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(71) Applicant: **Xenesys Inc.**
Akashi-Shi
Hyogo-Ken (JP)

(72) Inventors:
- **Matsuzaki, Toyoaki**
Tagata-Gun
Shizuoka-Ken (JP)
- **Watanabe, Taro**
Tokyo-To (JP)

(74) Representative: **Klunker . Schmitt-Nilson . Hirsch**
Winzererstrasse 106
80797 München (DE)

(54) Heat exchange unit

(57) A heat exchange unit (1) includes first and second plates (10,20), which are identical in configuration in a central irregularity pattern section (30), but different in configuration in a peripheral area (40,50). The first plate (10) has first terraced sections (41) projecting outward relative to a remaining part having a first flat section (42). The second plate (20) has a second terraced section (51) projecting outward relative to a remaining part having a second flat section (52). The first and second plates are placed alternately one upon another so that surfaces of said irregularity pattern sections (30) face a same direction. The first terraced sections (41) of the first plates (10) come into contact with the second flat sections (52) of the second plates (20) and the first flat sections (42) of the first plates (10) come into contact with the second terraced sections (51) of the second plates (20). The first and second plates are welded to each other at contact areas.

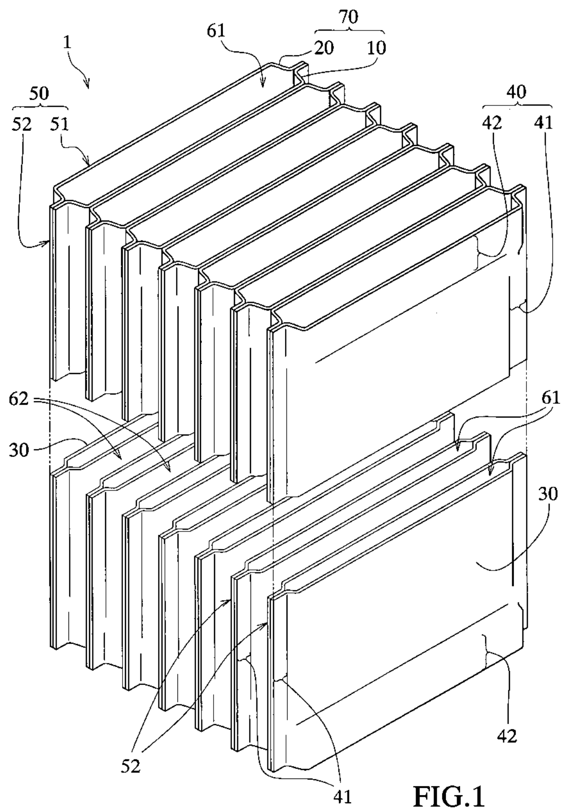

FIG.1

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates a heat exchange unit, which includes a plurality of heat transfer plates, which are formed of a metallic thin sheet and combined in parallel and integrally with each other, and especially to such a heat exchange unit in which the proper fluid passages are ensured in the combined state of the plates and heat exchange fluid having a high pressure can be introduced between the heat transfer plates to make an appropriate heat exchange.

Description of the Related Art

[0002] If there is a demand that heat transfer coefficient is increased to enhance heat exchange effectiveness, utilizing a heat exchanger by which transfer of heat (i.e., heat exchange) is made between a high temperature fluid and a low temperature fluid, a plate-type heat exchanger has conventionally been used widely. The plate-type heat exchanger has a structure in which a plurality of heat transfer plates having a plate-shape are placed parallelly one upon another at prescribed intervals so as to form passages, which are separated by means of the respective heat transfer plate. A high temperature fluid and a low temperature fluid flow alternately in the above-mentioned passages to make heat exchange through the respective heat transfer plates. An example of such a conventional plate-type heat exchanger is discussed as a prior art in Japanese Patent Provisional Publication No. H3-91695, with reference to FIGS. 5 and 6 thereof.

[0003] In the conventional plate-type heat exchanger, gasket members formed of elastic material are placed between the two adjacent plates to make the distance between them constant and define passages for fluid.

[0004] A pattern of irregularity of herringbone type has conventionally and widely applied to the heat transfer plates of the plate-type heat exchanger. However, such a pattern of irregularity could not achieve a balance of decrease in pressure loss and assured resistance to pressure. Accordingly, various kinds of different pattern of irregularities have been proposed. Japanese Patent Provisional Publication No. 2000-257488 describes an example of such different pattern of irregularities.

[0005] The plates for the above-mentioned conventional heat exchanger has a structure in which the plate includes a plurality of heat transfer sections each of which has a mound configuration provided at its top with a flat portion in a thickness direction of the plate (i.e., a cross section thereof) and a rectangular shape in a plan view of the plate, in the inner side of the sealing member (i.e., the gasket member). These plates are combined to each other so as to be placed one upon another to form a single heat exchanger.

[0006] The conventional heat exchanger has the structure as described in the above-mentioned prior art documents. With respect to the conventional plates described in Japanese Patent Provisional Publication No. 2000-257488, when manufacturing the heat exchanger, the plates are placed one upon another to form a heat exchanger so that alternating plates are turned upside down and upper end portions (i.e., tip ends of projections) of heat transfer sections of the plate faces flowing passage-intersections (i.e., root ends of the projections) of the adjacent plate. The plates are combined to each other so that the heat transfer sections protrude the same direction, with the result that the flowing passages formed between the two adjacent plates have the same pattern.

[0007] The same pattern of flowing passages formed on the opposite surfaces of the plate leads to substantially the same heat transfer conditions for the plate. As a result, it is possible to cause two kinds of heat exchange fluids flowing in the passages to perform their thermal functions under the same conditions. Temperatures and characteristic properties of the two kinds of heat exchange fluids between which heat exchange is made through the plate may provide appropriate heat transfer conditions, thus performing an effective heat exchange. However, the conventional heat exchanger described in Japanese Patent Provisional Publication No. 2000-257488 has a structure in which gasket members are provided between the plates in the same manner as Japanese Patent Provisional Publication No. H3-91695, with the result that a high pressure of the heat exchange fluid may disable the gasket member from keeping its proper shape to cause deformation thereof, thus disabling an appropriate separation of the fluids from being ensured or leading to an unfavorable variation in distance between the plates. In such a case, an effective heat exchange may not be carried out, thus causing a problem. Accordingly, such a heat exchanger cannot be used for heat exchange between fluids having high pressure.

SUMMARY OF THE INVENTION

[0008] An object of the present invention, which was made to solve the above-mentioned problems, is therefore to provide a heat exchange unit, which permits to ensure a sufficient heat transfer performance relative to fluids through optimization of a shape of a peripheral area of the plates to be used, ensure high strength in a combined state of the plates and cope with heat exchange fluids having high pressure.

[0009] In order to attain the aforementioned object, a heat exchange unit according to the first aspect of the present invention, comprises a plurality of heat exchange plates having a predetermined pattern of irregularity, which are formed of a metallic thin sheet and combined in parallel and integrally with each other so that first spaces through which a first heat exchange fluid is to pass and second spaces through which a second heat exchange fluid is to pass are provided alternately between

respective heat exchange plates,
wherein:

said heat exchange plates comprises first plates and second plates having a rectangular or square shape, said first and second plates being identical to each other in configuration in a central irregularity pattern section, but different from each other in configuration in a peripheral area thereof, each of said first plates is provided, on at least a pair of parallel opposite sides of the peripheral area, with first terraced sections, each of said first terraced sections being formed by deforming parts of the first plate including predetermined areas along the pair of parallel opposite sides to project outward relative to a remaining part, said remaining part having a first flat section that is placed at a lower position than said first terraced sections; each of said second plates is provided, on a predetermined area of the peripheral area corresponding to said first flat section of the first plate, with a second terraced section, said second terraced section being formed by deforming a part of the second plate to project outward relative to a remaining part, said remaining part of the peripheral area corresponding to said first terraced section of the first plate having a second flat section that is placed at a lower position than said second terraced section; and said first plates and said second plates are placed alternately one upon another so that surfaces of said irregularity pattern sections face a same direction, the first terraced sections of the first plates are brought into contact with the second flat sections of the second plates and the first flat sections of the first plates are brought into contact with the second terraced sections of the second plates, and the first and second plates are welded to each other at contact areas.

[0010] According to the first aspect of the present invention, there are used two kinds of heat exchange plates that are identical to each other in configuration in a central irregularity pattern section, but different from each other in configuration in a peripheral area thereof to provide an opposite positional relationship therebetween in a direction perpendicular to the plane of the peripheral area of the plate. These two kinds of plates are placed alternately one upon another so that projections of the irregularity pattern sections project in the same direction and welded together at the contact areas on the peripheries of the plates, to provide a heat exchange unit in which the plates are combined together. It is therefore possible to combine the heat exchange plates together without providing gasket members between the plates. No existence of the gasket members remarkably improves pressure-resistant strength in the unit into which the plates are combined together. Such a unit can be used even when heat exchange fluids have high pressure, thus being applicable to various purposes for heat exchange. The plates as arranged are identical to each other in configuration in the central irregularity pattern section, with the result that the flowing passages formed between the two adjacent plates have the same pattern. As a result, it is possible to provide the similar passages for heat exchange fluids flowing therein to cause these fluids to perform their thermal functions under the same conditions. When the flowing passages match with characteristic properties of the heat exchange fluids, an effective progress of heat transfer between the plates and the fluids can be made, thus providing an effective heat exchange between the heat exchange fluids.

[0011] In the second aspect of the heat exchange unit of the present invention, there may be adopted a structure in which the irregularity pattern section of each of the heat exchange plates has projections and recesses that are aligned respectively at predetermined intervals, said recesses being placed so as to deviate from the projections by a half of a distance between two adjacent projections, said projections and recesses being rotationally symmetric with respect to a center of the plate; each of the plates has a symmetrical shape so as to provide a same configuration even when the plate turns on a plane thereof around the center thereof by an angle of 180 degrees; the plates are placed one upon another so that the first plate turns on the plane thereof around the center thereof by an angle of 180 degrees upside down relative to the second plate, the projections of the first plate come into contact with backsides of the recesses of the second plate and the projections of the second plate come into contact with backsides of the recesses of the first plate, while the first terraced sections and the second flat sections come into contact with the first flat sections and the second terraced sections, respectively.

[0012] According to the second aspect of the present invention, the irregularity pattern section of each of the heat exchange plates has projections and recesses that are aligned respectively at predetermined intervals, and the recesses are placed so as to deviate from the projections by a half of the distance between two adjacent projections. Turning one of two plates located adjacently, when the plurality of plates are arranged in parallel with each other, by an angle of 180 degrees so as to be placed upside down relative to the other plate causes the places of the projections and recesses to be changed from each other in the turned plate. As a result, these plates can be kept in a combined state in which the projections of the plate face the recesses of the other plate. The projections of the plate come into contact with rear sides of the recesses of the other plate in such a combined state. It is therefore possible to bring the plates into contact with each other not only in the peripheral areas thereof, but also in many areas in the irregularity pattern sections. Accordingly, the plate can be held by the outside and inside other plates in the irregularity pattern sections thereof, resulting in a remarkably increased strength. Such a structure ensures appropriate passage configurations between the adjacent plates even when a heat exchange fluid having high pressure is introduced into the passage between the plates, performing an appropriate heat exchange.

[0013] In the third aspect of the heat exchange unit of the present invention, there may be adopted a structure in which the irregularity pattern section of each of the heat exchange plates has said projections that project outward from one surface of the heat exchange plate in a form of a truncated cone or a truncated pyramid, and a plurality of intermediate protrusions each of which is placed between two projections that are adjacent to each other at a shortest distance, each of the intermediate protrusions being defined by one or more flat or curved portions that extend to opposing surfaces of the two projection, and each of the intermediate protrusions having one or more peak portions that are placed in a lower position than a top of the projection; there is made arrangement providing simultaneously a plurality of combinations of the projection and another projection adjacent thereto at the shortest distance between which the intermediate protrusion is placed; and

a plurality of non-protruded portions each of which is placed between adjacent intermediate protrusions, each of the non-protruded portions being placed in a lowest position relative to a projecting direction of the projections, the non-protruded portions providing said recesses surrounded by the projections and the intermediate protrusions.

[0014] According to the third aspect of the present invention, the irregularity pattern section of each of the heat exchange plates has the projections that project outward from one surface of the heat exchange plate in a form of a truncated cone or a truncated pyramid, and the plurality of intermediate protrusions each of which is placed between two projections that are adjacent to each other at a shortest distance. When the heat exchange plates are arranged in parallel with each other, there is provided between the two adjacent plates a gap in which a unit of the similar pattern of irregularity is repeated in aligning directions of the projections, thus providing linear passages extending in the above-mentioned directions so as to cross each other. More specifically, each of the linear passages extending in a reticulation shape includes expanded areas and throat areas that are placed alternately in the same direction, on the one hand, and the linear passage extending in the perpendicular direction to the above-mentioned direction includes expanded areas and throat areas that are placed alternately in the same perpendicular direction, in the similar manner. Using the thus assembled plates can impart substantially the same behavior to the heat exchange fluid, irrespective the flowing system of the heat exchange fluid, i.e., any one of the parallel flowing system, the counter-flowing system and the cross flowing system. As a result, it is possible to perform a smooth heat transfer at a low pressure loss to make an effective heat exchange, even when the heat exchange fluids are combined in any manner in their flowing directions, thus providing a high degree of freedom in design of the heat exchanger and becoming excellent in general purpose use. In addition, the heat exchange fluid ca flow freely in the above-mentioned two directions along the plate, and the constant heat transfer property can be obtained, irrespective of the flowing direction of the heat exchange fluid. It is therefore possible to cause the heat exchange fluid to spread over the entire area of the plate so that such an entire area can serve as an effective heat transfer section, and vary flowing conditions through the intermediate protrusions in comparison with a simple combination of cones or pyramids so as to provide an improved heat transfer, thus increasing remarkably an amount of heat transfer per area and achieving a high performance. Further, the projections of the plate, which come into contact with the other plate, are provided in the form of the truncated cone or truncated pyramid so as to disperse force applied to the projections in the direction on the surface the truncated cone or truncated pyramid. As a result, the strength of the assembled plates can be improved remarkably in comparison with the conventional heat exchange plate, and it is therefore possible to keep the distance between the two adjacent plates constant, even when there exists a large difference in pressure between the heat exchange fluids, thus enhancing a pressure-resistant property.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

FIG. 1 is a perspective view illustrating a schematic structure of a heat exchange unit according to an embodiment of the present invention;

FIGS. 2(A) to 2(C) are views illustrating assembling steps for the heat exchange unit according to the embodiment of the present invention;

FIG. 3 is a plan view illustrating a heat exchange plate for forming the heat exchange unit according to the embodiment of the present invention;

FIG. 4 is an enlarged view of a central portion of the heat exchange plate for forming the heat exchange unit according to the embodiment of the present invention; and

FIG. 5 is an enlarged cross-sectional view illustrating a irregularity pattern section of the heat exchange unit according to the embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] Now, the embodiment of the present invention will be described in detail below with reference to FIGS. 1 to 5. FIG. 1 is a perspective view illustrating a schematic structure of a heat exchange unit according to an embodiment of the present invention, FIGS. 2(A) to 2(C) are views illustrating assembling steps for the heat exchange unit according to the embodiment of the present invention, FIG. 3 is a plan view illustrating a heat exchange plate for forming the heat exchange unit according to the embodiment of the present invention, FIG. 4 is an enlarged view of a central portion of the heat exchange plate for forming the heat exchange unit according to the embodiment of the present invention, and FIG. 5 is an enlarged cross-sectional view illustrating a irregularity pattern section of the heat exchange unit according to the embodiment of the present invention.

[0017] The heat exchange unit 1 according to the embodiment of the present invention is composed of two kinds of heat exchange plates 10, 20, which serve as the first and second plates, respectively, and are placed in parallel with each other and welded together. The heat exchange plates 10, 20 have irregularity pattern sections 30 and peripheral areas 40, 50 with which the irregularity pattern sections 30 are surrounded, respectively. Each of the plates 10, 20 has opposite surfaces, which are to be come into contact with heat exchange fluids, respectively.

[0018] The heat exchange plates 10, 20, which are formed of a metallic thin sheet having a rectangular shape, are subjected to a press forming process to form an irregularity pattern section in a central portion thereof and peripheral areas 40, 50 by which the irregularity pattern sections are surrounded. The peripheral area 40 of the heat exchange plate 10 is different in configuration from the peripheral area 50 of the heat exchange plate 20. The peripheral area 40 of the heat exchange plate 10 has a projection-to-recess relationship that is opposite to the peripheral area 50 of the heat exchange plate 20. As a result, the heat exchange plates 10, 20 are provided in the form of two different kinds of plates that are identical to each other in configuration of the central irregularity pattern section 30, but different from each other in configuration in the peripheral area.

[0019] The above-mentioned irregularity pattern section 30 includes a plurality of projections 31, a plurality of intermediate protrusions 33 and a plurality of recesses 34. The projections 31 are formed on the basis of a matrix arrangement in which the projections 13 project in the form of truncated pyramid from the surface of the plate so that four pyramidal surfaces of the projection faces the respective surrounding pyramidal surfaces of the adjacent projections and are aligned at regular intervals in four directions corresponding to the four pyramidal surfaces of the projection. Each of the intermediate protrusions 33 is placed in the form of a mound portion between the opposing pyramidal surfaces of the two adjacent projections 31 so that a pair of foot portions of the intermediate protrusion is located in the lowest positions at which corresponding ridgelines of the opposing pyramidal surfaces intersect and a peak portion of the intermediate protrusion is located between the intersecting points of the above-mentioned ridgelines. The peak portion of the intermediate protrusion 33 is placed in a lower position than the top 32 of the projection 31. Each of the recesses 34 is provided in the form of a non-protruded portion in a central position between the projections that are placed adjacent to each other without placing the intermediate protrusion 33 therebetween. The recess 34 is surrounded by the pyramidal surfaces of the projections 31 and inclines surfaces of the intermediate protrusions 33 so as to be placed in the lowest position in the direction perpendicular to the plane of the plate. The projections 31 and the recesses 34 are placed so as to deviate from each other by a half of a distance between two adjacent projections or recesses in aligning directions thereof so that the recesses 34 are also aligned on the basis of the same matrix arrangement as the projections 31. Each of the heat exchange plates 10, 20 has the same configuration in the irregularity pattern section 30.

[0020] The direction along which the two adjacent projections are aligned so as to place the recess 34 therebetween is in parallel with or perpendicular to the side of the rectangular plate. The irregularity pattern section 30 may have a structure in which the above-mentioned direction is inclined by an angle of 45 degrees or a desired angle relative to the side of the plate.

[0021] In addition, the irregularity pattern section 30 has a specific feature in a positional relationship between the projections 31 and the recesses 34 that the projections 31 and the recesses 34 are located so that the projection 31 placed closest to a center "O" of the plate deviates therefrom in the aligning direction by a quarter of the distance between the adjacent projections 31 and the recess 34 placed closest to the center "O" of the plate deviates therefrom in the opposite direction to the above-mentioned aligning direction by a quarter of the distance between the adjacent recesses 34. As a result, the projection 31 and the recess 34 are rotationally symmetric with respect to the center "O" of the plate so that the projection 31 and the recess 34 are placed in opposite positions to the recess 34 and the projection 31 relative to the center "O" of the plate by the same distance. Turning the plate on a plane thereof around the center thereof by an angle of 180 degrees to place the plate upside down provides a state in which the projections 31 and the recesses 34 change their places relative to the original position prior to the turn of the plate. When the plate turned upside down is placed on the other plate kept in a normal position so that the inner sides of the irregularity pattern sections 30 of these plates face each other, the tops 32 of the projections 31 of the former plate come into contact with the back sides of the recesses 34 of the latter plate.

[0022] The above-mentioned plate 10 is provided in its peripheral area 40 with first terraced sections 41, which are formed along a pair of parallel long sides of the plate in the form of a flat terraced edge placed in a higher position than the upper surface of the remaining part thereof, and with first flat sections 42, which are formed along a pair of parallel short sides of the plate in the form of a non-terraced edge. The above-mentioned plate 20 is provided in its peripheral area 50 with second terraced sections 51, which are formed along a pair of parallel short sides of the plate in the form of a flat terraced edge placed in a higher position than the upper surface of the remaining part thereof, and with second flat sections 52, which are formed along a pair of parallel long sides of the plate in the form of a non-terraced edge.

[0023] More specifically, the plate 10 having the peripheral area 40 has the long sides shifted upward from the upper surface of the plate and the short sides shifted downward from the lower surface thereof, and the plate 20 having the peripheral area 50 has the short sides shifted upward from the upper surface of the plate and the long sides shifted downward from the lower surface thereof, with the result that the long and short sides of the plate 10 has an opposite relationship in shifting direction perpendicular to the plane of the plates to those of the plate 20. Each of the plates 10, 20 has a symmetrical shape so as not to change the positional relationship of the terraced sections and the flat sections even when the plate turns on a plane thereof around the center thereof by an angle of 180 degrees to be placed upside down.

[0024] The heat exchange plate 10 provided on the upper surface with the projections 31 of the irregularity pattern section 30 is placed on the heat exchange plate 20 provided on the upper surface with the projections 31 of the irregularity pattern section 30 so that the upper surfaces of the plates 10, 20 face in the same direction and the plate 20 is placed upside down to bring the peripheral area 40 of the plate 10 into contact with the peripheral area 50 of the plate 20. A pair of plates 10, 20 is welded together in such a state and the same assembling steps are carried out to provide a plurality of pairs of plates. Such pairs of plates are welded together into a heat exchange unit 1. In such a heat exchange unit 1, the plates 10, 20 come into contact with each other not only at the peripheral areas 40, 50, but also at the tops 32 of the projections 31 of the irregularity pattern sections 30 of the plate 10 and the corresponding projections formed on the back sides of the recesses 34 of the plate 20, so as to form, between the plates 10, 20 excepting the contact areas, a gap in which a heat exchange fluid flows.

[0025] The width of the gap between the irregularity pattern sections 30 of the plates 10, 20 gradually increases from the contact area thereof to the maximum in a position between the recess 34 of the plate 10 and the corresponding recess formed on the back side of the projection 31 of the plate 20. More specifically, such a gap includes expanded areas and throat areas that are placed alternately in the same direction to form a linear passage, on the one hand, and the gap extends in the perpendicular direction to the direction of the linear passage to form another linear passage. Such linear passages cross each other so as to communicate with each other.

[0026] The above-mentioned gap formed between the two adjacent plates 10, 20 has a first gap section 61, which is defined by the first flat section 42 formed along the short side of the heat exchange plate 10 and the second terraced section 51 formed along the short side of the heat exchange plate 20 so as to communicate with the outside through an opening of the first gap section 61, on the one hand, and a second gap section 62, which is defined by the first terraced section 41 formed along the long side of the heat exchange plate 10 and the second flat section 52 formed along the long side of the heat exchange plate 20 so as to communicate with the outside through an opening of the second gap section 62, on the other hand. The above-mentioned first and second gap sections 61, 62 are formed between the other pairs of plates 10, 20 in the same manner. The first gap sections 61 of the heat exchange unit 1 are substantially identical in configuration and size with each other and the second gap sections 62 of the heat exchange unit are also substantially identical in configuration and size with each other, since the plates have the common irregularity pattern sections 30 and the same positional relationship of the projections, etc. within the gap.

[0027] It is possible to manufacture the two kinds of heat exchange plates 10, 20 that are different from each other only in configuration of the peripheral areas by utilizing a press-forming apparatus in which portions of a die of the press-forming apparatus corresponding to the peripheral areas of the plate can be adjusted in position, for example a press-forming apparatus an invention of which was made by the inventors of the present invention and described in Japanese Patent Provisional Publication No. 2003-275824. In use of such an apparatus, a positional adjustment of auxiliary die sections for forming the peripheral areas 40, 50 relative to a central main die section for forming the irregularity pattern section 30 in a pressing direction is made in the pressing apparatus and then, a press forming process is carried out. In such a case, it is possible to manufacture the two different kinds of plates with the use of the same dies, thus providing an remarkably enhanced manufacturing efficiency.

[0028] Now, assembling steps for the heat exchange unit according to the present invention will be described below. It is assumed that the two kinds of heat exchange plates 10, 20, i.e., a plurality of plates 10 and a plurality of plates 20, which have the same irregularity pattern sections 20 in the central portion thereof, but the different configuration in the peripheral areas 40, 50 have previously been prepared. The heat exchange plate 10 provided on the upper surface with the projections 31 of the irregularity pattern section 30 is placed on the heat exchange plate 20 provided on the upper surface with the projections 31 of the irregularity pattern section 30 so that the upper surfaces of the plates 10, 20 face in the same direction and the plate 20 is placed upside down to bring the first terraced sections of the peripheral area 40 of the plate 10 into contact with the second flat sections 51 of the peripheral area 50 of the plate 20.

[0029] The two heat exchange plates 10, 20 thus overlapped are welded together at the first terraced sections 41 and the second flat sections 51 serving as welded regions to prepare a single unit of plates 70. Such a single unit of plates 70 is placed on another single unit of plates 70, which has been prepared in the same manner so that the peripheral areas 40, 50 thereof come into contact with each other at the first flat sections 42 and the second terraced sections 51 formed on the short sides of the plates. A welding step is carried out between the first flat sections 42 and the second terraced sections 51 to prepare a combined body of the units of plates 70. Steps of placing the unit of plates 70 on the other unit of plates 70 and welding these units are repeated to obtain a heat exchange unit 1. Reinforcement members may be welded to predetermined portions such as corners of the thus obtained unit to enhance strength with which the plates are combined, as an occasion demands.

[0030] In such a heat exchange unit 1, the first gap section 61 is formed between the heat exchange plates 10, 20 for forming the unit of plates 70, and the opening that is defined by the first flat section 42 formed along the short side of the heat exchange plate 10 and the second terraced section 51 formed along the short side of the heat exchange plate 20 communicates with the above-mentioned first gap section 61. In addition, the second gap sections 62 are also formed in adjacent rows to the first gap section 61 through the heat exchange plates 10, 20 and the opening that is defined by the first terraced section 41 formed along the long side of the heat exchange plate 10 and the second flat section 52 formed along the long side of the heat exchange plate 20 communicates with the above-mentioned second gap section 62. The first gap section 61 and the second gap section 62, which are substantially identical to each other in configuration and size, provide flow passages having the same flow resistance and heat transfer characteristics.

[0031] Such a heat exchange unit 1 into which the heat exchange plates 10, 20 are combined, is placed usually so that the any one of the sides of the plate is located horizontally or vertically. As a result, main passage section between the plates, i.e., the gap section continuing along the recesses 34 and the intermediate protrusions 33 extends obliquely.

[0032] Now, an operation of the heat exchange unit according to the embodiment of the present invention serving as the heat exchanger will be described below. A heat exchange fluid is introduced into the first gap section 61 through the opening formed between the first flat section 42 and the second terraced section 51 formed on the short sides of the heat exchange plates 10, 20 for forming the heat exchange unit 1, and discharged from the first gap section 61 through the other opening formed therebetween, on the one hand, and another heat exchange fluid is introduced into the second gap section 62 through the opening between the first terraced section 41 and the second flat section 52 formed on the long sides of the heat exchange plates 10, 20, and discharged from the second gap section 62 through the other opening formed therebetween, on the other hand.

[0033] In the gap sections 61, 62 in which the heat exchange fluids flow, the passages extend in the direction along which the recesses 34 are aligned, mainly around the recesses 34 and the intermediate protrusions 33. The heat exchange fluids flow in the above-mentioned passages. As a result, the heat exchange fluids flows in the oblique direction in the passages that have specific configurations with the repeated expanded areas and throat areas in the gap sections 61, 62, which configurations are substantially identical with each other on the upper and lower surfaces of the plate, and naturally repeats divergence and confluence to smoothly spread over every areas on the upper and lower surfaces of the plate of the irregularity pattern sections 30 of the heat exchange plates 10, 20, thus facilitating the heat transfer between the heat exchange fluids. It is therefore possible to make an appropriate heat exchange between the heat exchange fluids through the heat exchange plates 10, 20, while causing the fluids to flow in the gap sections 61, 62 in this manner, thus performing an effective heat exchange without loss between the two heat exchange fluids through the heat exchange plates 10, 20.

[0034] According to the heat exchange unit according to the embodiment of the present invention, there are used two kinds of heat exchange plates 10, 20 that are identical to each other in configuration in a central irregularity pattern section 30, but different from each other in configuration in a peripheral area thereof to provide an opposite positional relationship therebetween in a direction perpendicular to the plane of the peripheral area of the plate. These two kinds of plates are placed alternately one upon another so that projections 31 of the irregularity pattern sections 30 project in the same direction and welded together at the contact areas on the peripheries 40, 50 of the plates, to provide a heat exchange unit 1 in which the plates are combined together. It is therefore possible to combine the heat exchange plates 10, 20 together without providing gasket members between the plates. No existence of the gasket members remarkably improves pressure-resistant strength in the unit into which the plates are combined together. Such a unit can be used even when heat exchange fluids have high pressure, thus being applicable to various purposes for heat exchange. The plates as arranged are identical to each other in configuration in the central irregularity pattern section 30, with the result that the flowing passages 61, 62 formed between the two adjacent plates have the same pattern. As a result, it is possible to provide the similar passages for heat exchange fluids flowing therein to cause these fluids to perform their thermal functions under the same conditions. When the flowing passages match with characteristic properties of the heat exchange fluids, an effective progress of heat transfer between the plates and the fluids can be made, thus providing an effective heat exchange between the heat exchange fluids.

[0035] In the heat exchange unit according to the embodiment of the present invention, the irregularity pattern section 30 has a basic structure in which the projection

31 is surrounded by four adjacent projections 31 through the intermediate protrusions 33 and the recesses 34 are placed so as to deviate from the projections by a half of the distance between the two adjacent projections. However, the present invention is not limited only to such an embodiment. Any desired structure may be adopted, except for two kinds of configuration in the peripheral areas of the heat exchange plates 10, 20, and for example, there may be made adjustment in shape of the projections of the irregularity pattern section 30, existence or inexistence of the intermediate protrusions between the projections, the number of the other projections by which the projection is surrounded. Such a modified structure permits adjustment to cope appropriately with the characteristic properties of the heat exchange fluids introduced into the gaps between the plates.

[0036] In the heat exchange unit according to the embodiment of the present invention, each of the projections 31 of the irregularity pattern section 30 has a truncated pyramid shape. However, the projection may have a shape of prismoid such as a pentagonal prismoid or a hexagonal prismoid, or a shape of truncated cone so as to be adapted to the desired performance of the heat exchanger.

[0037] In the heat exchange unit according to the embodiment of the present invention, the units of plates 70 each of which is composed of a pair of plates are assembled into the heat exchange unit. However, the present invention is not limited only to such an embodiment. There may be carried out an alternative assembling process of carrying out a basic step of placing alternately the heat exchange plates 10 and the heat exchange plates 20 as kept upside down one upon another, welding the first terraced sections 41 and the second flat sections 52 that come into contact with each other at the long sides of the peripheral areas, over the long sides thereof, and welding the first flat sections 42 and the second terraced sections 51 that come into contact with each other at the short sides of the peripheral areas, and repeating the above-mentioned basic step successively.

Claims

1. A heat exchange unit (1), comprising a plurality of heat exchange plates having a predetermined pattern of irregularity, which are formed of a metallic thin sheet and combined in parallel and integrally with each other so that first spaces through which a first heat exchange fluid is to pass and second spaces through which a second heat exchange fluid is to pass are provided alternately between respective heat exchange plates,
wherein:

   said heat exchange plates comprises first plates (10) and second plates (20) having a rectangular or square shape, said first and second plates being identical to each other in configuration in a central irregularity pattern section (30), but different from each other in configuration in a peripheral area (40,50) thereof;
   each of said first plates (10) is provided, on at least a pair of parallel opposite sides of the peripheral area (40), with first terraced sections (41), each of said first terraced sections (41) being formed by deforming parts of the first plate (10) including predetermined areas along the pair of parallel opposite sides to project outward relative to a remaining part, said remaining part having a first flat section (42) that is placed at a lower position than said first terraced sections (41);
   each of said second plates (10) is provided, on a predetermined area of the peripheral area (50) corresponding to said first flat section (42) of the first plate (10), with a second terraced section (51), said second terraced section (51) being formed by deforming a part of the second plate to project outward relative to a remaining part, said remaining part of the peripheral area (50) corresponding to said first terraced section (41) of the first plate (10) having a second flat section (52) that is placed at a lower position than said second terraced section (51); and
   said first plates (10) and said second plates (20) are placed alternately one upon another so that surfaces of said irregularity pattern sections (30) face a same direction, the first terraced sections (41) of the first plates (10) are brought into contact with the second flat sections (52) of the second plates (20) and the first flat sections (42) of the first plates (10) are brought into contact with the second terraced sections (51) of the second plates (20), and the first and second plates are welded to each other at contact areas.

2. The heat exchange unit as claimed in Claim 1, wherein:

   the irregularity pattern section (30) of each of the heat exchange plates (10,20) has projections (31) and recesses (34) that are aligned respectively at predetermined intervals, said recesses (34) being placed so as to deviate from the projections (31) by a half of a distance between two adjacent projections (31), said projections (31) and recesses (34) being rotationally symmetric with respect to a center of the plate;
   each of the plates (10,20) has a symmetrical shape so as to provide a same configuration even when the plate turns on a plane thereof around the center thereof by an angle of 180 degrees;
   the plates are placed one upon another so that

the first plate (10) turns on the plane thereof around the center thereof by an angle of 180 degrees upside down relative to the second plate (20), the projections (31) of the first plate (10) come into contact with backsides of the recesses (34) of the second plate (20) and the projections (31) of the second plate (20) come into contact with backsides of the recesses (34) of the first plate (10), while the first terraced sections (41) and the first flat sections (42) come into contact with the second flat sections (52) and the second terraced sections (51), respectively.

3. The heat exchange unit as claimed in Claim 2, wherein:

the irregularity pattern section (30) of each of the heat exchange plates (10,20) has said projections (31) that project outward from one surface of the heat exchange plate in a form of a truncated cone or a truncated pyramid, and a plurality of intermediate protrusions (33) each of which is placed between two projections (31) that are adjacent to each other at a shortest distance, each of the intermediate protrusions (33) being defined by one or more flat or curved portions that extend to opposing surfaces of the two projection (31), and each of the intermediate protrusions (33) having one or more peak portions that are placed in a lower position than a top (32) of the projection;
there is made arrangement providing simultaneously a plurality of combinations of the projection (31) and another projection adjacent thereto at the shortest distance between which the intermediate protrusion (33) is placed; and
a plurality of non-protruded portions each of which is placed between adjacent intermediate protrusions (33), each of the non-protruded portions being placed in a lowest position relative to a projecting direction of the projections (31), the non-protruded portions providing said recesses (34) surrounded by the projections (31) and the intermediate protrusions (33).

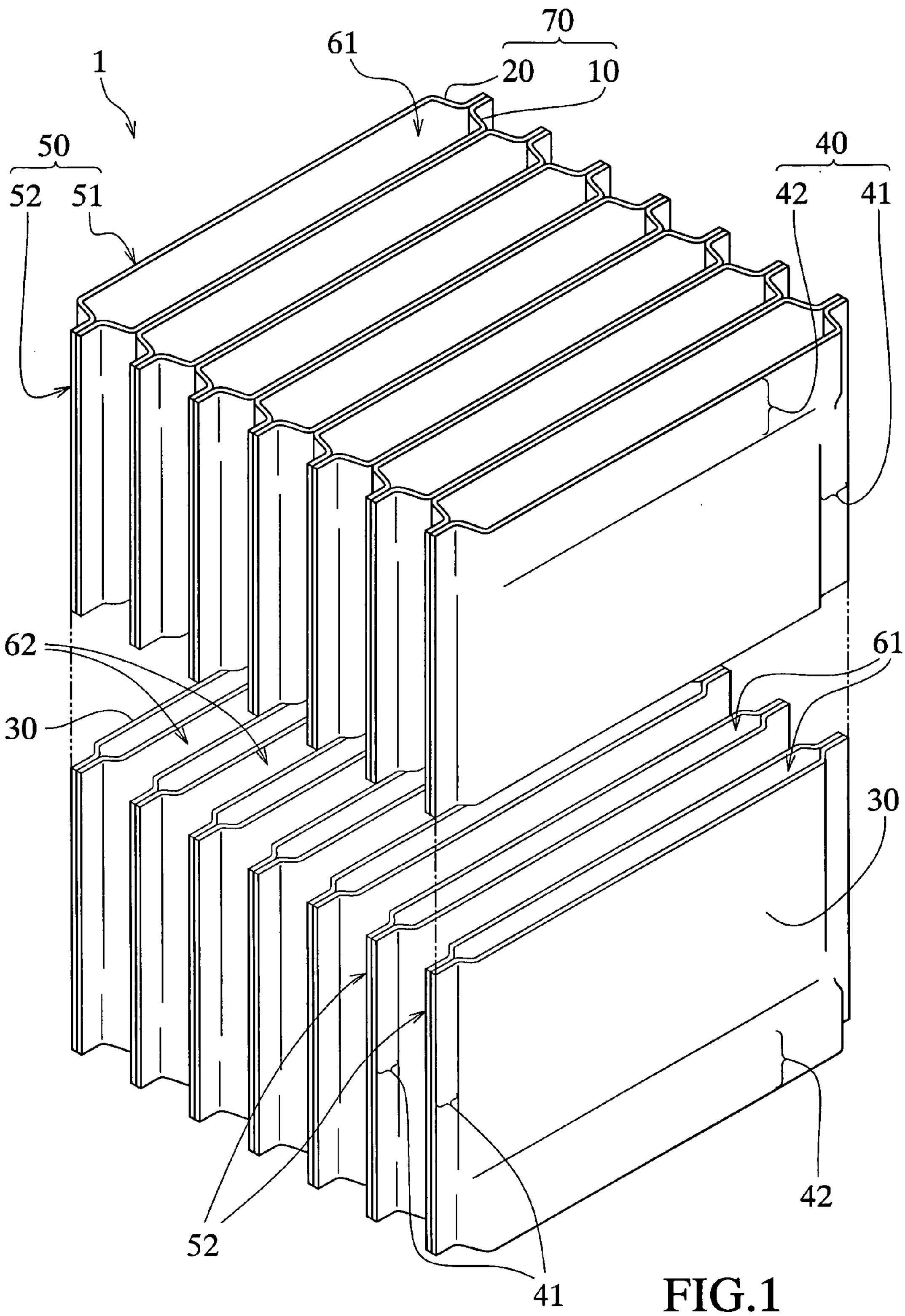

FIG.1

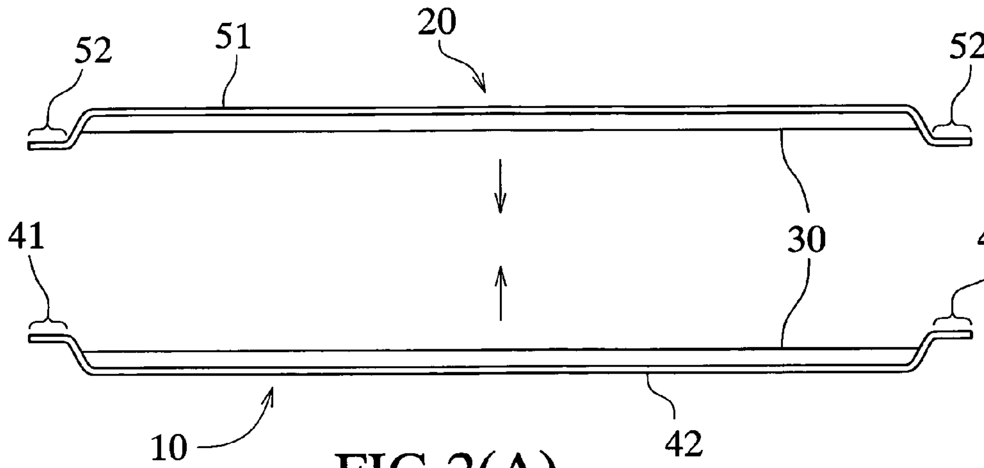

FIG.2(A)

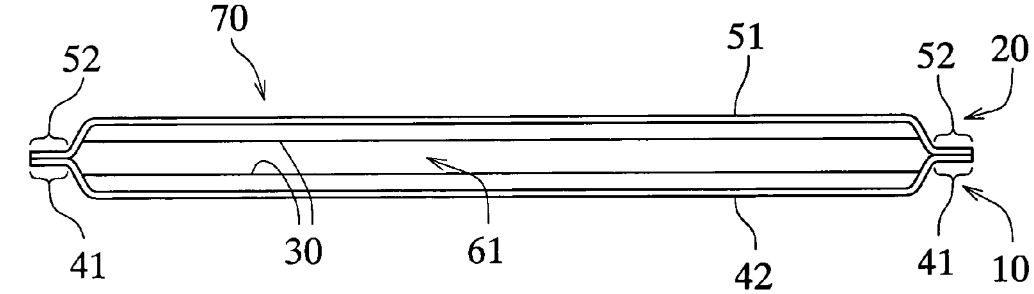

FIG.2(B)

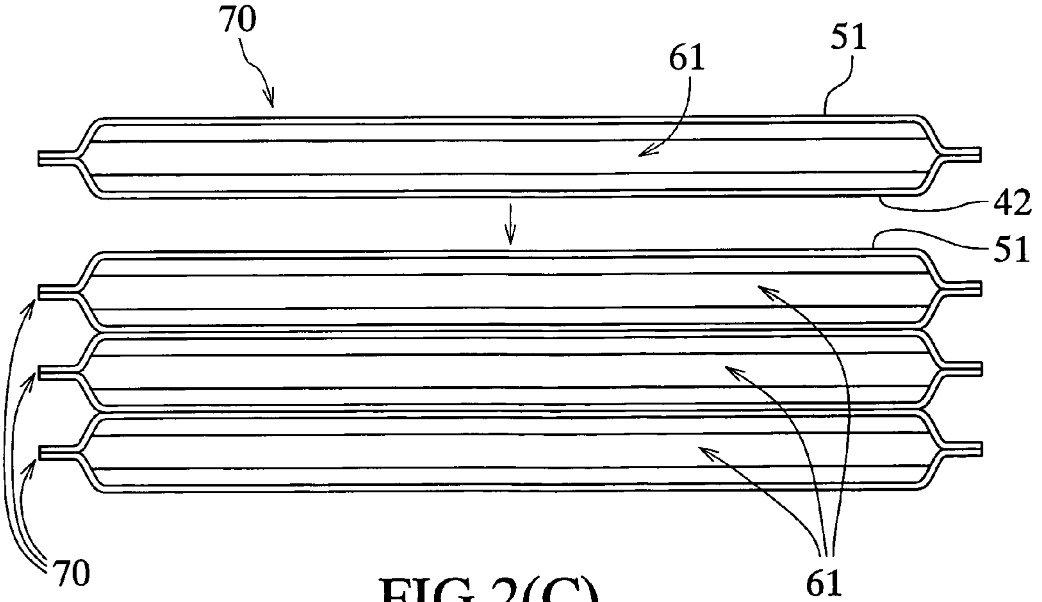

FIG.2(C)

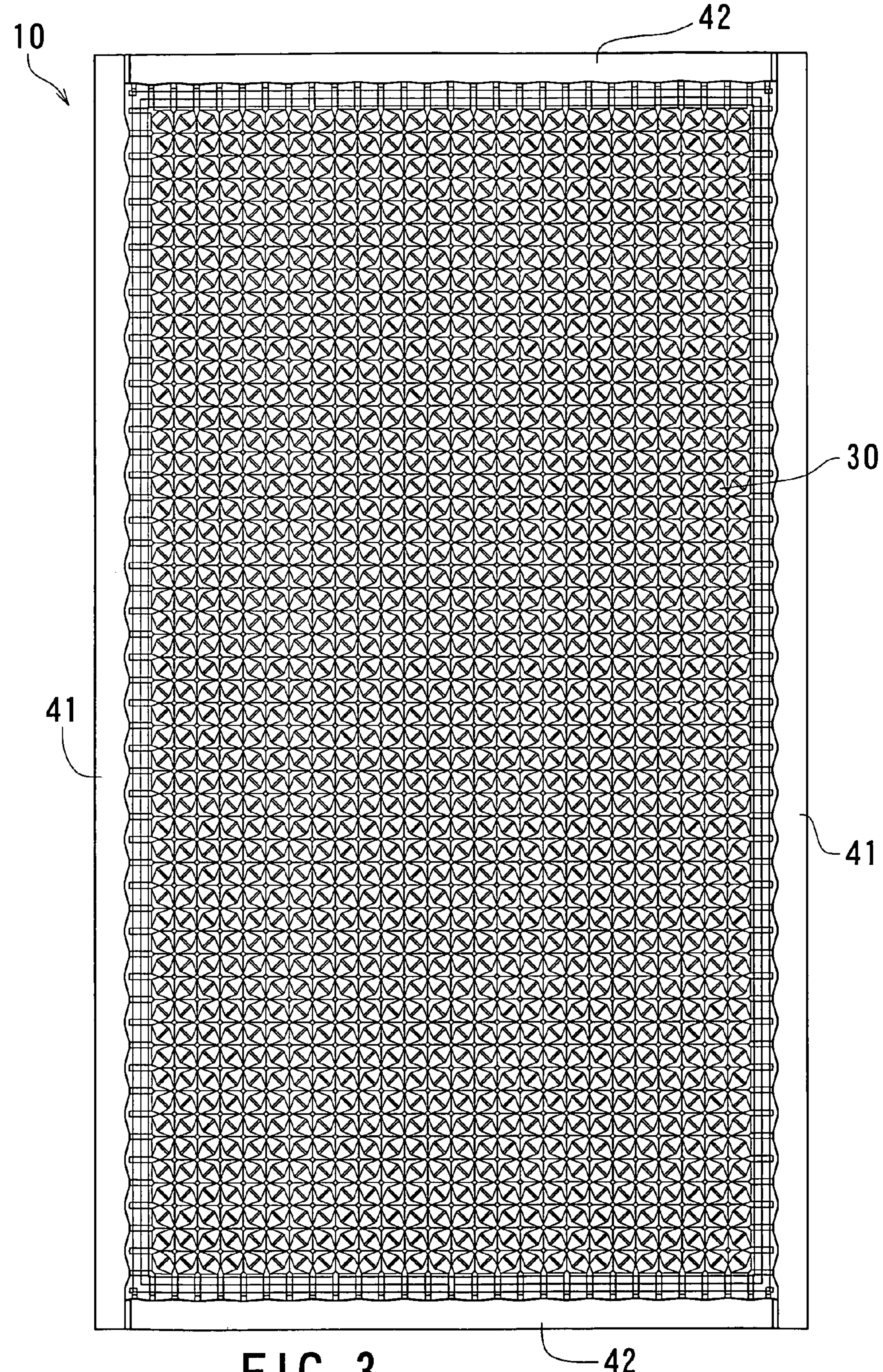

FIG. 3

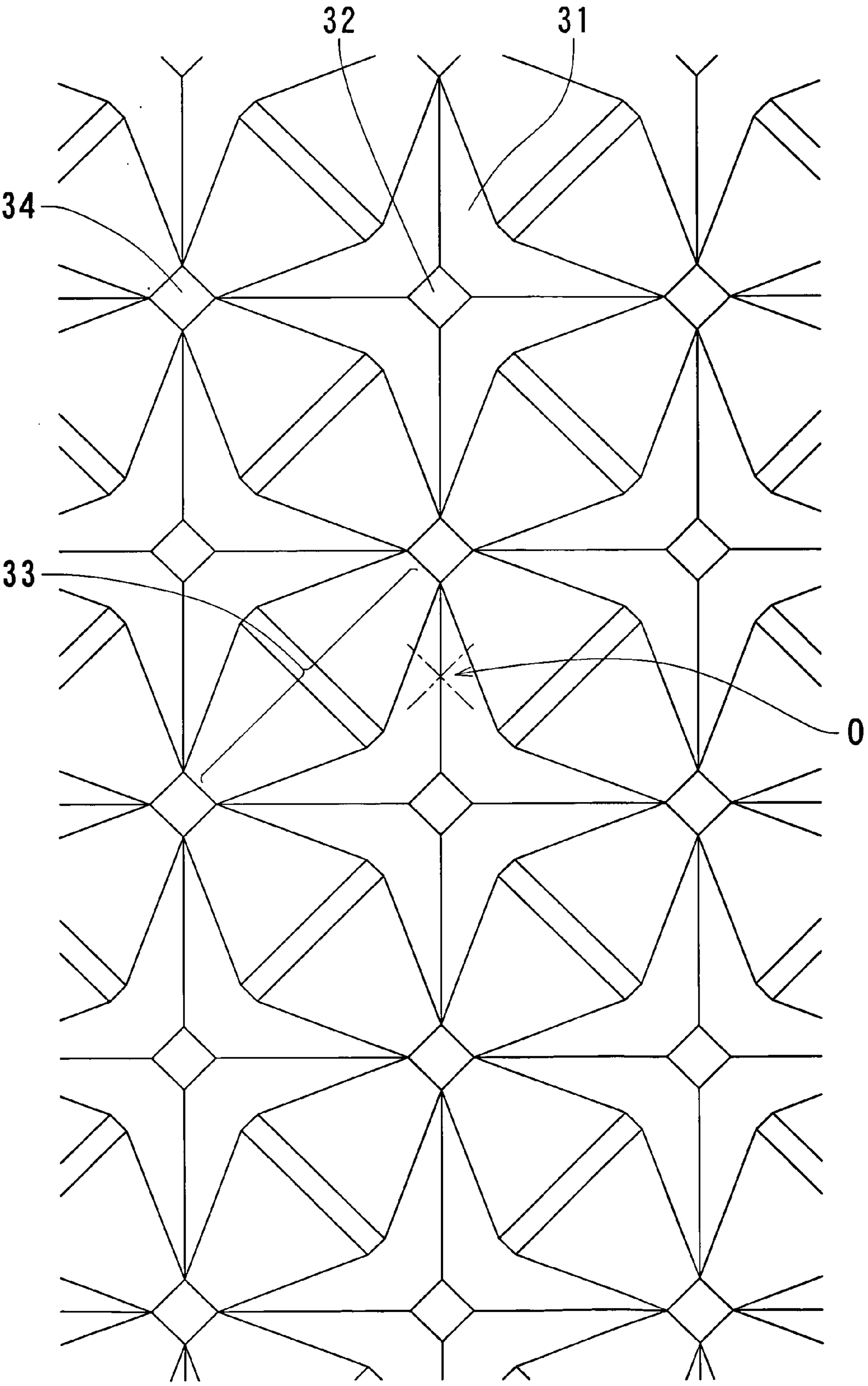

FIG. 4

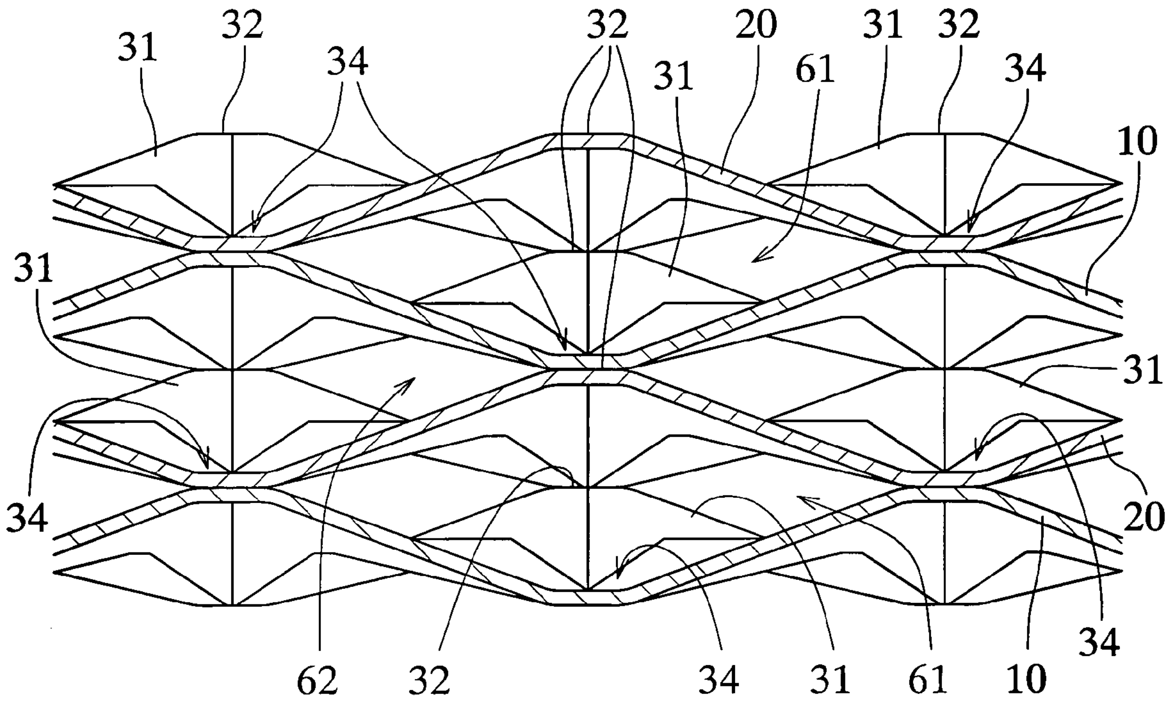

FIG.5

REFERENCES CITED IN THE DESCRIPTION

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