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(54) **Fin and heat exchanger having the same**

(57) The present invention discloses a fin (1) comprising straight segments (11), and substantially-circular arc segments (12) connected with the straight segments (11) in turn along a longitudinal direction such that the substantially-circular arc segments (12) form wave crests and wave troughs of the fin respectively, the fin (1) is divided in a lateral direction (C) into a first and second end portions (112, 114) and an intermediate portion (113) therebetween, each substantially-circular arc segment

(12) at least forming the wave troughs in the first end portion is separated from a substantially-circular arc segment (12) of a corresponding intermediate portion (113) via a longitudinal slot (111), and a top of each of the substantially-circular arc segments (12) at least forming the wave troughs in the first end portion (112) is formed with a lateral slot (110) such that each of the substantially-circular arc segments (12) at least forming the wave troughs in the first end portion (112) is divided into a first and second straight portions (12a, 12b).

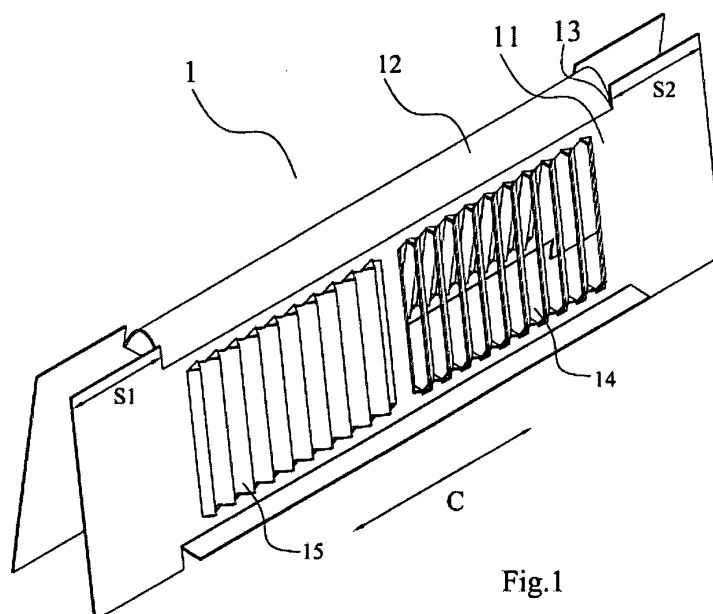


Fig.1

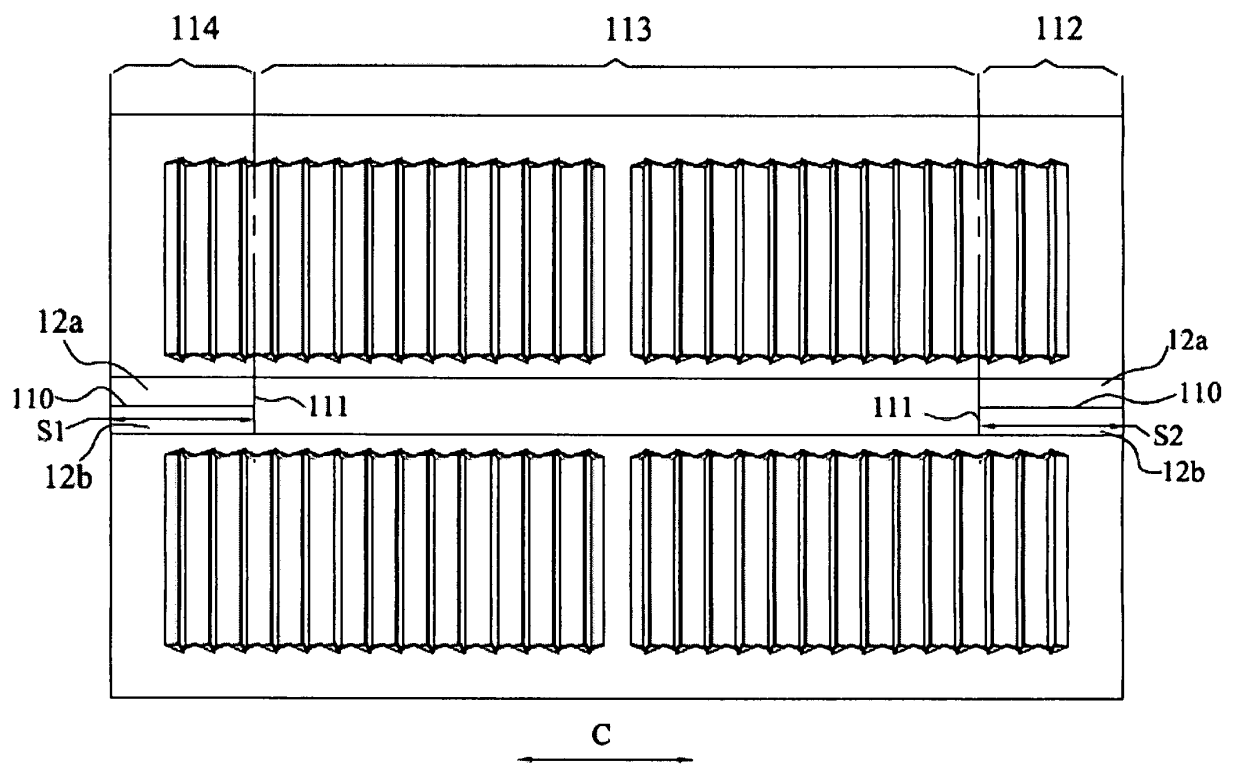


Fig.2

Description

BACKGROUND

Technical Field

[0001] The present invention relates to a fin and a heat exchanger having the same.

Description of the Related Art

[0002] When the heat exchanger of the so-called parallel flow type is used as an evaporator, condensation water will be generated on the surface of the heat exchanger. In order to improve the water drainage performance thereof, the headers of the heat exchanger of the parallel flow type are conventionally disposed horizontally and the tubes thereof are disposed vertically between the headers.

[0003] Fig. 10 is a structural schematic view of the conventional heat exchanger and Fig. 11 is an enlarged view of Portion G' in Fig. 10. For example, as shown in Figs. 10 and 11, in order to improve the water drainage performance of the heat exchanger, the headers 3a' and 3b are disposed horizontally, parallel to and spaced from each other, and the tubes 2' are disposed vertically and parallel to each other between the headers 3a' and 3b', in which fins 1' are disposed between adjacent tubes 2' respectively.

[0004] However, the conventional disposition manners of the headers and tubes are not suitable for heat exchangers of some types such as prolate type (that is, heat exchanger having a length greater than a height thereof).

[0005] With the heat exchanger of prolate type employing the above conventional disposition manners of the headers and tubes, there may be the following disadvantages.

[0006] The headers should be very long such that the manufacturing costs thereof are high, and it is difficult to achieve a uniform distribution of the refrigerant. Since the headers do not participate ventilation and heat transfer, the longer the headers, the larger the area blocking the air flow, thus decreasing the effective heat-transfer area. The tubes are short in length and large in number, that is, the number of the flow path of the refrigerant is large, so that the flow speed of the refrigerant in the tubes is low, thus causing poor heat-transfer performance.

[0007] Concerning the above, with the heat exchanger of prolate type, the headers are disposed vertically and the tubes are disposed horizontally between the headers conventionally, thus decreasing the length of the headers, increasing the length of the tubes and decreasing the number of the tubes.

[0008] However, because the conventional heat exchanger of prolate type with vertically disposed headers and horizontally disposed tubes employs conventional fins, there are some problems with the drainage of the

condensation water. For example, as shown in Fig. 12, if the air is blown along the direction D', due to the surface tension of the condensation water, most condensation water will be accumulated at the leeward side (i.e. region F' shown in Fig. 12 of the heat exchanger) and can be not drained smoothly.

SUMMARY

10 [0009] The present invention is directed to solve at least one of the problems existing in the prior art. Accordingly, an object of the present invention is to provide a fin for a heat exchanger, in which the water drainage performance of the fin is improved.

15 [0010] According to a first aspect of the present invention, an embodiment of the present invention provides a fin, comprising: straight segments, and substantially-circular arc segments connected with the straight segments in turn along a longitudinal direction such that the substantially-circular arc segments form wave crests and wave troughs of the fin respectively, in which the fin is divided in a lateral direction into a first end portion, in which a second end portion, and an intermediate portion between the first and second end portions, each of the substantially-circular arc segments at least forming the wave troughs in the first end portion is separated from a substantially-circular arc segment of a corresponding intermediate portion via a longitudinal slot, and in which a top of each of the substantially-circular arc segments at least forming the wave troughs in the first end portion is formed with a lateral slot along the lateral direction such that each of the substantially-circular arc segments at least forming the wave troughs in the first end portion is divided into a first straight portion and a second straight portion separated from each other.

30 [0011] According to the fin of the embodiment, because each of the substantially-circular arc segments at least forming the wave troughs in the first end portion is divided into the first straight portion and the second straight portion, the first straight portion and the straight segment connected therewith may be in the same plane and the second straight portion and the straight segment connected therewith may be in the same plane as well, and when the fin is disposed between adjacent tubes of a heat exchanger, one end of the fin may be extended beyond the tubes in the lateral direction, so that the condensation water may easily flow downwardly along the first and second straight portions and the straight segments to drop off the fin and may not be accumulated on the fin, thus improving the water drainage performance of the fin.

40 [0012] Preferably, each of the substantially-circular arc segments at least forming the wave troughs in the second end portion is separated from a substantially-circular arc segment of a corresponding intermediate portion via the longitudinal slot, and a top of each of the substantially-circular arc segments at least forming the wave troughs in the second end portion is formed with the lateral slot

along the lateral direction such that each of the substantially-circular arc segments at least forming the wave troughs in the second end portion is divided into a first straight portion and a second straight portion separated from each other.

[0013] According to this preferable embodiment, because each of the substantially-circular arc segments at least forming the wave troughs in the second end portion is divided into the first straight portion and the second straight portion, the first straight portion and the straight segment connected therewith may be in the same plane and the second straight portion and the straight segment connected therewith may be in the same plane as well, and when the fin is disposed between adjacent tubes of a heat exchanger, the condensation water may easily flow downwardly along the first and second straight portions and the straight segments to drop off the fin and may not be accumulated on the fin, thus further improving the water drainage performance of the fin.

[0014] Preferably, each of the substantially-circular arc segments forming the wave crests and wave troughs in the first and second end portions is separated from a substantially-circular arc segment of a corresponding intermediate portion via the longitudinal slot, and a top of each of the substantially-circular arc segments forming the wave crests and the wave troughs of the first and second end portions is formed with a lateral slot along the lateral direction such that each substantially-circular arc segment of the first and second end portions is divided into the first straight portion and the second straight portion separated from each other.

[0015] According to this preferable embodiment, because each of the substantially-circular arc segments forming the wave crests and wave troughs in the first and second end portions is divided into the first straight portion and the second straight portion, when the fin is disposed between adjacent tubes of the heat exchanger, the first and second end portions may be extended beyond the tubes in the lateral direction respectively, so that the condensation water may easily flow downwardly along the straight segments and the first and second straight portions to drop off the fin and may not be accumulated on the fin, thus further improving the water drainage performance of the fin.

[0016] Preferably, a substantially-circular arc transition segment is connected between adjacent straight segment and substantially-circular, in which $R > r$, where R is a radius of the substantially-circular arc segment and r is a radius of the substantially-circular arc transition segment.

[0017] Because the radius R of the substantially-circular arc segment is larger than the radius r of the substantially-circular arc transition segment, when the fin is assembled and welded between adjacent tubes of the heat exchanger, the substantially-circular arc segment is easy to deform, whereas the straight segments and the substantially-circular arc transition segments substantially retain their shape respectively, so that the deformation

of the fin is regular and easy to control, the fin is arranged uniformly in the heat exchanger, with a large heat-transfer coefficient, and the shape of the fin may meet the design requirements and be much more stable.

[0018] Preferably, the radius ratio R/r of the radius R of the substantially-circular arc segment to the radius r of the substantially-circular arc transition segment is larger than 2. Therefore, the substantially-circular arc segment is easier to deform, so that the deformation of the fin is more regular and easier to control.

[0019] In a preferable embodiment of the invention, $0.01 \text{ mm} \leq R(1 - \cos(\alpha/2)) \leq 0.1 \text{ mm}$, in which α is the central angle of the substantially-circular arc segment. Therefore, the manufacturability of the fin may be improved.

[0020] In a preferable embodiment of the invention, $(2 \times R \times \alpha \times \pi / 180) / P \geq 0.85$, in which P is one cycle length of the fin, α is the central angle of the substantially-circular arc segment, and π is circumference ratio. Therefore, after the fin is assembled and welded between adjacent tubes of the heat exchanger, an area surrounded by two adjacent straight segments, the substantially-circular arc segments becoming straight segments and the tubes may become substantially rectangular or trapezoid etc.

[0021] In a preferable embodiment of the invention, the central angle α of the substantially-circular arc segment is in a range of about 30° to about 170° . Therefore, the manufacture of the fin is more convenient.

[0022] In a preferable embodiment of the invention, each straight segment is formed with a window. Therefore, the heat-transfer coefficient may be further improved.

[0023] The window is formed by extending a portion of the straight segment away from a plane in which the straight segment is located.

[0024] In a preferable embodiment of the invention, $0.75 \leq L/H \leq 1.05$, in which L is a length of the window, and H is a height of the fin in the vertical direction after being deformed. Therefore, the manufacture performance of the fin may be further improved and the resistance on the air side is taken into consideration.

[0025] According to a second aspect of the present invention, an embodiment of the present invention provides a heat exchanger, comprising: a first header disposed vertically; a second header disposed vertically and spaced apart from the first header; a plurality of tubes, two ends of each flat tube being connected and communicated with the first and second headers respectively; and a plurality of fins, each of which is disposed between adjacent tubes, and a first end portion of each fin extended out from a first side of the adjacent tubes in a lateral direction,

wherein each fin comprises: straight segments; and substantially-circular arc segments connected with the straight segments in turn along a longitudinal direction such that the substantially-circular arc segments form wave crests and wave troughs of the fin respectively, wherein the fin is divided in a lateral direction into a first

end portion, a second end portion, and an intermediate portion between the first and second end portions, wherein each of the substantially-circular arc segments at least forming the wave troughs in the first end portion is separated from a substantially-circular arc segment of a corresponding intermediate portion via a longitudinal slot, and wherein a top of each of the substantially-circular arc segments at least forming the wave troughs in the first end portion is formed with a lateral slot along the lateral direction such that each of the substantially-circular arc segments at least forming the wave troughs in the first end portion is divided into a first straight portion and a second straight portion separated from each other.

[0026] In a preferable embodiment, a second end portion of each fin is extended out from a second side opposite to the first side of the adjacent tubes in the lateral direction. Therefore, the water drainage performance of heat exchanger may be further improved and it is not necessary to consider the air blowing direction during mounting.

[0027] Certainly, the heat exchanger according to the embodiment of the invention also has other advantages described above with reference to the fin.

[0028] The above summary of the present invention is not intended to describe each disclosed embodiment or every implementation of the present invention. The Figures and the detailed description which follow more particularly exemplify illustrative embodiments.

[0029] Additional aspects and advantages of the embodiments of present invention will be given in part in the following descriptions, become apparent in part from the following descriptions, or be learned from the practice of the embodiments of the present invention.

BRIEF DESCRIPTION OF DRAWINGS

[0030] These and other aspects and advantages of the invention will become apparent and more readily appreciated from the following descriptions taken in conjunction with the drawings in which:

Fig. 1 is a perspective view of a length of the fin according to an embodiment of the present invention, in which one substantially-circular arc segment and two straight segments are shown;

Fig. 2 is a view of the fin shown in Fig. 1 after being flattened;

Fig. 3 is a lateral side view of a length of the fin according to an embodiment of the present invention;

Fig. 4 is an enlarged schematic view of a portion of the fin shown in Fig. 3;

Fig. 5 is a schematic view of the fin according to an embodiment of the present invention after being assembled and welded to the tubes of a heat exchanger;

Fig. 6 is a structural schematic view of the heat exchanger according to an embodiment of the present invention;

Fig. 7 is an enlarged schematic view of Portion E in Fig. 6;

Fig. 8 is a lateral side view of a fin mounted between two tubes;

Fig. 9 is a perspective schematic view of a portion of the fin shown in Fig. 8;

Fig. 10 is a structural schematic view of a conventional heat exchanger;

Fig. 11 is an enlarged view of Portion G' shown in Fig. 10; and

Fig. 12 is a lateral side view of the conventional fin mounted between two tubes.

DETAILED DESCRIPTION

[0031] Reference will be made in detail to embodiments of the present invention. The embodiments described herein with reference to drawings are explanatory, illustrative, and used to substantially understand the present invention. The embodiments shall not be construed to limit the present invention. The same or similar elements and the elements having same or similar functions are denoted by like reference numerals throughout the descriptions.

[0032] In the description, relative terms such as "longitudinal", "lateral", "right", "left", "lower", "upper", "horizontal", "vertical", "above", "below", "up", "top", "bottom" as well as derivative thereof (e.g., "horizontally", "vertically", "downwardly", "upwardly", etc.) should be construed to refer to the orientation as then described or as shown in the drawings under discussion. These relative terms are for convenience of description and do not require that the present invention be constructed or operated in a particular orientation.

[0033] Hereinafter, the fin 1 according to an embodiment of the present invention will be described in detail with reference to Figs. 1-5.

[0034] As shown in Fig. 3, the fin 1 according to an embodiment of the present invention is substantially corrugated, and comprises straight segments 11, and substantially-circular arc segments 12 connected with the straight segments 11 in turn along a longitudinal direction B, in which the substantially-circular arc segments 12 form wave crests and wave troughs of the fin 1 respectively.

[0035] As shown in Figs. 1-2, the fin 1 is divided in a lateral direction C into a first end portion 112, a second end portion 114, and an intermediate portion 113 between the first and second end portions 112, 114. As shown in Fig. 2, the width of the first end portion 112 in the lateral direction C is S1, and the width of the second end portion 114 in the lateral direction C is S2. S1, S2 and the width of the intermediate portion 113 in the lateral direction C may be determined according to the specific applications and may be not particularly limited in the present invention.

[0036] Each of the substantially-circular arc segments 12 at least forming the wave troughs in the first end portion

tion 112 and a substantially-circular arc segment 12 of the corresponding intermediate portion 113, are split from each other in the up and down direction in Fig. 1. In other words, each of the substantially-circular arc segments 12 at least forming the wave troughs in the first end portion 112 is separated from a substantially-circular arc segment 12 of the corresponding intermediate portion 113 via a longitudinal slot 111 extended downwardly to the straight segments 11 as shown in Fig. 1. Meanwhile, a lateral slot 110 is formed along the lateral direction C in a top of each of the substantially-circular arc segments 12 at least forming the wave troughs in the first end portion 112, and the lateral slot 110 is extended through the whole first end portion 112, such that each of the substantially-circular arc segments 12 at least forming the wave troughs in the first end portion 112 is divided into a first straight portion 12a and a second straight portion 12b separated from each other. The first straight portion 12a and the straight segment 11 connected to the first straight portion 12a are in the same plane, and the second straight portion 12b and the straight segment 11 connected to the second straight portion 12b are in the same plane as well, as shown in Fig. 1. At this time, the substantially-circular arc segment 12 of the corresponding intermediate portion 113 is still substantially-circular arcuate.

[0037] When the fin 1 is disposed between adjacent tubes 2 (see Fig. 8), the first end portion 112 of the fin 1 may be extended out from a first side of the adjacent tubes 2 (i.e. the right side in Fig. 8) along the lateral direction C, that is, the first end portion 112 of the fin 1 may be extended beyond the tubes 2 in the lateral direction C. Because each of the substantially-circular arc segments 12 at least forming the wave troughs in the first end portion 112 is divided into the first straight portion 12a and the second straight portion 12b, the surface tension of the condensation water is destroyed, so that when the air is blown along a direction D, the condensation water may not be accumulated at Area F of the fin 1, and may easily flow downwardly along the straight segments 11, and the first and second straight portions 12a, 12b to drop off the fin 1, thus improving the water drainage performance of the fin 1.

[0038] In an example of the invention, each of the substantially-circular arc segments 12 at least forming the wave crests in the first end portion 112 is also divided into a first straight portion 12a and a second straight portion 12b via the longitudinal slot 111 and the lateral slot 110, such that when the fin 1 is disposed between adjacent tubes 2, the surface tension of the condensation water is destroyed by the first straight portion 12a and the second straight portion 12b, and the condensation water may easily flow downwardly along the first and second straight portions 12a, 12b of the substantially-circular arc segments 12 forming the wave crests, the straight segments 11, and the first and second straight portions 12a, 12b of the substantially-circular arc segments 12 forming the wave troughs, so as to drop off the fin 1, thus

further reducing the possibility of the accumulating of the condensation water in Area F of the fin 1 and improving the water drainage performance of the fin 1.

[0039] In another example of the invention, each of the substantially-circular arc segments 12 at least forming the wave troughs in the second end portion 114 of the fin 1 is also divided into a first straight portion 12a and a second straight portion 12b via the longitudinal slot 111 and the lateral slot 110. Further, optionally, each of the substantially-circular arc segments 12 at least forming the wave crests in the second end portion 114 is also divided into a first straight portion 12a and a second straight portion 12b via the longitudinal slot 111 and the lateral slot 110.

[0040] Therefore, when the fin 1 is disposed between adjacent tubes 2, the second end portion 114 may be extended out from a second side of the tubes 2 (i.e. the left side in Fig. 8) along the lateral direction C, that is, the second end portion 114 of the fin 1 may be extended beyond the tubes 2 in the lateral direction C. Because each of the substantially-circular arc segments 12 forming the wave troughs or both the wave troughs and the wave crests in the second end portion 114 is divided into the first straight portion 12a and the second straight portion 12b, the surface tension of the condensation water is destroyed. For example, when air is blown along a direction opposite to the direction D (i.e. the leftward direction in Fig. 8), the condensation water may not be accumulated in an area symmetrical to Area F of the fin 1, and may easily flow downwardly along the first and second straight portions 12a, 12b of the second end portion 114 and the straight segments 11 to drop off the fin 1, thus further improving the water drainage performance of the fin 1.

[0041] Because each of the substantially-circular arc segments 12 forming the wave troughs or both the wave troughs and the wave crests in both the first end portion 112 and the second end portion 114 of the fin 1 is divided into the first straight portion 12a and the second straight portion 12b, and when the fin 1 is disposed between adjacent tubes 2, both the first end portion 112 and the second end portion 114 are extended out from the two sides of the tubes 2 along the lateral direction C respectively, it is not necessary to consider the air blowing direction D during mounting, thus improving the mounting efficiency and the water drainage performance of the fin 1.

[0042] In some embodiments of the invention, as shown in Figs. 3-5, adjacent straight segment 11 and substantially-circular arc segment 12 are connected via a substantially-circular arc transition segment 13, in which $R > r$, where, R is a radius of the substantially-circular arc segment (its centre of circle is $O1$) and r is a radius of the substantially-circular arc transition segment (its centre of circle is $O2$).

[0043] As shown in Fig. 3, each end of one substantially-circular arc segment 12 is connected with an end of one substantially-circular arc transition segment 13,

and the other end of the substantially-circular arc transition segment 13 is connected with an end of another straight segment 11, and then the other end of the another straight segment 11 is connected with another substantially-circular arc transition segment 13, thus forming a substantially corrugated fin 1 extending along the longitudinal direction B. In some embodiments of the invention, two straight segment 11, two substantially-circular arc segment 12 and four substantially-circular arc transition segment 13 form one cycle of the fin 1, and one cycle length of the fin 1 is P. The fin 1 may be made, for example, by rolling metal foil. It may be understood by those skilled in the art that the cycle number of the fin 1 may be determined based on specific requirements, and is not particularly limited in the invention.

[0044] During manufacturing the heat exchanger, when the fin 1 is assembled between the tubes 2 and pressed against the tubes 2, because the radius R of the substantially-circular arc segment 12 is larger than the radius r of the substantially-circular arc transition segment 13, the substantially-circular arc segment 12 is easier to deform so as to become straight and clings to the surface of the tubes 2, as shown in Fig. 5 and Fig. 9, whereas the straight segments 11 and the substantially-circular arc transition segments 13 with a smaller radius keep their shape unchanged respectively.

[0045] Furthermore, the deformation of the substantially-circular arc segments 12 are regular, and the deformation of each of the substantially-circular arc segments 12 is uniform, so that the deformation of the fin 1 is regular and easy to control, the fin 1 is arranged uniformly in the heat exchanger, and the shape of the fin 1 may meet the design requirements and may be much more stable. After welding, Areas A surrounded by two adjacent straight segments 11, the substantially-circular arc segments 12 becoming straight and the tubes 2 becomes substantially trapezoid and the shape of each of Areas A is uniform, as shown in Fig. 5. The heat exchanger of the embodiments of the present invention has an increased heat-transfer coefficient on the air blowing side, an improved heat-transfer performance and a much more regular and aesthetic appearance.

[0046] In some examples of the invention, by changing the size of the substantially-circular arc segments 12, Areas A may be substantially rectangular or square after welding.

[0047] In some examples of the invention, the radius ratio R/r of the radius R of the substantially-circular arc segment 12 to the radius r of the substantially-circular arc transition segment 13 is larger than 2, so that the substantially-circular arc segment 12 is easier to deform. Compared with r, the larger the radius R, the easier the deformation of the substantially-circular arc segment 12 is. For example, R may be 5 times larger than r, and if R is 1 mm, r is 0.2 mm.

[0048] As shown in Fig. 4, when the substantially-circular arc segment 12 becomes straight, the compressed distance of the substantially-circular arc segment 12 is

N (i. e. the chordal height of the substantially-circular arc segment 12). In some examples of the invention, in order to make the manufacture of the fin 1 easier and more feasible, the compressed distance N is controlled within 0.01-0.1 mm, i.e. $0.01 \text{ mm} \leq R (1 - \cos(\alpha/2)) \leq 0.1 \text{ mm}$, in which R is the radius of the substantially-circular arc segment 12, and α is the central angle of the substantially-circular arc segment 12. Additionally, in order to make the manufacture more convenient, in an example of the invention, the central angle α of the substantially-circular arc segment 12 is set in a range of about 30° to about 170° .

[0049] In other examples of the invention, in order to make the shape of Area A regular (such as rectangular or trapezoid shape) after the fin 1 is assembled and welded to the tubes 2, $(2 \times R \times \alpha \times \pi / 180) / P \geq 0.85$, in which R is the radius of the substantially-circular arc segment 12, α is the central angle of the substantially-circular arc segment 12, π is circumference ratio, and P is one cycle length of the fin 1, in other words, P is the length of the straight line between two points having same phase, for example the distance between the lower ends of the two straight segments 11 inclined upwardly and rightward in Fig. 3, or the distance between the vertices of the two substantially-circular arc segments 12 forming the adjacent wave crests or wave troughs.

[0050] As shown in Figs. 1-3 and Fig. 5, in some examples of the invention, because the deformation of the fin 1 is mainly presented by the deformation of the substantially-circular arc segments 12 (becoming straight), and the straight segments 11 are substantially not deformed, so that the straight segments 11 may be formed with a window 14, thus further improving the heat-transfer coefficient and the heat-transfer performance of the heat exchanger. The window 14 may be formed by extending, such as punching, a middle portion 15 of the straight segment 11 away from the plane in which the straight segment 11 is located. The window 14 may be also formed by cutting a slot in the straight segment 11, and then punching to turn the portion 15 of the straight segment 11 from the plane in which the straight segment 11 is located, so that the portion 15 may not be separated from the straight segment 11, thus further improving the heat-transfer coefficient and the heat-transfer performance.

[0051] In an example of the invention, as shown in Fig. 3, taking into consideration the manufacture performance and the resistance on the air blowing side, the length L of the window 14 and the height H of the fin 1 satisfy the equation: $0.75 \leq L/H \leq 1.05$, thus achieving better performance. It should be noted that the length L is the length of the window 14 in the longitudinal direction (the direction indicated by Arrow Q in Fig. 3) of the straight segment 11, and the height H is the height in the vertical direction (the up and down direction in Fig. 5) after formation of the fin 1, i.e. the distance between two parallel substantially-circular arc segment 12 in the up and down direction when the substantially-circular arc segment 12 becomes straight, as shown in Fig. 5.

[0052] Hereinafter, the heat exchanger according to an embodiment of the present invention will be described in detail with reference to Figs. 6-9.

[0053] As shown in Figs. 6-7, the heat exchanger according to the embodiment of the present invention comprises a first header 3a, a second header 3b, a plurality of tubes 2, and a plurality of fins 1. In an example of the invention, the first header 3a is used as inlet header, and the second header 3b is used as outlet header, and the tube 2 may be a flat tube.

[0054] The first header 3a and the second header 3b are substantially disposed vertically, i.e. along the up and down direction in Fig. 6. The first header 3a and the second header 3b are substantially parallel with each other and spaced apart from each other by a predetermined distance.

[0055] The tubes 2 is disposed between the first header 3a and the second header 3b, and two ends of each flat tube 2 are connected and communicated with the first header 3a and the second header 3b respectively. A plurality of micro-channels are formed in each flat tube 2, so that the heat exchanger according to the invention is referred as a micro-channel heat exchanger.

[0056] It should be noted that the above terms "horizontally" and "vertically" are based on the orientation and position relations in the accompanying figures, used to facilitate describing the relative position relations between the tubes 2 and the first and second headers 3a, 3b respectively, and may not be understood to limit the invention.

[0057] As shown in Fig. 8, each fin 1 is disposed between adjacent tubes 2, and the first end portion 112 of each fin 1 may be extended out from a first side of the adjacent tubes 2 (i.e. the right side in Fig. 8) along the lateral direction C. The substantially-circular arc segments 12 forming the wave troughs and the wave crests in the intermediate portion 113 of each fin 1 are pressed and flattened by the tubes 2, as shown in Fig. 9. Because each of the substantially-circular arc segments 12 forming the wave troughs and the wave crests in the first end portion 112 are divided into the first straight portion 12a and the second straight portion 12b via the longitudinal slot 111 and the lateral slot 110, the surface tension of the condensation water is destroyed. Therefore, when blowing air along the direction D, the condensation water may be not accumulated in Area F of the fin 1, and may easily flow downwardly along the straight segments 11, and the first and second straight portions 12a, 12b to drop off each fin 1, thus improving the water drainage performance of the heat exchanger.

[0058] In an alternative embodiment of the invention, each of the substantially-circular arc segments 12 forming the wave troughs and the wave crests in the second end portion 114 is also divided into the first straight portion 12a and the second straight portion 12b via the longitudinal slot 111 and the lateral slot 110, so that when blowing air along a direction opposite to the direction D, the condensation water may be not accumulated in an

area (i.e. the left side in Fig. 8) symmetrical to the area F of the fin 1, and may easily flow downwardly along the first and second straight portions 12a, 12b of the second end portion 114, and the straight segments 11 to drop off the fin 1, thus further improving the water drainage performance of the heat exchanger, and it is not necessary to consider the direction D during mounting.

[0059] As described above, because the adjacent substantially-circular arc segment 12 and the straight segment 11 of the fin 1 are connected via the substantially-circular arc transition segment 13, in which the radius R of the substantially-circular arc segment 12 is larger than the radius r of the substantially-circular arc transition segment 13, when the fin 1 is disposed between adjacent tubes 2, the substantially-circular arc segments 12 forming the wave troughs and the wave crests in the intermediate portion 113 of each fin 1 are pressed and flattened by the tubes 2 more easily, as shown in Figs. 8-9 and Fig. 5, so that the shape of Areas A are regular, and the shape of Areas A is uniform. The heat exchanger so manufactured has an increased heat-transfer coefficient, an improved heat-transfer performance and a much more regular and aesthetic appearance.

[0060] Certainly, the heat exchanger according to the embodiment of the invention also has other advantages described with reference to the fin 1.

[0061] Accordingly, the heat exchanger according to embodiments of the invention has good water drainage performance, the condensation water does not tend to accumulate on the fin 1, and the fin 1 has a regular arrangement in the heat exchanger, an increased heat-transfer coefficient and a high heat-transfer performance.

[0062] Reference throughout this specification to "an embodiment," "some embodiments," "one embodiment," "an example," "a specific examples," or "some examples," means that a particular feature, structure, material, or characteristic described in connection with the embodiment or example is included in at least one embodiment or example of the invention. Thus, the appearances of the phrases such as "in some embodiments," "in one embodiment" "in an embodiment", "an example," or "some examples," in various places throughout this specification are not necessarily referring to the same embodiment or example of the invention. Furthermore, the particular features, structures, materials, or characteristics may be combined in any suitable manner in one or more embodiments or examples.

[0063] Although explanatory embodiments have been shown and described, it would be appreciated by those skilled in the art that changes, alternatives, and modifications can be made in the embodiments without departing from spirit and principles of the invention. Such changes, alternatives, and modifications all fall into the scope of the claims and their equivalents.

Claims**1.** A fin, comprising:

straight segments; and
 substantially-circular arc segments connected with the straight segments in turn along a longitudinal direction such that the substantially-circular arc segments form wave crests and wave troughs of the fin respectively,
 wherein the fin is divided in a lateral direction into a first end portion, a second end portion, and an intermediate portion between the first and second end portions,
 wherein each of the substantially-circular arc segments at least forming the wave troughs in the first end portion is separated from a substantially-circular arc segment of a corresponding intermediate portion via a longitudinal slot, and
 wherein a top of each of the substantially-circular arc segments at least forming the wave troughs in the first end portion is formed with a lateral slot along the lateral direction such that each of the substantially-circular arc segments at least forming the wave troughs in the first end portion is divided into a first straight portion and a second straight portion separated from each other.

2. The fin according to claim 1, wherein each of the substantially-circular arc segments at least forming the wave troughs in the second end portion is separated from a substantially-circular arc segment of a corresponding intermediate portion via the longitudinal slot, and
 wherein a top of each of the substantially-circular arc segments at least forming the wave troughs in the second end portion is formed with the lateral slot along the lateral direction such that each of the substantially-circular arc segments at least forming the wave troughs in the second end portion is divided into a first straight portion and a second straight portion separated from each other.

3. The fin according to claim 2, wherein each of the substantially-circular arc segments forming the wave crests and wave troughs in the first and second end portions is separated from a substantially-circular arc segment of a corresponding intermediate portion via the longitudinal slot, and
 wherein a top of each of the substantially-circular arc segments forming the wave crests and the wave troughs of the first and second end portions is formed with a lateral slot along the lateral direction such that each substantially-circular arc segment of the first and second end portions is divided into the first straight portion and the second straight portion separated from each other.

4. The fin according to any one of claims 1-3, wherein a substantially-circular arc transition segment is connected between adjacent straight segment and substantially-circular, in which $R > r$, where R is a radius of the substantially-circular arc segment and r is a radius of the substantially-circular arc transition segment.

5. The fin according to claim 4, wherein $R/r > 2$.

6. The fin according to claim 4, wherein

$$0.01\text{mm} \leq R(1 - \cos(\alpha/2)) \leq 0.1\text{mm} ,$$

where: α is a central angle of the substantially-circular arc segment.

7. The fin according to claim 4, wherein

$$(2 \times R \times \alpha \times \pi / 180) / P \geq 0.85 ,$$

where:

P is one cycle length of the fin,
 α is a central angle of the substantially-circular arc segment, and
 π is circumference ratio.

8. The fin according to claim 4, wherein $30^\circ \leq \alpha \leq 170^\circ$, where: α is a central angle of the substantially-circular arc segment.

9. The fin according to claim 4, wherein each straight segment is formed with a window.

10. The fin according to claim 9, wherein the window is formed by extending a portion of the straight segment away from a plane in which the straight segment is located.

11. The fin according to claim 9, wherein $0.85 \leq L/H \leq 1.05$,
 where:

L is a length of the window, and
 H is a height of the fin in the vertical direction after being deformed.

12. A heat exchanger, comprising:

a first header disposed vertically;
 a second header disposed vertically and spaced apart from the first header;
 a plurality of tubes, two ends of each flat tube

being connected and communicated with the first and second headers respectively; and a plurality of fins, each of which is disposed between adjacent tubes, a first end portion of each fin being extended out from a first side of the adjacent tubes in a lateral direction, and each fin is any one of claims 1-10. 5

13. The heat exchanger according to claim 12, wherein a second end portion of each fin is extended out from a second side opposite to the first side of the adjacent tubes in the lateral direction. 10

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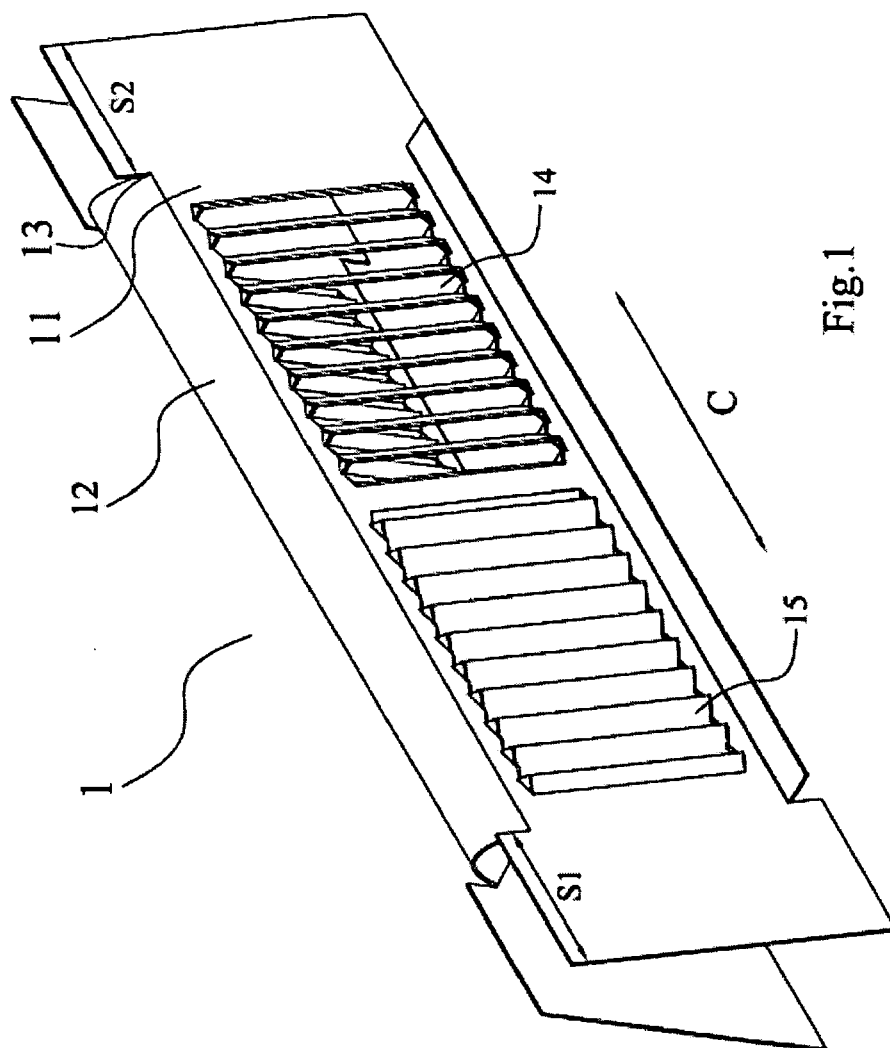
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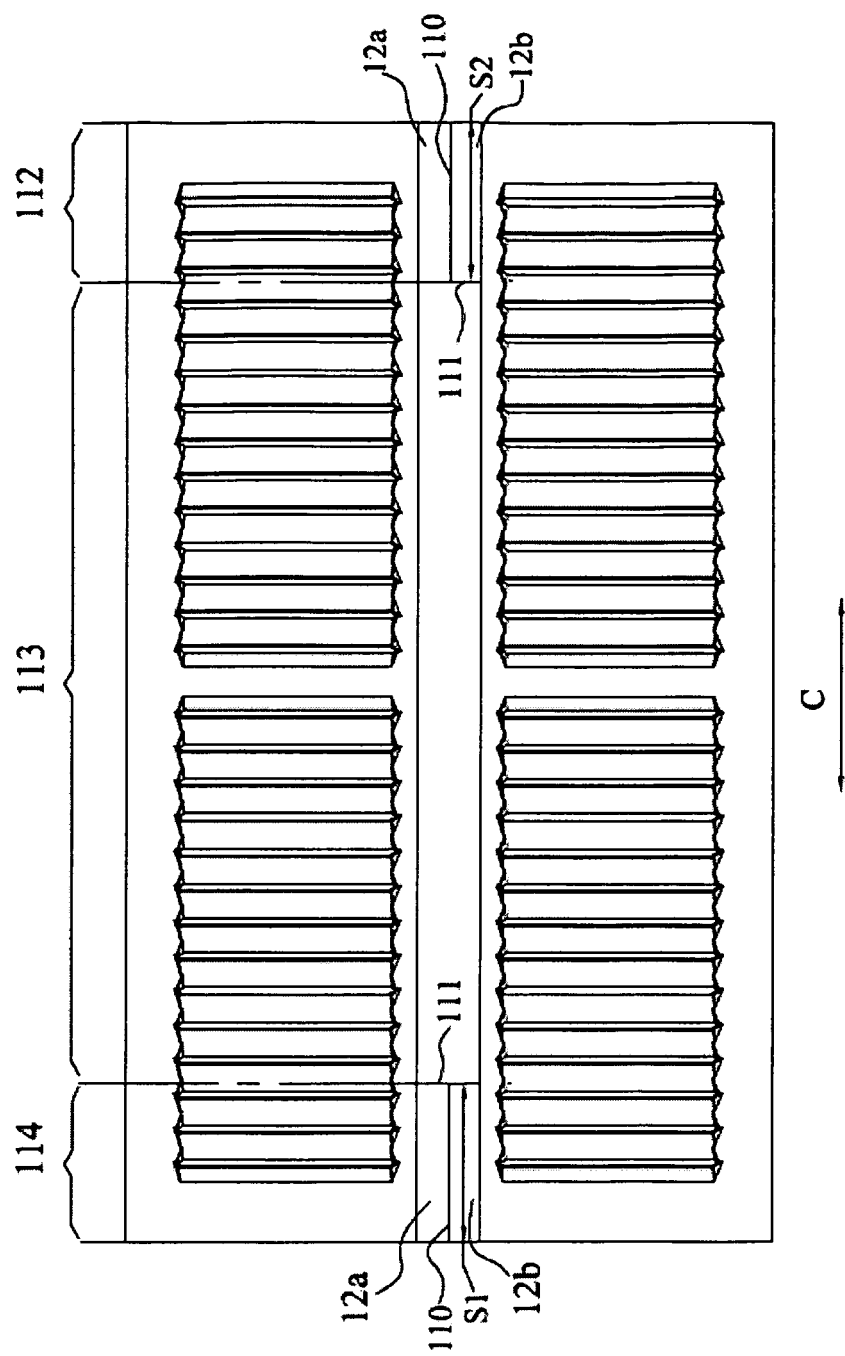


Fig.2

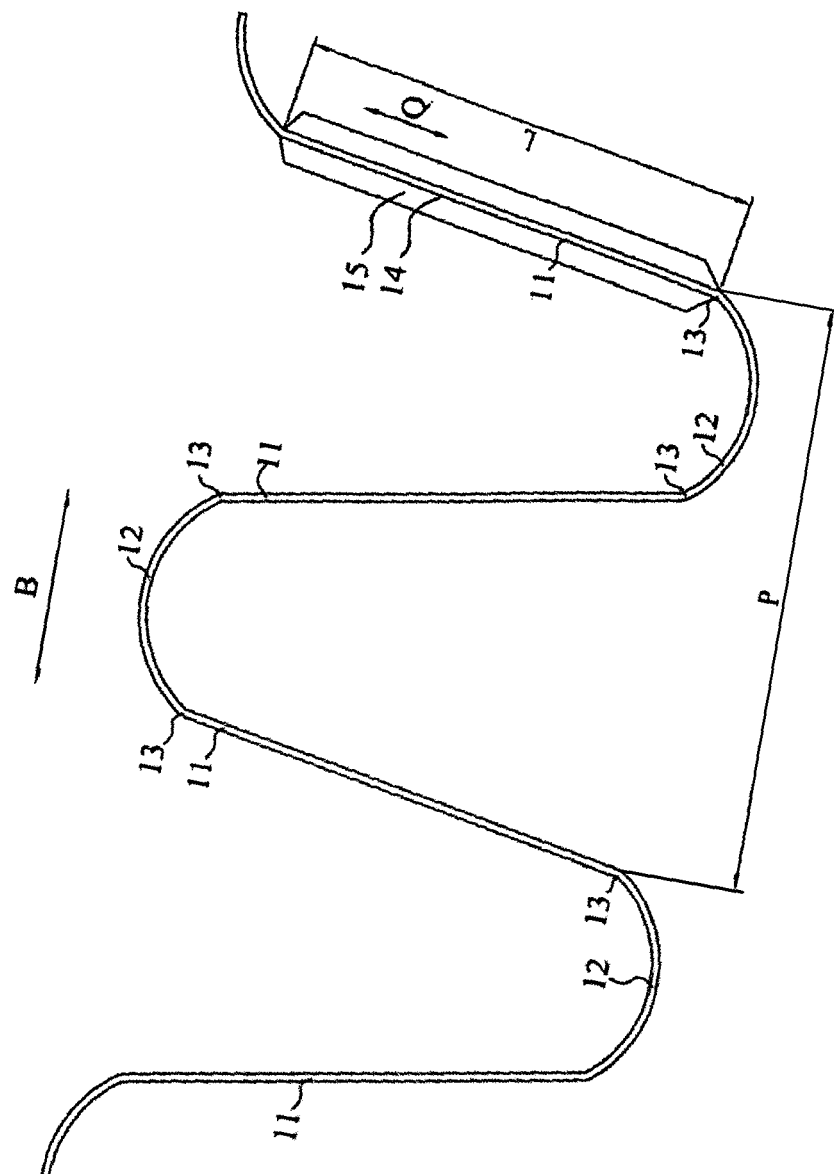


Fig.3

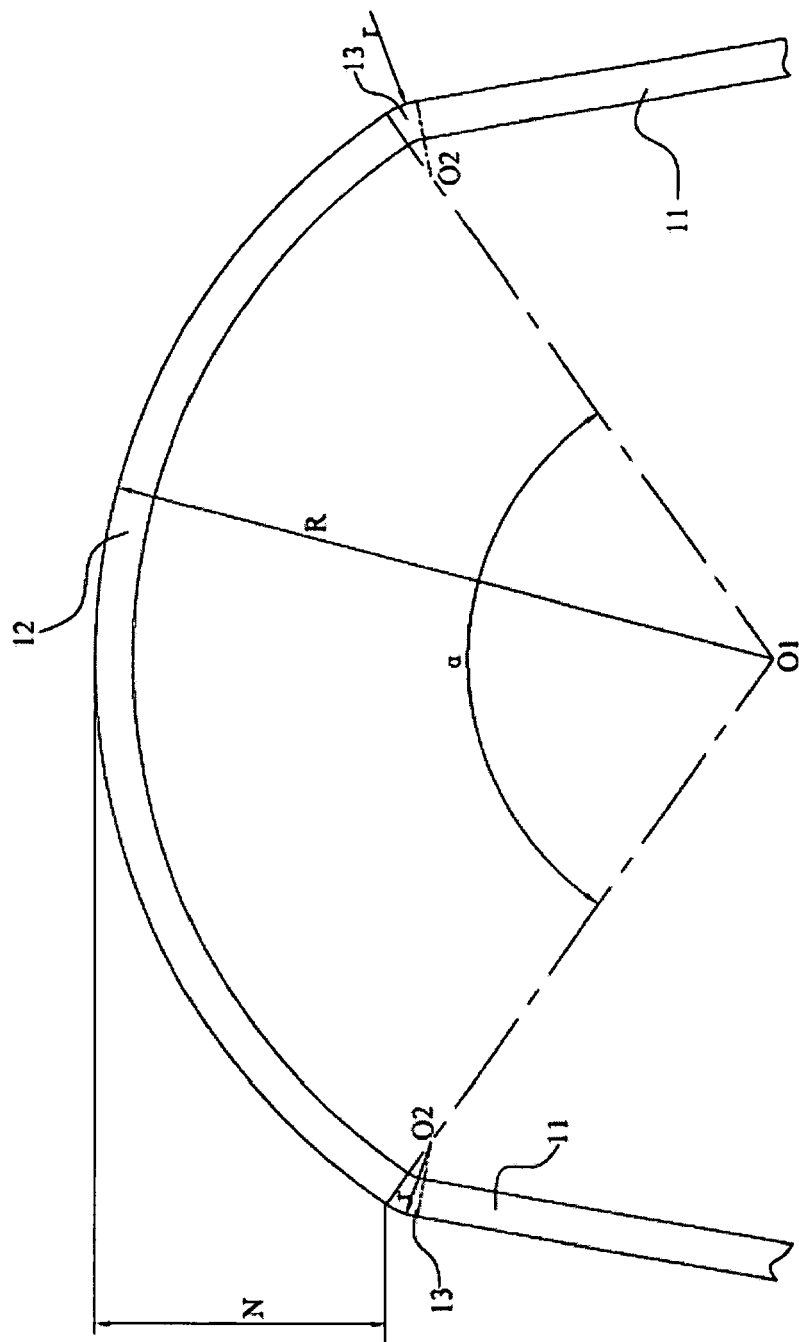


Fig.4

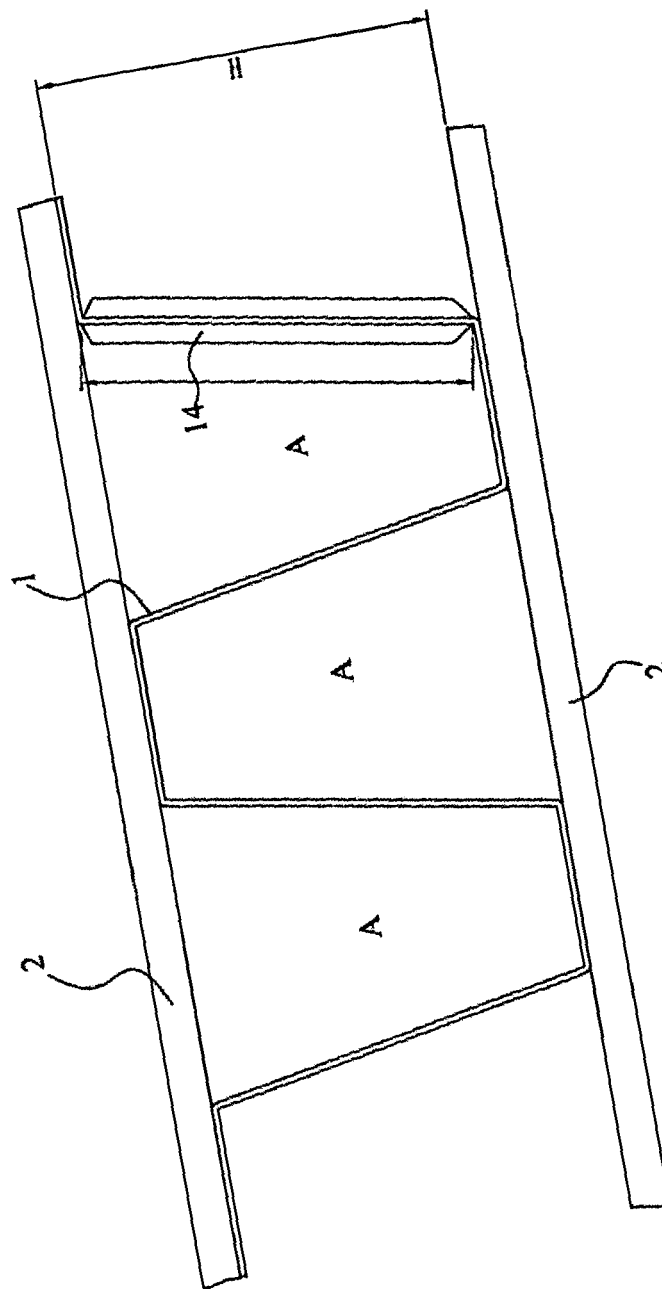


Fig. 5

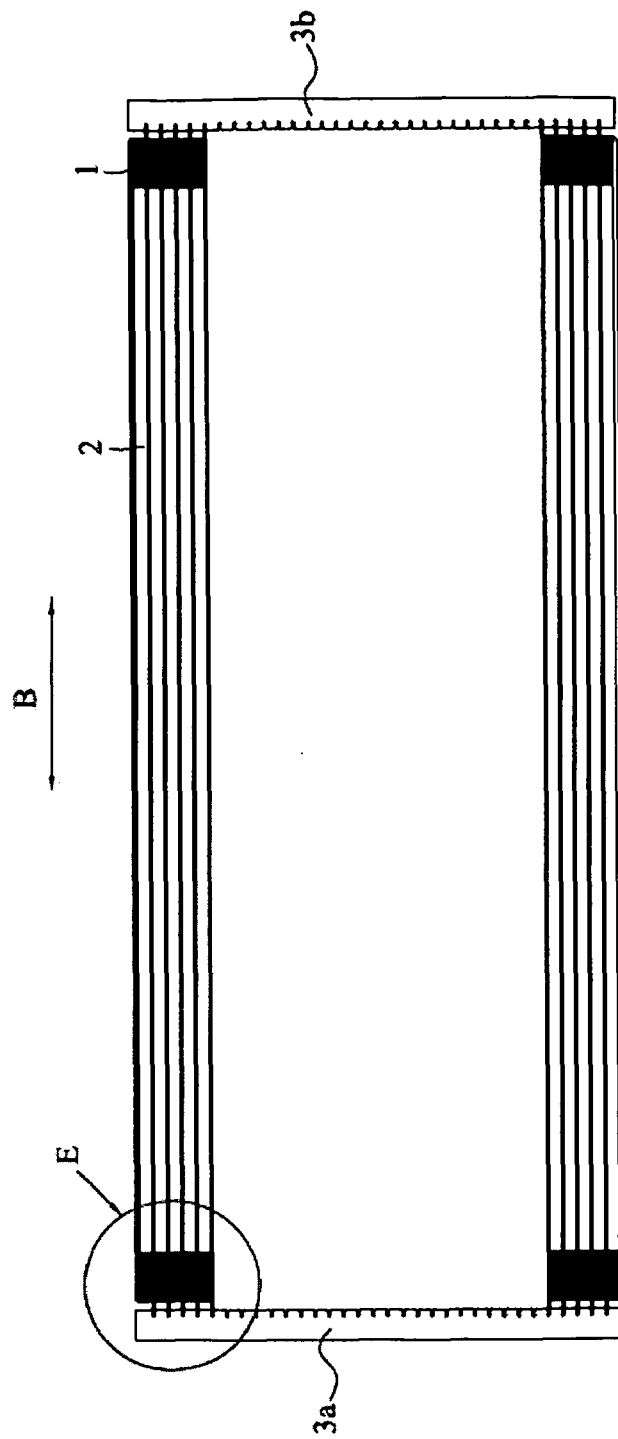


Fig.6

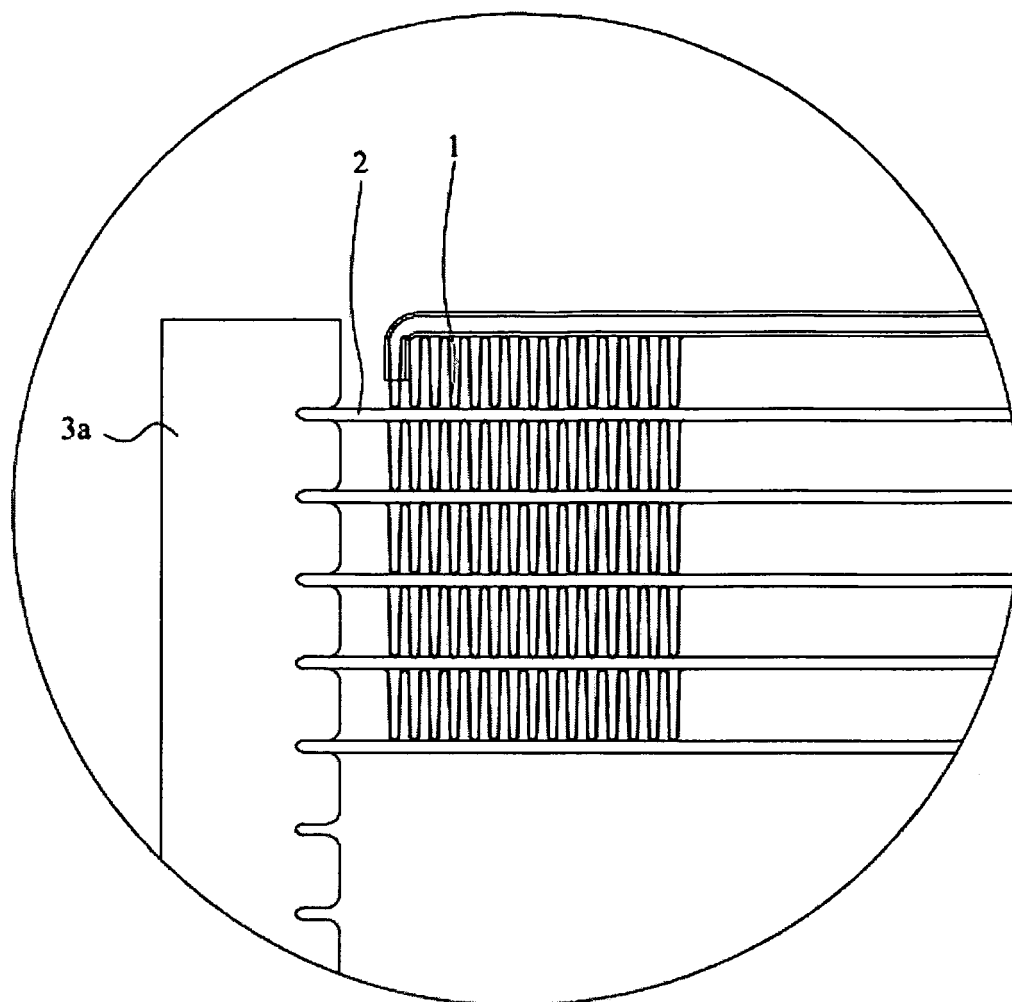


Fig.7

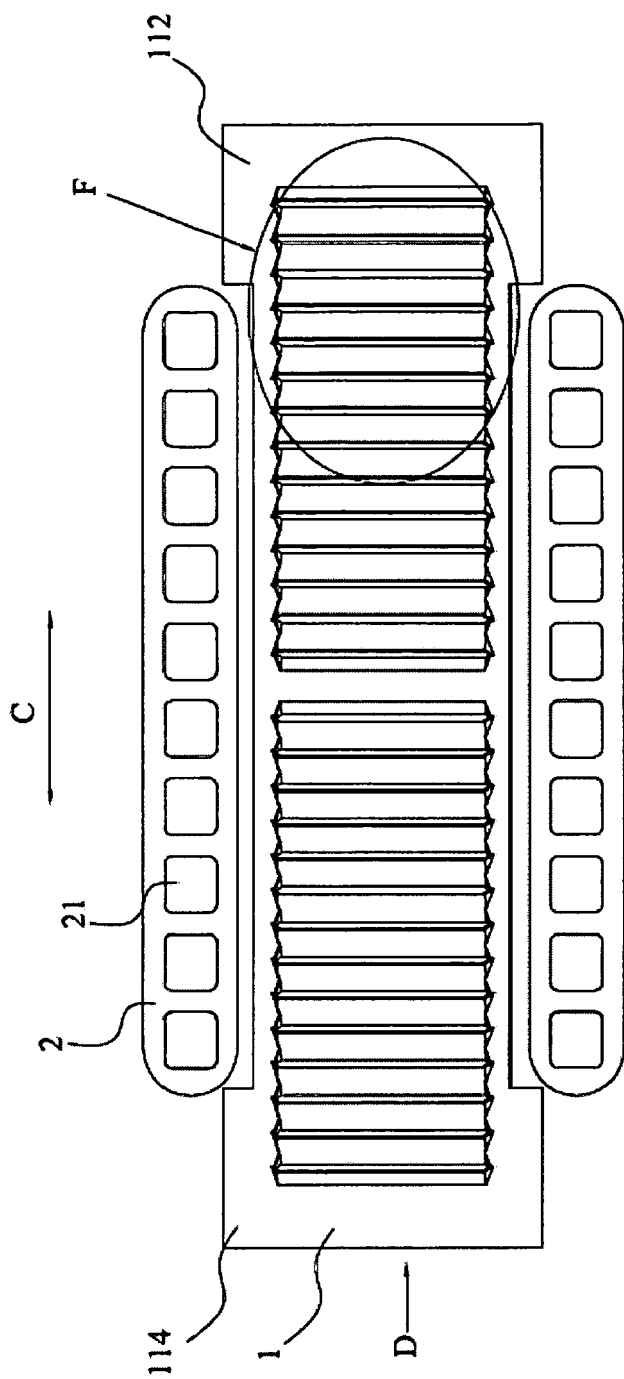


Fig.8

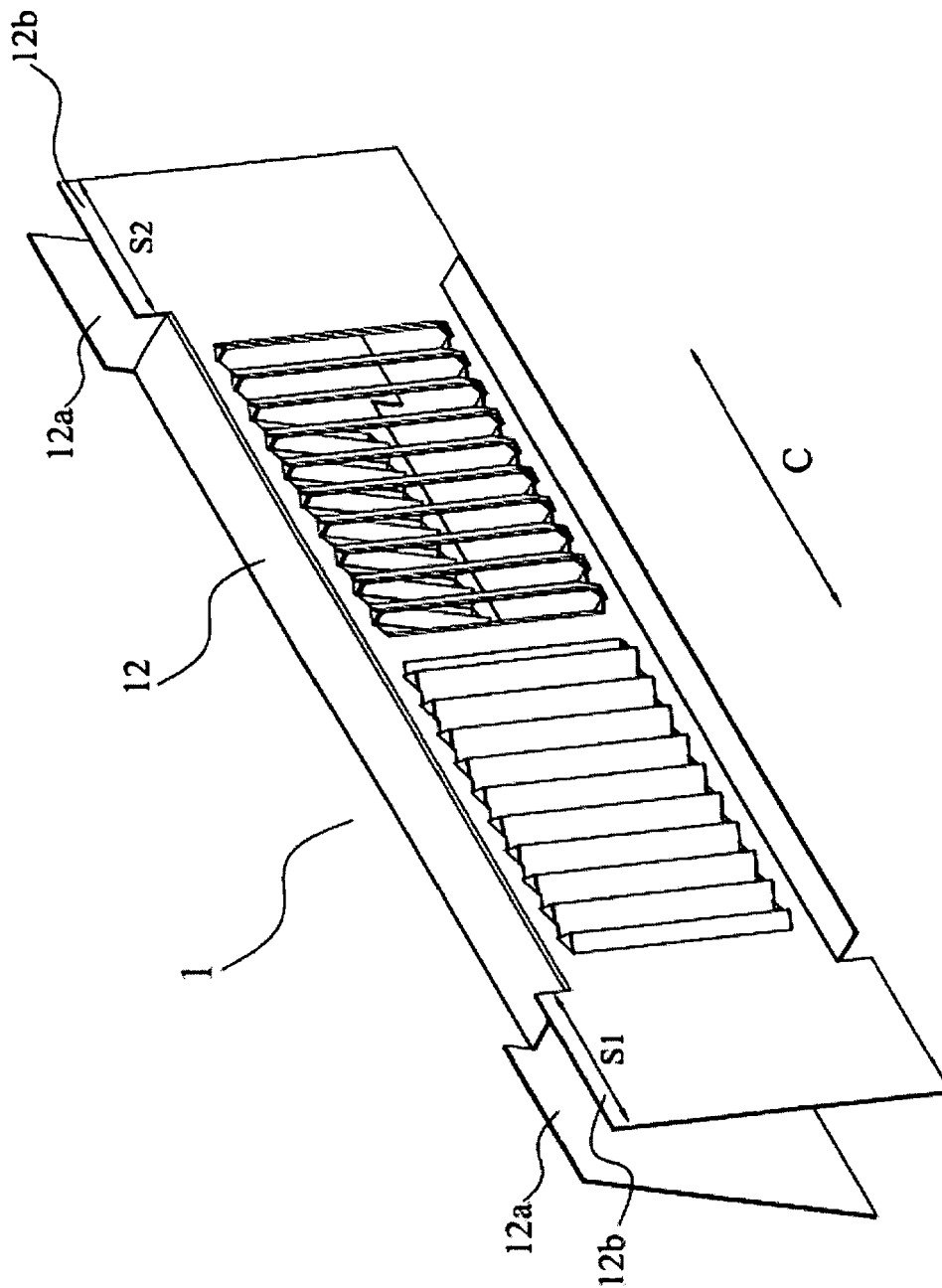


Fig. 9

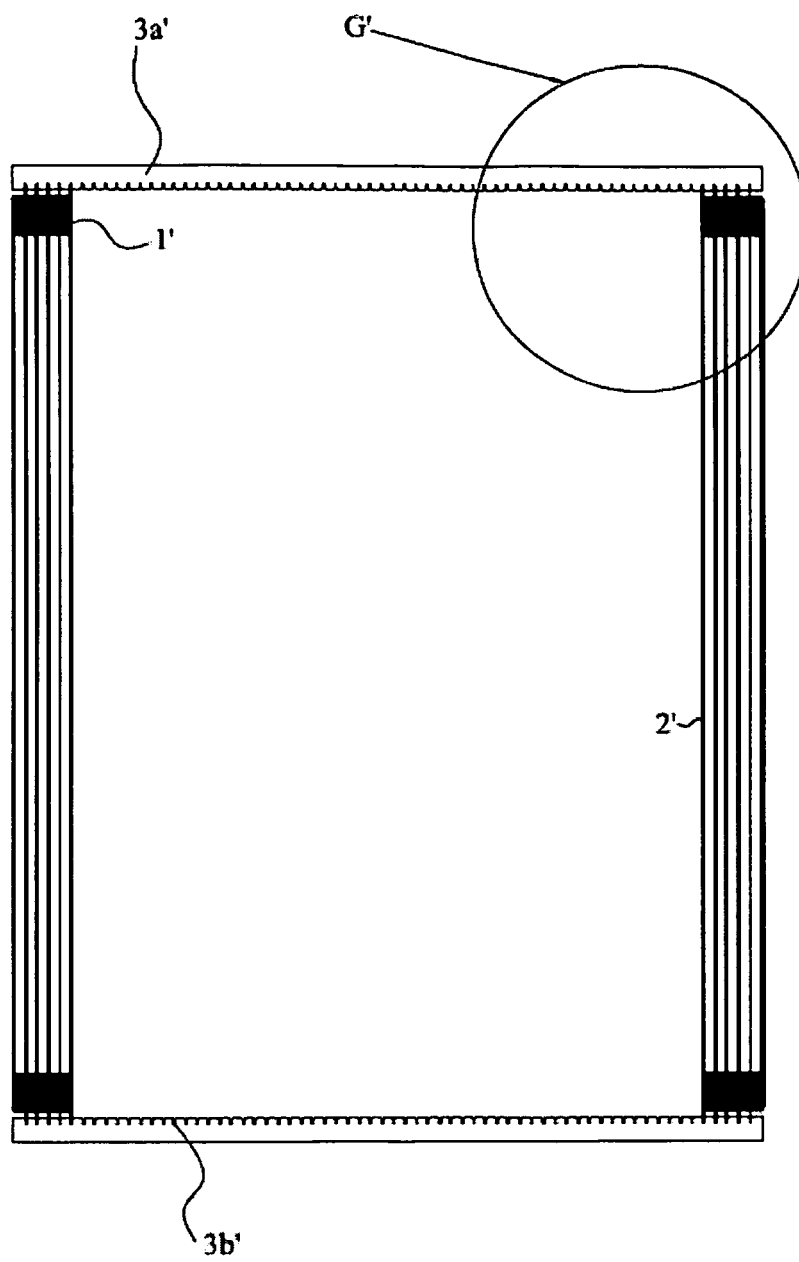


Fig.10

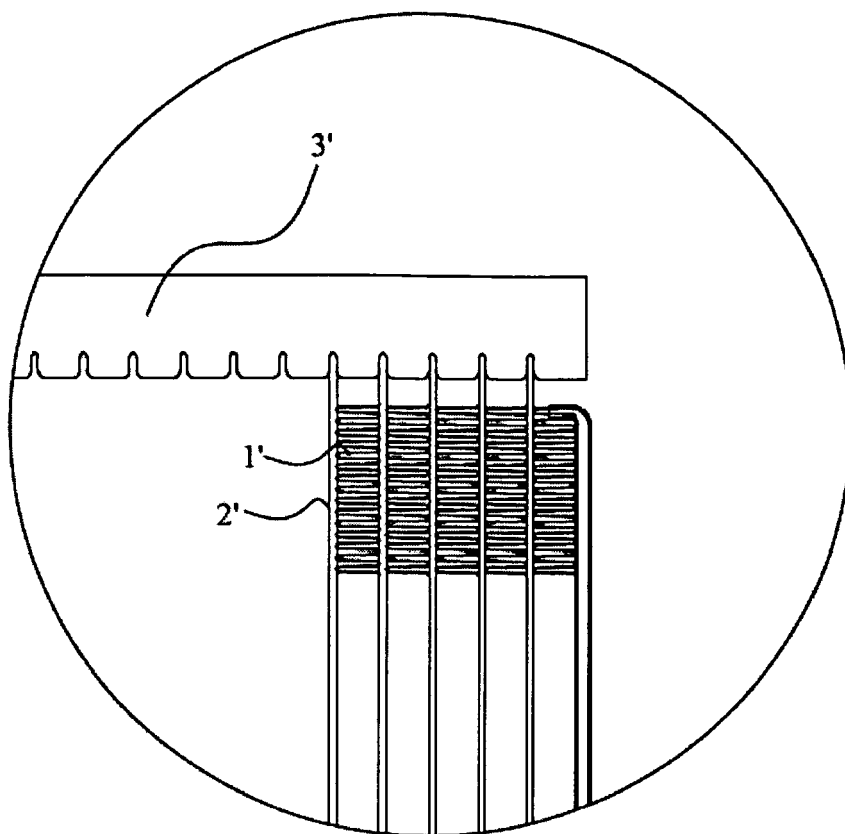


Fig.11

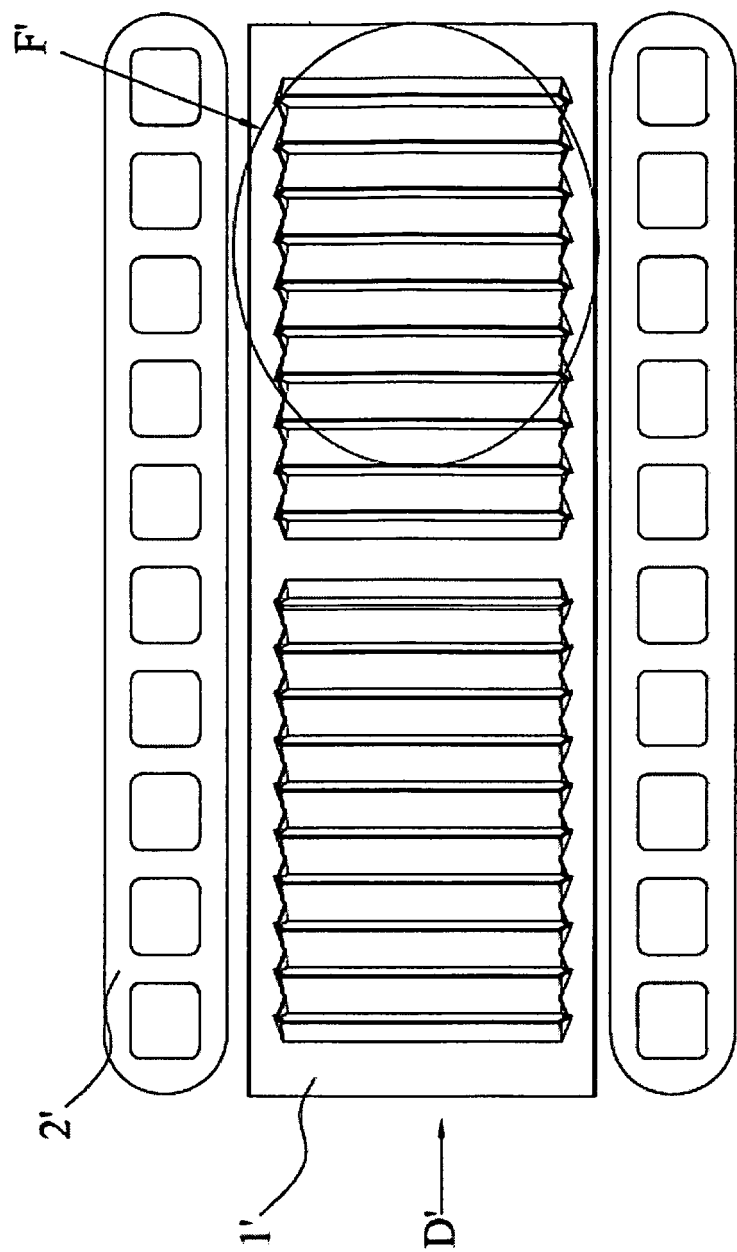


Fig.12