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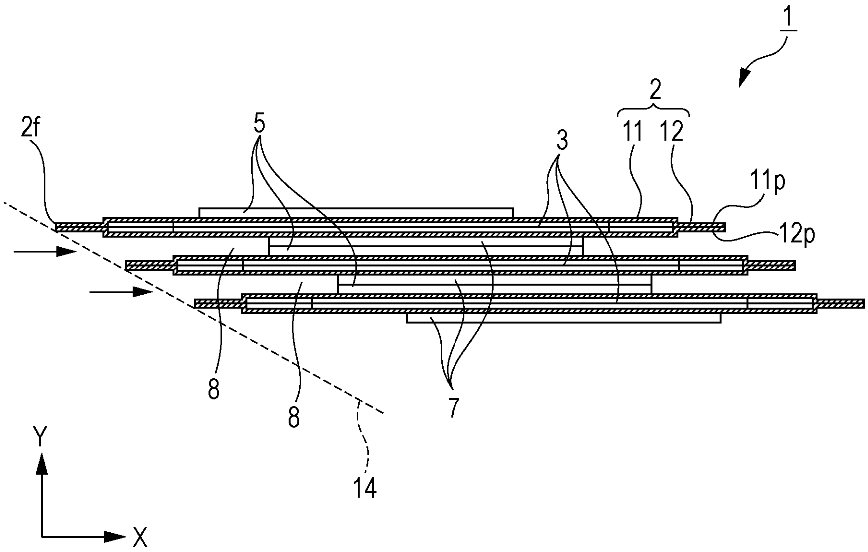
(54) HEAT EXCHANGER AND HEAT EXCHANGING UNIT

(57) A heat exchanger has a plurality of heat exchanger tubes. Each heat exchanger tube has an internal flow path through which a first fluid flows. These heat exchanger tubes are arranged so that an external flow path, through which a second fluid that exchanges heat with the first fluid flows, is formed between each two adjacent heat exchanger tubes. Each two adjacent heat exchanger tubes are bonded together at the inlets and outlets of the internal flow paths in the two heat exchanger tubes. One of each two adjacent heat exchanger tubes is offset with respect to the other heat exchanger tube in a direction perpendicular to an arrangement direction in which these heat exchanger tubes are arranged.

FIG. 2C



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Description

BACKGROUND

1. Technical Field

[0001] The present disclosure relates to a heat exchanger and a heat exchanging unit.

2. Description of the Related Art

[0002] Japanese Unexamined Patent Application Publication No. 2008-39322 discloses a heat exchanger 101 that has a plurality of heat exchanger tubes 102, as illustrated in Fig. 13. Each heat exchanger tube 102 is formed by bending a single plate material; the heat exchanger tube 102 has a middle portion 102A and open flared portions 102B and 102C. The middle portion 102A is a flat tube. The open flared portions 102B and 102C are about two to four times as thick as the middle portion 102A and are open at both ends of the heat exchanger tube 102. An external flow path is formed between each two adjacent heat exchanger tubes 102. It is described in Japanese Unexamined Patent Application Publication No. 2008-39322 that the heat exchanger tube 102 may have a meandering coolant path and that the meandering coolant path may be space-separated.

SUMMARY

[0003] One non-limiting and exemplary embodiment provides a technology that improves the performance of a heat exchanger formed with heat exchanger tubes.

[0004] In one general aspect, the techniques disclosed here feature that a heat exchanger includes a plurality of flat heat exchanger tubes, each of which includes a first plate member and a second plate member, a part of the first plate member and a part of the second plate member being bonded together, the first plate member and the second plate member constituting an internal flow path through which a first fluid flows, wherein an external flow path is located between each two adjacent heat exchanger tubes, a second fluid that flows through the external flow path, and that exchanges heat with the first fluid, each two adjacent heat exchanger tubes of the plurality of heat exchanger tubes are bonded together at inlets and outlets in the internal flow paths in the two heat exchanger tubes; one of each two adjacent heat exchanger tubes is offset with respect to the other of each two adjacent heat exchanger tube in a direction perpendicular to an arrangement direction in which the plurality of heat exchanger tubes are arranged, the first plate member has a first inlet bonding portion positioned on a first main plane, which is an external surface of the first plate member, and a first outlet bonding portion positioned on the first main plane, as portions at which the two adjacent heat exchanger tubes are bonded together; the second plate member has a second inlet bonding portion positioned on a second main plane, which is an external surface of the second plate member, and a second outlet bonding portion positioned on the second main plane, as portions at which the two adjacent heat exchanger tubes are bonded together; the first inlet bonding portion and first outlet bonding portion are located at positions relatively close to the edge of each of the plurality of the heat exchanger tubes, and the second inlet bonding portion and second outlet bonding portion are located at positions relatively distant from the edge of each of the plurality of the heat exchanger tubes.

[0005] The above technology can improve the performance of a heat exchanger formed with heat exchanger tubes.

[0006] Additional benefits and advantages of the disclosed embodiments will become apparent from the specification and drawings. The benefits and/or advantages may be individually obtained by the various embodiments and features of the specification and drawings, which need not all be provided in order to obtain one or more of such benefits and/or advantages.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

Fig. 1 is a perspective view of a heat exchanger according to a first embodiment of the present disclosure;

Fig. 2A is an exploded perspective view of a heat exchanger tube used in the heat exchanger in the first embodiment;
Fig. 2B is a plan view of the heat exchanger tube illustrated in Fig. 2A;
Fig. 2C is a cross-sectional view of the heat exchanger in the first embodiment;
Fig. 3A illustrates the structure of a heat exchanging unit in which conventional heat exchangers are used;
Fig. 3B illustrates the structure of a heat exchanging unit in which heat exchangers in the first embodiment are used;
Fig. 4A is a cross-sectional view of a heat exchanger according to a first variation;
Fig. 4B is an exploded perspective view of a second heat exchanger tube;
Fig. 4C is a cross-sectional view of the second heat exchanger;
Fig. 5A is a cross-sectional view of a heat exchanger according to a second variation;
Fig. 5B is an exploded perspective view of a heat exchanger tube used in the heat exchanger in the second variation;
Fig. 6A is a cross-sectional view of a heat exchanger according to a third variation;
Fig. 6B is a plan view of a heat exchanger tube used in the heat exchanger in the third variation;

Fig. 7A is a cross-sectional view of a heat exchanger according to a fourth variation;

Fig. 7B is a cross-sectional view of a heat exchanger according to a fifth variation;

Fig. 8 is a cross-sectional view of a heat exchanger according to a second embodiment of the present disclosure;

Fig. 9 is a cross-sectional view of a heat exchanger according to a third embodiment of the present disclosure;

Fig. 10A is an exploded perspective view of a heat exchanger tube used in the heat exchanger in the third embodiment;

Fig. 10B is a cross-sectional view of the heat exchanger in the third embodiment;

Fig. 10C is a cross-sectional view of a linking member used in the heat exchanger in the third embodiment;

Fig. 10D is a partial cross-sectional view of the heat exchanger in the third embodiment in which a laminated body of the linking members is used;

Fig. 10E is a partial cross-sectional view of the heat exchanger in the third embodiment in which a plurality of linking members that have different shapes are used;

Fig. 11A is a perspective view of a heat exchanger tube used in a heat exchanger according to a sixth variation;

Fig. 11B is a cross-sectional view of the heat exchanger in the sixth variation;

Fig. 11C is a cross-sectional view of a linking member used in the heat exchanger in the sixth variation;

Fig. 12 illustrates the structure of a heat exchanging unit in which heat exchangers in the third embodiment are used; and

Fig. 13 is a perspective view of the conventional heat exchanger.

DETAILED DESCRIPTION

[0008] With the technology described in Japanese Unexamined Patent Application Publication No. 2008-39322, when air is supplied into the heat exchanger 101 in an oblique direction, airflow separation occurs at the inlet of the external flow path and some heat transfer surfaces do not contribute heat exchange. Due to an increased loss in dynamic pressure, the amount of airflow in the external flow path is also reduced. As a result, the capacity of the heat exchanger 101 is lowered and an air blower demands much more power. If an angle formed by the inflow direction of air with respect to a direction parallel to the flat middle portion 102A exceeds about 40 degrees, wind noise due to the airflow separation is generated. This may force the heat exchanger to operate at a low airflow rate with the tradeoff of the heat exchanger's performance when the heat exchanger is used in an air conditioning apparatus or the like. This problem is likely to arise when a positional relationship between a blower and a heat exchanger is strictly restricted for, for example, a ceiling cassette type of indoor unit. On the basis of the above finding, the inventor devised inventions in aspects described below.

[0009] A heat exchanger according to a first aspect of the present disclosure includes a plurality of flat heat exchanger tubes, each of which has an internal flow path through which a first fluid flows, and a plurality of external flow paths, each of which is disposed between each two adjacent heat exchanger tubes, and through each of which a second fluid that exchanges heat with the first fluid flows; each two adjacent heat exchanger tubes of the plurality of heat exchanger tubes are bonded together at inlets and outlets in the internal flow paths in the two heat exchanger tubes; one of each two adjacent heat exchanger tubes is offset with respect to the other heat exchanger tube in a direction perpendicular to an arrangement direction in which the plurality of heat exchanger tubes are arranged; the heat exchanger tube includes a first plate member and a second plate member, which are bonded together; the first plate member has a first inlet bonding portion positioned on a first main plane, which is an external surface of the first plate member, and a first outlet bonding portion positioned on the first main plane, as portions at which the heat exchanger tube and its adjacent heat exchanger tube are bonded together; the second plate member has a second inlet bonding portion positioned on a second main plane, which is an external surface of the second plate member, and a second outlet bonding portion positioned on the second main plane, as portions at which the heat exchanger tube and its adjacent heat exchanger tube are bonded together; the first inlet bonding portion and first outlet bonding portion are located at positions relatively close to the edge of the heat exchanger tubes, and the second inlet bonding portion and second outlet bonding portion are located at positions relatively distant from the edge of the heat exchanger tubes.

[0010] According to the first aspect, it is possible to align the inflow direction of the second fluid and the flow direction of the second fluid in the external flow path or to narrow an angle formed by these directions. The flow direction of the second fluid does not much change at positions before and after the inlet plane of the heat exchangers. In this case, the flow separation of the second fluid is suppressed and a large pressure loss is hard to occur. Accordingly, the performance of the heat exchanger can be fully derived.

[0011] According to the first aspect, the heat exchanger tube includes a first plate member and a second plate member, which are bonded together. Therefore, the thickness of the heat exchanger tube can be reduced, which is advantageous in that the heat exchanger can be made compact.

[0012] According to the first aspect: the first plate member has a first inlet bonding portion positioned on the first main plane and a first outlet bonding portion positioned on the first main plane, as portions at which the heat exchanger tube and its adjacent heat exchanger tube are bonded together; the second plate member has a second inlet bonding portion positioned on the second main plane and a second outlet bonding portion positioned on the second main plane, as portions at which the heat exchanger tube and its adjacent heat exchanger tube are bonded together; and the first inlet bonding portion and first outlet bonding portion are located at positions relatively close to the edge of the heat exchanger tubes, and the second inlet bonding portion and second outlet bonding portion are located at positions relatively distant from the edge of the heat exchanger tubes. With this structure, a plurality of heat exchanger tubes can have an offset structure and the extent of the external flow path can be determined.

[0013] In a second aspect, for example: the plurality of heat exchanger tubes in the heat exchanger according to the first aspect may include a plurality of first heat exchanger tubes and a plurality of second heat exchanger tubes; the structure of the first heat exchanger tube may differ from the structure of the second heat exchanger tube; and the first heat exchanger tube and second heat exchanger tube may be adjacent to each other in the arrangement direction. Even if an amount of offset, the extent of the external flow path, and other dimensions are strictly restricted, when the first heat exchanger tube and second heat exchanger tube are used in combination, an oblique angle of the inlet plane of the heat exchangers can be easily adjusted to an optimum angle. That is, in the second aspect, the heat exchanger can be designed with increased freedom.

[0014] In a third embodiment, for example: the first heat exchanger tube in the heat exchanger according to the second aspect may have a first plate member and a second plate member, which are bonded together; the first plate member may have a first inlet bonding portion positioned on a first main plane, which is an external surface of the first plate member, and a first outlet bonding portion positioned on the first main plane, as portions at which the heat exchanger tube and its adjacent heat exchanger tube are bonded together; the second plate member may have a second inlet bonding portion positioned on a second main plane, which is an external surface of the second plate member, and a second outlet bonding portion positioned on the second main plane, as portions at which the heat exchanger tube and its adjacent heat exchanger tube are bonded together; the first inlet bonding portion and first outlet bonding portion may be located at positions relatively close to the edge of the first heat exchanger tubes, and the second inlet bonding portion and second outlet bonding portion may be located at positions relatively distant from the edge of the first heat exchanger tubes; the second heat exchanger tube may have a third plate member and a fourth plate member, which are bonded together; the third plate member may have a third inlet bonding portion positioned on a third main plane, which is an external surface of the third plate member, and a third outlet bonding portion positioned on the third main plane, as portions at which the heat exchanger tube and its adjacent heat exchanger tube are bonded together; the fourth plate member may have a fourth inlet bonding portion positioned on a fourth main plane, which is an external surface of the fourth plate member, and a fourth outlet bonding portion positioned on the fourth main plane, as portions at which the heat exchanger tube and its adjacent heat exchanger tube are bonded together; and in a plane perpendicular to the arrangement direction of the plurality of heat exchanger tubes, the position of the third inlet bonding portion may match the position of the fourth inlet bonding portion and the position of the third outlet bonding portion may match the position of the fourth outlet bonding portion. With this structure, a plurality of heat exchanger tubes can have an offset structure and the extent of the external flow path can be determined.

[0015] In a fifth aspect, for example, the third plate member in the heat exchanger according to the first aspect may have the same shape as the fourth plate member. According to the fifth aspect, since the number of parts is reduced, cost reduction can be expected.

[0016] In a sixth embodiment, for example, at least one of the third plate member and fourth plate member in the third or fourth aspect may have the same shape as the first plate member or second plate member. According to the sixth aspect, since the number of parts is reduced, cost reduction can be expected.

[0017] In the sixth embodiment, for example: the internal flow path of the heat exchanger in any one of the first to fifth aspects may include a plurality of segments extending in a particular row direction of the heat exchanger tube; the heat exchanger tube may further include a plurality of flow path portions, each of which protrudes toward both ends of the heat exchanger tube in its thickness direction and determines one segment in the internal flow path, and may also include thin portions, each of which is positioned between two flow path portions adjacent in a width direction perpendicular to the row direction and separates two adjacent segments along the internal flow path; on a cross section perpendicular to the row direction, the flow path portion in one of two adjacent heat exchanger tubes may face the thin portion of the other heat exchanger tube with the external flow path intervening between them, and the flow path portion in the other heat exchanger tube may face the thin portion of the one heat exchanger tube with the external flow path intervening between them; and the plurality of flow path portions in the one heat exchanger tube and the plurality of flow path portions in the other heat exchanger tube may be placed in a staggered arrangement in the width direction. With this structure, the extent of the external flow path in the thickness direction of the heat exchanger tube is kept substantially constant in the width direction of the heat exchanger tube (flow direction of the second fluid). As a result, the pressure loss of the second fluid in the external flow path can be reduced. When heat exchanger tubes are stacked at a small pitch, the heat transfer area per unit volume can be enlarged. In addition, since flow separation of the second fluid on the surfaces of the heat exchanger tube is suppressed, an effective heat transfer area is enlarged.

[0018] A heat exchanging unit according to a seventh aspect of the present disclosure includes a blower that has a rotational axis and an impeller secured to the rotational axis, the blower delivering a second fluid in the circumferential direction of the rotational axis due to rotation of the impeller, and heat exchangers described in any one of the first to sixth aspects, the heat exchangers being disposed around the blower in a plane perpendicular to the rotational axis; each of the plurality of external flow paths is disposed so that the downstream end of the external flow path is at a more forward position in the rotational direction of the rotational axis than the upstream end of the external flow path when viewed from the rotational axis. According to the seventh aspect, the heat exchanger tubes can be optimally placed with respect to a spiral flow coming from a centrifugal blower. This reduces a pressure loss and improves heat exchange efficiency. The seventh aspect is suitable to a ceiling cassette type of indoor unit.

[0019] A heat exchanger according to an eighth aspect of the present disclosure includes a plurality of flat heat exchanger tubes, each of which has an internal flow path through which a first fluid flows, and a plurality of external flow paths, each of which is disposed between each two adjacent heat exchanger tubes, and through each of which a second fluid that exchanges heat with the first fluid flows; each two adjacent heat exchanger tubes of the plurality of heat exchanger tubes are bonded together at inlets and outlets in the internal flow paths in the two heat exchanger tubes; one of each two adjacent heat exchanger tubes is offset with respect to the other heat exchanger tube in a direction perpendicular to an arrangement direction in which the plurality of heat exchanger tubes are arranged; the heat exchanger tube includes a first plate member and a second plate member, which are bonded together; the first plate member has a first bonding portion provided on a first main plane, which is an external surface of the first plate member, as a portion at which the heat exchanger tube and its adjacent heat exchanger tube are bonded together; the second plate member has a second bonding portion positioned on a second main plane, which is an external surface of the second plate member, as a portion at which the heat exchanger tube and its adjacent heat exchanger tube are bonded together; a bonding plane on which the first bonding portion and second bonding portion are bonded together is inclined with respect to a direction perpendicular to the arrangement direction of the plurality of heat exchanger tubes; the axis of the first bonding portion and the axis of the second bonding portion are inclined with respect to the arrangement direction of the plurality of heat exchanger tubes.

[0020] According to the eighth aspect, it is possible to align the inflow direction of the second fluid and the flow direction of the second fluid in the external flow path or to narrow an angle formed by these directions. The flow direction of the second fluid does not much change at positions before and after the inlet plane of the heat exchangers. In this case, the flow separation of the second fluid is suppressed and a large pressure loss is hard to occur. Accordingly, the performance of the heat exchanger can be fully derived.

[0021] According to the eighth aspect, the heat exchanger tube includes a first plate member and a second plate member, which are bonded together. Therefore, the thickness of the heat exchanger tube can be reduced, which is advantageous in that the heat exchanger can be made compact.

[0022] According to the eighth aspect: the first plate member has a first bonding portion provided on a first main plane, which is an external surface of the first plate member, as a portion at which the heat exchanger tube and its adjacent heat exchanger tube are bonded together; the second plate member has a second bonding portion positioned on a second main plane, which is an external surface of the second plate member, as a portion at which the heat exchanger tube and its adjacent heat exchanger tube are bonded together; a bonding plane on which the first bonding portion and second bonding portion are bonded together is inclined with respect to a direction perpendicular to the arrangement direction of the plurality of heat exchanger tubes; and the axis of the first bonding portion and the axis of the second bonding portion are inclined with respect to the arrangement direction of the plurality of heat exchanger tubes. Therefore, the plurality of heat exchanger tubes can be mutually offset in their width direction.

[0023] In the ninth embodiment, for example: the internal flow path of the heat exchanger in the eighth aspect may include a plurality of segments extending in a particular row direction of the heat exchanger tube; the heat exchanger tube may further include a plurality of flow path portions, each of which protrudes toward both ends of the heat exchanger tube in its thickness direction and determines one segment in the internal flow path, and may also include thin portions, each of which is positioned between two flow path portions adjacent in a width direction perpendicular to the row direction and separates two adjacent segments along the internal flow path; on a cross section perpendicular to the row direction, the flow path portion in one of two adjacent heat exchanger tubes may face the thin portion of the other heat exchanger tube with the external flow path intervening between them, and the flow path portion in the other heat exchanger tube may face the thin portion of the one heat exchanger tube with the external flow path intervening between them; and the plurality of flow path portions in the one heat exchanger tube and the plurality of flow path portions in the other heat exchanger tube may be placed in a staggered arrangement in the width direction. With this structure, the extent of the external flow path in the thickness direction of the heat exchanger tube is kept substantially constant in the width direction of the heat exchanger tube (flow direction of the second fluid). As a result, the pressure loss of the second fluid in the external flow path can be reduced. When heat exchanger tubes are stacked at a small pitch, the heat transfer area per unit volume can be enlarged. In addition, since flow separation of the second fluid on the surfaces of the heat exchanger tube is suppressed, an effective heat transfer area is enlarged.

[0024] A heat exchanging unit according to a tenth aspect of the present disclosure includes a blower that has a rotational axis and an impeller secured to the rotational axis, the blower delivering a second fluid in the circumferential direction of the rotational axis due to rotation of the impeller, and heat exchangers described in the eighth or ninth aspect, the heat exchangers being disposed around the blower in a plane perpendicular to the rotational axis; each of the plurality of external flow paths is disposed so that the downstream end of the external flow path is at a more forward position in the rotational direction of the rotational axis than the upstream end of the external flow path when viewed from the rotational axis. According to the tenth aspect, the heat exchanger tubes can be optimally placed with respect to a spiral flow coming from a centrifugal blower. This reduces a pressure loss and improves heat exchange efficiency. The tenth aspect is suitable to a ceiling cassette type of indoor unit.

[0025] The heat exchanger according to the eleventh aspect of the present disclosure includes a plurality of flat heat exchanger tubes, each of which has an internal flow path through which a first fluid flows, and a plurality of external flow paths, each of which is disposed between each two adjacent heat exchanger tubes, and through each of which a second fluid that exchanges heat with the first fluid flows; each two adjacent heat exchanger tubes of the plurality of heat exchanger tubes are bonded together at inlets and outlets in the internal flow paths in the two heat exchanger tubes; one of each two adjacent heat exchanger tubes is offset with respect to the other heat exchanger tube in a direction perpendicular to an arrangement direction in which the plurality of heat exchanger tubes are arranged; the plurality of heat exchanger tubes are arranged in a fan shape; the plurality of external flow paths extend radially.

[0026] According to the eleventh aspect, it is possible to align the inflow direction of the second fluid and the flow direction of the second fluid in the external flow path or to narrow an angle formed by these directions. The flow direction of the second fluid does not much change at positions before and after the inlet plane of the heat exchangers. In this case, the flow separation of the second fluid is suppressed and a large pressure loss is hard to occur. Accordingly, the performance of the heat exchanger can be fully derived.

[0027] According to the eleventh aspect, the plurality of heat exchanger tubes are arranged in a fan shape and the plurality of external flow paths extend radially. If, for example, heat exchangers having external flow paths oriented in a fixed direction are placed around a blower (centrifugal blower), a space is left between each two adjacent heat exchangers. The heat exchanger according to the eleventh aspect can be placed in this space. Since the external flow paths extend radially, the second fluid expelled from the blower easily flows into the external flow paths. This reduces the pressure loss of the second fluid. Furthermore, since flow separation of the second fluid can be suppressed, the effective heat transfer area is expanded.

[0028] In a twelfth aspect, for example: the heat exchanger tube in the heat exchanger according to the eleventh aspect may include one set of plate members that are bonded together; the inlet and outlet of the internal flow path may be open in their main planes; to mutually bond each two adjacent heat exchanger tubes at the inlets or outlets of their internal flow paths, the heat exchanger may further include a linking member disposed between the inlets of the internal flow paths of the two adjacent heat exchanger tubes or between the outlets of the internal flow paths of the two adjacent heat exchanger tubes; the linking member may be a flat ring-shaped member; and the thickness of the linking member may be continuously increased from the upstream side of the external flow path toward its downstream side. By using the linking member, the heat exchanger in the eleventh aspect can be easily implemented.

[0029] In a thirteenth aspect, for example, the linking member in the heat exchanger in the twelfth aspect may have a wedge-shaped cross section. By using the linking member shaped like this, the heat exchanger in the eleventh aspect can be easily implemented.

[0030] In a fourteenth aspect, for example, if a linking plane between the linking member and one of two adjacent heat exchanger tubes, in the heat exchanger according to the twelfth or thirteenth aspect, between which the linking member is placed is defined as a first linking plane and a linking plane between the linking member and the other of the two adjacent heat exchanger tubes is defined as a second linking plane, the first linking plane may be inclined with respect to the second linking plane. An angle formed by the first linking plane and second surface can be determined by the linking member. That is, the extent of the external flow path can be adjusted by the linking member.

[0031] In a fifteenth aspect, the linking member in any one of the twelfth to fourteenth aspects may have a plate-like protrusion that protrudes toward the downstream side of the external flow path. With the linking member structured in this way, the protrusion functions as a partition that divides the external flow path. Since the flow of the second fluid is corrected so that the flow proceeds along the surfaces of the heat exchanger tube, the effective heat transfer area is expanded. The protrusion itself functions as a fin and contributes to the expansion of the heat transfer surfaces, heat exchanging performance is further improved.

[0032] In a sixteenth aspect, for example, a laminated body formed with a plurality of linking members may be placed between two adjacent heat exchanger tubes in any one of the twelfth to fifteenth aspects. When more linking members are used, the external flow path can be more expanded. That is, the heat exchanger can be designed with increased freedom.

[0033] In a seventeenth aspect, for example, if the linking member of the heat exchanger according to any one of the twelfth to fifteenth aspects is defined as a first linking member, the heat exchanger may further include a second linking member that has a different shape from the first linking member. According to the seventeenth aspect, the extent of the external flow path can be freely adjusted.

[0034] In an eighteenth aspect, for example, the internal flow path of the heat exchanger in any one of the first to seventeenth aspects may include a plurality of segments extending in a particular row direction of the heat exchanger tube and may be a meandering flow path in which the flow direction of the first fluid is reversed at intermediate points between the inlet and the outlet. In the meandering flow path, a temperature gradient is created on the surfaces of the heat exchanger tube from the upstream end of the external flow path to its downstream end. Thus, it is possible to flow the first fluid and second fluid so as to face each other spuriously, so improved temperature efficiency of the heat exchanger and accompanying improved heat exchange efficiency can be expected.

[0035] In a nineteenth aspect, for example, the heat exchanger tube in the heat exchanger according to one of the first to eighteenth aspect may further have a hindering structure, disposed between each two adjacent segments, that hinders heat transfer between the two adjacent segments. According to the nineteenth aspect, the temperature gradient on the surfaces of the heat exchanger tube is increased in the flow direction of the second fluid, so temperature efficiency and heat exchange efficiency of the heat exchanger are further improved.

[0036] A heat exchanging unit according to a twentieth aspect of the present disclosure includes a blower that has a rotational axis and an impeller secured to the rotational axis, the blower delivering a second fluid in the circumferential direction of the rotational axis due to rotation of the impeller, and heat exchangers described in any one of the first to nineteenth aspects, the heat exchangers being disposed around the blower in a plane perpendicular to the rotational axis; each of the plurality of external flow paths is disposed so that the downstream end of the external flow path is at a more forward position in the rotational direction of the rotational axis than the upstream end of the external flow path when viewed from the rotational axis. According to the twentieth aspect, the heat exchanger tubes can be optimally placed with respect to a spiral flow coming from a centrifugal blower. This reduces a pressure loss and improves heat exchange efficiency. The twentieth aspect is suitable to a ceiling cassette type of indoor unit.

[0037] A heat exchanger according to a twenty-first aspect of the present disclosure is a heat exchanger used in a heat exchanging unit that includes a blower that has a rotational axis and an impeller secured to the rotational axis, the blower delivering a second fluid in the circumferential direction of the rotational axis due to rotation of the impeller, and heat exchangers disposed around the blower in a plane perpendicular to the rotational axis; the heat exchanger includes a plurality of flat heat exchanger tubes, each of which has an internal flow path through which a first fluid flows, and a plurality of external flow paths, each of which is disposed between each two adjacent heat exchanger tubes, and through each of which a second fluid that exchanges heat with the first fluid flows; the heat exchanger tube includes a first plate member and a second plate member, which are bonded together; the first plate member has a first inlet bonding portion positioned on a first main plane, which is an external surface of the first plate member, and a first outlet bonding portion positioned on the first main plane; the second plate member has a second inlet bonding portion positioned on a second main plane, which is an external surface of the second plate member, and a second outlet bonding portion positioned on the second main plane; each two heat exchanger tubes are bonded together by bonding the first inlet bonding portion of one of these heat exchanger tubes to the second inlet bonding portion of the other heat exchanger tube and bonding the first outlet bonding portion of the one heat exchanger tube to the second outlet bonding portion of the other heat exchanger tube; each of the plurality of external flow paths is disposed so that the downstream end of the external flow path is at a more forward position in the rotational direction of the rotational axis than the upstream end of the external flow path when viewed from the rotational axis; the first inlet bonding portion is disposed upstream of the second inlet bonding portion in the external flow path when viewed from the thickness direction of the heat exchanger tube; the first outlet bonding portion is disposed upstream of the second outlet bonding portion in the external flow path when viewed from the thickness direction of the heat exchanger tube.

[0038] A heat exchanger according to a twenty-second aspect of the present disclosure according to the present disclosure is a heat exchanger used in a heat exchanging unit that includes a blower that has a rotational axis and an impeller secured to the rotational axis, the blower delivering a second fluid in the circumferential direction of the rotational axis due to rotation of the impeller, and heat exchangers disposed around the blower in a plane perpendicular to the rotational axis; the heat exchanger includes a plurality of flat heat exchanger tubes, each of which has an internal flow path through which a first fluid flows, and a plurality of external flow paths, each of which is disposed between each two adjacent heat exchanger tubes, and through each of which a second fluid that exchanges heat with the first fluid flows; the heat exchanger tube includes a first plate member and a second plate member, which are bonded together; the first plate member has a first inlet bonding portion positioned on a first main plane, which is an external surface of the first plate member, and a first outlet bonding portion positioned on the first main plane; the second plate member has a second inlet bonding portion positioned on a second main plane, which is an external surface of the second plate member, and a second outlet bonding portion positioned on the second main plane; each two heat exchanger tubes are bonded together by bonding the first inlet bonding portion of one of these heat exchanger tubes to the second inlet bonding portion of the other heat exchanger tube and bonding the first outlet bonding portion of the one heat exchanger tube to the second outlet bonding portion of the other heat exchanger tube; each of the plurality of external flow paths is disposed so that the downstream end of the external flow path is at a more forward position in the rotational direction of the rotational axis than the upstream end of the external flow path when viewed from the rotational axis; a bonding plane on which the first inlet bonding portion and second inlet bonding portion are bonded together is inclined with respect to a plane on which the heat exchanger tubes are present; a bonding plane on which the first outlet bonding portion and second outlet bonding portion are bonded together is inclined with respect to the plane on which the heat exchanger tube is present; the axis of the first inlet bonding portion and the axis of the second inlet bonding portion are inclined with respect to the thickness direction of the plurality of heat exchange tubes; the axis of the first outlet bonding portion and the axis of the second outlet bonding portion are inclined with respect to the thickness direction of the plurality of heat exchange tubes.

[0039] A heat exchanger according to a twenty-third aspect of the present disclosure is a heat exchanger used in a heat exchanging unit that includes a blower that has a rotational axis and an impeller secured to the rotational axis, the blower delivering a second fluid in the circumferential direction of the rotational axis due to rotation of the impeller, and heat exchangers disposed around the blower in a plane perpendicular to the rotational axis; the heat exchanger includes a plurality of flat heat exchanger tubes, each of which has an internal flow path through which a first fluid flows, and a plurality of external flow paths, each of which is disposed between each two adjacent heat exchanger tubes, and through each of which a second fluid that exchanges heat with the first fluid flows; the heat exchanger tube includes a first plate member and a second plate member, which are bonded together; the first plate member has a first inlet bonding portion positioned on a first main plane, which is an external surface of the first plate member, and a first outlet bonding portion positioned on the first main plane; the second plate member has a second inlet bonding portion positioned on a second main plane, which is an external surface of the second plate member, and a second outlet bonding portion positioned on the second main plane; each two heat exchanger tubes are bonded together by bonding the first inlet bonding portion of one of these heat exchanger tubes to the second inlet bonding portion of the other heat exchanger tube and bonding the first outlet bonding portion of the one heat exchanger tube to the second outlet bonding portion of the other heat exchanger tube; the plurality of external flow paths extend radially.

[0040] In a twenty-fourth aspect, each of the plurality of external flow paths in the heat exchanger according to the twenty-third aspect is disposed so that the downstream end of the external flow path is at a more forward position in the rotational direction of the rotational axis than the upstream end of the external flow path when viewed from the rotational axis; the plurality of heat exchanger tubes are arranged in a fan shape.

[0041] Embodiments of the present disclosure will be described below with reference to the drawings. However, the present disclosure is not limited to the embodiments below.

First embodiment

[0042] As illustrated in Fig. 1, a heat exchanger 1 according to a first embodiment of the present disclosure includes a plurality of flat heat exchanger tubes 2, an inlet header 10A, and an outlet header 10B. Each of the plurality of heat exchanger tubes 2 has a rectangular shape in a plan view. A first fluid (coolant, for example) flows in the plurality of heat exchanger tubes 2. The plurality of heat exchanger tubes 2 are arranged so that flow paths of a second fluid (air, for example) that exchanges heat with the first fluid are externally formed. Specifically, one flow path of the second fluid is formed between each two adjacent heat exchanger tubes 2. The inlet header 10A and outlet header 10B are attached to a heat exchanger tube 2 that forms an end face of the heat exchanger 1 in an arrangement direction in which the heat exchanger tubes 2 are arranged.

[0043] As illustrated in Figs. 2A to 2C, the heat exchanger tube 2 has an internal flow path 3, through which the first fluid flows. The inlet header 10A is a tube through which the first fluid is supplied to the inlet 3a of the internal flow path 3. The outlet header 10B is a tube through which the first fluid is discharged from the outlet 3b of the internal flow path 3. The inlet header 10A and outlet header 10B can be connected to an external device (not illustrated).

[0044] As indicated by the arrow A in Fig. 1, the first fluid is supplied from the inlet header 10A into the internal flow paths 3 of the heat exchanger tubes 2. After the first fluid has passed through the internal flow paths 3 and has exchanged heat with the second fluid, the first fluid is discharged from the outlet header 10B into the external device, as indicated by the arrow B in Fig. 1. The second fluid flow passes through spaces (a plurality of external flow paths 8), each of which is formed between each two adjacent heat exchanger tubes 2, in a direction parallel to the width direction of the heat exchanger tubes 2, as illustrated by the arrow C in Fig. 1. The width direction of the heat exchanger tube 2 is perpendicular to both the arrangement direction of the plurality of heat exchanger tubes 2 and the longitudinal direction of the heat exchanger tubes 2.

[0045] In Fig. 1, the width direction of the heat exchanger tube 2 corresponds to the X direction, the arrangement direction of the plurality of heat exchanger tubes 2 corresponds to the Y direction, and the longitudinal direction of the heat exchanger tube 2 corresponds to the Z axis. In this description, the arrangement direction (lamination direction) of the heat exchanger tubes 2 is parallel to the thickness direction of the heat exchanger tube 2. Basically, the second fluid flows in parallel to the width direction (X direction) of the heat exchanger tube 2.

[0046] The heat exchanger tube 2 is formed with one set of a first plate member 11 and a second plate member 12, which are bonded together. At least one of the one set of the plate members 11 and 12 has a recess that forms the internal flow path 3. Specifically, the heat exchanger tube 2 is formed with the first plate member 11 and second plate member 12. The first plate member 11 and second plate member 12 each have a recess that forms the internal flow path 3. The internal flow path 3 is formed by bonding the first plate member 11 and second plate member 12 together. With this structure, the heat exchanger tube 2 can be thinned, which is advantageous in that the heat exchanger 1 can be made compact. Since the heat exchanger tube 2 is formed by bonding the first plate member 11 and second plate member 12 together, it is relatively easy to use a jig and perform brazing.

[0047] The plate members 11 and 12 are made of aluminum, an aluminum alloy, stainless steel, or another metal. The plate members 11 and 12 are obtained by stamping a metal plate so that a desired shape is formed. The plate members 11 and 12 are bonded together by, for example, brazing. As the material of the plate members 11 and 12, a cladding material having a heartwood and at least one brazing layer can be used.

[0048] The heat exchanger 1 in this embodiment is formed only with a plurality of heat exchanger tubes 2, except the inlet header 10A and outlet header 10B. The heat exchanger tube 2 is a simple part formed with one set of the plate members 11 and 12. Stamping to obtain the plate members 11 and 12 is also easy. The heat exchanger 1 is advantageous in that, for example, it can be easily manufactured and condensed water is less likely to stay on the surface of the heat exchanger 1 when compared with a fin-tube heat exchanger.

[0049] As illustrated in Figs. 2A to 2C, each two adjacent heat exchanger tubes 2 are bonded together at the inlets 3a and outlets 3b of the internal flow paths 3 in the two heat exchanger tubes 2. One of each two adjacent heat exchanger tubes 2 is offset with respect to the other heat exchanger tube in a direction (X direction) perpendicular to the arrangement direction of the plurality of heat exchanger tubes 2. Specifically, the plurality of heat exchanger tubes 2 are mutually offset in their width direction. Thus, a structure is formed that is stepped from one end in the arrangement direction (Y direction) of the plurality of heat exchanger tubes 2 toward the other end.

[0050] As illustrated in Fig. 2C, the inlet plane 14 of the heat exchangers 1 is inclined with respect to the arrangement direction (Y direction) of the plurality of heat exchanger tubes 2. The inlet plane 14 is a plane that includes the front edges 2f of the plurality of heat exchanger tubes 2. The external shape of the heat exchanger 1 is a parallelogram when the heat exchanger 1 is viewed in a plan view from a direction (Z direction) parallel to the longitudinal direction of the heat exchanger tube 2. The heat exchanger 1 having this structure is beneficial as described below. The front edge 2f of the heat exchanger tube 2 is an edge, of the heat exchanger tube 2, that is positioned on the upstream side of an external flow path 8 in the flow direction of the second fluid.

[0051] As illustrated in Fig. 3A, a conventional heat exchanging unit 104 includes a plurality of heat exchangers 101 (see Fig. 13) and a blower 16. The plurality of heat exchangers 101 are placed around the blower 16. However, most of the second fluid is supplied into the inlet plane 102 of the heat exchangers 101 from an oblique direction. The second fluid flows into the external flow paths of the heat exchanger 101 while changing the flow direction. In this case, the second fluid is likely to cause flow separation and produce a large pressure loss. As a result, the performance of the heat exchanger 101 can be fully derived. In view of a space allowed for the heat exchanging unit 104, a capacity demanded for the heat exchanging unit 104, and the like, it is not easy to change the position, size, orientation, and other parameters of the heat exchanger 101.

[0052] As illustrated in Fig. 3B, a heat exchanging unit 200 according to this embodiment includes a plurality of heat exchangers 1 and the blower 16. The blower 16 is, for example, a centrifugal blower. The blower 16 includes a rotational axis and an impeller secured to the rotational axis. The blower 16 delivers the second fluid in the circumferential direction of the rotational axis due to rotation of the impeller. In other words, the blower 16 delivers the second fluid toward the circumferential direction of a virtual circle tangent to the outer edge of the impeller when the rotation of the impeller is viewed from the axial direction of the rotational axis. The plurality of heat exchangers 1 are disposed around the blower 16 in a plane perpendicular to the rotational axis of the blower 16. The external flow paths 8 (indicated by oblique lines) on the heat exchanger 1 extend in an oblique direction with respect to the inlet plane 14 of the heat exchangers 1. Each of the plurality of external flow paths 8 is disposed so that the downstream end of the external flow path 8 is at a more forward position in the rotational direction of the rotational axis than the upstream end of the external flow path 8 when viewed from the rotational axis of the blower 16. The flow direction of the second fluid in the external flow path 8 on the heat exchanger 1 is substantially parallel to the inflow direction in which the second fluid flows into the heat exchanger 1. That is, with the heat exchanger 1, it is possible to align the inflow direction of the second fluid with the flow direction of the second fluid in the external flow paths 8 or to narrow an angle formed by these directions. The flow direction of the second fluid does not much change at positions before and after the inlet plane 14 of the heat exchangers 1. In this case, the flow separation of the second fluid is suppressed and a large pressure loss is hard to occur when compared with the heat exchanging unit 104 in which the conventional heat exchangers 101 are used. Accordingly, the performance of the heat exchanger 1 can be fully derived. In addition, a large design change for a case used to secure the heat exchangers1 is not demanded.

[0053] The structure of the heat exchanger 1 will be described below in detail.

[0054] The external surface of the first plate member 11 will be defined as a first main plane 11 p and the external surface of the second plate member 12 will be defined as a second main plane 12p, as illustrated in Figs. 2A to 2C. The inlet 3a and outlet 3b of the internal flow path 3 are open in both the first main plane 11 p and second main plane 12p. The inlet 3a is positioned at one end of the longitudinal direction of the heat exchanger tube 2, and the outlet 3b is positioned at the other end. The first plate member 11 has a first inlet bonding portion 4 and a first outlet bonding portion 5. The first inlet bonding portion 4 is formed on the first main plane 11 p as a portion at which two adjacent heat exchanger tubes 2 are bonded together at the inlets 3a of their internal flow paths 3. The first outlet bonding portion 5 is formed on the first main plane 11 p as a portion at which the two adjacent heat exchanger tubes 2 are bonded together at the outlets 3b of their internal flow paths 3. The second plate member 12 has a second inlet bonding portion 6 and a second outlet bonding portion 7. The second inlet bonding portion 6 is formed on the second main plane 12p as a portion at which the two adjacent heat exchanger tubes 2 are bonded together at the inlets 3a of their internal flow paths 3. The second outlet bonding portion 7 is formed on the second main plane 12p as a portion at which the two adjacent heat exchanger tubes 2 are bonded together at the outlets 3b of their internal flow paths 3. Since the two adjacent heat exchanger tubes 2 are bonded together by the bonding portions 4 to 7 formed in the plate members 11 and 12, special bonding parts are not needed. Parts needed to manufacture the heat exchanger 1 are only the plate members 11 and 12. Therefore, since the number of parts is reduced, cost reduction and a simplified manufacturing process can be expected.

[0055] The inlet bonding portions 4 and 6 are each a ring-shaped protrusion that slightly protrudes around the inlet 3a of the internal flow path 3 in the thickness direction of the heat exchanger tube 2. The outlet bonding portions 5 and 7 are each a ring-shaped protrusion that slightly protrudes around the outlet 3b of the internal flow path 3 in the thickness direction of the heat exchanger tube 2. The first inlet bonding portions 4 and first outlet bonding portion 5 are located at positions relatively close to the front edge 2f of the heat exchanger tubes 2. The second bonding portions 6 and second outlet bonding portion 7 are located at positions relatively distant from the front edge 2f of the heat exchanger tubes 2. The first inlet bonding portion 4 is bonded to the second inlet bonding portion 6 of the adjacent heat exchanger tube 2. The first outlet bonding portion 5 is bonded to the second outlet bonding portion 7 of the adjacent heat exchanger tube 2. Thus, the plurality of heat exchanger tubes 2 can be mutually offset in their width direction. The bonding portions 4 to 7 can be used not only to form an offset structure of the plurality of heat exchanger tubes 2 but also to determine the extent of the external flow path 8.

[0056] In this embodiment, the first inlet bonding portion 4 is bonded directly to the second inlet bonding portion 6 of the adjacent heat exchanger tube 2 and the first outlet bonding portion 5 is bonded directly to the second outlet bonding portion 7 of the adjacent heat exchanger tube 2. Therefore, the internal flow paths 3 of each two adjacent heat exchanger tubes 2 communicate with each other. However, a linking member may be provided between the bonding portions 4 and 6 and they may be bonded indirectly, as in a third embodiment described later. When the linking member is used, the extent of the external flow path 8 can be determined by the linking member, so the bonding portions 4 and 6 can be eliminated. This is also true for the bonding portions 5 and 7.

[0057] The amount of offset between two adjacent heat exchanger tubes 2 is equal the amount of offset between the first inlet bonding portion 4 and second inlet bonding portion 6. The inclination angle of the inlet plane 14 of the heat exchangers 1 with respect to the width direction of the heat exchanger tube 2 can be adjusted by adjusting the amount of offset. In this embodiment, the amount of offset is constant. However, this is not a requisite. For example, the amount of offset between two adjacent heat exchanger tubes 2 may differ from the amount of offset between another two adjacent heat exchanger tubes 2. In this embodiment, all heat exchanger tubes 2 have the same structure, so each heat exchanger tube 2 is offset from its adjacent heat exchanger tube 2. However, a non-offset structure may be partially included as in a fifth embodiment described later.

[0058] The first plate member 11 may have the same shape as the second plate member 12. When the bonding portions 4 and 5 are formed at positions offset from the center in the width direction, the heat exchanger tube 2 illustrated in Figs. 2A to 2C can be manufactured by bonding two first bonding members 11. Then, since the number of parts is reduced, cost reduction can be expected.

[0059] Some variations of the heat exchanger 1 will be described below. Elements common to the heat exchanger 1 illustrated in Figs. 2A to 2C and these variations are assigned the same reference characters, and descriptions of these common elements may be some-times omitted. That is, the description for the heat exchanger 1 can also be applied to the variations below as long as the description has no technical contradiction.

First variation

[0060] In a heat exchanger 1A according to a first variation, a plurality of heat exchanger tubes include a plurality of first heat exchanger tubes 2A and a plurality of second heat exchanger tubes 2B, as illustrated in Fig. 4A. The first heat exchanger tube 2A has a different structure from the second heat exchanger tube 2B. The first heat exchanger tube 2A and second heat exchanger tube 2B are adjacent to each other in the arrangement direction. Specifically, the first heat exchanger tubes 2A and second heat exchanger tubes 2B are alternately placed in the arrangement direction. If the first heat exchanger tubes 2A and second heat exchanger tubes 2B are used in combination, even in a case in which the amount of offset, the extent of the external flow path 8, and other dimensions are severely restricted, the inclination angle of the inlet plane 14 of the heat exchangers 1A can be easily adjusted to an optimum angle. That is, in this variation, the heat exchanger 1A can be designed with increased freedom.

[0061] The first heat exchanger tube 2A is the same as the heat exchanger tube 2, which has been described with reference to Figs. 2A to 2C. Therefore, the description of the first heat exchanger tube 2A will be omitted.

[0062] As illustrated in Figs. 4B and 4C, the second heat exchanger tube 2B includes a third plate member 17 and a fourth plate member 18, which are bonded together. The external surface of the third plate member 17 will be defined as a third main plane 17p and the external surface of the fourth plate member 18 will be defined as a fourth main plane 18p. The inlet 3a and outlet 3b of the internal flow path 3 are open in both the third main plane 17p and fourth main plane 18p. The third plate member 17 has a third inlet bonding portion 24 and a third outlet bonding portion 25. The third inlet bonding portion 24 and third outlet bonding portion 25 are each formed on the third main plane 17p as a portion at which two adjacent heat exchanger tubes 2 (first heat exchanger tube 2A and second heat exchanger tube 2B) are bonded together. The fourth plate member 18 has a fourth inlet bonding portion 26 and a fourth outlet bonding portion 27. The fourth inlet bonding portion 26 and fourth outlet bonding portion 27 are each formed on the fourth main plane 18p as a portion at which two adjacent heat exchanger tubes 2 (first heat exchanger tube 2A and second heat exchanger tube 2B) are bonded together.

[0063] The inlet bonding portions 24 and 26 are each a ring-shaped protrusion that slightly protrudes around the inlet 3a of the internal flow path 3 in the thickness direction of the heat exchanger tube 2B. The output bonding portions 25 and 27 are each a ring-shaped protrusion that slightly protrudes around the outlet 3b of the internal flow path 3 in the thickness direction of the heat exchanger tube 2B. In a plane perpendicular to the arrangement direction (Y direction) of the plurality of heat exchanger tubes 2A and 2B, the position of the third inlet bonding portion 24 matches the position of the fourth inlet bonding portion 26 and the position of the third outlet bonding portion 25 matches the position of the fourth outlet bonding portion 27. In other words, when the bonding portions 24 to 27 are projected to a plane perpendicular to the thickness direction of the heat exchanger tube 2B, the projected image of the third inlet bonding portion 24 matches the projected image of the fourth inlet bonding portion 26, and the projected image of the third outlet bonding portion 25 matches the projected image of the fourth outlet bonding portion 27. The bonding portions 24 to 27 can be used not only to form an offset structure of the plurality of heat exchanger tubes 2A and 2B but also to determine the extent of the external flow path 8.

[0064] In this variation, the third plate member 17 has the same shape as the fourth plate member 18. When the front and back of the third plate member 17 is reversed, the third plate member 17 completely matches the fourth plate member 18. In this case, since the number of parts is reduced, cost reduction can be expected.

[0065] If the first plate member 11 has a different structure from the second plate member 12, at least one of the third plate member 17 and fourth plate member 18 may have the same shape as the first plate member 11 or second plate member 12. In this case as well, since the number of parts is reduced, cost reduction can be expected.

Second variation

[0066] A heat exchanger 1 C according to a second variation is formed with a plurality of heat exchanger tubes 2C as illustrated in Figs. 5A and 5B. Each heat exchanger tube 2C includes a first plate member 21 and a second plate member 22, which are bonded together. The external surface of the first plate member 21 will be defined as a first main plane 21 p and the external surface of the second plate member 22 will be defined as a second main plane 22p. The first plate member 21 has a first inlet bonding portion 34 and a first outlet bonding portion 35. The first inlet bonding portion 34 and first outlet bonding portion 35 are each formed on the first main plane 21 p as a portion at which two adjacent heat exchanger tubes 2C are bonded together. The second plate member 22 has a second inlet bonding portion 36 and a second outlet bonding portion 37. The second inlet bonding portion 36 and second outlet bonding portion 37 are each formed on the second main plane 22p as a portion at which two adjacent heat exchanger tubes 2C are bonded together.

[0067] The inlet bonding portions 34 and 36 are each a ring-shaped protrusion that slightly protrudes around the inlet 3a of the internal flow path 3 in the thickness direction of the heat exchanger tube 2C. The bonding portions 35 and 37 are each a ring-shaped protrusion that slightly protrudes around the outlet 3b of the internal flow path 3 in the thickness direction of the heat exchanger tube 2C. However, the heights of the protrusions of the bonding portions 34 to 37 are continuously increased or decreased in the width direction of the heat exchanger tube 2C. A bonding plane 38 is formed between the first inlet bonding portion 34 of a heat exchanger tube 2C and the second inlet bonding portion 36 of the adjacent heat exchanger tube 2C. A bonding plane 39 is formed between the first outlet bonding portion 35 of a heat exchanger tube 2C and the second outlet bonding portion 37 of the adjacent heat exchanger tube 2C. The bonding planes 38 and 39 are inclined with respect to a direction perpendicular to the arrangement direction (Y direction) of the plurality of heat exchanger tubes 2C. Specifically, the bonding planes 38 and 39 are ring-shaped in a plan view. The bonding planes 38 and 39 are inclined with respect to the width direction (X direction) of the heat exchanger tube 2C and also inclined with respect to the arrangement direction (Y direction) of the plurality of heat exchanger tubes 2C. The inclination angle of the bonding plane 38 is equal to the inclination angle of the bonding plane 39. The axis C1 of the first outlet bonding portion 35 and the axis C2 of the second outlet bonding portion 37 are perpendicular to the bonding plane 39. Similarly, the axis of the first inlet bonding portion 34 and the axis of the second inlet bonding portion 36 are perpendicular to the bonding plane 38. That is, the axis of each bonding portion is inclined with respect to the arrangement direction (Y direction) of the plurality of heat exchanger tubes 2C and also inclined with respect to the width direction (X direction) of the heat exchanger tube 2C. The axis of each bonding portion is an axis that passes through the center of the bonding portion, which has a cylindrical side surface. The bonding portions 34 to 37 enable the plurality of heat exchanger tubes 2C to be mutually offset in their width direction. The bonding portions 34 to 37 have the role of forming an offset structure of the plurality of heat exchanger tubes 2C and the role of determining the extent of the external flow path 8. The inclination angle of the inlet plane 14 of the heat exchangers 1C with respect to the width direction of the heat exchanger tube 2C (X direction) can be adjusted by adjusting amounts by which the bonding portions 34 to 37 protrude. In this variation, the inclination angle of the inlet plane 14 can be adjusted without restrictions on a pitch at which heat exchanger tubes 2C are stacked, an amount by which they are offset, and other parameters.

[0068] In this variation as well, the first plate member 21 may have the same structure as the second plate member 22.

Third variation

[0069] In a heat exchanger tube 2D in a heat exchanger 1 D according to a third variation, the internal flow path 3 is meandering, as illustrated in Figs. 6A and 6B. In the heat exchanger tubes 2, 2A, 2B, and 2C, which have been described above, as well, the internal flow path 3 may be meandering.

[0070] In this variation, the heat exchanger tube 2D is formed with a first plate member 41 and a second plate member 42, which are bonded together so that the internal flow path 3 is formed. The internal flow path 3 is a meandering flow path in which the flow direction of the first fluid is reversed at intermediate points between the inlet 3a and the outlet 3b. In this variation, the flow direction of the first fluid is reversed a plurality of times (twice). The internal flow path 3 includes an odd number of segments extending in a row direction parallel to the longitudinal direction of the heat exchanger tube 2D. In this variation, the internal flow path 3 has three segments, which are mutually parallel. With this structure, the inner diameters of the inlet header 10A and outlet header 10B can be enlarged, so a pressure loss in the inlet header 10A and outlet header 10B can be reduced. In addition, since the length of the heat exchanger tube 2D can be shortened in its width direction, the heat exchanger 1 D can be made compact.

[0071] As illustrated in Figs. 6A and 6B, the internal flow path 3 has a plurality of segments extending in a particular row direction of the heat exchanger tube 2D. Specifically, the internal flow path 3 has a first segment 51, a second segment 52, a third segment 53, a first bent segment 54, a second bent segment 55, an upstream-end segment 56, and a downstream-end segment 57. The heat exchanger tube 2D includes a plurality of flow path forming portions 46, 47, and 48, which protrude on both sides of the heat exchanger tube 2D in its thickness direction and respectively form the segments 51, 52, and 53 of the internal flow path 3. The plurality of flow path forming portions 46, 47, and 48 include a first flow path forming portion 46, a second flow path forming portion 47, and a third flow path forming portion 48. The first segment 51 extends from the inlet 3a along the longitudinal direction of the heat exchanger tube 2D. The second segment 52 extends so that the first fluid flows in a direction opposite to the direction in which the first fluid flows in the first segment 51. The third segment 53 extends so that the first fluid flows in a direction opposite to the direction in which the first fluid flows in the second segment 52. The first bent segment 54 links the first segment 51 to the second segment 52. The second bent segment 55 links the second segment 52 to the third segment 53. The upstream-end segment 56 is formed upstream of the first segment 51 and around the inlet 3a. The downstream-end segment 57 is formed downstream of the third segment 53 and around the outlet 3b. While meandering, the first fluid flows through the inlet 3a, upstream-end segment 56, first segment 51, first bent segment 54, second segment 52, second bent segment 55, third segment 53, downstream-end segment 57, and outlet 3b in that order.

[0072] The heat exchanger tube 2D has a first thin portion 44 and a second thin portion 45. The first thin portion 44 is positioned between the first flow path forming portion 46 and second flow path forming portion 47, which are adjacent to each other in the width direction of the heat exchanger tube 2D, to separate the first segment 51 and second segment 52 from each other along the row direction. The second thin portion 45 is positioned between the second flow path forming portion 47 and third flow path forming portion 48, which are adjacent to each other in the width direction of the heat exchanger tube 2D, to separate the second segment 52 and third segment 53 from each other along the row direction. The first thin portion 44 and second thin portion 45 are each a bonding portion between the first plate member 41 and the second plate member 42.

[0073] As illustrated in Fig. 6A, in a cross section perpendicular to the longitudinal direction (row direction) of the heat exchanger tube 2D, the flow path forming portions 46 and 47 in one of two adjacent heat exchanger tubes 2D respectively face the thin portions 44 and 45 in the other heat exchanger tube 2D with the external flow path 8 intervening therebetween. Similarly, the flow path forming portions 47 and 48 in the other of the two adjacent heat exchanger tubes 2D respectively face the thin portions 44 and 45 in the one heat exchanger tube 2D with the external flow path 8 intervening therebetween. That is, the plurality of flow path forming portions 46 to 48 in the one heat exchanger tube 2D and the flow path forming portions 46 to 48 in the other heat exchanger tube 2D are placed in a staggered arrangement in the width direction (X direction). With this structure, the extent of the external flow path 8 in the thickness direction of the heat exchanger tube 2D is kept substantially constant in the width direction of the heat exchanger tube 2D (flow direction of the second fluid). As a result, the pressure loss of the second fluid in the external flow path 8 can be reduced. When the heat exchanger tubes 2D are stacked at a small pitch, the heat transfer area per unit volume can be enlarged. In addition, since flow separation of the second fluid on the surfaces of the heat exchanger tube 2D is suppressed, an effective heat transfer area is enlarged.

[0074] The heat exchanger tube 2D further has hindering structures, each of which is disposed between each two adjacent segments to hinder heat transfer between the two adjacent segments (specifically, heat transfer between the first fluid flowing through one of the two segments and the first fluid flowing through the other). Specifically, a plurality of first through-holes 44h are formed in the first thin portion 44 and a plurality of second through-holes 45h are formed in the second thin portion 45. The first through-holes 44h function as a hindering structure that hinders heat transfer between the first segment 51 and the second segment 52. The second through-holes 45h function as a hindering structure that hinders heat transfer between the second segment 52 and the third segment 53.

[0075] In the meandering internal flow path 3, a temperature gradient is created on the surfaces of the heat exchanger tube 2D from the upstream end of the external flow path 8 to its downstream end. Thus, it is possible to flow the first fluid and second fluid so as to face each other spuriously, so improved temperature efficiency of the heat exchanger 1 D and accompanying improved heat exchange efficiency can be expected. In addition, with the above hindering structures, the temperature gradient on the surfaces of the heat exchanger tube 2D is increased in the width direction of the heat exchanger tube 2D (flow direction of the second fluid), so temperature efficiency and heat exchange efficiency of the heat exchanger 1 D are further improved. When the hindering structures are the through-holes 44h and 45h, each two adjacent segments are space-separated. Therefore, the above heat transfer is reliably hindered.

[0076] In this variation, each first through-hole 44h is a through-hole (specifically, a slit) that passes through the first thin portion 44 in the thickness direction of the first plate member 41 and second plate member 42. The first through-hole 44h is formed at the center of the first thin portion 44 in its width direction and has a rectangular shape in a plan view. Each second through-hole 45h is a through-hole (specifically, a slit) that passes through the second thin portion 45 in the thickness direction of the first plate member 41 and second plate member 42. The second through-hole 45h is formed at the center of the second thin portion 45 in its width direction and has a rectangular shape in a plan view. The plurality of first through-holes 44h are spaced at a prescribed interval in the longitudinal direction of the first thin portion 44. The plurality of second through-holes 45h are spaced at a prescribed interval in the longitudinal direction of the second thin portion 45.

[0077] In arbitrary cross sections, of the first plate member 41 and second plate member 42, perpendicular to their thickness direction, the cross-sectional area (total cross-sectional area) of the first through-hole 44h is larger than half the cross-sectional area of the first thin portion 44. The length L1 of the first through-hole 44h in its longitudinal direction is longer than an interval L2 between each two adjacent first through-holes 44h. In arbitrary cross sections, of the first plate member 41 and second plate member 42, perpendicular to their thickness direction, the cross-sectional area of the second through-hole 45h is larger than half the cross-sectional area of the second thin portion 45. The length L3 of the second through-hole 45h in its longitudinal direction is longer than an interval L4 between each two adjacent second through-holes 45h. The length L3 of the second through-hole 45h in its longitudinal direction is equal to the length L1 of the first through-hole 44h in its longitudinal direction. The interval L4 between each two adjacent second through-holes 45h is equal to the interval L2 between each two adjacent first through-holes 44h. With this structure, heat transfer between the first fluid flowing through the first segment 51 and the first fluid flowing through the second segment 52 can be hindered efficiently and reliably and heat transfer between the second segment 52, and the third segment 53 can be hindered efficiently and reliably.

[0078] There are no particular limitations to the shapes, placements, quantities, cross-sectional areas, and other parameters of the through-holes 44h and 45h. For example, the shape of the first through-hole 44h may be circular, polygonal, elliptical, or the like. Only one first through-hole 44h may be formed in the first thin portion 44. If, however, a plurality of first through-holes 44h are formed in the first thin portion 44 at a prescribed interval as in this variation, heat transfer between the first segment 51 and the second segment 52 can be efficiently hindered while a drop in the strength of the first thin portion 44 is suppressed. This is also true for the second through-hole 45h.

[0079] The heat exchanger tube 2D further includes an upstream-end thin portion 63, which separates the second bent segment 55 and upstream-end segment 56 from each other, and a third through-hole 63h formed in the upstream-end thin portion 63. The upstream-end thin portion 63 is formed when the first plate member 41 and second plate member 42 are bonded together. The third through-hole 63h functions as an upstream hindering structure that hinders heat transfer between the second bent segment 55 and the upstream-end segment 56. In the upstream-end thin portion 63, the third through-hole 63h is formed closest to the inlet 3a. The third through-hole 63h is a through-hole (specifically, a slit) that passes through the upstream-end thin portion 63 in the thickness direction of the first plate member 41 and second plate member 42. The third through-hole 63h is formed at the center of the upstream-end thin portion 63 and has a rectangular shape in a plan view. With this structure, heat transfer between the second bent segment 55 and the upstream-end segment 56 can be hindered efficiently and reliably.

[0080] The heat exchanger tube 2D further includes a down-end thin portion 65, which separates the first bent segment 54 and downstream-end segment 57 from each other, and a fourth through-hole 65h formed in the down-end thin portion 65. The down-end thin portion 65 is formed when the first plate member 41 and second plate member 42 are bonded together. The fourth through-hole 65h functions as a downstream hindering structure that hinders heat transfer between the first bent segment 54 and the downstream-end segment 57. In the down-end thin portion 65, the fourth through-hole 65h is formed closest to the outlet 3b. The fourth through-hole 65h is a through-hole (specifically, a slit) that passes through the down-end thin portion 65 in the thickness direction of the first plate member 41 and second plate member 42. The fourth through-hole 65h is formed at the center of the down-end thin portion 65 and has a rectangular shape in a plan view. With this structure, heat transfer between the first bent segment 54 and the downstream-end segment 57 can be hindered efficiently and reliably. As with the first through-hole 44h, there are no particular limitations to the shapes, placements, quantities, cross-sectional areas, and other parameters of the third through-hole 63h and fourth through-hole 65h.

[0081] The hindering structure that hinders heat transfer is not limited to a though-hole. As the hindering structure that hinders heat transfer, the thin portions 44, 45, 63, and 65 may be made of a material having a relatively low thermal conductivity (for example, a resin) and portions other than the thin portions 44, 45, 63, and 65 may be made of a material having a relatively high thermal conductivity (for example, a metal).

[0082] As illustrated in Fig. 6A, in a cross section perpendicular to the row direction, part or the whole of the surfaces of the flow path forming portions 46 to 48 extend from the thin portions 44 and 45 toward a direction inclined with respect to both the thickness direction and width direction of the heat exchanger tube 2D. With this structure, when the second fluid flows through the external flow path 8, it is possible to suppress separation of the second fluid on the surfaces of the flow path forming portions 46 to 48. Therefore, heat transfer efficiency of the heat exchanger 1 D is further improved.

[0083] In this variation, only one type of heat exchanger tube 2D is used. Therefore, cost reduction and a simplified manufacturing process can be expected. However, a plurality of types of heat exchanger tubes having different structures may be used.

Fourth variation

[0084] The number of segments in the internal flow path 3 is not limited to 3. As illustrated in Fig. 7A, a heat exchanger tube 2E used in a heat exchanger 1 E according to a fourth variation differs from the heat exchanger tube 2D used in the heat exchanger 1 D in the third variation in that five segments are included in the internal flow path 3.

Fifth variation

[0085] It is not a necessity that each heat exchanger tube is offset from its adjacent heat exchanger tube in its width direction. As illustrated in Fig. 7B, a heat exchanger tube 1 F according to a fifth variation is formed with a plurality of heat exchanger tube groups 20. Two adjacent heat exchanger tube groups 20 are offset from each other in their width direction (X direction). The heat exchanger tube group 20 is formed with a plurality of heat exchanger tubes 2D and 2F. Specifically, the heat exchanger tube group 20 includes a heat exchanger tube 2D and heat exchanger tubes 2F. The heat exchanger tube 2D is the heat exchanger tube used in the heat exchanger 1 D in the third variation. The heat exchanger tube 2F is a variation of the heat exchanger tube 2D. In the heat exchanger tube 2F, the inlet bonding portion and outlet bonding portion formed in the first plate member are not respectively offset from the inlet bonding portion and outlet bonding portion formed in the second plate member. In the heat exchanger tube group 20, the heat exchanger tube 2D is not offset from the heat exchanger tube 2F.

When a heat exchanger tube having a plurality of bonding portions that are offset in their width direction and a heat exchanger tube having a plurality of bonding portions that are not offset in their width direction are combined as described above, the inclination angle of the inlet plane 14 (angle at which the second fluid flows into the heat exchanger) can be appropriately adjusted.

Other structures

[0086] The cross section of the internal flow path 3 may have a streamline shape, an aerofoil shape, or another curved shape. All or part of the corners of the cross section of the internal flow path 3 may have a round shape or another curved shape. With this structure, the pressure loss of the second fluid can be reduced and its flow separation can be suppressed.

[0087] At least one end of the heat exchanger tube in its width direction, a plate-like protrusion may be provided that protrudes from a flow path forming portion in the internal flow path 3 in the width direction. This plate-like protrusion restricts the flow direction of the second fluid and suppresses its flow separation. Accordingly, the effective heat transfer area of the heat exchanger tube is enlarged. Since the plate-like protrusion itself plays the role of a fin, the surfaces of the plate-like protrusion increase the entire heat transfer surface. Therefore, the heat exchanger can be made compact by providing a plate-like protrusion in the heat exchanger tube.

[0088] A heat exchanger according to another embodiment will be described below. Elements common to the heat exchanger described in the first embodiment and the heat exchanger in the other embodiment are assigned the same reference characters and descriptions of these common elements may be omitted. That is, the description in the first embodiment can also be applied to the embodiment below as long as the description has no technical contradiction.

Second embodiment

[0089] As illustrated in Fig. 8, a heat exchanger 1 G according to this embodiment includes a plurality of heat exchanger tubes 2G, each of which has the internal flow path 3. The plurality of heat exchanger tubes 2G are arranged so that one flow path 8, through which the second fluid flows, is formed between each two adjacent heat exchanger tubes 2G. In this embodiment, however, the plurality of heat exchanger tubes 2G are not mutually offset. The positions of the plurality of heat exchanger tubes 2G are the same in the longitudinal direction (Z direction) and width direction (X direction). The second embodiment differs from the first embodiment in this point. The second embodiment is the same as in the first embodiment in other points.

[0090] Each heat exchanger tube 2G has a plate-like protrusion 29 at both ends in its width direction (flow direction of the second fluid). Each two adjacent protrusions 29 form an inlet portion 8a and output portion 8b in the external flow path 8. The protrusion 29 contributes to the expansion of the heat transfer area of the heat exchanger tube 2G.

[0091] The inlet portion 8a of the external flow path 8 extends in a direction inclined with respect to the inlet plane 14 of the heat exchangers 1 G so that the flow direction of the second fluid at the inlet portion 8a of the external flow path 8 comes close to a direction parallel to the flow direction of the second fluid in which it flows from the blower 16 (see Fig. 3G) to the heat exchanger 1 G. According to this embodiment, the angle of the protrusion 29 can be adjusted in consideration of an angle at which the second fluid flows into the inlet portion 8a of the external flow path 8. Accordingly, the pressure loss of the second fluid can be reduced and its flow separation can be suppressed.

[0092] In this embodiment, the protrusion 29 is the front edge (or rear edge) of the heat exchanger tube 2G and is inclined with respect to the arrangement direction (Y direction) of the plurality of heat exchanger tubes 2G and the width direction (X direction) of the protrusion 29. With this structure, it is possible to reduce an angle formed by the direction of the inlet portion 8a of the external flow path 8 and the flow direction of the second fluid without a significant design change. As a result, the heat exchanger 1 G with superior performance can be provided with its cost suppressed.

[0093] The protrusion 29 can be formed by bending an end of a plate member that is part of the heat exchanger tube 2G. The inclination angle α of the protrusion 29 with respect to its width direction is constant in the arrangement direction (Y direction) of the heat exchanger tubes 2G. However, it is not a necessity that the inclination angle α is constant. When, for example, the inflow angle at which the second fluid flows into the heat exchanger 1 G is changed, the inclination angle α can be changed according to the inflow angle of the second fluid. That is, in the heat exchanger 1 G, protrusions 29 with different inclination angles α may be formed.

Third embodiment

[0094] As illustrated in Fig. 9, a heat exchanger 1 H according to this embodiment includes a plurality of heat exchanger tubes 2H, each of which has the internal flow path 3. The plurality of heat exchanger tubes 2H are arranged in a fan shape so that one flow path 8 is formed between each two adjacent heat exchanger tubes 2H. The width direction of the heat exchanger tube 2H matches a radial direction of the fan. A plurality of external flow paths 8 extend radially. The second fluid flows from the inner circumference toward the outer circumference.

[0095] As illustrated in Fig. 12, when heat exchangers 204 having external flow paths oriented to a constant direction are placed around the blower 16 (centrifugal blower), a space is left between each two adjacent heat exchangers 204. The heat exchanger 1 H in this embodiment can be placed in this space. Since the external flow paths 8 extend radially, the second fluid expelled from the blower 16 easily flows into the external flow paths 8. This reduces the pressure loss of the second fluid. Furthermore, since flow separation of the second fluid can be suppressed, the effective heat transfer area is expanded.

[0096] As the heat exchanger 204 having external flow paths oriented to a constant direction, a conventional heat exchanger may be used. Alternatively, the heat exchanger described in the first embodiment or second embodiment may be used.

[0097] As illustrated in Figs. 10A to 10C, the heat exchanger 1 H further includes a plurality of linking members 70. In this embodiment, two linking members 70 are placed between each two adjacent heat exchanger tubes 2H. The heat exchanger tube 2H includes one set of plate members 71, which are bonded together. The inlet 3a and outlet 3b of the internal flow path 3 are open in the main planes of the plate members 71. One of the two linking members 70 is placed between the inlets 3a of two adjacent heat exchanger tubes 2H to bond the two heat exchanger tubes 2H together at the inlets 3a of the internal flow paths 3. The other of the two linking members 70 is placed between the outlets 3b of the two adjacent heat exchanger tubes 2H to bond the two heat exchanger tubes 2H together at the outlets 3b of the internal flow paths 3. The internal flow paths 3 in the two adjacent heat exchanger tubes 2H mutually communicate through the linking members 70. The linking member 70 is a flat ring-shaped member. The inner diameter of the linking member 70 is equal to the diameter of the opening at the inlet 3a and outlet 3b of the internal flow path 3. The thickness of the linking member 70 is continuously increased from the upstream side of the external flow path 8 toward its downstream side. By using the linking member 70, the heat exchanger 1 H, which has the structure illustrated in Fig. 9, can be easily implemented.

[0098] As illustrated in Fig. 10B, a linking plane between the linking member 70 and one of two adjacent heat exchanger tubes 2H between which the linking member 70 is placed is defined as a first linking plane 71 p, and a linking plane between the linking member 70 and the other of the two adjacent heat exchanger tubes 2H is defined as a second linking plane 71 q. Then, the first linking plane 71 p is inclined with respect to the second linking plane 71 q. An angle formed by the first linking plane 71 p and second surface 71 q can be determined. That is, the extent of the external flow path 8 can be adjusted by the linking member 70.

[0099] As illustrated in Fig. 10C, the linking member 70 is a circular member having a wedge-shaped cross section. By using the linking member 70 shaped like this, the heat exchanger 1 H, which has the structure illustrated in Fig. 9, can be easily implemented. Since the extent of the external flow path 8 can be determined by the linking member 70, the heat exchanger tube 2H does not need to have an inlet bonding portion and an outlet bonding portion. Of course, the heat exchanger tube 2H may have an inlet bonding portion and outlet bonding portion as described in the first and second embodiments.

[0100] As illustrated in Fig. 10D, a laminated body 170 formed with a plurality of linking members 70 may be placed between two adjacent heat exchanger tubes 2H. For example, the laminated body 170 formed with two linking members 70 can be placed between two heat exchanger tubes 2H. When more linking members 70 are used, the external flow path 8 can be more expanded. That is, the heat exchanger 1 H can be designed with increased freedom.

[0101] As illustrated in Fig. 10E, a plurality of linking members 70 and 72 that have different shapes may be used in the heat exchanger 1 H. Specifically, if the linking member 70, which has been described with reference to Fig. 10C, is defined as a first linking member 70, the heat exchanger 1 H may further include a second linking member 72 that has a different shape from the first linking member 70. In the example in Fig. 10E, the first linking member 70 and second linking member 72 are alternately placed along a circumferential direction. With this structure, the extent of the external flow path 8 can be freely adjusted. A laminated body formed with the first linking member 70 and second linking member 72 may be placed between two adjacent heat exchanger tubes 2H, as described with reference to Fig. 10D.

[0102] With the heat exchanger 1 H in the third embodiment, one of two adjacent heat exchanger tubes 2H may be offset with respect to the other heat exchanger tube 2H in a direction perpendicular to the arrangement direction of a plurality of heat exchanger tubes 2H.

Sixth variation

[0103] A heat exchanger 1J according to a sixth variation includes linking members 73, each of which has a plate-like protrusion 73t, as illustrated in Figs. 11A to 11C. The protrusion 73t protrudes toward the downstream side of the external flow path 8. In other words, the protrusion 73t protrudes toward the outside in a radial direction of the heat exchanger 1J. The heat exchanger 1J in the sixth variation has the same structure as the heat exchanger 1 H in the third embodiment except that the linking member 73 has a different structure.

[0104] Specifically, the linking member 73 has a ring-shaped main body 73s besides the plate-like protrusion 73t. The main body 73s has the same structure as the linking member 70 described in the third embodiment and is placed between the inlets 3a (or outlets 3b) of the internal flow paths 3 of the two adjacent heat exchanger tubes 2H. The protrusion 73t is attached to the outer circumferential surface of the main body 73s; the protrusion 73t has a rectangular shape in a plan view. Specifically, the protrusion 73t is a plate-like portion that is about one-fourth the size of the heat exchanger tube 2H. With the linking member 73 structured in this way, the protrusion

73t functions as a partition that divides the external flow path 8. Since the flow of the second fluid is corrected so that the flow proceeds along the surfaces of a heat exchanger tube 2J, the effective heat transfer area is expanded. The protrusion 73t itself functions as a fin and contributes to the expansion of the heat transfer surfaces, heat exchanging performance is further improved.

[0105] In this variation, only one type of linking member 73 is used. However, the linking member 70 in the third embodiment and the linking member 73 in this variation may be alternately placed along the circumferential direction.

[0106] The technology disclosed in this description is effective for air conditioning apparatuses, cooling apparatuses for computers, household electric appliances, and the like.

Claims

1. A heat exchanger comprising:

   a plurality of heat exchanger tubes, each of which includes a first plate member and a second plate member, a part of the first plate member and a part of the second plate member being bonded together, the first plate member and the second plate member constituting an internal flow path through which a first fluid flows, wherein
   an external flow path is located between each two adjacent heat exchanger tubes,
   a second fluid that flows through the external flow path, and that exchanges heat with the first fluid,
   each two adjacent heat exchanger tubes of the plurality of heat exchanger tubes are bonded together at inlets and outlets in the internal flow paths in the two heat exchanger tubes,
   one of each two adjacent heat exchanger tubes is offset with respect to the other of each two adjacent heat exchanger tube in a direction perpendicular to an arrangement direction in which the plurality of heat exchanger tubes are arranged,
   the first plate member has a first inlet bonding portion positioned on a first main plane, which is an external surface of the first plate member, and a first outlet bonding portion positioned on the first main plane, as portions at which the two adjacent heat exchanger tubes are bonded together,
   the second plate member has a second inlet bonding portion positioned on a second main plane, which is an external surface of the second plate member, and a second outlet bonding portion positioned on the second main plane, as portions at which the two adjacent heat exchanger tubes are bonded together, and
   the first inlet bonding portion and first outlet bonding portion are located at positions relatively close to an edge of each of the plurality of the heat exchanger tubes, and the second inlet bonding portion and second outlet bonding portion are located at positions relatively distant from the edge of each of the plurality of the heat exchanger tubes.

2. The heat exchanger according to Claim 1, wherein:

   the plurality of heat exchanger tubes include a plurality of first heat exchanger tubes and a plurality of second heat exchanger tubes;
   a structure of the first heat exchanger tube differs from a structure of the second heat exchanger tube; and
   the first heat exchanger tube and second heat exchanger tube are adjacent to each other in the arrangement direction.

3. The heat exchanger according to Claim 2, wherein:

   the first heat exchanger tube has a first plate member and a second plate member, which are bonded together;
   the first plate member has a first inlet bonding portion positioned on a first main plane, which is an external surface of the first plate member, and a first outlet bonding portion positioned on the first main plane, as portions at which the heat exchanger tube and an adjacent heat exchanger tube are bonded together;
   the second plate member has a second inlet bonding portion positioned on a second main plane, which is an external surface of the second plate member, and a second outlet bonding portion positioned on the second main plane, as portions at which the heat exchanger tube and an adjacent heat exchanger tube are bonded together;
   the first inlet bonding portion and first outlet bonding portion are located at positions relatively close to an edge of the first heat exchanger tubes, and the second inlet bonding portion and second outlet bonding portion are located at positions relatively distant from the edge of the first heat exchanger tubes;
   the second heat exchanger tube has a third plate member and a fourth plate member, which are bonded together;
   the third plate member has a third inlet bonding portion positioned on a third main plane, which is an external surface of the third plate member, and a third outlet bonding portion positioned on the third main plane, as portions at which the heat exchanger tube and an adjacent heat ex-

changer tube are bonded together;

the fourth plate member has a fourth inlet bonding portion positioned on a fourth main plane, which is an external surface of the fourth plate member, and a fourth outlet bonding portion positioned on the fourth main plane, as portions at which the heat exchanger tube and an adjacent heat exchanger tube are bonded together; and in a plane perpendicular to the arrangement direction of the plurality of heat exchanger tubes, a position of the third inlet bonding portion matches a position of the fourth inlet bonding portion and a position of the third outlet bonding portion matches a position of the fourth outlet bonding portion.

4. The heat exchanger according to Claim 3, wherein the third plate member has the same shape as the fourth plate member.

5. The heat exchanger according to Claim 3 or 4, wherein at least one of the third plate member and fourth plate member has the same shape as the first plate member or second plate member.

6. The heat exchanger according to any one of Claims 1 to 5, wherein:

the internal flow path includes a plurality of segments extending in a particular row direction of the heat exchanger tube;

the heat exchanger tube further includes a plurality of flow path portions, each of which protrudes toward both ends of the heat exchanger tube in a thickness direction of the heat exchanger tube and determines one segment in the internal flow path, and also includes thin portions, each of which is positioned between two flow path portions adjacent in a width direction perpendicular to the row direction and separates two adjacent segments along the internal flow path;

on a cross section perpendicular to the row direction, the flow path portion in one of each two adjacent heat exchanger tubes faces the thin portion of the other of each two adjacent heat exchanger tubes with the external flow path intervening between the flow path portion and the thin portion, and the flow path portion in the other of each two adjacent heat exchanger tubes faces the thin portion of the one of the each two adjacent heat exchanger tubes with the external flow path intervening between the flow path portion and the thin portion; and

the plurality of flow path portions in the one of the two heat exchanger tubes and the plurality of flow path portions in the another of the two heat exchanger tubes are placed in a staggered arrangement in the width direction.

7. A heat exchanging unit comprising:

a blower that has a rotational axis and an impeller secured to the rotational axis, the blower delivering a second fluid in the circumferential direction of the rotational axis due to rotation of the impeller; and

the heat exchanger according to any one of Claims 1 to 6, the heat exchanger being disposed around the blower in a plane perpendicular to the rotational axis; wherein

each of the plurality of external flow paths is disposed so that a downstream end of the external flow path is at a more forward position in the rotational direction of the rotational axis than an upstream end of the external flow path when viewed from the rotational axis.

8. A heat exchanger comprising:

a plurality of heat exchanger tubes, each of which includes a first plate member and a second plate member, a part of the first plate member and a part of the second plate member being bonded together, the first plate member and the second plate member constituting an internal flow path through which a first fluid flows, wherein

an external flow path is located between each two adjacent heat exchanger tubes,

a second fluid that flows through the external flow path, and that exchanges heat with the first fluid,

each two adjacent heat exchanger tubes of the plurality of heat exchanger tubes are bonded together at inlets and outlets in the internal flow paths in the two heat exchanger tubes,

one of each two adjacent heat exchanger tubes is offset with respect to the other of each two adjacent heat exchanger tube in a direction perpendicular to an arrangement direction in which the plurality of heat exchanger tubes are arranged;

the first plate member has a first bonding portion provided on a first main plane, which is an external surface of the first plate member, as a portion at which the two adjacent heat exchanger tubes are bonded together;

the second plate member has a second bonding portion positioned on a second main plane, which is an external surface of the second plate member, as a portion at which the two adjacent heat exchanger tubes are bonded together;

a bonding plane on which the first bonding portion and second bonding portion are bonded together is inclined with respect to a direction per-

pendicular to the arrangement direction of the plurality of heat exchanger tubes; and
an axis of the first bonding portion and an axis of the second bonding portion are inclined with respect to the arrangement direction of the plurality of heat exchanger tubes.

9. The heat exchanger according to Claim 8, wherein:

the internal flow path includes a plurality of segments extending in a particular row direction of the heat exchanger tube;
the heat exchanger tube further includes a plurality of flow path portions, each of which protrudes toward both ends of the heat exchanger tube in a thickness direction of the heat exchanger tube and determines one segment in the internal flow path, and also includes thin portions, each of which is positioned between two flow path portions adjacent in a width direction perpendicular to the row direction and separates two adjacent segments along the internal flow path;
on a cross section perpendicular to the row direction, the flow path portion in one of each two adjacent heat exchanger tubes faces the thin portion of the other of the each two adjacent heat exchanger tubes with the external flow path intervening between the flow path portion and the thin portion, and the flow path portion in the other of each two adjacent heat exchanger tubes faces the thin portion of the one of each two adjacent heat exchanger tubes with the external flow path intervening between the flow path portion and the thin portion; and
the plurality of flow path portions in the one of the two heat exchanger tubes and the plurality of flow path portions in the another of the two heat exchanger tubes are placed in a staggered arrangement in the width direction.

10. A heat exchanging unit comprising:

a blower that has a rotational axis and an impeller secured to the rotational axis, the blower delivering a second fluid in the circumferential direction of the rotational axis due to rotation of the impeller; and
the heat exchanger according to Claim 8 or 9, the heat exchanger being disposed around the blower in a plane perpendicular to the rotational axis; wherein
each of the plurality of external flow paths is disposed so that a downstream end of the external flow path is at a more forward position in the rotational direction of the rotational axis than an upstream end of the external flow path when viewed from the rotational axis.

11. A heat exchanger comprising:

a plurality of heat exchanger tubes, each of which includes a first plate member and a second plate member, a part of the first plate member and a part of the second plate member being bonded together, the first plate member and the second plate member constituting an internal flow path through which a first fluid flows, wherein
an external flow path is located between each two adjacent heat exchanger tubes,
a second fluid that flows through the external flow path, and that exchanges heat with the first fluid,
each two adjacent heat exchanger tubes of the plurality of heat exchanger tubes are bonded together at inlets and outlets in the internal flow paths in the two heat exchanger tubes,
one of each two adjacent heat exchanger tubes is offset with respect to the other of each two adjacent heat exchanger tube in a direction perpendicular to an arrangement direction in which the plurality of heat exchanger tubes are arranged,
the plurality of heat exchanger tubes are arranged in a fan shape, and
the external flow paths extend radially.

12. The heat exchanger according to Claim 11, wherein:

the heat exchanger tube includes one set of plate members that are bonded together;
the inlet and outlet of the internal flow path are open in their main planes;
to mutually bond each two adjacent heat exchanger tubes at the inlets or outlets of the internal flow paths, the heat exchanger further includes a linking member disposed between the inlets of the internal flow paths of each two adjacent heat exchanger tubes or between the outlets of the internal flow paths of each two adjacent heat exchanger tubes;
the linking member is a flat ring-shaped member; and
a thickness of the linking member is continuously increased from an upstream side of the external flow path toward a downstream side of the external flow path.

13. The heat exchanger according to Claim 12, wherein the linking member has a wedge-shaped cross section.

14. The heat exchanger according to Claim 12 or 13, wherein if a linking plane between the linking member and one of each two adjacent heat exchanger tubes between which the linking member is placed is defined as a first linking plane and a linking plane between the linking member and the other of the each two adjacent heat exchanger tubes is defined as a second linking plane, the first linking plane is inclined with respect to the second linking plane.

15. The heat exchanger according to any one of Claims 12 to 14, wherein the linking member has a plate-like protrusion that protrudes toward the downstream side of the external flow path.

16. The heat exchanger according to any one of Claims 12 to 15, wherein a laminated body formed with a plurality of linking members is placed between each two adjacent heat exchanger tubes.

17. The heat exchanger according to any one of Claims 12 to 15, wherein if the linking member is defined as a first linking member, the heat exchanger further includes a second linking member that has a different shape from the first linking member.

18. The heat exchanger according to Claim 1, 8 or 11, wherein the internal flow path includes a plurality of segments extending in a particular row direction of the heat exchanger tube and is a meandering flow path in which a flow direction of the first fluid is reversed at an intermediate point between the inlet and the outlet.

19. The heat exchanger according to Claim 18, wherein the heat exchanger tube further has a hindering structure, disposed between each two adjacent segments, that hinders heat transfer between the two adjacent segments.

20. A heat exchanging unit comprising:

a blower that has a rotational axis and an impeller secured to the rotational axis, the blower delivering a second fluid in the circumferential direction of the rotational axis due to rotation of the impeller; and

the heat exchanger according to any one of Claims 1 to 10, the heat exchanger being disposed around the blower in a plane perpendicular to the rotational axis; wherein

each of the plurality of external flow paths is disposed so that a downstream end of the external flow path is at a more forward position in the rotational direction of the rotational axis than an upstream end of the external flow path when viewed from the rotational axis.

FIG. 1

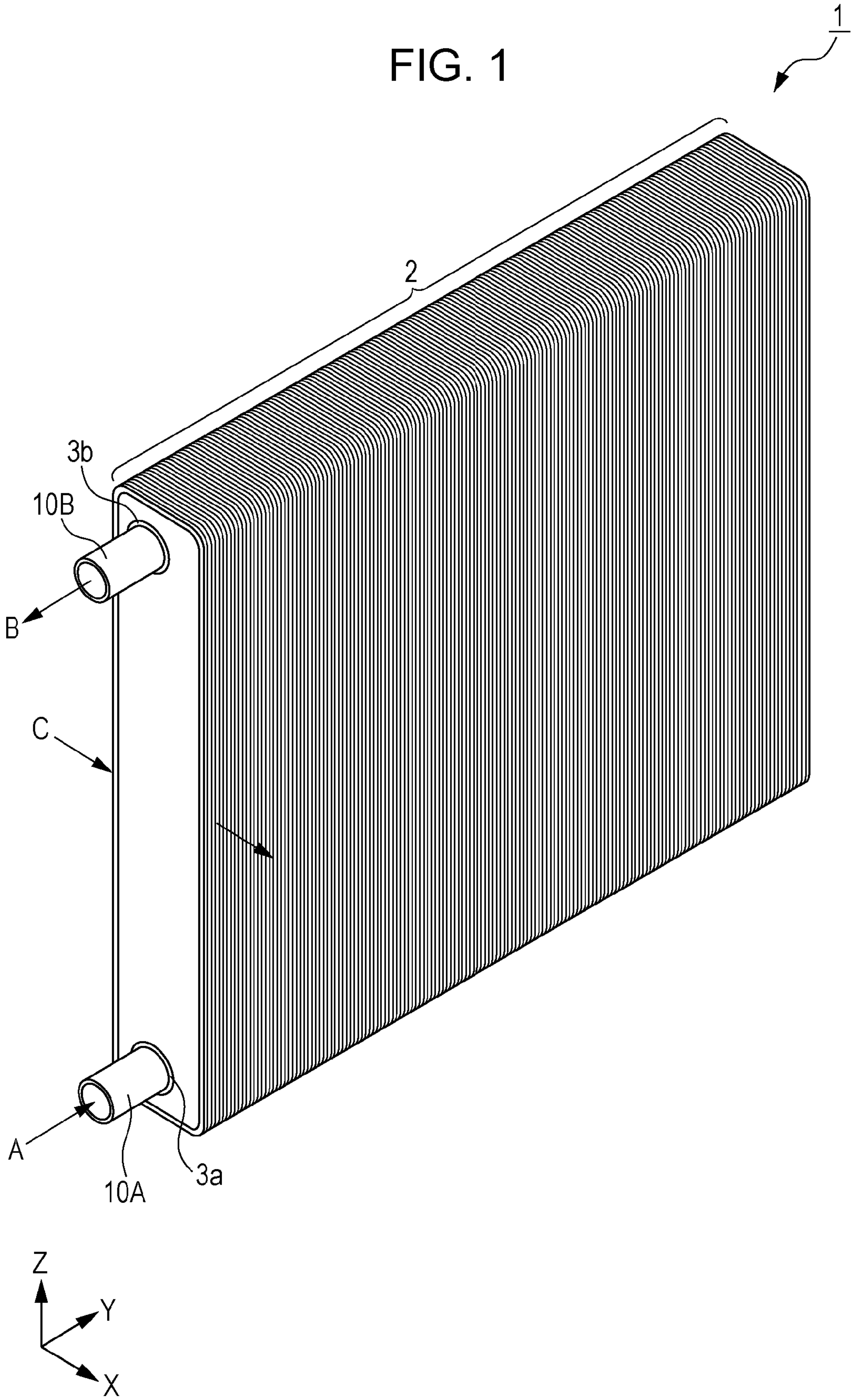


FIG. 2A

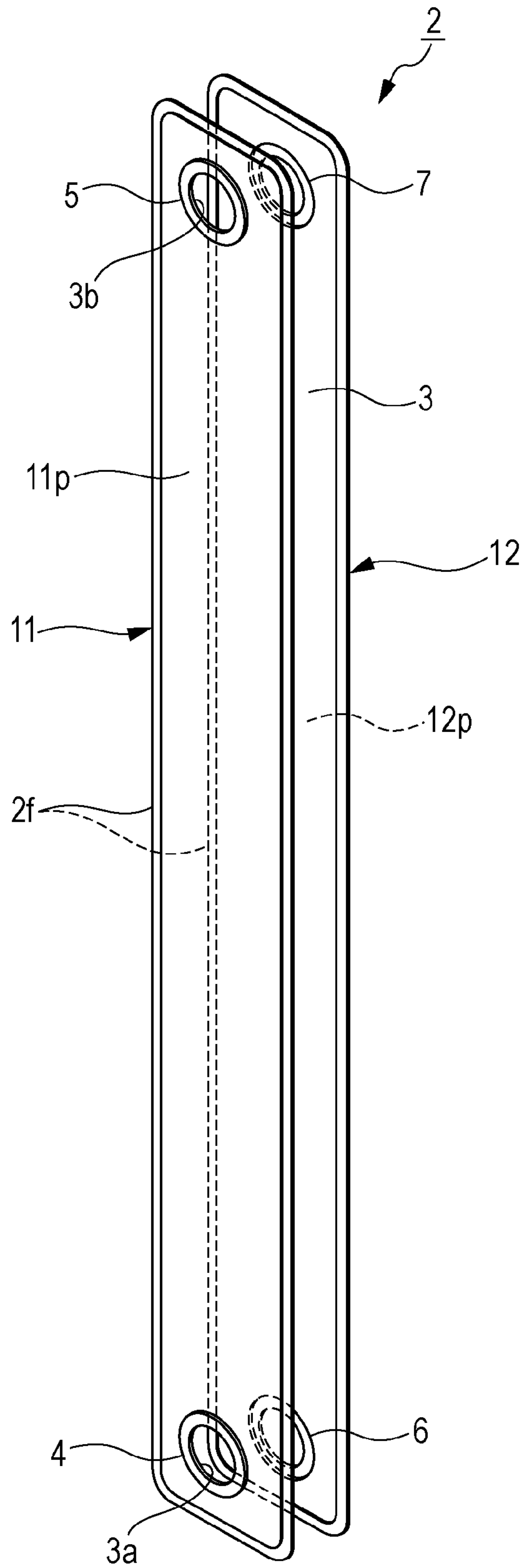


FIG. 2B

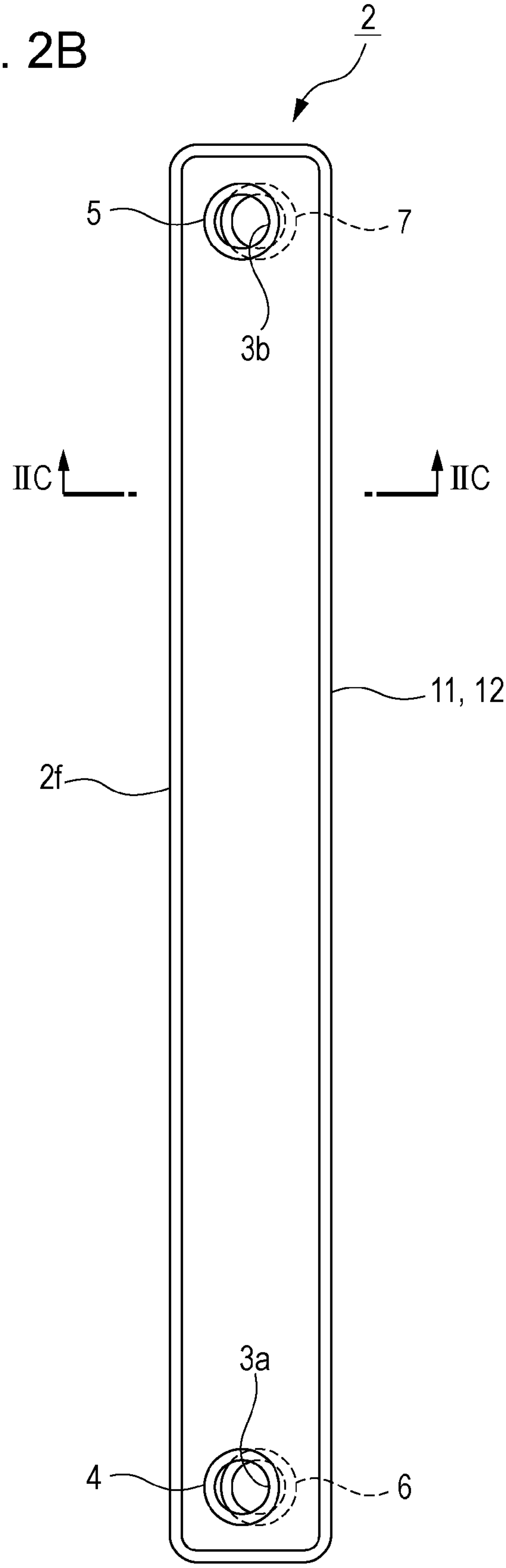


FIG. 2C

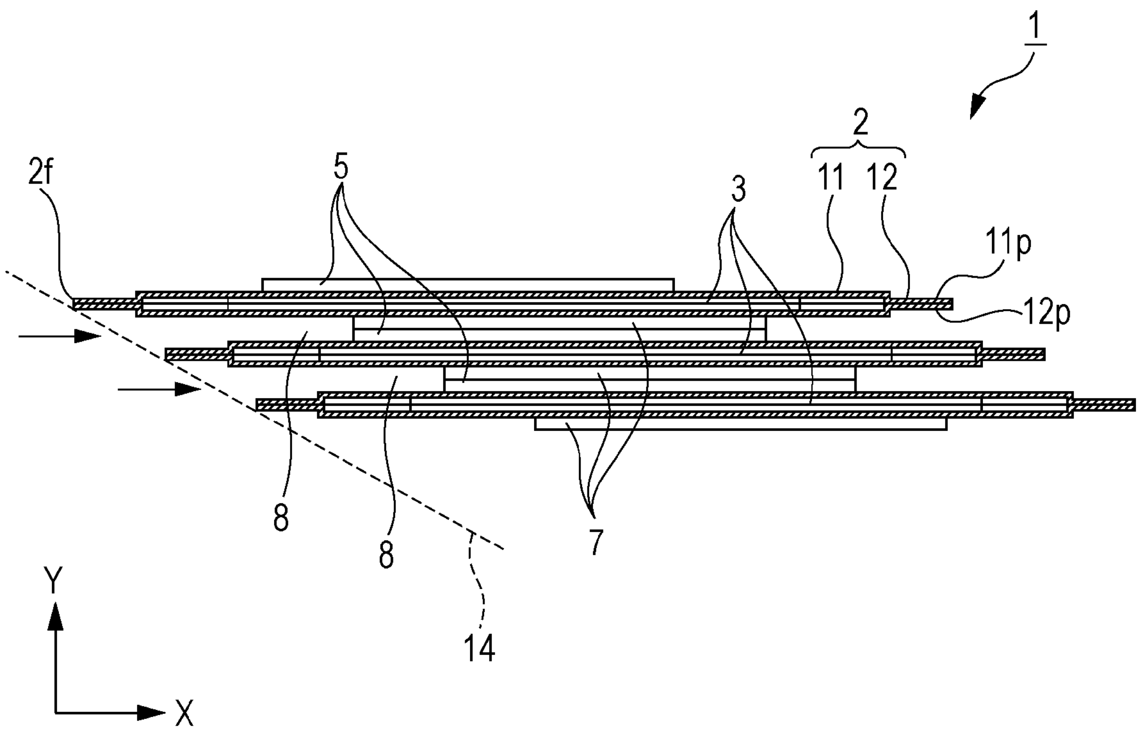


FIG. 3A

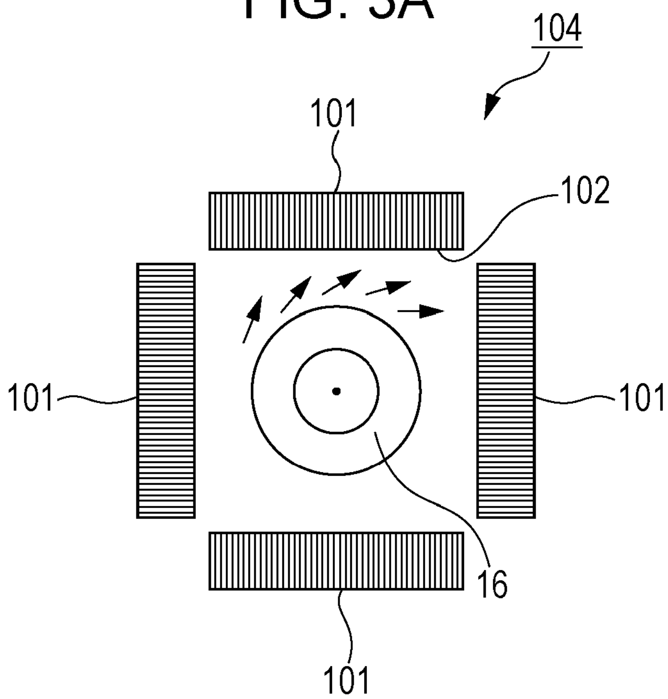


FIG. 3B

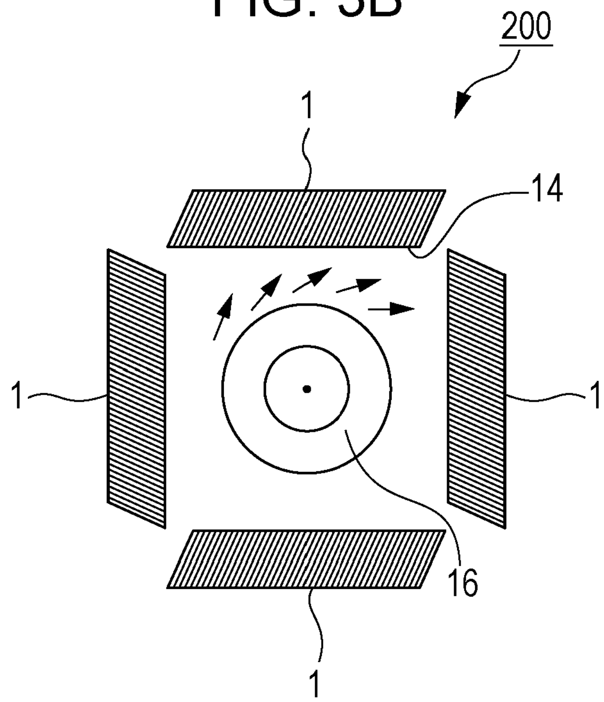


FIG. 4A

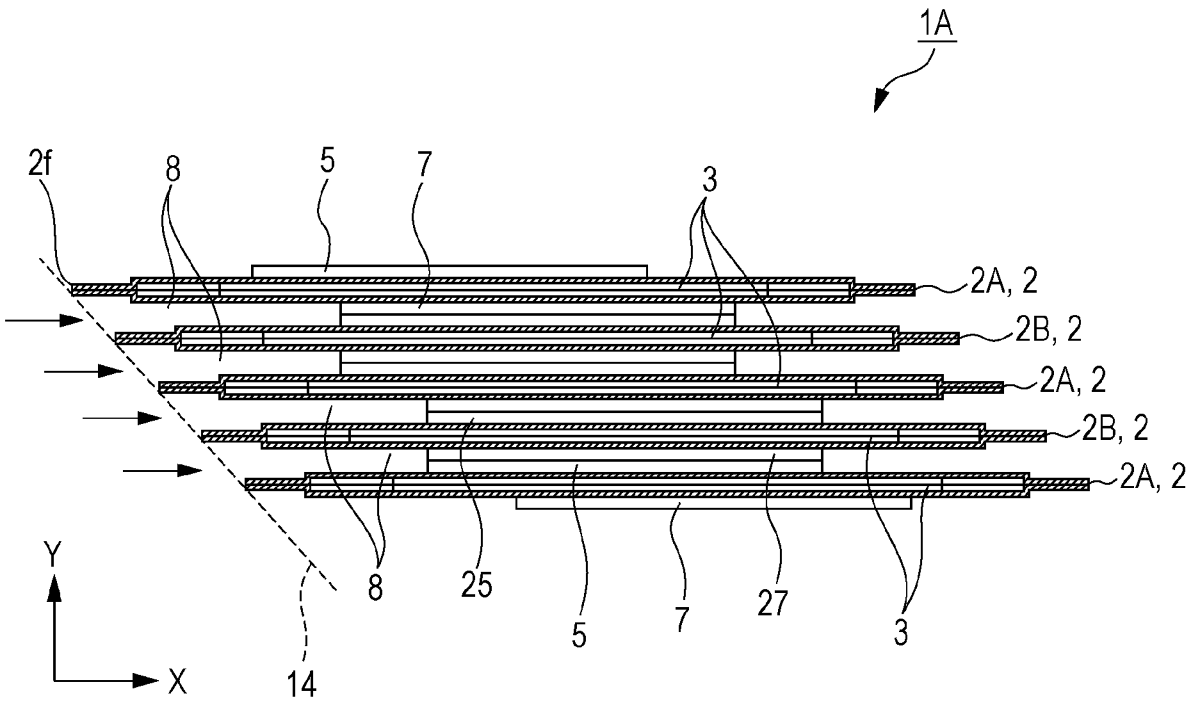


FIG. 4B

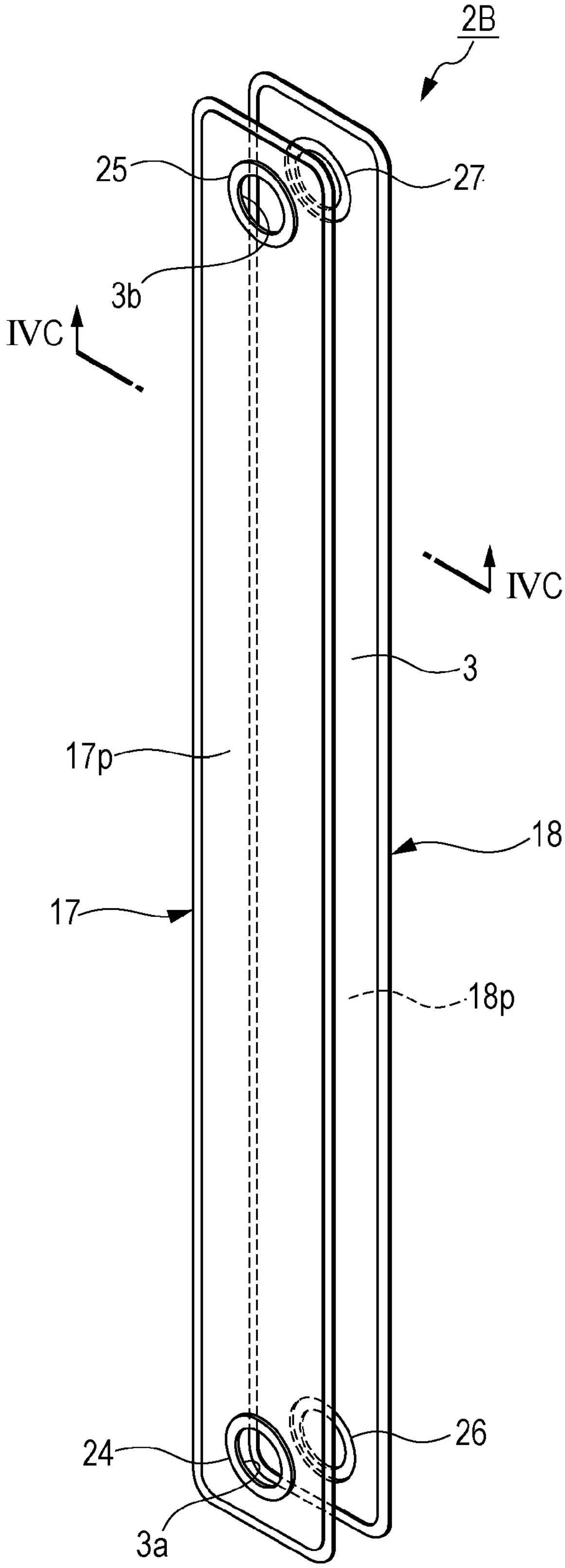


FIG. 4C

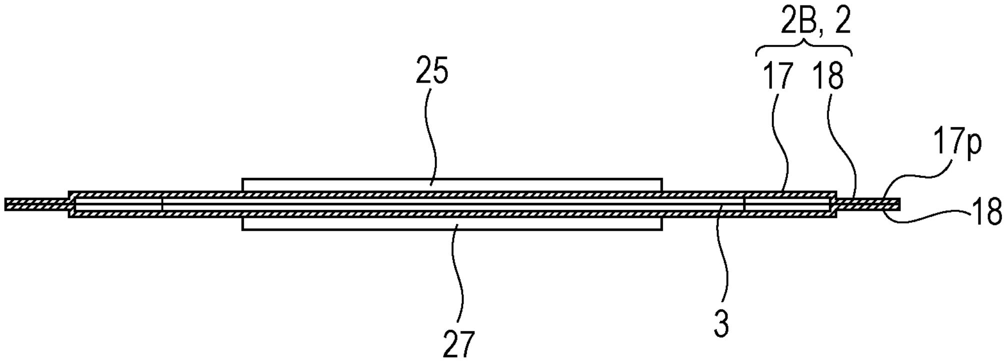


FIG. 5A

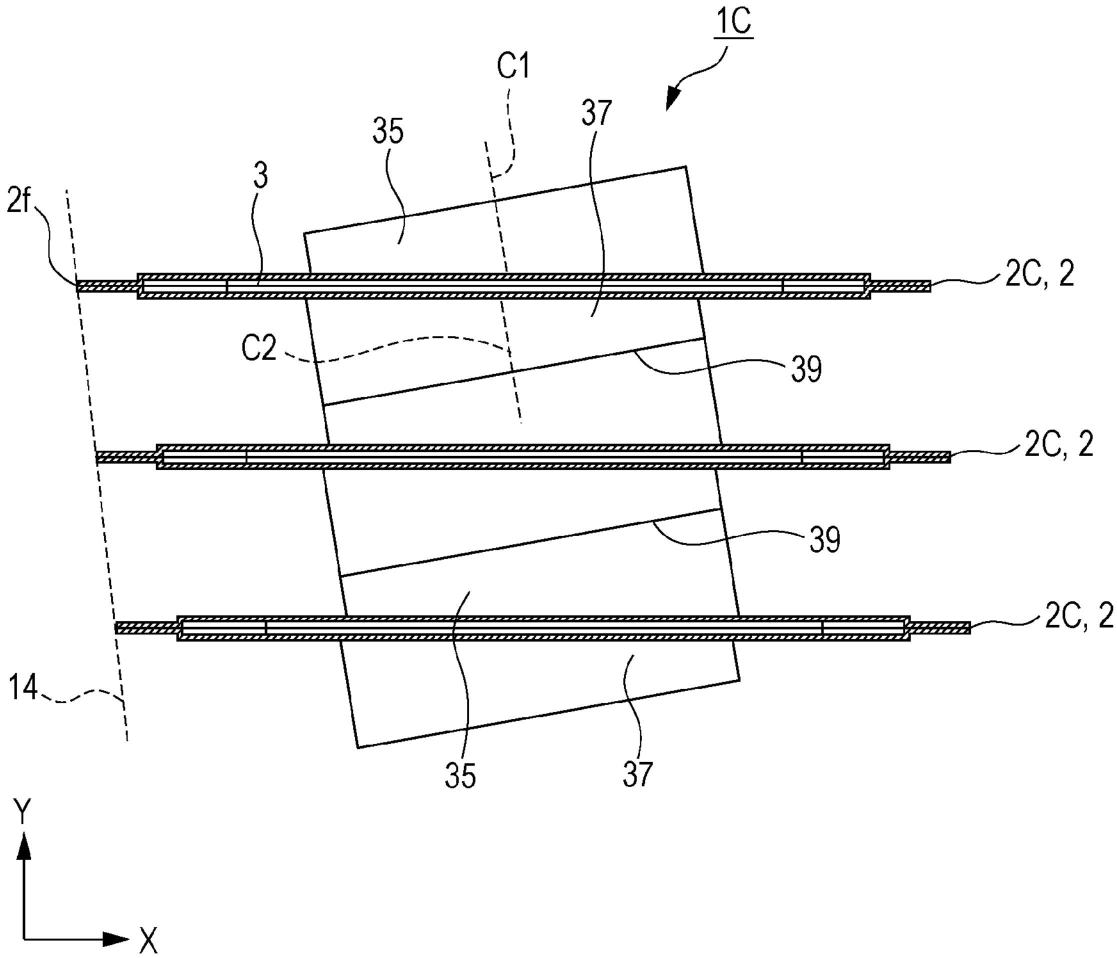


FIG. 5B

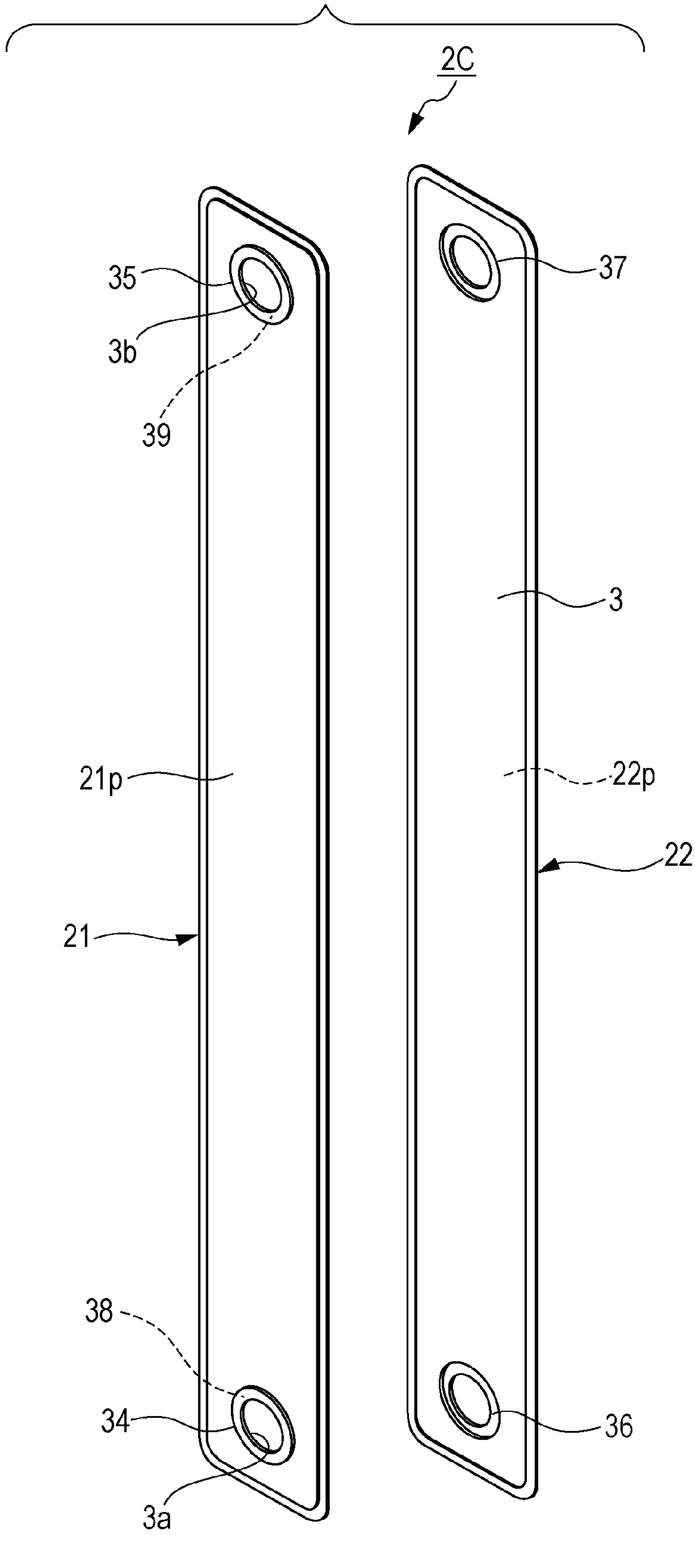


FIG. 6A

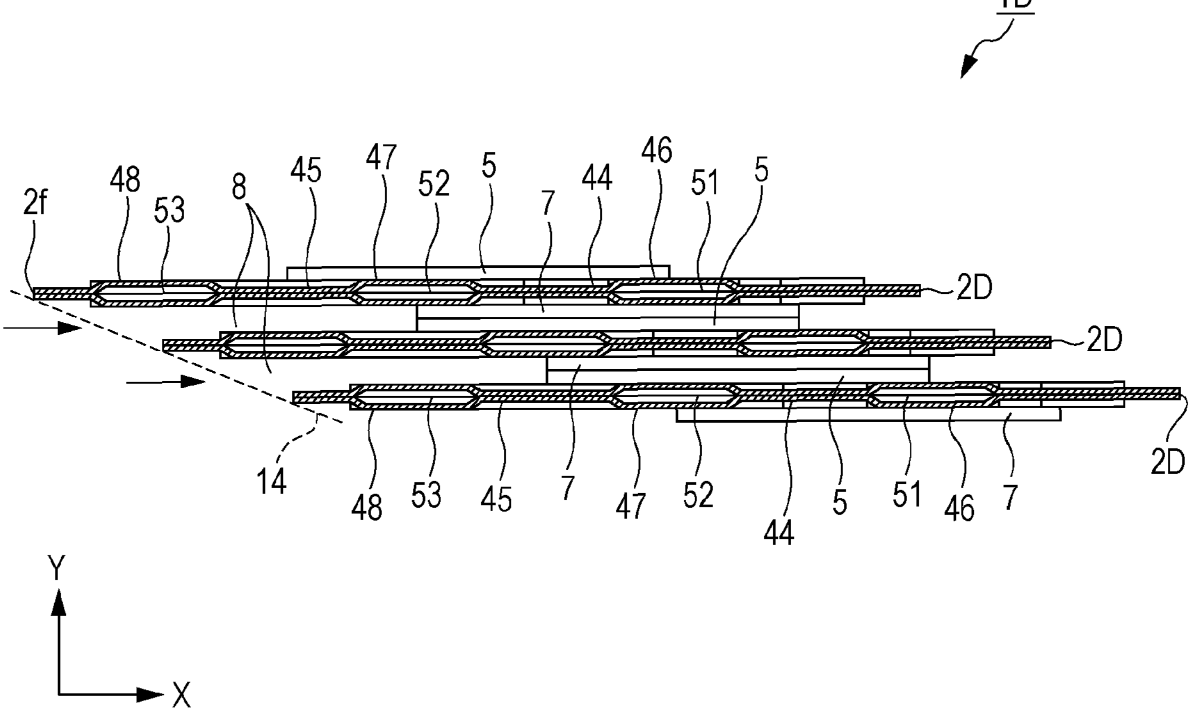

1D
2f
48
53
8
45
47
52
5
7
44
46
51
5
2D
2D
2D
14
48
53
45
7
47
52
44
5
51
46
7
Y
X

FIG. 6B

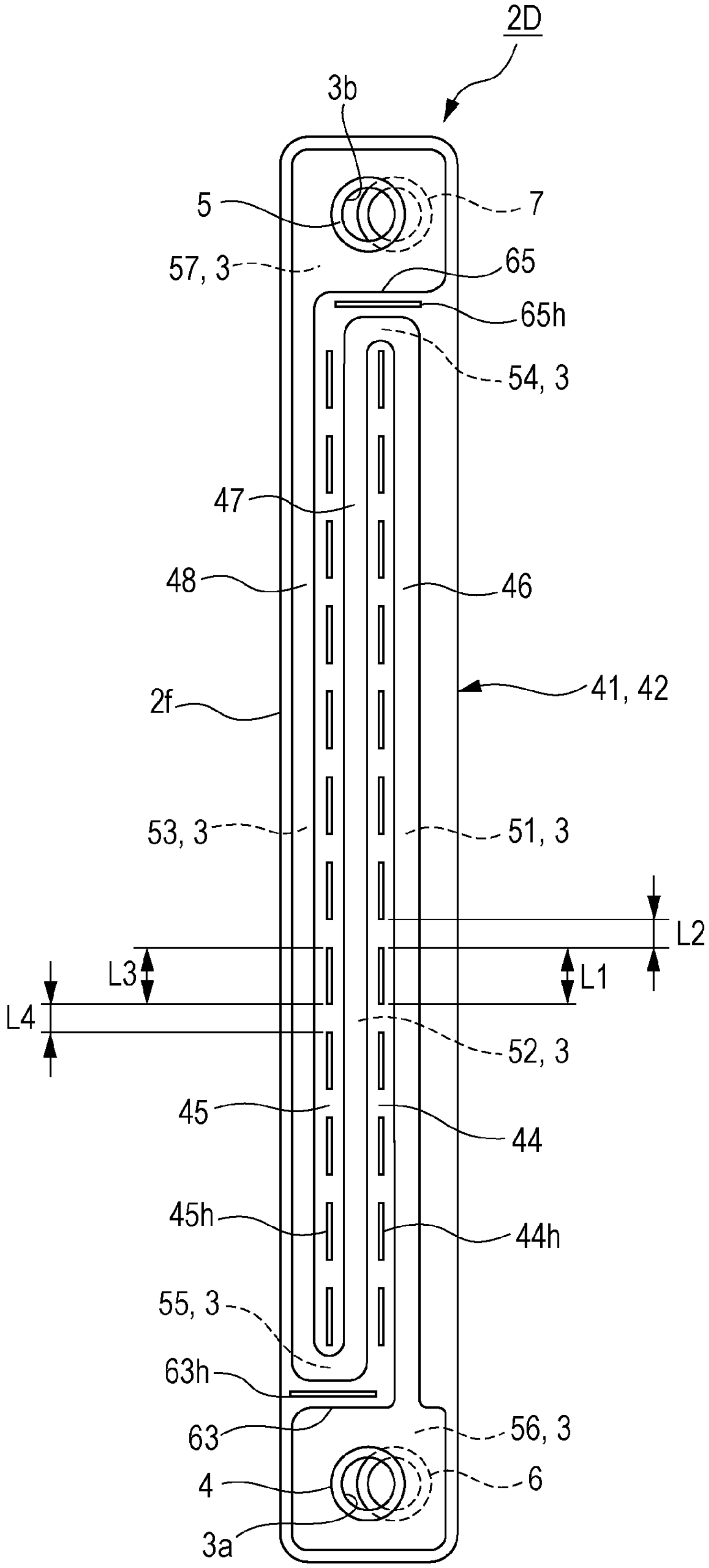

2D
3b
5
7
57, 3
65
65h
54, 3
47
48
46
2f
41, 42
53, 3
51, 3
L2
L3
L1
L4
52, 3
45
44
45h
44h
55, 3
63h
63
56, 3
4
6
3a

FIG. 7A

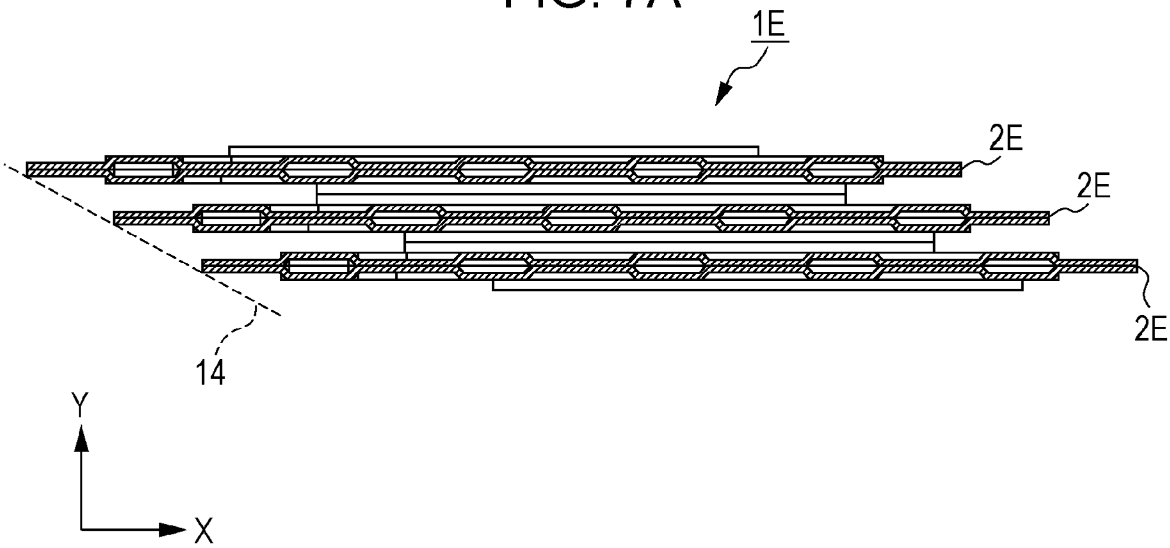


FIG. 7B

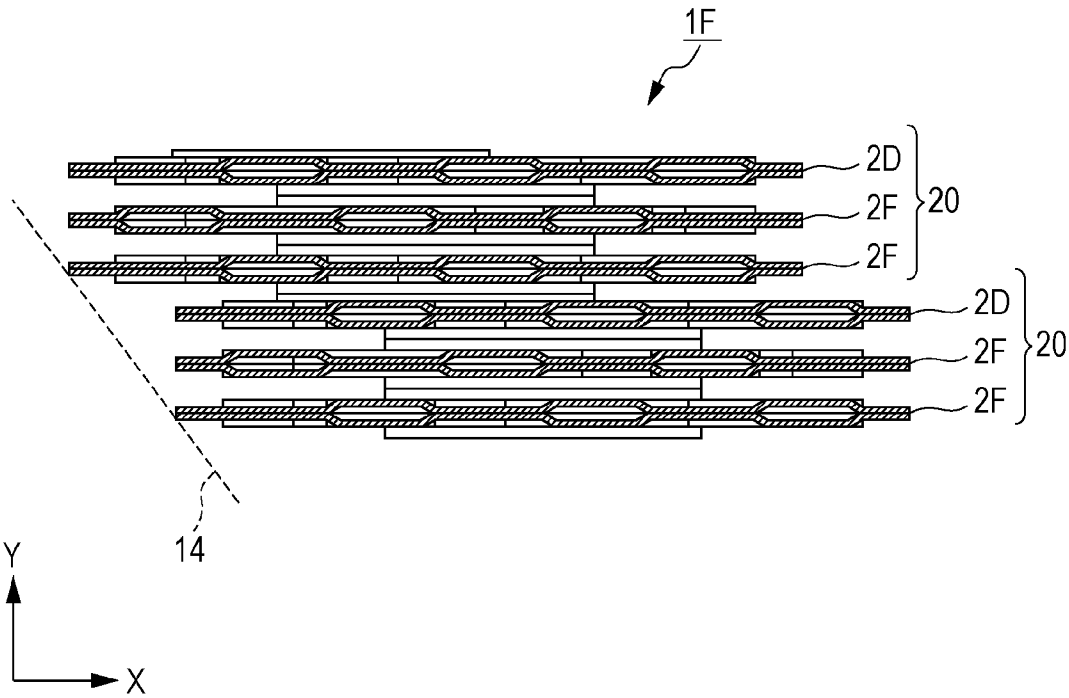


FIG. 8

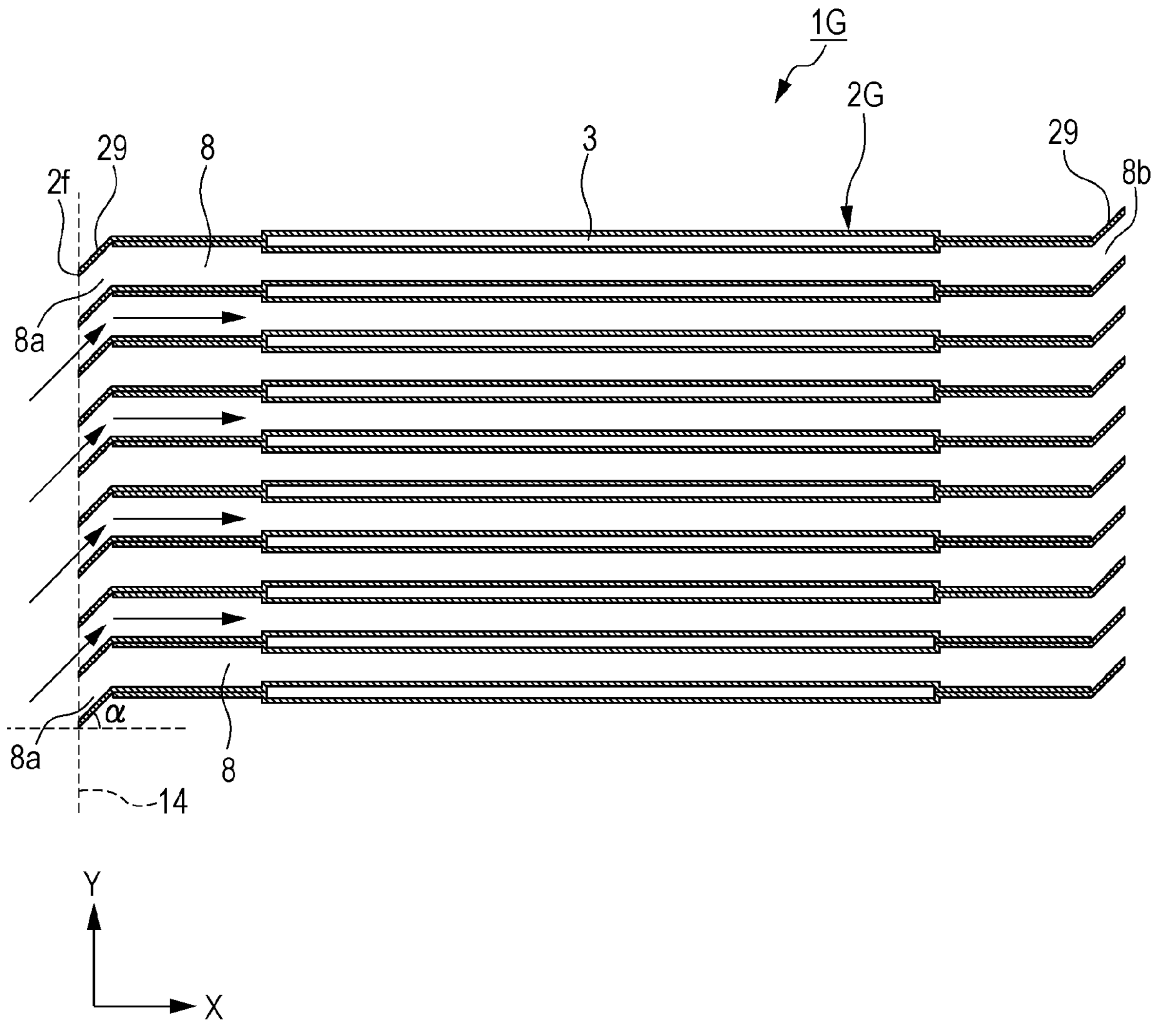


FIG. 9

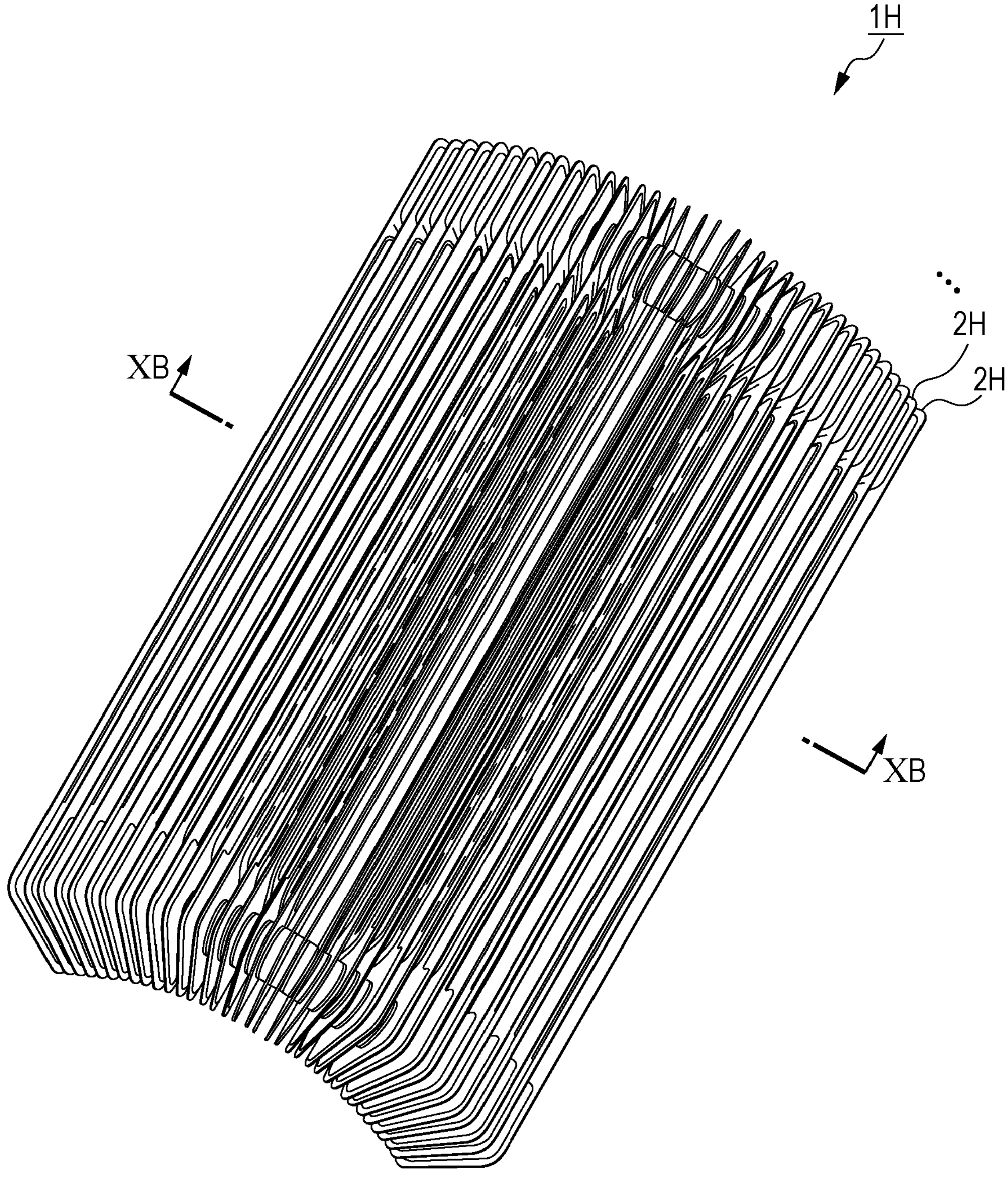


FIG. 10A

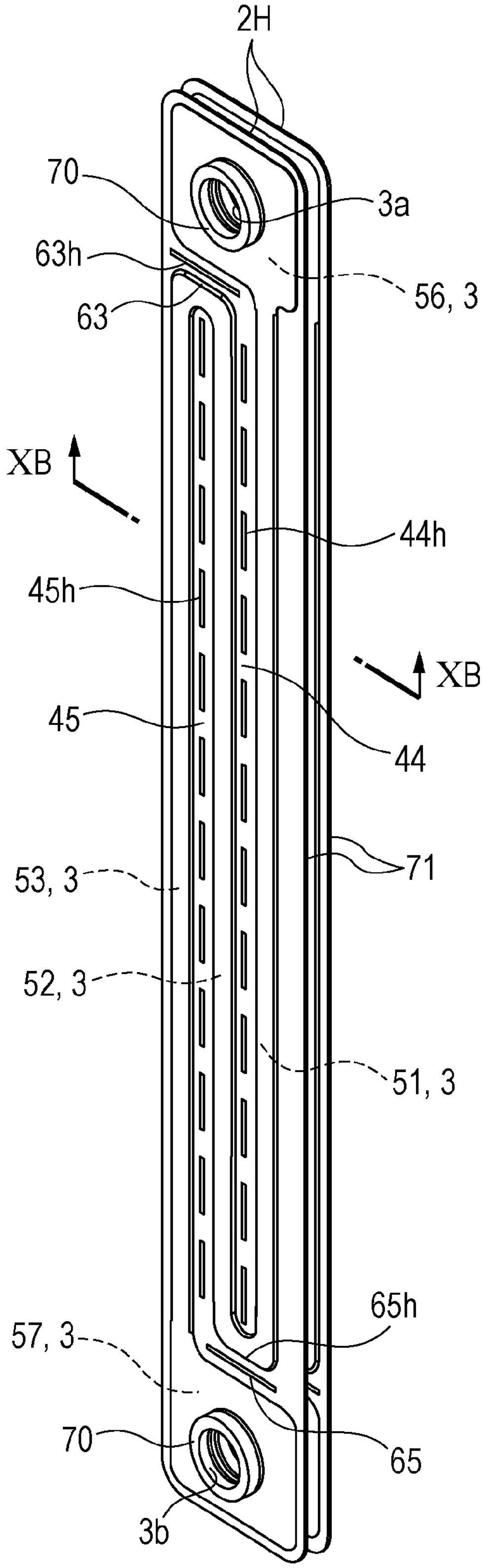

2H
70
3a
63h
56, 3
63
XB
44h
45h
XB
45
44
71
53, 3
52, 3
51, 3
65h
57, 3
70
65
3b

FIG. 10B

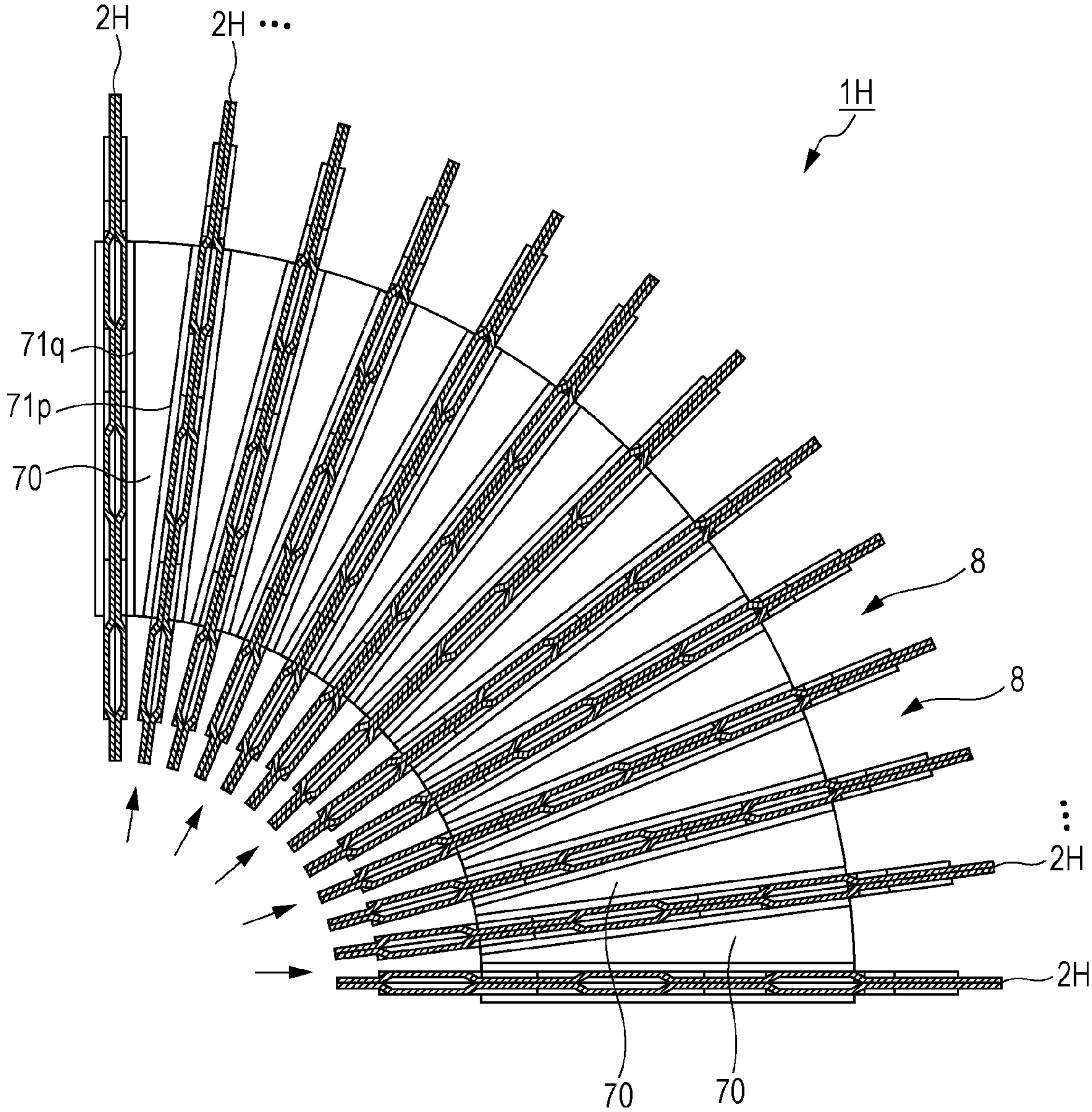


FIG. 10C

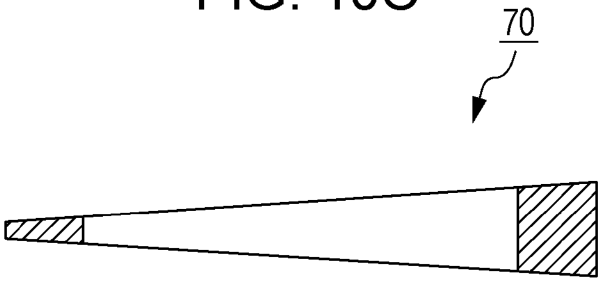


FIG. 10D

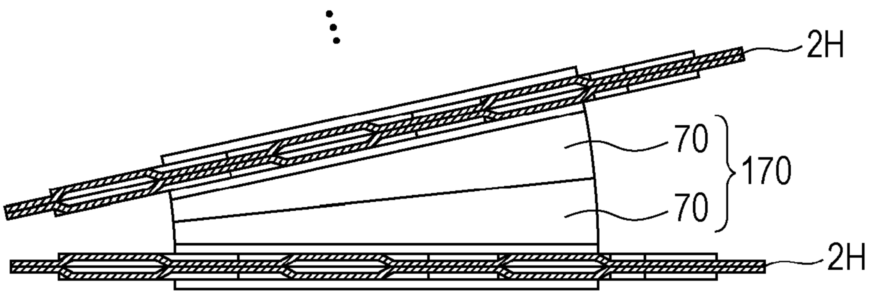


FIG. 10E

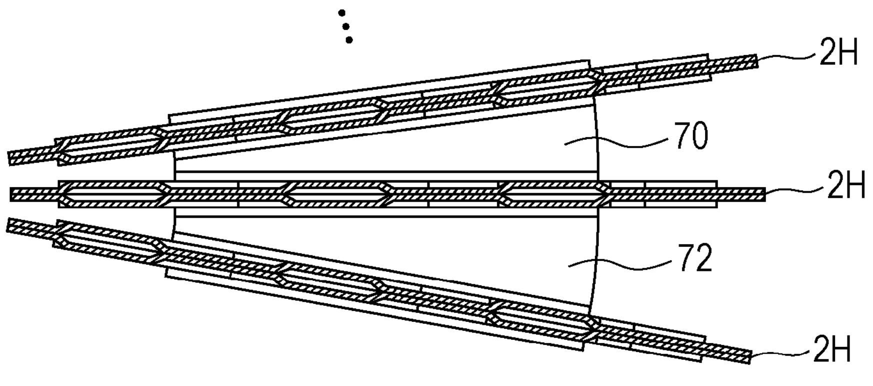


FIG. 11A

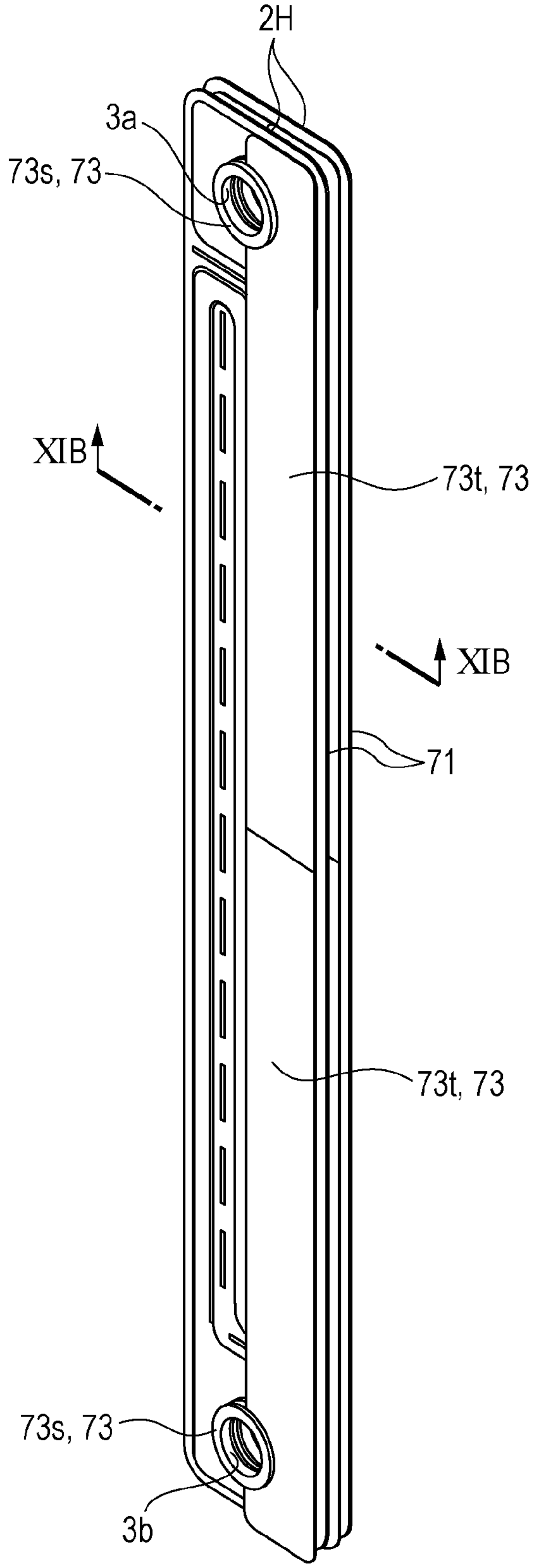


FIG. 11B

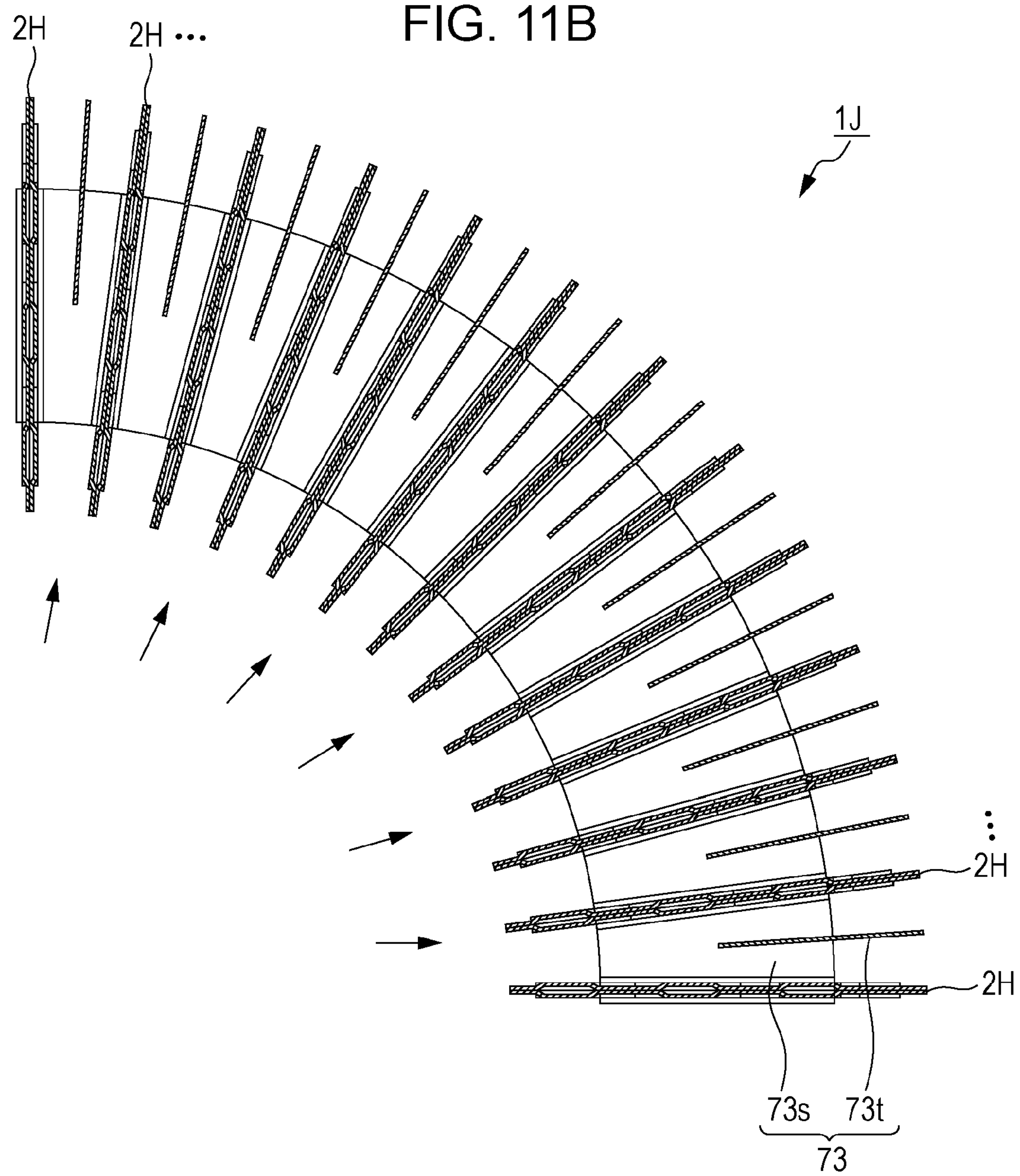


FIG. 11C

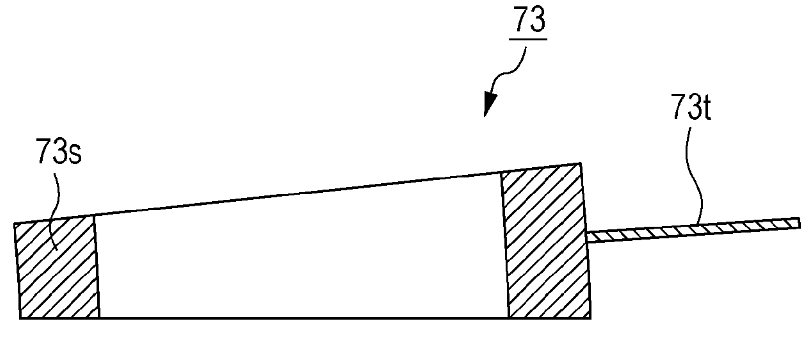


FIG. 12

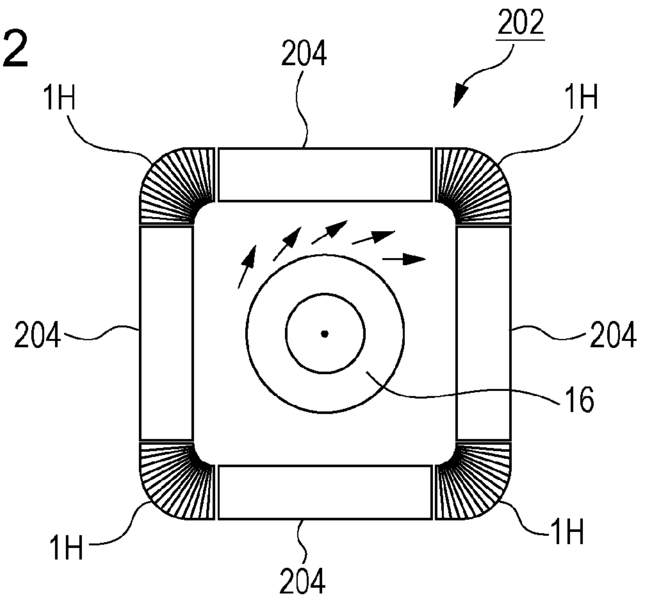
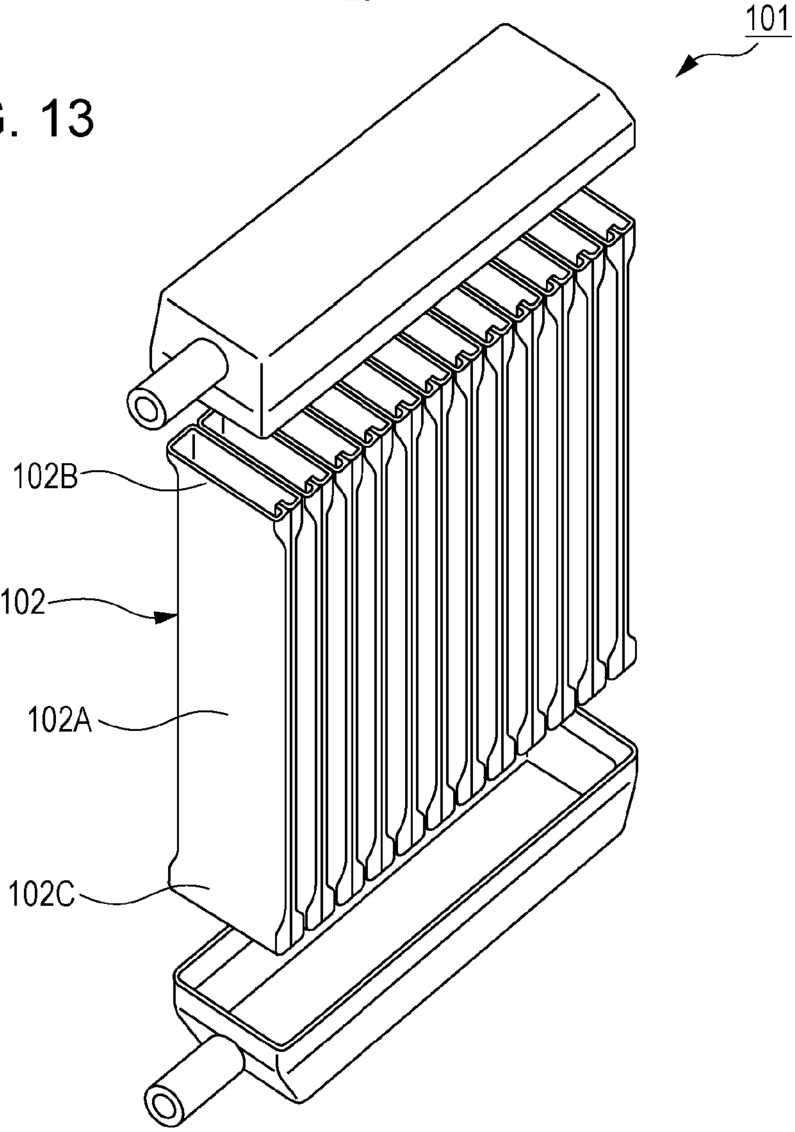


FIG. 13



REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2008039322 A **[0002] [0008]**