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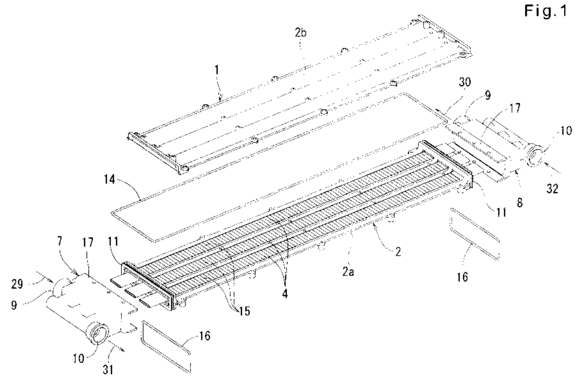
(54) HEAT EXCHANGER

(57) A heat exchanger is provided of which the heat exchange efficiency is significantly improved by providing a flat tube with an increased surface area and increasing the flow speed of fluid that flows outside the flat tube. The heat exchanger includes an outer case (2) defining therein a tubular space (3), and a flat tube (4) received in the tubular space (3). A first fluid and a second fluid are fed through the tubular space, outside and inside the flat tube, respectively, to exchange heat between the first and second fluids. The flat tube (4), which defines a flow passage (6) therein, includes a peripheral wall having a surface increasing shape (15) which is in the form of a longitudinally continuous helical corrugation, longitudinally continuous corrugations, corrugations continuous in section in a width direction, or longitudinally extending fins formed on an outer surface of the peripheral wall of the flat tube so as to be spaced apart from each other in the width direction. Fluid passages (5) are defined by a large number of fluid flow rectifying grooves (5a) formed parallel to each other in the inner periphery of the tubular space (3) of the outer case (2).

Fig.1



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Description

TECHNICAL FIELD

[0001] This invention relates to a flat heat exchanger used e.g. to supply hot water, and more specifically to a heat exchanger capable of exchanging heat with significantly high efficiency.

BACKGROUND ART

[0002] A typical flat type heat exchanger used to supply hot water includes a flat elongated outer case in which at least one flat tube is mounted in the outer case with a gap left between the outer surface of the flat tube and the inner wall of the outer case as a fluid passage. Heated fluid is fed through the fluid passage from one to the other end, while fluid to be heated is fed through a flow passage defined in the flat tube from the other end thereof to the one end. Thus, heat is exchanged between the heated fluid and the fluid to be heated, which flow outside and inside of the flat tube, thus heating the fluid fed through the flow passage defined in the tube.

[0003] The flat tube of a conventional such heat exchanger is made of a material having high heat conductivity in an attempt to improve heat exchange efficiency between fluid fed through the fluid passage outside the flat tube and fluid fed through the flow passage defined in the flat tube.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0004]

Patent document 1: JP Utility Model Registration 3133996

SUMMARY OF THE INVENTION

OBJECT OF THE INVENTION

[0005] It is known that the efficiency of heat exchange is influenced not only by the heat conductivity of the flat tube, but also by the surface area of the flat tube and the flow speeds of the fluids flowing inside and outside of the flat tube. Conventional flat tubes have smooth inner and outer surfaces, so that the heat exchange efficiency was low.

[0006] An object of the present invention is to provide a heat exchanger of which the heat exchange efficiency is significantly improved by providing a flat tube with an increased surface area and increasing the flow speed of fluid that flows outside the flat tube.

MEANS TO ACHIEVE THE OBJECT

[0007] In order to achieve this object, the present invention provides a heat exchanger comprising an outer case defining therein a tubular space, and a flat tube received in the tubular space, wherein a first fluid and a second fluid are fed through the tubular space, outside and inside the flat tube, respectively, to exchange heat between the first and second fluids, wherein the flat tube has a peripheral wall having a surface area increasing shape, wherein the tubular space has fluid passages formed on an inner periphery of the tubular space through which fluid can flow in a longitudinal direction outside of the flat tube, the fluid passages being defined by a large number of fluid flow rectifying grooves arranged parallel to each other.

[0008] In one arrangement, the outer case comprises a lower half member and an upper half member disposed over and joined to the lower half member, the lower and upper half members having opposed recessed grooves opposed to each other and defining the tubular space, and the fluid flow rectifying grooves are formed in bottom surfaces of the opposed recessed grooves.

[0009] In another arrangement, the outer case comprises a lower half member carrying mounting frames at two ends thereof to which fluid supply and discharge heads are mounted, respectively, and an upper half member having a length such that it is received between the mounting frames. The lower half member is formed with three longitudinal recessed grooves on its top surface, and the upper half member is formed with three longitudinal recessed grooves on its bottom surface. The upper and lower half members are joined together with an annular packing disposed between the abutting outer edges of the upper and lower half members. With the upper and lower half members joined together, tubular spaces are defined between the respective longitudinal recessed grooves of the lower half member and the corresponding longitudinal recessed grooves of the upper half members. Flat tubes are inserted in the respective tubular spaces. A large number of longitudinally extending narrow fluid flow rectifying grooves are formed on the bottom surface of each of the longitudinal recessed grooves so as to be arranged parallel to each other in the width direction. The fluid flow rectifying grooves define fluid passages for fluid that flows outside the respective flat tubes.

[0010] In a further preferred arrangement, the outer case comprises a case body in the shape of a pipe, and two fluid passage forming members in the form of split members that are joined together into a tubular member and received in the case body, the fluid passage forming members being formed with opposed recessed grooves on opposed surfaces of the respective fluid passage forming members, the opposed recessed grooves defining the tubular space, in which the flat tube is received. The fluid flow rectifying grooves are formed in bottom surfaces of the opposed recessed grooves.

[0011] The surface area increasing shape of the peripheral wall of the flat tube may be one kind selected from the group consisting of a longitudinally continuous helical corrugation or corrugations, longitudinally continuous corrugations, corrugations continuous in section in a width direction, longitudinally extending fins formed on an outer surface of the peripheral wall of the flat tube so as to be spaced apart from each other in the width direction.

[0012] In another arrangement, the heat exchanger further comprises fluid supply and discharge heads watertightly fixed to the respective ends of the outer case, respectively, each of the fluid supply and discharge heads comprising a supply and discharge pipe for a first fluid communicating with a flow passage defined in the flat tube, and a supply and discharge pipe for a second fluid communicating with the fluid passage of the outer case.

[0013] The flat tube is made of a material having high heat conductivity, and has a flat elliptical section that snugly fits in the tubular space. Its length is determined such that its ends protrude from the respective mounting frames of the lower half member, and its interior serves as the fluid flow passage. The peripheral wall of the flat tube has the surface area increasing shape at its portion located inside of the tubular space.

[0014] If the surface area increasing shape of the peripheral wall of the flat tube comprises longitudinally continuous helical corrugation or corrugations, the helical corrugation or corrugations may be thread or threads having an arcuate section. If the surface area increasing shape comprises double helical corrugations, such double helical corrugations may comprise two threads which are inclined in opposite directions to each other.

[0015] If the surface area increasing shape comprises longitudinally continuous corrugations, the flat tube has a structure similar to an ordinary corrugated pipe. If the surface area increasing shape comprises corrugations continuous in section in the width direction, the corrugations may comprise alternating arcuate recesses and protrusions, or may consist only of continuous recesses, or continuous chevron-shaped corrugations.

ADVANTAGES OF THE INVENTION

[0016] According to the present invention, the surface area increasing shape of the peripheral wall of the flat tube significantly increases the surface areas of both inner and outer surfaces of the flat tube, which in turn markedly improve the efficiency of heat exchange between fluids that flow inside and outside of the flat tube.

[0017] Since the fluid passages formed in the inner surface of the tubular space of the outer case are defined by the large number of fluid flow rectifying grooves extending parallel to each other, the fluid flow rectifying grooves rectify, and thus increase the speed of, the flow of fluid that flows outside the flat tube. Thus, by feeding a heating fluid through the fluid passages, it is possible to exchange heat with high efficiency between the heating fluid and a fluid that flows through the flow passage defined in the flat tube.

[0018] The heat exchange efficiency further dramatically increases due to the synergetic effect between the surface area increasing shape of the flat tube and the fluid flow rectifying grooves, which define the fluid passages.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

Fig. 1 is an exploded perspective view of a heat exchanger according to a first embodiment of the present invention.

Fig. 2(a) is a perspective view of a lower half member of the heat exchanger of the first embodiment according to the present invention; Fig. 2(b) is its plan view; and Fig. 2(c) is a side view of the lower half member as viewed from one end thereof.

Fig. 3(a) is a perspective view of an upper half member of the heat exchanger of the first embodiment according to the present invention, shown with its bottom up; Fig. 3(b) is its plan view; and Fig. 3(c) is a side view of the upper half member as viewed from one end thereof with its bottom up.

Fig. 4(a) is an enlarged sectional view of the upper and lower half members, showing the state in which the upper and lower half members are spaced from each other and not yet assembled together; and Fig. 4(b) is an enlarged view of the upper and lower half members, showing the state in which the upper and lower half members have been assembled together.

Figs. 5(a) to 5(e) show various surface area increasing shapes of a flat tube, of which: Figs. 5(a) and 5(b) are a plan view and an enlarged longitudinal sectional view, of a longitudinally continuous helical corrugation, respectively; Fig. 5(c) is a plan view of a surface area increasing shape comprising double helical threads which are inclined in opposite directions to each other and overlap with each other; and Figs. 5(d) and 5(e) are a plan view and an enlarged longitudinal sectional view, of a corrugated pipe having continuously alternating arcuate protrusions and recesses.

Fig. 6(a) to 6(d) are sectional views of flat tubes having various surface area increasing shapes, as taken along a place extending in the width direction, of which: Fig. 6(a) is a sectional view of corrugations comprising continuously alternating arcuate protrusions and recesses; Fig. 6(b) is a sectional view of continuous U-shaped recesses; Fig. 6(c) is a sectional view of continuous chevron-shaped corrugations; and Fig. 6(d) is a sectional view of a large number of protruding fins.

Fig. 7(a) is an exploded view of a heat exchanger according to a second embodiment of the present invention; and Fig. 7(b) is its vertical sectional view. Fig. 8(a) is a perspective view of a heat exchanger according to a third embodiment of the present invention; and Fig. 8(b) is a perspective view of a fluid passage forming member used in the heat exchanger of Fig. 8(a).

BEST MODE FOR EMBODYING THE INVENTION

[0020] Now the embodiments of the invention are described with reference to the drawings.

[0021] Figs. 1 to 6 show the heat exchanger according to the first embodiment of the invention. This heat exchanger 1 includes a longitudinally elongated flat outer case 2 formed with three tubular spaces 3 extending through the entire length of the outer case 2 in parallel to each other. Flat tubes 4 are received in the respective tubular spaces 3. The tubular spaces 3 are each formed with fluid passages 5 in its inner periphery through which a first fluid can flow in the longitudinal direction, and the interiors of the flat tubes 4 each define a flow passage 6 through which a second fluid can flow such that heat can be exchanged between the first and second fluids.

[0022] Fluid supply and discharge heads 7 and 8 are watertightly fixed to the respective ends of the outer case 2. The fluid supply and discharge heads 7 and 8 have fluid supply and discharge passages 9 for the first fluid, respectively, which communicate with the respective first and second longitudinal ends of the fluid passages 5. The fluid supply and discharge heads 7 and 8 further include fluid supply and discharge passages 10 for the second fluid, which communicates with the respective first and second longitudinal ends of the flow passages 6, which are defined in the respective flat tubes 4. As a whole, the heat exchanger 1 has a flat shape.

[0023] The outer case 2 is formed by assembling together lower half and upper half members 2a and 2b which are made of a synthetic resin or a metal. The lower half member 2a is a longitudinally elongated flat strip having mounting frames 11 at the respective longitudinal ends thereof to which the respective fluid supply and discharge heads 7 and 8 are mounted. The lower half member 2a has in its top surface three recessed grooves 12 extending longitudinally parallel to each other.

[0024] As shown in Figs. 3 and 4, the upper half member 2b is a flat strip substantially equal in width to the lower half member 2a and having a length such that it is received between the mounting frames 11 at the respective longitudinal ends. The upper half member 2b has a bottom surface located over the lower half member 2a and formed with recessed grooves 13 facing the respective recessed grooves 12 of the lower half member 2a so as to extend the entire length of the upper half member 2b. The upper half member 2b is placed on top of the lower half member 2a with an annular packing 14 disposed therebetween along their outer edges, and the two members 2a and 2b are assembled into the outer case 2 by tightening screws at a plurality of locations.

[0025] With the upper half member 2b disposed over the lower half member 2a as shown in Fig. 4(a), the upper half member 2b is placed on top of the lower half member 2a and the screws are tightened at the plurality of locations. In this state, as shown in Fig. 4(b), the recessed grooves 12 of the lower half member 2a are located under and communicate with the respective recessed grooves 13 of the upper half member 2b, defining the respective three flat tubular spaces 3, which are arranged parallel to each other, while being spaced from each other. The tubular spaces 3 are surrounded, and watertightly sealed from outside, by the annular packing 14, which are disposed between the lower half member 2a and the upper half member 2b along their outer edges placed one over the other.

[0026] In order that the flat tubes 4 can be snugly received in the respective tubular spaces 3, the recessed grooves 12 and 13 have such cross-sectional shapes that the recessed grooves 12 and 13 can be located right under and right over the respective flat tubes 4. Thus, the fluid passages 5 are defined in the inner peripheral surface of each tubular space 3.

[0027] As shown in Figs. 4(a) and 4(b), the fluid passages 5 are defined by fluid flow rectifying grooves 5a formed in the bottom surfaces of the recessed grooves 12 of the lower half member 2a and in the top surfaces of the recessed grooves 13 of the upper half member 2b so as to extend the entire length of the lower half member 2a and the upper half member 2b.

[0028] The fluid flow rectifying grooves 5a are narrow grooves each having a relatively small cross-sectional area, and a large number of them are arranged in the width direction of each of the recessed grooves 12 and 13 at regular intervals. Narrow ribs 5b provided between the adjacent grooves 5a and defining the grooves 5a form, in cooperation with the grooves 5a, a rugged terrain on the surface of each recessed groove 12, 13. With the flat tube 4 received in each tubular space 3 defined by the recessed grooves 12 and 13, the apexes of the ribs 5b are located close to or abut the outer surface of the flat tube 4, with the open ends of the fluid flow rectifying grooves 5a facing the outer surface of the flat tube 4.

[0029] When the first fluid is fed through the fluid passages 5, which are defined by the fluid flow rectifying grooves 5b outside the respective flat tubes 4, the first fluid flows in the longitudinal direction while kept in contact with the flat tubes 4, so that the flow of the first fluid is rectified along the longitudinal shape of the fluid flow rectifying grooves 5. This speeds up the flow of the first fluid.

[0030] The depth, width and intervals of the fluid flow rectifying grooves 5a formed on the surface of each recessed groove 12, 13 are not particularly limited. For example, the grooves 5a may extend longitudinally in straight lines as viewed from top, or as shown in Figs. 2(b) and 3(b), the grooves 5a may extend longitudinally in a zigzag manner, as viewed from top. The grooves 5b extending in a zigzag manner increases the length of contact of the first fluid with the outer surface of the flat tubes 4, thus improving the efficiency of heat exchange.

[0031] The flat tubes 4 are made of e.g. a metal having high heat conductivity, and have a flat elliptical cross-section such that they can be snugly fitted in the respective tubular spaces 3, which are defined by the recessed grooves 12 and 13. The flat tubes 4 each have their respective ends protruding by a predetermined length from the respective mounting frames 11, which are provided at both ends of the lower half member 2a. The flat tubes 4 each have a peripheral wall having a surface-area-increasing shape 15 at its longitudinal portion located inside the tubular space 3.

[0032] Figs. 5(a) to 5(e) and Figs. 6(a) to 6(d) show different surface area increasing shapes 15. The shape 15 shown in Fig. 5(a) and 5(b) comprises a single or multiple longitudinally continuous helical corrugations or threads having an arcuate section and formed on the peripheral wall of each flat tube 4. The shape 15 shown in Fig. 5(c) comprises two helical threads formed on the peripheral wall of each flat tube 4 so as to be inclined in the opposite directions to each other and overlap with each other.

[0033] The shape 15 shown in Figs. 5(d) and 5(e) comprises longitudinally continuous corrugations, i.e. alternating circular recesses and protrusions formed on the peripheral wall of each flat tube 4. This flat tube of this embodiment is therefore similar to a well-known corrugated pipe.

[0034] The surface area increasing shapes 15 of Figs. 6(a) to 6(d) each comprise bent shapes formed on the top and bottom surfaces of the peripheral wall of each flat tube 4 so as to be continuous in the width direction, the peripheral wall having a flat rectangular widthwise section. The shape 15 of Fig. 6(a) has a corrugated section comprising alternating arcuate recesses and protrusions that are continuous with each other. The shape 15 of Fig. 6(b) comprises, in section, a plurality of continuous U-shaped recesses. The shape 15 of Fig. 6(c) comprises, in section, a plurality of continuous chevron-shaped corrugations.

[0035] The surface area increasing shape 15 of Fig. 6(d) comprises a large number of fins 15a protruding from the top and bottom outer surfaces of the peripheral wall of each flat tube 4 so as to be arranged at regular intervals in the width direction, the peripheral wall having a flat rectangular cross-section.

[0036] Any one of the shapes shown in Figs. 5(a) to 5(e) and Figs. 6(a) to 6(d) may be selected as the surface area increasing shape 15 formed on the peripheral wall of each flat tube 4.

[0037] By forming the rugged outer surface, i.e. the surface area increasing shape 15 on the peripheral wall of each flat tube 4, the depth of each of the fluid passages 5, which surround the flat tubes 4, varies in the longitudinal direction. But since its depth never decreases below the depth of the fluid flow rectifying groove 5a, the first fluid can reliably flow through the respective fluid passages 5.

[0038] As shown in Fig. 1, the fluid supply and discharge heads 7 and 8 each include a U-shaped mounting portion 17 watertightly fitted around the mounting frame 11 through a packing 16 fitted around the mounting frame 11. The fluid supply and discharge passage 9 for the first fluid and the fluid supply and discharge passage 10 for the second fluid are provided outside the mounting portion 17. With the heads 7 and 8 mounted to the respective mounting frames 11, the fluid supply and discharge passages 9 for the first fluid watertightly communicate with the respective ends of the fluid passages 5 of the outer case 2, while the fluid supply and discharge passages 10 for the second fluid watertightly communicate with the respective ends of the flow passages 6 defined in the respective flat tubes 4, which are received in the respective tubular spaces 3 of the outer case 2.

[0039] Figs. 7(a) and 7(b) show a heat exchanger according to the second embodiment of this invention. Elements identical to those of the first embodiment are denoted by identical numerals and their description is omitted.

[0040] The heat exchanger 1 of the second embodiment does not include the annular packing 14 and the screws, which are used in the outer case 2 of the first embodiment. The heat exchanger of this embodiment includes a case body 21 in the form of a monolithic pipe having a flat rectangular cross-section, and a plurality of pairs of fluid passage forming members 22 mounted in the case body 21.

[0041] The mounting frames 11 are mounted on the outer surface of the case body 21 at the respective end portions thereof. The interior of the case body 21 is partitioned into four tubular chambers 24 arranged in parallel to each other and each having a slightly larger sectional area than that of the flat tubes 4, by partitioning walls 23.

[0042] Each pair of fluid passage forming members 22 are longitudinally split thin strips having a length equal to the length of the case body 21 and forming a square tube which can be snugly received in one of the tubular chambers 24. When each pair of fluid passage forming members 22 are formed into the square tube, a tubular space 3 is defined by opposed recessed grooves of the respective fluid passage forming members 22 in which a flat tube 4 can be snugly received. With the pairs of fluid passage forming members 22 received in the respective tubular spaces 3, bent pieces 25 at both ends of the respective members 22 are fixed to the respective mounting frames 11 by screws 26.

[0043] A large number of longitudinally continuous thin fluid flow rectifying grooves 5a similar to those of the first embodiment are formed on the bottom surface of the recessed groove of each fluid passage forming member 22 so as to be arranged in parallel to each other in the width direction of the fluid passage forming member 22.

[0044] With the pairs of fluid passage forming members fixed in position in the outer case 2, the flat tubes 4 are inserted through the respective tubular spaces 3. In this state, fluid passages 5 are defined outside the respective flat tubes 4 by the respective fluid flow rectifying grooves 5a.

[0045] The flat tubular heat exchanger 1 of the second embodiment is assembled as follows: The respective pairs of fluid passage forming members are combined together and inserted into the respective tubular chambers 24; the flat tubes 4 are inserted through the tubular spaces 3 defined between the respective pairs of fluid passage forming members 22; and the fluid supply and discharge heads 7 and 8 are fixed to the respective mounting frames 11 at the respective ends of the case body 21 such that the fluid supply and discharge passages 9 for the first fluid of the respective heads 7 and 8 watertightly communicate with the respective ends of the fluid passages 5 of the outer case 2, and the fluid supply and discharge passages 10 for the second fluid of the respective heads 7 and 8 watertightly communicate with the respective ends of the flow passages 6 defined in the respective flat tubes 4.

[0046] Fig. 8 shows the heat exchanger of the third embodiment, of which the outer case 2 includes, as in the second embodiment, a case body 21 and fluid passage forming members 22. The third embodiment is characterized in that the case body 21 can be easily formed by molding of synthetic resin and can be made long.

[0047] The fluid passage forming members 22 of this embodiment are similar to those of the second embodiment in that each pair are longitudinally split strips. With the respective pairs combined into square tubes, the fluid passage forming members 22 are set in a mold for forming the case body 21, which is in the shape of a square tube, and a resin is injected into the mold to form the case body 21 with the pairs of fluid passage forming members 22 embedded in the resin. The case body 21 is thus formed by insert molding.

[0048] The case body 21 can be formed by insert molding using a mold including upper and lower split mold members. Since no draft is necessary as in the case with a monolithic pipe, a long case body 21 can be formed from synthetic resin. Since the fluid passage forming members 22 are longitudinally split members, they can also be formed using split molds. By using such molds, a large number of thin fluid flow rectifying grooves 5a can be easily formed on the fluid passage forming members 22, even if they are non-straight complex-shaped grooves such as zigzag grooves.

[0049] In the second and third embodiments, instead of resin molding, the fluid passage forming members 22 can also be formed easily by cutting or pressing a metal.

[0050] In the third embodiment, shown in Fig. 8, the case body 21 is formed by insert molding with two pairs of the fluid passage forming members 22 set in the case body 21 in parallel to each other. During insert molding, the mounting frames 11 are integrally formed at the respective ends of the case body 21, and a large number of reinforcing ribs 27 are formed on the outer periphery of the case body 21 at predetermined intervals. Two or more of such case bodies 21 are connected together at their abutting ends through the mounting frames 11 and a connecting member 28 to form a long heat exchanger.

[0051] Now the heat exchange operation of the heat exchanger of the first embodiment is described with reference to Figs. 1 to 6.

[0052] As shown in Fig. 1, the outer case 2 is formed by combining the lower half member 2a and the upper half member 2b. The flat tubes 4 are inserted into the respective tubular spaces 3 defined in the outer case 2. A supply pipe 29 for heating fluid is connected to the fluid supply and discharge passage 9 for the first fluid of the fluid supply and discharge head 7, which is mounted at one end of the outer case 2. A discharge pipe 30 for heating fluid is connected to the fluid supply and discharge passage 9 for the first fluid of the fluid supply and discharge head 8, which is mounted at the other end of the outer case 2.

[0053] A discharge pipe 31 for fluid to be heated is connected to the fluid supply and discharge passage 10 for the second fluid of the fluid supply and discharge head 7. A supply pipe 32 for fluid to be heated is connected to the fluid supply and discharge passage 10 for the second fluid of the fluid supply and discharge head 8.

[0054] In this state, heating fluid is fed into the fluid passages 5, which are formed in the inner peripheries of the tubular spaces 3 of the outer case 2, from the supply pipe for heating fluid. Simultaneously, fluid to be heated is fed into the flow passages 6 defined in the respective flat tubes 4 from the supply pipe 32 for fluid to be heated. Thus, the heating fluid and the fluid to be heated flow in the opposite longitudinal directions, outside and inside of the respective flat tubes 4. As a result, heat is exchanged between the two fluids through the peripheral walls of the flat tubes 4. In other words, the fluid to be heated is heated, while flowing through the flow passages 6 of the flat tubes 4, by the heat of the heating fluid, which is flowing through the outer fluid passages 5, and the thus heated hot water is discharged from the discharge pipe 31.

[0055] While heat is being exchanged between the heating fluid and the fluid to be heated through the peripheral walls of the flat tubes 4, the surface area increasing shape 15 on the inner and outer surfaces of peripheral wall of each flat tube 4 provides a larger surface area and thus a larger contact area for both the heating fluid and the fluid to be heated. The heat exchange efficiency thus improves corresponding to an increase in surface area due to the provision of the surface area increasing shape 15, which makes it possible to efficiently heat the fluid to be heated.

[0056] The flow of heating fluid through the fluid passages 5, which are located outside the flat tubes 4, is rectified by the thin fluid flow rectifying grooves 5a formed on the inner peripheries of the tubular spaces 3 in the longitudinal direction of the flat tubes in straight lines or in a zigzag pattern. Since the flow of the heating fluid is rectified and guided in the desired direction by the fluid flow rectifying grooves 5a, the heating fluid flows at an increased speed, which quickens displacement of the heating fluid in the fluid passages 5, thus improving the heat exchange efficiency.

[0057] The operation of the heat exchanger 1 of the second or third embodiment is the same as the above-described operation of the heat exchanger of the first embodiment.

[0058] In any of the embodiments, the number of the flat tubes 4 used, which is equal to the number of the tubular spaces 3 defined in the outer case 2, is not limited to two to four, as shown, and may be one or larger than four.

DESCRIPTION OF THE NUMERALS

[0059]

1. Heat exchanger
2. Outer case
2a. Lower half member
2b. Upper half member
3. Tubular space
4. Flat tube
5. Fluid passage
6. Flow passage
7. Fluid supply and discharge head
8. Fluid supply and discharge head
9. Fluid supply and discharge passage
10. Fluid supply and discharge passage
11. Mounting frame
12. Recessed groove
13. Recessed groove
14. Annular packing
15. Surface area increasing shape
16. Packing
17. U-shaped mounting portion
21. Case body
22. Fluid passage forming member
23. Partitioning wall
24. Tubular chamber
25. Bent piece
26. Screw
27. Reinforcing rib
28. Connecting member
29. Supply pipe
30. Discharge pipe
31. Discharge pipe
32. Supply pipe

Claims

1. A heat exchanger comprising an outer case defining therein a tubular space, and a flat tube received in the tubular space, wherein a first fluid and a second fluid are fed through the tubular space, outside and inside the flat tube, respectively, to exchange heat between the first and second fluids,
characterized in that the flat tube has a peripheral wall having a surface area increasing shape, wherein the tubular space has fluid passages formed on an inner periphery of the tubular space through which fluid can flow in a longitudinal direction outside of the flat tube, the fluid passages being defined by a large number of fluid flow rectifying grooves arranged parallel to each other.

2. The heat exchanger of claim 1, wherein the outer case comprises a lower half member and an upper half member disposed over and joined to the lower half member, the lower and upper half members having opposed recessed grooves opposed to each other and defining the tubular space, and wherein the fluid flow rectifying grooves are formed in bottom surfaces of the opposed recessed grooves.

3. The heat exchanger of claim 1, wherein the outer case comprises a case body in the shape of a pipe, and two fluid passage forming members in the form of split members that are joined together into a tubular member and received in the case body, the fluid passage forming members being formed with opposed recessed grooves on opposed surfaces of the respective fluid passage forming members, the opposed recessed grooves defining said tubular space, in which the flat tube is received, and wherein the fluid flow rectifying grooves are formed in bottom surfaces of the opposed recessed grooves.

4. The heat exchanger of any of claims 1 to 3, wherein said surface area increasing shape of the peripheral wall of the flat tube is one kind selected from the group consisting of a longitudinally continuous helical corrugation, longitudinally continuous corrugations, corrugations continuous in section in a width direction, and longitudinally extending fins formed on an outer surface of the peripheral wall of the flat tube so as to be spaced apart from each other in the width direction.

5. The heat exchanger of any of claims 1 to 4, further comprising fluid supply and discharge heads watertightly fixed to two ends of the outer case, respectively, each of the fluid supply and discharge heads comprising a supply and discharge pipe for a first fluid communicating with a flow passage defined in the flat tube, and a supply and discharge pipe for a second fluid communicating with the fluid passage of the outer case.

Fig. 1

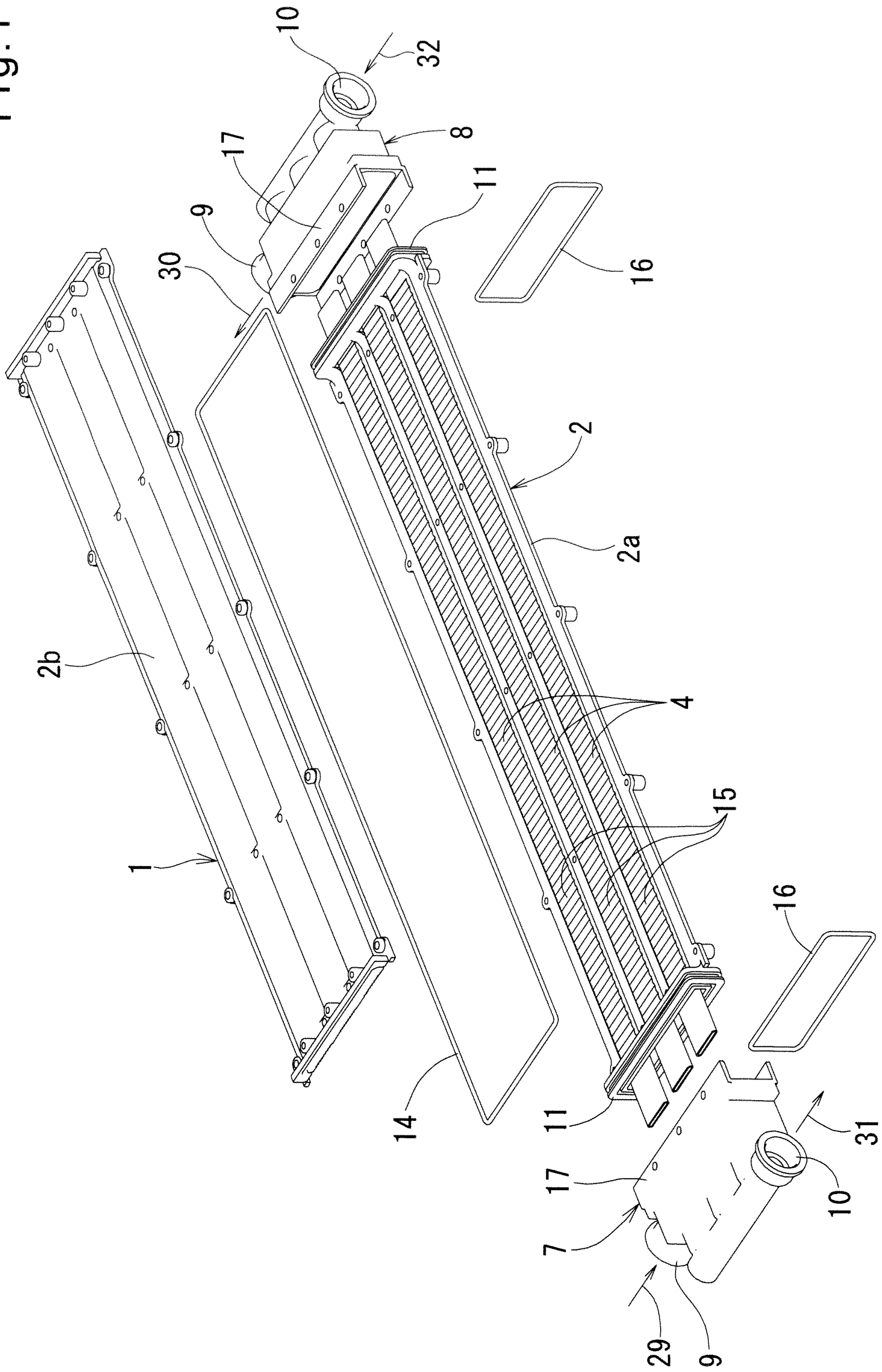
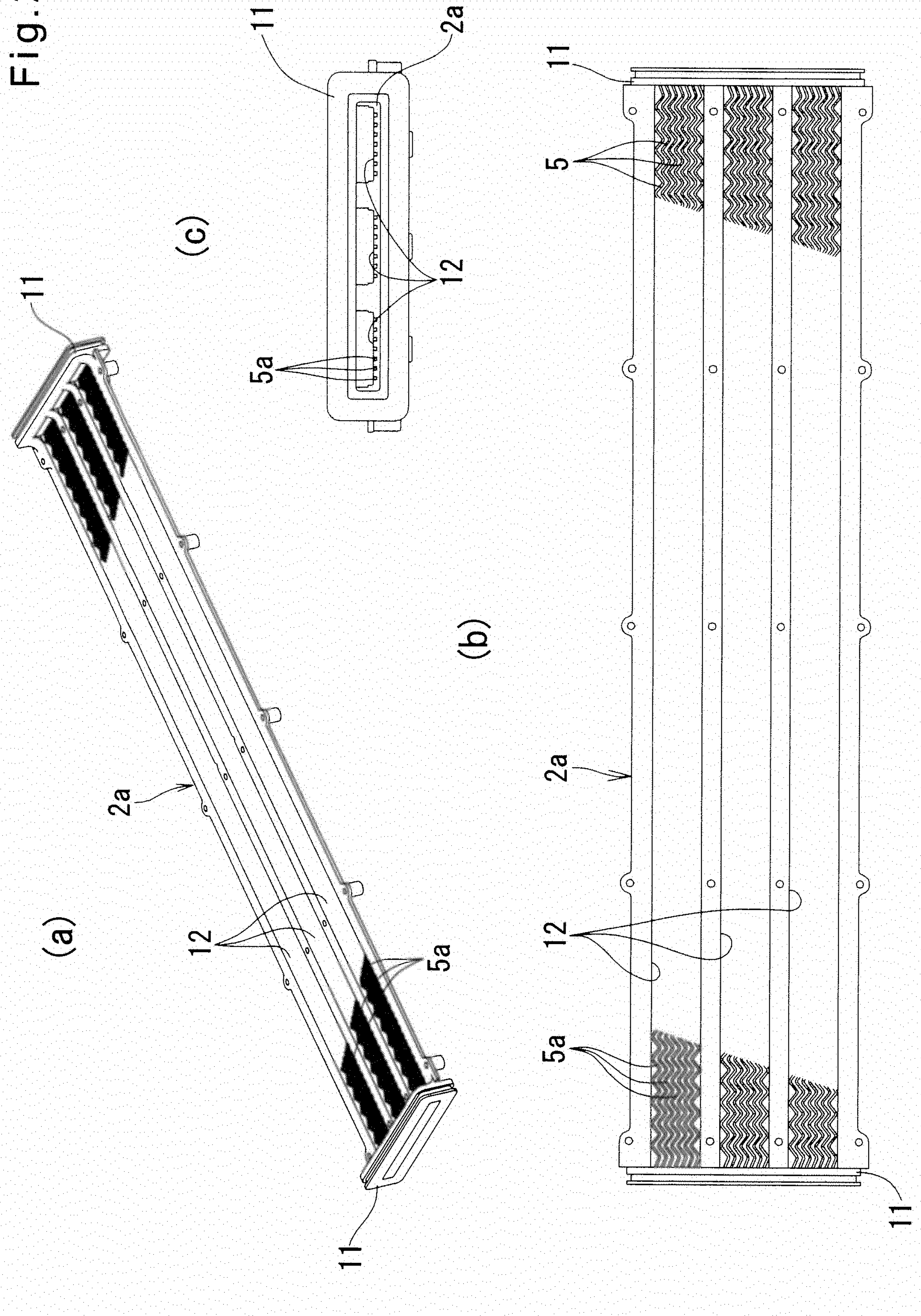


Fig.2



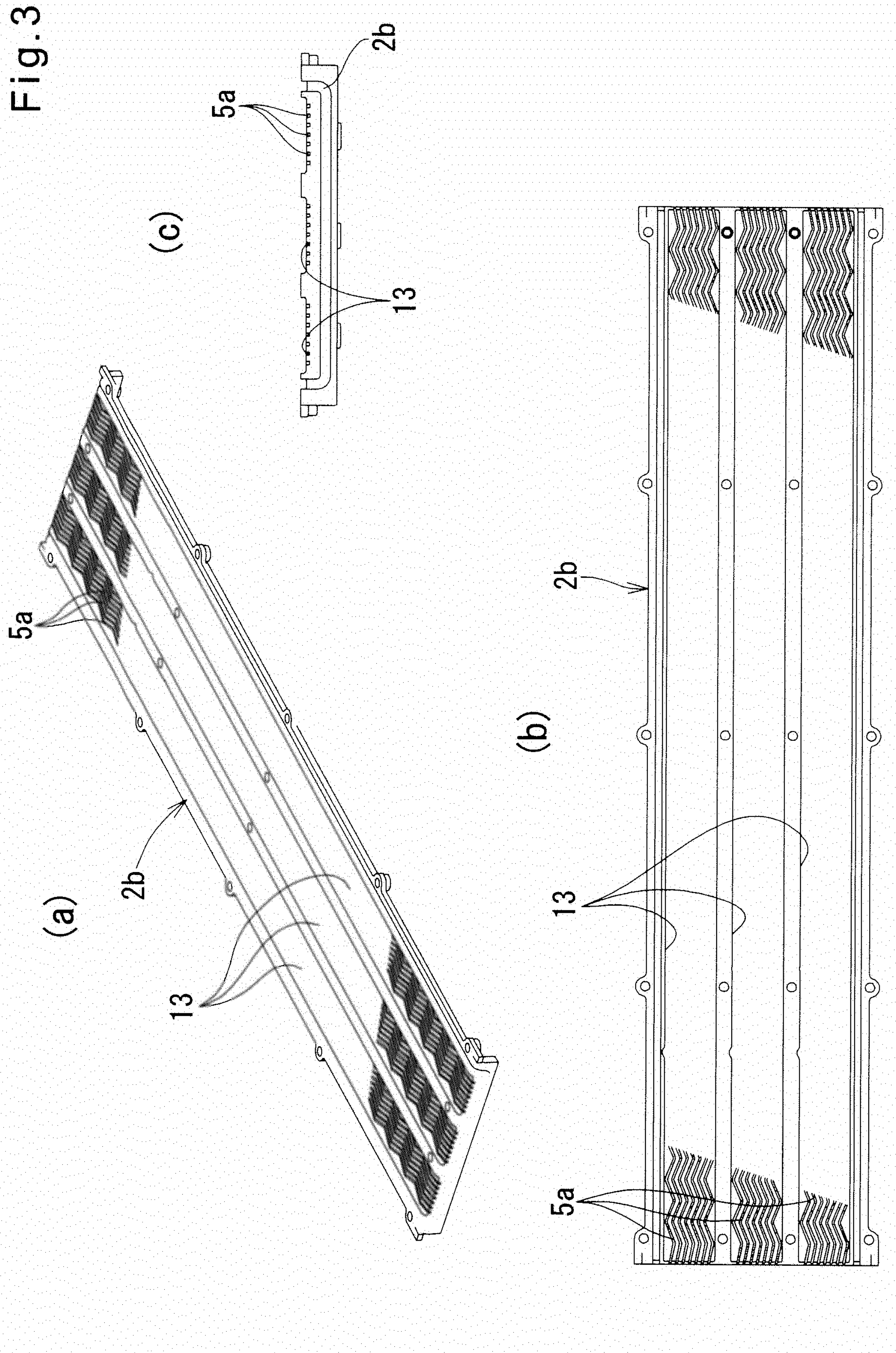
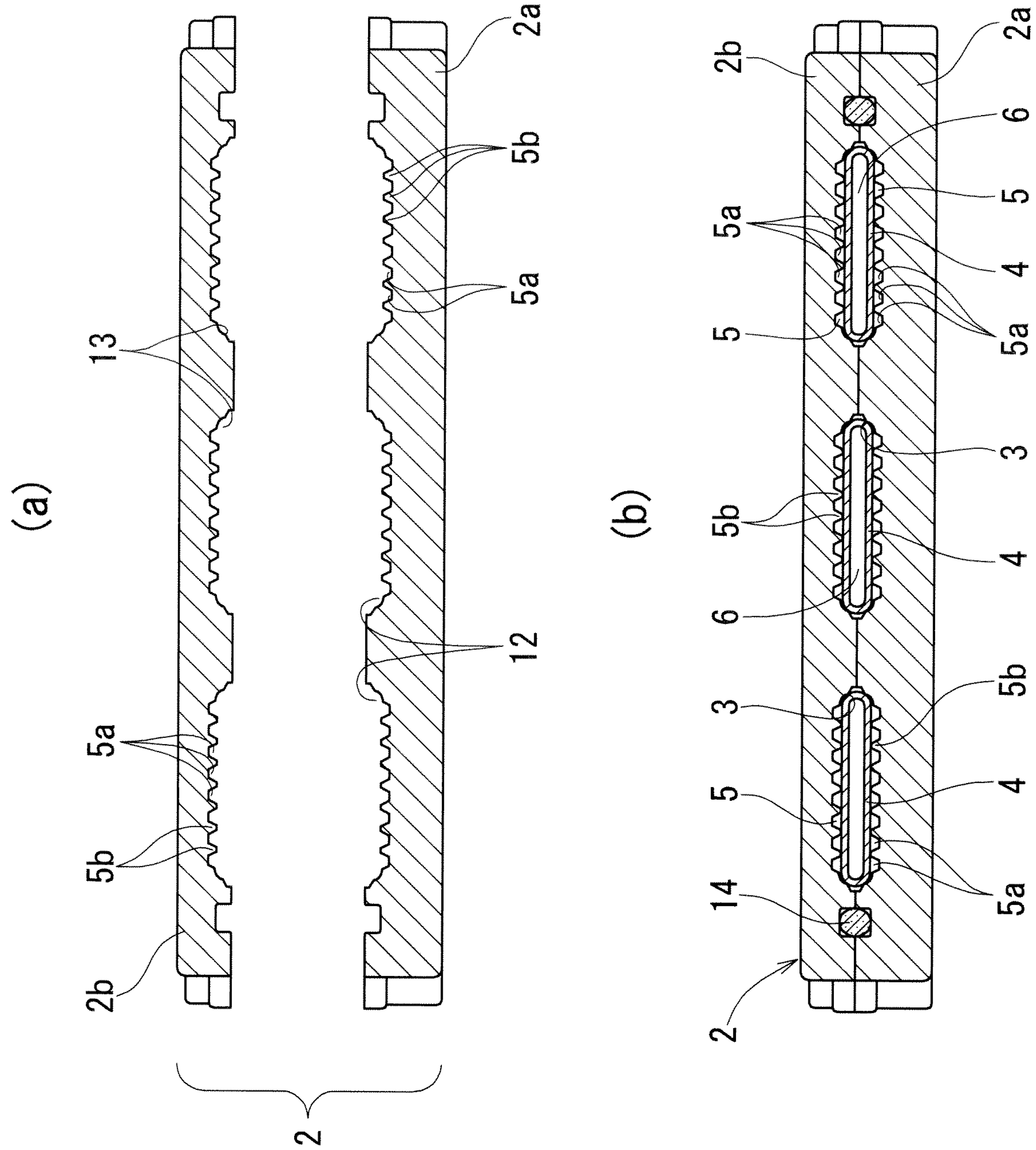


Fig.3
(a)
(b)
(c)
2b
5a
13
2b
5a
13
2b
5a
13

Fig.4



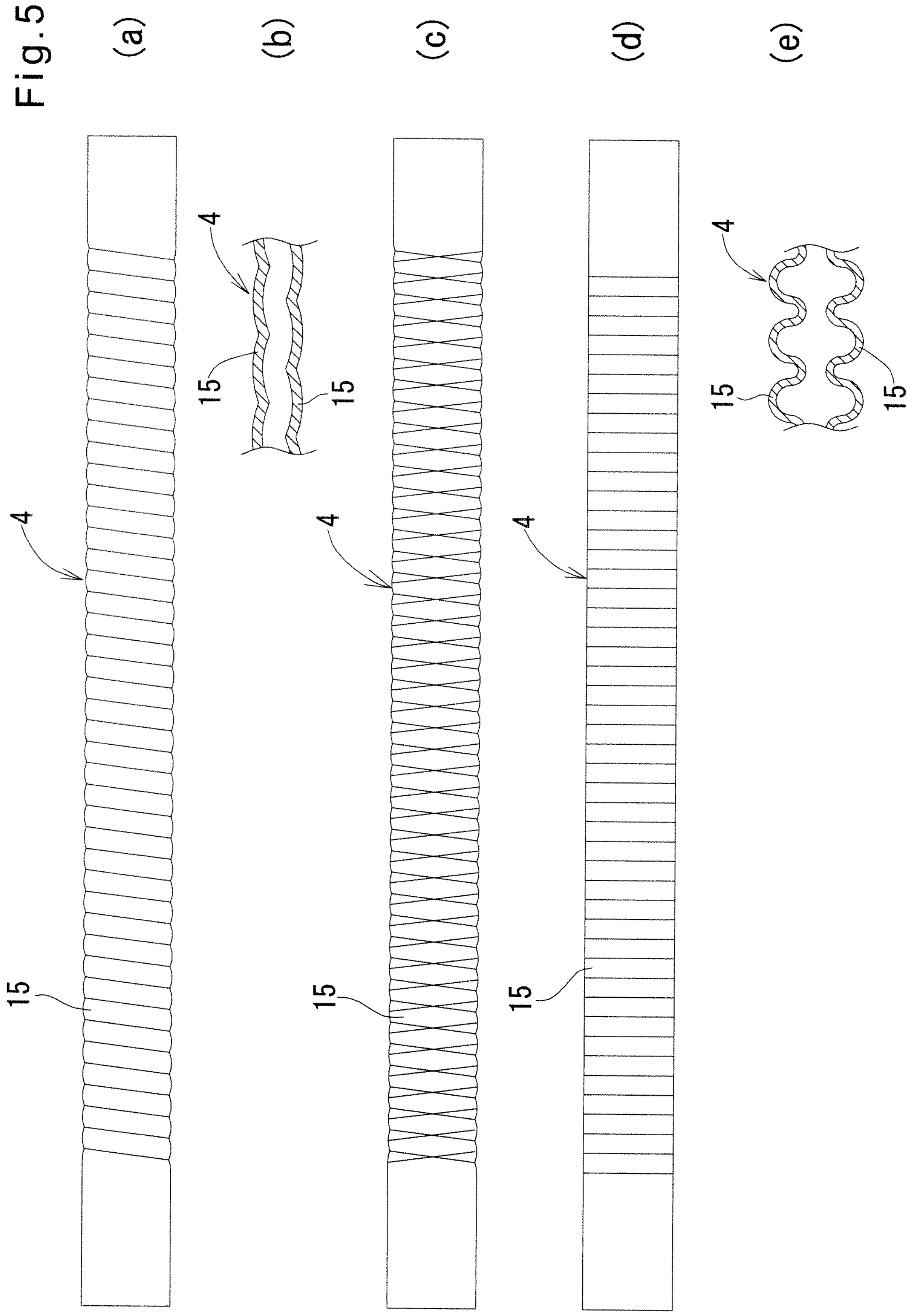
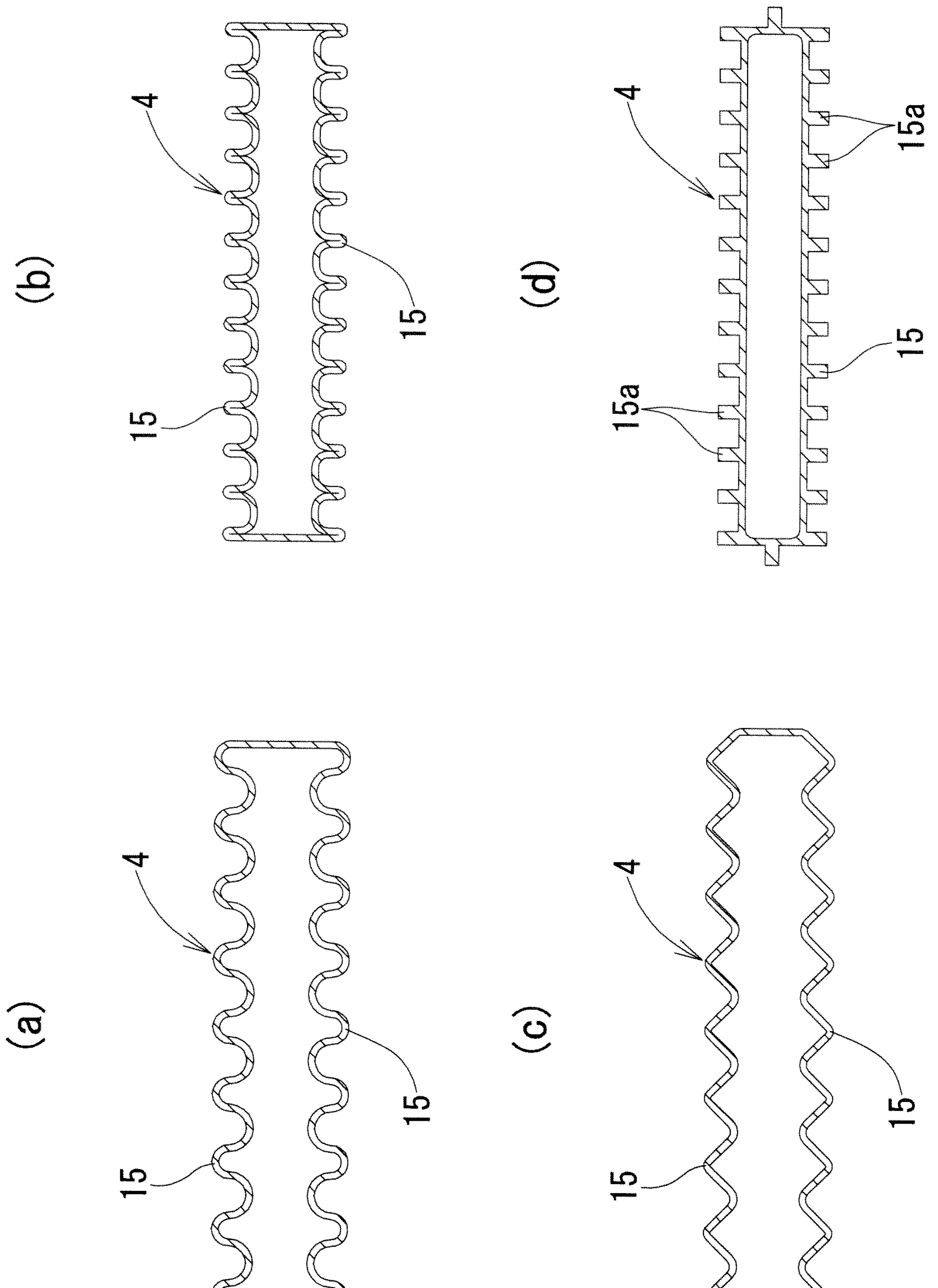


Fig. 5

Fig.6



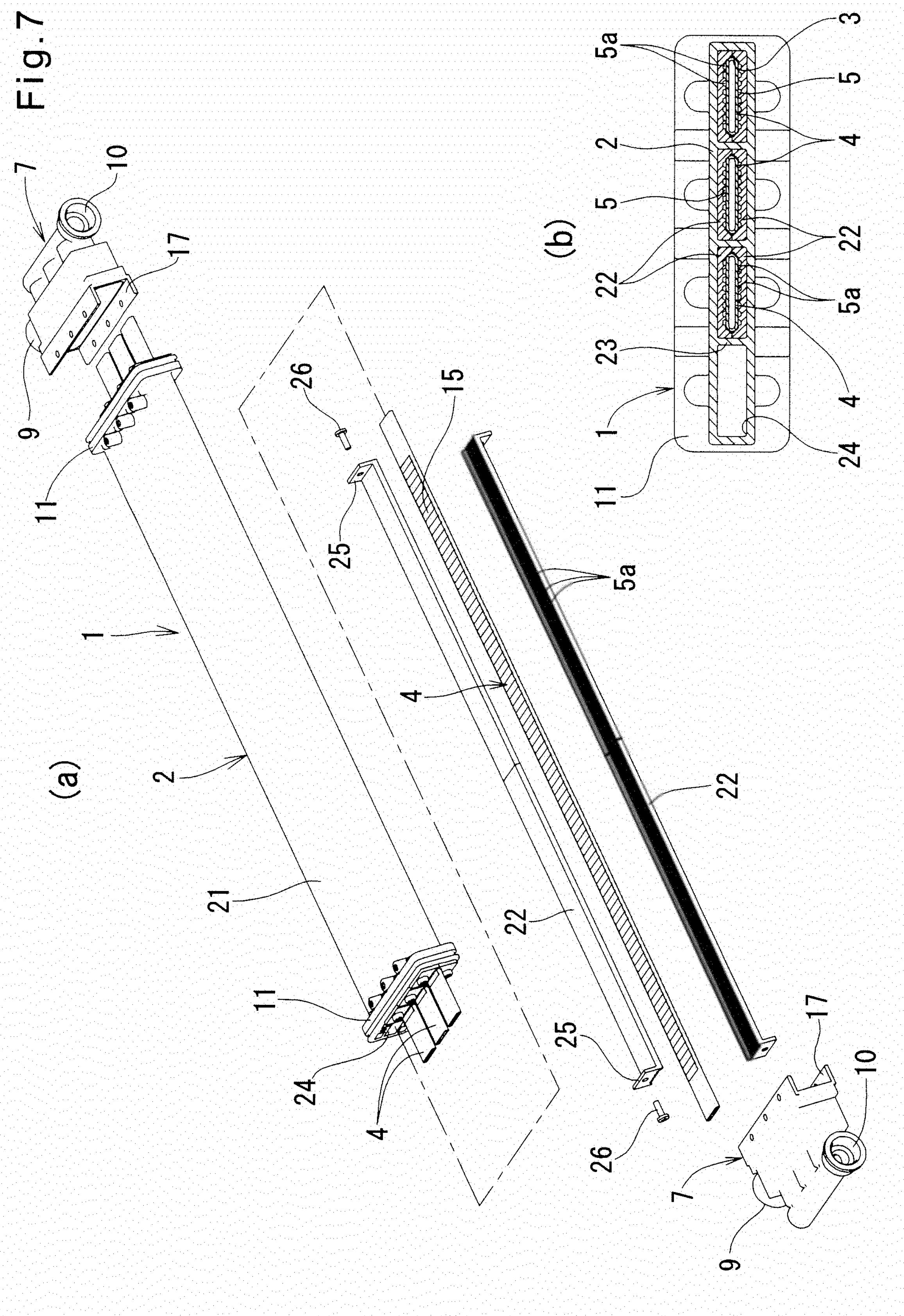
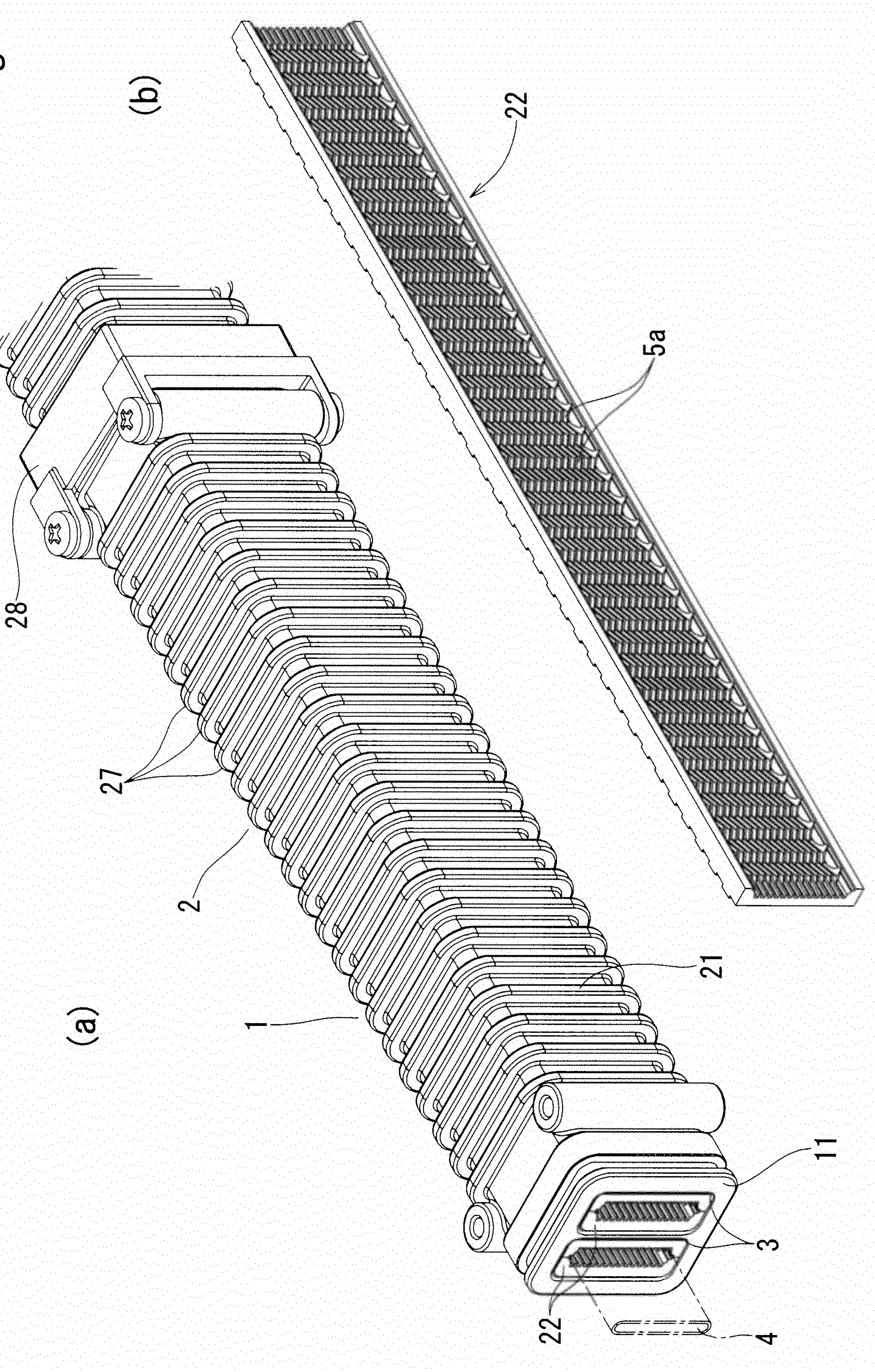


Fig. 7

Fig.8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/058709

A. CLASSIFICATION OF SUBJECT MATTER
F28D7/10(2006.01)i, *F24H9/00*(2006.01)i, *F28F3/12*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F28D7/10, F24H9/00, F28F3/12

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2011
Kokai Jitsuyo Shinan Koho	1971-2011	Toroku Jitsuyo Shinan Koho	1994-2011

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2003-185362 A (Denso Corp.), 03 July 2003 (03.07.2003), entire text; all drawings (Family: none)	1-5
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 128937/1988(Laid-open No. 54056/1990) (Showa Aluminum Corp.), 19 April 1990 (19.04.1990), entire text; all drawings (Family: none)	1-5

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

* Special categories of cited documents:
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"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search
21 April, 2011 (21.04.11)

Date of mailing of the international search report
10 May, 2011 (10.05.11)

Name and mailing address of the ISA/
Japanese Patent Office

Facsimile No.

Authorized officer

Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/058709

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2008-149210 A (Kyowa Vacuum Engineering, Ltd.), 03 July 2008 (03.07.2008), entire text; all drawings (Family: none)	1-5
A	JP 2004-93127 A (The Furukawa Electric Co., Ltd.), 25 March 2004 (25.03.2004), entire text; all drawings (Family: none)	1-5
A	JP 2005-221087 A (Matsushita Electric Industrial Co., Ltd.), 18 August 2005 (18.08.2005), entire text; all drawings (particularly, fig. 4) (Family: none)	1
A	JP 2003-240456 A (Toyo Radiator Co., Ltd.), 27 August 2003 (27.08.2003), entire text; all drawings (particularly, fig. 4) (Family: none)	1
A	JP 2005-49066 A (Toyo Radiator Co., Ltd.), 24 February 2005 (24.02.2005), entire text; all drawings (Family: none)	5
A	JP 2007-225190 A (Maruyasu Industries Co., Ltd.), 06 September 2007 (06.09.2007), entire text; all drawings (Family: none)	5

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REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 3133996 A **[0004]**