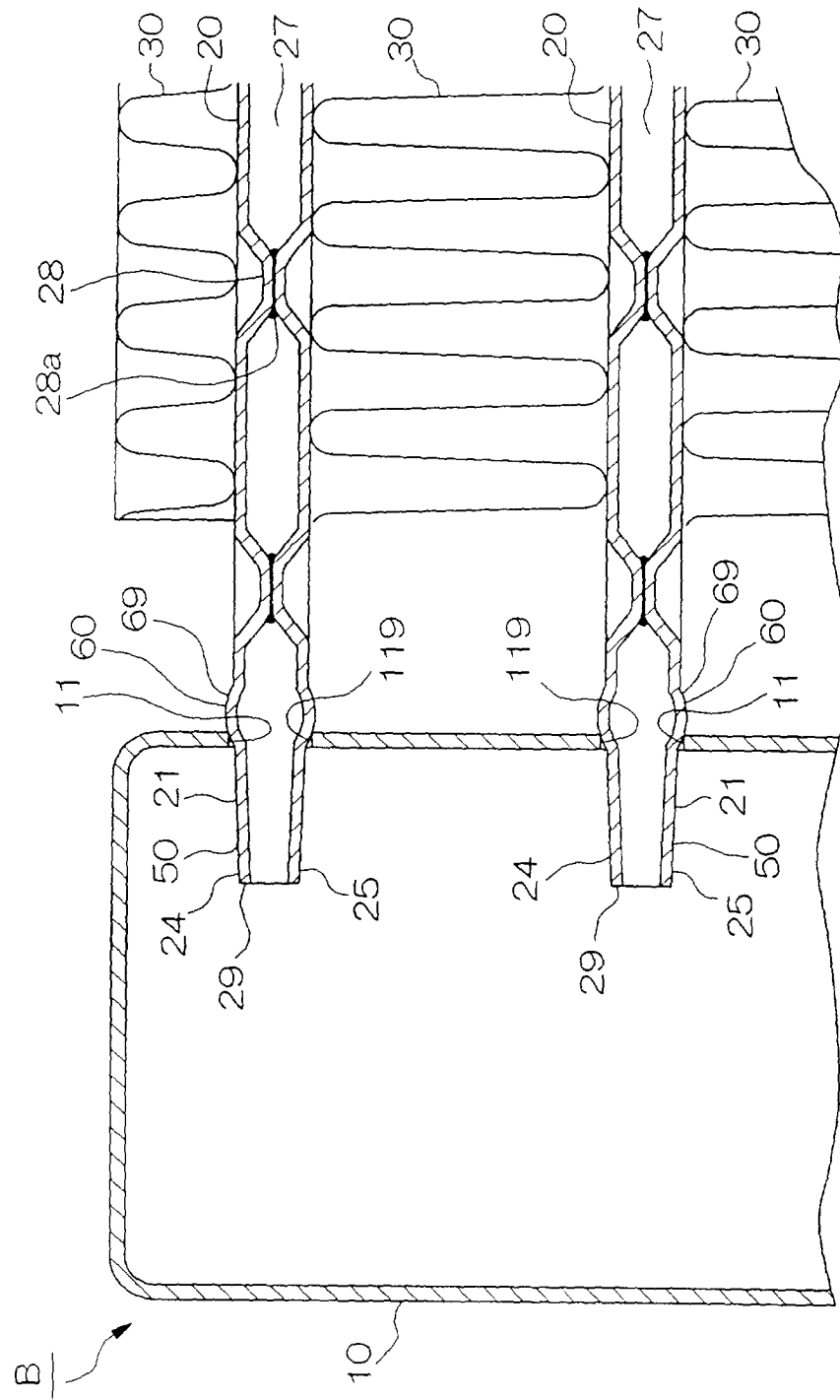


FIG. 15

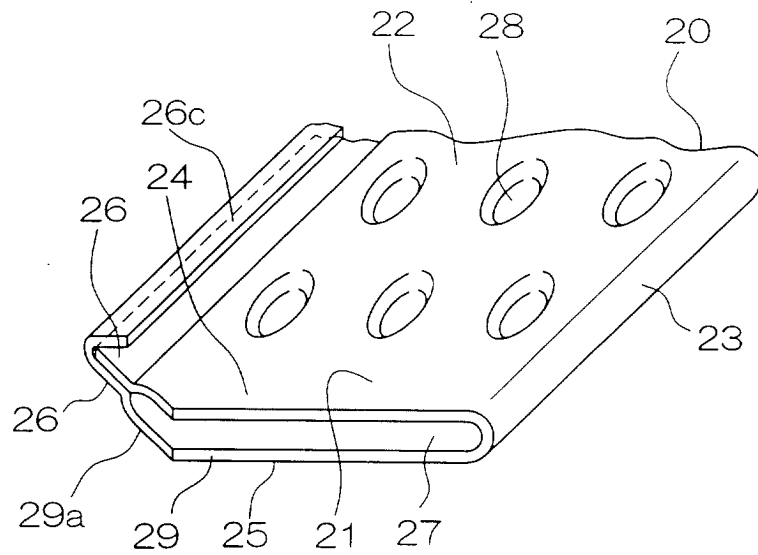


FIG. 16

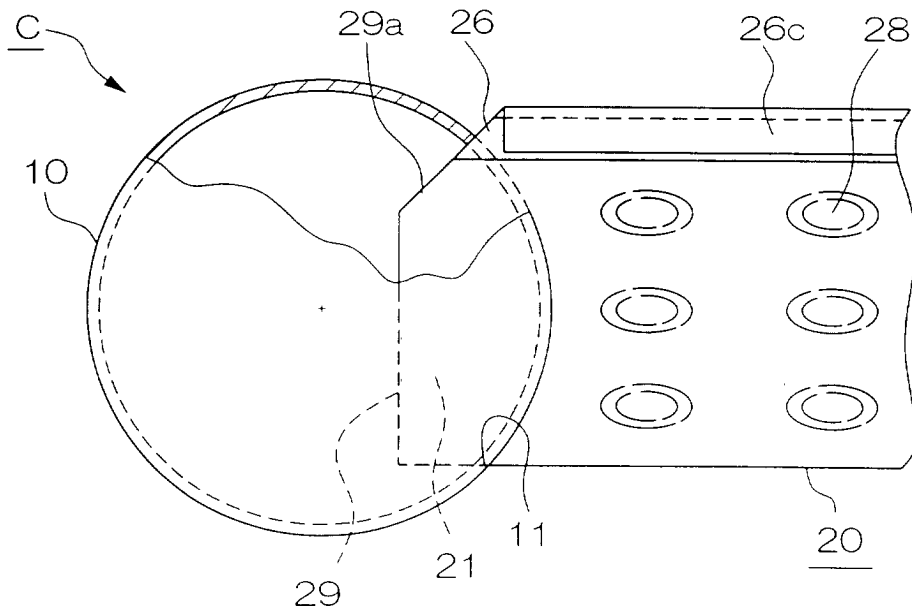


FIG. 17

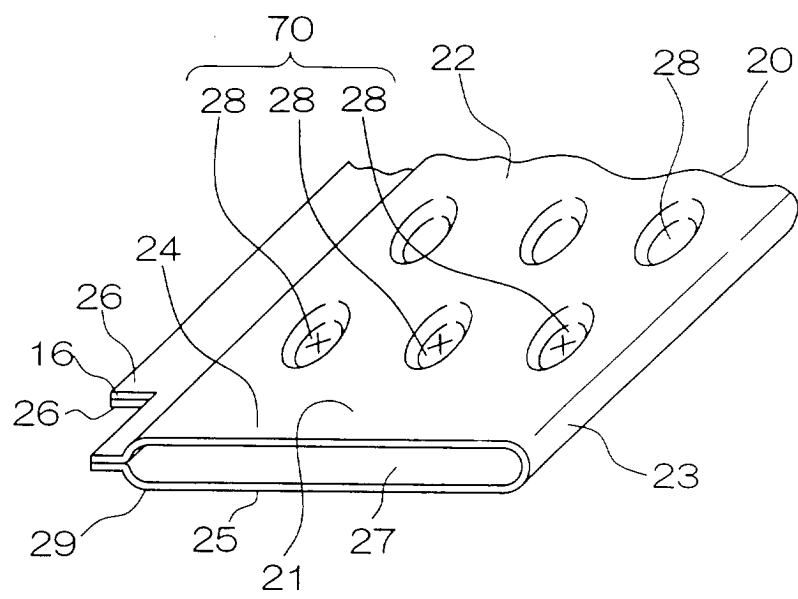


FIG. 18

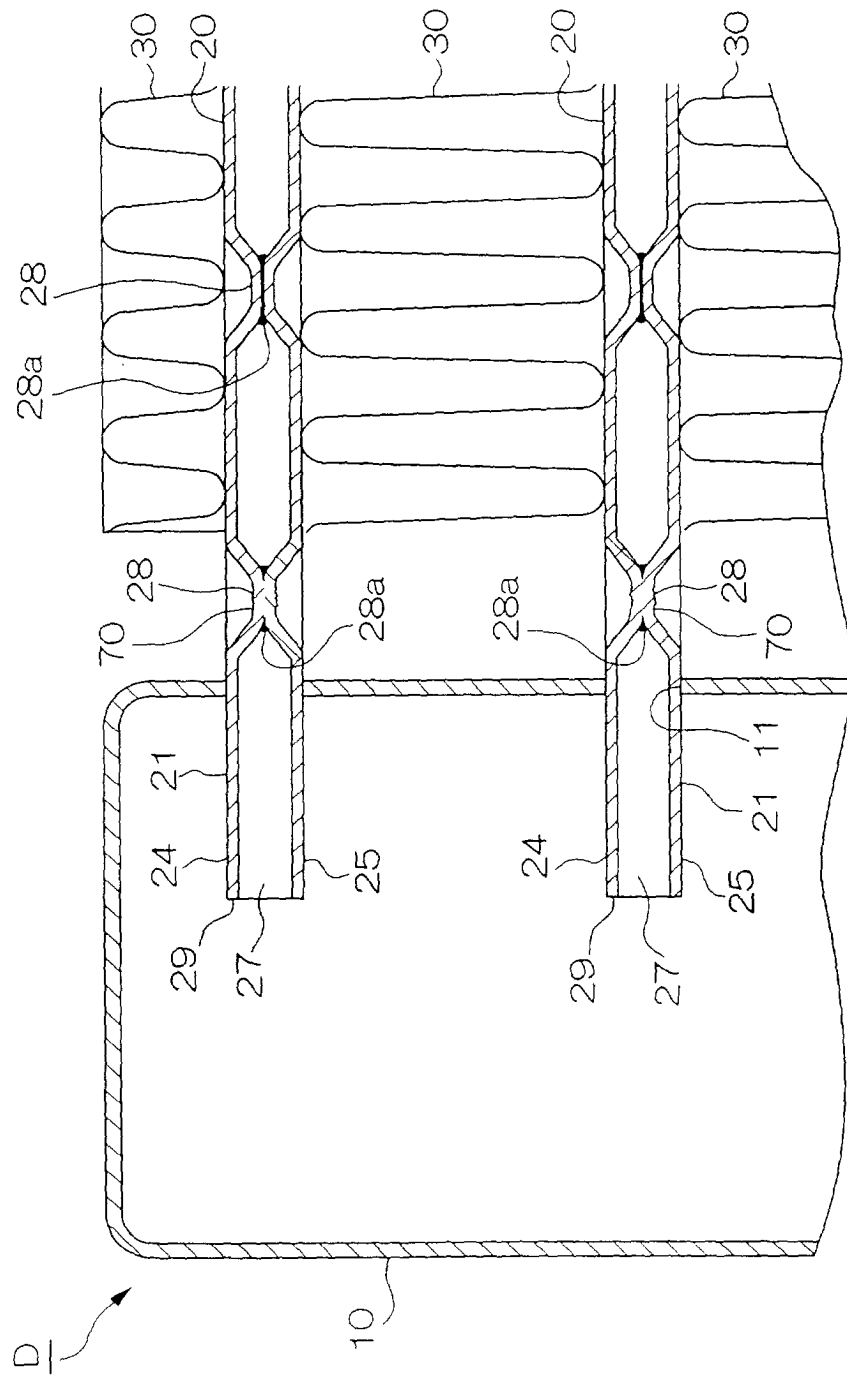


FIG. 19

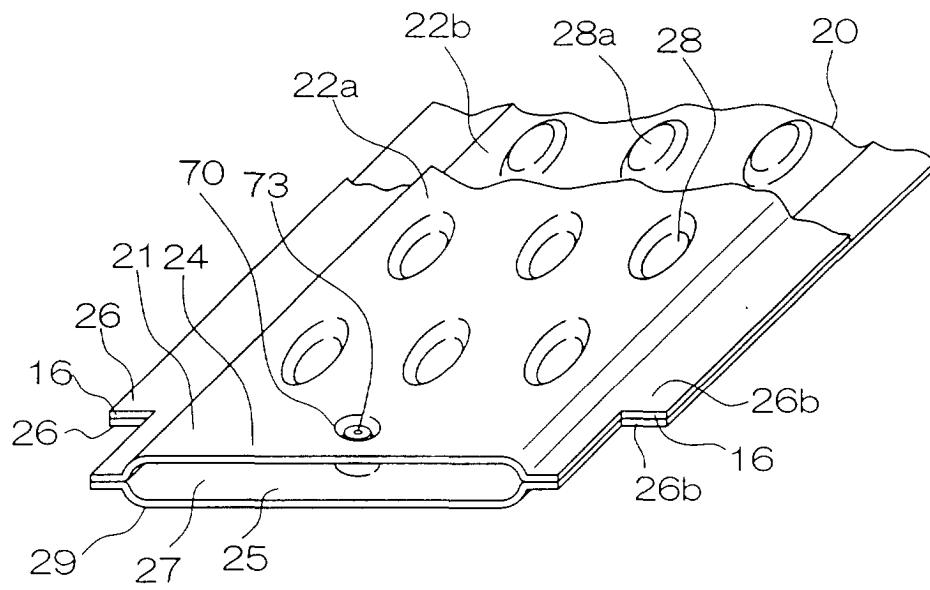


FIG. 20

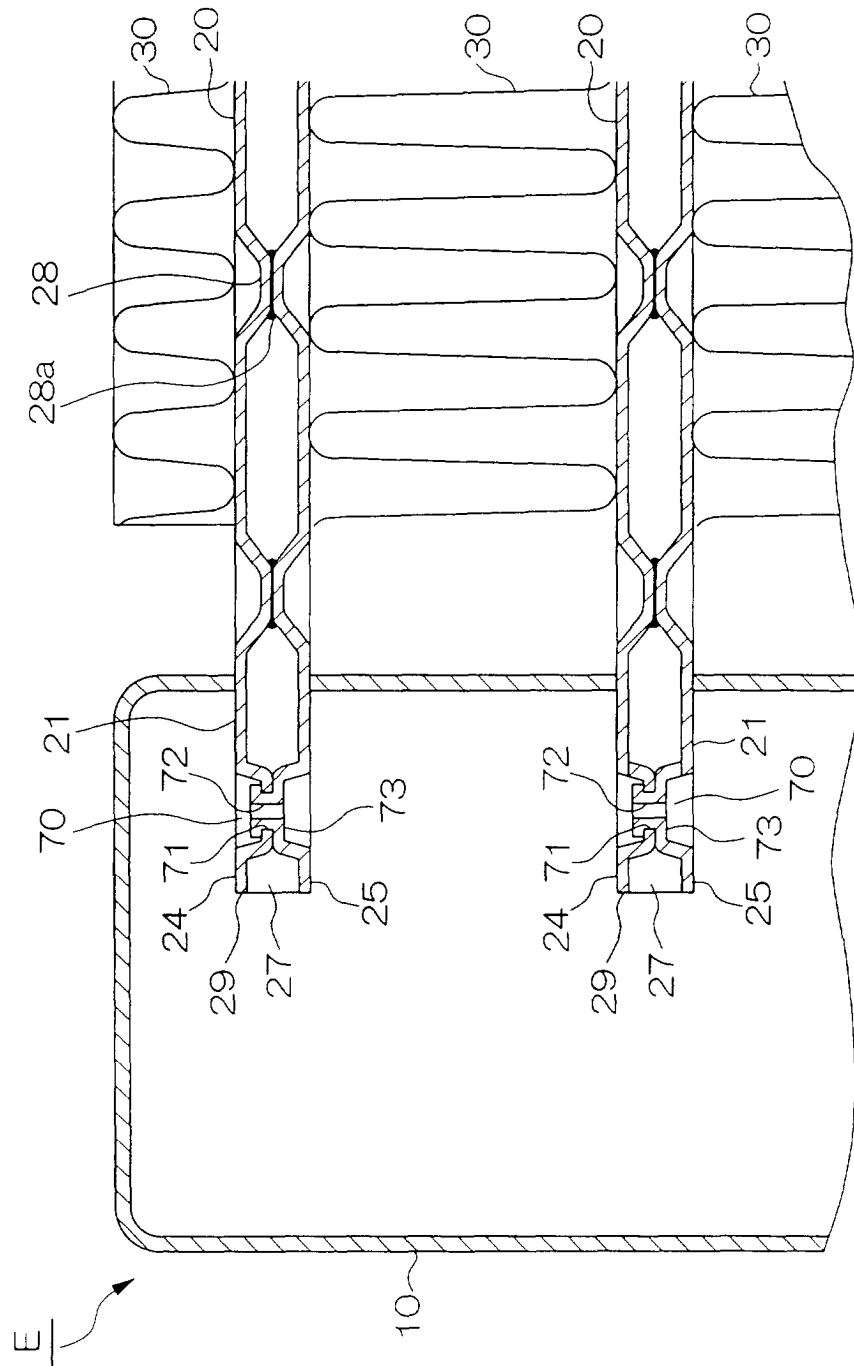


FIG. 21

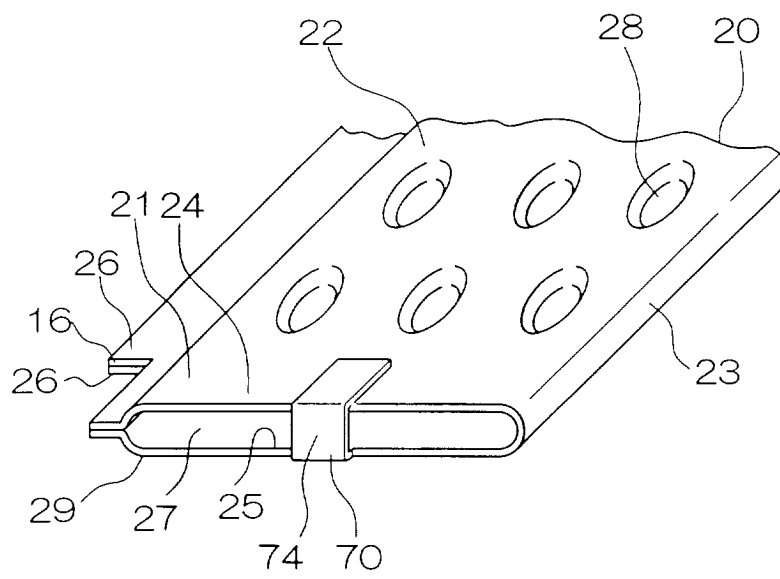


FIG. 22

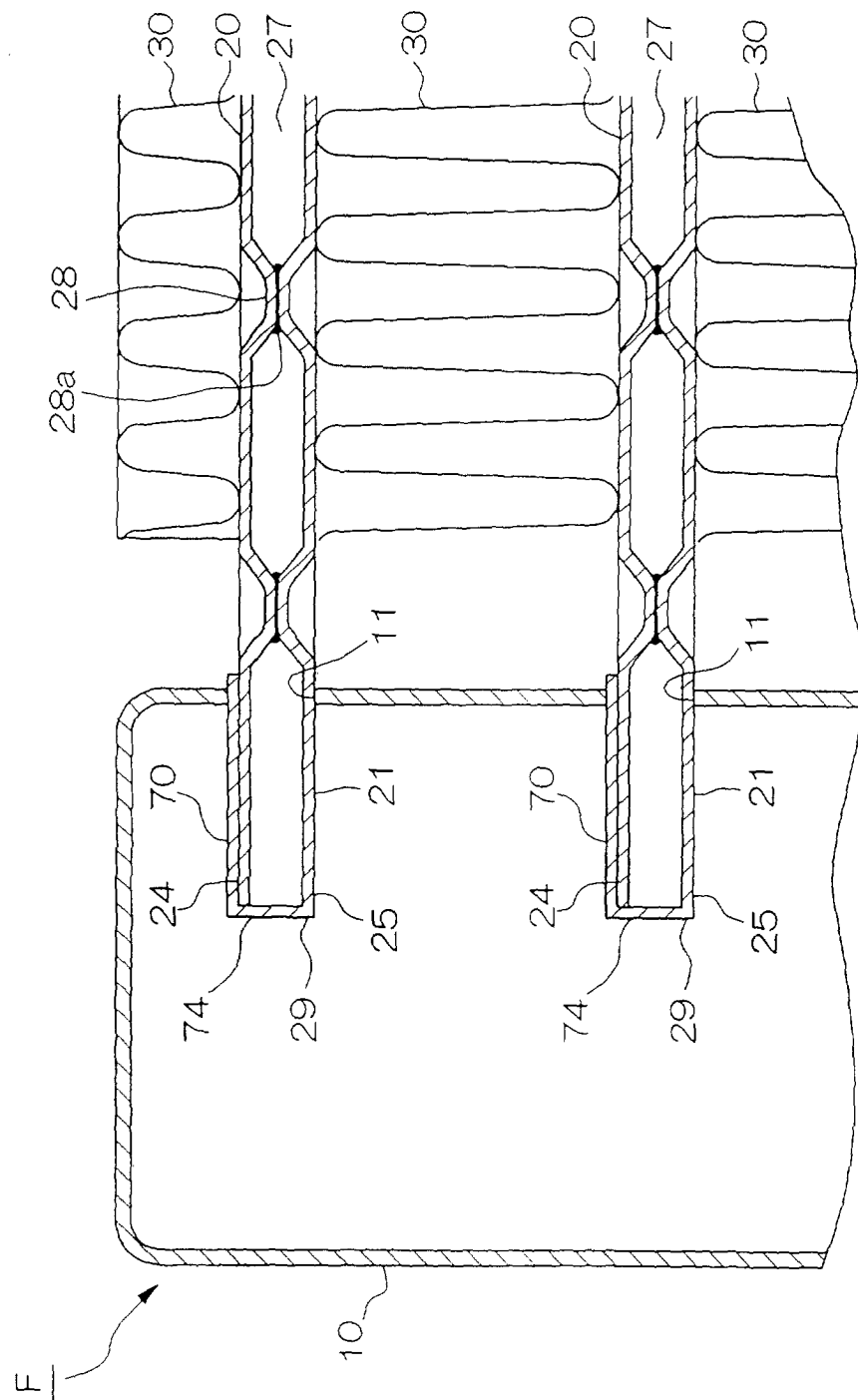


FIG. 23

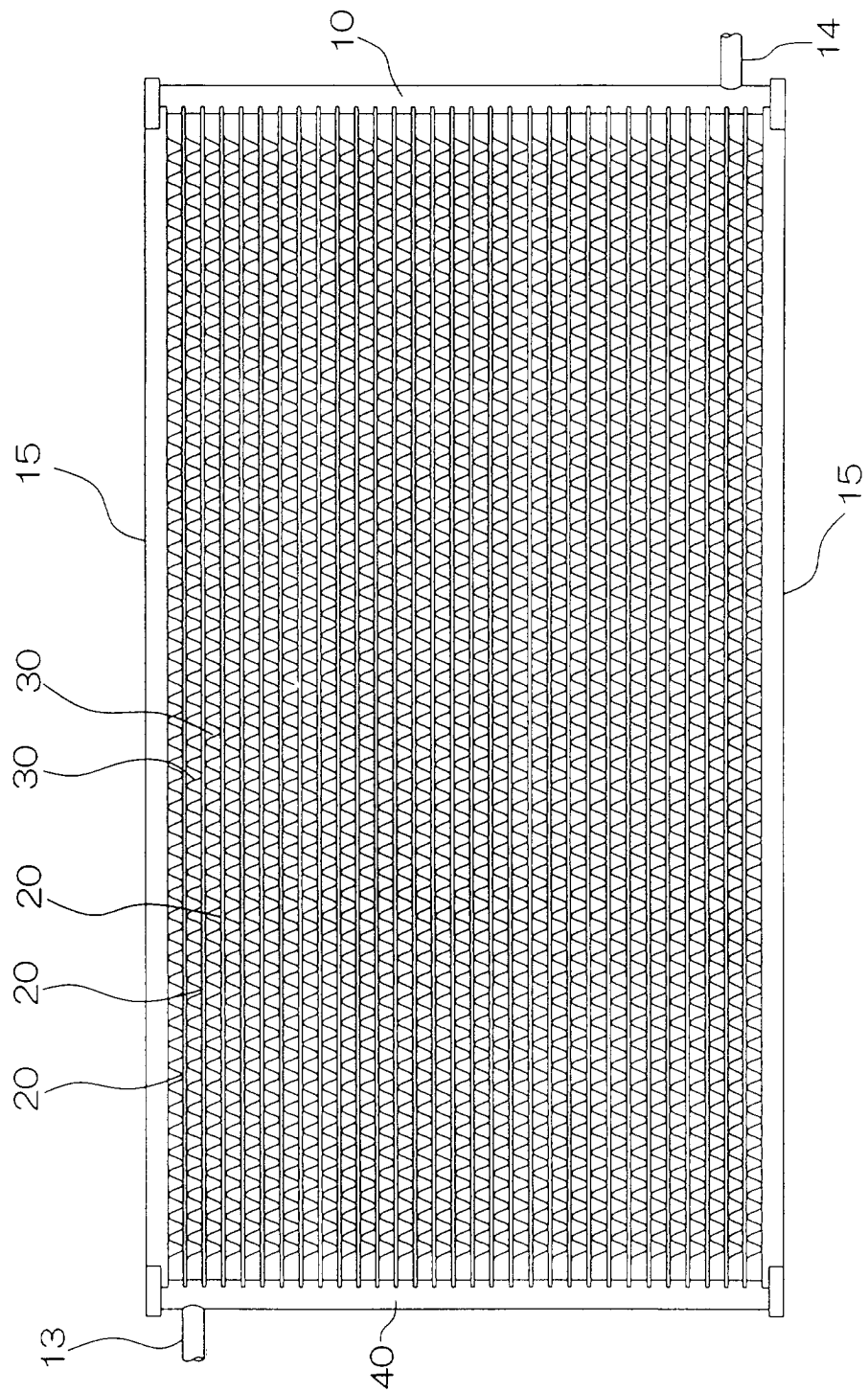


FIG. 24

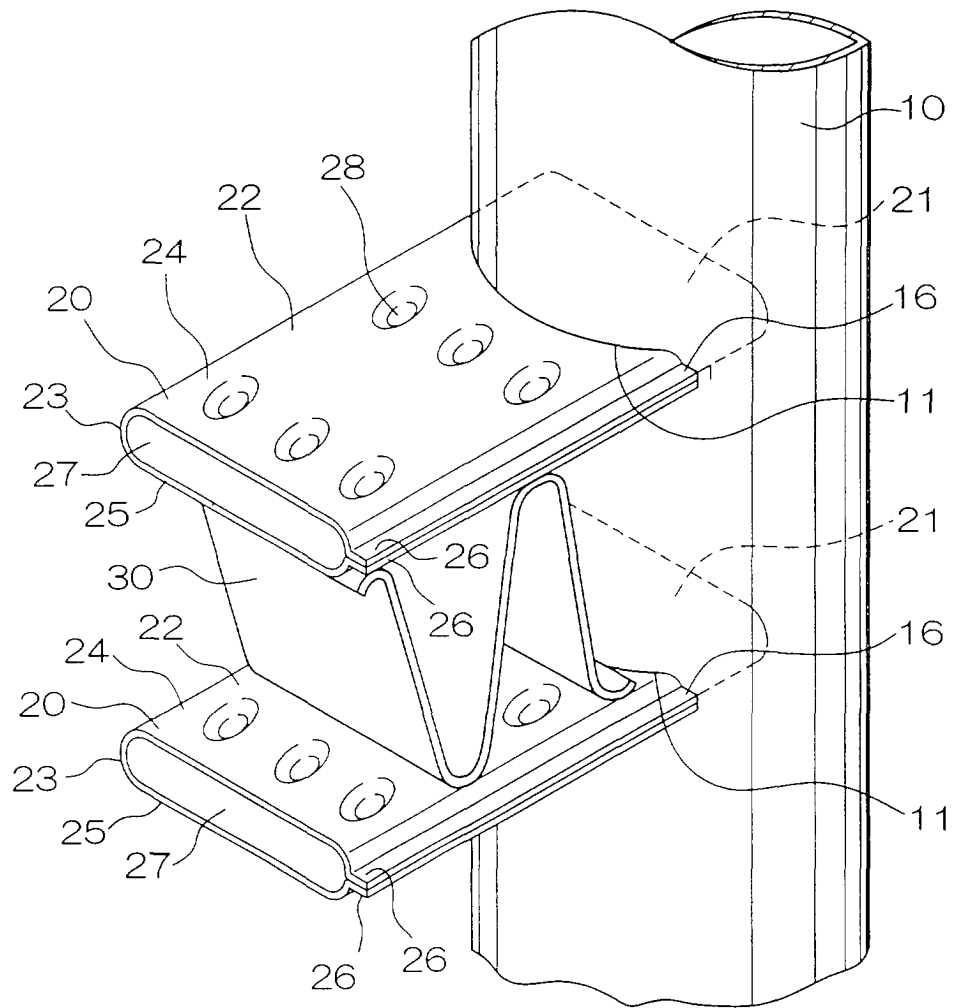


FIG. 25

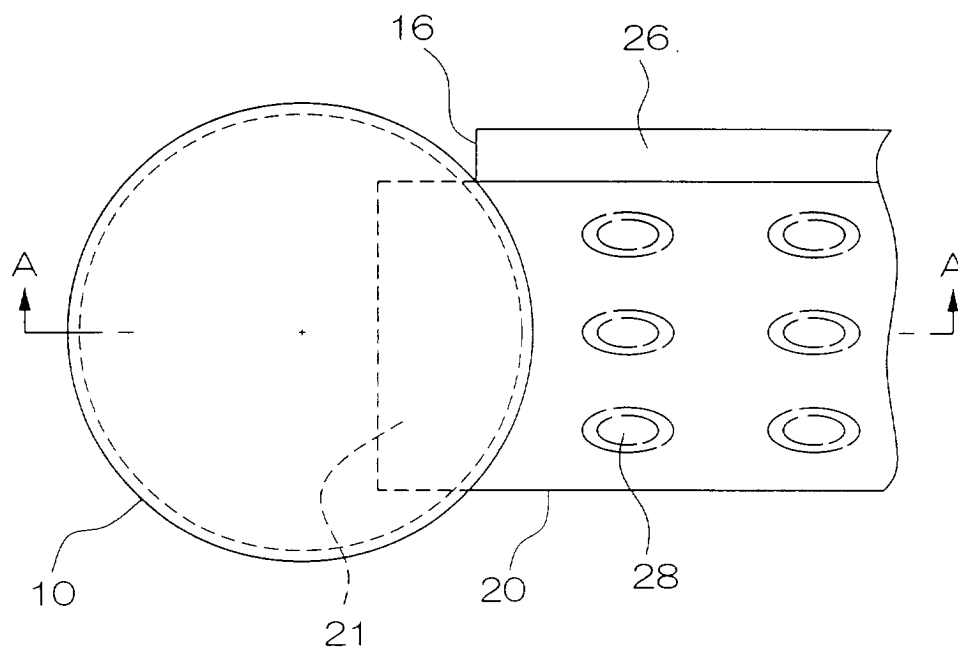


FIG. 26

