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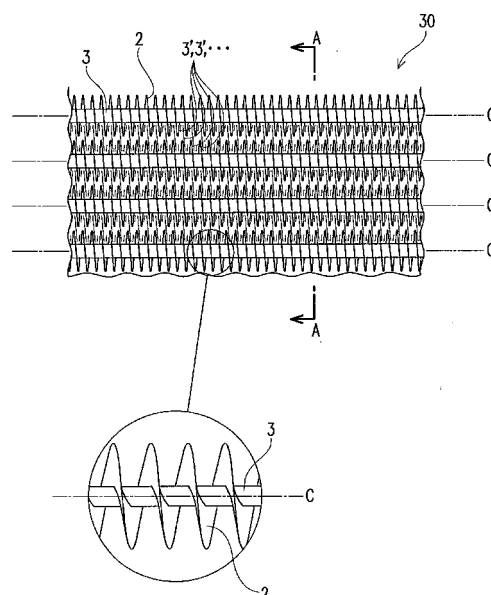
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(54) **SPIRAL FIN TUBE TYPE HEAT EXCHANGER**

(57) It is an object to provide a finned tube type heat exchanger (spiral tube fin heat exchanger) capable of having a reduced size and having an increased heat exchange efficiency and, therefore, an increased performance. A spiral tube fin heat exchanger includes a plurality of heat transfer tubes that allow a heat exchanging object to flow therein and each including a radially-extending tube fin on an outer peripheral surface thereof, the plurality of heat transfer tubes being arranged to be oriented in an identical direction, wherein the tube fin has a spiral shape and has a spiral axis being coincident with a center axis of each of the heat transfer tubes, and the plurality of heat transfer tubes are arranged such that tip ends of tube fin portions in one of adjacent heat transfer tubes intrude between tube fin portions in the other one of adjacent heat transfer tubes.

FIG. 3



## Description

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## TECHNICAL FIELD

**[0001]** The present invention relates to a finned tube type heat exchanger for use in a cooling system such as an inter cooler for electric power generation equipment and, more particularly, relates to a finned tube type heat exchanger with a spiral tube fin (spiral tube-fin type heat exchanger).

## BACKGROUND ART

**[0002]** Conventionally, there have been suggested various types of heat exchangers for performing heat exchange on a heat medium. As one of the heat exchangers, there has been known a finned tube type heat exchanger 100, as illustrated in FIG. 12(a).

**[0003]** This finned tube type heat exchanger 100 has a plurality of finned tubes formed by hollow cylindrical tubes (finned tubes arranged in parallel to each other) (finned tubes (heat transfer tubes) including parallel tube fins) 101, each tube including, a plurality of heat transfer tube fins (heat conduction plates) 102, 102,... that are arranged on the outer peripheral surface of each tube to be parallel to each other in a longitudinal direction with an equal interval. Thus, the plurality of finned tubes constitute a finned tube bank (heat transfer tube bank) 101', through which a heat-exchanging object W' made of fluid flows. With this arrangement, a heat medium M' made of fluid is passed through in a substantially orthogonal direction of the finned tube bank 101', thereby performing heat exchange between the fluid outside of the tubes (the heat medium M') and the fluid inside of the tubes (the heat exchanging object W').

**[0004]** Such a finned tube type heat exchanger (hereinafter simply referred to as a "parallel tube fin heat exchanger" in some cases) 100 including the parallel tube fins 102, 102,... as described above has been required to have a reduced size (be compacted), in order to reduce space as an installation area and in order to reduce a cost for increasing price competitiveness.

**[0005]** Therefore, as illustrated in FIG. 12(b), there has been proposed a finned tube type heat exchanger 110 that has finned tubes 101, 101,..., each including a plurality of parallel tube fins 102 arranged such that a tip end of each tube fin 102 of one of the adjacent finned tubes 101, 101 intrudes between the tube fins 102, 102 of the other one of the adjacent finned tubes, for making a distance between adjacent finned tubes 101, 101 (a pitch of the finned tubes: a distance between center axes C", C" of adjacent finned tubes 101, 101) P" to be shorter (smaller) than twice a length L" from the center axes C" of the finned tubes 101 to the tip ends of the tube fins 102 (refer to Patent Document 1).

**[0006]**

Patent Document 1: Japanese Unexamined Patent

## SUMMARY OF THE INVENTION

## 5 PROBLEMS TO BE SOLVED BY THE INVENTION

**[0007]** However, in recent years, a finned tube type heat exchanger 110 has been required to have an increased heat exchange efficiency and, therefore, higher performance, in addition to having a reduced size (being compacted) for reducing space and a cost as described above, due to intended uses and conditions for installation and the like.

**[0008]** Therefore, in view of the aforementioned problems, it is an object of the present invention to provide a finned tube type heat exchanger (spiral tube fin heat exchanger) including spiral tube fins while enabling reduction of a size thereof and also an increase of the heat exchange efficiency and, therefore, an increase of the performance.

## MEANS FOR SOLVING THE PROBLEMS

**[0009]** Therefore, in order to attain the aforementioned object, a spiral tube fin heat exchanger according to the present invention is a heat exchanger including a plurality of heat transfer tubes that allow a heat exchanging object to flow therein and that each include a radially-extending tube fin on an outer peripheral surface thereof, the plurality of heat transfer tubes being arranged to be oriented in an identical direction, wherein the tube fin has a spiral shape and has a spiral axis being coincident with a center axis of each of the heat transfer tubes, and the plurality of heat transfer tubes are arranged such that tip ends of tube fin portions in one of adjacent heat transfer tubes intrude between tube fin portions in the other one of adjacent heat transfer tubes.

**[0010]** With this structure, it is possible to reduce a pitch of the heat transfer tubes (a distance between the center axes of adjacent heat transfer tubes), without changing (decreasing) a height of the tube fin. In the present invention, the height of the tube fin refers to a distance from the outer peripheral surface of the tube portion to the tip end of the tube fin in a radial direction of the heat transfer tubes.

**[0011]** Namely, in focusing attention on certain areas (the tube fin portions) of the heat transfer tubes (the finned tubes) including the spiral-shaped tube fins (the spiral tube fins) in a direction of the center axes, they can be regarded as heat transfer tubes including a plurality of tube fins provided in parallel to one another and evenly spaced apart from one another in the direction of the center axes (finned tubes including parallel tube fins). Therefore, even heat transfer tubes including spiral-shaped fins can be structured such that the tip ends of the tube fin portions in one of adjacent heat transfer tubes intrude between the tube fin portions in the other one of adjacent heat transfer tubes, which can reduce the pitch

of adjacent heat transfer tubes.

**[0012]** Since the tube fin portions in one of adjacent heat transfer tubes intrude between the tube fin portions of the other one of adjacent heat transfer tubes, the spacing of the tube fin portions is significantly small. Accordingly, since the entire heat exchanger processes a constant amount of the heat medium per unit time when the heat medium flows within the heat exchanger for attaining heat exchange, a velocity of a flow of the heat medium flowing through the narrowed spacing of the tube fin portions is increased, thereby increasing the heat-transfer coefficient. This increases the heat exchange efficiency attained with the heat medium which exchanges heat with the heat exchanging object which flows through the insides of the heat transfer tubes.

**[0013]** Further, since the tube fins are formed to have a spiral shape (be spiral tube fins), the heat medium flowing through the bank of the heat transfer tubes in a direction orthogonal (or substantially orthogonal) to the center axes of the heat transfer tubes impinges on the spiral-shaped tube fins to induce disturbances in the flow, which increases an effect of mixing and diffusing the heat medium, thereby increasing the heat exchange efficiency.

**[0014]** Namely, in cases of flat-plate shaped tube fins (parallel tube fins) orthogonal to the direction of the center axes of the heat transfer tubes, the tube fins extend along a direction that extends along the flow of the heat medium flowing in the direction orthogonal to the heat transfer tubes (parallel thereto) and, therefore, the flow of the heat medium passes through the inside of the heat transfer tube bank, while hardly inducing disturbances. On the contrary, in cases of spiral-shaped tube fins, the flow of the aforementioned heat medium impinges on surface portions of the spiral-shaped tube fins which are inclined with respect to this flow, and this impingement induces irregular flows, which partially increases the velocity of the flow, thus inducing mixing and diffusion.

**[0015]** Since the velocity of the flow of the heat medium is increased as described above, a heat-transfer coefficient is increased, which increases an amount of heat transferred from the heat medium to the surfaces of the heat transfer tubes, thereby increasing the amount of heat transferred to (absorbed by) the heat exchanging object from the heat medium through tube walls of the heat transfer tubes. This results in an increase of the heat exchange efficiency. Further, the heat medium has a uniform temperature at respective positions since the heat medium is mixed and diffused, which prevents reduction and the like of the amount of heat transfer due to temperature unevenness, thereby increasing the amount of heat transferred to the heat exchanging object from the heat medium through the heat transfer tubes and, thus, increasing the heat exchange efficiency.

**[0016]** Further, the spiral tube fin heat exchanger according to the present invention refers to a finned tube type heat exchanger including spiral tube fins. Further, the term "the tube fin portions" refers to portions of the

tube fins included in the heat transfer tubes which are faced to the heat transfer tubes adjacent thereto. Further, the term "the heat exchanging object" refers to a fluid which flows through the insides of the heat transfer tubes and comes into contact with the inner peripheral surfaces of the heat transfer tubes to exchange heat with the heat medium flowing outside the heat transfer tubes (inside the heat transfer tube bank).

**[0017]** Further, the spiral-shaped tube fin can be structured such that the tube fin rotate in an opposite direction from a rotating direction of the corresponding tube fin in the adjacent heat transfer tubes.

**[0018]** With this structure, the corresponding spiral-shaped tube fins in adjacent heat transfer tubes rotate in directions opposite from each other and, therefore, the corresponding tube fin portions are inclined in an identical direction (parallel to each other), which prevents the corresponding tube fin portions from coming into contact with each other even if the pitch of the heat transfer tubes is decreased. Accordingly, similarly to heat transfer tubes including parallel tube fins, it is possible to make the pitch of the heat transfer tubes to be a minimum pitch (a pitch which causes the tip ends of the tube fins in one of the heat transfer tubes to come into contact with the outer peripheral surface of the other heat transfer tube).

**[0019]** Further, since the corresponding tube fin portions are parallel to each other, the corresponding tube fin portions are prevented from coming into contact with each other, when the plurality of heat transfer tubes are brought close to one another for forming the heat transfer tube bank. This can facilitate operations for assembling the heat transfer tube bank.

**[0020]** Furthermore, since the tube fins are provided in a spiral shape, it is possible to increase the effect of mixing and diffusing the flow of the heat medium flowing through the inside of the heat transfer tube bank, which increases the heat exchange efficiency, in comparison with a heat transfer tube bank which is constituted by heat transfer tubes including parallel tube fins. Therefore, the aforementioned structure enables reducing a size of the finned tube type heat exchanger and increasing the heat exchange efficiency and, therefore, increasing performance and, also, facilitates assembling.

**[0021]** Also, the spiral-shaped tube fin can be structured such that the tube fin rotate in an identical direction as a rotating direction of the corresponding tube fin in the adjacent heat transfer tubes.

**[0022]** With this structure, since the corresponding spiral-shaped tube fins in adjacent heat transfer tubes rotate in the identical direction, the corresponding tube fin portions are inclined in directions opposite from each other (in directions intersecting with each other) and, therefore, if the pitch of the heat transfer tubes is decreased, they come into contact with each other at portions other than the tip ends. This increases the velocity of the flow of the heat exchanging object flowing near these contacted portions and also increases the effect of mixing and diffusing it, thereby increasing the heat exchange efficiency.

**[0023]** Namely, if the pitch of adjacent heat transfer tubes in the heat transfer tube bank which is constituted by the heat transfer tubes including the plurality of spiral-shaped tube fins is decreased, the corresponding tube fin portions come into contact with each other at the portions other than the tip ends as described above, and these contacted portions form narrow flow-path portions within the heat transfer tube bank. These narrow flow-path portions are portions which induce disturbances in the flow of the heat medium and, also, induce turbulent flows inside the heat transfer tube bank, since the heat medium impinges on or intrudes around the narrow flow-path portions.

**[0024]** Since the tube fin portions in adjacent heat transfer tubes form these narrow flow-path portions at the respective portions brought into contact with each other, many narrow flow-path portions are formed inside the heat transfer tube bank. Therefore, a large number of turbulent flows are induced in the flow of the heat medium flowing through the inside of the heat transfer tube bank including these many narrow flow-path portions, which partially increases the velocity of the flow thereof, thereby further increasing the mixing and diffusing effect. This enables reducing the size of the finned tube type heat exchanger and also increasing the heat exchange efficiency and, thus, increasing the performance.

**[0025]** Further, with this structure, the corresponding tube fin portions in adjacent heat transfer tubes are brought into contact with each other and, thus, are supported by each other, which increases a strength of the tube fins including these tube fin portions brought into contact with each other against forces applied thereto from the outside. Further, the corresponding tube fin portions are supported by each other, which can suppress vibrations of these tube fins due to the flow of the heat medium.

**[0026]** Further, since the corresponding tube fin portions are supported by each other, the plurality of heat transfer tubes constituting the heat transfer tube bank are brought into contact with the heat transfer tubes adjacent thereto at many positions, thereby increasing rigidity of the heat transfer tube bank itself, even though the heat transfer tubes have a greater length.

**[0027]** Further, the corresponding tube fin portions in the adjacent heat transfer tubes can be structured such that the tube fin portions in at least one of the adjacent heat transfer tubes is provided with protruding portions such that the corresponding tube fin portions are brought into contact with each other through these protruding portions.

**[0028]** This structure can increase the strength of the tube fins including the tube fin portions brought into contact with one another, further can suppress the vibrations induced by the flow of the heat medium and, also, can increase the rigidity of the heat transfer tube bank itself, as described above.

**[0029]** Further, due to the reduction of the areas of the corresponding tube fin portions in adjacent heat transfer

tubes which contact with each other, it is possible to suppress the reduction of the heat exchange efficiency due to the contact between the corresponding tube fin portions.

**[0030]** Namely, the portions (the surfaces) of the tube fin portions which contact with each other are prevented from coming into contact with the heat medium and, thus, are prevented from exchanging heat with the heat medium, which reduces the areas usable for heat exchange. However, by causing the tube fin portions to contact with each other through the aforementioned protruding portions, it is possible to reduce the areas of the tube fin portions which contact with each other, which increases the areas of the heat transfer tubes which come into contact with the heat medium (which suppresses the reduction of the areas of the heat transfer tubes which come into contact with the heat medium), thereby suppressing the reduction of the heat exchange efficiency due to the contact between the corresponding tube fin portions.

## ADVANTAGES OF THE INVENTION

**[0031]** As described above, with the present invention, it is possible to provide a spiral tube fin heat exchanger which enables reducing a size thereof and also increasing heat exchange efficiency thereby increasing performance.

## BRIEF DESCRIPTION OF THE DRAWINGS

### **[0032]**

FIG. 1 is a schematic perspective view of a spiral tube fin heat exchanger according to the present embodiment.

FIG. 2(a) illustrates a front view of a heat transfer tube bank according to the present embodiment, and FIG. 2(b) illustrates a plan view thereof.

FIG. 3 illustrates a partially enlarged front view of the heat transfer tube bank according to the present embodiment.

FIG. 4(a) illustrates a schematic side view of rolling formation processing on a heat transfer tube according to the present embodiment, and FIG. 4(b) illustrates a view as viewed from an arrow B-B.

FIG. 5(a) illustrates a cross-sectional view along A-A in FIG. 3, according to the present embodiment, wherein adjacent heat transfer tubes in adjacent rows are arranged such that a square is formed if center axes of the adjacent heat transfer tubes are connected to one another, and FIG. 5(b) illustrates a cross-sectional view along A-A in FIG. 3, according to another embodiment, wherein adjacent heat transfer tubes in adjacent rows are arranged such that a rhombus is formed if center axes of the adjacent heat transfer tubes are connected to one another.

FIG. 6(a) illustrates a partially enlarged cross-section

tional perspective view of the adjacent heat transfer tubes according to the present embodiment, and FIG. 6(b) illustrates an end view along C-C in FIG. 6(a).

FIG. 7 is a plan view illustrating flows of a heat medium and a to-be-heated medium within the spiral tube fin heat exchanger according to the present embodiment.

FIG. 8(a) illustrates a heat transfer tube bank constituted by heat transfer tubes including parallel tube fins which are parallel to one another and are evenly spaced apart from one another in a direction of the center axes of the heat transfer tubes and a result of flow analysis thereof, FIG. 8(b) illustrates a heat transfer tube bank constituted by heat transfer tubes including tube fins having a spiral shape in the direction of the center axes of the heat transfer tubes and being reversed spiral tube fins adapted such that the corresponding spiral-shaped tube fins in adjacent heat transfer tubes rotate in directions opposite from each other, and the result of flow analysis thereof, and FIG. 8(c) illustrates a heat transfer tube bank constituted by heat transfer tubes including tube fins having a spiral shape in the direction of the center axes of the heat transfer tubes and being identical spiral tube fins adapted such that the corresponding spiral-shaped tube fins in adjacent heat transfer tubes rotate in an identical direction, and the result of flow analysis thereof.

FIG. 9(a) illustrates a partially enlarged perspective view of heat transfer tubes according to another embodiment, and FIG. 9(b) illustrates a cross-sectional side view of the heat transfer tube bank.

FIG. 10 is an enlarged view of tube fins in heat transfer tubes according to another embodiment, wherein FIG. 10(a) illustrates an enlarged view of tube fins including radial protruding strips, and FIG. 10(b) illustrates an enlarged view of tube fins including protruding strips along the tip end portions.

FIG. 11(a) illustrates a partially enlarged cross-sectional perspective view of adjacent heat transfer tubes according to another embodiment, and FIG. 11(b) illustrates an end view along D-D in FIG. 11(a).

FIG. 12 is a schematic front view of a conventional independent finned tube type heat exchanger, wherein FIG. 12(a) illustrates a schematic front view of a heat exchanger including heat transfer tubes arranged such that the fins in one of adjacent heat transfer tubes do not intrude between the fins of the other one of adjacent heat transfer tubes, and FIG. 12(b) illustrates a schematic front view of a heat exchanger including heat transfer tubes arranged such that the fins in one of adjacent heat transfer tubes intrude between the fins in the other one of adjacent heat transfer tubes.

## DESCRIPTION OF REFERENCE SYMBOLS

### [0033]

|    |                  |                                                                             |
|----|------------------|-----------------------------------------------------------------------------|
| 5  | 1                | Spiral tube fin heat exchanger (heat exchanger)                             |
|    | 2                | Tube fin (spiral tube fin)                                                  |
|    | 2'               | Tube fin portion                                                            |
|    | 3                | Heat transfer tube (finned tube)                                            |
|    | 4                | Supporting member                                                           |
| 10 | 5                | Inlet of a heat transfer tube bank (inlet for a heat exchanging object)     |
|    | 6                | Outlet of a heat transfer tube bank (outlet for the heat exchanging object) |
|    | 7                | Coupling portion of a heat transfer tube bank                               |
| 15 | 8                | Shell                                                                       |
|    | 9                | Shell flow-in portion (heat medium inlet)                                   |
|    | 10               | Shell flow-out portion (heat medium outlet)                                 |
|    | 11               | Protruding portion                                                          |
|    | C                | Center axis of heat transfer tube                                           |
| 20 | M                | Heat medium                                                                 |
|    | W                | Heat exchanging object                                                      |
|    | P                | Pitch                                                                       |
|    | P <sub>min</sub> | Minimum pitch                                                               |

### 25 PREFERRED EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0034] Hereinafter, an embodiment of a spiral tube fin heat exchanger according to the present invention will be described with reference to attached drawings.

[0035] As illustrated in FIGS. 1 to 3, a finned tube type heat exchanger (hereinafter simply referred to as a "spiral tube fin heat exchanger" or "heat exchanger", in some cases) 1 including spiral tube fins 2 according to the present embodiment is a heat exchanger for use in an inter cooler for electric power generation equipment. The finned tube type heat exchanger 1 includes, inside a shell 8 for flowing a heat medium M inside thereof, heat transfer tubes (finned tubes) 3 constituted by hollow cylindrical tubes including radially-extending tube fins (heat conduction plates) 2 on outer peripheral surfaces thereof, through which tubes a heat exchanging object W made of a fluid such as water flows; a heat transfer tube bank 30 which is constituted by a plurality of heat transfer tubes 3, 3,... and includes a flow-in heat transfer tube bank 30a for the heat exchanging object W and a flow-out heat transfer tube bank 30b for the heat exchanging object W; a pair of supporting members 4, 4 for supporting the heat transfer tube bank 30 at opposite ends thereof; a heat-transfer-tube-bank-inlet 5 for flowing the heat exchanging object W from the outside into the respective heat transfer tubes 3, 3, ... in the flow-in heat transfer tube bank 30a and a heat-transfer-tube-bank-outlet 6 for collectively discharging, to the outside, the heat exchanging object W from the respective heat transfer tubes 3, 3, .. in the flow-out heat transfer tube bank 30b, outside of one of the supporting members 4; and a heat-transfer-tube-bank-coupling portion 7 which couples the flow-in

heat transfer tube bank 30a and the flow-out heat transfer tube bank 30b to each other, outside the other supporting member 4, such that the heat exchanging object W flows from the flow-in heat transfer tube bank 30a to the flow-out heat transfer tube bank 30b.

**[0036]** The tube fins 2 are plate-shaped members (plates) extending in a radial direction of the heat transfer tubes 3 in order to increase surface areas of the heat transfer tubes 3 which come into contact with the heat medium M flowing outside the heat transfer tubes 3 and are made of a metal having a high heat conductivity (aluminum, copper and the like). More specifically, the tube fins 2 are spiral plate-shaped members provided on the outer peripheral surfaces of the heat transfer tubes 3 and are formed such that the axes of the spirals are coincident with the center axes C of the heat transfer tubes 3 and a pitch of the spirals is constant. Further, the tube fins 2 are formed such that peripheral edges thereof have a circular shape, in a direction of the center axes of the heat transfer tubes 3.

**[0037]** The heat transfer tubes 3 are tubes including the tube fins 2 on outer peripheral surfaces thereof and are made of a metal having a high heat conductivity (such as carbon steel, stainless steel and the like), as straight tubes with the same diameter (straight tubes). More specifically, as illustrated in FIG. 4, an outer tube (an aluminum tube in the present embodiment) g is overlaid (externally fitted) on an inner tube k made of carbon steel and, then, spiral-shaped disk blades b are pushed against an outer peripheral surface of the outer tube g in three directions with an interval of 120 degrees while the outer peripheral surface of the outer tube g is rotated with a rolling machine to extrude tube fins 2 in the radial direction on the outer tube g (the heat transfer tube 3) and to bring the outer tube g into intimate contact with the inner tube k, at the same time.

**[0038]** Further, in the present embodiment, the heat transfer tubes 3 are structured, such that the carbon steel is not exposed at the outer peripheral surfaces of the heat transfer tubes 3, since the outer tube g made of aluminum is overlaid on the outer side of the inner tube k made of the carbon steel and, also, the outer peripheral surface of the outer tube g is drawn in the radial direction to form the spiral tube fins 2. Accordingly, the heat transfer tubes 3 are not corroded since the carbon steel does not contact with the heat medium M flowing outside thereof and, also, the heat transfer tubes 3 have a high heat conductivity since they are structured such that the aluminum with a high heat conductivity comes into intimate contact with the carbon steel. However, the structure of the heat transfer tubes 3 is not necessarily limited to this structure. Namely, the heat transfer tubes 3 can be structured such that tube fins 2 formed as separate members are coupled to straight tube portions (tube portions) through welding or the like. Also, the tube fins 2 and the straight tube portions can be formed from separate members (different materials) and are required only to form finned tubes including radially-extending tube fins on the

outer peripheral surfaces of the straight tubes.

**[0039]** Further, in the present embodiment, general-purpose products are employed as the heat transfer tubes 3. By employing such general-purpose heat transfer tubes 3 as described above, it is possible to reduce a cost of the heat exchanger 1 and delivery time for the heat exchanger 1. However, the heat transfer tubes 3 are not necessarily limited thereto, and the heat transfer tubes 3 can be dedicated products.

**[0040]** Returning to FIGS. 1 to 3, the spiral tube fin heat exchanger 1 includes the plurality of heat transfer tubes 3, 3,... including such spiral-shaped tube fins 2, and these heat transfer tubes 3, 3, ... are arranged in parallel to form the heat transfer tube bank 30.

**[0041]** Hereinafter, a tube layout of the heat transfer tubes 3 will be described. As illustrated in FIG. 5(a), the heat transfer tubes are laterally arranged in a plurality of rows such that each single row is along a vertical direction, in the direction of the center axes of the heat transfer tubes 3. The respective rows are arranged such that the heat transfer tubes 3,3,... are spaced apart from one another by the same interval (the distance between the center axes C of heat transfer tubes 3 adjacent to each other in the vertical direction is d), and adjacent rows are arranged such that they are deviated from each other in the vertical direction by half the aforementioned same interval d (1/2d). Namely, the heat transfer tubes 3,3, ...are arranged such that a line connecting the center axes C, C of adjacent heat transfer tubes 3, 3 in adjacent rows forms an angle of 45 degrees with respect to an upward and downward (vertical) direction or a lateral (horizontal) direction. Further, the heat transfer tubes 3,3, ...are arranged such that a rectangular shape is formed if the center axes C, C,... of adjacent heat transfer tubes 3, 3, ... in different rows are connected to one another. While, in the present embodiment, the heat transfer tubes 3,3, ...are arranged such that the aforementioned rectangular shape is a square, the arrangement thereof is not limited thereto and, as illustrated in FIG. 5 (b), it is also possible to employ an arrangement which forms a rhombus if the center axes C, C, ... of adjacent heat transfer tubes 3, 3, ... in adjacent rows are connected to one another, namely an arrangement which causes the lines connecting the center axes C, C, ... of adjacent heat transfer tubes 3, 3, ... in adjacent rows to one another to form an angle of 60 degrees with respect to the lateral (horizontal) direction.

**[0042]** Further, as illustrated in FIG. 6, the heat transfer tubes 3, 3,... in adjacent rows are formed (set), such that the tube fins 2 therein are rotated in directions opposite to each other. Accordingly, the corresponding tube fin portions 2', 2',... in adjacent heat transfer tubes 3, 3 are parallel to each other (or substantially parallel to each other) (see FIG. 6(b)). This enables making the pitch of adjacent heat transfer tubes 3, 3 (the distance between the center axes C of the heat transfer tubes 3, 3) P to be a minimum pitch (the pitch which brings tip ends of the tube fin portions 2', 2',... in one (the other one) of the

adjacent heat transfer tubes 3, 3 into contact with the outer peripheral surface (of the tube portion) of the other one (one) of the heat transfer tubes 3)  $P_{\min}$ . Further, since the corresponding tube fin portions 2', 2',... in adjacent heat transfer tubes 3, 3 are parallel (or substantially parallel) to each other, the corresponding tube fin portions 2', 2',... are prevented from coming into contact with each other when the plurality of heat transfer tubes 3, 3,... are brought close to one another to form the heat transfer tube bank 30, which facilitates operations for assembling the heat transfer tube bank 30.

**[0043]** Further, in the present embodiment, the tube fin portions 2' are portions of the tube fins 2 in the heat transfer tubes 3 which are faced to the heat transfer tubes 3 adjacent thereto. Further, in the present embodiment, the heat transfer tubes 3, 3,... are arranged such that the pitch P of adjacent heat transfer tubes 3, 3 is the minimum pitch  $P_{\min}$ , but it is not necessary that the pitch P is limited thereto, and the pitch P is required only to cause the tip ends of the tube fin portions 2', 2',... in one (the other one) of adjacent heat transfer tubes 3, 3 to intrude between the tube fin portions 2', 2',... in the other one (one) of them. Namely, adjacent heat transfer tubes 3, 3 can have, therebetween, any positional relationship which causes the tube fin portions 2', 2',... in these heat transfer tubes 3, 3 to be superimposed on (overlapped with) each other in the direction of the center axes of the heat transfer tubes 3, 3. Since the heat transfer tube bank 30 is structured at a state where the tube fin portions 2', 2',... in adjacent heat transfer tubes 3, 3 are overlapped with each other as described above, it is possible to make the pitch P of the heat transfer tubes 3, 3,... smaller than those of heat transfer tube banks 30 including tube fin portions 2', 2',... which are not overlapped with each other, which enables reduction of a size of the entire heat transfer tube bank 30. This enables reduction of a size of the heat exchanger 1.

**[0044]** The heat transfer tube bank 30 including the heat transfer tubes 3, 3,... which are arranged as described above is divided into the flow-in heat transfer tube bank 30a which causes the heat exchanging object W which has been flown from the outside of the spiral tube fin heat exchanger 1 to flow through the insides of the heat transfer tubes 3, 3 therein, and the flow-out heat transfer tube bank 30b which causes the heat exchanging object W which is to flow to the outside of the spiral tube fin heat exchanger 1 to flow through the insides of the heat transfer tubes 3, 3,... therein.

**[0045]** The heat-transfer-tube-bank-inlet 5 is provided at an end portion of the flow-in heat transfer tube bank 30a at one side thereof and is structured to flow the heat exchanging object W which has been flown thereto from the outside of the spiral tube fin heat exchanger 1 into the end portions of the respective heat transfer tubes 3, 3,... which constitute the flow-in heat transfer tube bank 30a at one sides thereof.

**[0046]** The heat-transfer-tube-bank-outlet 6 is provided at an end portion of the flow-out heat transfer tube

bank 30b at one side thereof and is structured to collectively flow, to the outside of the spiral tube fin heat exchanger 1, the heat exchanging object W which has been flown thereto from the end portions of the respective heat transfer tubes 3, 3,... constituting the flow-out heat transfer tube bank 30b at one sides thereof.

**[0047]** The heat-transfer-tube-bank-coupling portion 7 is provided at an end portion of the heat transfer tube bank 30 (the flow-in heat transfer tube bank 30a and the flow-out heat transfer tube bank 30b) at an other side thereof and couples the end portion of the flow-in heat transfer tube bank 30a (the heat transfer tubes 3, 3,... constituting the bank 30a) at the other side to the end portion of the flow-out heat transfer tube bank 30b (the heat transfer tubes 3, 3,... constituting the bank 30b) at the other side, in order to guide the heat exchanging object W which has flowed through the insides of the heat transfer tubes 3, 3,... constituting the flow-in heat transfer tube bank 30a to the insides of the heat transfer tubes 3, 3,... constituting the flow-out heat transfer tube bank 30b.

**[0048]** Namely, the heat exchanging object W which has flowed through the heat-transfer-tube-bank-inlet 5 from the outside of the spiral finned tube heat exchanger 1 flows through the insides of the heat transfer tubes 3, 3,... constituting the flow-in heat transfer tube bank 30a from the end portions at one side to the end portions at the other side, then flows back at the heat-transfer-tube-bank-coupling portion 7, then flows through the insides of the heat transfer tubes 3, 3,... constituting the flow-out heat transfer tube bank 30b from the end portions at the other side to the end portions at the one side and, then, flows to the outside of the spiral finned tube heat exchanger 1 through the heat-transfer-tube-bank-outlet 6.

**[0049]** The shell 8 is a cylindrical-shaped casing member which enables arranging the heat transfer tube bank 30 inside thereof and is provided, at an end portion at the other side, with a shell flow-in port 9 as a flow-in port and a shell flow-out port 10 as a flow-out port for the heat medium M flowing through the inside thereof. More specifically, as illustrated in FIG. 7, in the shell 8, at a center portion of the inside thereof in a plan view, the heat transfer tube bank 30 arranged, along the longitudinal direction, such that the end portion at the one side thereof (the heat-transfer-tube-bank-inlet 5 and the heat-transfer-tube-bank-outlet 6) is protruded, and such that the flow-in heat transfer tube bank 30a is positioned near a front surface (a side where the shell flow-in port 9 and the shell flow-out portion 10 are opened) and the flow-out heat transfer tube bank 30b is positioned near a rear surface.

**[0050]** The spiral finned tube heat exchanger 1 according to the present embodiment has the aforementioned structure and, hereinafter, the operations thereof will be described.

**[0051]** The heat exchanging object W flows into the heat-transfer-tube bank-inlet 5 protruding from the end portion of the shell 8 at the one side thereof, then flows through the insides of the respective heat transfer tubes

3, 3,... constituting the flow-in heat transfer tube bank 30a from the one side to the other side thereof, then flows back at the heat-transfer-tube-bank-coupling portion 7, then flows through the insides of the respective heat transfer tubes 3, 3,... constituting the flow-out heat transfer tube bank 30b from the other side to the one side, and then flows from the spiral tube fin heat exchanger 1 through the heat-transfer-tube-bank-outlet 6 protruding from the end portion of the shell 8 at the one side thereof.

**[0052]** On the other hand, the heat medium M flows into the flow-in port 9 provided at the end portion of an outer side of the shell 8 at the other side and, then, flows through the inside of the heat transfer tube bank 30 in a direction orthogonal or substantially orthogonal to the longitudinal direction of the heat transfer tube bank 30 from the side of the flow-out heat transfer tube bank 30b to the side of the flow-in heat transfer tube bank 30a in the heat transfer tube bank 30 arranged inside thereof, and the heat medium M which has passed through the heat transfer tube bank 30 flows out through the flow-out port 10 provided at an inner side of the end portion of the shell 8 at the other side.

**[0053]** When the heat medium M passes through the inside of the heat transfer tube bank 30 as described above, heat possessed by the heat medium M flowing outside of the heat transfer tubes 3 is transferred to the heat exchanging object W flowing through the insides of the heat transfer tubes 3, 3,... constituting the heat transfer tube bank 30, thus resulting in a decrease (reduction) of the temperature of the heat medium M passed through the heat transfer tube bank 30 to a predetermined temperature. More specifically, since the heat medium M comes into contact with the tube fins 2 and the outer peripheral surfaces of the tube portions of the heat transfer tubes 3, the aforementioned heat is transferred to the tube fins 2 and the outer peripheral surfaces of the tube portions of the heat transfer tubes 3, the transferred heat is transferred to the inner peripheral surfaces of the heat transfer tubes 3 through the tube fins 2 and tube walls of the heat transfer tubes, and heat is continuously transferred to (absorbed by) the heat exchanging object W which is flowing while being in contact with these inner peripheral surfaces. Thus, heat exchange between the heat medium M and the heat exchanging object W is attained. Namely, the heat medium M flowing outside of the heat transfer tubes 3 exchanges heat possessed thereby with the heat exchanging object W flowing inside of the heat transfer tubes 3 through the tube fins 2 and the tube portions of the heat transfer tubes 3.

**[0054]** There will be further described the flow of the heat medium M when passing through the inside of the heat transfer tube bank 30. In the heat transfer tube bank 30, the heat transfer tubes 3, 3,... are arranged such that the tube fin portions 2', 2',... in one of adjacent heat transfer tubes 3, 3 intrude between the tube fin portions 2', 2',... in the other one of adjacent heat transfer tubes 3, 3. Accordingly, a spacing of the tube fin portions 2', 2',... in the heat transfer tube bank 30 is significantly small. In

this case, an amount of the heat medium M which is to be processed by the spiral finned tube heat exchanger 1 according to the present embodiment is set to be equal to that of a heat exchanger including tube fin portions 2', 2',... which are arranged such that they are not overlapped with one another in the direction of the center axes C of the heat transfer tubes 3. Accordingly, a velocity of the flow of the heat medium M passing through the aforementioned small spacing of the tube fin portions 2', 2',... is significantly greater (the velocity of the flow is increased). This increases a heat-transfer coefficient, which results in an increase of an amount of heat which is absorbed from the heat medium M (transferred to the heat transfer tubes 3), thereby increasing heat exchange efficiency of the spiral finned tube heat exchanger 1.

**[0055]** Further, the tube fins 2 are formed to have a spiral shape (are spiral tube fins) and, therefore, form a predetermined angle with respect to a plane orthogonal to the center axes C of the heat transfer tubes 3. Accordingly, the heat medium M flowing through the heat transfer tube bank 30 in the direction orthogonal (or substantially orthogonal) to the center axes C of the heat transfer tubes 3 impinges on the spiral-shaped tube fins 2. This impingement induces disturbances in the flow of the heat medium M. An occurrence of the disturbances in the fluid (the heat medium M) as described above increases an effect of mixing and diffusing the heat medium M.

**[0056]** This increases the heat-transfer coefficient, which increases the amount of heat transferred from the heat medium M to the surfaces of the heat transfer tubes 3, thereby increasing the amount of heat transferred to (absorbed by) the heat exchanging object W from the heat medium M through the tube walls of the heat transfer tubes 3. This results in an increase of the heat exchange efficiency of the spiral tube fin heat exchanger 1. Further, the heat medium M has a uniform temperature, since the fluid is mixed and diffused by the occurrence of the aforementioned disturbances in the fluid. This prevents a reduction of the amount of heat transfer due to temperature unevenness, which increases the amount of heat transferred from the heat medium M to the heat exchanging object W through the heat transfer tubes 3, thereby increasing the heat exchange efficiency.

**[0057]** As described above, in the spiral finned tube heat exchanger 1 according to the present embodiment, the plurality of heat transfer tubes 3, 3,... constituting the heat transfer tube bank 30 are structured such that the tube fin portions 2', 2',... in one (the other one) of adjacent heat transfer tubes 3, 3 intrude between the tube fin portions 2', 2',..., in the other one (one) of them, which can make the pitch P of the heat transfer tubes 3, 3,... smaller (the minimum pitch  $P_{\min}$  in the present embodiment), thereby enabling reduction of the size of the heat exchanger 1 and, also, increasing performance of the heat exchanger 1 due to the above-described increase of the heat exchange efficiency.

**[0058]** FIG. 8 illustrates results of flow analysis (CFD: Computational Fluid Dynamics), in cases where gas

flows through the inside of a heat transfer tube bank including spiral tube fins according to the present embodiment, a heat transfer tube bank adapted such that the spiral tube fins in all the heat transfer tubes rotate in an identical direction, and a heat transfer tube bank including parallel tube fins.

#### <Conditions of Analysis>

#### [0059]

\*Size of the heat transfer tubes (common to all the heat transfer tube banks)

Outer diameter of the fins: 58.4 mm

Root diameter (the outer diameter of the tube portions of the heat transfer tubes): 27.18 mm

Thickness of the fin tip ends: 0.2 mm

Thickness of base portions of the fins (portions of the fins which are coupled to the tube portions of the heat transfer tubes): 1.5 mm

Pitch of the fins (or the spirals) (the size between the centers of adjacent fins): 5.08 mm

\*Arrangement of the heat transfer tubes (common to all the heat transfer tube banks)

Arrangement of the heat transfer tubes in FIG. 5(a)

Distance between adjacent tubes (the distance between the center axes):  $d = 62.2 \text{ mm}/P = 44 \text{ mm}$  (see FIG. 5)

\*Used gas (common to all the heat transfer tube banks)

Type: air

Pressure: 1 atm

Temperature: 25°C

Velocity of flow: 3 m/s

Direction of the flow of the gas: left-to-right direction along the horizontal direction in FIG. 5(a)

[0060] As a result of the CFD analysis under the conditions of the analysis, it was proven that, in the case of the gas (lines in the lower stage in FIG. 8(a)) passed through the inside of the heat transfer tube bank including the parallel tube fins (a diagram in the upper stage in FIG. 8(a)), the direction of the flow of this gas was parallel to the fins and, therefore, the gas was insufficiently mixed and diffused within the heat transfer tube bank (see FIG. 8(a)). On the other hand, it was proven that, in the case of the gas (the lines in the lower stage in FIG. 8(b)) flowed through the inside of the heat transfer tube bank adapted such that the spiral tube fins in adjacent heat transfer tubes rotate in opposite directions (the heat transfer tube bank according to the present embodiment: the diagram in the upper stage in FIG. 8(b)), the direction of the flow

of this gas was not parallel to the fins (intersected therewith) and, therefore, disturbances occurred in the gas impinged on the fins within the heat transfer tube bank, thus causing the gas to be sufficiently mixed and diffused within the heat transfer tube bank (see FIG. 8(b)). Further, it was proven that, in the case of the gas (the lines in the lower stage in FIG. 8(c)) flowed through the inside of the heat transfer tube bank adapted such that the spiral tube fins in all the heat transfer tubes rotate in an identical direction (the diagram in the upper stage in FIG. 8(c)), the direction of the flow of this gas was not parallel to the fins (intersected therewith) and, in addition thereto, the corresponding tube fin portions in adjacent heat transfer tubes were partially brought into contact with each other to form a plurality of narrow flow path portions within the heat transfer tube bank, thus causing the gas to be more sufficiently mixed and diffused within the heat transfer tube bank (see FIG. 8(c)).

[0061] From the above, it was proven that the gas (the fluid) passed through the inside of the heat transfer tube bank including the spiral tube fins was more sufficiently mixed and diffused within the heat transfer tube bank than the gas (the fluid) passed through the inside of the heat transfer tube bank including the parallel tube fins.

[0062] Further, the spiral finned tube heat exchanger 1 according to the present invention is not limited to the aforementioned embodiment, and various types of changes can be made without departing from the spirits of the present invention.

[0063] For example, in the present embodiment, as described above, the heat transfer tubes 3, 3,... in adjacent rows are formed such that the smooth tube fins 2 having no recess and protrusion therein are rotated in directions opposite to each other. Therefore, the corresponding tube fin portions 2', 2',... in adjacent heat transfer tubes are parallel (or substantially parallel) to each other, and the tip ends of the tube fin portions 2', 2',... in one (the other one) of adjacent heat transfer tubes 3, 3 are brought into contact with the outer peripheral surface of the other one (one) of the heat transfer tubes 3, while the corresponding tube fin portions 2', 2',... are prevented from coming into contact with each other. However, the present invention is not limited thereto and, as illustrated in FIG. 9, the tube fin portions 2', 2',... can be provided with protruding portions 11, 11,..., such that the corresponding tube fin portions 2', 2',... in adjacent heat transfer tubes 3, 3 are brought into contact with each other through the protruding portions.

[0064] With this structure, the corresponding fin portions 2', 2',... are brought into contact with each other through the protruding portions 11 and, therefore, are supported by each other (held by each other), which increases rigidity of the tube fins 2 against forces applied thereto from the outside in the direction of the center axes C of the heat transfer tubes 3. Further, this can suppress vibrations of the tube fin portions 2', 2',... (the tube fins 2) which are caused by the flow of the fluid (the heat medium M) between adjacent tube fin portions 2', 2',...

Further, the tube fin portions 2', 2',... in adjacent heat transfer tubes 3, 3 are brought into contact with each other at a plurality of positions to be supported by each other, which increases rigidity of the heat transfer tube bank 30 which is constituted by the heat transfer tubes 3, 3,... having a smaller diameter and a greater length.

**[0065]** Further, while, in FIG. 9, the protruding portions 11 are provided in only one of the tube fin portions 2', 2' which contact with each other in adjacent heat transfer tubes 3, 3, the protruding portions 11, 11 can be formed in the tube fin portions 2', 2' which contact with each other at portions facing to each other, such that the protruding portions 11, 11 contact with each other at tip ends (top portions) thereof.

**[0066]** Further, the protruding portions 11 are formed at the peripheral edge portions (the radially-tip end portions) of the tube fin portions 2', 2',... and, also, are formed by partially bending the peripheral edge portions of the tube fin portions 2' so as to protrude in the direction of the center axes C, such that the tip ends of the tube fin portions 2' come into contact with the surface portions of the tube fin portions 2' facing thereto. However, the protruding portions 11 are not limited thereto. Namely, as illustrated in FIG. 10, the protruding portions 11 can be protruding strips 11a along the radial direction of the heat transfer tubes 3 (see FIG. 10(a)), protruding strips 11b along the spiral-shaped fin tip ends (see FIG. 10(b)) or the like, and the protruding portions 11 are required only to have a shape which prevents the tube fins 2, 2 facing to each other from coming into surface-to-surface contact with each other, namely brings them into point-to-point contact or line-to-line contact. Further, the number of the formed protruding portions is not limited to four and can be one or two or more. Further, even in the case where the tube fins come into surface-to-surface contact, it is also possible to form protruding portions with a reduced area (such as protruding strips with a trapezoid cross-sectional area). By employing such a shape, it is possible to make the contact areas smaller than in cases where plate-shaped tube fins come into surface-to-surface contact with each other, which can suppress the reduction of the areas which come into contact with the heat medium M (the surface areas of the exposed portions of the tube fin portions 2'), thereby suppressing the reduction of the heat exchange efficiency. Further, the tube fins 2, 2 are supported by each other with larger forces than those provided by point-to-point contact and line-to-line contact, which can increase the rigidity of the tube fins 2 and can more largely suppress vibrations when the heat exchanging object W flows between adjacent tube fins 2, 2.

**[0067]** Further, while, in the present embodiment, the heat transfer tubes 3, 3,... in adjacent rows in the heat transfer tube bank 30 are formed such that the tube fins 2, 2 therein rotate in directions opposite to each other, it is also possible to employ spiral-shaped tube fins (spiral fins) 52, 52,... all of which rotate in an identical direction, as illustrated in FIG. 11.

**[0068]** With this structure, the corresponding tube fin portions 52', 52',... in adjacent heat transfer tubes 53, 53 are inclined in such directions that they intersect with each other (see FIG. 11(b)) and, therefore, if a pitch P' of the heat transfer tubes 53, 53 is decreased such that the tip end portions of the tube fin portions 52', 52',... in one (the other one) of the heat transfer tubes 53 are positioned between the tube fin portions 52', 52',... in the other one (one) of them, the tube fin portions 52', 52',... (the tube fins 52, 52) partially come into contact with each other.

**[0069]** Therefore, the tube fin portions 52', 52',... corresponding to each other (brought into contact with each other) in adjacent heat transfer tubes 53, 53 are supported by each other, even through the tube fins 52 are provided with no protruding portions. This can increase a strength of the tube fin portions 52', 52',... (the tube fins 52) and a strength of the heat transfer tubes 53, 53,... and also can suppress vibrations of the tube fin portions 52', 52',...

**[0070]** Further, since the tube fin portions 52', 52',... come into contact with each other at portions thereof, these portions form a plurality of narrow flow path portions inside the plurality of heat transfer tubes 53, 53,... which are arranged in parallel to one another (the heat transfer tube bank). Accordingly, when the heat medium flows through the inside of the heat transfer tube bank, a greater number of irregular flows are induced at portions of this flow due to the narrow flow path portions, which increases the velocity of the flow of the heat exchanging object at a greater number of portions. The occurrence of these disturbances increases the amount of heat possessed by the heat medium M which is transferred to (absorbed by) the surfaces of the heat transfer tubes 53 as described above, thereby increasing the heat exchange efficiency. This results in an increase of the heat exchange efficiency of the heat transfer tube bank 30 (the spiral finned tube heat exchanger 1').

## Claims

1. A spiral tube fin heat exchanger comprising a plurality of heat transfer tubes that allow a heat exchanging object to flow therein and that each include a radially-extending tube fin on an outer peripheral surface thereof, the plurality of heat transfer tubes being arranged to be oriented in an identical direction, wherein the tube fin has a spiral shape and has a spiral axis being coincident with a center axis of each of the heat transfer tubes, and the plurality of heat transfer tubes are arranged such that tip ends of tube fin portions in one of adjacent heat transfer tubes intrude between tube fin portions in the other one of adjacent heat transfer tubes.
2. The spiral tube fin heat exchanger according to claim 1, wherein the spiral-shaped tube fin is structured

such that the tube fin rotates in an opposite direction from a rotating direction of the corresponding tube fin in the adjacent heat transfer tubes.

3. The spiral tube fin heat exchanger according to claim 1, wherein the spiral-shaped tube fin is structured such that the tube fin rotates in an identical direction as a rotating direction of the corresponding tube fin in the adjacent heat transfer tubes.
4. The spiral tube fin heat exchanger according any one of claims 1 to 3, wherein the corresponding tube fin portions in the adjacent heat transfer tubes are structured such that the tube fin portions in at least one of the adjacent heat transfer tubes are provided with protruding portions such that the corresponding tube fin portions are brought into contact with each other through the protruding portions.

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FIG. 1

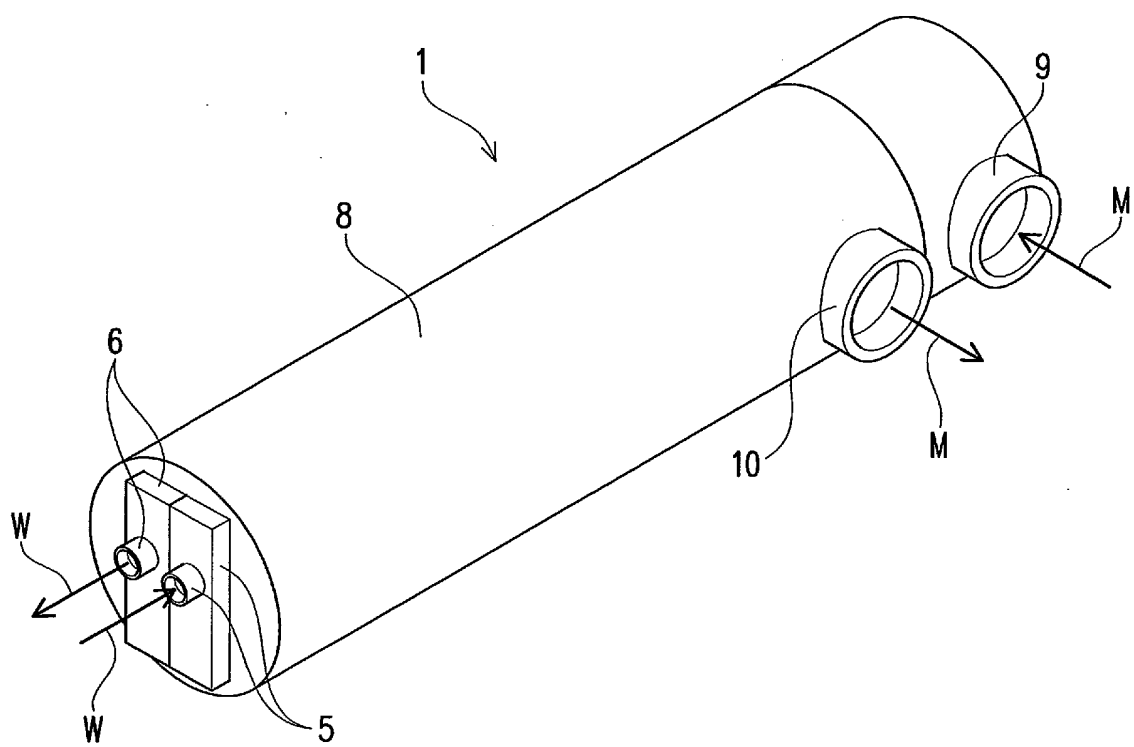


FIG. 2(a)

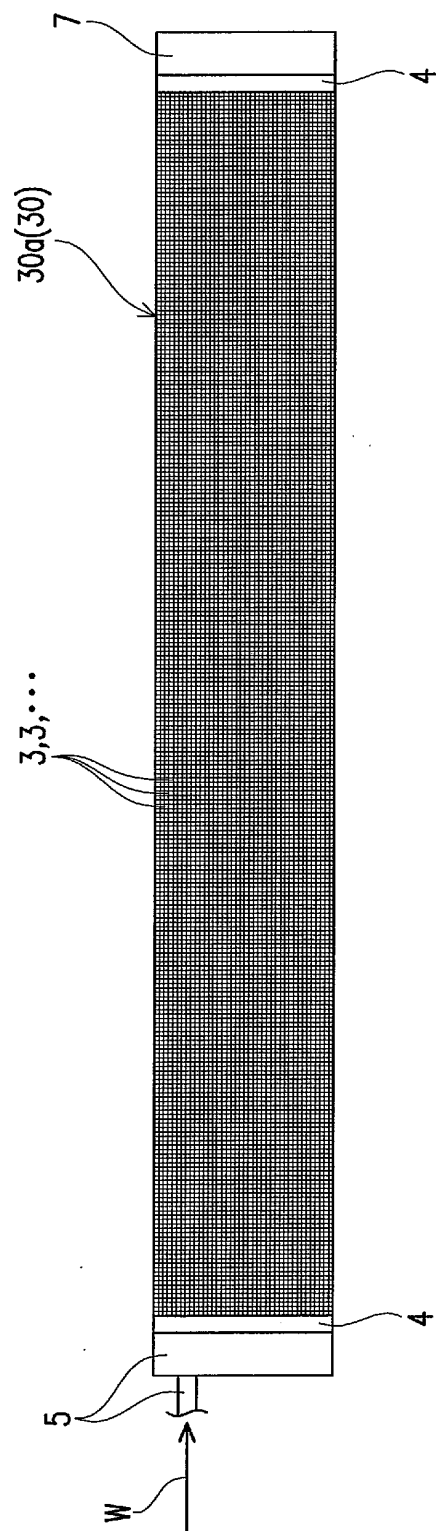


FIG. 2(b)

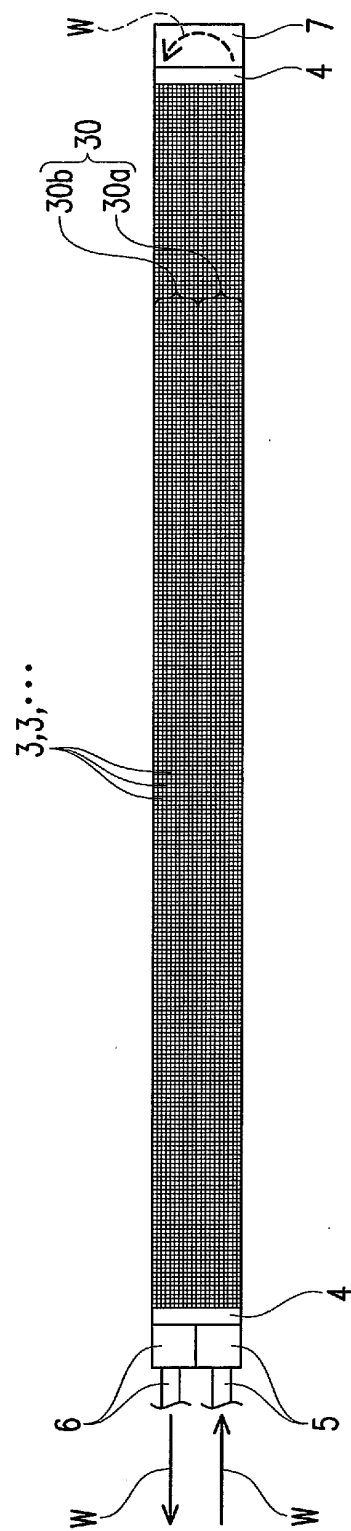
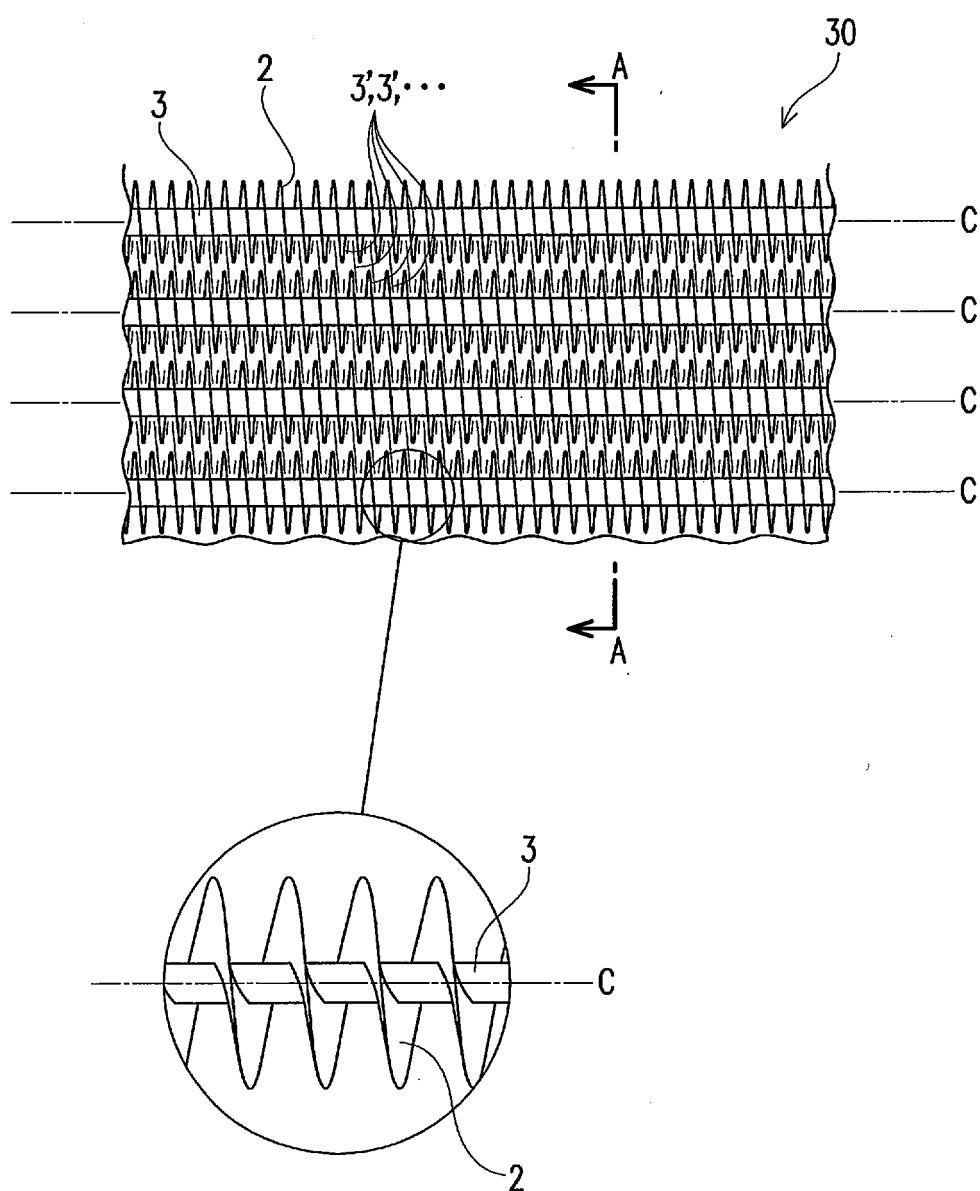
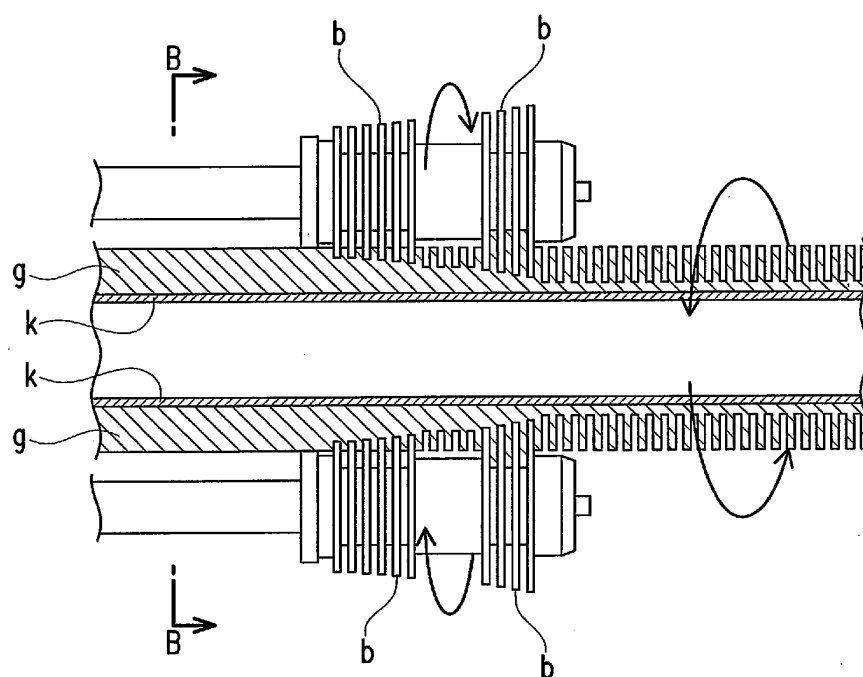


FIG. 3



F I G . 4(a)



F I G . 4(b)

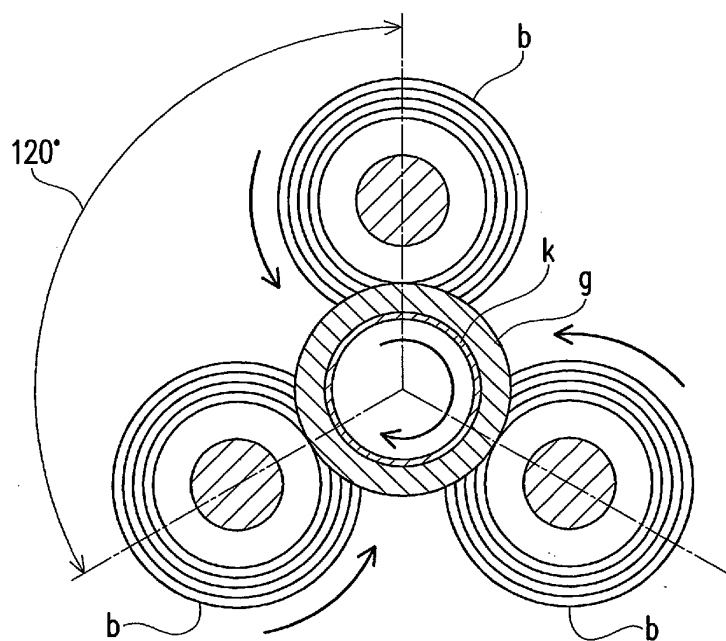


FIG. 5(a)

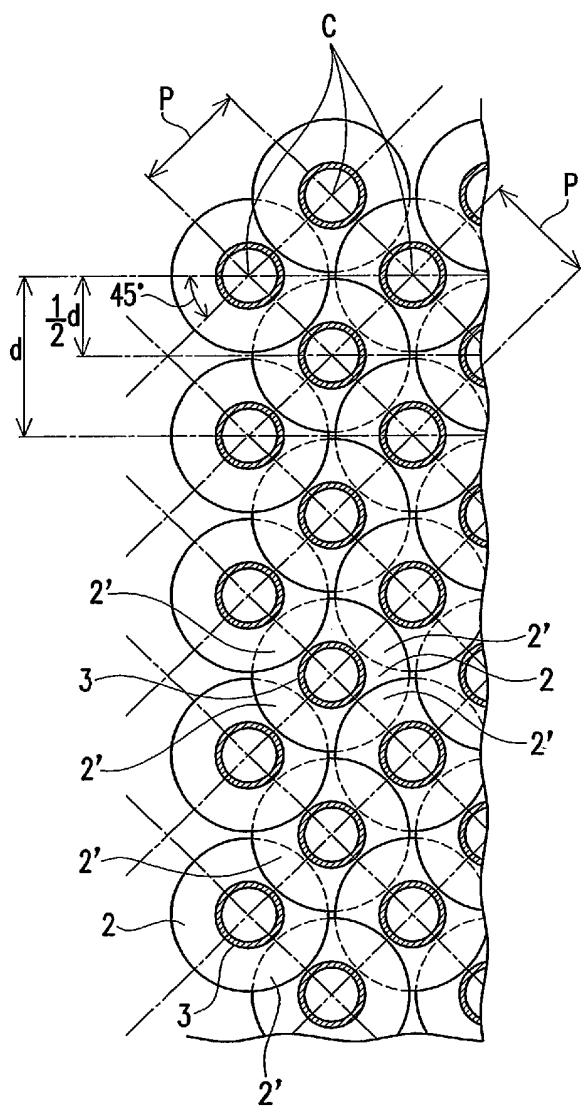


FIG. 5(b)

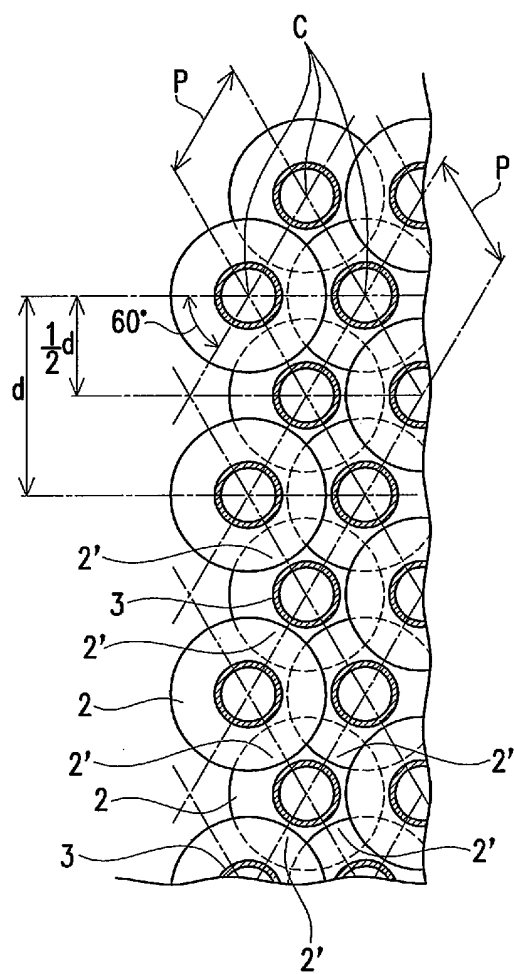


FIG. 6(a)

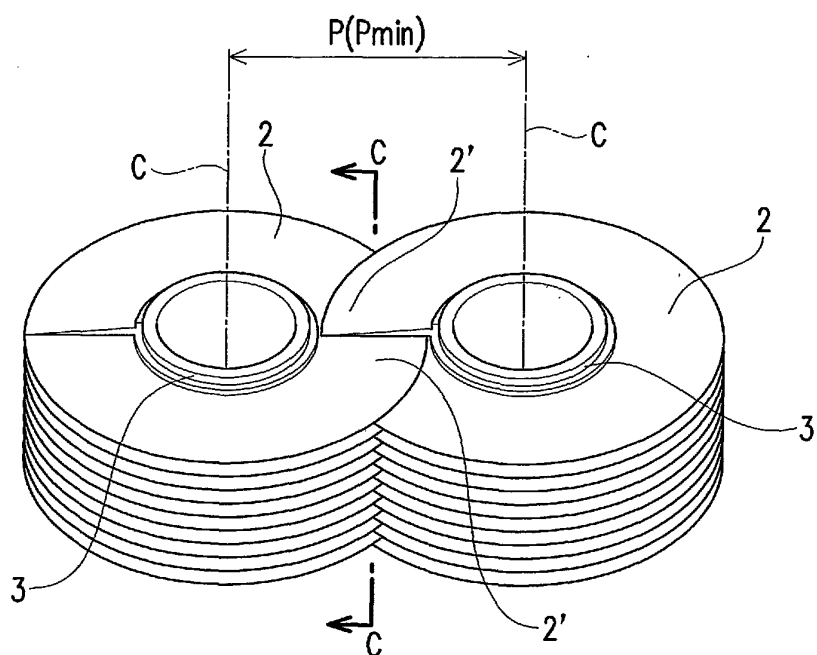


FIG. 6(b)

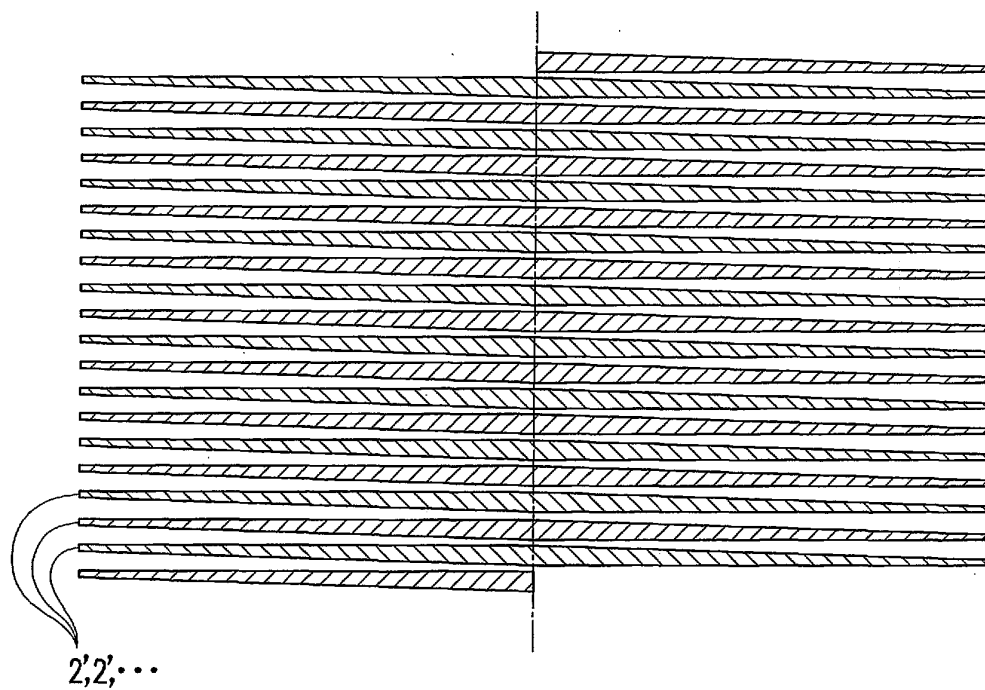
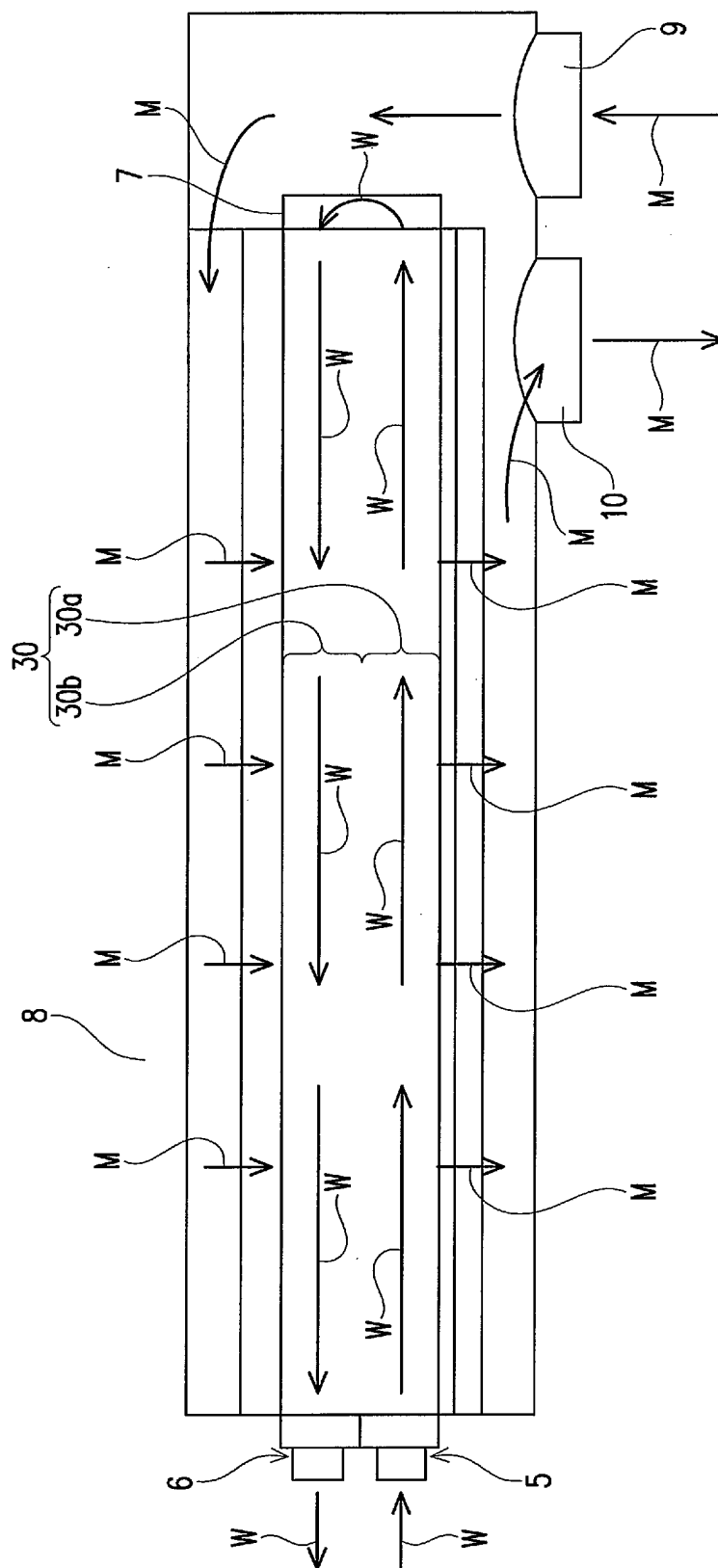
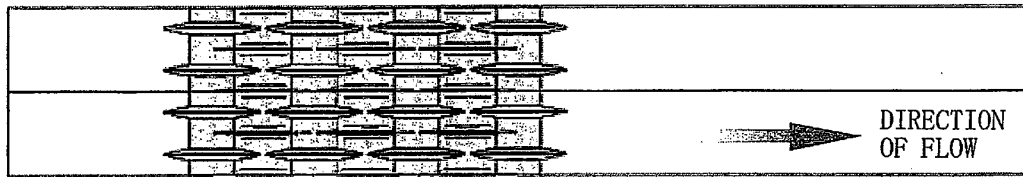


FIG. 7



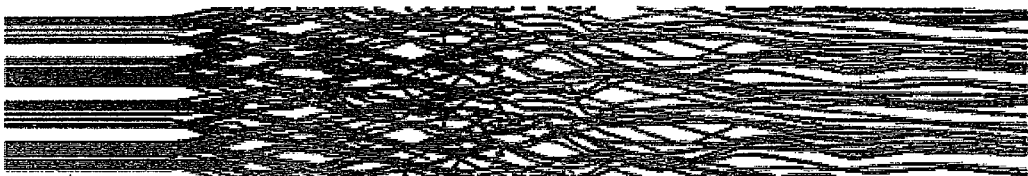
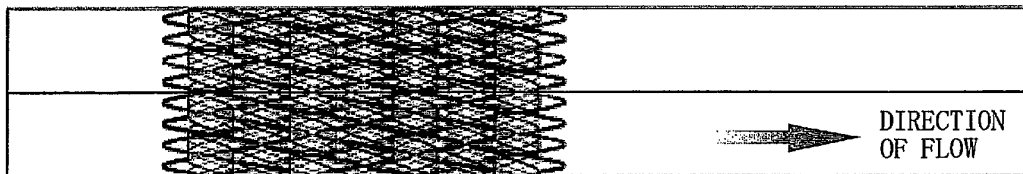
F I G . 8(a)

PARALLEL TUBE FINS



F I G . 8(b)

REVERSED SPIRAL TUBE FINS



F I G . 8(c)

IDENTICAL SPIRAL TUBE FINS



FIG. 9(a)

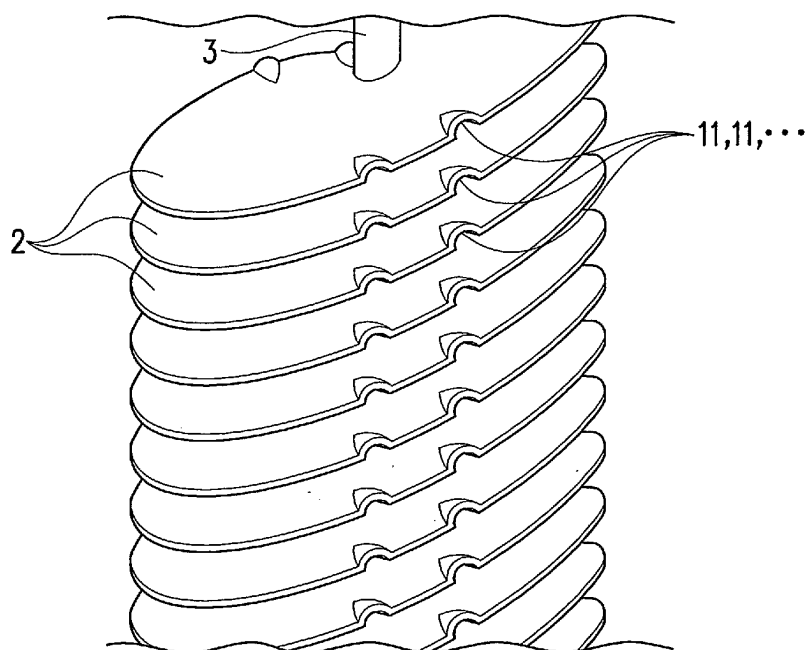
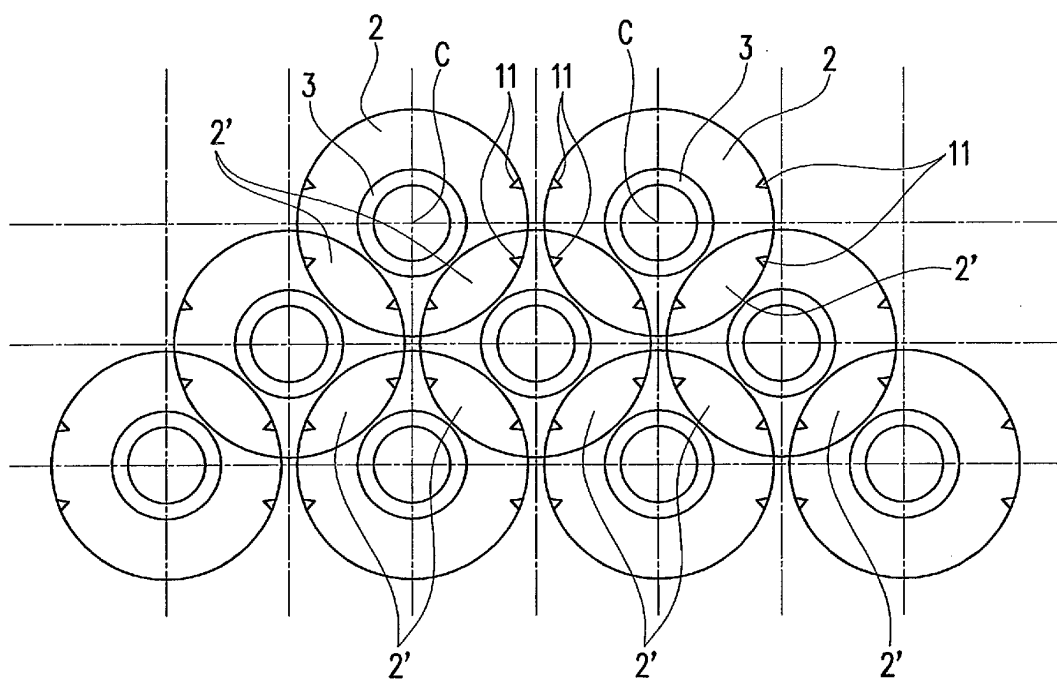
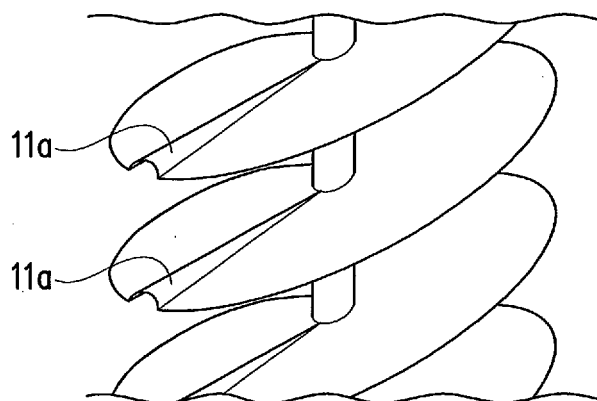


FIG. 9(b)



F I G . 10(a)



F I G . 10(b)

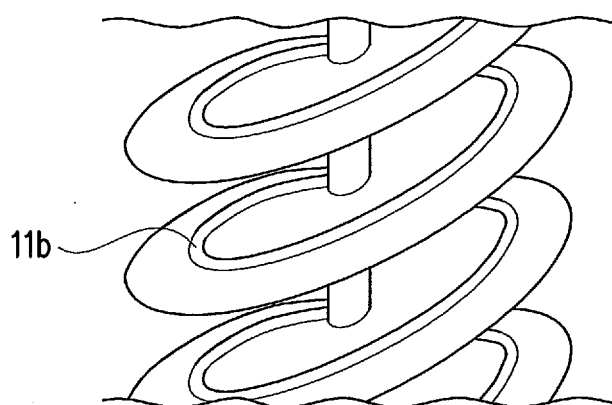


FIG. 11(a)

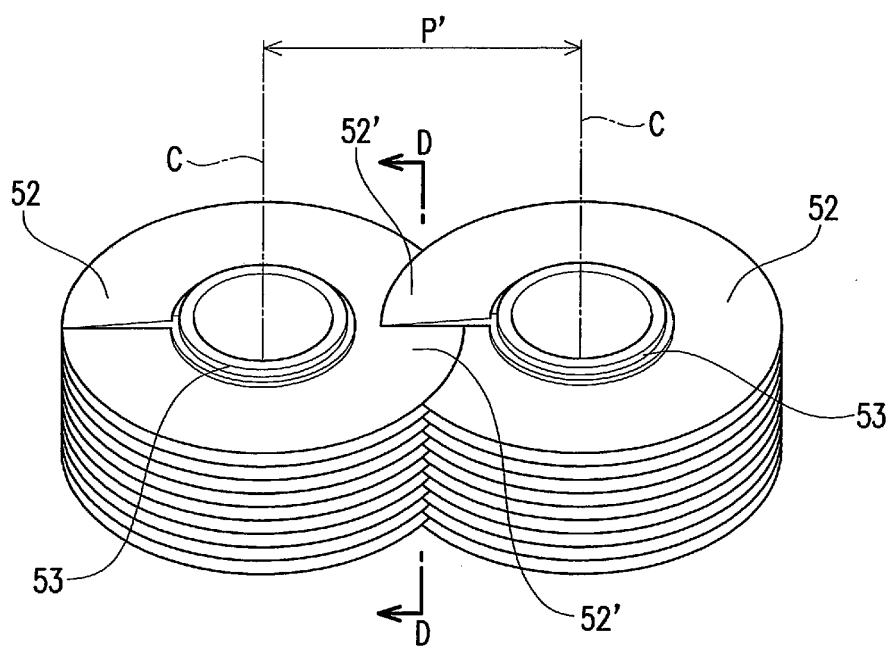
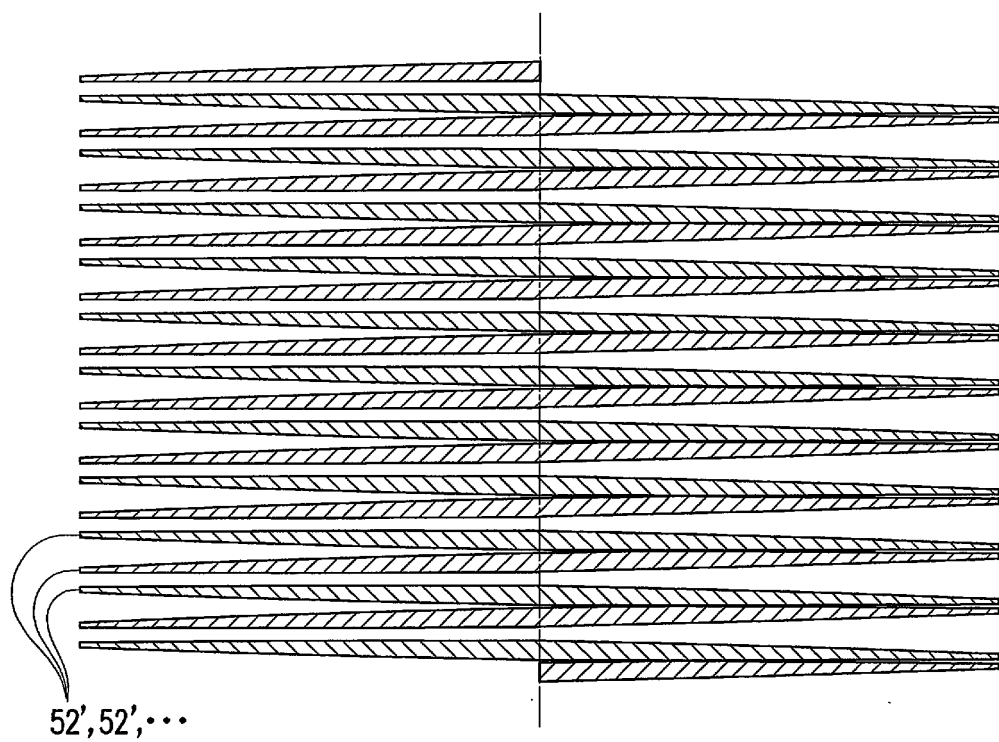
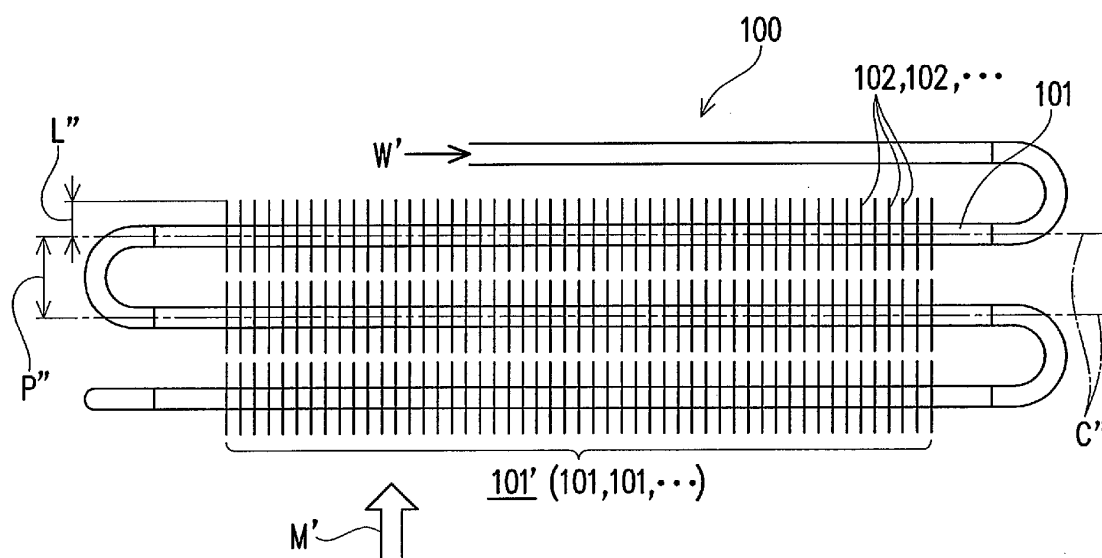


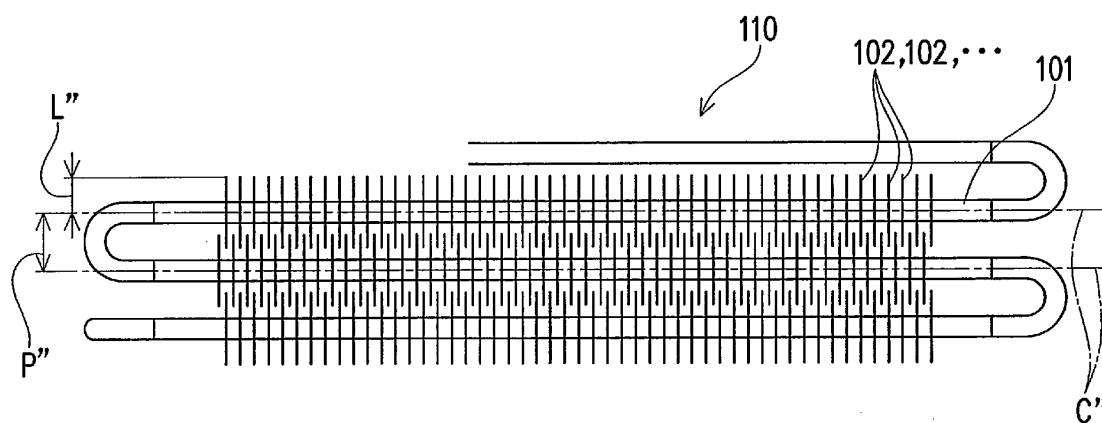
FIG. 11(b)



F I G . 12(a)



F I G . 12(b)



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2007/051594

## A. CLASSIFICATION OF SUBJECT MATTER

F28D7/16(2006.01) i, F28F1/36(2006.01) i

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

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F28D7/16, F28F1/36

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

|                           |           |                            |           |
|---------------------------|-----------|----------------------------|-----------|
| Jitsuyo Shinan Koho       | 1922-1996 | Jitsuyo Shinan Toroku Koho | 1996-2007 |
| Kokai Jitsuyo Shinan Koho | 1971-2007 | Toroku Jitsuyo Shinan Koho | 1994-2007 |

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

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                       | Relevant to claim No. |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Y         | JP 2005-233452 A (San Kagaku Kikai Kabushiki Kaisha),<br>02 September, 2005 (02.09.05),<br>Par. No. [0022]; Figs. 2, 4<br>(Family: none) | 1-4                   |
| Y         | JP 48-63353 A (Nobuo WAKASAWA),<br>03 September, 1973 (03.09.73),<br>Fig. 1<br>(Family: none)                                            | 1-4                   |

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

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Date of the actual completion of the international search

19 April, 2007 (19.04.07)

Date of mailing of the international search report

01 May, 2007 (01.05.07)

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