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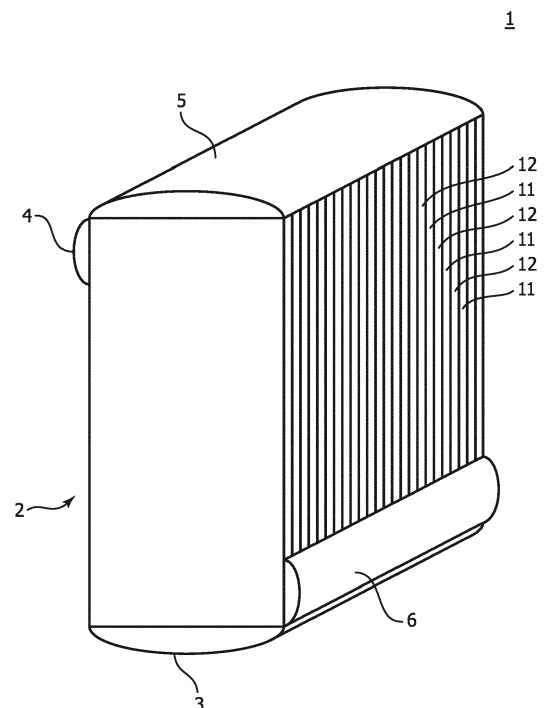
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(54) **HEAT EXCHANGER AND HEAT EXCHANGE METHOD**

(57) A heat exchanger includes a channel structure including a first substrate in which a first channel is arrayed, and a second substrate stacked on the first substrate, in which a second channel is arrayed. The first channel has an effective area overlapping a range where the second channel is provided, when viewed in a lamination direction of the first and second substrates. The effective area includes a standard heat transfer channel part including a high temperature end, and a high heat transfer channel part including a low temperature end, which is a part of the effective area other than the standard heat transfer channel part. The high heat transfer channel part has a bent shape so that a channel length thereof per unit distance of an end-to-end distance thereof is greater than a channel length of the standard heat transfer channel part per unit distance of an end-to-end distance thereof.

FIG. 1



DescriptionBACKGROUND OF THE INVENTION

(FIELD OF THE INVENTION)

[0001] The present invention relates to a heat exchanger and a heat exchange method.

(DESCRIPTION OF THE RELATED ART)

[0002] Conventionally, a stacked-type heat exchanger has been known as one kind of a heat exchanger having excellent heat exchanger performance. This stacked-type heat exchanger includes a stacked body obtained by stacking a plurality of substrates in each of which a plurality of microchannels are arrayed. This heat exchanger is configured so that heat exchange is performed between fluid flowing through microchannels arrayed in one substrate and fluid flowing through microchannels arrayed in another substrate adjacent to the foregoing substrate. JP 2010-286229 A discloses one example of such a stacked-type heat exchanger.

[0003] The stacked-type heat exchanger disclosed in JP 2010-286229 A includes a stacked body in which a high temperature part layer and a low temperature part layer are stacked with a partition wall being interposed therebetween. In the high temperature part layer, a plurality of microchannels through which high temperature fluid is caused to flow are arrayed, and in the low temperature part layer, a plurality of microchannels through which low temperature fluid is caused to flow are arrayed. This heat exchanger has a configuration in which a straight channel is provided in a fluid distributing part, whereas a corrugated channel having higher heat transmission and causing greater pressure drop is provided in a heat transfer part, so that the heat exchanger is made compact.

[0004] In the heat exchanger of JP -2010-286229-A, priority is given to heat transfer performance in order to make the heat exchanger compact, but this leads to a risk that an excessive pressure drop is caused by the corrugated channel of the microchannel, that is, an excessive pressure loss occurs.

[0005] An object of the present invention is to improve heat transfer performance of a heat exchanger, and prevent excessive pressure loss from occurring, while preventing the increase in the size of the heat exchanger.

[0006] A heat exchanger according to the present invention is a heat exchanger that causes a plurality of fluids to flow therethrough so as to cause heat exchange to occur between the fluids. The heat exchanger includes a channel structure that includes: a first layer in which a first channel that is a microchannel through which one fluid is caused to flow is arrayed; and a second layer stacked on the first layer, in which a second channel that is a microchannel through which another fluid is caused to flow is arrayed, the other fluid being a fluid different from the one fluid. The first channel has an effective area that overlaps a range where the second channel in the second layer is provided, when viewed in a direction in which the first layer and the second layer are stacked. The effective area includes: a standard heat transfer channel part that includes a high temperature end that is one of ends of the effective area; and a high heat transfer channel part that is equivalent to a part of the effective area other than the standard heat transfer channel part, the high heat transfer channel part including a low temperature end that is an end of the effective area on a side opposite to the high temperature end and through which the one fluid having a temperature lower than a temperature of the one fluid flowing at the high temperature end. The high heat transfer channel part has a channel shape bent in such a manner that a channel length thereof per unit distance of an end-to-end distance thereof is greater than a channel length of the standard heat transfer channel part per unit distance of an end-to-end distance thereof.

[0007] In this heat exchanger, the effective area of the first channel includes the high heat transfer channel part, and this high heat transfer channel part has a channel shape bent in such a manner that the channel length thereof per unit distance of the end-to-end distance thereof is greater than the channel length of the standard heat transfer channel part of the effective area per unit distance of the end-to-end distance thereof. In other words, the high heat transfer channel part has a greater number of bent portions than the standard heat transfer channel part, or alternatively, has a bent portion having a greater degree of bending than the standard heat transfer channel part. This makes it possible to improve heat transfer performance owing to the fluid turbulence at the bent portions of the high heat transfer channel part. Further, with the high heat transfer channel part formed in the bent channel shape, which suppresses the increase in the end-to-end distance thereof, the increase in the size of the heat exchanger can be prevented. Accordingly, the increase in the size of this heat exchanger can be prevented, and the heat transfer performance thereof can be improved.

[0008] Moreover, in this heat exchanger, the standard heat transfer channel part is a part that includes the high temperature end of the effective area, and the high heat transfer channel part is equivalent to a part of the effective area other than the standard heat transfer channel part, which includes the low temperature end of the effective area. The amplitude of the increase in the pressure loss in the effective area of the first channel, therefore, can be reduced. More specifically, since a pressure loss in a channel is proportional to a flow rate of a fluid flowing through the channel, the configuration in which a part of the effective area through which the first fluid having a low temperature and hence having

a relatively higher density flows and that includes the low temperature end at which the first fluid comes to have a smaller flow rate is the high heat transfer channel part, and the other part of the effective area that includes the high temperature end is the standard heat transfer channel part, enables to reduce the amplitude of the increase in the pressure loss, even if the pressure loss is increased by the high heat transfer channel part thus bent. It is therefore possible to prevent excessive pressure loss from occurring in the first channels. Still further, since the first fluid has a higher density and hence has a smaller flow rate at and near the low temperature end of the effective area as described above, the heat transfer performance is relatively low in this part. In this heat exchanger, however, since the high heat transfer channel part includes the low temperature end, the relatively low heat transfer performance at and near the low temperature end can be improved by the high heat transfer channel part. This makes it possible to achieve the high heat transfer performance with a good balance in the entirety of the effective area of the first channel.

[0009] In the above-described heat exchanger, preferably, the standard heat transfer channel part is a straight channel, and the high heat transfer channel part is a wavy type channel.

[0010] With this configuration in which the standard heat transfer channel part is a straight channel, the pressure loss in the standard heat transfer channel part can be reduced, as compared with a case where the standard heat transfer channel part has a curved channel shape or a bent channel shape. To this extent, the increase in the pressure loss in the effective area can be suppressed.

[0011] In this case, preferably, the high heat transfer channel part meanders in such a manner as being deflected to both sides with respect to a center line that is a straight line, and the end-to-end distance of the high heat transfer channel part in a direction along the center line is 60% or less of an end-to-end distance of the effective area.

[0012] With this configuration, the pressure loss in the effective area can be suppressed to less than twice the pressure loss in the effective area in a case where the entirety of the effective area is a straight channel. In view of practical application of the heat exchanger, if the pressure loss in the effective area of the first channel increases to twice or more the value of pressure loss in an effective area in a case where the entire effective area is a straight channel, it is difficult to use a first channel having such an effective area. With the present configuration, the increase in the pressure loss can be suppressed to less than twice as described above, and hence, a first channel that is sufficiently able to be adopted for practical application in view of pressure loss can be obtained.

[0013] Further, in this case, the end-to-end distance of the high heat transfer channel part in a direction along the center line is preferably 10% or more of the end-to-end distance of the effective area.

[0014] With this configuration, a heat transfer area that can sufficiently compensate the reductions in the heat transfer performance that are generally expected due to dirt and/or fluid conditions in the effective area can be ensured in the effective area.

[0015] Still further, in the configuration in which the standard heat transfer channel part is a straight channel and the high heat transfer channel part is a wavy type channel, preferably, the high heat transfer channel part meanders in such a manner as being deflected to both sides with respect to a center line that is a straight line, and the end-to-end distance of the high heat transfer channel part in a direction along the center line is smaller than the end-to-end distance of the standard heat transfer channel part.

[0016] With this configuration, the improvement of the heat transfer performance and the prevention of excessive increase in the pressure loss can be achieved with a good balance, while the increase in the size of the heat exchanger can be prevented.

[0017] A heat exchange method according to the present invention includes causing one fluid to flow through the first channel in the above-described heat exchanger from the standard heat transfer channel part toward the high heat transfer channel part, and at the same time, causing a refrigerant as another fluid to flow through the second channel in the heat exchanger, so as to cause heat exchange to occur between the one fluid and the refrigerant.

[0018] Further, a heat exchange method according to the present invention includes causing one fluid to flow through the first channel in the above-described heat exchanger from the high heat transfer channel part toward the standard heat transfer channel part, and at the same time, causing a hot medium as another fluid to flow through the second channel of the heat exchanger, so as to cause heat exchange to occur between the one fluid and the hot medium.

[0019] As described above, according to the present invention, it is possible to improve heat transfer performance of a heat exchanger, and prevent excessive pressure loss from occurring, while preventing the increase in the size of the heat exchanger

BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

FIG. 1 is a schematic perspective view of a heat exchanger according to one embodiment of the present invention.
FIG. 2 is a plan view of a first substrate that composes a channel structure of the heat exchanger illustrated in FIG. 1.
FIG. 3 is a plan view of a second substrate that composes the channel structure heat exchanger illustrated in FIG. 1.

FIG. 4 is an enlarged view of high heat transfer channel parts of first channels.

FIG. 5 is a partial sectional view of the first substrate in which the first channels are formed and its surrounding area, in the channel structure.

FIG. 6 illustrates correlation between a ratio of an end-to-end distance of a high heat transfer channel part of a first channel to an end-to-end distance of an effective area of the same and a pressure loss calculated by simulation.

FIG. 7 illustrates correlation between a ratio of an end-to-end distance of a high heat transfer channel part of a first channel to an end-to-end distance of an effective area of the same and a heat transfer coefficient calculated by simulation.

FIG. 8 illustrates correlation between a ratio of an end-to-end distance of a high heat transfer channel part of a first channel to an end-to-end distance of an effective area of the same and a ratio of pressure loss to a heat transfer coefficient calculated by simulation.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] The following description describes an embodiment of the present invention, while referring to the drawings.

[0022] FIG. 1 illustrates an overall configuration of a heat exchanger 1 according to one embodiment of the present invention. The heat exchanger 1 has such a configuration that a first fluid and a second fluid are caused to exchange heat while flowing through the heat exchanger. The heat exchanger 1 includes a channel structure 2, a first supply header 3, a second supply header 4, a first discharge header 5, and a second discharge header 6.

[0023] The channel structure 2 is a rectangular parallelepiped structure that includes, in the inside thereof, a multiplicity of first channels 21 (see FIG. 2) that are microchannels through which the first fluid is caused to flow, and a multiplicity of second channels 22 (see FIG. 3) that are microchannels through which the second fluid is caused to flow. The channel structure 2 includes a plurality of first substrates 11 in each of which a plurality of the first channels 21 are arrayed, and a plurality of second substrates 12 in each of which a plurality of the second channels 22 are arrayed. The first substrate 11 is one example of the first layer in the present invention, and the second substrate 12 is one example of the second layer in the present invention.

[0024] Each of the first substrates 11 and the second substrates 12 is a flat plate in a rectangular shape when viewed from one side in the thickness direction thereof, and is formed with, for example, a stainless steel plate. In the channel structure 2, the first substrates 11 and the second substrates 12 are alternately stacked and bonded to one another. This results in that, in the channel structure 2, the first channels 21 arrayed in the first substrate 11, and the second channels 22 arrayed in the second substrate 12 are arrayed alternately in a lamination direction where the substrate 11 and the substrate 12 are stacked. The channel structure 2 has four lateral faces that are formed with end faces that correspond to four sides of each of the substrates 11, 12.

[0025] On one of plate surfaces of each first substrate 11, as illustrated in FIG. 2, a plurality of first grooves 23 that form a plurality of the first channels 21 are formed. Each of the first grooves 23 is formed by etching, and has an arc-shaped cross section, as illustrated in FIG. 5. The openings of the first grooves 23 on one of plate surfaces of the first substrate 11 are sealed by the second substrate 12 stacked on the plate surface of the first substrate 11, whereby a plurality of the first channels 21 arrayed on the one plate surface are formed.

[0026] Each first channel 21 extends approximately in the longitudinal direction of the first substrate 11. In the present embodiment, the channel structure 2 is arranged in such a posture that a standard heat transfer channel part 25 to be described below of each first channel 21 extends in an up-to-down direction. In other words, the channel structure 2 is arranged in such a posture that the longitudinal direction of each of the substrates 11, 12 coincides with the vertical direction.

[0027] Each first channel 21 has, at one end thereof, an introduction port 21a (see FIG. 2) through which the first fluid is introduced, and at an end on a side opposite to the introduction port 21a, an outflow port 21b through which the first fluid having flown through the first channel 21 is allowed to flow out. The introduction ports 21a are open on a lateral face of the channel structure 2, which is formed with end faces on one side in the longitudinal direction of the substrates 11, 12, and the outflow ports 21b are open on a lateral face on a side opposite to the side of the lateral face where the introduction ports 21a are open. In other words, the introduction ports 21a are open on a lateral face of the channel structure 2 that faces downward, and the outflow ports 21b are open on a lateral face of the channel structure 2 that faces upward.

[0028] In the present embodiment, to the first channels 21, a first fluid having a low temperature is introduced from the introduction ports 21a, respectively, and the first fluid thus introduced thereto, as flowing toward the outflow port 21b, exchanges heat with the high temperature second fluid flowing through the second channels 22, whereby the temperature of the first fluid rises. In the present embodiment, therefore, in a part closer to the introduction port 21a in each first channel 21, the first fluid flowing there has a lower temperature, and in a part closer to the outflow port 21b in each first channel 21, the first fluid flowing there has a relatively higher temperature.

[0029] The first channel 21 has an effective area 24 (see FIG. 2) that contributes to heat exchange between the first

fluid flowing through the first channel 21 and the second fluid flowing through the second channel 22. The effective area 24 is an area of the first channel 21 that overlaps a range where the second channels 22 are provided in the second substrate 12 when viewed in the lamination direction of the substrates 11, 12. More specifically, when viewed in the lamination direction of the substrates 11, 12, a small area at and near the introduction ports 21a and a small area at and near the outflow ports 21b in the first channels 21 do not overlap the range where the second channels 22 are provided in the second substrate 12, and hence, the effective area 24 is equivalent to an area of the first channel 21 from which these small areas are excluded.

[0030] The effective area 24 is composed of the standard heat transfer channel part 25 and the high heat transfer channel part 26, as illustrated in FIG. 2.

[0031] The standard heat transfer channel parts 25, in the present embodiment, are straightly extending channels, that is, straight channels, and extend in the longitudinal direction of the first substrate 11. The standard heat transfer channel part 25 includes a high temperature end 24a, which is one end of the effective area 24. The high temperature end 24a is a part through which the first fluid flows that has a higher temperature as compared with the first fluid flowing through a low temperature end 24b to be described below. More specifically, the high temperature end 24a is a part through which the first fluid flows that has the highest temperature in the effective area 24. The standard heat transfer channel part 25 is equivalent to a part of the effective area 24 having a predetermined length from the high temperature end 24a toward the introduction port 21a.

[0032] The high heat transfer channel part 26 is equivalent to a part of the effective area 24 other than the standard heat transfer channel part 25. The high heat transfer channel part 26 includes a low temperature end 24b that is an end of the effective area 24 on a side opposite to the high temperature end 24a. The low temperature end 24b is a part through which the first fluid flows that has a lower temperature as compared with the first fluid flowing through the high temperature end 24a. More specifically, the low temperature end 24b is a part through which the first fluid flows that has the lowest temperature in the effective area 24. The high heat transfer channel part 26 is equivalent to a part of the effective area 24 having a predetermined length from the low temperature end 24b toward the high temperature end 24a.

[0033] Each high heat transfer channel part 26 has a channel shape bent in such a manner that a channel length thereof per unit distance of the end-to-end distance thereof is greater than a channel length of the standard heat transfer channel part 25 per unit distance of the end-to-end distance thereof. More specifically, each high heat transfer channel part 26 is a wavy type channel that meanders in such a manner as being deflected to both sides with respect to, as the center, a meander center line 27 that is a straight line. The meander center line 27 is a line extending in the same direction as the direction of the center line of the channel width of the standard heat transfer channel part 25. Further, the "end-to-end distance of the high heat transfer channel part 26" refers to an end-to-end distance of the high heat transfer channel part 26 in the direction along the meander center line 27. Still further, the channel length of the high heat transfer channel part 26 per unit distance of the end-to-end distance thereof is equivalent to a value obtained by dividing the entire channel length of the high heat transfer channel part 26 by the end-to-end distance of the high heat transfer channel part 26. Still further, the end-to-end distance of the standard heat transfer channel part 25 is equivalent to the end-to-end straight distance of the standard heat transfer channel part 25. Still further, the channel length of the standard heat transfer channel part 25 per unit distance of the end-to-end distance thereof is equivalent to a value obtained by dividing the entire channel length of the standard heat transfer channel part 25 by the end-to-end distance of the standard heat transfer channel part 25.

[0034] The high heat transfer channel part 26, as illustrated in FIG. 4, includes a plurality of first straight parts 26a, a plurality of second straight parts 26b, and a plurality of corner parts 26c.

[0035] The first straight part 26a is a part that straightly extends from a side of one end of the high heat transfer channel part 26 toward a side of the other end thereof, intersecting with the meander center line 27 obliquely from one side thereto to the other side thereto. The second straight part 26b is a part that straightly extends from a side of one end of the high heat transfer channel part 26 toward a side of the other end thereof, intersecting with the meander center line 27 obliquely from the above-described other side to the above-described one side. The first straight parts 26a and the second straight parts 26b are alternately repeatedly arranged from a side of one end of the high heat transfer channel part 26 toward a side of the other end thereof.

[0036] The channel width center line of each of the first straight parts 26a is tilted by an angle D with respect to the meander center line 27. The channel width center line of each of the second straight parts 26b is tilted with respect to the meander center line 27, in an orientation opposite to the orientation where the center line of the first straight part 26a is tilted, by the same angle as the tilt angle of the center line of the first straight part 26a, that is, the angle D. Each corner part 26c is formed in a rounded shape, and connects an end of the first straight part 26a and an end of the second straight part 26b that are opposite each other.

[0037] By forming each of the first straight parts 26a, each of the second straight parts 26b, and each of the corner parts 26c as is described above, the high heat transfer channel part 26 is formed in a zig-zag shape with respect to the meander center line 27, and in an overall configuration, extends along the meander center line 27.

[0038] The end-to-end distance of the high heat transfer channel part 26 in the direction along the meander center

line 27 is given as " L_x ", a pressure loss of the effective area 24 is given as " f_x ", and a film coefficient of heat transfer of the first fluid in the effective area 24 (hereinafter referred to simply as the "heat transfer coefficient for the effective area 24) is given as " j_x ". Then, the end-to-end distance L_x of the high heat transfer channel part 26, the pressure loss f_x of the effective area 24, and the heat transfer coefficient j_x satisfy the following relational expression (1):

$$(\alpha f_x / j_x) < A \times L_x \dots (1)$$

[0039] In the relational expression (1), α is a correction coefficient defined by the following relational expression (2):

$$\alpha f_0 / j_0 = 1 \dots (2)$$

[0040] In this relational expression (2), " f_0 " represents a pressure loss of an effective area in a case where the entirety of the effective area 24 is composed of a straight channel such as the standard heat transfer channel part 25, and " j_0 " represents a heat transfer coefficient for an effective area in a case where the entirety of the effective area 24 is composed of a straight channel such as the standard heat transfer channel part 25.

[0041] Further, in the above-described relational expression (1), " A " represents a value defined by the following relational expression (3):

$$A = (\alpha f_{all} / j_{all}) / L_{all} \dots (3)$$

[0042] In this relational expression (3), " f_{all} " represents a pressure loss of an effective area in a case where the entirety of the effective area 24 is formed in a bent channel shape like the high heat transfer channel part 26, and " j_{all} " represents a heat transfer coefficient of an effective area in a case where the entirety of the effective area 24 is formed in a bent channel shape like the high heat transfer channel part 26. Further, " L_{all} " represents an end-to-end distance of the effective area 24, and is equivalent to the distance between the low temperature end 24b and the high temperature end 24a. The end-to-end distance of the effective area 24, more specifically, refers to the end-to-end distance of the effective area 24 in a direction along the channel width center line of the standard heat transfer channel part 25 and the meander center line 27 of the high heat transfer channel part 26.

[0043] In the present embodiment, the end-to-end distance of the high heat transfer channel part 26 in the direction along the meander center line 27 is set to 10% or more of the end-to-end distance of the effective area 24 and 60% or less of the end-to-end distance of the effective area 24. In addition, preferably, the end-to-end distance of the high heat transfer channel parts 26 in the direction along the meander center lines 27 is set to be a distance smaller than the end-to-end distance of the standard heat transfer channel parts 25, in other words, a distance smaller than 50% of the end-to-end distance of the effective area 24.

[0044] Further, each first channel 21 includes an introduction channel part 29 and an outflow channel part 30, as illustrated in FIG. 2.

[0045] The introduction channel part 29 is a small part at and near the introduction port 21a of the first channel 21, and is equivalent to a part of the first channel 21 that does not overlap a range where the second channels 22 are provided on the second substrate 12. In other words, the introduction channel part 29 is equivalent to a part of the first channel 21 positioned on the introduction port 21a side with respect to the effective area 24. The introduction channel part 29 straightly extends from the introduction port 21a, and is connected to the high heat transfer channel part 26. The first fluid supplied to the introduction port 21a passes through the introduction channel part 29, and flows to the high heat transfer channel part 26.

[0046] The outflow channel part 30 is a small part at and near the outflow port 21b of the first channel 21, and is equivalent to a part that does not overlap a range where the second channels 22 are provided on the second substrate 12. In other words, the outflow channel part 30 is equivalent to a part of the first channel 21 positioned on the outflow port 21b side with respect to the effective area 24. The outflow channel part 30 straightly extends in the same direction as the standard heat transfer channel part 25 on a line of extension of the standard heat transfer channel part 25, and is connected to the outflow port 21b. The first fluid that has flown through the standard heat transfer channel part 25 passes through the outflow channel part 30, and flows out of the outflow port 21b.

[0047] On one of the plate surfaces of each second substrate 12 (see FIG. 3), a plurality of second grooves 32 that form the second channels 22 are formed by etching. FIG. 3 principally illustrates an outer shape of a collective configuration of the second grooves 32 formed on the second substrate 12, and the illustration of each second groove 32 and each second channel 22 is omitted, except for parts thereof at and near the upstream ends thereof and parts thereof at and

near the downstream ends thereof. The opening of each second groove 32 on one of plate surfaces of the second substrate 12 is sealed by the first substrate 11 stacked on the plate surface, whereby a plurality of the second channels 22 arrayed on the one of the plate surfaces are formed.

[0048] In the present embodiment, in each second channel 22, a part that straightly extends from one side to the other side in the transverse direction of the second substrate 12, and a part that is turned back therefrom and straightly extends from the above-described other side to the above-described one side, are repeatedly provided, so that the second channel 22 as a whole is in a largely wavy type shape.

[0049] Each second channel 22 has, at one end thereof, an introduction port 22a through which the second fluid is introduced, and at an end on a side opposite to the introduction port 22a, an outflow port 22b through which the second fluid having passed through the second channel 22 is allowed to flow out.

[0050] The introduction ports 22a are open on a lateral face of the channel structure 2, which is formed with end faces on one side in the transverse direction of the substrates 11, 12. In the present embodiment, the introduction ports 22a are open on a lateral face of the channel structure 2 that faces to one side in the horizontal direction, and are arranged at and near an upper end part of the lateral face. In other words, the introduction ports 22a are arranged closer to the outflow ports 21b of the first channels 21.

[0051] The outflow ports 22b are open on a lateral face of the channel structure 2 on a side opposite to the lateral face of the channel structure 2 where the introduction ports 22a are open. In the present embodiment, the outflow ports 22b are arranged at and near a lower end part of the lateral face of the channel structure 2 where the outflow ports 22b are open. In other words, the outflow ports 22b are arranged closer to the introduction ports 21a of the first channel 21.

[0052] In the present embodiment, to the second channels 22, the second fluid having a temperature higher than the first fluid is introduced from the introduction ports 22a, and the second fluid thus introduced thereto, as flowing to the outflow port 22b, exchanges heat with the first fluid having a low temperature flowing through the first channels 21, whereby the temperature of the second fluid drops.

[0053] The first supply header 3 (see FIGS. 1 and 2) distributes and supplies the first fluid to all of the respective introduction ports 21a of the first channels 21 provided in the channel structure 2. The first supply header 3 is attached to one of the lateral faces of the channel structure 2 where the introduction ports 21a of the first channels 21 are open. The first supply header 3 collectively covers all of the introduction ports 21a that are open on the lateral face of the channel structure 2 to which the first supply header 3 is attached. This allows the space in the first supply header 3 to communicate with each introduction port 21a. To the first supply header 3, a supply pipe (not illustrated) is connected, so that the first fluid supplied through the supply pipe to the first supply header 3 is distributed from the space in the first supply header 3 to the introduction ports 21a.

[0054] The first discharge header 5 (see FIGS. 1 and 2) receives the first fluid flowing out of all of the outflow ports 21b of the first channels 21 provided in the channel structure 2. The first discharge header 5 is attached to one of the lateral faces of the channel structure 2 where the outflow ports 21b of the first channels 21 are open. The first discharge header 5 collectively covers all of the outflow ports 21b that are open on the lateral face of the channel structure 2 to which the first discharge header 5 is attached. This allows the space in the first discharge header 5 to communicate with each outflow port 21b. To the first discharge header 5, a discharge pipe (not illustrated) is connected, so that the first fluid having flown out of each outflow port 21b to the space in the first discharge header 5 is discharged through this discharge pipe.

[0055] The second supply header 4 (see FIGS. 1 and 3) distributes and supplies the second fluid to all of the introduction ports 22a of the second channels 22 provided in the channel structure 2. The second supply header 4 is attached to the one of the lateral faces of the channel structure 2 where the introduction ports 22a of the second channels 22 are open, and collectively covers all of the introduction ports 22a that are open on the lateral face. This allows the space in the second supply header 4 to communicate with each introduction port 22a. To the second supply header 4, a supply pipe (not illustrated) is connected, so that the second fluid having been supplied through the supply pipe to the second supply header 4 is distributed from the space in the second supply header 4 to the introduction ports 22a.

[0056] The second discharge header 6 (see FIGS. 1 and 3) receives the second fluid flowing out of all of the outflow ports 22b of the second channels 22 provided in the channel structure 2. The second discharge header 6 is attached to one of the lateral faces of the channel structure 2 where the outflow ports 22b of the second channels 22 are open, and collectively covers all of the outflow ports 22b that are open on the lateral face to which the second discharge header 6 is attached. This allows the space in the second discharge header 6 to communicate with each outflow port 22b. To the second discharge header 6, a discharge pipe (not illustrated) is connected, so that the second fluid having flown out of the each outflow port 22b to the space in the second discharge header 6 is discharged through this discharge pipe.

[0057] In the present embodiment, a heat exchange method for heat exchange between the first fluid and the second fluid is performed by using the heat exchanger 1 having a configuration as described above. For example, in order to raise the temperature of the first fluid, a heat exchange method for heat exchange between the first fluid and a hot medium (heat medium) as the second fluid having a temperature higher than that of the first fluid is performed.

[0058] More specifically, the first fluid is supplied through the supply pipe to the first supply header 3 so that the first

fluid is supplied from the first supply header 3 to each first channel 21, whereby the first fluid is caused to flow through each first channel 21 from the high heat transfer channel part 26 toward the standard heat transfer channel part 25. On the other hand, the hot medium as the second fluid is supplied through the supply pipe to the second supply header 4 so that the hot medium is supplied from the second supply header 4 to each second channel 22, whereby the hot medium is caused to flow through each second channel 22. By doing so, heat exchange is caused to occur between the first fluid flowing through the first channels 21 and the hot medium flowing through the second channels 22, whereby the temperature of the first fluid is raised.

[0059] In the heat exchanger 1 according to the present embodiment, the effective area 24 of the first channel 21 includes the high heat transfer channel part 26, and this high heat transfer channel part 26 is a wavy type channel that is bent in such a manner that the channel length of the high heat transfer channel part 26 per unit distance of the end-to-end distance thereof is greater than the channel length of the standard heat transfer channel part 25 per unit distance of the end-to-end distance thereof. This causes fluid turbulence at bent portions of the high heat transfer channel part 26, which improves heat transfer performance.

[0060] Further, since the bent channel shape of the high heat transfer channel part 26 makes it possible to suppress the increase in the end-to-end distance thereof, in the present embodiment, it is possible to prevent the increase in the size of the heat exchanger 1. In the present embodiment, therefore, it is possible to improve the heat transfer performance while preventing the increase in the size of the heat exchanger 1.

[0061] Still further, in the heat exchanger 1 according to the present embodiment, the standard heat transfer channel part 25 is a part that includes the high temperature end 24a of the effective area 24, and the high heat transfer channel part 26 is a part that is equivalent to a part of the effective area 24 other than the standard heat transfer channel part 25 and includes the low temperature end 24b of the effective area 24. This makes it possible to reduce the amplitude of the increase in the pressure loss in the effective area 24 of the first channel 21. In other words, since a pressure loss of a channel is proportional to a flow rate of a fluid flowing through the channel, the configuration in which a part of the effective area 24 through which the first fluid having a low temperature and hence having a relatively higher density flows and that includes the low temperature end 24b at which the first fluid comes to have a smaller flow rate is formed with the high heat transfer channel part 26, and the other part of the effective area 24 that includes the high temperature end 24a is the standard heat transfer channel part 25, enables to reduce the amplitude of the increase in the pressure loss, even if the pressure loss is increased by the high heat transfer channel part 26 thus bent. It is therefore possible to prevent excessive pressure loss from occurring in the first channels 21.

[0062] Still further, since the first fluid has a higher density and hence has a smaller flow rate at and near the low temperature end of the effective area as described above, the heat transfer performance is relatively low in this part. In the present embodiment, however, since the high heat transfer channel part 26 includes the low temperature end 24b, the relatively low heat transfer performance at and near the low temperature end 24b can be improved by the high heat transfer channel part 26. This makes it possible to achieve the high heat transfer performance with a good balance in the entirety of the effective areas 24 of the first channels 21.

[0063] Still further, in the present embodiment, since the high heat transfer channel part 26 is a wavy type channel, it is possible to increase the channel length of the high heat transfer channel part 26 so as to increase the heat transfer area, while suppressing the increase in the end-to-end distance of the high heat transfer channel part 26, as compared with a configuration in which a high heat transfer channel part is simply curved. In other words, it is possible to improve the heat transfer performance more effectively, while suppressing the increase in the end-to-end distance of the high heat transfer channel part 26. Still further, since the standard heat transfer channel part 25 is a straight channel, the pressure loss in the standard heat transfer channel part 25 can be reduced, as compared with a case where the standard heat transfer channel part has a curved channel shape or a bent channel shape. To this extent, the increase in the pressure loss in the effective area 24 can be suppressed.

[0064] Still further, in the present embodiment, since the end-to-end distance of the high heat transfer channel part 26 in the direction along the meander center line 27 is set to 60% or less of the end-to-end distance of the effective area 24, the pressure loss in the effective area 24 can be suppressed to less than twice the pressure loss in an effective area in a case where the entirety of the effective area is a straight channel, which sufficiently satisfies the requirements regarding the pressure loss of the heat exchanger for practical application.

[0065] Still further, in the present embodiment, the end-to-end distance of the high heat transfer channel part 26 in the direction along the meander center line 27 is set to 10% or more of the end-to-end distance of the effective area 24.

[0066] In a heat exchanger, generally, a heat transfer area is set with a margin with respect to the theoretical value of a heat transfer area determined by computation, with consideration given to a possibility that the heat transfer performance decreases due to dirt (deposit) in channels and/or fluid conditions such as temperature and pressure of fluid. In this case, generally, a heat transfer area about 5% to 10% larger than the theoretical value of the heat transfer area is set. In contrast, with such a setting that the end-to-end distance of the high heat transfer channel part 26 in the direction along the meander center line 27 is set to 10% or more of the end-to-end distance of the effective area 24, as is the case with the present embodiment, a heat transfer area that can sufficiently compensate the reductions in the heat

transfer performance that are generally expected due to dirt and/or fluid conditions in the effective area 24 can be ensured in the effective area 24.

[0067] Still further, in a more preferable configuration of the present embodiment, the end-to-end distance of the high heat transfer channel part 26 in the direction along the meander center line 27 is set to be smaller than the end-to-end distance of the standard heat transfer channel part 25. In this case, the improvement of the heat transfer performance and the prevention of excessive increase in the pressure loss can be achieved with a good balance, while the increase in the size of the heat exchanger 1 can be prevented.

[0068] More specifically, if it is assumed that the end-to-end distance of the high heat transfer channel part 26 is greater than the end-to-end distance of the standard heat transfer channel part 25, the effect of improvement of the heat transfer performance owing to the high heat transfer channel parts 26 would increase, but on the other hand, the amplitude of the increase in the pressure loss would be expanded. To suppress the increase in the pressure loss, for example, the number of the first channels 21 provided in the channel structure 2 may be increased, but this necessarily increases the size of the channel structure 2. In other words, this necessarily increases the size of the heat exchanger 1. In contrast, with the configuration in which the end-to-end distance of the high heat transfer channel part 26 is smaller than the end-to-end distance of the standard heat transfer channel part 25, the improvement of the heat transfer performance and the prevention of excessive increase in the pressure loss can be achieved with a good balance, which results in that the increase in the size of the heat exchanger 1 can be prevented.

[0069] The following description describes results of simulation performed in order to examine the effects achieved by the heat exchanger 1 of the present embodiment, that is, the effects achieved by the configuration in which parts of the effective areas 24 that are other than the standard heat transfer channel parts 25 and that include the low temperature ends 24b of the effective areas 24 are the high heat transfer channel parts 26.

[0070] First of all, as examples corresponding to the present embodiment, Examples 1 to 4 were set in which only an end-to-end distance of the high heat transfer channel part 26 as a wavy type channel, that is, an end-to-end distance of the high heat transfer channel part 26 in the direction along the meander center line 27, was varied, as follows.

(Example 1)

[0071] The end-to-end distance of each high heat transfer channel part 26 was set to a distance equivalent to 20% of the end-to-end distance of the effective area 24, and a part of each effective area 24 other than the high heat transfer channel part 26 was the standard heat transfer channel part 25, which was a straight channel.

(Example 2)

[0072] The end-to-end distance of each high heat transfer channel part 26 was set to a distance equivalent to 40% of the end-to-end distance of the effective area 24, and a part of each effective area 24 other than the high heat transfer channel part 26 was the standard heat transfer channel part 25, which was a straight channel.

(Example 3)

[0073] The end-to-end distance of each high heat transfer channel part 26 was set to a distance equivalent to 60% of the end-to-end distance of the effective area 24, and a part of each effective area 24 other than the high heat transfer channel part 26 was the standard heat transfer channel part 25, which was a straight channel.

(Example 4)

[0074] The end-to-end distance of each high heat transfer channel part 26 was set to a distance equivalent to 80% of the end-to-end distance of the effective area 24, and a part of each effective area 24 other than the high heat transfer channel part 26 was the standard heat transfer channel part 25, which was a straight channel.

[0075] In addition, as comparative examples for comparison of effects with the examples, Comparative Examples 1 to 6 described below were set.

(Comparative Example 1)

[0076] The entirety of each effective area 24 was a straight channel.

(Comparative Example 2)

[0077] A part of each effective area 24 ranging from the high temperature end 24a toward the low temperature end

24b which was equivalent to 20% of the end-to-end distance of the effective area 24, was a wavy type channel corresponding to the high heat transfer channel part 26, and the other part of each effective area 24 was a straight channel.

(Comparative Example 3)

[0078] A part of each effective area 24 ranging from the high temperature end 24a toward the low temperature end 24b, which was equivalent to 40% of the end-to-end distance of the effective area 24, was a wavy type channel corresponding to the high heat transfer channel part 26, and the other part of each effective area 24 was a straight channel.

(Comparative Example 4)

[0079] A part of each effective area 24 ranging from the high temperature end 24a toward the low temperature end 24b, which was equivalent to 60% of the end-to-end distance of the effective area 24, was a wavy type channel corresponding to the high heat transfer channel part 26, and the other part of each effective area 24 was a straight channel.

(Comparative Example 5)

[0080] A part of each effective area 24 ranging from the high temperature end 24a toward the low temperature end 24b, which was equivalent to 80% of the end-to-end distance of the effective area 24, was a wavy type channel corresponding to the high heat transfer channel part 26, and the other part of each effective area 24 was a straight channel.

(Comparative Example 6)

[0081] The entirety of each effective area 24 was a wavy type channel corresponding to the high heat transfer channel part 26.

[0082] As to each of Examples 1 to 4 and Comparative Examples 1 to 6 described above, a pressure loss and a heat transfer coefficient in the effective areas 24 as a whole were calculated by simulation. Here, the pressure loss and the heat transfer coefficient were calculated, with physical properties and flow rates of the fluid flowing through the channels, and other conditions being set to be equal in all of the examples and the comparative examples.

[0083] Table 1 shown below indicates, regarding each of Examples 1 to 4, calculation results of the pressure loss f and the heat transfer coefficient j , and a ratio f/j of a pressure loss f to the heat transfer coefficient j . Further, Table 2 shown below indicates, regarding each of Comparative Examples 1 to 6, calculation results of the pressure loss f and the heat transfer coefficient j , and the ratio f/j of the pressure loss f to the heat transfer coefficient j . In each table shown below, the value of the pressure loss calculated regarding Comparative Example 1 is assumed to be 100, and values of the pressure loss calculated regarding Examples 1 to 4 and Comparative Examples 2 to 6 are expressed as values with respect to the value of the pressure loss of Comparative Example 1. Besides, in each table shown below, the value of the heat transfer coefficient calculated regarding Comparative Example 1 is assumed to be 100, and values of the heat transfer coefficient calculated regarding Examples 1 to 4 and Comparative Examples 2 to 6 are expressed as values with respect to the value of the heat transfer coefficient of Comparative Example 1.

[Table 1]

	Example 1	Example 2	Example 3	Example 4
f	128	160	195	234
j	123	147	170	191
f/j	104%	109%	115%	123%

[Table 2]

	Comparative example 1	Comparative example 2	Comparative example 3	Comparative example 4	Comparative example 5	Comparative example 6
f	100	142	181	216	248	276
j	100	120	142	165	188	211
f/j	100%	118%	127%	131%	131%	131%

[0084] Further, FIG. 6 illustrates, regarding each of Examples 1 to 4 denoted by "E1" to "E4", and Comparative Examples 1 to 6 denoted by "R1" to "R6", correlation between the ratio of the end-to-end distance of the high heat transfer channel part to the end-to-end distance of the effective area and the calculated pressure loss f . FIG. 7 illustrates, regarding each of Examples 1 to 4 denoted by "E1" to "E4", and Comparative Examples 1 to 6 denoted by "R1" to "R6", correlation between the ratio of the end-to-end distance of the high heat transfer channel part to the end-to-end distance of the effective area and the calculated heat transfer coefficient j . Still further, FIG. 8 illustrates, regarding each of Examples 1 to 4 denoted by "E1" to "E4", and Comparative Examples 1 to 6 denoted by "R1" to "R6", correlation between the ratio of the end-to-end distance of the high heat transfer channel part to the end-to-end distance of the effective area and the calculated ratio f/j of the pressure loss f to the heat transfer coefficient j .

[0085] With reference to Tables 1 and 2 as well as FIG. 7, the heat transfer coefficients j are compared between examples having the same end-to-end distance of the high heat transfer channel part, among E1 to E4 of Examples 1 to 4 and R2 to R5 of Comparative Examples 2 to 5. Then, it is clear that Examples had slightly greater heat transfer coefficients j as compared with Comparative Examples. On the other hand, with reference to Tables 1 and 2 as well as FIG. 6, the pressure losses f are compared between examples having the same end-to-end distance of the high heat transfer channel part among E1 to E4 of Examples 1 to 4 and R2 to R5 of Comparative Examples 2 to 5. Then, it is clear that Examples had significantly smaller pressure losses f as compared with Comparative Examples.

[0086] Further, with reference to Tables 1 and 2 as well as FIG. 8, the ratios f/j of the pressure loss f to the heat transfer coefficient j are compared between examples having the same end-to-end distance of the high heat transfer channel part among E1 to E4 of Examples 1 to 4 and R2 to R5 of Comparative Examples 2 to 5. Then, it is clear that Examples had significantly smaller ratios f/j as compared with Comparative Examples.

[0087] What is described above clarifies the following: in a case where the parts including the low temperature ends of the effective areas are high heat transfer channel parts (wavy type channels) as is the case with Examples, the pressure loss increases as compared with a case where no high heat transfer channel part is provided in the effective areas; but excellent heat transfer performance can be achieved, while the amplitude of the increase in the pressure loss can be reduced, as compared with a case where a part of the effective area having a distance equal to the end-to-end distance of the high heat transfer channel part from the high temperature end of the effective area is the high heat transfer channel part (wavy type channel), as is the case with each Comparative Example.

[0088] Further, a reference line S illustrated in FIG. 8 is a straight line extended between the point of R1 of Comparative Example 1 and the point of R6 of Comparative Example 6, and this line can be used as a reference for determining whether or not the disadvantage of the increase in the pressure loss in the effective area 24 exceeds the advantage of the increase in the heat transfer coefficient for the effective area 24, which is achieved by the increase in the end-to-end distance of the high heat transfer channel part 26. More specifically, in a case where the point specified by the relationship between the end-to-end distance of the high heat transfer channel part 26 and the above-described ratio f/j is positioned in a range below the reference line S , this indicates that the disadvantage of the increase in the pressure loss in the effective area 24 does not exceed the advantage of the increase in the heat transfer coefficient for the effective area 24. Since a comprehensive heat transfer coefficient, which is a factor for determining the size of the heat exchanger 1, is determined according to the film coefficient of heat transfer in the first channel 21 of the first fluid flowing through the first channel 21 and the film coefficient of heat transfer in the second channel 22 of the second fluid flowing through the second channel 22, the comprehensive heat transfer coefficient of the heat exchanger 1 can be improved by the increase in the film coefficient of heat transfer of the first fluid in the effective area 24, and to this extent, the heat

exchanger 1 can be made compact.

[0089] In a case where the point specified by the relationship between the end-to-end distance of the high heat transfer channel part 26 and the above-described ratio f/j is positioned in a range above the reference line S, this indicates that the disadvantage of the increase in the pressure loss in the effective area 24 exceeds the advantage of the increase in the heat transfer coefficient for the effective area 24. The range below the reference line S corresponds to the range defined by the relational expression (1), and the tilt of this reference line S corresponds to the value of A in the relational expression (1).

[0090] According to FIG. 8, E1 to E4 of Examples 1 to 4 are positioned in the range below the reference line S, and it is therefore clear that in the cases of E1 to E4 of Examples 1 to 4, the disadvantage of the increase in the pressure loss in the effective area 24 does not exceed the advantage of the increase in the heat transfer coefficient for the effective area 24, which indicates that the relationship satisfies the above-described expression (1). On the other hand, R2 to R5 of Comparative Examples 2 to 5 are positioned in the range above the reference line S, and it is therefore clear that in the cases of R2 to R5 of Comparative Examples 2 to 5, the disadvantage of the increase in the pressure loss in the effective area 24 exceeds the advantage of the increase in the heat transfer coefficient for the effective area 24, which indicates that the relationship does not satisfy the above-described relational expression (1).

[0091] Further, in a heat exchanger, a pressure loss in a channel is a very important factor in view of practical application. For example, a compressor for compressing fluid is included in a supply device for supplying fluid to a channel of a heat exchanger in some cases, and when in such a case the pressure loss in the channels of the heat exchanger increases, it becomes necessary to boost the pressure of the fluid supplied to the channels, which causes the power of the compressor necessary for boosting the pressure of the fluid to increase, which results in an increase in the energy consumption. Even if providing high heat transfer channel parts in channels inevitably results in an increase in pressure loss, therefore, it is important to reduce the amplitude of the increase. In a case where providing high heat transfer channel parts in the effective areas of the first channels causes the pressure loss in the effective areas to increase to twice or more the value of pressure loss in a case where the entire effective areas are straight channels, such first channels cannot be used in view of practical application of the heat exchanger.

[0092] As is clear from Table 1, in Examples 1 to 3 among Examples 1 to 4, the pressure loss f can be suppressed to less than 200, which is a value twice the pressure loss f of Comparative Example 1. It is therefore clear that, in a case where the end-to-end distance of the high heat transfer channel parts including the low temperature ends of the effective area is 60% or less of the end-to-end distance of the effective areas, the first channels are sufficiently able to be adopted for practical application, in view of pressure loss.

[0093] The heat exchanger according to the present invention is not necessarily limited to a heat exchanger according to the above-described embodiment. As a configuration of the heat exchanger according to the present invention, the following configuration, for example, can be adopted.

[0094] As a bent channel shape of the high heat transfer channel part, for example, a corrugated shape formed with continuous curves, such as a sine curve, may be used. Further, corners of a zig-zag shape of the high heat transfer channel part do not have to be rounded, but may be angular.

[0095] Further, the lengths of the first straight part and the second straight part of the high heat transfer channel part in the above-described embodiment, and the tilt angle D formed between the first straight part or the second straight part and the wavy type center line, can be set appropriately. More specifically, the lengths and/or the tilt angle D of the first and second straight parts may be by appropriately increased/decreased, and thereby the amplitude of the zig-zag of the high heat transfer channel part or the repetition period of zig-zag thereof may be appropriately changed. Further, the curvature of the rounded corner parts may be appropriately changed.

[0096] Still further, the channel shape of the standard heat transfer channel part is not limited to the straight shape, and may be any one as long as the channel shape is such that the channel length of the standard heat transfer channel part per unit distance of the end-to-end distance (straight distance) thereof is smaller than the channel length of the high heat transfer channel part per unit distance of the end-to-end distance thereof. For example, the channel shape of the standard heat transfer channel part may be a gradually curved shape or the like.

[0097] Still further, the second channel does not necessarily have a meander shape, and the overall shape thereof may be a straight channel shape or another channel shape, for example.

[0098] Still further, the fluids flowing through the channels in the heat exchanger are necessarily limited to two types of fluids, i.e., the first fluid and the second fluid. More specifically, three or more types of the fluids may be caused to flow through respective channels in the heat exchanger, so that heat exchange occurs among the fluids.

[0099] Still further, the configuration of the fluid is not necessarily limited to a configuration in which the first fluid flowing through the first channels is a low temperature fluid and the second fluid flowing through the second channels is a high temperature fluid. More specifically, a first fluid having a high temperature may be caused to flow through the first channels, and a second fluid having a low temperature may be caused to flow through the second channels. For example, such a heat exchange method may be performed that in order to lower the temperature of the first fluid, heat exchange is performed between the first fluid and a refrigerant as a second fluid having a temperature lower than that of the first fluid.

[0100] In this case, the first discharge header 5 is used as a first supply header to which a supply pipe for supplying the first fluid is connected, and the first supply header 3 is used as a first discharge header that receives the first fluid flowing out of the first channels 21. Further, the second discharge header 6 is used as a second supply header to which a supply pipe for supplying the refrigerant is connected, and the second supply header 4 is used as a second discharge header for receiving the refrigerant flowing out of the second channels 22. Still further, in this case, the introduction ports 21a of the first channels 21 serve as outflow ports through which the first fluid is allowed to flow out, and the outflow ports 21b of the first channels 21 serve as introduction ports through which the first fluid is introduced. Still further, the introduction ports 22a of the second channels 22 serve as outflow ports through which the second fluid is allowed to flow out, and the outflow ports 22b of the second channels 22 serve as introduction ports through which the second fluid is introduced.

[0101] Then, the first fluid is supplied through the supply pipe to the first supply header and then the first fluid is supplied from the first supply header to each first channel 21, whereby, to each first channel 21, the first fluid is caused to flow from the standard heat transfer channel part 25 toward the high heat transfer channel part 26. In other words, the first fluid is caused to flow through each first channel 21 in an orientation opposite to the orientation in the case of the above-described embodiment. On the other hand, the refrigerant as the second fluid is supplied through the supply pipe to the second supply header, and then is supplied from the second supply header to each second channel 22, whereby the refrigerant is caused to flow through each second channel 22 in an orientation opposite to the orientation in which the second fluid is caused to flow in the above-described embodiment. This causes heat exchange to occur between the first fluid flowing through the first channels 21 and the refrigerant flowing through the second channels 22, thereby to lower the temperature of the first fluid.

- 1 Heat exchanger
- 2 Channel structure
- 11 First substrate (first layer)
- 12 Second substrate (second layer)
- 21 First channel
- 22 Second channel
- 24 Effective area
- 24a High temperature end
- 24b Low temperature end
- 25 Standard heat transfer channel part
- 26 High heat transfer channel part
- 27 Meander center line

[0102] A heat exchanger includes a channel structure including a first substrate in which a first channel is arrayed, and a second substrate stacked on the first substrate, in which a second channel is arrayed. The first channel has an effective area overlapping a range where the second channel is provided, when viewed in a lamination direction of the first and second substrates. The effective area includes a standard heat transfer channel part including a high temperature end, and a high heat transfer channel part including a low temperature end, which is a part of the effective area other than the standard heat transfer channel part. The high heat transfer channel part has a bent shape so that a channel length thereof per unit distance of an end-to-end distance thereof is greater than a channel length of the standard heat transfer channel part per unit distance of an end-to-end distance thereof.

Claims

1. A heat exchanger that causes a plurality of fluids to flow therethrough so as to cause heat exchange to occur between the fluids, the heat exchanger comprising a channel structure that includes:

a first layer in which a first channel that is a microchannel through which one fluid is caused to flow is arrayed; and a second layer stacked on the first layer, in which a second channel that is a microchannel through which another fluid is caused to flow is arrayed, the other fluid being a fluid different from the one fluid,

wherein the first channel has an effective area that overlaps a range where the second channel in the second layer is provided, when viewed in a direction in which the first layer and the second layer are stacked, wherein the effective area includes:

a standard heat transfer channel part that includes a high temperature end that is one of ends of the effective area; and

a high heat transfer channel part that is equivalent to a part of the effective area other than the standard heat transfer channel part, the high heat transfer channel part including a low temperature end that is an end of the effective area on a side opposite to the high temperature end and through which the one fluid having a temperature lower than a temperature of the one fluid flowing at the high temperature end, and

wherein the high heat transfer channel part has a channel shape bent in such a manner that a channel length thereof per unit distance of an end-to-end distance thereof is greater than a channel length of the standard heat transfer channel part per unit distance of an end-to-end distance thereof.

2. The heat exchanger according to claim 1,
wherein the standard heat transfer channel part is a straight channel, and
wherein the high heat transfer channel part is a wavy type channel.
3. The heat exchanger according to claim 2,
wherein the high heat transfer channel part meanders in such a manner as being deflected to both sides with respect to a center line that is a straight line, and
wherein the end-to-end distance of the high heat transfer channel part in a direction along the center line is 60% or less of an end-to-end distance of the effective area.
4. The heat exchanger according to claim 3,
wherein the end-to-end distance of the high heat transfer channel part in a direction along the center line is 10% or more of the end-to-end distance of the effective area.
5. The heat exchanger according to claim 2,
wherein the high heat transfer channel part meanders in such a manner as being deflected to both sides with respect to a center line that is a straight line, and
wherein the end-to-end distance of the high heat transfer channel part in a direction along the center line is smaller than the end-to-end distance of the standard heat transfer channel part.
6. A heat exchange method comprising:

causing one fluid to flow through the first channel in the heat exchanger according to claim 1 from the standard heat transfer channel part toward the high heat transfer channel part, and at the same time, causing a refrigerant as another fluid to flow through the second channel in the heat exchanger, so as to cause heat exchange to occur between the one fluid and the refrigerant.
7. A heat exchange method comprising:

causing one fluid to flow through the first channel in the heat exchanger according to claim 1 from the high heat transfer channel part toward the standard heat transfer channel part, and at the same time, causing a hot medium as another fluid to flow through the second channel in the heat exchanger, so as to cause heat exchange to occur between the one fluid and the hot medium.

FIG. 1

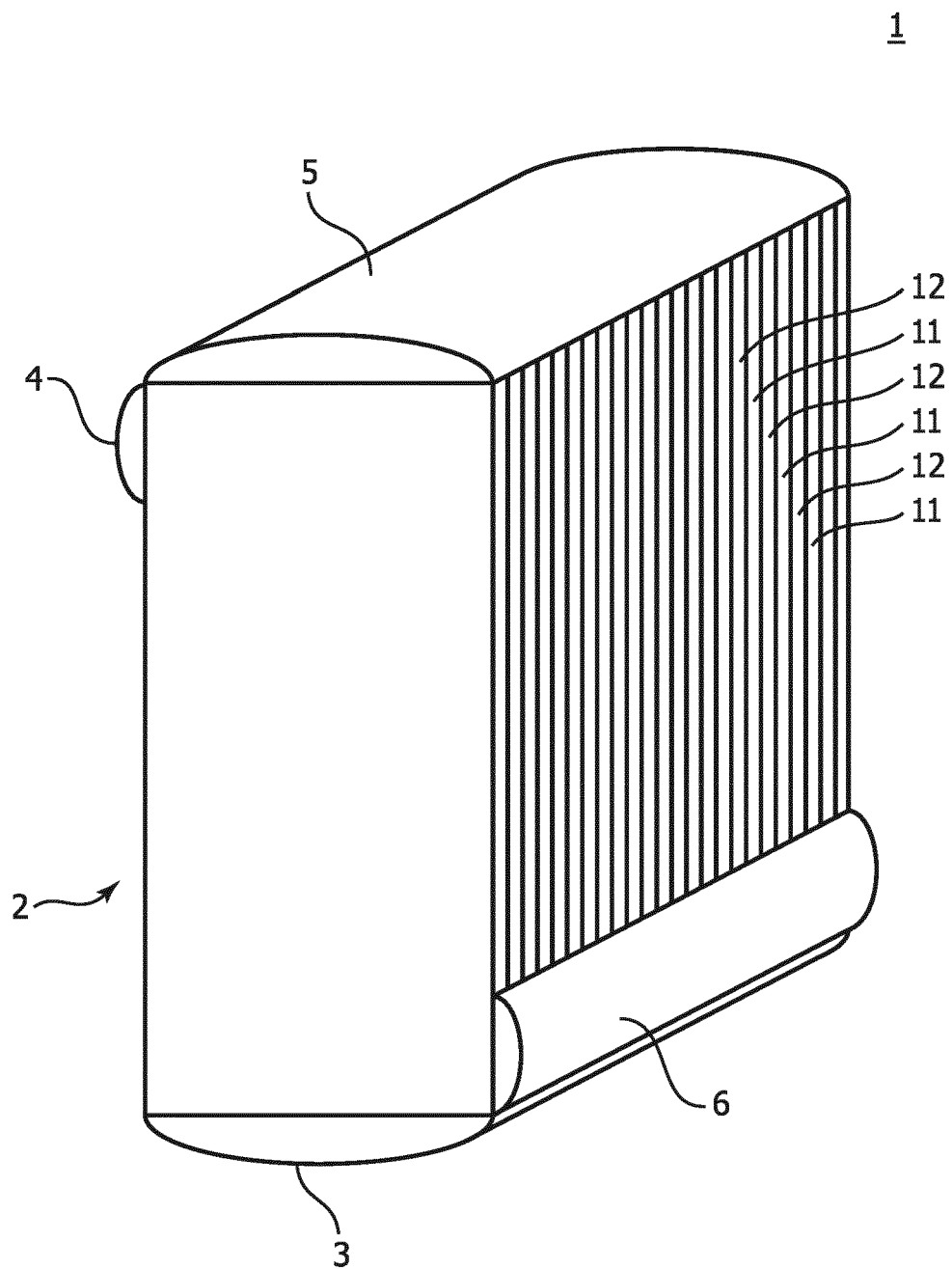


FIG. 2

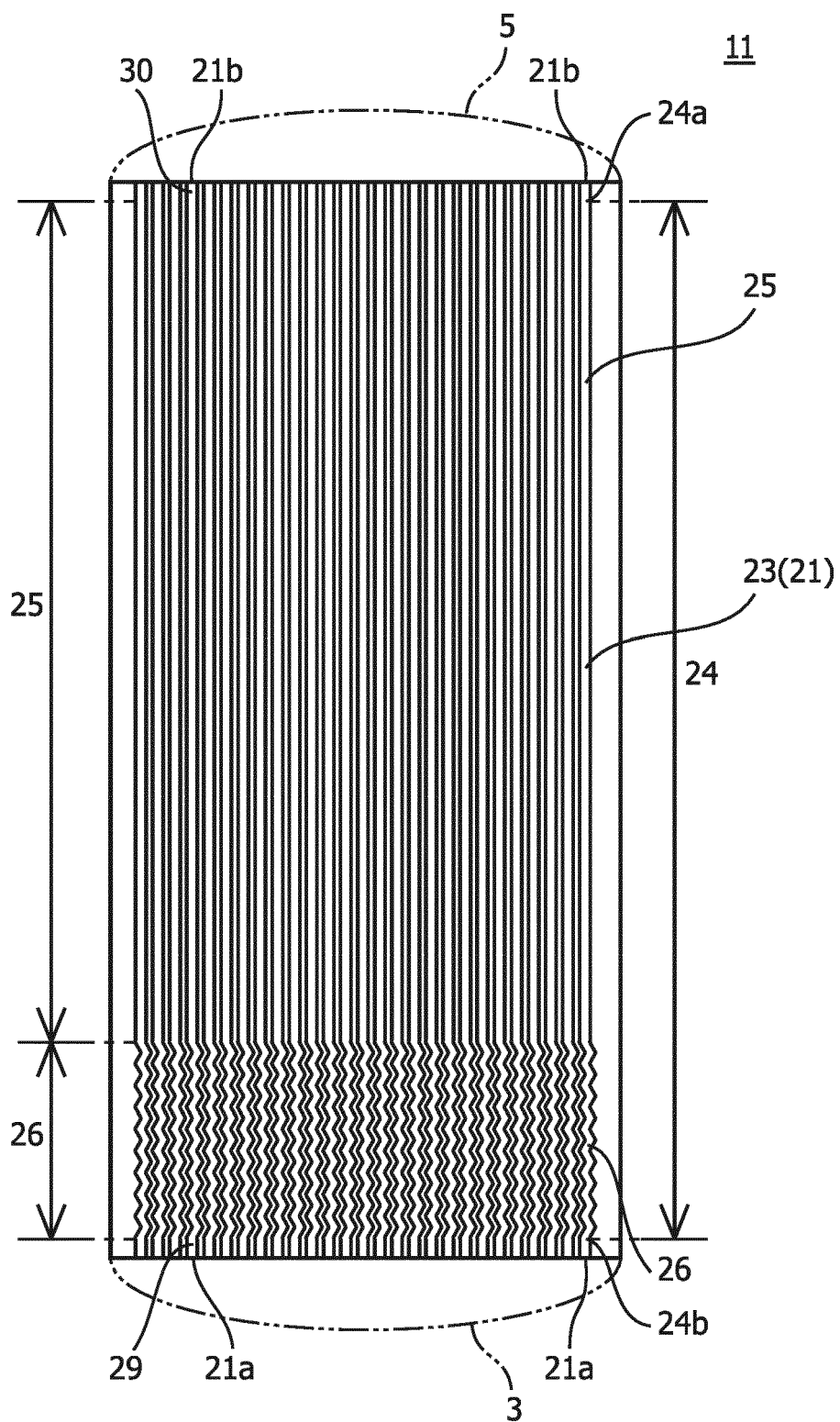


FIG. 3

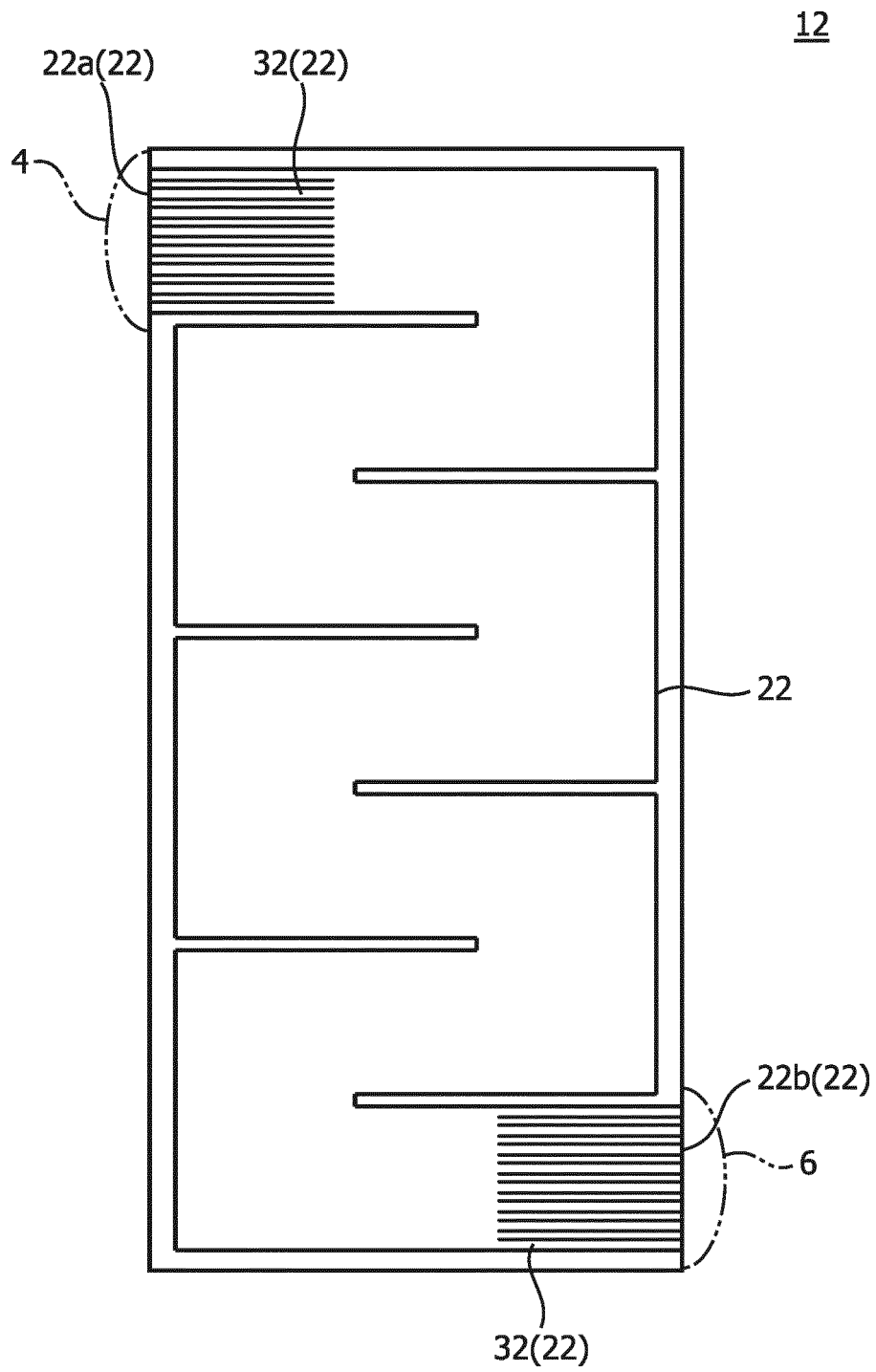


FIG. 4

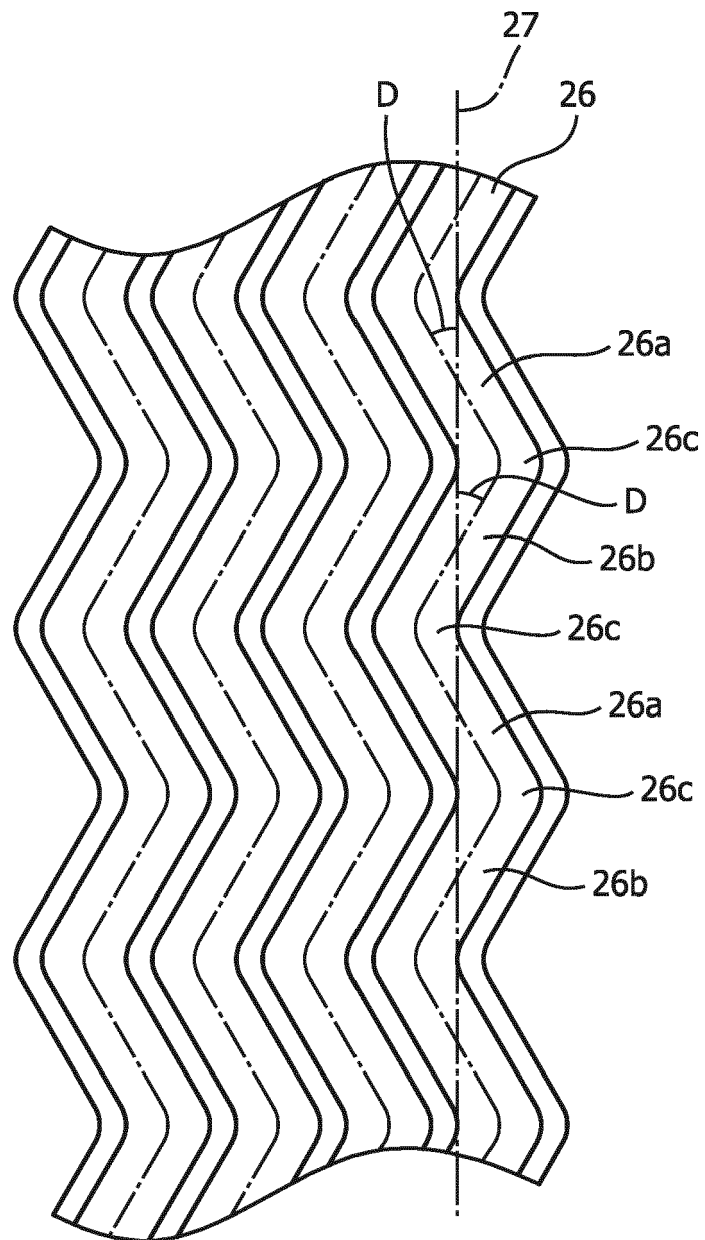


FIG. 5

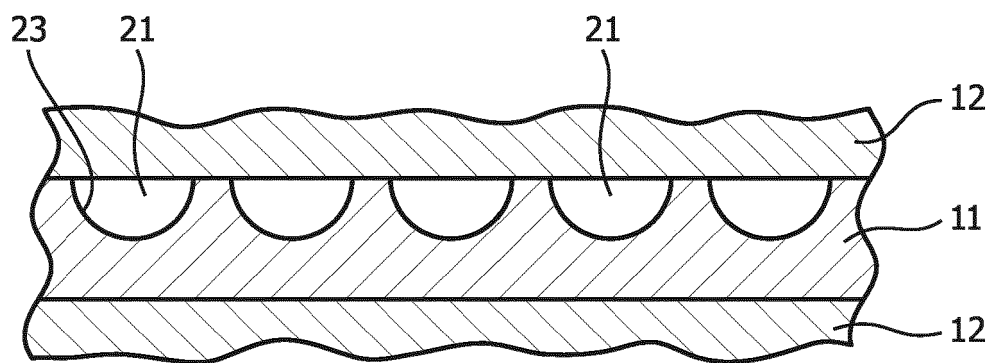


FIG. 6

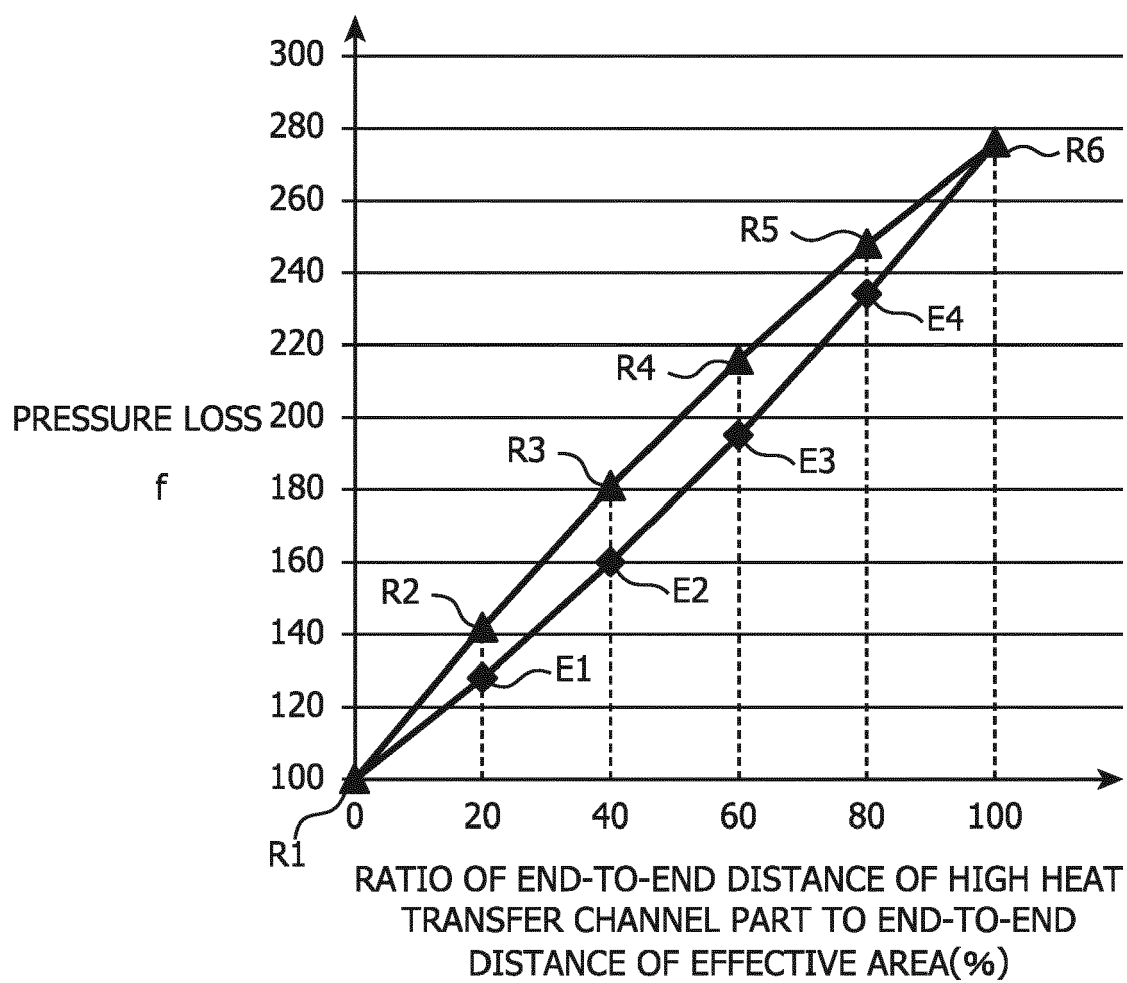


FIG. 7

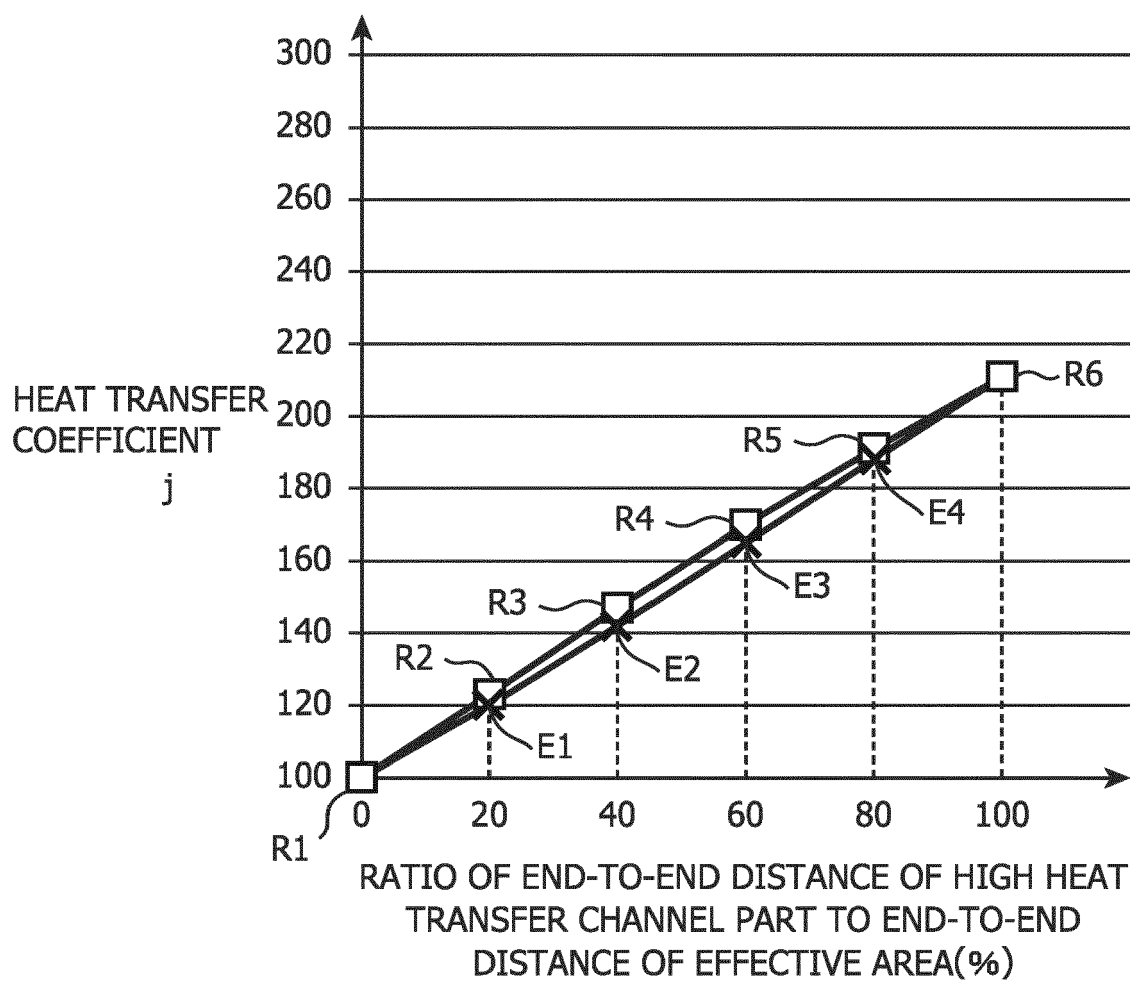
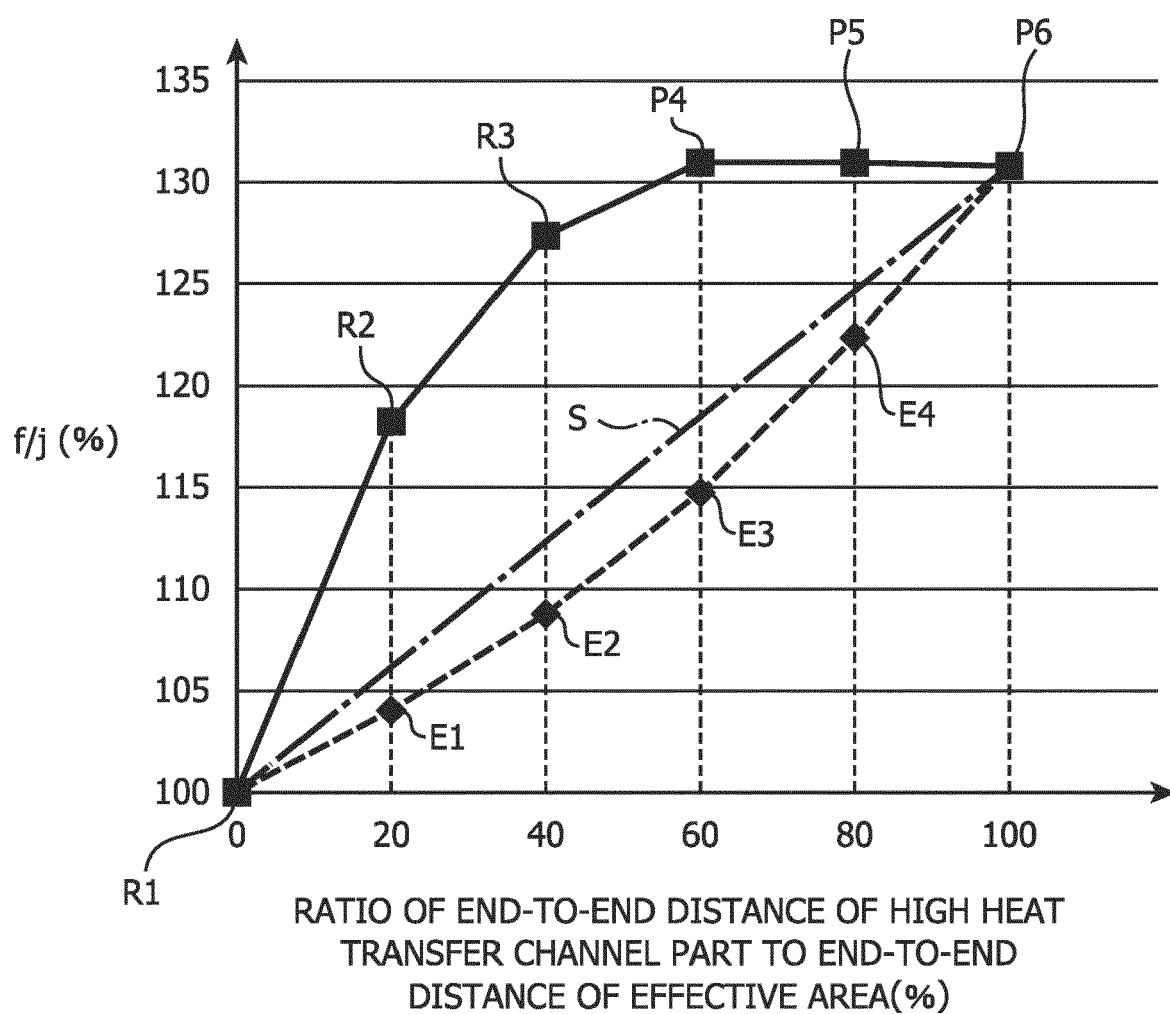


FIG. 8





EUROPEAN SEARCH REPORT

Application Number
EP 16 20 0003

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2010/314088 A1 (YOO YOUNG JUNE [KR] ET AL) 16 December 2010 (2010-12-16) * figures 3,5,7 *	1-7	INV. F28F13/12 F28D9/00
X	EP 1 653 185 A2 (TOKYO INST TECH [JP]; LUFTWASSER PROJECT INC [JP]) 3 May 2006 (2006-05-03) * figures 14a,b *	1-7	
X	WO 2015/056906 A1 (KOREA ATOMIC ENERGY RES [KR]) 23 April 2015 (2015-04-23) * figure 16 *	1-7	
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 22 June 2017	Examiner Vassoille, Bruno
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

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